Department of Energy

Condition Assessment **Survey** **(CAS)** Program

Deficiency Standards & Inspections Methods Manual

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for
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CAS PROGRAM OVERVIEW

WHAT IS CAS?

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INTRODUCTION

GENERAL

Welcome to the DOE Condition Assessment Survey (CAS) Program. In the next few pages you will be introduced to a new way of seeing familiar things. As an introduction to CAS, this Program Overview will explain how the various parts of CAS have been developed and integrated to meet the needs of DOE sites, Field Offices, and Headquarters. Our discussion will center around three broad topics:

- WHY CAS?

  This section will discuss issues DOE has faced in previous inspection approaches and explain the CAS goals of providing creative "standardized" solutions.

- WHAT IS CAS?

  Here, key elements of the CAS Program and how they relate to each other will be examined.

- HOW IS CAS IMPLEMENTED?

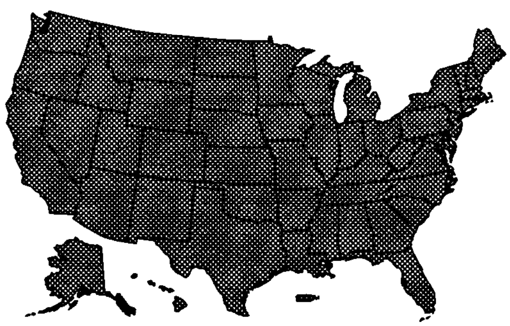
  Strategies for beginning to use CAS and the key roles facility managers and CAS inspectors play within the CAS process are detailed.

Again, welcome to the CAS Program. Your role in this program is essential to its overall success.

INTRODUCTION

WHY CAS?

DOE NATIONWIDE INVENTORY:



- 10,000 BUILDINGS AND 15,000 STRUCTURES ON 52 SITES NATIONWIDE
- LACK OF DOE STANDARDS
- VARYING DEGREES OF INSPECTION
- INCONSISTENT RESULTS LEADING TO INEQUITIES AMONG SITES

INTRODUCTION

WHY CAS? - The State of DOE

The use of standards, from simple weights and measures to complex computer language, has been a fundamental part of human development. Because of standards, we can be assured that a meter of length in one place is the same in another. This question of standards has become increasingly important for DOE. Over the past 50 years, DOE and predecessor agencies have been at the forefront of the nation's technical advances. This investment has left the department a vast array of facilities under its care. With 10,000 facilities and 15,000 miscellaneous structures comprising over 100,000,000 square feet at 52 sites across the country, the problem of design, construction, and maintenance of all DOE physical plants is acute. Add aging facilities, revised missions, and changing technology, and condition assessment becomes a vital tool to use to ensure facilities will continue to meet DOE's and the nation's program goals.

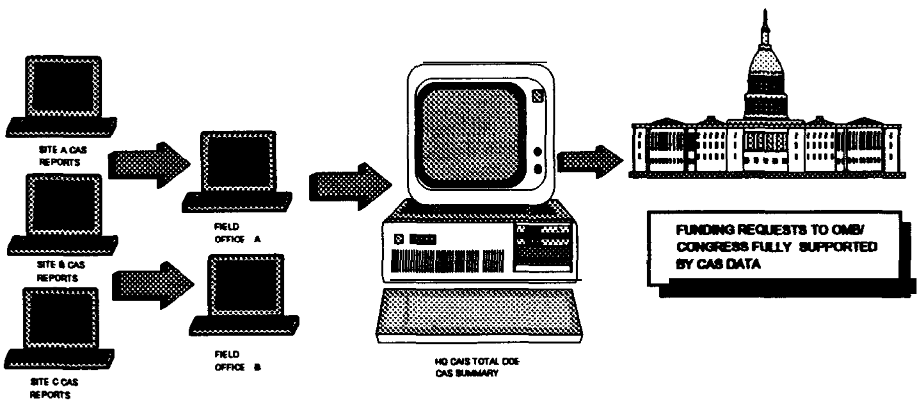
The current state of condition assessment across all DOE assets is mixed. While DOE regulations dictate facility assessments be made, no one methodology is mandated to conduct them. As a result, DOE surveys have varied from site to site, with some locations providing exhaustive in-depth analysis while others have used a more limited approach. Because of such different interpretations, it is difficult to judge the validity and comparability of data being provided. This, in turn, has led to funding requests that cannot be fully substantiated to Congress.

This lack of standards for use in the facility assessment process and the resultant inconsistencies in developing program budgets have convinced DOE that a standardized, clearly defined methodology for condition assessment is essential to support DOE's program missions.

INTRODUCTION

WHY CAS?

- ASSESS PHYSICAL CONDITION OF EXTENSIVE AND VARIED DOE FACILITY AND EQUIPMENT INVENTORY
- STANDARDIZE INSPECTION PROGRAM FOR ALL SITES
- IDENTIFY REPAIR/REPLACEMENT NEEDS TO FACILITATE KEY BUDGET DECISION MAKING
- DEVELOP SUPPORTABLE FUNDING REQUESTS BASED ON "UNIVERSAL" STANDARDS



INTRODUCTION

WHY CAS? - Four Key Requirements

In today's economic environment, it is essential that the DOE knows with confidence the condition of its vast asset inventory. To accomplish this, a method to review all DOE assets in a "standardized" approach is required. In designing guidelines for such a program, DOE established four key requirements:

Assess Physical Condition of All Assets:

To be valid, all sites eventually must be included in the program. Universal participation will ensure that all DOE sites and installations will be using the same "score card."

Standardize Inspection Programs:

To remove the problem of inconsistent and misinterpreted facility inspection data, a "standard" evaluation method used by all DOE sites is required. Results from such a program will allow DOE to determine a "base condition" for all of its assets.

Identify Repair/Replacement Funding:

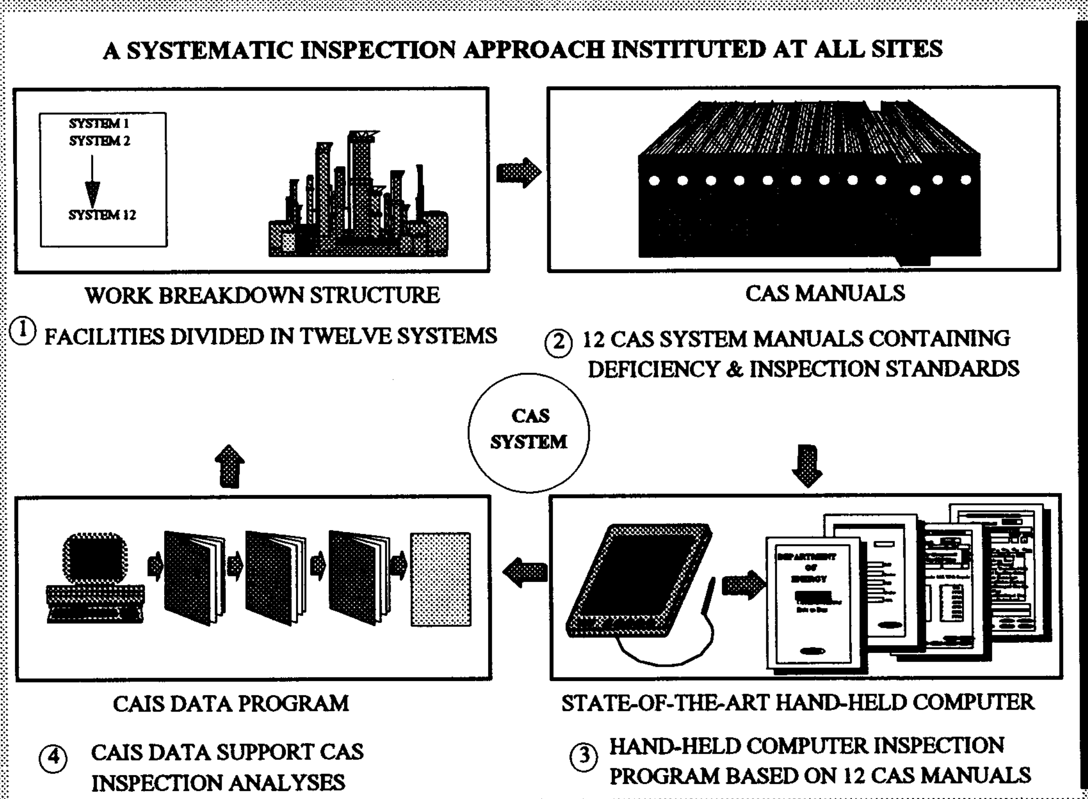
Using inspection data from all sites, a general picture across all DOE assets and programs can be used to direct limited resources to crucial areas. Standardized reports form "a level playing field" to ensure that all programs and missions will receive a fair analysis.

Develop Supportable Fundlng Requests:

In today's atmosphere of fiscal constraint, requests for funds from Congress require extensive justification, backed up by reliable, consistent field data, if such programs are to be successfully supported.

INTRODUCTION

WHAT IS CAS?



INTRODUCTION

WHAT IS CAS? • The Work Breakdown Structure (WBS)

The CAS system has been developed to answer the critical questions facing DOE. Using state-of-the-art hand-held computers and system software programs, the CAS process will establish a systemized, standard approach to facility and asset evaluations. This program will help DOE provide the necessary assets as it seeks to bring our nation's premier research and development agency into the year 2000 and beyond.

The condition assessment process involves evaluating separate building "systems" that comprise the entire facility. These systems traditionally fall under three broad professional disciplines: architectural (including structural), mechanical, and electrical. Specialty assessments (e.g. industrial hygiene, chemical engineering) are usually performed as adjuncts to these primary disciplines when required. The WBS employed under CAS is based on the 12 system assemblies that R.S. Means employs in its square foot cost analysis. Using this system as a foundation to define assemblies and components in the CAS Program will create a direct link to a broadly accepted industry-wide standard.

TABLE ONE

WORK BREAKDOWN STRUCTURE

SYSTEM (R.S. MEANS CAT.)	**CONTRO** I. NO.
FOUNDATIONS & FOOTINGS..	0.01 SYSTEM
SUBSTRUCTURE	0.02 SYSTEM
SUPERSTRUCTURE..	0.03 SYSTEM
EXTERIOR CLOSURE..	0.04 SYSTEM
ROOFING..	0.05 SYSTEM
INTERIOR FINISHES & CONSTRUCTION	0.06 SYSTEM
CONVEYING SYSTEMS	0.07 SYSTEM
MECHANICAL SYSTEMS	0.08 SYSTEM
ELECTRICAL SYSTEMS	0.09 SYSTEM
*PROD/LAB/OTHER EQUIPMENT..	0.10 SYSTEM
SPECIALTY SYSTEMS..	0.11 SYSTEM
SITEWORK	0.12 SYSTEM

CONSTRUCTION SPECIFICATIONS

DIVISION **(MASTERFORMAT)**	DESCRIPTION
01000	GENERAL REQUIREMENTS
02000	SITEWORK
03000	CONCRETE
04000	MASONRY
05000	METALS
06000	WOOD & PLASTICS
07000	THERMAL& MOISTURE PROTECTION
08000	DOORS & WINDOWS
09000	FINISHES
10000	SPECIALTIES
11000	EQUIPMENT
12000	FURNISHINGS
13000	SPECIAL CONSTRUCTION
14000	CONVEYING SYSTEMS
15000	MECHANICAL
16000	ELECTRICAL

The WBS of the CAS Program will be linked to the MASTERFORMAT system developed by the Construction Specifications Institute (CSI) and used as the basis for the DOE Design Guide (DOE 6430.1A). These CSI numbers will be referenced after each system assembly and component in the CAS Manuals as follows:

EXAMPLE: Roofing (CSI 07000)

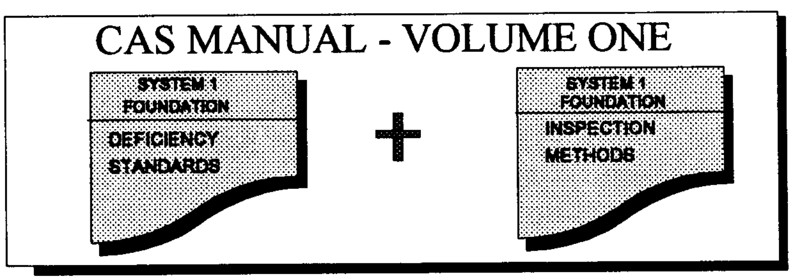
*NOTE: This section supersedes Means 0.10 category and includes FIS 700 Series Asset Codes.

INTRODUCTION

WHAT IS CAS?

DEFICIENCY STANDARDS & INSPECTION METHODS MANUAL

- DEVELOPED SEPARATELY FOR EACH SYSTEM
- DEFICIENCY STANDARDS CONTAIN NARRATIVE AND GRAPHICS FOR DESCRIBING DEFICIENCIES AFFECTING SYSTEM ASSEMBLIES
- INSPECTION METHODS CONTAIN PROCEDURES TO IDENTIFY TYPE, SEVERITY, AND PERCENT COVERAGE OF EACH COMPONENT OR SYSTEM DEFICIENCY ILLUSTRATED



INTRODUCTION

WHAT IS CAS? - DOE CAS Manual Format

Using these 12 systems as the basic organizing principal, the DOE CAS Manual will contain Deficiency Standards and Inspection Methods. It will be divided into 12 volumes corresponding to these established WBS systems, The internal organization of manuals is outlined below:

SECTION 1 - SYSTEM INFORMATION

1.1 Asset Determinant Factor/CAS Repair Codes/CAS Cost Factors - Discusses the Asset Determinant Factor (ADF), a decision matrix used to provide a graded approach to inspections commensurate with the use and relative importance of the asset inspected. Also addresses the CAS repair codes, and a general overview of cost estimating techniques.

1.2 Guide Sheet Tools & Materials Listing - Contains tools and materials groups used in conjunction with the inspection methods process for the system outlined in each volume.

1.3 Testing Methods - Contains the specific requirements for testing methods applicable to the systems

1.4 inspection Frequency - Schedule of CAS inspection frequencies for systems/components.

1.5 Standard System Design Life Tables - Standard design life tables for the system assemblies/components.

1.6 System Work Breakdown Structure (WBS) - Complete listing of all assemblies/components.

1.7 General System/Material Data - General material data relevant to system deficiency problems. (Optional, not included for all systems.)

SECTION 2 - DEFICIENCY STANDARDS

Each major assembly/component is defined by a brief narrative and accompanying graphic(s) that visually illustrate the general characteristics. Major deficiencies affecting this assembly/component are described, including probable failure points. A deficiency characteristics profile and graphic illustrations are provided with each deficiency defined.

SECTION 3 - **INSPECTION** METHODS

This section contains discussions of methods and procedures involved in inspecting each of the WBS systems. Each system contains an Inspection Method, including a narrative and a System/Component Inspection Guide Sheet Listing that provides a general overview for each defined major assembly/component type. This information will be developed for Standard and Non-Standard Inspections and testing methods that would be used in conjunction with Standard or Non-Standard Inspection Methods. Also included is a simulated example, "walking' the inspector through the data collection process.

SECTION 4 - REFERENCES

All major reference standards used and/or associated with the system are described, including government, industry, and DOE references.

APPENDICES

Appendix A Abbreviations - All abbreviated terms contained in the CAS manuals.

Appendix B Glossary - All technical terms directly related to the particular systems discussed will be defined in this subsection.

Appendix C Technical **Bulletins/Updates/Advisories** - This subsection contains technical information issued by the government and/or private industry that may affect specific data as developed in the particular volume. DOE guidelines may also be included in this subsection.

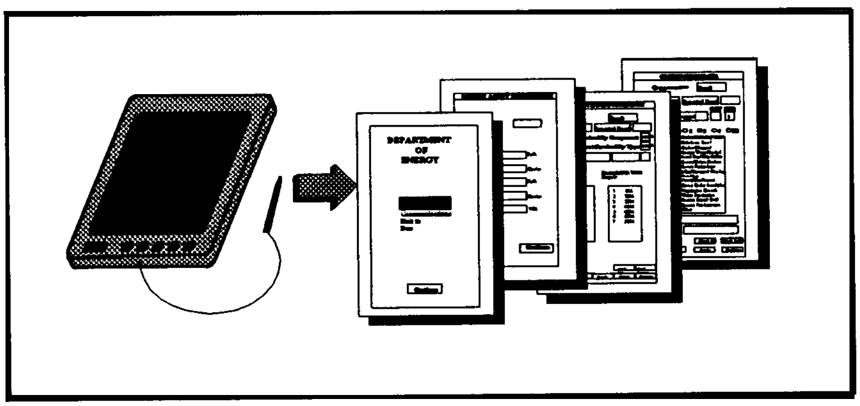
Appendix D **Revisions** Summary - All revisions listed in chronological sequence. The last revision listed will be the most current modification.

INTRODUCTION

WHAT IS CAS?

STATE-OF-THE-ART TECHNOLOGY STREAMLINES FIELD **CONDITION ASSESSMENT SURVEY PROCESS**

- HAND-HELD COMPUTER "PROMPTS" INSPECTOR WITH PRELOADED SOFTWARE SYSTEM "MENUS"
- INSPECTOR SELECTS DEFICIENCIES, SEVERITY, PERCENTAGE OF COVERAGE, LOCATION, ETC. FROM "MENU" SYSTEM



INTRODUCTION

WHAT IS CAS? - State-Of-The-Art Technology

At the outset of this introduction, we talked about a "new way" of seeing familiar things. The traditional methods of facility assessment inspection, using hard copy forms then entering data either by laptop or into a PC, have given way to a new, exciting technology: The Pen-Based Computer. This hardware, and the Condition Assessment Information System (CAIS) software developed to support it, form the heart of the DOE CAS data collection process. Using the CAS manuals as the basis to develop the inspection process, CAIS software will create pre-stocked survey "menus". These will be used to record defined deficiencies in terms of severity and coverage. With this user-friendly device, inspectors will simply use a pen-like device to record their observations directly on the prompted inspection screens developed for each system.

The advantages in using this technology for the DOE CAS Program are exceptional. The efficiency gained by using the hand-held computer technology to prompt the inventory and facility inspection process will be significant. This eliminates the manhour-intensive and error-prone process of converting manually developed data into an automated database. This technology system ensures that all pertinent data is collected, guiding the inspector through each step of the process. This method will significantly enhance the effectiveness of quality assurance/quality control of the DOE CAS Program, permitting editing as data is entered, eliminating illogical or erroneous choices.

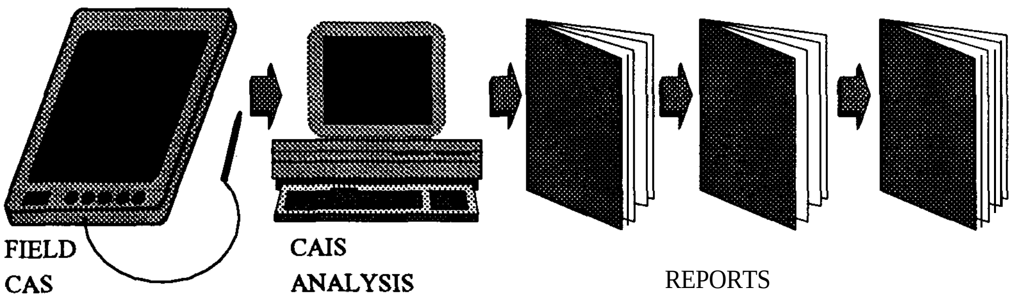
In short, the CAS process will be conducted in a carefully structured, "standardized" manner to ensure that the quality of raw inspection data is consistent throughout all DOE installations.

INTRODUCTION

WHAT IS CAS?

CAIS PROGRAM FOR HAND-HELD & PCs SUPPORT THE CAS PROGRAM

- INSPECTION DATA DOWNLOADED TO PC-BASED CAIS PROGRAM
- DATA ANALYZED, CATEGORIZED, AND SORTED
- REPORTS GENERALIZED, INCLUDING UNIVERSAL AND SUMMARY VERSIONS
- REPORTS WILL INCLUDE DEFICIENCY DESCRIPTIONS, COSTS TO REPAIR/REPLACE, AND SCHEDULE



INTRODUCTION

HOW IS CAS IMPLEMENTED? - **Support** Roles

While CAS manuals, hardware and the CAIS database are the main building blocks of the CAS Program, CAS support personnel will form the standing framework. Your role in the implementation process is crucial if the CAS system is to succeed. In reviewing this process, three key support groups are highlighted.

CAS Contractor Support Personnel:

In conjunction with DOE managers and Site Management & Operations (M&O) contractors, CAS contractor support personnel will work closely with DOE in setting up and conducting the training program, installing CAIS, and validating CAS through a Quality Assurance (QA) program. This team of CAS trainers, CAIS programmers, and QA engineers and architects will form, along with DOE M&O personnel, the strong team required to support the CAS Program as it proceeds.

Manager Support:

No group is more important in implementing CAS than the DOE managers and M&O contractors. Their in-depth knowledge of the sites and their personnel will help guide and strengthen the entire CAS system.

CAS Inspectors:

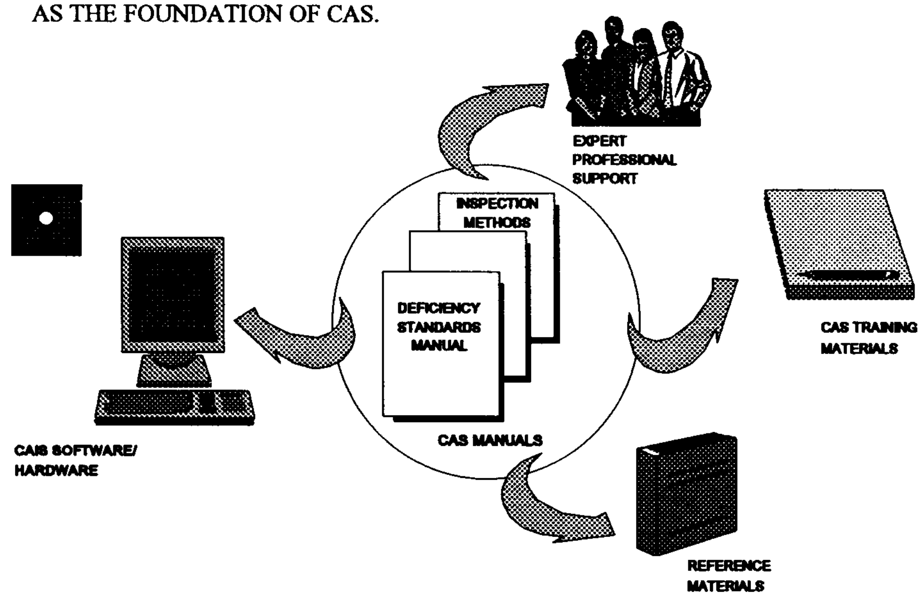
Without highly skilled, knowledgeable inspectors, the CAS Program will not succeed. The integrity of these inspectors and their expertise will ensure that the base data supporting the entire CAS process will be an accurate reflection of the condition of the DOE inventory of facilities and assets.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

CAS SUPPORT RESOURCES

- DEFICIENCY STANDARDS AND INSPECTION METHODS MANUALS SERVE AS THE FOUNDATION OF CAS.



INTRODUCTION

WHAT IS CAS? - The **CAIS** Connection

Asset condition information is uploaded directly to the PC and the CAIS program, eliminating the laborious hand input of data. If the hand-held is the "eyes and ears" of CAS, then the CAIS database is the "brain." In the program, raw data is sorted and analyzed to create CAS reports. Several key factors are determined during the process:

Deficiencies Affecting Survey Assets:

The inspector describes each deficiency noting its severity and coverage, i.e. how much of the component or assembly reflects the deficiency. The inspector also codes each component or assembly as to condition and the urgency and purpose of proposed repair or replacement actions.

Corrective Repairs:

Based on these recorded deficiencies, corrective actions and their associated repair codes are defined and processed by the CAIS database.

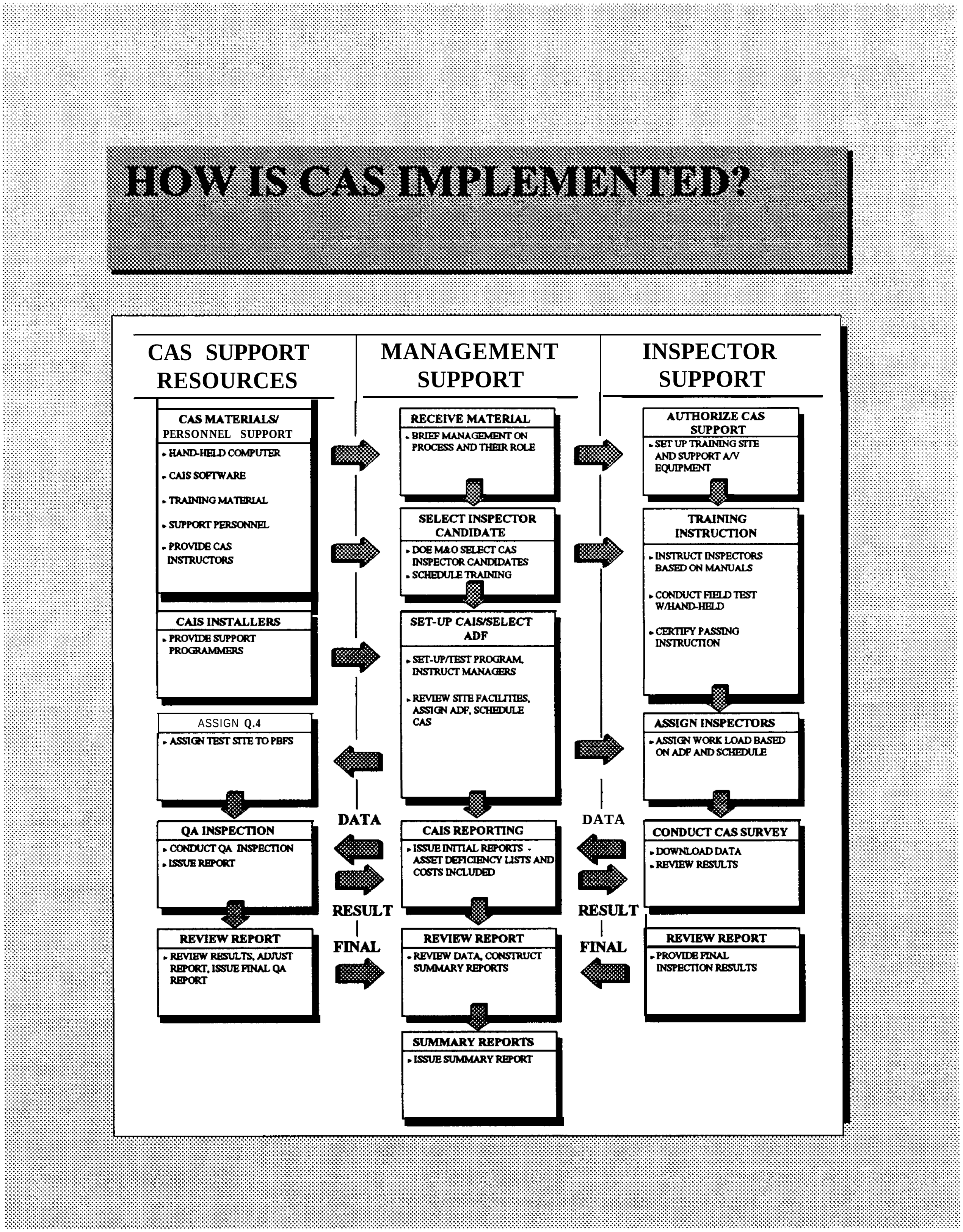
Project Costs:

Costs to accomplish repairs and replacements are generated by the manipulation of field data in the CAIS program, which employs several methods including determining cost as a percentage of total replacement and/or direct entry of costs. (See Section 1, Subsection 1.1 for discussion of cost development.)

Asset **Reports:**

Preformatted reports and tables are generated by the CAIS System. Report types include "universal" reports listing all deficiencies and observations recorded by the Inspector, summary asset reports, and summary site reports. Data within the CAIS system can also be manipulated readily to create "custom" reports.

INTRODUCTION



INTRODUCTION

HOW IS CAS IMPLEMENTED? - CAS Support Resources

We have spoken generally of the CAS Process and those resources (manuals, hardware, CAIS software) required to implement the system. Additionally, the CAS contractor will supply all of the technical personnel to support, implement, and guide the CAS Program. Among those key professionals are:

CAS Training Instructors:

Professionals with a technical background and well-versed in training methods, will train CAS inspector candidates. Their mission will be to instruct and guide CAS inspector candidates through the entire process, supervise field exercises, and provide final testing. Their goal is that all candidates will be successful participants in the CAS Inspection process.

CAIS Programmers:

A key CAS Program element is the CAIS. Expert programmers will supervise the installation of the PC-based program and provide guidance and instruction for DOE M&O managers in using the system.

CAS/CAIS Hotline:

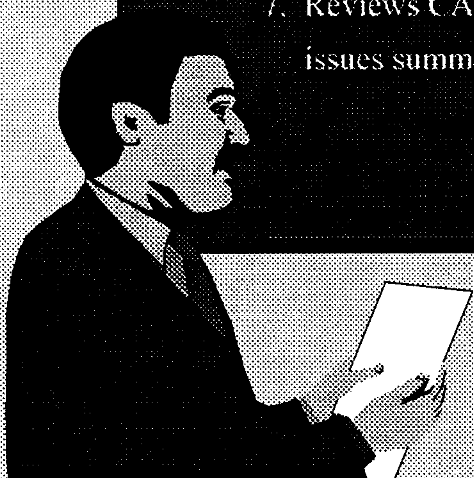
The Contractor will provide support resources in order to field questions from various site locations. Expert engineers, architects, and computer programmers will answer with written and/or verbal responses all inquiries originating from the field.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

MANAGEMENT KEY ROLES

1. Coordinates CAS program implementation
2. Sets up training location & equipment support
3. Selects CAS inspector candidates
4. With CAS/CAIS contractor, coordinates CAIS installation and testing
5. Analyzes site assets and assigns Asset Determinant Factor (ADF)
6. Schedules inspection
7. Reviews CAIS reports, provides analysis, and issues summary reports



INTRODUCTION

HOW IS CAS IMPLEMENTED? - The Management Role

The critical role DOE M&O managers will play in the CAS process cannot be overstated. Their understanding and direct input will guide the construction of the CAS Program. Their chief responsibilities are:

Initial Implementation:

CAS start-up will include a general briefing by the CAS contractor at designated sites to instruct all key managers in the process and their responsibilities. DOE M&O management actions include training site set-up (to hold maximum of 25 students), arrangements for required A/V equipment (overheads, slide projectors, etc.), and CAS inspector candidate selection (see Guidelines for Implementation of CAS Certification Training under separate cover).

Setting Up CAIS:

In conjunction with CAIS programmers, DOE M&O managers will be instructed in the function and various uses of CAIS software. Data input, system operation, report generation with predetermined report format, and how data can be manipulated to customize reports, will be examined during this training.

ADF Selection & CAS Schedule:

A vital element of the CAS Program is the development of a CAS "strategy." DOE M&O managers will be instructed in the use of the Asset Determinant Factor (ADF) to sort site assets into varied inspection effort levels. See Section 1, Subsection 1 .1 Asset Determinant Factor (ADF), CAS Repair Codes, and CAS Cost Factors. The ADF will guide the DOE M&O managers in scheduling the survey and assigning CAS Inspectors to various assets.

Report Analysis:

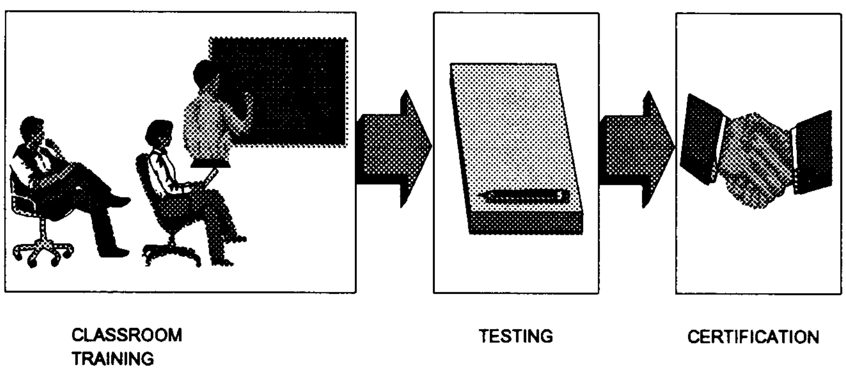
The process of up-loading CAS field data to the PC-based CAIS program will be demonstrated to the M&O CAS managers. Analysis processes will be examined using predetermined, formatted reports. Final management project "sorts" and prioritization schemes, and construction of summary reports for higher authorities, will comprise the basic CAS report development sequence.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

CAS INSPECTOR CERTIFICATION

- INSPECTOR CANDIDATES ARE TRAINED, TESTED, AND CERTIFIED USING THE CAS PROGRAM



INTRODUCTION

HOW IS CAS IMPLEMENTED? CAS Inspector Certification

While the CAS manuals, hand-held computer, and CAIS software program are the tools of the CAS system, the CAS Inspector is the system "operator." The old adage, "The data output is only as good as the data input," truly applies to the inspectors' role in the CAS process. As part of the effort to assure accurate, consistent results, the CAS Program includes an Inspector training phase that will "certify" all candidates in the use of the CAS system. It should be noted that it is not the training course's intent to train personnel to be inspectors: it is assumed that candidates will come to the CAS Program with a strong background and past experience in the disciplines they will inspect (see Guidelines for Implementation of CAS Certification Training (GICT) under separate cover for detailed information). Key phases of the course include:

Prequalification:

Based on experience levels set by GICT, candidates are selected by the M&O contractors and sent to the CAS training program.

Classroom Training:

Classroom instruction will be conducted at the sites selected by DOE. Course materials, based on the Deficiency Standards and Inspection Methods sections in the manuals, will clearly demonstrate the nature of the CAS system and how it is to be used. Hand-held computers will be used during the course. At course conclusion, these units will be turned over to the inspectors for use in the CAS Program and become the property of the site that the inspectors represent.

Field Exercise:

During the training course, a field exercise using the hand-held will be conducted at a predetermined test asset. This survey and its results will be an integral part of the inspection education program.

Certification Test:

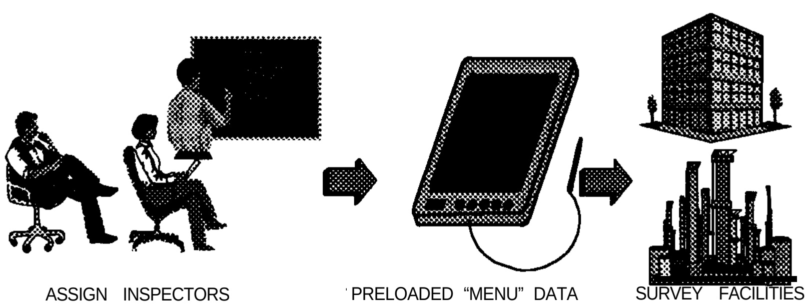
At the completion of the CAS training, each candidate is required to take and pass a written examination based on the material covered in the class. It is the goal of the training team to pass 100% of the candidates. Those having difficulty will receive additional instructor attention during the class as required. After passing this examination, candidates will be fully certified CAS Inspectors.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

THE SURVEY PROCESS

- CERTIFIED CAS INSPECTORS FOR EACH MAJOR DISCIPLINE ARE ASSIGNED FACILITY ASSETS TO INSPECT
- PRE-LOADED SURVEY ROUTINES FOR EACH SYSTEM ARE PROVIDED THROUGH HAND-HELD COMPUTER CAS SOFTWARE PROGRAM



INTRODUCTION

HOW IS CAS IMPLEMENTED? - The Survey Process

At the completion of CAS training and upon the M&O managers' ADF asset selection and development of survey schedules, certified CAS inspectors will be assigned assets to inspect. This step initiates the CAS process, which will involve several major phases.

start-up:

The objective during start-up is to prepare a profile information file for the asset being surveyed and to verify preloaded information (RPIS data, name, and address, etc.). Such a review might include part and/or all of the material listed below:

- As-built and/or construction documents
- Square footage, type of construction, and age of each building
- Existing studies, surveys, and reports; and
- Existing repair, alteration, or construction projects

Conduct CAS **Inspection/Evaluation:**

With the benefit of the information contained in the asset file, the CAS Inspector will perform a thorough evaluation of the WBS systems required for each of the assigned assets. The Inspector will initially review the asset file to note particular problems. With this accomplished, the CAS Inspector will methodically survey each of his assets and record deficiencies (in terms of severity and coverage) and other observations on the preprogrammed hand-held computer. He accomplishes this data recording through "menu" screens contained in the CAS hand-held computer software, which will guide the CAS Inspector through the process (see Section 3 for full detailed information outlining step-by-step the CAS inspection process).

CAS Report Generated by CAIS:

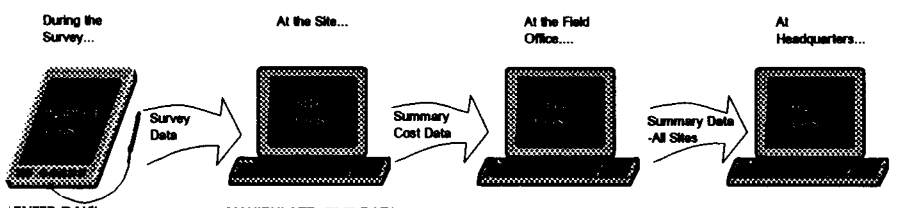
After completing the CAS Inspection, information is uploaded to the PC-based CAIS system. "Universal" reports showing all asset deficiencies, observations, associated cost, scheduling priorities, and repair purposes will be produced. As part of the QA, the Inspector will review this information with the manager to ensure that all aspects of the inspection asset information are correct.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

SUMMARY REPORTS

- IMPROVE ACCURACY AND PROVIDE QA FOR ALL SITE INSPECTION DATA
- FINAL REVIEW OF PRELIMINARY REPORTS BY THE MANAGERS TO "PRIORITIZE" REPAIR/REPLACEMENT REQUIREMENTS FROM ASSET TO ASSET
- ISSUE SUMMARY RESULTS WITH FULL BACK-UP AT SITE



ENTER RAW SURVEY **INSPECTION** DATA

MANIPULATE, EDIT **DATA - ASCERTAIN** PRIORITIES, COSTS

RECENE **SUMMARIZED** SITE **DATA,** ASSIGN FINAL **PRIORITIES**

PROVIDE FINAL PROGRAM REVIEW FOR APPROVAL

INTRODUCTION

HOW IS CAS IMPLEMENTED? • Report Development

With the completion of the CAS Inspector's survey, data uploaded into the PC-based CAIS program is analyzed to provide the survey reports. The primary preformatted reports include:

'Universal' Report:

This document contains all the information recorded concerning deficiencies found in the WBS systems surveyed in each asset. The report lists all deficiencies and observations system by system. The summary section provides the cost of repairing surveyed asset deficiencies and repair codes showing condition, purpose, and urgency. Costs are calculated in CAIS based on deficiencies noted. Inspectors can also directly input repair costs either as a percentage of replacement costs or as an absolute dollar value.

Asset **Summary** Report:

This report contains summary asset deficiency data at the WBS system level only. The report lists deficiency/corrective repair action by codes (see Subsection 1.1 for more information). All assets surveyed by the Inspector will be listed here. Manager input to these reports includes resorting the priority list (including additions and/or deletions) and recommendations.

Site Asset Summary Report:

After all inspector surveys have been processed, analyzed, and final recommendations input by the manager, this preliminary site-wide report lists all assets included and preliminary manager sorts (Asset Summary Report). Manager input includes selecting of final projects recommended for the budget cycle, including cost and priority schedules.

Site Summary **Report:**

This report, issued to DOE Headquarters, contains a site project summary and synopsis of back-up data. This report will serve as the basis for establishing the site maintenance and repair backlog which in turn supports funding recommendations to OMB and Congress.

OTHER REPORTS

QA Report:

As part of the QA process, the contractor QA team will randomly select assets inspected by site CAS Inspectors. Results will be analyzed to determine both accuracy and content of the CAS Program to ensure the validity of CAS procedures.

Custom **Reports:**

Data within the CAS/CAIS database can be manipulated to create various reports. Examples might include a report showing all site roofs, cost magnitude, and/or by building type.

INTRODUCTION

CAS SUMMARY

- STANDARD APPROACH TO CONDITION ASSESSMENT
- EASE/ACCURACY OF DATA COLLECTION
- SITE-CONTROLLED DATABASE
- SUMMARY DATA TO FIELD OPERATIONS & HQ LEVELS
- MORE CREDIBLE DOE BUDGET SUBMISSIONS

INTRODUCTION

THE CAS SYSTEM: - A Summary

In summary, the CAS System has been designed to support the vital process of creating a facility condition baseline that is founded on recognized, fully defined Standards. This established baseline will determine the direction and cost of future assets required to define the DOE's changing mission against a background of government fiscal constraint. As you have seen, your role in this overall program is vital if the CAS framework is to be created and supported. The CAS System is your tool for constructing the essential, realistic requirements needed to obtain budgetary funding. Obtaining these funds is the final measure of whether a site program will move forward or be eliminated.

We began this introduction by promising you a "new way" of seeing familiar things. The CAS Program's combination of state-of-the-art technology and the DOE M&O's talented professionals will be the essential mix to successfully initiate and sustain the CAS process.

END OF SUBSECTION

ASSET DETERMINANT **FACTOR/CAS** REPAIR CODES/GAS COST FACTORS

GENERAL

The CAS Program is built on the physical analysis of each asset through the inspection of the major systems as defined by the WBS. System-specific deficiencies (as defined for each assembly/component in the Deficiency Standards section of this Manual) and the extent of their severity "bracket" the general asset conditions as of the inspection date. Recording actual deficiencies, however, is only part of the process. The CAS process also documents the urgency and purpose of repairs or replacements as well as the overall condition of the assembly/component surveyed.

The following elements are important parts of the CAS process and will be discussed in detail in this subsection:

- ASSET DETERMINANT FACTOR (ADF): Discusses various possible levels of CAS inspections, and the manager's role in determining the type survey appropriate for each asset.
- CAS REPAIR CODES: Describes categories used by the inspector to document the urgency and purpose of repairs and replacements, and the general condition of the assembly/-component.
- CAS COST FACTORS: The general overview of CAS cost development and the factors used to build project costs are outlined in this section.

CAIS Interface:

As outlined in the Introduction "A CAS Program Overview," the Condition Assessment Information System (CAIS) is a key element. CAIS software will provide critical data analyses required to process CAS raw field data, including repair codes and costing factors for recorded facility asset conditions. The CAS Manuals, the hand-held data collection device and software, and the CAIS Program together form the foundation of the CAS process.

In DOE's vast inventory, asset conditions vary widely in terms of age and use, new or renovated facilities are mixed with assets built during the 1940s and 1950s. It is therefore recognized that not all assets at a given site require the full CAS inspection. The ADF has been developed as a tool that provides site facility managers with a means to categorize each site asset by identifying the type of survey to conduct.

CAS Survev Levels:

For the purposes of allowing flexible CAS Program implementation, three broad categories of asset inspections are defined:

- CAS - Base Level: Assessment is primarily a visual inspection (augmented in some instances by simple testing; eg., light level measured by light meter) recorded at the assembly level of the Work Breakdown Structure (WBS). Deficiencies typical to each assembly are recorded in terms of severity and coverage.
- CAS - Component Level: Provides more extensive inspection information based on conducting the assessment at a component level. Components are defined as major parts of an assembly.
- CAS - Limited: Survey not requiring assessments of all systems for a given asset.

ASSET DETERMINANT FACTOR/CAS REPAIR CODES/CAS COST FACTORS

ASSET DETERMINANT FACTOR (ADF)

Ten key categories to be used as ADF guidelines are illustrated below. These classifications are sensitive to key DOE criteria, including short-term and mothballed facilities.

ADF#	Guidance	Description	Systems
1	Existing asset (>3 years), program projected to last 5 years	Full CAS Inspection (base CAS - assembly level or optional component level)[1]	ALL
2	Existing temporary asset (>3 years) program projected to last <5 years	Limited CAS Inspection (base CAS - assembly level only)	ALL
3	Asset decommissioned - "warm mothball" (maintained for future unidentified function)	ARCH(ext), MECH & ELEC (base CAS - assembly level or optional component level)'	0.04, 0.05, 0.08, 0.09
4	Asset decommissioned - "cold mothball" (to be removed, dismantled, destroyed at some future date)	Exterior envelope (base CAS - assembly level only)	0.04, 0.05
5	Asset ROOF inspection only	ROOF inspection (base CAS - assembly level or optional component level)[1]	0.05
6	Asset ARCHITECTURAL only	ARCH/STRUCTURAL inspection (base CAS - assembly level or optional component level)[1]	0.01, 0.02, 0.03, 0.04, 0.05, 0.06, and 0.11
7	Asset MECHANICAL only	MECHANICAL inspection (base CAS - assembly level or optional component level including incidental electrical)[1]	0.07, 0.08
8	Asset ELECTRICAL only	ELECTRICAL inspection (base CAS - assembly level or optional component level)'	0.09
9	Asset SITE inspection only	SITE inspection (base CAS - assembly or optional component level) [1]	0.12
10	As developed by each site	As constructed bv site[2]	As Required

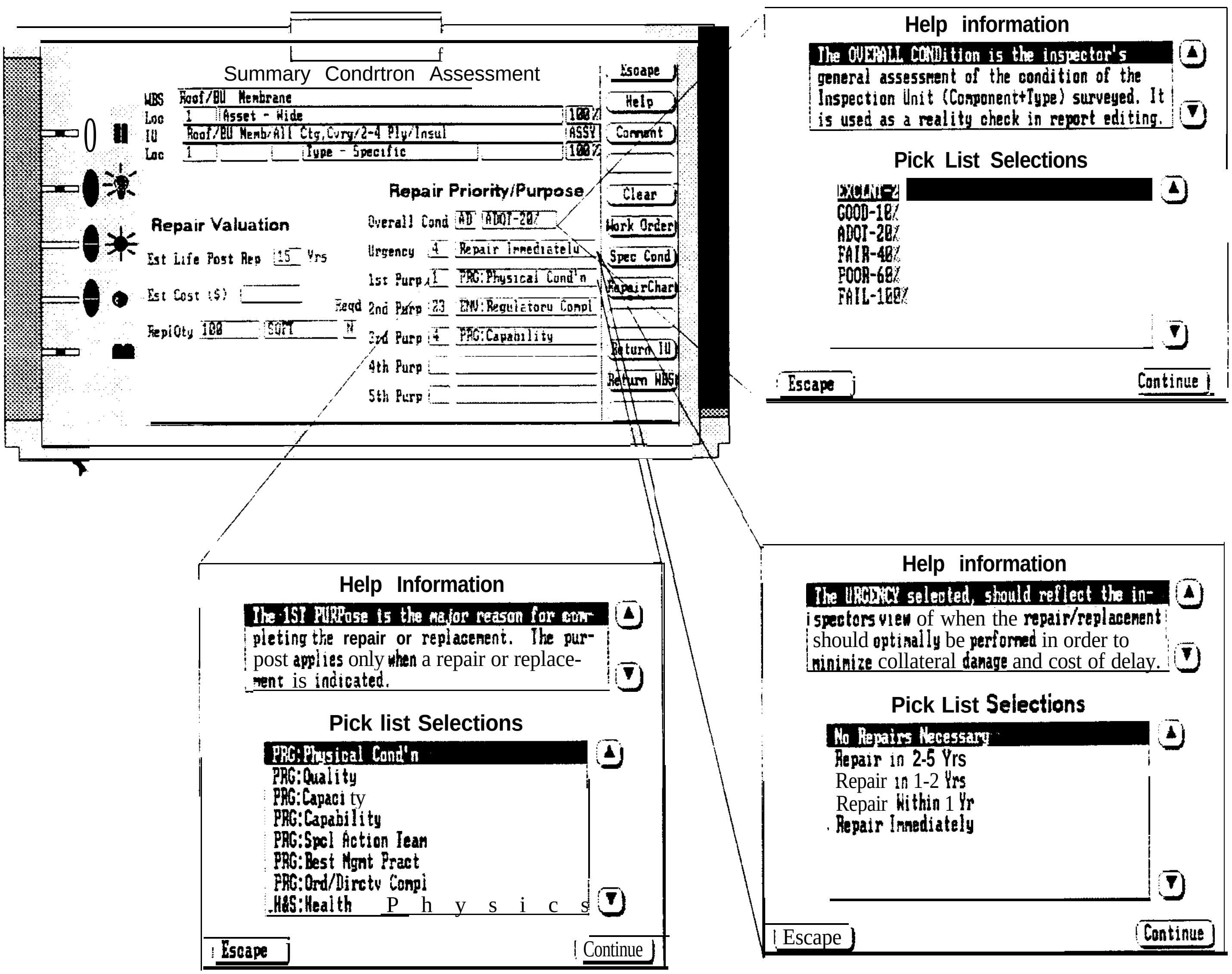
GENERAL NOTES:
1. Survey may combine levels (eg., ADF #1, Systems 0.01-0.06, 0.11, and 0.12 Assembly level survey; 0.07, 0.08, and 0.09 Component level survey.)
2. Other surveys may be structured on an as-required by sites.
3. ADF values are guidelines only and systems may be added to base ADF values as required.

ASSET DETERMINANT **FACTOR/CAS** REPAIR **CODES/CAS** COST FACTORS

ASSET DETERMINANT FACTOR (ADF) (Continued)

ADF #	Definition
1	Assets within this factor represent "typical" DOE facility assets. These assets are over three years old and serve current programs projected to last over five years. A full CAS inspection at the assembly level is required. Component level CAS may be conducted as resources permit.
2	For temporary facilities supporting short-term programs (less than five years), a limited CAS inspection at assembly level involving all systems.
3	For currently unused assets that will be considered for future program development. In this case, only exterior envelope and interior mechanical and electrical systems are assessed at the assembly level.
4	For facilities deemed unfit for future use, a limited CAS inspection is recommended. This would involve exterior envelope only to ensure that asset will not deteriorate prior to scheduled decommission and disposal action (eg., destroy, dismantle).
5	Covers circumstances when only a roof inspection is required.
6	For assets requiring architectural survey only, including 0.01 Foundations and Footings, 0.02 Substructure, 0.03 Superstructure, 0.04 Exterior Closure, 0.05 Roofing, and 0.06 Interior Finishes and Construction, and 0.11 Specialty Systems.
7	For assets requiring mechanical survey only, including 0.07 Conveying, and 0.08 Mechanical.
8	For assets requiring electrical survey only, 0.09 Electrical.
9	General site survey system 0.12 Site Systems only.
10	This factor allows sites to build their own inspection. These will be reviewed by Headquarters for possible addition to the ADF Guidelines.

CAS REPAIR CODES



Refer to the following page for definitions of the three (3) major CAS Repair Codes.

ASSET DETERMINANT **FACTOR/CAS** REPAIR **CODES/CAS** COST FACTORS

CAS REPAIR CODES

One of the key aspects of the assessment process, once significant deficiencies are recorded, is determining the repair category. CAS defines three major repair codes: condition, purpose, and urgency. Condition is derived both by the CAIS algorithm based on raw deficiency data and by the inspector's subjective judgment. Purpose and urgency are each selected by the inspector. Definitions for each major code are listed as follows:

(CAS Repair Codes are guidelines only. Codes may vary as required by sites.)

CONDITION CODE	DEFINITION
A	Excellent: Performs to original specifications as measured using non-standard tests; easily restorable to "like new' condition; only minimal routine maintenance required at cost <2% of replacement value.
B	Good: Performs to original specifications as measured using historical data and non-standard tests; routine maintenance or minor repair required at cost <5% of replacement value.
C	Adequate: Performance meets requirements; some corrective repair and/or preventive maintenance required at cost < 10% of replacement value.
D	Fair: Performance fails to meet code or functional requirement in some cases; failure(s) are inconvenient; extensive corrective maintenance and repair required at cost <25% of replacement value.
E	poor: Consistent substandard performance; failures are disruptive and costly; fails most code and functional requirements; requires constant attention, renovation, or replacement. Major corrective repair or overhaul required at cost <60% of replacement value.
F	Fail: Non-operational or significantly substandard performance. Replacement required because repair cost is >60% of replacement cost.

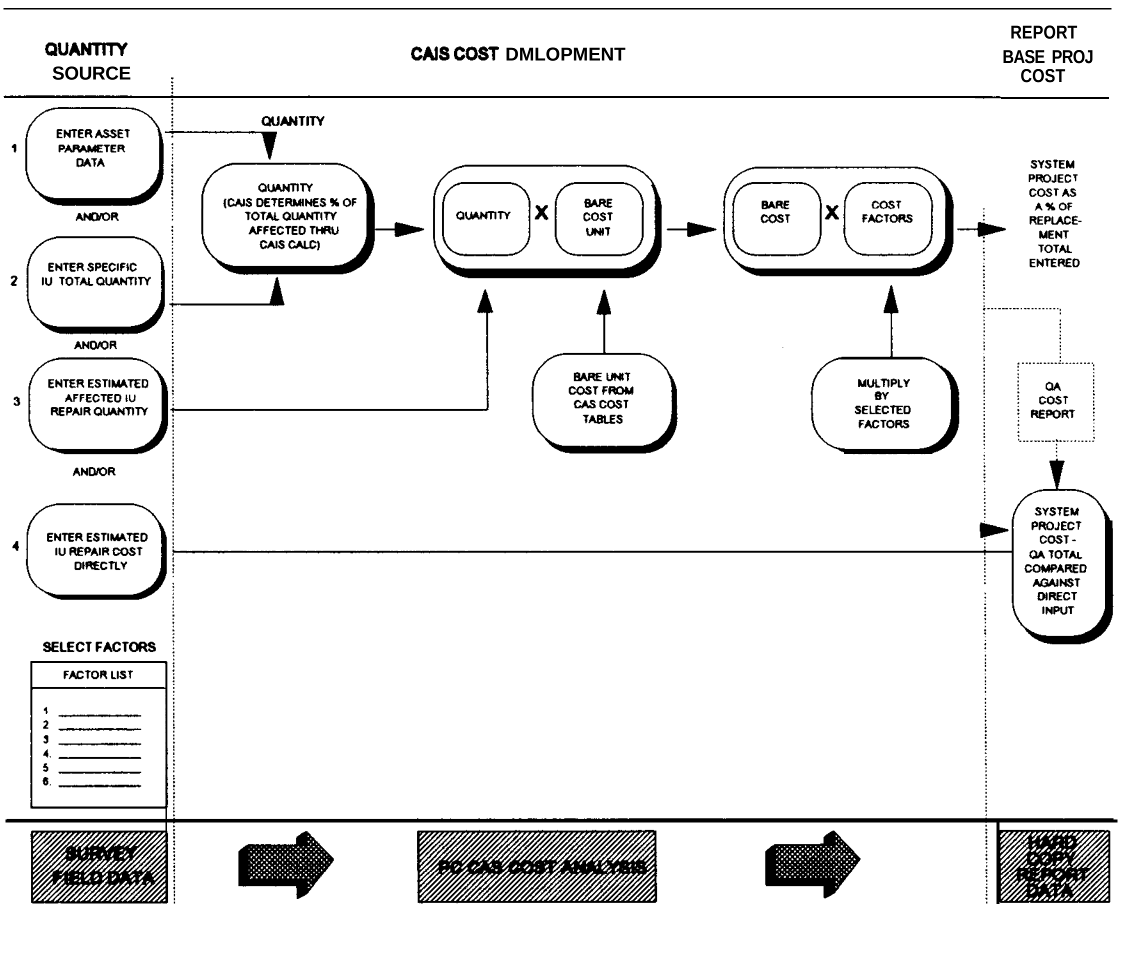
PURPOSE CODE*	**DEFINITION**
P2	PRG: Capacity
H2	H&S: Industrial Safety
E2	ENV: Solid Waste Management
S4	S&S: Security
*	Partial list based on CAMP Order DOE 4330.4A dated 1 0-1 7-90.

URGENCY CODE	**DEFINITION**
1	Repair Immediately: Asset condition critical; initiate corrective action immediately.
2	Repair within 1 Year: Asset condition serious: initiate corrective action within 1 vear.
3	Repair in 1 to 2 Years: Asset condition degraded; initiate repair in 1 - 2 years.
4	Repair in 3 to 5 Years: Asset stable for period; integrate repairs into appropriate schedules.
5	No Repairs Necessary: Continue life cycle maintenance actions.

ASSET DETERMINANT FACTOR/CAS REPAIR CODES/CAS COST FACTORS

The following illustrates the cost development process for the Department of Energy CAS/CAIS Project and the various processes involved.

COST DEVELOPMENT PROCESS



END OF SUBSECTION

GUIDE SHEET TOOL & MATERIAL LISTING

SAFETY REQUIREMENTS

GENERAL

Inspections shall comply with all Federal, State and Local regulations and all applicable safety and health regulations or requirements (including reporting requirements) of DOE.

TOOLS

This subsection contains tool and material listings for use in standard and non-standard inspections in addition to the basic tool group outlined below.

Standard inspection methods are primarily non-invasive visual observations. The accomplishment of the activities identified in the maintenance guides and inspection guides requires tools: basic or craft (standard) and specialized (non-standard). Specialized tools included in the non-standard tool group consist of special instruments and unique tools, and are identified in the guides.

All crafts involved in the inspection and maintenance of sitework systems employ a standard or basic tool set. This basic tool group may vary somewhat between equally qualified personnel; however, the following is a representative set of common tools.

BASIC TOOL GROUP

Architectural/Civil	Electrical	Mechanical
Flashlight	Flashlight	Flashlight
Measuring tape	Measuring tape	Measuring tape
Mirror	Mirror	Mirror
Pocket knife	Pocket knife	Pocket knife
Rags	Rags	Rags

GUIDE SHEET TOOL & MATERIAL LISTING

STAINDARD TOOL GROUP

Architectural/Civil	Electrical	Mechanical
20-oz Masonry hammer	Adjustable wrench set	<u>All Trades</u>
3x5 card stock to indicate photograph locations	Allen wrench set	3/8" drive socket set & ratchet
6-oz Geologist pick	Ammeter, Clamp-on, O-100 A Scale	Assorted center & drift punches, steel chisel
6" Drag chain	Ball peen hammer	Ball peen hammer
Aerosol can of bright colored paint **to mark** deficiency locations	Cleaning materials	Crescent wrenches, 4" & 8"
Assorted center & drift punches, steel chisel	Electrical Insulation materials	Emery cloth
Awl/Icepick	Electrician's knife	Extension cords & inspection lights
Ball peen hammer	Extension cord	File
Binoculars	File	Grease guns & oilers
Broom	Flashlight	Hack saw & spare blades
C-Clamps	Hack saw with blade assortment	Open & box end wrenches, 1/4" & 3/8"
Caliper	Hammer, ball peen	Pipe wrenches to 14
Camera	Infrared Camera	Pliers - vise grip (2), slip joint, needlenose, diagonal cutting, side cutters
Claw hammer	Infrared Thermometer	Small level & square
Crack comparator	Locks	Small set of Allen wrenches
Crescent wrenches, 4" & 8"	Measuring tape, non-metallic	Standard & Phillips head screwdrivers - various sizes
Drive socket set & ratchet	Pipe wrench	Various cleaning tools - brushes, scrapers, etc.
Emery cloth	Pliers: vise grip, slip joint, lineman	Wire brush
Extension cords & inspection lights	Portable light	
File	Socket set, 3/8-inch with ratchet	
Grease guns & oilers	Standard & Phillips head Screwdrivers	
Hack saw & spare blades	StaticScope, 5000 Volt	
Hand brace & bits - to bore suspect areas of timber elements	Tags, caution & hold	
Level, 4	Tape, Measuring, Non-metallic, 10 feet	
Lumber crayon	vibration analyzer	
Measuring tape, 100' nonmetallic	Volt-Ohm-Ampere Meter, Pocket Size, Analog or Digital	
Metal square	Wrench set, open end	
Open & box end wrenches, 1/4" & 3/8"	Wrench set, box end	
Permanent black marker, lumber crayons		
Pipe wrenches to 14"		
Pliers - vise grip (2), slip joint, needle-nose, diagonal, cutting, side cutters		
Plumb bob		
Probing awl w/handle		
Shovel		
Small crowbar		
Small set of Allen wrenches		
Standard & Phillips head screwdrivers - various sizes		
Stiff bristle brush		
Straightedge, 2' to 3		
Switch & signal keys		
Torpedo level		
Track gauge & level rod		
Various cleaning tools - brushes, scrapers, putty knife, etc.		
Wire brush		

GUIDE SHEET TOOL & MATERIAL LISTING

NON-STANDARD TOOL GROUP

Architectural/Civil

Acoustical emission analyzer
Borescope or fiberscope
Core driller
Curve string lining apparatus
Dye penetrant
Eddy current
Infrared measuring device
Lighted magnifying glass (eg., five times &ten times)
Magnetic scanning device
Microwave absorption scanning device
Moisture detection devices
Nuclear analysis mechanism
Paint film gauge
Plane surveying equipment
Rail profiling device
Thermometer
Tiltmeter & protractor
Ultrasonic measuring device
Ultrasonic rail flaw detection equipment
Video camera
X-Ray or Radiography testing device

Electrical

Ammeter, precision
Borescope
Circuit breaker test set
Constant current test set
Constant Voltage test set
Contact resistance test set
Current transformer, laboratory standard
Eddy current test set
Gas analyzer
Ground resistance test set
Growler
High potential test set
High voltage rubber gear
High voltage sticks
Industrial analyzer
Insulation materials
MegOhmmeter
MicroAmmeter, precision
Micrometers
MilliAmmeter, precision
MilliVoltmeter, precision
Nitrogen
Oil analyzer
Oscilloscope
Potential transformer, laboratory standard
Power Factor meter
Protective relay test set
Protective relay tool set
Recorder, Timer, Voltage &Ampere
Sample bottles &thief
Slings
Statiscope
Thermometer, precision
Timer, electric
Turns ratio test set
Vibration analyzer
Voltmeter, precision
Watt-hour meter standard
Wattmeter

Mechanical

Acoustical analyzer
Borescope
Displacement gauges
Dye penetrants
Eddy current techniques
Gas Detector
InfraScope
Moisture Detector
Sample Bottles for Chemical Analysis
Shock Pulse Monitor
Smoke capsules
Stroboscope
Tracer gases for leak detection
Ultrasonic Analyzer
Ultrasonic Flowmeters
Ultrasonic Noise Meter
vibration Analyzer
video camera

Refrigeration

Clamp-on ammeter
Crescent wrenches to 14"
Flaring tools
Leak detector - electronic or halogen
Packing kit & packing
Pliers, cutting and side cutters
Pocket thermometer
Refrigeration gauges
Tubing cutters
Voltmeter-Ohmmeter-Milliammeter

Plumbing

3/4" socket set
Crescent wrenches to 14
Flaring tools
Packing kit & packing
Pipe wrenches to 24
Small acetylene outfit
Tubing cutters

NOTE: It is not the intent of this manual to have sites perform non-standard tests. These guidelines may be used in the event standard inspection is not sufficient to determine system condition. Such non-standard inspections will be provided by others (eg., consultants, outside labs).

GUIDE SHEET TOOL & MATERIAL LISTING

END OF SUBSECTION

TESTING METHODS

GENERAL

During the course of the CAS, various tests will be employed to better ascertain the condition of the assets. These are indicated on the Component Specific Guide Sheets included in Section 3 of this Manual.

The critical nature of concrete, masonry, metal, or wood and their overall condition cannot be understated. Concrete, masonry, metal, or wood compressive strength is vital to maintain structural integrity. Where direct characteristics can be observed, surface deficiencies such as cracks, spalling, and exposed reinforcing may indicate hidden problems. In this case, underlying deterioration can be determined by further test measures. Testing materials in-situ seeks to gauge current conditions including position and size of any reinforcement, poor consolidation areas, voids, cracks, honey-combing, material integrity, degree of rot or decomposition, and moisture content to quantify current strength, durability, and elastic parameters as they exist in view of observed physical deficiencies.

Testing methods do not specify the following:

- Expertise of user (to use the instrument or interpret results).
- The advantage of one testing method versus another.
- The limitations of the testing method.
- Whether the user must be trained and licensed to operate (such as the Nuclear Moisture Meter test, which requires licensing).

Standard vs Non-Standard

Inspection Methods are classified as Standard versus Non-Standard based on techniques employed.

The Standard Methods are generally quick, visual, hands-off walk-throughs not requiring a component to be taken out of service or consist of limited tests such as voltage and current measurements using small hand-held devices. Few tests are required in the associated Guide Sheets. Where tests are indicated, they are non-invasive. Examples include vibration analysis and thermographic observations.

The testing methods associated with the Non-Standard Inspection of a facility go beyond the visual and non-contact process and involve invasive and possibly destructive testing procedures. Given the invasive nature, the non-standard survey should be accomplished in conjunction with scheduled maintenance to ensure that the system is fully serviceable and operable on completion of the survey. Specific non-standard electrical tests are described in greater detail in NFPA 70B.

Non-Standard Methods are generally those that require a component to be taken out-of-service, locked down, deenergized, or are destructive in nature to allow internal inspections or variations in operation not allowed while in service; they should be accomplished as part of a scheduled outage. Examples include Circuit Breaker Time Travel Analysis, Core Sampling, Flat Jack testing, Insulating Liquid Analysis, Smoke testing, Transformer Polarity test, etc.

Some tests could be conducted as part of either type inspection. For discussion purposes, they will be classified according to their “out-of-service” requirements; i.e., if a test can be conducted while equipment is in service, it will be listed under Standard Test Methods.

TESTING METHODS

STANDARD TEST METHODS

- Acoustic Emission Testing
- Acoustic Resonance
- Chemical Analysis
- Correlation Water Leak Testing
- Drag Chain Test for Invert
- Gas Detection-Gas Leak Detection with Tracers
- Ground Penetration Radar Test
- Ground Radar Moisture Tracer
- Infrared Testing
- Moisture Tracer
- Noise Recording and Analysis
- Pavement Deflection Testing
- Pick Test
- Shock Pulse Monitoring
- Stress Monitor Analysis
- Stroboscopes
- Surface Hardness Testing
- Thermography
- Ultrasonic Flowmeters
- Ultrasonic Testing
- Velocity/Volume Flowmeters (Mechanical)
- Vibration Analysis
- Visual Crack Classification

STANDARD TEST DESCRIPTION

Acoustic Emission Testing

Acoustic waves are generated at weak points in a structure under stress. This may result from the propagation of the fault itself (cracking of metal or concrete) or the expansion of a liquid or gas through the fault. Sonic detectors may be used to monitor these emissions and locate the fault. Although useful in identifying cracks and voids, this method is best used to identify leaks.

Acoustic **Resonance**

The application of energy to a structure (single impact or cyclic) will establish a resonant vibration in the structure. The resonant frequency emissions will differ in areas with faults. Sonic detectors may be used to monitor these emissions and locate the fault. Primarily used to identify cracks and voids.

Chemical Analysis

Most fluids and gases used in mechanical systems have a prescribed chemical content. Routine sampling of actual content and analysis through visual, chemical, and/or spectrometric means can identify improper chemical maintenance levels, wear products, and contamination. Excellent for analysis of piping systems, bearings, and gears.

Correlation Water Leak Tasting

A special application of acoustic emission techniques using multiple sonic detectors and applying signal processing methodology can determine leak position relative to detector location.

Drag Chaln **Test**

A drag chain is held by inspection personnel and slowly moved over the inverted surface, a tunnel, or other structure. Hollow sounds indicate delamination or voids in the surface material.

Gas Detection - Gas Leak Detection with Tracers

A generic term used for a series of mechanical, chemical, and/or electronic devices that are sensitive to specific gas environments.

In most, a sample is drawn with an aspirator or an electric pump into a reaction chamber where the it is exposed to various chemicals. The reaction causes a visible change in color or volume or changes the resistance of an electronic circuit that subsequently displays a reading proportional to the gas content. These devices are particularly useful in identifying gas leaks in refrigeration systems, determining the efficiency of fueled boilers and furnaces, etc.

TESTING METHODS

STANDARD TEST DESCRIPTION (Continued)

Ground Penetration Radar Test

This test employs a device that is positioned over the surface and directs radar waves down through the material that reflect back to measure existing defects or voids.

Ground Radar **Moisture** Tracer

Applying short pulse radar emissions to structures allows imaging. Waves are reflected off structural interfaces. This technique is especially useful in identifying flaws such as delaminations in concrete and locating piping by detecting cracks and leaks.

Infrared Testing

Infrared testing measures heat loss or gain. The areas of the superstructure that absorb water will not insulate. Heat is lost more rapidly through these water absorbing areas, so higher temperatures are detected with an infrared scanner. Cracks, voids and other discontinuities in the surface all affect heat emissions: scanners can show the difference between sound and unsound surfaces. Also used as a process in which the temperature of an electrical or mechanical device is derived based on the remote sensing of infrared radiation. Infrared is accomplished by scanning the surface with a hand-held instrument.

Moisture Tracer

Moisture trapped in materials affects the material's electronic conductance. By passing low frequency radio signals between a transmitter and a receiver traversing the questionable material, moisture can be detected. This technique identifies moisture in roofing without cutting into the membrane.

Noise **Recording &** Analysis

This test measures of the noise level and frequency emitted from a piece of operating equipment. The noise level and frequency contain information that may refine survey data.

Pavement Deflection Testing

This testing involves several methods of using pulse, static, vibrating, or impulse loading to cause deflection in the pavement surface. It is measured and then analyzed to generate data such as remaining life, limitations on loading, and overlay requirements. Various types of devices are employed including the Benkelman Beam, Dynaflect, and "falling weight deflecto-meter."

Pick Test

The Pick test is a standard test for trackwork and consists of inserting any pointed tool, such as an ice pick, into the surface of wood to lift a sliver. A sharp break indicates sound wood and a brash break suggests decay. Lack of resistance or excessive softness to penetration also indicates decay. The pick is also inserted into splits and cavities of railway ties to determine their extent and severity.

Shock Pulse Monitoring

Bearings transmit very weak mechanical shock waves throughout their housing as they go through each compression cycle. Ultrasonic transducers can be calibrated to sense these waves and differentiate them from other equipment vibrations. Analysis of the monitor output allows operator to determine bearing condition and remaining useful life.

TESTING METHODS

STANDARD TEST DESCRIPTION (Continued)

Stress Monitor Analysis

Stress analysis consists of documenting the presence, location, pattern, depth, and width of foreign materials and elevation differences between two cracked concrete or masonry masses and other horizontal or vertical surfaces. Determine if crack is active or dormant by following the steps:

- Mark the end of the crack and check after a few days to see if it has extended past mark. Note direction.
- Place a notched piece of tape across the crack, wait for a period of a month of more. If the tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
- Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

Stroboscopes

By varying the frequency of illumination on an object in motion, it is possible to produce a freeze frame or slow motion image of the object. Application allows inspection of operating equipment, showing leakage, distortion, vibration, etc. that would not be evident during shutdown. This can also be used to determine equipment rotating speed.

Surface Hardness Testing

This test (sometimes known as sounding test) consists of impacting the concrete or masonry surface using standard devices to gauge with given energy pulse and measuring the size of rebound. A rebound hammer is the most commonly used method. Problems and limitations of this test are affected by concrete surface smoothness carbonation, moisture condition, size, age, and aggregate type. A similar test is striking a wood surface with a hammer. A sharp ring usually indicates sound wood, and a dull or hollow sound usually indicaties decay or rot. This is not a very reliable test, so additional testing should be performed if deterioration is suspected.

Thermography

Thermal radiation is emitted by all bodies in proportion to the temperature of the body. This radiation can be filtered with optical lenses to allow discrimination by the human eye. It can also be focused on sensors and processed to provide temperature readouts and/or graphical displays of temperature distribution. It is more commonly used to produce energy loss profiles of structures, ascertain water leakage in roofing, and identify overheated connections in electrical distribution systems.

Ultrasonic Flowmeters

Bubbles and suspended solids in flowing liquid cause agitation, which produces sound. Transducers can be clamped to piping to monitor intensity and direction of this sound. Microprocessors can be used to convert this information into velocity, and given the piping dimensions, determine volumetric flowrate. Although primarily used in balancing water distribution systems and process monitoring, these devices can be used to ascertain restrictions in distribution systems and piping corrosion.

Ultrasonic Testing

Ultrasonic emissions are attenuated by materials during transmission and are reflected by material interfaces; generated pulse echo can be monitored to identify interface location. Measurement of the velocity and attenuation of the pulse can be used to determine characteristics of the material. Commonly used to identify flaws in metal structures. Ultrasonic testing is not a standard test for Section 0.12.04.

TESTING METHODS

STANDARD TEST DESCRIPTION (Continued)

Velocity/Volume Flowmeters (Mechanical)

Various piping configurations (pitot tubes) can be inserted into a gas/fluid stream to determine static and velocity heads produced by the media. Using known piping or duct characteristics, these data are readily converted to velocity and volumetric flow rates. Many devices currently on the market are portable and contain parameter processors to allow immediate readout. Although primarily used in balancing water distribution systems and process monitoring, these devices can be used to ascertain restrictions in distribution systems and piping corrosion.

Vibration Analysis

Probes in contact with, or transducers mounted on, operating equipment can sense motion (vibration) in terms of displacement, velocity, and acceleration. Instrumentation can convert these signals into digital/analog readouts and graphical displays of signal strength (amplitude) at various frequencies. By measuring and recording these parameters at key points on equipment, an equipment signature can be developed. Periodic monitoring will allow changes (trends) and rates of change in the signature to be identified. Worn or broken parts will change the vibration signature frequency. These techniques can be used as precursors to equipment failure and predict remaining useful life.

Visual Crack Classlflcatlon

Cracks are inspected visually and divided into categories according to width. Widths are determined with a plastic crack comparator.

NON-STANDARD TEST METHODS

- Acoustic Emission Testing
- Ballast (Track) Resistance Test
- Borescopic or Fiberscopic Inspections
- Boring
- Brinell Hardness Test
- Charpy Impact Test
- Circuit Breaker Time Travel Analysis Test
- Contact Resistance Test
- Core Sampling
- Delamination Detection Machinery
- Dielectric Absorption Test
- Displacement Gauges
- Dye Penetrants
- Eddy Current Techniques
- Electrical Resistivity Testing
- Equipment Ground Impedance Test
- Fault Gas Analysis Test
- Flat Jack Testing
- Flood Testing
- Gas Leak Detection with Tracers
- Grounded Conductor Neutral Test
- Grounding Electrode Resistance Test
- High Potential Test
- Infrared Testing
- Insulating Liquid Analysis Test
- Insulation Power Factor Test
- Insulation-Resistance Test
- Magnetic Testing
- Maturity Concept Analysis
- Microwave Absorption Scanning
- Nuclear Analysis
- Pick Test
- Polarization Index Test
- Pol-Tek
- Protective Device Test
- Radiography (X-Ray Testing)
- Rail Defect Testing
- Rotating Machinery Tests
- Smoke Testing
- Television Inspection
- Transformer Polarity Test
- Transformer Turns Ratio Test
- Ultrasonic Pulse Velocity Testing
- Vibration Test or Vibration Analysis

TESTING METHODS

NON-STANDARD TEST DESCRIPTION

Acoustic Emission Testing

Acoustic Emission testing measures the acoustic or stress emissions from cracks or surfaces under strain. The stresses are detected as small displacements by sensors positioned on the surface. This type of testing has been used in recent years; however, its major drawback is that it can only be used during periods of high stress and deformations and does not work for static loading conditions.

Ballast (Track) Resistance Test

Ballast (Track) Resistance is used to measure current leakage from rail into the ballast and ground. A minimum resistance between rail and ground, normally provided by the wood ties, is necessary for proper operation of the signal system. The test is conducted by applying a voltage at one end of a rail section and determining the voltage drop at the other end of the rail. Rail-to-ground resistance and current leakage can then be calculated.

Borescopic or Fiberscopic Inspections

Using a combination of lens and fiber optic cables, light can be directed to areas otherwise inaccessible to the human eye. The reflected image is usually magnified by the borescope, enhancing detection capabilities. Excellent tool for small tank and pipe inspections and internals of engines, pumps, and masonry to locate deficiencies such as cracks or material deterioration.

Boring

Boring is the most dependable and widely used method for detecting internal decay in timber. Boring permits direct examination of an actual sample from a questionable member. An increment borer is used to extract wood cores for examination.

Brinell Hardness Test (Stool Bridges: Destructive Test)

The Brinell Hardness test measures steel resistance to penetration. A hardened steel ball is pressed into the test coupon by a machine-applied load. The applied load and the surface area of the indentation are used to calculate steel hardness.

Charpy Impact Test

This test is usually performed on a controlled core field sample in a laboratory. The impact test determines the amount of energy required to fracture a specimen.

Circuit Breaker Time Travel Analysis Test

This test is employed only on medium and high Voltage circuit breakers and measures the effectiveness of breaker operation.

Contact Resistance Test

A test to determine the resistance in the contacts of a switch or circuit breaker. The test is normally accomplished using a special instrument capable of measuring resistances of 10 microOhms or less. The test may be accomplished using ammeters and Voltmeters if these devices are of sufficient accuracy. Contact resistance should be kept as low as possible to minimize heat damage to the contacts.

TESTING METHODS

NON-STANDARD TEST DESCRIPTION (Continued)

Core Sampling

Core Sampling involves taking core samples at various controlled sections to ascertain (by laboratory mechanical/chemical analysis), the condition or strength of the material. Sample holes must be patched immediately. Actual concrete strength and quality can be determined only by removing a concrete core and performing such laboratory tests as:

- Compressive strength
- Cement content
- Air voids
- Static modulus of elasticity
- Dynamic modulus of elasticity
- Splitting tensile strength

Delamination Detection Machinery

Delamination Detection Machinery is based on sonic responses and can be used to inspect concrete decks. An instrument is moved across the deck as acoustic signals are passed through it. These signals are then received and electronically interpreted, and the output is used to generate a plan of the deck showing delaminated areas. This method can be used on asphalt covered surfaces, although accuracy decreases.

Dielectric Absorption Test

Dielectric Absorption testing is similar to insulation resistance testing except that much higher Voltages are used in the test process. It is not unusual to have Voltages in excess of 100,000 Volts.

Unlike the insulation resistance test, dielectric absorption testing is independent of temperature and volume of the insulation.

Displacement Gauges

A generic term used to cover a group of devices that measure the relative motion between two points. Employs electro-optical equipment for large structures and mechanical or electrical gauges for closely spaced points. Primarily used in mechanical testing for identifying warpage, distortion in shafting, wear in bearing, etc.

Dye **Penetrants**

Certain dyes have the ability to penetrate small surface cracks in materials. Examination, in some cases under ultraviolet light, is used to identify faults not otherwise visible. Particularly useful for stressed metals.

Eddy Current Techniques

When a coil is excited by a radio frequency current and moved along the surface of a metal conductor, an electrical network is established that includes the metal conductor. The system has a defined reference impedance. Changes in the surface of the metal conductor cause a change in the system impedance, which can be measured. This technique is especially useful in identifying pitting, surface cracks, and other discontinuities in tubing of heat exchangers.

TESTING METHODS

NON-STANDARD TEST DESCRIPTION (Continued)

Electrical Resistivity Testing

Electrical Resistivity testing involves passing electrical currents through the material to determine the resistance offered. This test is used to determine reinforcement corrosion and thickness of concrete pavements. This method may also determine the moisture content or moisture penetration of concrete surfaces and degree of decay in wood members. Even though this is a relatively simple test method, it is highly dependent on moisture and salt content and the temperature of the material.

Equipment Ground Impedance lest

This test is accomplished to determine the integrity of the grounding path from the point of test back to the source point. It is very important to ensure personnel safety and to improve power sources to microprocessor equipment.

Fault Gas Analysis Test

An analysis of the gases present in the nitrogen-filled cap of sealed pressurized oil-filled transformers can provide potential failure information. When arcing occurs in the oil, decomposition occurs. Some decomposition products appear as combustible gases, which rise to the top of the transformer.

Flat Jack Testing

The Flat Jack method was originally developed to test the in-situ stress and deformation of rock and is now being applied to masonry structures. A portion of the horizontal mortar joint is removed, and the flat jack (an envelope made of metal) is inserted and pressurized to determine the state of stress.

Flood Testing

Flood testing involves forcing water at an exterior surface under pressure to locate any cracks or penetrations by observing any water leaks on the interior surface.

Gas Leak Detection with Tracers

For systems where leakage does not produce easily monitored effluent, specific tracer gases may be introduced into the system. Sensors that are sensitive to the particular tracer gas are then used to identify leak location.

Grounded Conductor Impedance Test

A test used to determine the quality of the grounded conductor (neutral) from the point of test back to the source. A low impedance neutral is necessary to reduce interference to microprocessors and other similar devices from harmonic currents. Equipment used to conduct equipment ground impedance tests are often used to conduct this test.

Grounding Electrode Resistance Test

A test to determine the effectiveness of the grounding system. The test is usually performed to validate the effectiveness of a grounding system using driven ground rods.

The test is performed periodically because soil conditions do change, and may increase ground resistance to a point where personnel and equipment are in jeopardy.

High Potential Tot

A High Potential test applies a Voltage across an insulation at or above the DC equivalent of the 60 Hertz operating crest Voltage. This test can be applied as a dielectric absorption test or a step-Voltage test.

TESTING METHODS

NON-STANDARD TEST DESCRIPTION (Continued)

Infrared Testing

Infrared testing measures heat loss or gain. Those areas of the superstructure that absorb water will not insulate. Heat is lost more rapidly through these water absorbing areas, so higher temperatures are detected with an infrared scanner. Cracks, voids, and other discontinuities in the surface all affect heat emissions: scanners can show the difference between sound and unsound surfaces. Also used as a process in which the temperature of an electrical or mechanical device is derived based on the remote sensing of infrared radiation. Infrared is accomplished by scanning the surface with a hand-held instrument.

Insulating Liquid Analysis lest

Regular tests conducted on insulating oils and askarels on a semiannual basis. The tests are conducted in accordance with specific ASTM standards and the results are measured against values established in NFPA 70B. The sampling process is critical to test accuracy.

Insulation power Factor Test

Insulation Power Factor testing measures the power factor of the charging Volt Amperes. This test is sensitive to humidity and temperature. The test Voltage is always greater than 500 Volts, and a desirable Voltage is at least 2500.

Insulation Resistance Test

Insulation is tested by applying a known Voltage across the insulation and measuring the resulting current flow with a meter calibrated in Ohms. The Voltage source for most low Voltage testing is a megOhmmeter (megger), and the results are volume sensitive.

Because insulation testing is often temperature sensitive, consistent testing conditions will ensure better accuracy.

Magnetic Testing

Magnetic testing involves scanning concrete surfaces with a U-shaped magnetic core with two coils in which an alternating current is passed through one coil and the current is measured in the second. This test is used to measure the depth and detect position of reinforcement in concrete. It should be noted that temperatures below freezing and heavily reinforced sections adversely affect the performance and results.

Maturity Concept Analysis

The Maturity Concept used in measuring in-situ concrete is based on the fact that concrete strength varies due to both time and temperature. These conditions are measured by thermocouples and/or instruments.

Microwave Absorption **Scanning**

Microwaves are electromagnetic in nature and can be reflected, diffracted, and absorbed. Wave absorption by water determines moisture content of the material. This is relatively new and unproven; the technique based on the reflection of electromagnetic waves has been used successfully. Although this method is fast and easy to perform, planning and skill are required to interpret and evaluate the results.

TESTING METHODS

NON-STANDARD TEST DESCRIPTION (Continued)

Nuclear Analysis

Nuclear analysis is accomplished using a mechanism that scatters neutrons on the foundation or footing. Where water is present, radiation or neutron energy is taken back into the unit. The surface is squared off in a grid pattern and readings are taken from various points. Another method (relatively new and underdeveloped) involves bombarding the concrete surface with neutrons, which causes the surface materials to become radioactive. A comparative analysis is performed as the radioisotopes decay to a stable state.

Pick Test

Pick testing consists of inserting any pointed tool, such as an ice pick, into the surface of wood to lift a sliver. A sharp break indicates sound wood and a brash break suggests decay. Lack of resistance or excessive softness to penetration also indicates decay.

Polarization Index Test

The Polarization Index is a special application of the dielectric absorption test. The index is the ratio of insulation resistance at two different times after application of the test Voltage. The interval between readings is normally ten minutes. An index of less than one indicates that the insulation is not adequate.

Pol-Tek

Pol-Tek is a sonic testing device used to detect rot or other low density regions in timber poles. Starting about 6 inches below the ground line, probes are pressed on opposite sides of the timber member. A trigger trips a hammer that sends a sound wave down one probe, through the member, and up the other probe to a dial.

Protective **Device** Tests

There is no way to test fuse operation because excess current will destroy the fuse. The only feasible test is a continuity test with a low-current device.

Circuit breaker testing is determined by the breaker type. Most molded-case circuit breakers are not adjustable and therefore not tested for calibration. However, such breakers are tested to ascertain trip currents and times. These tests are performed with special test equipment that measures the current applied and the application time.

Other types of breakers (such as power circuit breakers) have adjustable devices or use protective relays as current and time sensitive devices. These circuit breakers and protective relays are tested using equipment to measure the applied current and the application time. The applied current and application time are compared to established standards, manufacturer's literature, or an approved engineering study.

Radiography (X-Ray) **Testing**

Radiography testing involves passing radiation in the form of X-rays through an object to expose photographic film on the opposite side to detect cracking, voids, or reinforcing position. It is seldom used for these building systems due to the cost and dangerous equipment required. Testing with gamma rays, on the other hand, is relatively portable and easier to use. The only limiting factor appears to be high cost and safety concerns.

Rail Defect Testing

A modified rail car or other track mounted equipment is equipped with ultrasonic detectors capable of locating internal rail defects. The equipment travels over the track and locations, of rail defects are marked in-situ. This testing is generally performed by specialty contractors.

TESTING METHODS

NON-STANDARD TEST DESCRIPTION

Rotating Machinery Tests

Rotating Machinery tests are standard tests applied to rotating equipment of 600 Volts or less using hand crank, rectifier, or battery-operated instruments . For equipment rated over 600 Volts, a 1000- or 2500-Volt, motor-driven or rectifier-operated test set is employed.

Rotating equipment should be tested immediately following shutdown while the equipment is hot and dry. Temperatures should be recorded and converted to a base temperature to permit comparisons over long periods of time.

In addition to the tests cited above, the following are applied to rotating equipment.

- Over-Potential Testinq: A test in which an overvoltage is applied to the equipment insulation. The test Voltage is normally 50 percent of the new equipment Voltage, which is twice the rated Voltage plus 1000 Volts.
- Surae Comparison Test: A test used to determine turn-to-turn, group-to-group, and phase-to-phase winding flaws. These flaws are not detectable in overVoltage and insulation resistance testing.

Other tests include slot discharge and corona tests, winding impedance tests, power factor value test, and core loss tests. These tests are conducted in response to a specific need or to further refine an analysis based on other tests. Such tests are normally supervised by an engineering department.

Smoke Testing

Some chemical reagents produce smoke when introduced into the air; they are frequently supplied in sealed pellet packages or liquid vials. By exposing these chemicals in an air stream, it is possible to visually follow the air movement through a system. This technique is useful in identifying blockages in ductwork such as duct collapses and failed dampers.

Television Inspections

Using remotely operated cameras and lighting systems, the inspector can scan and record inaccessible surfaces. Excellent when used as a tool for large tanks and underground pipe inspections.

Transformer Polarity Test

The Polarity test is used to determine the vectorial relationship of the various transformer windings, which is very important in the protection scheme of transformers.

Transformer Turns Ratio Test

The Turns Ratio test is used to determine the number of turns of one winding relative to another winding. The test is normally performed with instruments designed for that purpose.

If a turns ratio test set is not available, the test can be performed with two Voltmeters or two ammeters. These devices should have an accuracy of at least 0.25 percent of full scale.

Ultrasonic Pulse Velocity Testing

Ultrasonic testing is performed by passing ultra-high frequency sound waves through a material. An oscilloscope, chart recorder, or computer printout then records or displays the sound waves converted into electrical signals deflected off the rear surfaces or any defects within the material and can quantify strength characteristics (elastic moduli values).

TESTING METHODS

Ultrasonic Pulse Velocity Testing (Continued)

The basic concept used in the Ultrasonic Pulse Velocity test consists of generating an ultrasonic wave through the concrete, masonry, or wood and measuring the travel time. This technique is excellent for establishing existing material (concrete, masonry, or wood) uniformity and strength. It should be noted that concrete conditions such as age, moisture, aggregate to cement ratio, aggregate type, and steel reinforcement placement location may adversely influence test results.

Vibration lest or Vibration Analysis

Probes in contact with or transducers mounted on operating equipment can sense motion (vibration) in terms of displacement, velocity, and acceleration. Instrumentation can convert these signals into digital/analog readouts and graphical displays of signal strength (amplitude) at various frequencies. By measuring and recording these parameters at key points on equipment, an equipment signature can be developed. Periodic monitoring will allow changes (trends) and rates of change in the signature to be identified. Worn or broken parts will change the signature, and that change may be used as a predictor.

END OF SUBSECTION

INSPECTION FREQUENCY

CAS INSPECTION SCHEDULE

The following constitutes recommended inspection frequencies for the listed assemblies and components. The purpose of these inspections is to support the Condition Assessment Survey (CAS) and are not necessarily for maintenance purposes. Each site has the option of varying the inspection frequencies to meet individual site requirements.

The recommended Base CAS inspection frequencies are listed below in Table One for the system described in this manual. The base CAS constitutes standard inspection only and uses the standard guide sheets as a reference. All Non-Standard inspections are optional for all assemblies and components listed below unless specifically noted.

TABLE ONE

Assembly/Component	Year One	Year Two	Year Three	Year Five
Utility Distribution System				
Plumbing				
Concrete Tanks	S			NS
Conveyors (Belt, Bucket, Screw)	S, NS			
Manholes	S			
Underground Piping	S			NS
Central Heating				
Dust Collector	S, NS			
Steam Turbines	S			NS
Stokers	S, NS			
Pulverizers	S			NS
Scrubbers	S, NS			
Central Cooling				
Rotary Screw Chillers	S			NS
Electrical				
Switchyards		S		NS
Substations		S		NS
Overhead Transmission System		S		NS
Underground Transmission System		S		NS
Utility Support Structures				
Steel Towers & Poles			S	S, NS
Precast Concrete Poles			S	S, NS
Wood Poles	S			NS
Tower & Pole Foundations			S	
Utility Service Tunnels		S		
Utility Service Tunnels: Dampproofing/Waterproofing		S		
Concrete Support Pads			S	
Paving Roadways/Walkways		S		
Tunnels		S		
Railways				
Trackwork	S			
Signals & Communications	S			
Fountains & Pools			S	

S - STANDARD INSPECTIONS — NS - NON-STANDARD INSPECTIONS

INSPECTION FRQEUENCY

TABLE ONE

Assembly/Component	Year One	Year Two	Year Three	Year Five
Security Gates & Fences			S	
Landscaping	S			
Bridges & Abutments		S		

S - STANDARD INSPECTIONS — NS - NON-STANDARD INSPECTIONS

END OF SUBSECTION

NOTES: 1. Severe weather or facility operational conditions may require additional inspections.
2. Non-Standard inspections will be Drovided on an "as required" basis unless noted otherwise.

STANDARD SYSTEM DESIGN LIFE TABLES

GENERAL

The Standard (nominal) Design Life of a given System Assembly/Component is defined as the projected service design life measured from the date of installation to the date of replacement. These time periods are based on manufacturers' product specifications and tests that determine the average "outside" time parameter a given System Assembly/Component will last. The Standard Design Life Tables that follow list design life and replacement cost parameters for WBS. TABLE ONE below illustrates key column headings.

TABLE ONE

ITEM DESCRIPTION	Replacement Life, Years*	percent Replaced
Note 1:	Used to document the replacement life* of significant WBS System Assembly/Components.	
Note 2:		Used to estimate percent of WBS System Assembly/Component cost replaced at the year specified (measured from installation date to end date specified by the replacement life period*).

*Note: The term Replacement Life is synonymous with Design Life.

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.12 SITEWORK		
0.12.01 Utility Distribution System		
PLUMBING		
Concrete Tanks	*NIA	
Conveyors (Belt, Bucket, Screw)	NIA	
Manholes	NIA	
Underground Piping	NIA	
CENTRAL HEATING		
Dust Collector	NIA	
Steam Turbines	NIA	
Stokers	NIA	
Pulverizers	NIA	
Scrubbers	NIA	
CENTRAL COOLING		
Rotary Screw Chillers	NIA	
Chilled Water Distribution System	NIA	NIA
ELECTRICAL		
Switchyards	Life	N/A
Substations	Life	N/A
Overhead Transmission System	Life	N/A
Underground Transmission System	Life	N/A
UTILITY SUPPORT STRUCTURES		
Steel Towers & Poles	45	100
Precast Concrete Poles	75	100
Wood Poles	25	100
Tower & Pole Foundations	Life	N/A
Utility Service Tunnels	Life	N/A
Utility Service Tunnels: Dampproofing/Waterproofing	50	100
Concrete Support Pads	Life	N/A
0.12.02 Paving Roadways/Walkways		
Curb	40	100
Walk	20	100
Roadway:		
Asphalt	15	100
Concrete	25	100
Stone (Gravel)	2	25

*NOTE: NIA = No information available

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.12.03 Tunnels		
ELECTRICAL:		
Service & Distribution	Life	N/A
Lighting	20	100
MECHANICAL:		
Drainage	40	100
Ventilation	25	100
STRUCTURAL:		
Arch	Life	N/A
Circular	Life	N/A
Columns	Life	N/A
Beams	Life	N/A
Walls	Life	N/A
Structural Slabs	Life	N/A
Joints	Life	N/A
Foundation	Life	N/A
FINISHES:		
Walls	60	100
Ceilings	45	100
Floors	25	100
0.12.04 Railways		
Trackwork	NIA	N/A
Signals & Communications	NIA	N/A
0.12.05 Fountains & Pools	NIA	N/A
0.12.06 Security Gates & Fences	25	100
0.12.07 Landscaping	NIA	N/A
0.12.08 Bridges & Abutments		
APPROACHES:		
Pavement, Asphalt	15	100
Pavement, Concrete	25	100
Guide Railing, Concrete	25	100
DECK ELEMENTS:		
Curbs, Concrete	40	100
Mono Deck Surface, Concrete	25	100
Railings/Parapets, Concrete	25	100
Sidewalks/Fascias, Concrete	20	100
Sidewalks/Fascias, Steel	40	100
Wearing Surface, Asphalt	15	100
Wearing Surface, Concrete	25	100

STANDARD SYSTEM DESIGN LIFE TABLES

END OF SUBSECTION

SYSTEM WORK BREAKDOWN STRUCTURE

GENERAL

Facilities are composed of various assemblies/components which, in turn, form the primary facility systems. These systems, such as foundations, roofs, heating and cooling units, and electrical distribution, have varying life spans. They require maintenance, repair, and renovation over a period of time and do not all “fail” at the same time. Systems have varying life spans. Their condition may be influenced by the deterioration of other assembly/component parts within the systems.

To consider each facility and their major systems, the CAS Program uses the Work Breakdown Structure (WBS) based on the R.S. Means square foot costing system. This industry accepted standard allows a logical “breakdown” of facilities into their major systems, assemblies, components, etc. The WBS is a heirarchical structure; this concept is illustrated in Figure 1. The development of project costs are then applied within this framework as shown in Figure 2.

The Work Breakdown Structure for this volume follows.

SYSTEM WORK BREAKDOWN STRUCTURE

0.12 SYSTEM - SITEWORK

0.12.01	UTILITY DISTRIBUTION SYSTEMS
0.12.01 .01	PLUMBING
0.12.01 .01.01	Water Treatment Plant
0.12.01 .01.02	Water Distribution System
0.12.01 .01.03	Sewage & Drainage Collection System
0.12.01 .01.04	Waste Water Treatment Plant
0.12.01 .01.05	Gas Distribution System
0.12.01.02	CENTRAL HEATING
0.12.01.02.01	Fuel Oil Storage & Distribution System
0.12.01.02.02	Coal Handling System
0.12.01.02.03	Boilers
0.12.01.02.04	Elevated Temperature Water Distribution System
0.12.01.02.05	Steam Distribution & Condensate Return System
0.12.01.03	CENTRAL COOLING
0.12.01.03.01	Rotary Screw Chillers
0.12.01.03.02	Chilled Water Distribution System
0.12.01.04	ELECTRICAL
0.12.01.04.01	Switchyards
0.12.01.04.02	Substations
0.12.01.04.03	Overhead Transmission System
0.12.01.04.04	Underground Transmission System
0.12.01.05	UTILITY SUPPORT STRUCTURES
0.12.01.05.01	Steel Towers & Poles
0.12.01.05.02	Precast Concrete Poles
0.12.01.05.03	Wood Poles
0.12.01.05.04	Tower & Pole Foundations
0.12.01.05.05	Utility Service Tunnels
0.12.01.05.06	Utility Service Tunnels: Dampproofing/Waterproofing
0.12.01.05.07	Concrete Support Pads
0.12.02	PAVING ROADWAYS/WALKWAYS
0.12.03	TUNNELS
0.12.04	RAILWAYS
0.12.04.01	Trackwork
0.12.04.02	Signals & Communications
0.12.05	FOUNTAINS & POOLS
0.12.06	SECURITY GATES & FENCES
0.12.07	LANDSCAPING
0.12.08	BRIDGES & ABUTMENTS

SYSTEM WORK BREAKDOWN STRUCTURE

WBS LEVEL TABLE

0.05	*LEVEL I*	0.00
ROOFING	***SYSTEM***	MECHANICAL
0.05.01	*LML 2*	**0.08.01**
BUILT-UP	ASSEMBLY	**PLUMBING**
0.05.01.01	*LML 3*	**0.08.01.01**
MEMBRANE	*COMPONENT*	*Don.* **WATER**
0.05.01.01.01	*LML 4*	**0.08.01.01.01**
3-PLY ASPHALT	***SUBCOMPONENT/ TYPE***	**PIPE**
0.05.01.01.01.01	***LEVEL5***	**0.08.01.01.01.01**
NOT USED	***TYPE***	**3/4" DIA. COPPER**

WBS ORGANIZATION HIERARCHY

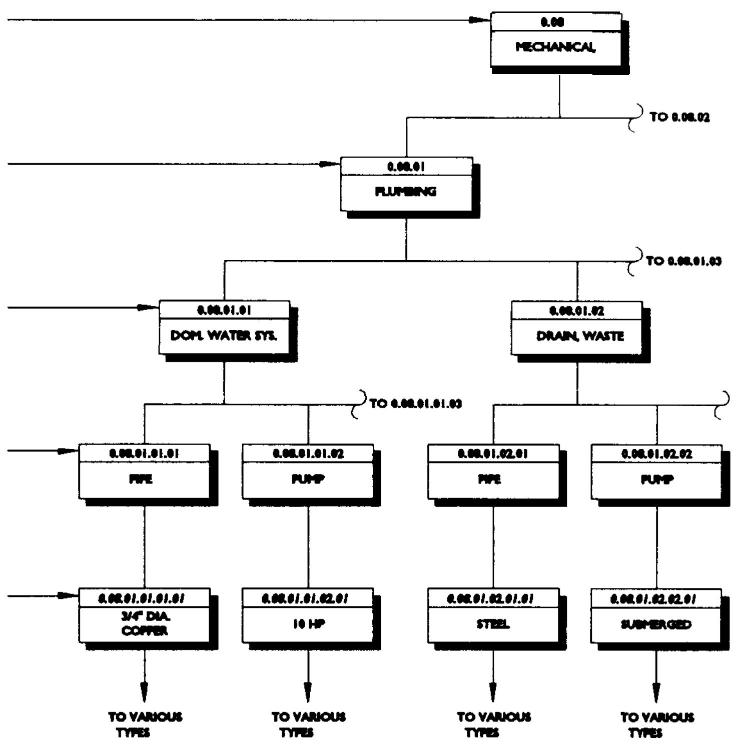


FIG. I

SYSTEM WORK BREAKDOWN STRUCTURE

WBS LEVEL TABLE

0.05	*LML I*	0.08
ROOFING	***SYSTEM***	MECHANICAL
0.05.01	*LML 2*	0.08.0 I
BUILT-UP	*ASSEMBLY*	PLUMING
0.05.01.01	*LML 3*	0.08.01.01
MEMBRANE	***COMPONENT***	*Don.* WATER
0.05.01.01.01	LML 4	0.08.01.01.01
3-PLY ASPHALT	***SUBCOMPONENT/ TYPE***	PIPE
0.05.01.01.01.01	***LEVEL5***	0.08.01.01.01.01
NOT USED	***TYPE***	3/4" DIA. COPPER

WBS COST DEVELOPMENT HIERARCHY

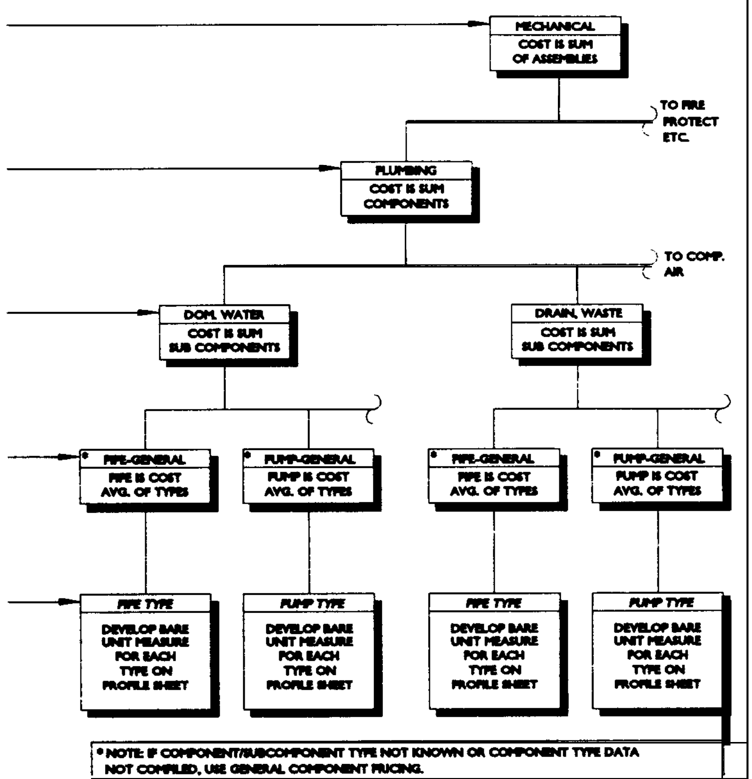


FIG. 2

END OF SUBSECTION

GENERAL SYSTEM/MATERIAL DATA

INTRODUCTION

With the increasing cost of new construction and equipment, it is becoming more of a necessity to ensure that existing buildings and systems are maintained at regular intervals and repairs are made to last over the long term. This section is composed of several tables consisting of Concrete Deterioration, Deterioration of Structural Steel, Imperfections in Wood, Causes of Timber Deterioration, Preservations, Effects of Chemicals on Concrete, and Common Paint Finishes/Coatings irregularities.

The purpose of this section is to give a general description of damages, diagnosis, and causes of deterioration of building materials such as concrete, structural steel, wood, and paint finishes/coatings. This is oriented toward locating defects and potential material failure problems prior to major damage or complete failure of systems/components. Recognition of Exterior Closure defects and their effects on the building and its occupants and contents are stressed. Special attention should be given to the causes and correction or repair of common defects. Data herein should be used in conjunction with specific System/Assembly data that follows this general section.

GENERAL SYSTEM/MATERIAL DATA

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GENERAL SYSTEM/MATERIAL DATA

COMMON CAUSES OF CONCRETE **DETERIORATION**
(Similar for **Pre-Cast** Co**ncrete)**

Damage	Diagnosis	Cause
Alkali-Aggregate Expansion	Slight cracking to complete breakup.	Chemical reaction between aggregate and cement paste.
Cavitation	Spalling around projections. Honey-combing. Popping and cracking noises when water moves over the surface.	Rapid movement of water or other liquids across the surface.
Cracks (Active and Dormant)	Random, isolated or patterned cracks.	Construction movement, settlement, shrinkage around reinforcement. Setting shrinkage due to inadequate finishing and curing.
Before hardening of the concrete:	Patterned cracking, protruding aggregate, popouts. Chemical analysis indicates deterioration of cement paste.	Chemical reactions, such as corrosion.
After hardening of the concrete:	Surface cracking, patterned.	Physical, such as drying shrinkage.
	Extreme change in measured temperatures between inner and outer surfaces. Shallow cracking.	Thermal changes (subjected to temperature extremes, such as from freezing and thawing cycles).
	Localized cracking.	Stress concentration.
	Cracks, usually isolated.	Structural design.
	Cracks can be isolated or patterned depending on crack-producing agent.	Accidents from overload, vibration, fatigue and earthauake.
Corrosion of Reinforcing Steel	Cracks will occur at the level of the reinforcement and parallel to it. Rusting or discoloration will be evident.	Insufficient cover of steel. Quality of concrete Over-use of calcium chloride as admixture.
Crazing	Shallow cracks forming a hexagonal pattern.	Surface shrinkage more rapid than interior of concrete to the surface and depositing salts.
Dusting	Appearance of a powdery substance on the surface of the concrete.	Too wet of a concrete mixture. Premature or excessive working of the surface. Organic materials in the aggregate. Inadequate curing.
Efflorescence	Appearance of crystalline salts on the concrete surface.	Water migrating from the interior mass of the concrete to the surface and depositing salts.
Fire	Charred and spalled surfaces.	Fire.
Form Scabbing	Difficult to remove forms. Uneven, spalled areas.	Form oil improperly applied.
Holes (Small and Large)	Popouts, holes, random pattern or isolated in extreme.	Chemical reaction. Inadequate construction and design.
Honeycombing	Surface defects-voids. Coarse aggregate broken away from the surface.	Placing concrete aggregate with insufficient type of mortar. Improper placing techniques, such as inadequate vibration.

Source: **Means Facilities Maintenance Standards - "R.S. Means** Co., Inc., Kingston, **Massachusetts"**

GENERAL SYSTEM/MATERIAL DATA

COMMON CAUSES OF CONCRETE DETERIORATION
(Similar for Pre-Cast Concrete)

Damage	Diagnosis	Cause
Popouts	Breaking away of a particle near the surface. Excessive amount of moisture or temperature changes in the region.	Depressions left by material popping out. Presence of disintegrated material near the popout.
Sand Streaking	Vertical streaks of sand which appear on the surface. most noticeable when forms are immediately stripped.	Concrete mixed with a high water content or a deficiency of finer sand sizes are placed in a formwork that is not water-tight.
Scaling	Flaking or peeling away of thin layers of concrete.	Severe freeze/thaw conditions. Improper use of deicing salts. Repeated wetting and drying of concrete. Improper finishing. Chemical attack of concrete. Heat blast.
Spalling	Fragments of concrete that have been broken from the surface. Corrosion of reinforcement.	Corrosion of reinforcement. Mechanical damage. Incorrect form removal. Shock-waves.
Stain and Uneven Color	Discoloration or lacking uniformity in appearance.	Chemical action of foreign materials on the surface. Mixing of different types of cement with each other. Reaction of materials comprising the concrete mixture.

A SUMMARY OF THE TYPES & CAUSES OF DETERIORATION OF STRUCTURAL STEEL

Type of Deterioration	Cause
Abrasion	Members subjected to contact with moving parts Members subjected to wave action. Members immersed in a moving liquid. Worn, smooth appearance, general depression of the abraded area.
Corrosion	Resulting from a chemical or electrc-chemical reaction which converts the metal into an oxide, carbonate and sulfides. Pitted, oxidized surface showing loose flakes, reddish-brown rust colored appearance.
Fatigue	Repetitive, cyclic loading occurring at stresses at or below allowable design values. Small fractures oriented perpendicular to the line of stress.
Impact	Local distortion of the member in the form of a sharp crimp. Will occur in a tension member of flange.
Lamellar Tearing	Minute, often times unseen cracking in the weldment. May need microscopic instruments to observe. Incorrect welding process.
Loosening of Connections	Impact and fatigue loading. Vibrations and improper tightness.

Souroe: Means Facilities Maintenance Standards • "R.S. Means Co., Inc. Kingston, Massachusetts'

GENERAL SYSTEM/MATERIAL DATA

COMMON IMPERFECTIONS IN WOOD

Imperfection	Description	Effects on Strength	Effect on Grading Structural Lumber
Checks and Splits	Split in the wood.	In lumber subjected to bending, checks and splits reduce the resistance to shear; they do not affect the strength for longitudinal compression.	Checks and splits are restricted in those parts of a bending member where shearing stresses are highest,
Holes	Either a knothole or a hole caused by some other means.	Reduces tensile strength some what more than compressive and shear strength and affect stiffness.	The size, number and location of knots is restricted for structural lumber; cluster knots are prohibited.
Knots	Localized imperfections.	Same as for holes	Same as for holes.
Pitch Pockets	Opening between growth rings containing pitch or bark.	Little or no effect.	Usually disregarded except if a large number occur; shake may be present or bond between annual growth rings mav be weakened.
Shakes	A separation of the wood between the annual growth rings.	Same as for checks and splits	Same as for checks and splits
Slope of Grain	Areas where the direction of the wood grain is not parallel to the edges of the piece of lumber.	Will twist with changes in moisture content.	Cross-grained pieces are undesirable; reduction of strength due to cross grain in structure is taken as twice the reduction observed in tests of small clear specimens.
Wane	Bark or lack of wood on the edge or corner of the piece of lumber.	Affects nailing and bearing.	Limited in structural lumber requirements for fabrication, bearing, nailing and appearance and not for effect on strenath.

SUMMARY OF CAUSES OF TIMBER **DETERIORATION** WITH **SYMPTOMS**

Cause of Deterioration	Symptoms
Carpenter Ants, Beetles & Carpenter Bees	Similar to termites.
Termites	Bore holes; lacing/cavitation of wood; connecter tunnels from grade to wood source (usually mud). Premature wood bowing and failure.
Decay (Rot) Due to Fungi	Softening and discoloration of wood, fluffy or cottony appearance, destruction of wood cells, appearance of fruity bodies in the form of mushrooms, incrustations in the advanced stage.
Excessive Splitting and Checking	Excessive relative amount of members at a joint, bowing of compressron members (shown by broken paint lines or newly exposed wood), elongated bolt holes.
Fire Damage	Surface cellular damage, charred surfaces, easily probed with a knife.
Hardware	Loose connections, formation of rust on hardware surfaces, discoloration of wood adjacent to hardware.
Loosened Connections	Loose connections, excessive deflection
Marine Borers	Minute openings in the timber, hollow sound when struck with a hammer, a myriad of surface grooves, narrowing of a section giving it an hourglass appearance.

Source: Means **Facilities** Maintenance Standards - **"R.S.** Means Co., Inc.. Kingston, Massachusetts'

GENERAL SYSTEM/MATERIAL DATA

PRESERVATIVES -ADVANTAGES & DISADVANTAGES

Oil-Based Wood Preservatives

Type **of Preservative**	Advantages	Disadvantages
Anthracene Oils	High toxicity to wood-destroying organisms; insoluble in water; low volatility; ease of application; permanence.	Dark brown color, cannot be painted; strong, unpleasant odor; easily ignited when first applied.
Coal-Tar Creosotes	See Anthracene Oils.	See Anthracene Oils.
Copper Naphthenate	High protection against decay fungi and termites; can be painted; not unpleasant odor; less easily ignited than coal-tar creosotes.	Gives wood greenish or dark color and provides less protection against marine borers than creosote.
Creosotes Derived From Wood. Oil and Water Gas	Same as Anthracene Oils and Coal-Tar Creosotes.	About the same as Anthracene Oils and Coal-Tar creosotes, but less effective.
Creosote Solutions	See Anthracene Oils and Coal-Tar Creosotes.	About the same as Anthracene Oils and Coal-Tar creosotes, but less effective.
Water-Repellent Preservatives	Retards moisture changes in wood; good protection against decay and insects.	Cannot be used in contact with ground or areas where continual dampness can occur unless preservative is thoroughly applied.

Water-Based Wood Preservatives

Acid Copper Chromate	Provides protection against decay and insects; can be painted; no objectionable odor; if thoroughly impregnated has some resistance to marine borers.	Wood can be used in contact with ground, but generally not recommended for contact with water.
Ammonical Copper Arsenite	Good protection against decay and insects and some protection against marine borers.	Wood can be used in contact with ground, but generally not recommended for contact with water.
Chromated Zinc Chloride	Provides protection against decay, insects and fire; can be painted; no objectionable odor.	Wood cannot be used in contact with ground or water.
Chromated Zinc Chloride (FR)	See Chromated Zinc Chloride.	See Chromated Zinc Chloride.
Copperized Chromated Zinc Chloride	See Chromated Zinc Chloride.	See Chromated Zinc Chloride.
Tanalith (Wolman Salts)	Protects against decay and insects; can be painted; no objectionable odor.	Wood cannot be used in contact with ground or water.
Zinc Meta Arsenite	Good protection against decay and insects; can be painted; no objectionable odor.	Wood can be used in contact with ground, but generally not recommended for contact with water.

Source: **Means Facilities Maintenance Standards** . **"R.S. Means** Co., Inc.. **Kingston, Massachusetts"**

GENERAL SYSTEM/MATERIAL DATA

Acetic Acid, all Concentrations	Disintegrates slowly.
Acetone	Liquid loss by penetration. May contain acetic acid as impurity.
Acid Waters	(pH of 6.5 or less) (a) Disintegrates slowly. In porous or cracked concrete, attacks steel.
Aluminum Chloride	Disintegrates rapidly. In porous or cracked concrete, attacks steel.
Ammonia Vapors	May disintegrate moist concrete slowly or attack steel in porous or cracked moist concrete.
Ammonium Bisulf ate	Disintegrates. In porous or cracked concrete, attacks steel.
Ammonium Carbonate	Not harmful.
Ammonium Cyanide	Disintegrates slowly.
Ammonium Fluoride	Disintegrates slowly.
Ammonium Nitrate	Disintegrates. In porous or cracked concrete, attacks steel.
Ammonium Oxalate	Not harmful.
Ammonium Sulfide	Disintegrates.
Ammonium Sulfite	Disintegrates.
Ammonlum Superphosphate	Disintegrates. In porous or cracked concrete, attacks steel.
Ammonium Thiosulfate	Disintegrates.
Ashes	Harmful if wet, when sulfides and sulfates leach out (see sodium sulfate).
Ashes, hot	Cause thermal expansion.
Automobile and Diesel Exhaust Gases (d)	May disintegrate moist concrete by action of carbonic, nitric, or sulfurous acid.
Benzol (Benzene)	Liquid loss by penetration.
Bromine	Gaseous bromine disintegrates. Liquid bromine disintegrates if it contains hydrobromic acid and moisture.
Butyl Stearate	Disintegrates slowly.
Calcium Bisulfite	Disintegrates rapidly.
Chlorine Gas	Slowly disintegrates moist concrete.
Chrome Plating Solutions (e)	Disintegrates slowly.
Chromic Acid, & Concentrations	Attacks steel in porous or cracked concrete
Cinders	Harmful if wet, when sulfides and sulfates leach out (see, for example, sodium sulfate).
Coal	Sulfides leaching from damp coal may oxidize to sulfurous or sulfuric acid, or ferrous sulfate (see ferrous sulfate).
Coal Tar Oils	See anthracene, benzol, carbazole, chrysen, creosote, creosol, cumol, paraffin, phenanthrene, phenol, toluol, xylol.
Cobalt Sulfate	Disintegrates concrete of inadequate sulfate resistance.
Coke	Sulfides leaching from damp coke may oxidize to sulfurous or sulfuric acid.
Copper Chloride	Disintegrates slowly.
Copper Sulfate	Disintegrates concrete of inadequate sulfate resistance.
Copper Sulfide	Harmful if it contains copper sulfate.
Corrosive Sublimate	See mercuric chloride.
Creosote	Phenol present disintegrates slowly.
Cresol	Phenol present disintegrates slowly.
Cumol	Liquid loss by penetration,
Deicing Salts	Scaling of non-air-entrained or insufficiently aged concrete (b).
Diesel Gases	See automobile and diesel exhaust gases.
Ferric Chloride	Disintegrates slowly.
Ferric Sulfate	Disintegrates concrete of inadequate quality.
Ferric Sulfide	Harmful if it contains ferric sulfate.
Ferrous Chloride	Disintegrates slowly.
Ferrous Sulfate	Disintegrates concrete of inadequate sulfate resistance.

GENERAL SYSTEM/MATERIAL DATA

Flue Gases	Hot gases (400-l 100°F) causes thermal stresses. Cooled. condensed sulfurous. hydro-chloric acids disintegrate slowly.
Gas Water (e)	Ammonium salts seldom present in sufficient quantity to disintegrate.
Gasoline	Liquid loss by penetration.
Hydrofluoric Acid, all Concentrations	Disintegrates rapidly, including steel.
Hydrogen Sulfide	Not harmful dry. In moist, oxidizing environments converts to sulfurous acid and disintegrates slowly.
Hypochlorous Acid, 10 percent	Disintegrates slowly.
Iodine	Disintegrates slowly.
Kerosene	Liquid loss by penetration of concrete.
Lead Nitrate	Disintegrates slowly.
Lead Refining Solutions (t)	Disintegrates slowly.
Lignite Oils	If fatty oils are present, disintegrates slowly.
Locomotive Gases	May disintegrate moist concrete by action of carbonic, nitric or sulfurous acids (see also automobile and diesel exhaust gases).
Lubricating Oil	Fatty oils, if present, disintegrate slowly.
Machine Oil	Fatty oils, if present, disintegrate slowly.
Magnesium Nitrate	Disintegrates slowly.
Manganese Sulfate	Disintegrates concrete of Inadequate sulfate resistance.
Mercuric Chloride	Disintegrates slowly.
Yercurous Chloride	Disintegrates slowly.
Methyl Alcohol	Liquid loss by penetration.
Methyl Ethyl Ketone	Liquid loss by penetration.
Methyl **Isobutyl** Ketone	Liquid loss by penetration.
Mine Water, Waste	Sulfides, sulfates, or acids present disintegrate concrete and attack steel in porous or cracked concrete.
Mineral Spirits	Liquid loss by penetration.
Muriatic Acid	See hydrochloric acid.
Nickel Plating Solutions	Nickel ammonium sulfate disintegrates slowly.
Nickel Sulfate	Disintegrates concrete of inadequate sulfate resistance.
Nitric Acid, all Concentrations	Disintegrates rapidly.
ores	Sulfides leaching from damp ores may oxidize to sulfuric acid or ferrous sulfate.
Oxalic Acid	Not harmful. Protects tanks against acetic acid, carbon dioxide, salt water. Poisonous. Do not use with food or drinking water.
Paraffin	Shallow penetration not harmful, but should not be used on highly porous surfaces like concrete masonry (g).
Perchloric Acid, 10 percent	Disintegrates.
Perchloro- Ethylene	Liquid loss by penetration
petroleum Oils	Liquid loss by penetration. Fatty oils, if present, disintegrate slowly.
Phenanthrene	Liquid loss by penetration.
Phenol, **5-25** percent	Disintegrates slowly.
potassium Cyanide	Disintegrates slowly.
potassium **Dichromate**	Disintegrates,
potassium Hydroxide, 25 percent or over	Disintegrates concrete
Potassium Permanganate	Harmless unless potassium sulfate present.
potassium Persulfate	Disintegrates concrete of inadequate sulfate resistance.
potassium Sulfate	Disintegrates concrete of inadequate sulfate resistance.

GENERAL SYSTEM/MATERIAL DATA

Potassium Sulfide	Harmless unless potassium sulfate present.
Pyrites	See ferric sulfide, copper sulfide.
Sal Soda	See sodium carbonate.
Salt for Deicing Roads	Also calcium chloride. magnesium chloride, sodium chloride.
Saltpeter	See potassium nitrate.
Sea Water	Disintegrates concrete of inadequate sulfate resistance. Attacks steel in porous or cracked concrete.
Sewage	Usually not harmful (see hydrogen sulfide).
Silage	Acetic, butyric, lactic acids (and sometimes fermenting agents of hydrochloric or sulfuric acids) disintegrate slowly.
Sodium Birulfate	Disintegrates.
Sodium **Bisulfite**	Disintegrates.
Sodium Bromide	Disintegrates slowly.
Sodium Carbonate	Not harmful, except to calcium aluminate cement.
Sodium Chloride	Magnesium chloride, if present, attacks steel in porous or cracke concrete. (b) Steel corrosion ma cause concrete to spall.
Sodium Cyanide	Disintegrates slowly.
Sodium **Dichromate**	Dilute solutions disintegrate slowly.
Sodium **Hypochlorite**	Disintegrates slowly.
Sodium **Nitrite**	Disintegrates slowly.
Sodium phosphate (Monobasic)	Disintegrates slowly.
Sodium Sulfate	Disintegrates concrete of inadequate sulfate resistance.
Sodium Sulfide	Disintegrates slowly.
Sodium **Thiosulf** ate	Slowly disintegrates concrete of inadequate sulfate resistance.
Strontium Chloride	Not harmful.
Sulfite Liquor	Disintegrates.
Sulfite Solution	See calcium bisulfate.
Sulfurous Acid	Disintegrates rapidly.
Toluol (Toluene)	Liquid loss by penetration.
lung Oil	Liquid disintegrates slowly. Dried or drying films are harmless.
Turpentine	Mild attack. Liquid loss by penetration.
Urine	Attacks steel in porous or cracked concrete.
Xylol (Xylene)	Liquid loss by penetration.
Zinc Nitrate	Not harmful.
Zinc Refining Solution8 **(l)**	Hydrochloric or sulfuric acids, if present, disintegrate concrete.
Zinc Slag	Zinc sulfate sometimes formed by oxidation.
Zinc Sulfate	Disintegrates slowly.

GENERAL SYSTEM/MATERIAL DATA

SPECIAL NOTATIONS

a. Waters of pH higher than 6.5 may be aggressive, if they also contain bicarbonates. (Natural waters are usually of pH higher than 7.0 and seldom lower than 6.0 though pH values as low as 0.4 have been reported. For pH values below 3, protect as for dilute acid.)

b. Frequently used as a deicer for concrete pavements. If the concrete contains too little entrained air or has not been aged more than one month, repeated application may cause surface scaling. For protection under these conditions, see “deicing salts.”

c. Water used for cleaning coal gas.

d. Composed mostly of nitrogen, oxygen, carbon dioxide, carbon monoxide, and water vapor. Also contains unburned hydrocarbons, partially burned hydrocarbons, oxides of nitrogen, and oxides of sulfur. Nitrogen dioxide and oxygen in sunlight may produce ozone, which reacts with some of the organics to produce formaldehyde, peracylnitrates, and other products.

e. These either contain chromium trioxide and a small amount of sulfate, or ammonium chromic sulfate (nearly saturated) and sodium sulfate.

f. Contains lead fluosilicates and fluosilicic acid.

g. Porous concrete which has absorbed considerable molten paraffin and then been immersed in water after the paraffin has solidified, has been known to disintegrate from sorptive forces.

h. Contains nickelous chloride, nickelous sulfate, boric acid, and ammonium ion.

i. Usually contains zinc sulfate in sulfuric acid. Sulfuric acid concentration may be low (about 6 percent in “low current density” process) or higher (about 22-28 percent in “high current density” process).

GENERAL SYSTEM/MATERIAL DATA

COMMON PAINT **FINISHES/COATINGS IRREGULARITIES**

Film Irregularities	Probable **Cause**	**Correction**
ALLIGATORING Cross-hatch pattern of surface cracking.	1. Incompatibility of topcoat and underfilm, or coating over a soft underfilm	1. Remove failed coating and recoat with compatible system suitable for exposure conditions. Do not topcoat until underfilm is dry enough to recoat.
BUBBLING Bubbles on the surface of the dried film. May be microscopic in size.	1. Rapid volatilization of solvents within the film.	1. Level surface defects by sanding and reapply coating at lower air or surface temperature, or add slower solvent to increase open time of wet film.
	2. Air displacement resulting from absorption of wet film into porous substrate.	2a. Bridge or fill voids by applying a mist coat, a filler or sealer. 2b. Hose down concrete and masonry with water and allow to drain before applying water-thinned coat.
CRACKING Visible cracks through the surface of the film.	1. Stress or compression cracking or rigid substrate.	1. Patch cracks and recoat.
	2. Bending or flexing on non-rigid substrates.	2. Replace with coating having sufficient flexural strength to tolerate condition.
	3. Physical damage: Impact, heat, cold, exposure, etc.	3. Replace with coating that will tolerate physical conditions.
	4. Surface freezing of fresh latex coating.	4. Recoat when air and surface temperatures are above minimum recommendations.
	5. Application of excessive number of coats.	5. Remove failed coating and recoat with appropriate system.

GENERAL SYSTEM/MATERIAL DATA

COMMON **PAINT FINISHES/COATINGS IRREGULARITIES**

Film **Irregularities**	Probable Cause	Correction
CRATERING Round-shaped thin spots or voids.	1. Caused when bubbles break. 2. Water in spray equipment lines.	1. See "Bubbling." 2. Level defect by sanding. Correct equipment malfunc-tion and flush lines before recoating.
CRAZING Fine line cracking forming a network or overall pattern.	1. See *Cracking.*	1. See "Cracking."
DRY SPRAY Rough, sandy surface texture on spray applied coating.	1. Spray particles partially dry before reaching surface.	1. Sand smooth and adjust material, equipment and technique for prevailing temperature and humidity conditions.
FLATTING Loss of gloss.	1. Rain, fog, high humidity, or damp surfaces. 2. Overthinning or use of wrong solvent.	1. Recoat when surface is dry and weather conditions are satisfactory. 2. Remove coating if film properties or adhesion are affected and recoat with properly thinned material.
FRAMING Color texture or hiding variations where roller applied surfaces join work cut in with brush.	1. Uneven film build between roller and brush applied work.	1. Recoat deficient work, apply heavier wet film or additional coat on new work.
(POOR) HIDING Uneven color or shadowy appearance of topcoat.	1. Insufficient number of coats or low film build. 2. Insufficient mixing.	1. See "Framing." (Note: Some colors have weak hiding properties and require an additional coat for satisfactory hiding.) 2. Stir material thoroughly before use and keep in suspension during application.
HOLIDAYS Skipped or missed area.		1. Touch-up or recoat.

GENERAL SYSTEM/MATERIAL DATA

COMMON PAINT FINISHES/COATINGS IRREGULARITIES

Film Irregularities	Probable Cause	Correction
LAPPING (Lap Marks) Color sheet or texture variations where one freshly painted area overlaps another.	1. First area painted has set up before overlap was made. `	la. Adjust material equipment and technique for weather conditions. 1 b. Work smaller areas to reduce lap time.
MUD CRACKING Cross-hatched pattern of surface cracking.	1. Excessive film build or hot, dry weather.	1. Remove failed coating and recoat at recommended film thickness. Add additional solvent or slower solvent to retard drying during hot, dry weather
ORANGE PEEL Fine pebbled surface texture on spray applied coating.	1. Insufficient atomization.	1. Sand smooth and recoat after adjusting material, equipment and technique to obtain better flow and leveling.
OVERSPRAY Rough sandy areas on spray applied work.	1. Deflected spray mist that settles on dry or partially dry coated surfaces,	1. Sand smooth and recoat using proper application technique and lap time. Protect dry film from overspray.
PINHOLING Small holes or discontinuities in the film. May be microscopic.	1. Solvent migration through the film after the film has begun to set. (Also see - "Bubbling" and "Cracking.")	la. If occasional pinholes are detected, touch-up or recoat. Ib. If pinholing is a general surface condition, it indicates that coating was applied and cured under adverse environmental conditions. Apply a thin or mist coat to fill surface voids, followed by a full wet coat when environmental conditions are suitable for recoating.

GENERAL SYSTEM/MATERIAL DATA

COMMON PAINT FINISHES/COATINGS IRREGULARITIES

Film Irregularities	Probable Cause	Correction
ROLLER TRACKS (a) V-Shaped texture pattern on roller applied surface (Chicken Tracks) or (b) Lines at edge of roller passes.	1. Use of long nap roller cover on smooth surfaces, 2. Material not properly thinned 3. Material not rolled properly.	1. Change to shorter nap roller cover. 2. Make solvent adjustment to improve flow and leveling. 3. Sand runs smooth and recoat with properly thinned material.
RUNS Heavy V-shaped or pencil shaped vertical build-ups on surface of coating.	1. Excessive film build. 2. Overthinning.	1. Sand runs smooth and touch-up or recoat. 2. Sand runs smooth and recoat with properly thinned material.
SAGS Heavy U-shaped buildups or horizontal lips on the surface of coatings. (Long sags may also be referred to as curtains.)	1. See "Runs."	1. See "Runs."
SANDY (Appearance) Dull, rough appearance of film.	1. Dust and dirt contamination of the wet film.	1. Sand smooth and recoat. protect freshly painted areas against dust and dirt contamination or suspend painting operations until environmental conditions are satisfactory.
SHADOWING See "Hiding."		
SOLVENT TRAP Residual solvents remaining within film.	1. Excessive film build. 2. Low temperature curing.	1. Try to drive solvents out of film by force drying. (See manufacturer's data.) Test for hardness and adhesion. If film will not adhere or cure properly, remove and recoat. 2. Same as "1."

GENERAL SYSTEM/MATERIAL DATA

EXTERIOR PAINT SYSTEMS

Material	Surfaces	Finish	Vehicle Type
Wood, Painted	Clapboard, Siding, Factory Primed Hardboard Siding, Doors, Trim Sash, Fascia, Rough Sawn Textured Siding, Shakes & Shingles	Flat	Alkyd-Modified Vinyl Acrylic Latex
		Flat	Alkyd
		Eggshell	Alkyd
			Alkyd-Modified Vinyl Acrylic Latex
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex
		High Gloss	Long Oil Alkyd
		High Gloss	Maleinized Linseed Oil
	Doors, Trim Shutters	High Gloss	Acrylic Latex Alkyd
Wood, Stained	Textured or Rough Sawn Siding, Trim, Decks, Patios, Shakes, Shingles Fencing	Semi-Transparent	Acrylic
		Semi-Transparent	Linseed Alkyd
		Semi-Transparent	Linseed Alkyd
			Alkyd
		Flat	Alkyd-Modified Vinyl Acrylic Latex
		Flat	Vinyl Acrylic
		Flat	Linseed Alkyd
Wood, Weathered		Bleaching Oil	Linseed Alkyd
Wood, Natural		Penetrating Clear	Phenolic Linseed Castor-Tung Oil Resin
Wood, Varnished	Doors, Trim, Shutters	High Gloss	Phenolic Modified Tung, Linseed Castor Oil
	Porches, Platforms, Steps, Decking	High Gloss	Urethane Modified
Metal, Ferrous	Structural Steel and Iron Sash, Trim, Doors, Storage Tanks,	Flat	Alkyd-Modified Vinyl Acrylic Latex
		Flat	Alkyd-Modified Vinyl Acrylic Latex
		Flat	Alkyd
		Eggshell	Alkyd
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex
		High Gloss	Acrylic Latex

GENERAL SYSTEM/MATERIAL DATA

EXTERIOR PAINT **SYSTEMS**

Material	Surfaces	Flnlsh	Vehicle Type
Metal, Ferrous (Continued)	Fire Escapes, Ornamental Iron Catwalks, Handrails	High Gloss	Long Oil Alkyd
			Maleinized Linseed Oil
			Alkyd
			Modified Epoxy
			Polyamide Epoxy
Metal, Aluminum	Doors, Vents, Gutters, Downspouts, Miscellaneous Surfaces	Flat	Alkyd-Modified Vinyl Acrylic Latex
			Alkyd
		Eggshell	Alkyd
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Satin	Alkyd
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex
		High Gloss	Acrvlic Latex
			Long Oil Alkyd
			Maleinized Linseed Oil
			Alkvd
			Pclyamide Epoxy
Metal, Galvanized Iron	Siding, Doors, Vents, Gutters, Downspouts. Ducts, Framing	Flat	Alkyd-Modified Vinvl Acrvlic Latex
			Alkyd
		Eggshell	Alkyd
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex
		High Gloss	Acrvlic Latex
			Long Oil Alkyd
			Maleinized Linseed Oil
			Alkvd
			Polyamide Epoxy
	Chain Link Fencing	Satin	Linseed Coumerone Indene
Masonry, **Textured**	Concrete Masonry Units	Flat	Alkyd-Modified Vinvl Acrvlic Latex
			Alkyd
		Eggshell	Alkyd

GENERAL SYSTEM/MATERIAL DATA

EXTERIOR PAINT SYSTEMS

Material	Surfaces	Finish	Vehicle Type
Masonry, Textured (Continued)	Concrete Masonry Units	Low Lustre	Alkyd-Modified Vinvl Acrvlic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrvlic Latex
		Satin	Vinyl Acrylic Latex
Masonry, Smooth	stucco, Brick, Poured and Precast Concrete	Flat	Alkyd-Modified Vinyl Acrylic Latex
			Alkyd
		Eggshell	Alkyd
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex
		High Gloss	Acrylic Latex
		Low Sheen	Silicone Acrylic
		Satin	Epoxy-Modified Acrylic Latex
		High Gloss	Phenolic Reinforced Alkyd
			Modified Epoxy
			Polvamide Epoxv
Masonry, Weathered	Cement & Cinder Block, stucco, Brick, Poured & Precast Concrete	Flat	Alkyd-Modified Vinyl Acrylic Latex
			Alkyd
		Eggshell	Alkyd
		Low Lustre	Alkyd-Modified Vinyl Acrylic Latex
		Medium Gloss	Acrylic Latex
		Soft Gloss	Acrylic Latex

GENERAL SYSTEM/MATERIAL DATA

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GENERAL SYSTEM/MATERIAL DATA

SPECIAL CO,ATINGS SYSTEMS 8t APPLICATIONS

Exposure	Applications	Type System	Resistance: ALCOHOLS	ALIPHATIC HYDROCARBONS	ALKALI SOLUTIONS	AROMATIC HYDROCARBONS	FRESH WATER	KETONES	MINERAL ACIDS	MINERAL OILS	ORGANIC ACIDS	OXIDIZING AGENTS	SALT SOLUTIONS	VEGETABLE OILS	WASTE WATER	WEATHERING
Rural, Urban Light Industrial	Warehouses, Manufacturing Plants, Schools, Storage Tank Exteriors	\lkyd Primer &Alkyd 'opcoat	③	③	④	④	③	④	④	①	④	④	④	④	④	G
Mild Chemical	Wood Yards, Plywood Plants Sawmills	ligh Build Epoxy 'olyamide Cured & Jrethane Topcoat	①	①	①	③	①	④	③	①	③	③	①	①	①	E
Fresh & Salt Water Immersion; Moderate Chemical Exposure	Pilings, Waste Treatment Plants, Pulp & Paper Mills, Marine Structures & Barges, Coaeneration	꞉oal Tar Epoxy 'olyamide Cured	①	①	①	①	②	④	③	①	③	③	②	①	②	F
Fresh & Potable Water Immersion	Water Storage Tank Interiors, Locks & Water Control Gates	ligh Build Epoxy \mine Cured	①	①	①	①	②	③	③	①	③	③	②	②	②	F
Severe Chemical	Pulp & Paper Mills, Coal Handling, Chemical Plants, Sour Crude Refineries, Fertilizer Plants	ligh Build Epoxy 'olyamide Cured & Jrethane Topcoat	①	①	①	③	①	③	③	①	③	③	①	①	①	E
Severe Chemical-Acid Resistance	Pulp & Paper Mills, Dockside Exposures, Fertilizer Plants, Acid Loading Docks, Dye Plants	ligh Build Epoxy \mine Cured	①	①	①	①	②	③	③	①	③	③	②	②	②	F
Severe Chemical-Alkali & Solvent Resistance	Pulp & Paper Mills, Coal Handling Facilities, Dockside Exposures	Organic Zinc Rich Epoxy Primer & High Build Epoxy Polyamide Cured Topcoat	①	①	①	①	②	③	③	①	③	③	①	①	②	F
Severe Chemical-Alkali Resistance	Capital structures where color & gloss retention are needed	Organic Zinc Rich Epoxy Primer, High Build Epoxy Polyamide Cured & Urethane Topcoat	①	①	①	③	①	③	③	①	③	③	①	①	①	E
Severe Chemical Solvent & Alkali Resistance	New Construction, Pulp & Paper Mills, Power Plants, Coal Liquification, Cogeneration	Inorganic Zinc Rich Primer & High Build Epoxy Polyamide Cured Topcoat	①	①	①	①	②	③	③	①	③	③	①	①	②	F

GENERAL SYSTEM/MATERIAL DATA

SPECIAL COATINGS SYSTEMS & APPLICATIONS

Exposure	Applications	Type System	Resistance													
			ALCOHOLS	ALIPHATIC HYDROCARBONS	ALKALI SOLUTIONS	AROMATIC HYDROCARBONS	FRESH WATER	KETONES	MINERAL ACIDS	MINERAL OILS	ORGANIC ACIDS	OXIDIZING AGENTS	SALT SOLUTIONS	VEGETABLE OILS	WASTE WATER	WEATHERING
Severe Chemical	Where gloss retention and color are important	Zinc Rich Primer & Urethane Topcoat	①	①	①	③	①	①	③	③	①	③	③	①	①	E
High Temperature (up to 1 200° F)	Stacks, Incinerators, Super Heated Steam Lines, Boiler Casings & Drums	Heat Resistant Silicone Aluminum	③	③	④	④	④	④	④	①	④	④	④	④	④	E
Immersion, Severe Exposures	Waste Treatment Plts., Pulp & Paper Mills, Cogeneration, Power Plants., Sour Crude Exposures	Coal Tar Epoxy Polyamide Cured	①	①	①	③	②	④	③	①	③	③	②	①	②	F

CODES: ① = infrequent contact; ③ = immersion; ② = occasional contact; ④ = not recommended; F = fair; G = good; E = excellent

GENERAL SYSTEM/MATERIAL DATA

CHECK LIST FOR RAILWAYS

ITEM	WHAT TO	OOK FOR	
TO CHECK	WALKING	TRACK MOTOR CAR OR HY RAIL	TRAIN
Rail	Broken, vertical or horizontal split heads, crushed heads, corrugation, wear, shelling, engine burns, rail end batter, discoloration, rust streaks, damaged by equipment	Broken, vertical split heads, crushed heads, engine burns, discoloration	Broken
Bars Bolts Washers	Broken, bent cracked Loose, missing, bent Missing	Broken Loose, missing —	— — —
Plates	Broken, bent, badly corroded, missing, skewed	Broken, missing	—
Spikes Anchors	High, missing, bent Off, loose, away from tie or plate	High, missing Off —	 —
Ties	Broken, split, spike killed, plate cut, damaged by equipment	Broken, damaged by equipment	—
Ballast tine	Pumping, hanging ties Misalignment	Pumping Misalignment	— Misalignment, ride quality
Surface	Poor surface	Poor surface	Poor surface, ride aualitv
Cross Level Gauge	Poor cross level Irregularities	Poor cross level Irregularities	Ride quality Irregularities, ride quality
Turnouts and Diamond Crossing	As per SPC 3507, Turnout and Diamond Crossing Inspection	Misalignment or damaged components	Ride quality
Drainage Slides	Ditches or culverts blocked Slides	Ditches or culverts blocked Slides	High Water Slides
Fencing	Damaged, open gates	Damaged, open gates	—
Clearances	Vertical and horizontal restricted clearances	Restricted clearances	—
Highway and Farm Crossing	Loose, missing, or high planks, or other surface material, high spikes, obstructed flangeways.	Missing or high planks or other surface material, high spikes, obstructed flangeways	—
Track signs	Defective or missing	Defective or missing	Defective or missina

GENERAL SYSTEM/MATERIAL DATA

END OF SUBSECTION

0.12.01 .Ol .01 WATER TREATMENT PLANT

DESCRIPTION

Water Treatment Systems are primarily used to render water fit for human consumption. The typical system takes water from a source, eg., reservoir, river, lake, or well, processes it, stores it, and then supplies a local water distribution system. The processes remove harmful bacteria, organic and inorganic chemicals, and other materials from the water that affect palatability (taste, odor, color). These processes rely primarily on filtration and sedimentation. Chemicals are usually added to facilitate these processes and provide other benefits.

The major system components are intake screens, pumps, tanks, filters, chlorinators, and softeners. In addition, there are the related piping, metering devices, flow regulators, valves, motors, and other equipment controls. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Intake Screens

An intake is the structure or collection point that allows surface water to be taken from the source to the process tanks at the treatment plant. Intake placement is a very important part of the water purification process; it should be located where the best quality and most adequate supply will be available for present and future populations.

Major water sources such as rivers and lakes may contain large suspended solids such as cans, rags, and wood that could damage pumps and block metering devices. Large screens are placed at critical points in the influent flow, primarily upstream of the supply pumps. They should have openings small enough to stop floatage but large enough to permit water to enter at low velocity.

Some screens are automated to effect routine cleaning. The cleaners are typically motorized stripping arms that lift waste and place it on a cross conveyor. Removed waste is transferred to a holding bin and periodically removed to a landfill or incinerated.

pumps (CSI 15160)

Raw water pumps are used to transfer untreated water from the source to the primary treatment facility. They are usually located near the source and are frequently not within the water treatment compound. At least two raw water pumps are typically used due to possible pump or motor failure.

Transfer pumps are used to transfer treated water to holding tanks and to the main distribution systems.

Within the treatment plant, pumps are used for water circulation between major components (filters, settling tanks, etc.) for chemical addition and for sludge and scum removal.

Chlorinators are used to inject liquid (gaseous) chlorine into the water supply to kill undesirable bacteria, either by a direct feed or solution feed device (metering pump). Large facilities will employ a dedicated “chlorine contact” tank to ensure effective mixing of the chlorine with the supply.

Fluorinators are used to inject fluorine into the water supply. Fluorine has been found to positively affect (reduce) dental decay in most populations. The fluorine is introduced to the system by either a direct feed or solution feed device (metering pump).

0.12.01 .01 .Ol WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Pumps (CSI 15160) (Continued)

Pump types vary significantly depending on use. Water wells most frequently employ line-shaft and submersible classes of vertical turbine pumps. Less frequently, wells use reciprocating or rotary, positive displacement pumps, straight single-stage and regenerative turbine centrifugal pumps, and jet pumps.

Reservoir, river, and lake sources most frequently employ horizontal, multi-stage centrifugal pumps for the primary transfer units.

Water transfer units within the plant are typically single-stage horizontal centrifugal pumps; sludge pumps are typically reciprocating pumps; and chemical addition units are special diaphragm pumps.

Pumps should be arranged to provide easy access for periodic maintenance and repair.

Motors (CSI 15170)

Most pumps are electric motor driven, but diesel or gasoline engine drives are frequently provided in remote locations. Type of motor varies significantly with duty.

Pumps are typically driven via a closed motor with coupling.

Engines (CSI 15320)

In some large installations, especially those in remote areas with unreliable electrical power, the pumps are driven by small engines. Both gasoline and diesel are frequently used and natural gas can be used where fuel is available. Engines require a battery bank and a battery charger to keep the system prepared for demand.

Tanks

Tanks are used for many functions throughout water treatment facilities.

Tanks are typically large, open, rectangular concrete structures. These units frequently have baffling and adjustable weirs to control flow volume and velocity and to facilitate segregation of scum, sludge, and effluent water.

Rapid mixing tanks are relatively high velocity tanks in which chemicals are added to raw water to promote separation of products and/or to reduce bacteria in the water. The higher velocity is required to prevent coagulation of the treated products. Typical additives are alum, ferric sulfate, lime, and soda ash. Mixing tanks may be in-line concrete structures, flow bypass units or direct injection tanks (usually metal). Although mixing is possible with simple injection, mixing tanks generally employ some method of agitation, either using a mechanical agitator, aeration or circulating pumps, or baffles.

Slow mixing tanks are used to advance the process of flocculation. In this process, flocculated particles grow and form firm, dense, settleable particles.

Settling or sedimentation tanks are used to separate solids from the influent. They are generally large and reduce the water velocity to a point where solids can settle to the tank bottom as sludge. The sludge is pumped to other tanks for further processing and disposal.

Storage tanks are used to hold processed water to meet fluctuation in demand. Many are also pressurized to enhance product distribution. Perhaps the most common storage tank is the elevated tower.

0.12.01 .OI .OI WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Tanks (Continued)

Storage Tanks Typically Have:

- Tank Manholes for periodic servicing and inspections
- Pipe connections for supply, return, overflow, vent, gauging
- Ladders inside and outside the tank, anchored to top and bottom
- Corrosion protection system (sacrificial elements)

Some small storage tanks use compressed air for pressurization, segregating the two media with bladder or other impermeable membrane.

Scrapers **& Skimmers**

Settling, mixing, and flocculation tanks all produce waste byproducts. Tank design may allow for gravity removal, but it is common to facilitate this process with motorized skimmers and scrapers.

Skimmers are rotating or traveling blades that engage the surface of the water to push products that float to the surface. A weir or collection sump is typically located at the end or periphery of the tank to catch the product.

Scrapers rotate or travel across the bottom of the tank to force collected sludge into a catch basin or trough.

Rectangular tanks will frequently combine these functions in one drive mechanism.

Because these units are most effective at slow speed, the drive mechanism typically includes gear reducers and chain sprockets assemblies allowing speed step-down.

Filters

Various filters are installed in the water flow to remove suspended solids from the water after it passes through the settling tanks. These filters are also typically large, open, rectangular concrete structures consisting of two sections, the forebay and the sand area, and filled with various filtration media such as sand, gravel, charcoal, anthracite coal, diatomaceous earth, or finely woven fabric. Smaller plants may employ metal tanks with replaceable filter media.

All filters eventually become blocked or restricted by the filtered material and most have some means of periodically backflushing and rinsing the filter media to restore efficiency.

Softeners/Water Conditioners (CSI **15457)**

Softeners generally adjust the pH of incoming water and control water hardness. In most large installations, more than one softener will be provided to allow for regeneration of the softener's capability.

Softeners Typically Have:

- Conditioner tank with manholes for periodic service and inspection
- Sand/gravel bed for filtration
- Resin bed for ion exchange (softening of water)
- Spray nozzles to distribute incoming water
- Valve manifold (frequently automated) to cycle conditioner phases
  - Conditioning (in service)
  - Backwash - remove filtered solids
  - Regeneration - reverse the ion exchange process
  - Rinse - clear unit before return to service
- Brine tank w/float controlled water makeup, for regeneration

Other filtration products may be used, as well as other softening methods (eg., lime-soda treatment).

0.12.01 .Ol .01 WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

piping & Fifflngs (CSI 15060)

Piping and fittings provide the transfer network for the water treatment system. Most of the network is constructed of ductile iron or steel pipe coated with coal tar enamels, epoxy paint, cement mortar, and polyethylene.

All fittings should be compatible with the type of piping materials used in the system. This is required to minimize corrosion induced by galvanic action.

Dielectric unions should be provided with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion. Although permitted in non-potable applications, lead solder is not allowed for joining potable water piping.

Strainers are typically provided at the suction side of all pumps to protect the pumps themselves and the sensitive control devices downstream. Additional strainers should be provided on the supply side of each control valve.

Flexible connectors are generally used on the suction and discharge side of each base-mounted pump to minimize the effects of pump vibration.

Pipe sleeve seals should be provided at foundation and basement wall penetrations.

Flanged pipe is generally used above ground, and mechanical joint pipe is frequently used underground. The “slip-on” joint is the most commonly used because of its quick change-out time and reduced cost.

Valves (CSI 15100)

Valves are used to switch/tanks and pumps and isolate system components for maintenance and repair. In addition, shut-off valves are typically provided at each branch connection to supply mains.

Regulating valves may be used to control the flow of water to/from the tanks. Many isolation valves are motorized (electric or electro/pneumatic) to facilitate operation.

Drain valves should be installed at low points in tanks, mains, risers, branch lines, and elsewhere as required for system drainage.

All valves should be installed in accessible locations, protected from physical damage. Underground valves should be provided with a valve box to provide access to the operating unit. Valves should be tagged and records kept indicating location, make, size, thread direction, and all maintenance data.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge sides of each pump or pump group.

Flow meters are provided at the influent and effluent of the water treatment plant to monitor the amount of water treated and put into the water distribution and to set chemical dosage rates. Influent flow rates can be used.

Level indication is usually provided for all tanks to allow the operator to provide hydraulic balance through the plants.

Large plants also provide instrumentation to measure pH, turbidity, temperature, and chlorine residue.

0.12.01 .01 .Ol WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Equipment Controls & Panels (CSI 15950)

Many controls are used in the typical water treatment system. Water treatment is closely tied to the amount and character of the raw water itself. Therefore, most systems require one or more methods of measuring the plant influent and effluent rates. Measuring devices include venturi nozzles, magnetic flow detectors, orifice plates and pitot tubes.

Output signals from the flow measurement devices are used to start/stop/vary the speed of pumps and the position of flow control valves.

Additional detectors and controllers are used to monitor and adjust the injection rate for various chemicals.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect).

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

0.12.01 .01 .OI WATER TREATMENT PLANT

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DEFICIENCY FACTORS
0.12.01 .Ol .01 WATER TREATMENT PLANT

PROBABLE FAILURE POINTS

- Tank leakage due to age, excessive corrosion, physical damage.
- Inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network, blocked filters, pumping failure.
- Pipe leakage due to internal corrosion.

SYSTEM ASSEMBLIES/DEFICIENCIES

Intake Screens

Extreme Distortion, Damage:	Allows passage of large waste.
Damaged Mechanical Cleaner:	Failure of drive mechanism, worn guides, extreme wear, or corrosion.
Damaged, Missing Fasteners:	Age, wear, poor maintenance.

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked rotor, power supply failure.
Excessive Noise, Vibration:	Gas or vapor in liquid, inlet suction line not sufficiently submerged; bearing wear, lack of lubrication, imbalance in internal components, misalignment, contamination, failed isolators.
Excessive Load:	Bearing wear, misalignment, failed internal relief.
Inadequate Capacity:	Low pressure, low flow caused by wear in impeller, failed internal relief.
Leakage in Packing or Mechanical Seal:	Normal wear.
Defective Bearings:	Age, improper lubrication, moisture in oil, abuse, misalignment, bent shaft, vibration.
Severe Corrosion:	Normal aging, leakage, poor maintenance, local environment.
Stuffing Box Overheats:	Packing too tight, wrong grade of packing, box not properly packed.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion, failed power supply.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance, local environment.
Motor Runs Hot:	Packing too tight, speed too high, impeller binding or rubbing, voltage and frequency lower than rating.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.

DEFICIENCY FACTORS
0.12.01 .Ol .Ol WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors (Continued)

Defective Bearings:	Age, normal wear, improper lubrication.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charge.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, failed isolators.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Age, poor maintenance, local environment.
Compression Loss:	Defective rings or valves, cracked block.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.
Battery Charger Defective:	Poor maintenance.
Battery Dead:	Lack of maintenance, bad cells.

Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

DEFICIENCY FACTORS
0.12.01 .Ol .01 WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Scrapers & Skimmers

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Excessive Wear Chains:	Age, normal wear, improper lubrication.
Excessive Wear Guides:	Age, normal wear, improper lubrication.
Defective Reducer:	Age, normal wear, improper lubrication.
Loose, Missing Fasteners:	Corrosion, damage.

piping & Fittings

Strainers inaccessible:	Corroded fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.

DEFICIENCY FACTORS
0.12.01.01.01 WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Instrumentation

Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

Equipment Controls & Panels

Motor Starter Inoperative:	Overloaded, open coils, wear in linkage.
Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance, local environment.

END OF SUBSECTION

0.12.01.01.02 WATER DISTRIBUTION SYSTEM

DESCRIPTION

The site Water Distribution System is the piping network that ties the sources of water (wells, water reservoirs, treatment plants, etc.) to the end users (occupied buildings and structures, residences, production facilities, and agricultural centers). It serves to distribute and regulate the available flow. In addition to the pipe, it includes insulation, valves, manholes, reservoirs, pumps, motors, hydrants, metering devices, and equipment controls. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 02668)

The distribution system is normally buried underground, below the frost line. This helps protect against freezing and minimizes conflict with ground transportation, but also makes inspection and maintenance very difficult. The latter is a major reason that DOE sometimes puts their distribution network above ground.

Most distribution piping is ductile iron, although steel, polyethylene, PVC, concrete pressure pipe, and asbestos cement pipe are sometimes used. Brass and copper are rarely used anymore because of cost. Asbestos cement has also fallen into disuse due to environmental concerns. Pipe sizes vary significantly, ranging from 4 inches in small complexes (residential, agricultural) to 12 inches in large site/municipal type environments. Larger sizes (up to 54 inches) may be used, but are uncommon. Pipe over 24 inches is generally concrete pressure pipe.

Ferrous piping is generally lined with a cement mortar and seal-coated. Where soil is corrosive, the pipe should be encapsulated, usually in a polyethylene film tube.

Mechanical fittings use rubber gaskets or elastomeric joints to improve reliability.

Dielectric unions effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion. They should be provided with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged).

Underground piping is installed in trenches. Adequate bedding is provided in the trench and backfill is consolidated around the pipe to carry the pipe weight and to minimize disturbance.

Insulation (CSI 15250)

Above ground piping should be insulated and heat traced to provide protection from freezing.

Supports & Anchors (CSI 15140)

Pipe hangers and supports are provided to minimize piping disturbance and allow for expansion and contraction. They should be securely attached to foundation material at sufficiently close intervals.

Valves (CSI 15100)

Valves are primarily used to isolate sections of distribution piping for maintenance and to terminate service.

Main isolation valves are almost always rising stem gate valves. They are usually installed in-ground in cast iron valve boxes with 5 inch access plates. In large distribution systems, the valves may be installed in precast concrete pits, generally 24 inches minimum diameter.

Service termination valves are usually plug or ball valves. They are also installed in the ground in cast iron valve boxes with 3 inch access plates.

0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Manholes (CSI 02730)

Manholes are typically precast concrete rings positioned at critical connection points in the distribution system. They are essentially inspection and maintenance accesses found in systems with pipe 10 inches or larger. They are located at key mechanical connections such as vent and isolation valves and expansion joints.

The lowest section is referred to as the base, channel, and bench, and connects incoming pipe to outgoing. Riser rings (typically 48 inches) and grade rings are stacked above and joined with rubber gaskets. The top section is an eccentric cone matching a 24 inch diameter frame.

Older manhole units may be built of brick or cast-in-place concrete. All units are fitted with access covers and ladders.

Reservoirs

The purified water discharge from a treatment plant is typically stored in large concrete tanks or lined earth embankments. At nominal capacity, the plant supply is typically equal to system demands. However, during heavy demand periods, individual plant components may not be able to handle the total demand, so, many distribution system designs include one or more large capacity reservoirs that act as buffer zones or holding areas.

Pumps (CSI 15160)

Treated water from the plant is pumped into the distribution main and into elevated storage tanks to maintain adequate system pressure. Large systems may employ additional booster pumps in the network, which are frequently horizontal, multi-stage centrifugal pumps.

Motors (CSI 15170)

Most pumps are electric motor driven, usually an AC closed motor with coupling.

Engines (CSI 15320)

In some large installations, especially those in remote areas with unreliable electrical power, the pumps are driven by a small engine or an engine-driven generator is provided. Both gasoline and diesel are frequently used, and natural gas can be used if available. Engines require a battery bank and charger to keep the system prepared for demand.

Hydrants (CSI 02668)

Fire hydrants are above ground extensions of the underground water mains. They are generally equipped with isolation valves and standardized hose connections, usually 2 1/2 inches to hose connections and 4 1/2 inches for pumper connections. Although primarily used for protection, hydrants are also used to flush out pipelines, fill water trucks and street sweepers, and provide temporary water service. The two basic types are the dry barrel (compression, corey) and the wet barrel. One distinct feature is the safety flange, which allows the hydrant to break when struck by a vehicle.

Motoring Devices (CSI 15150)

Water meters are primarily installed for billing purposes, but are also useful in quantifying and isolating leaks. These devices are either turbine, compound, or disc type positive displacement meters. Like the isolation valves, they are frequently installed in the ground in cast iron pits like the valve boxes, usually near and downstream of the isolation valve.

In large distribution systems, the meters may be installed in precast concrete pits.

0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Metering Devices (CSI 15150) (Continued)

Additional meters are sometimes installed to provide information on source yields, control excess water uses, alert end users regarding system demand and the need for new sources or increased production, provide indication of pump conditions, and monitor consumption for irrigation, cooling towers, etc. These meters are usually above ground and are disc, turbine, or propeller types.

Equipment Controls & Panels (CSI 15950)

Few controls are used in a site water distribution system.

Where pumps are used, control is performed via a typical motor assembly (motor, starter, and disconnect). They may be controlled by water levels in a reservoir or elevated tank or distribution system pressure.

Where storage tanks are used, pressure and level controls will be included.

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

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DEFICIENCY FACTORS
0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

PROBABLE FAILURE POINTS

- Pipe leakage due to age, excessive corrosion, physical breakage, and water hammer.
- Inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network; pumping failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Flfflngs

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.

Insulation

Missing:	Never installed or taken off, not replaced.
Wet:	System leakage or external causes.
Damaged:	Physical abuse.

Supports & Anchors

Missing:	Improper installation, removed and not replaced.
Improper Alignment:	Improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, improper design.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Inadequate Seating:	Worn parts, blocked by scale.

Manholes & Catch Basins

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment.
Physical Damage:	Collapsed, cracked.

pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked rotor.

DEFICIENCY FACTORS
0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps (Continued)

Excessive Noise, Vibration:	Bearing wear, gas or vapor in liquid, imbalance in internal components, misalignment, contamination, wear on shaft, failed isolators.
Excessive Load:	Bearing wear, misalignment, failed internal relief.
Inadequate Capacity:	Low pressure, low flow caused by wear in impeller, failed internal relief, worn impellers.
Leakage in Packing or Mechanical Seal:	Normal wear, poor maintenance.
Defective Bearings:	Age, improper lubrication, moisture in oil, abuse, misalignment, bent shaft, vibration.
Severe Corrosion:	Normal aging, leakage, poor maintenance, local environment.
Stuffing Box Overheats:	Packing too tight, wrong grade of packing, box not properly packed.

Motors

Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion, failed power supply.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Motor Runs Hot:	Packing too tight, speed too high, impeller binding or rubbing, voltage and frequency lower than rating.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charge.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, improper anchorage, failed isolators.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Age, poor maintenance, local environment.
Compression Loss:	Defective rings or valves, cracked block.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.

DEFICIENCY FACTORS
0.12.01.01.02 WATER DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Engines (Continued)

Battery Charger Defective:	Poor maintenance.
Battery Dead:	Lack of maintenance, bad cells.
Hydrants	
Leakage:	Corrosion, physical damage, defective gaskets.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.
Meters	
Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion.
inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.
Equipment Controls & Panels	
Motor Starter Inoperative:	Overloaded, open coils, wear in linkage.
Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance, local environment.

DEFICIENCY FACTORS
0.12.01 .01.02 WATER DISTRIBUTION SYSTEM

END OF SUBSECTION

0.12.01 .01 .03 SEWAGE & DRAINAGE COLLECTION SYSTEM (CSI 02720)

DESCRIPTION

The Sewage and Drainage Collection Systems are the piping networks that tie the sources of waste water (buildings, utilities, etc.) and storm water drainage to their respective collection points. For sewage, this is the local waste water treatment facility. Its purpose is to convey the raw sewage safely; i.e., without leaking and contaminating the areas it passes through. For storm water drainage, separate piping is generally used to return untreated water to rivers, lakes, etc.

In addition to the piping, these collection systems also include manholes, valves, metering devices, and stations. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 02720, 02730)

The collection system is normally buried underground, below the frost line. This helps protect against freezing and minimizes conflict with ground transportation, but also makes inspection and maintenance very difficult.

The most familiar collection piping is cast iron and reinforced concrete pipe for gravity flow conveyance of sewage, industrial wastes, and storm drainage water. Pipe sizes vary significantly, ranging from 4 to 24 inches in small complexes (residential, agricultural) and from 12 to 144 inches in large site/municipal type environments. Sizes over 12 inches are generally reinforced concrete.

Asbestos cement sewer pipe has also been used for years. It has better chemical resistance qualities and has been employed primarily in high acid conditions. Although the asbestos content is nonfriable, it is no longer allowed in new installations due to environmental concerns. Other pipe products include ABS and PVC plastic pipe, vitrified clay pipe, and a limited range of copper pipe.

Force mains are generally made from ductile iron pipe or polyethylene pipe. Ferrous piping is usually lined with a cement mortar and seal-coated. Where soil is corrosive, the pipe should be encapsulated, usually a poiyethylene film tube.

Many fittings in a collection system are mechanical, using hub and spigot or slip on joints. Hub and spigot have used oakum and lead as a sealant. Other mechanical fittings use rubber gaskets or elastomeric joints to improve reliability.

Supports & Anchors (CSI 15140)

Underground piping is installed in trenches. Sometimes suitably supported cradles and crowns are used, depending on soil condition, to carry the pipe weight and to minimize disturbance.

Where piping is exposed, pipe hangers, and supports are provided to minimize piping disturbance and allow for expansion and contraction, They should be securely attached to foundation material at sufficiently close intervals.

Valves (CSI 15100)

Collection systems are primarily gravity flow and use few valves for control or isolation.

Force mains (pressure flow piping) employ isolation and cross-over valves between mains. The mains also have air valves (for venting purposes) located at high points in the systems. Valves are also used in pumping stations to isolate pumps, tanks, and sections of distribution piping for maintenance and repair.

Main isolation valves are almost always rising stem gate valves. Valves on buried piping are usually non-rising stem gate valves.

Storm drainage systems feeding lakes and rivers typically use backwater valves for protection against high water backup.

0.12.01 .01.03 SEWAGE & DRAINAGE COLLECTION SYSTEM (CSI 02720)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Manholes & Catch Basins (CSI 02730)

Manholes and catch basins are typically precast concrete rings positioned at critical connection points in the drainage/collection system. They are essentially cleanout and inspection accesses found in systems with pipe 8 inches or larger. They are located at the upper end of the system, at every change of direction or alignment, at each junction of two or more branches, at each change of grade and size, and at intervals not to exceed 400 linear feet.

The lowest section is referred to as the base; it is benched and serves to connect incoming pipe to outgoing. Riser rings (typically 48 inches) and grade rings are stacked above and joined with rubber gaskets. The top section is an eccentric cone matching a 24 inch diameter frame and cover.

Older units may be built of brick or cast-in-place concrete. All units are fitted with access covers and ladders.

Ponds & Reservoirs

In many storm drainage systems, ponds and reservoirs are used as holding areas to compensate for heavy influent periods. These holding areas are generally large concrete reservoirs. To prevent stagnation and increased turbidity, reservoirs are frequently outfitted with agitators.

Pumps (CSI 15160)

Pumping stations are strategically located in collection systems to lift water to higher elevations. In effect, they connect the gravity mains to the force mains. They consist of transient holding tanks, pumps and control valves. Compressed air systems are sometimes used to operate the valves.

The pumps are normally horizontal or vertical, single or multi-stage, close coupled centrifugal pumps or submersible pumps.

Motors (CSI 15170)

Most pumps are electric motor driven, usually with an AC close coupled motor.

Engines (CSI 15320)

In some large installations, especially those in remote areas or with unreliable electrical power, the pumps are driven by a small engine or an engine-driven generator is provided. Both gasoline and diesel are frequently used; natural gas is rarely used as a fuel source. Engines require a battery bank and a battery charger to keep the system prepared for demand.

Metering Devices (CSI 15150)

Metering devices are useful in isolating leaks (influx) into the collection system, but permanent installations are generally found only in newer systems.

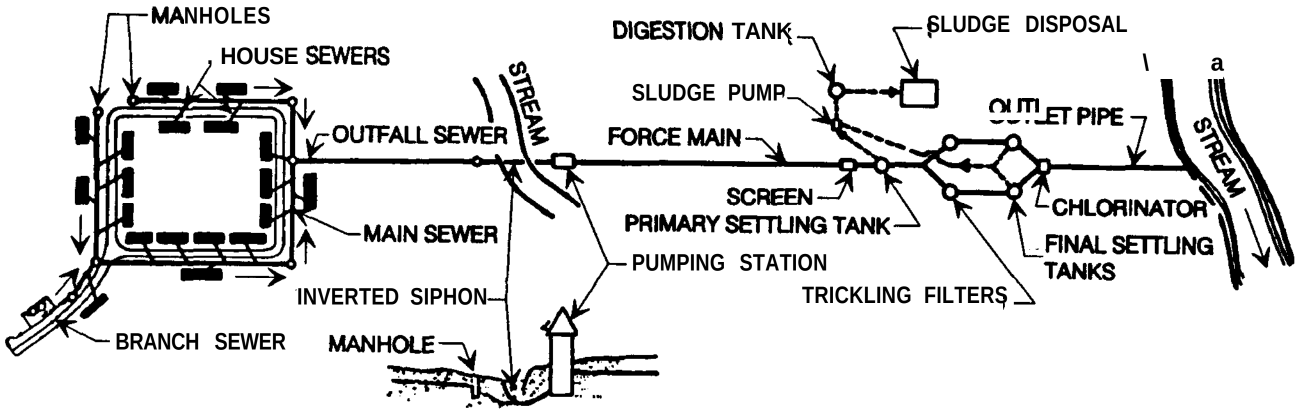
Equipment Controls & Panels (CSI 15950)

Few controls are used in a site sewage and storm drainage collection system.

Where pumping stations are used, pump control is performed via a typical motor assembly (motor, starter, and disconnect).

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.



SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL WASTE SYSTEM		
PLUMBING-SEWAGE & DRAINAGE COLLECTION SYSTEMS	Revision No.	Issue Date 5/93	Drawing No. A12010103-1

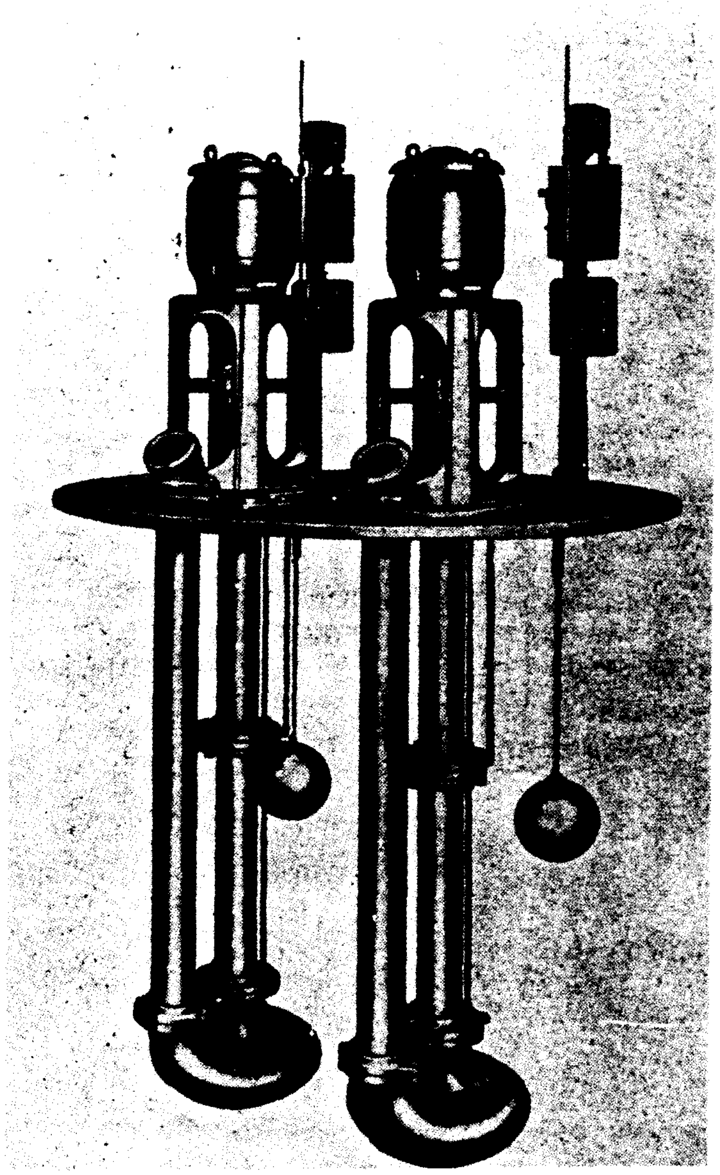


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	VERTICAL SUBMERGED CENTRIFUGAL PUMP, DUPLEX UNIT		
PLUMBING-SEWAGE & DRAINAGE COLLECTION SYSTEMS	Revision No.	Issue Date 5/93	Drawing No. A12010103-2

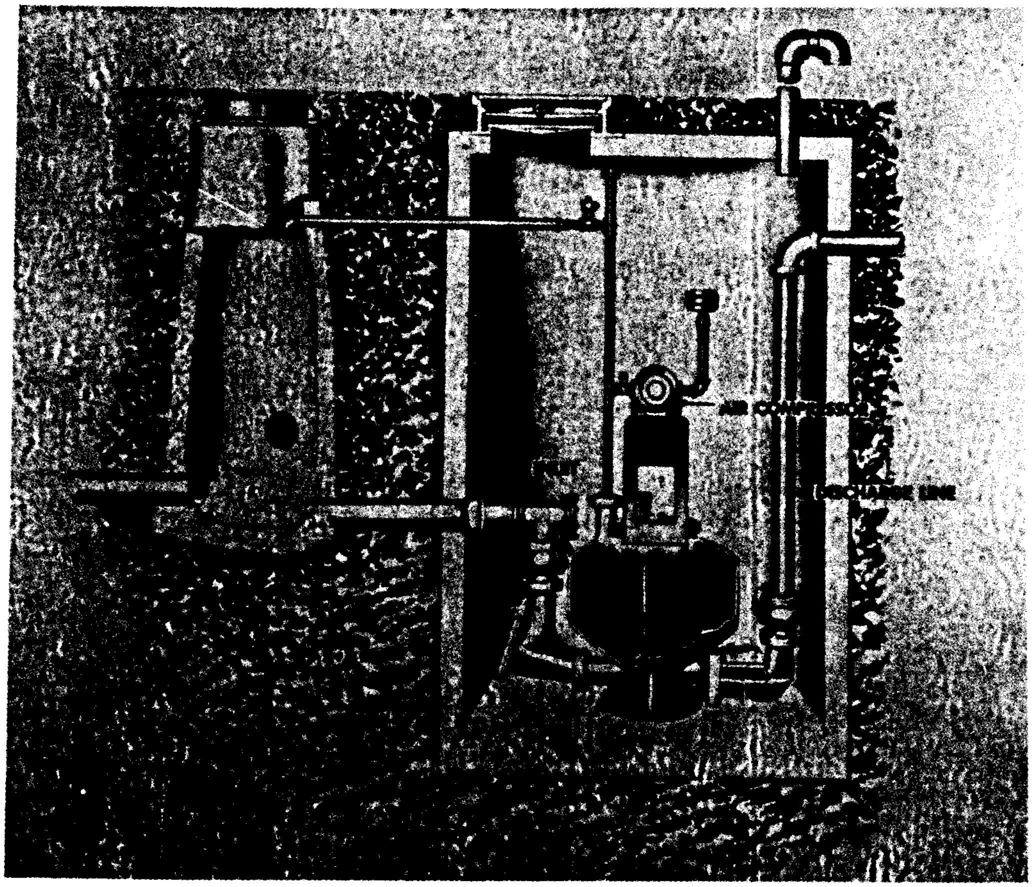


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION a SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	SEWAGE EJECTOR INSTALLATION		
PLUMBING-SEWAGE & DRAINAGE COLLECTION SYSTEMS	Revision No.	Issue Date 5/93	Drawing No. A12010103-3

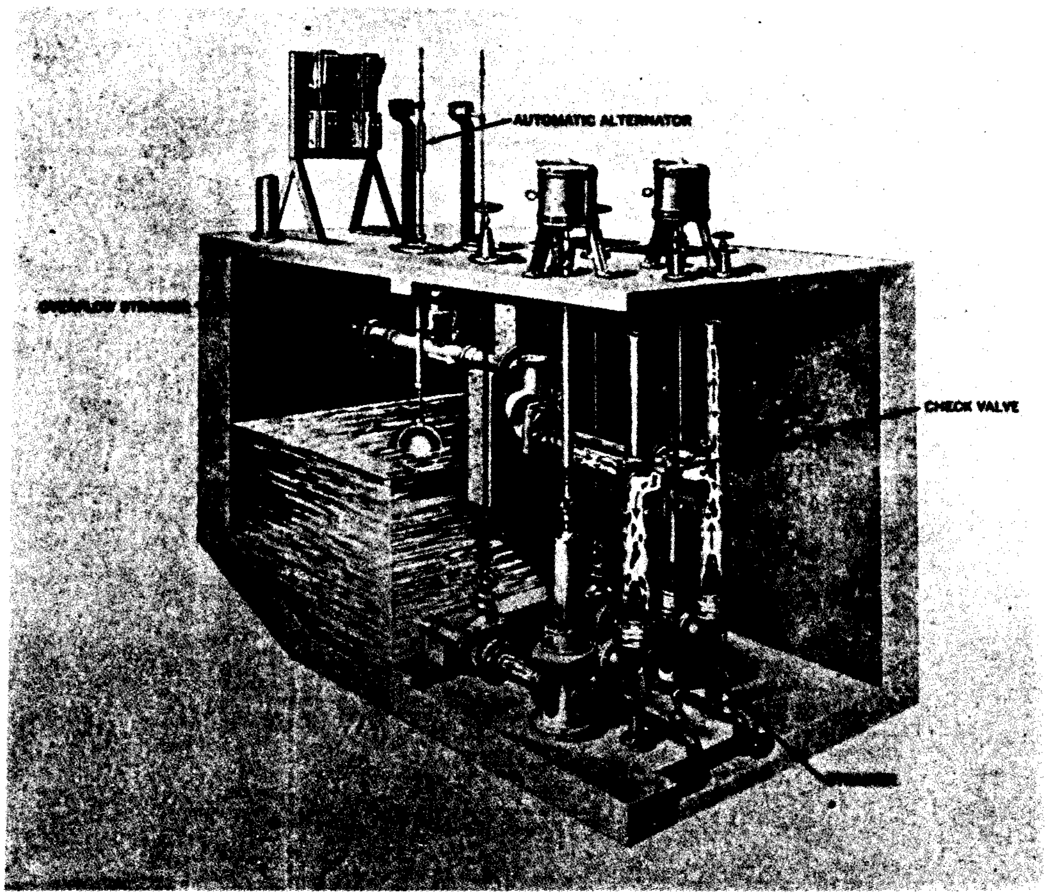


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	SEWAGE LIFT UNIT		
PLUMBING-SEWAGE & DRAINAGE COLLECTION SYSTEMS	Revision No.	Issue Date 5/93	Drawing No. A12010103-4

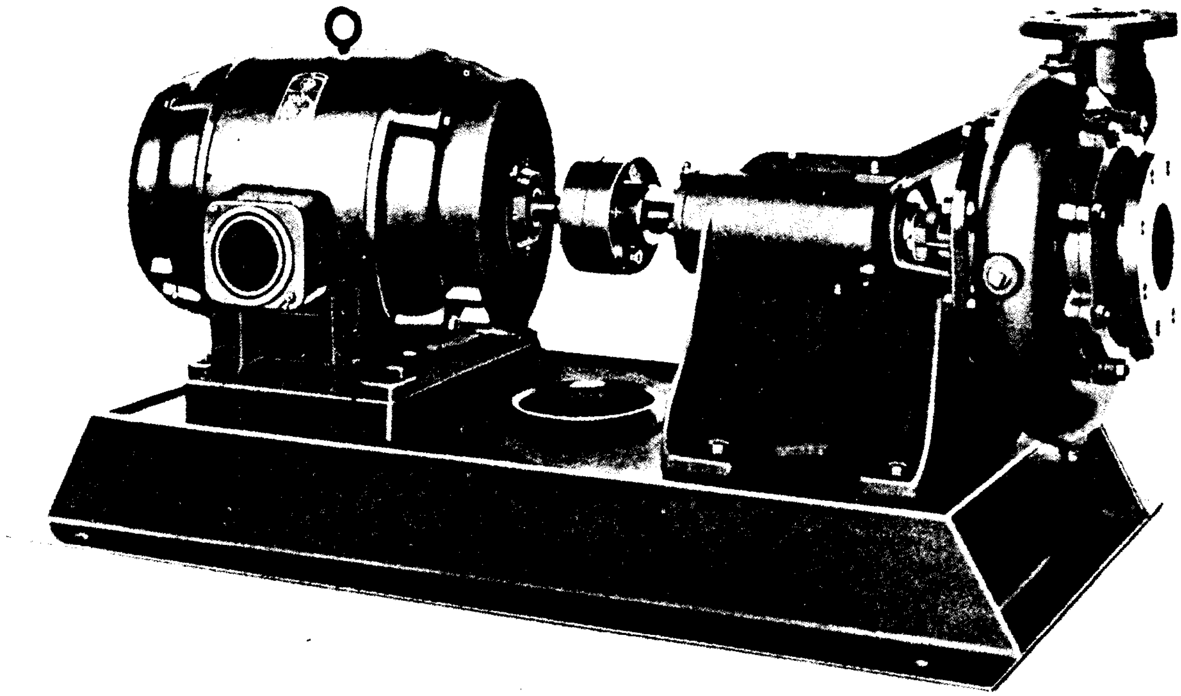


PHOTO ILLUSTRATION SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, AC Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	HORIZONTAL CENTRIFUGAL PUMP		
PLUMBING-SEWAGE & DRAINAGE COLLECTION SYSTEMS	Revision No.	Issue Date 5/93	Drawing No. A12010103-5

DEFICIENCY FACTORS
0.12.01 .01.03 SEWAGE & DRAINAGE COLLECTION SYSTEM
(CSI 02720)

PROBABLE FAILURE POINTS

- Inability of system to handle rated capacity (flow and pressure) due to internal blockage of mains; pumping failure.
- Pipe leakage due to internal corrosion, erosion

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment, industrial waste materials.
Physical Damage:	Collapsed, cracked.

Supports & Anchors

Missing:	Improper installation, poor maintenance.
Improper Alignment:	Improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, poor maintenance, poor design.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Inadequate Seating:	Worn parts, blocked by scale.

Manholes & Catch Basins

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment.
Physical Damage:	Collapsed, cracked.

pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked rotor.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, contamination, failed isolators.
Excessive Load:	Bearing wear, misalignment, failed internal relief, poor design.

DEFICIENCY FACTORS
0.12.01 .01.03 SEWAGE & DRAINAGE COLLECTION SYSTEM (CSI 02720)

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps (Continued)

Inadequate Capacity:	Low pressure, low flow caused by wear in impeller, failed internal relief.
Leakage in Packing or Mechanical Seal:	Normal wear.
Defective Bearings:	Age, improper lubrication, abuse.
Severe Corrosion:	Normal aging, leakage, poor maintenance.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charge.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment, poor system design.
Corrosion:	Age, poor maintenance, local environment.
Compression Loss:	Defective rings or valves, cracked block.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.
Battery Charger Defective:	Poor maintenance.
Battery Dead:	Lack of maintenance.

Meters

Missing:	Taken out for service or repair, not replaced.
inoperative:	Failed internal mechanism, corrosion.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

DEFICIENCY FACTORS
0.12.01 .01.03 SEWAGE & DRAINAGE COLLECTION SYSTEM (CSI 02720)

SYSTEM ASSEMBLIES/DEFICIENCIES

Meters (Contmued)

Damaged :	Abuse, stress.

Equipment Controls & Panels

Motor Starter Inoperative:	Overloaded, open coils, wear in linkage.
Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance, local environment.

DEFICIENCY FACTORS
0.12.01.01.03 SEWAGE & DRAINAGE COLLECTION SYSTEM
(CSI 02720)

END OF SUBSECTION

0.12.01 .01.04 WASTE WATER TREATMENT PLANT

DESCRIPTION

A typical Waste Water Treatment System receives waste water from a collection system and processes it for safe discharge to a river, stream, or similar water body, or to an absorbent field. It relies primarily on mechanical processes of aeration, mixing, and sedimentation, and on the natural activities of oxidation and decomposition by aerobic bacteria to purify the waste. Air injection and chemicals are normally used to facilitate these processes. Extracted solids, referred to as bio sludges or sludges, are generally collected, dried, and transferred to a solid waste landfill. Some modern systems will incorporate a sludge treatment or dewatering facility in the same compound as the waste water unit.

Although the basic processes are very similar, system construction varies significantly depending on volume of waste to be treated, the character of the influent, and local requirements for effluent characteristics. The typical system consists of combinations of the following: influent screens, comminutors, grit chambers, conveyors, settling tanks, aeration tanks, aerators, clarifiers, filters, and chlorination facilities. Other process components include: oxidation ponds, percolation beds, reservoirs, and sludge drying beds. In addition to connecting pipes, there are also metering devices, flow monitors and regulators, motors, pumps, air compressors, valving, and equipment controls. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Influent Screens

Large sewage sources such as municipal areas, military bases, etc. may contain large suspended solids such as cans, rags, and wood that could damage pumps and block metering devices. Therefore, influent screens are placed at critical points in the influent flow, primarily upstream of the supply pumps.

Some screens are automated to effect routine cleaning. The cleaners are typically motorized stripping arms that lift waste and place it on a cross conveyor. Removed waste is transfer to a holding bin and periodically removed to a landfill.

Pumps (CSI 15160)

Pumps are used to transfer untreated waste water from the influent screens to comminutor, grit chamber, or primary treatment tanks. They are usually located near the screens in the waste treatment compound. Pumps may also be used to transfer treated water from the plant to the effluent systems (absorbent fields, river, or stream), although gravity discharge is common.

Within the treatment plant, most of the primary flow is effected by gravity, accomplished through the design of the tanks (relative levels) and the positioning of level control devices. However, additional pumps are used to recirculate sludge (activated sludge process), transfer sludge and scum to sludge treatment components, remove grit from influent, and to provide for chemical injection.

Pump types vary significantly depending on application. Water transfer and activated sludge pumps most frequently employ single-stage, open-faced impeller centrifugal pumps; sludge transfer pumps are usually reciprocating or rotary, positive displacement pumps. Chlorinators and other chemical injection units are usually special design, reciprocating, and diaphragm pumps.

Pumps should be arranged to provide easy access for periodic maintenance and repair.

0.12.01 .01.04 WASTE WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Comminuton

Much of the solid waste trapped in the influent and extracted requires digestion and further treatment before disposal. To allow regular processing, this material is ground, chopped, cut, etc. by comminutors, mechanical devices similar to a garbage disposal. The discharge is returned to the influent flow for normal treatment.

Grit Chambers

Another contaminant in the waste water influent is sand and other fine particles that would be very destructive to pumps, measuring, and metering devices. As part of the influent separation process, a chamber or tank is typically provided to allow settling and collection of this material. Although manual cleaning is sometimes used, a mechanical device is typically provided for screening out and transporting the grit to another location. Cyclone separators, screw and belt conveyors, and pumps are common components.

Conveyors

Conveyors are frequently used to transport solid materials in waste water treatment plants.

Belt or screw conveyors are commonly associated with automated influent screens. The screen cleaner discharge is deposited on a conveyor that moves the waste to a holding bin. The basic assembly of a belt conveyor consists of a frame, support/drive /idler rolls, a continuous belt, and a drive unit. Motor speed is typically reduced through a gear reducer, drive chains, and sprockets.

Screw conveyors are sometimes used in grit chambers to lift separated solids, sand, and grit from the chamber bottom and deposit them on a cross conveyor. The basic assembly consists of a frame, an inclined screw, and a drive unit. Motor speed is typically reduced through a gear reducer, drive chains, and sprockets.

Motors (CSI 15170)

Most pumps are electric motor driven, but diesel or gasoline engine drives are frequently provided in remote locations. Type of motor varies significantly with duty. Pumps are typically driven via a closed motor with coupling.

Engines (CSI 15320)

In some large installations, especially those in remote areas with unreliable electrical power, the pumps are driven by small engines. Both gasoline and diesel are frequently used while natural gas is rare. Engines require a battery bank and charger to keep the system prepared for demand.

Tanks

Tanks are used for many functions throughout waste water treatment facilities.

Settling or sedimentation tanks are used to separate solids from the wastewater. They are generally large and reduce the water velocity to a point where solids can precipitate to the tank bottom as sludge. The sludge is pumped or gravity flows to other tanks for further processing and disposal.

These tanks are typically large, open, rectangular, concrete structures. They frequently have baffling and adjustable weirs or bell valves to permit control of flow volume and velocity and to facilitate segregation of scum, sludge, and effluent water.

0.12.01 .01.04 WASTE WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Tanks (Continued)

Mixing tanks are used to add chemicals that promote product separation and/or reduce the bacteria in the water. Typical additives are ferric chloride (a settling agent) and polymer slurries (coagulant). Mixing tanks may be in-line concrete structures, flow bypass units or direct injection tanks (usually metal). Although mixing is possible with simple injection, mixing tanks generally employ some method of agitation, either using a mechanical agitator, aeration, or circulating pumps.

Aeration tanks are used to inject air into the water to promote treatment by controlled bacteria growth. They are normally of concrete construction. Aeration is accomplished by various methods. In many, remotely generated compressed air is fed through perforated mechanical piping submerged in the water flow. In others, individual aerators are mounted in the aeration tank. The quantity of oxygen introduced is controlled by the number and position of piping/aerators in action or in regulating the source pressure/speed.

Clarifiers are also large separation and settling tanks with added mechanical equipment to facilitate byproduct (sludge and scum) removal.

Chlorine contact tanks are large holding tanks (generally concrete) used for chlorine injection to kill remaining bacteria after the beneficial bacterial activities (digestion and decomposition) have taken place.

Scrapers & Skimmers

Settling tanks, mixing tanks, and flocculation tanks all produce solid waste byproducts. Tank design may allow for the removal of these products through gravity, but it is common to facilitate this process with motorized skimmers and scrapers.

Skimmers are rotating or traveling blades that engage the surface of the water to push products that float to the surface. There is typically a weir or collection sump at the end or periphery of the tank to catch the product.

Scrapers rotate or travel across the bottom of the tank to force collected sludge into a chamber or trough.

Rectangular tanks will frequently combine these functions in one drive mechanism.

Because these units are most effective at slow speed, the drive mechanism typically includes gear reducers and chain sprockets assemblies to allow speed step-down.

Filters, Percolation Beds

Various filter mechanisms are installed in the water flow to remove suspended solids from the water after it passes through the settling tanks. These filtering mechanisms are typically known as percolation beds and are normally large, open, rectangular, concrete structures. These units are filled with various filtration media such as sand, gravel, charcoal.

Percolation beds will frequently employ a piping manifold for distribution of the influent over the filter bed. Sometimes this is a rotating mechanism using suspended nozzle assemblies. Smaller plants may employ metal tanks with replaceable filter media.

All filter media eventually becomes blocked or restricted by the filtered material. Therefore, most filters have some means of periodically backflushing and rinsing the filter media to restore efficiency.

0.12.01 .01.04 WASTE WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Oxidation Ponds & Reservoirs

Oxidation ponds are used to treat wastewater and use mechanical devices to aerate the water in the pond. Oxidation ponds can be of several different configurations. These ponds are concrete or earthen structures.

The treated water discharge from a treatment plant is sometimes fed to a reservoir. At nominal capacity, the plant influent is typically equal to the effluent. However, during heavy influent periods, individual plant components may not be able to handle the demand, so design typically includes one or more buffer zones or holding areas. This is especially true in a multistage plant where tertiary treatment is required.

These holding areas are generally large concrete reservoirs. To prevent stagnation and increased turbidity, reservoirs are frequently outfitted with agitators.

Sludge Drying Beds

Sludge removed from the treatment facility still contains a significant amount of water. The drying beds promote further drying by drainage and evaporation.

Piping & Fittings (CSI 15060)

Piping and fittings provide the transfer network between major components in the waste water treatment system. Most of the network is constructed of iron or steel pipe.

All fittings should be compatible with the type of piping materials used in the system to minimize corrosion induced by galvanic action.

Dielectric unions should be provided with appropriate end connections for the pipe material in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Strainers are provided at the suction of some pumps to protect the pumps themselves and the sensitive control devices downstream.

Flexible connectors are usually used on the suction and discharge side of each base-mounted pump to minimize the effects of pump vibration.

Valves (CSI 15100)

Valves are used to switch tanks and pumps and to isolate system components for maintenance and repair. In addition, shut-off valves are typically provided at each branch connection to supply mains.

Regulating valves may be used to control the flow of water to/from the tanks. Many isolation valves are motorized (electric or electro/pneumatic) to facilitate operation.

Drain valves should be installed at low points in tanks, mains, risers, branch lines, and elsewhere as required for system drainage. All valves should be installed in accessible locations, protected from physical damage. Valves should be tagged.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge of each pump or pump group.

Flow meters are provided at the influent and effluent of most tanks. These vary significantly in design and with the age of the plant. Parshall flumes and large venturi units are common.

Level indication is usually provided for all tanks, typically a remote hydraulic unit or electronic level probe.

0.12.01.01.04 WASTE WATER TREATMENT PLANT

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Instrumentation (CSI 15130) (Continued)

Large plants also provide instrumentation for chemical readouts such as water pH, oxygen, and chlorine content.

Equipment Controls & Panels (CSI 15950)

Many controls are used in the typical waste water treatment system.

Water treatment is closely tied to the amount and character of the water itself. Therefore, most systems require one or more methods of measuring the influent and effluent rates of the plant. Measuring devices include Parshall flumes, venturi nozzles, and magnetic flow detectors.

Output signal from the flow measurement devices are used to start/stop/vary the speed of pumps and the position of flow control valves.

Additional detectors and controllers are used to monitor and adjust the injection rate for various chemicals.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect).

OTHER RELATED COMPONENTS

See the following subsections for related components:

0.12.01.01.03 Sewage & Storm Drainage Collection System 2.1.1.3-l

0.12.01 .01.04 WASTE WATER TREATMENT PLANT

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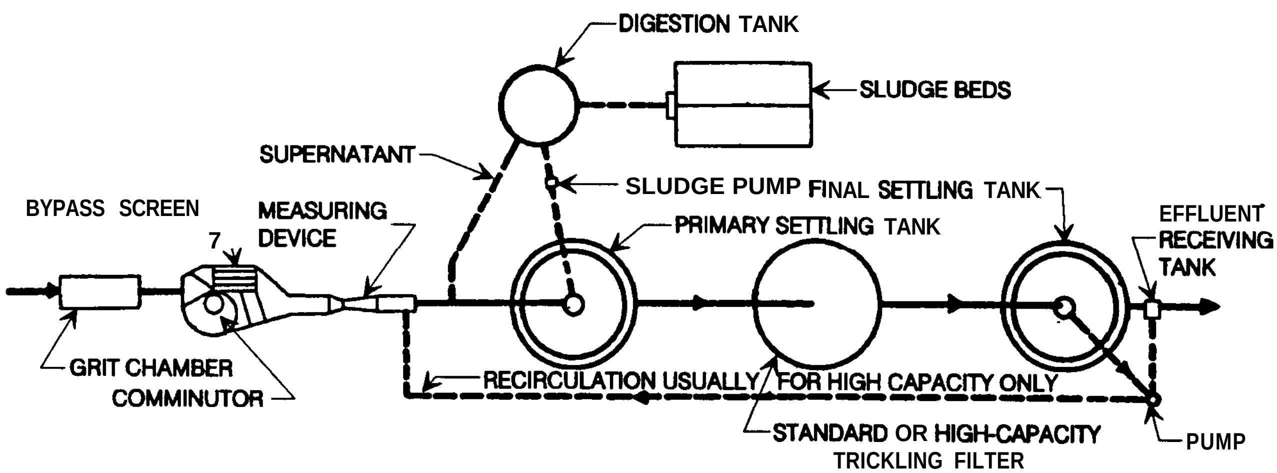


SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	SIMPLE WASTE TREATMENT PLANT		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-1

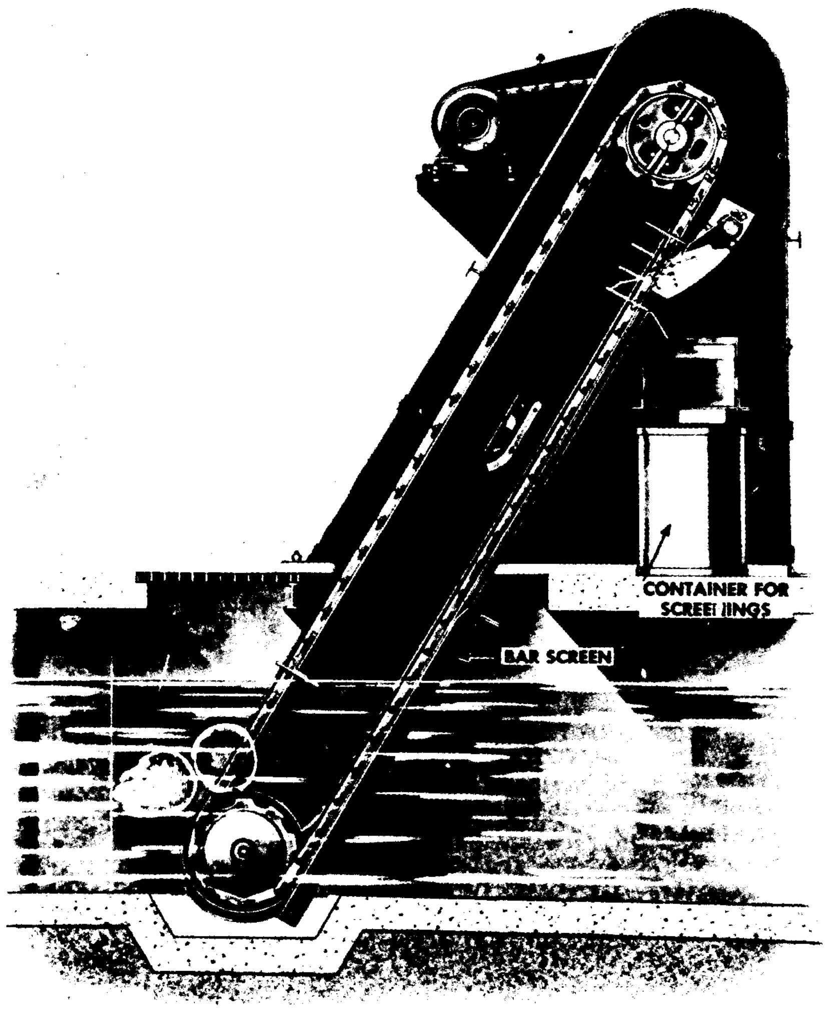


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS. Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	MECHANICALLY CLEANED BAR SCREEN		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-2

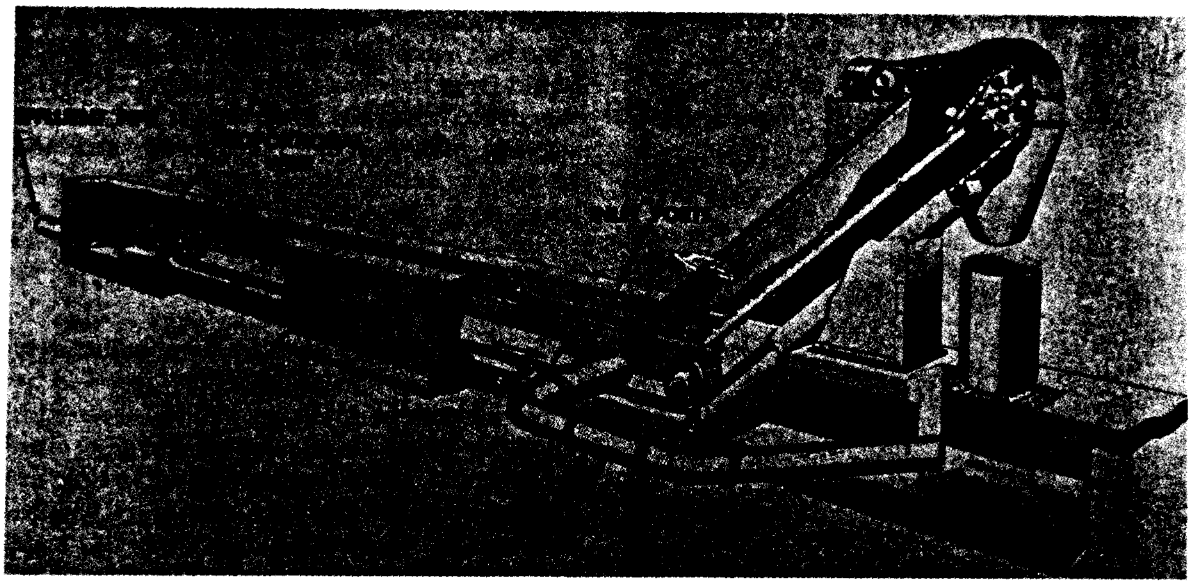


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	GRIT CHAMBER		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-3

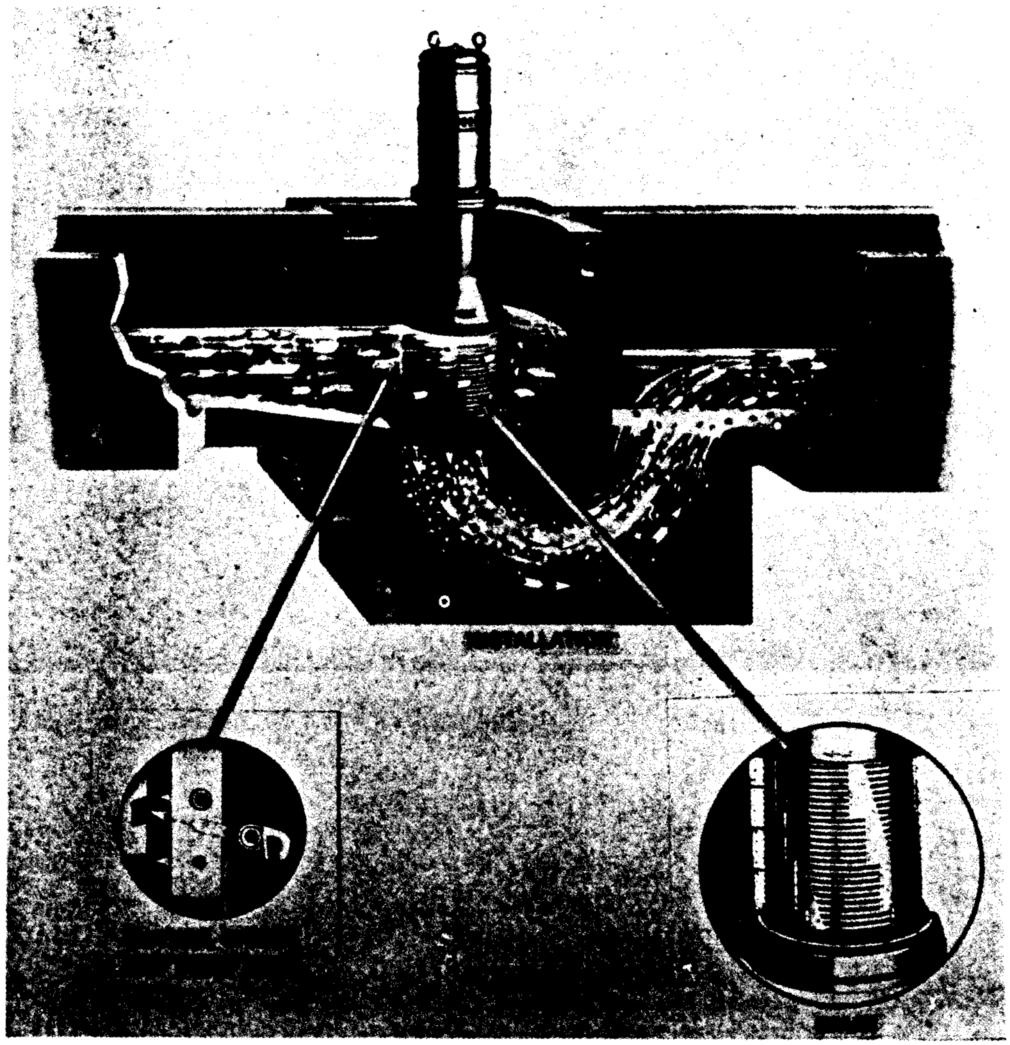
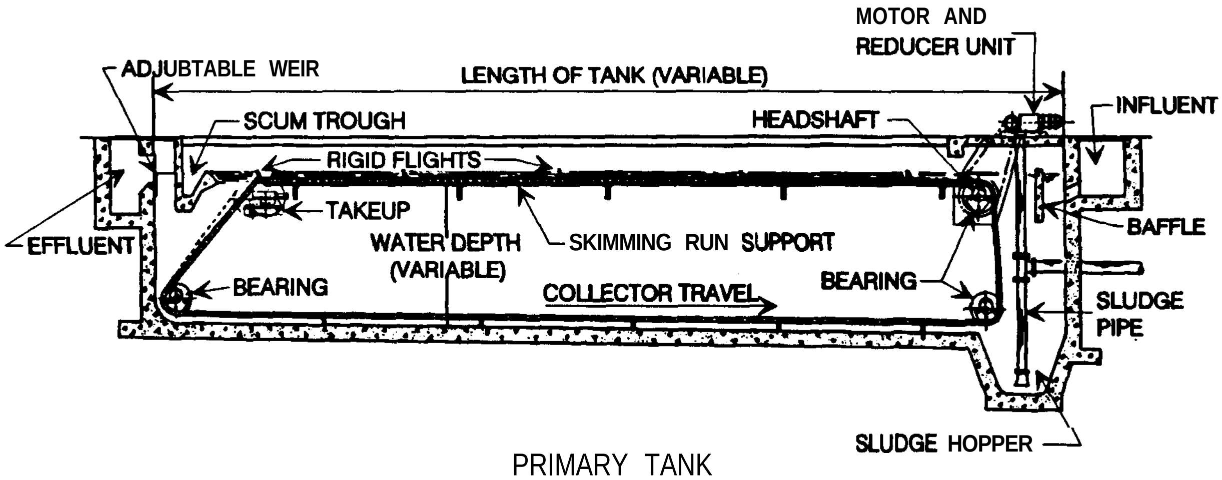


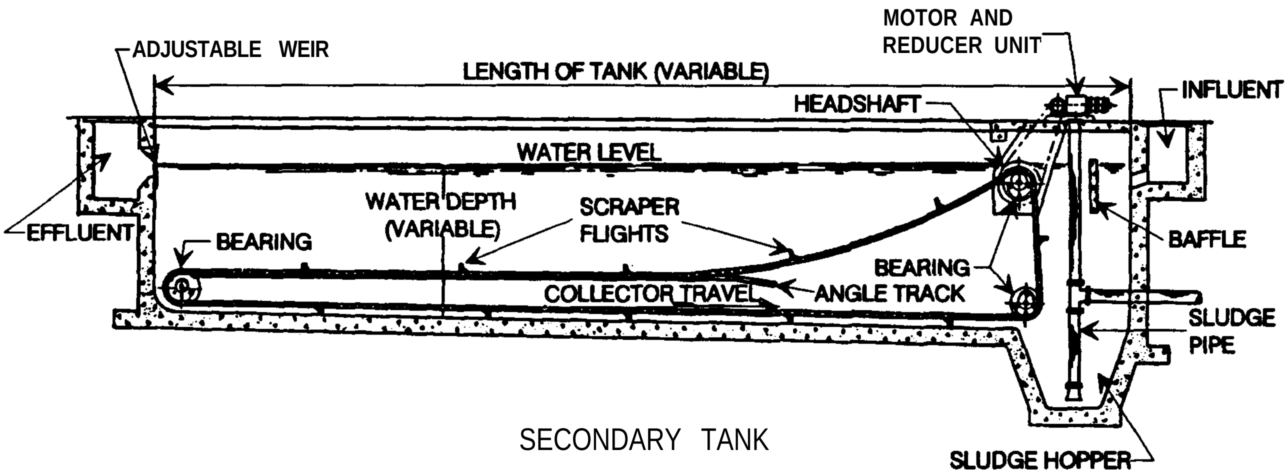
PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	COMMINUTOR		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-4



PRIMARY TANK



SECONDARY TANK

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	RECTANGULAR SETTLING TANKS		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-5

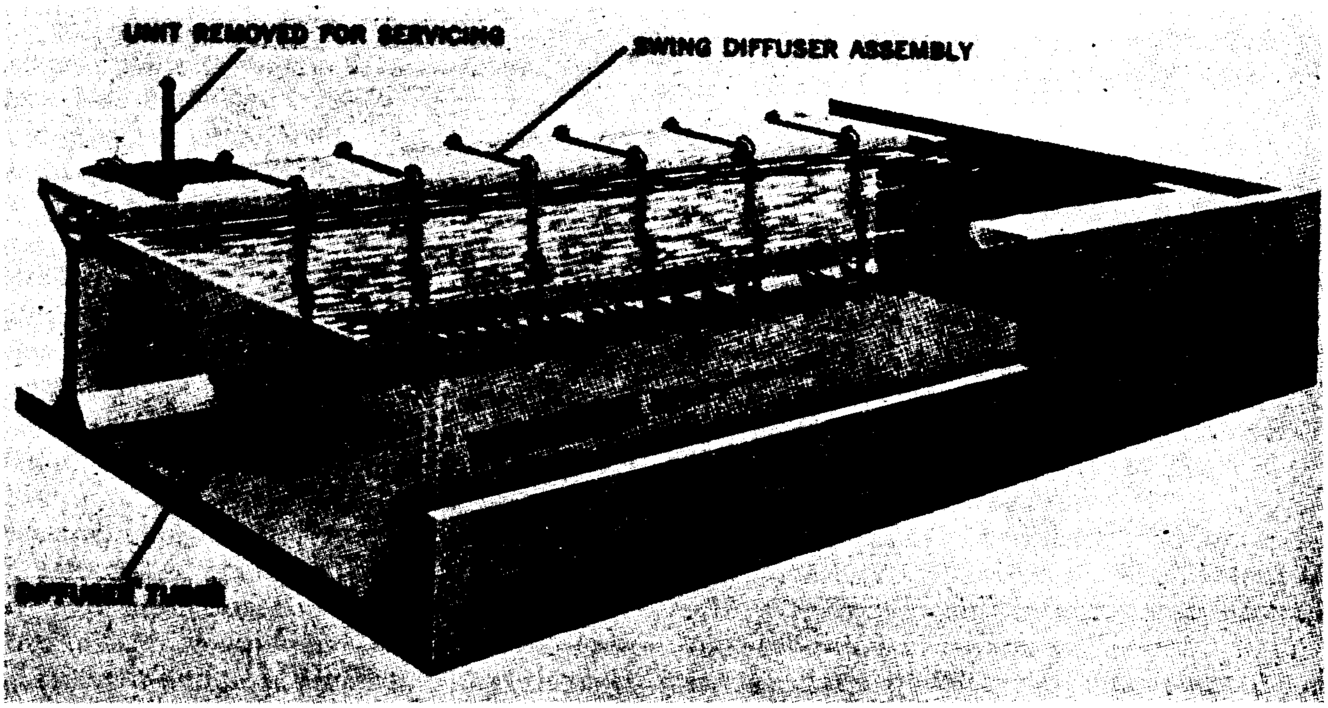
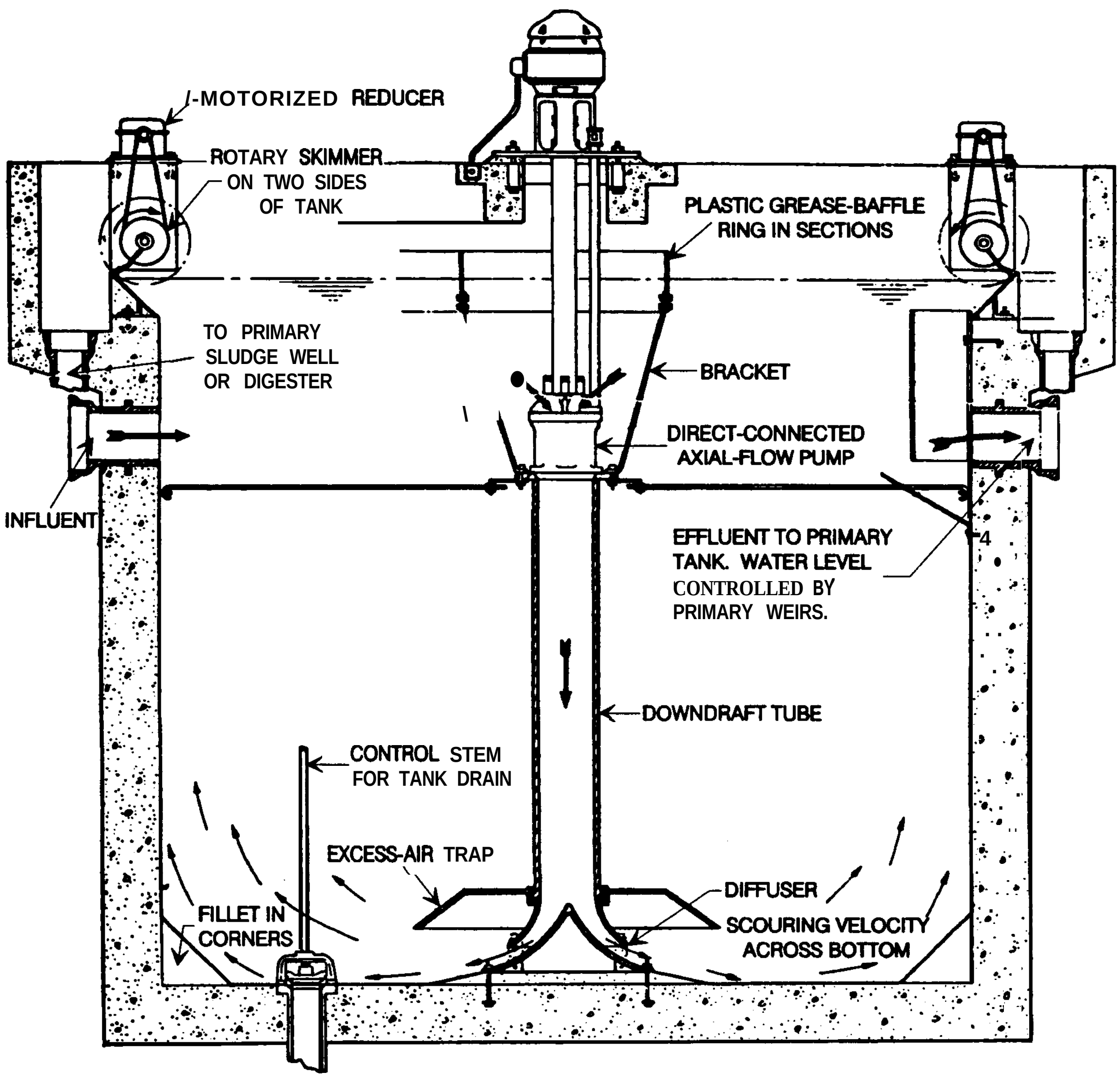


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	**AERATION TANK**		
PLUMBING-WASTE WATER TREATMENT PLANT	**Revision** No.	**Issue Date** 5/93	**Drawing** No. A12010104-6



SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85–14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	AERATOR AND TANK		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-7

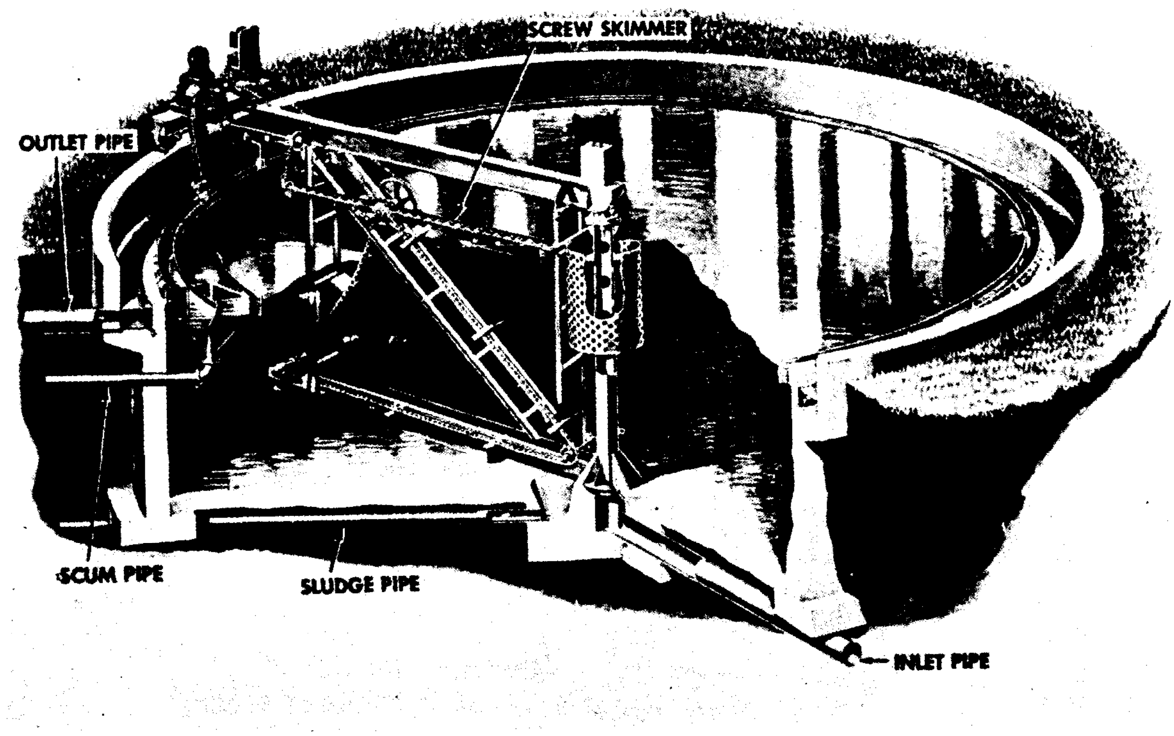
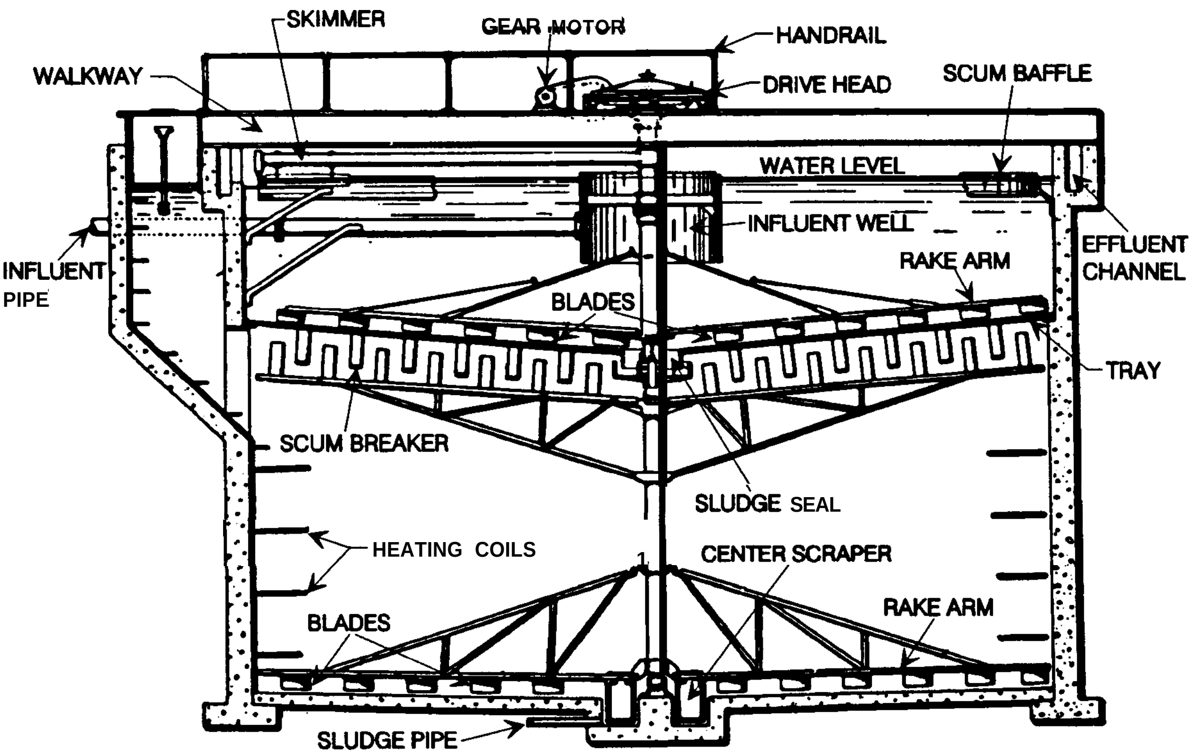


PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	CIRCULAR SETTLING TANK		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-8



SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	SKIMMERS AND SCRAPERS		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Date 5/93	Drawing No. A12010104-9

PHOTO ILLUSTRATION

SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS, Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	FILTER WITH FIXED NOZZLES		
PLUMBING-WASTE WATER TREATMENT PLANT	**Revision** No.	**Issue** Date 5/93	Drawing No. A12010104-10

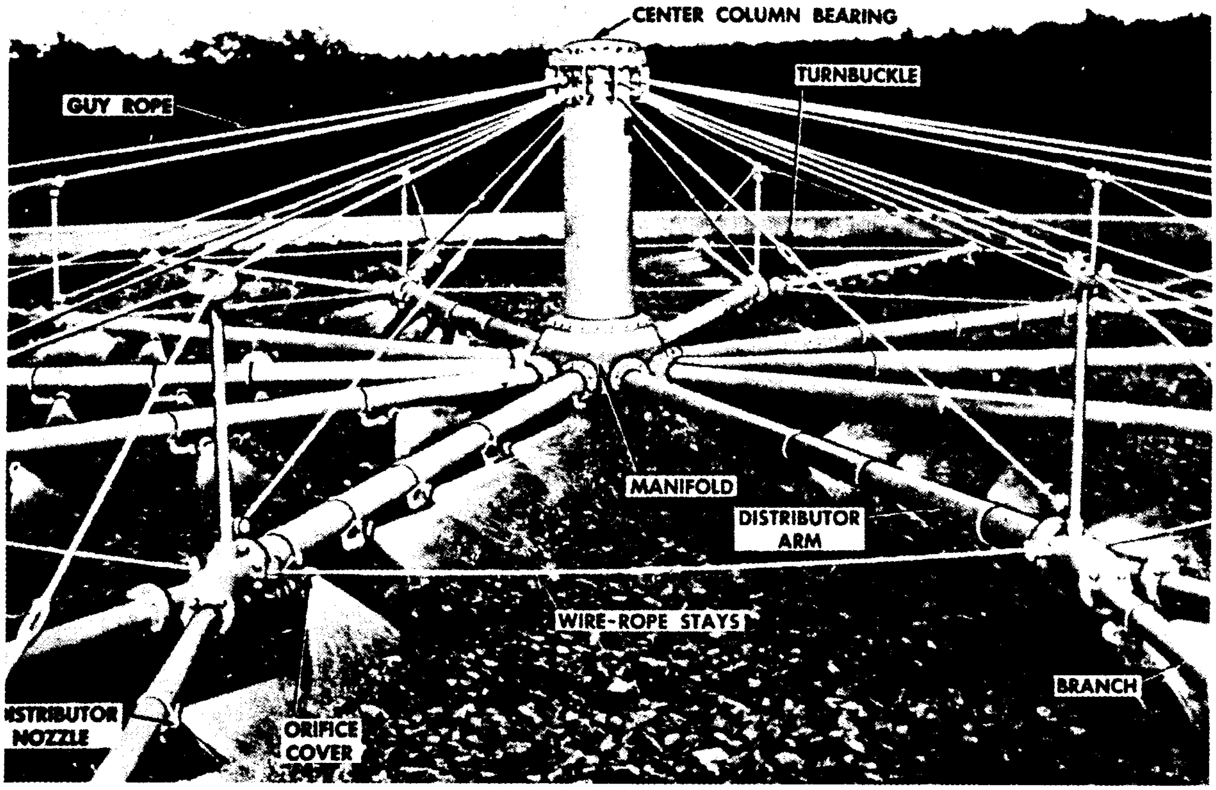


PHOTO ILLUSTRATION SOURCE: MAINTENANCE AND OPERATION OF SEWAGE AND INDUSTRIAL WASTE PLANTS AND SYSTEMS. Air Force Manual AFM 85-14, 1967

SYSTEM ASSEMBLY DETAILS-SITEWORK	ROTARY DISTRIBUTOR FOR FILTER		
PLUMBING-WASTE WATER TREATMENT PLANT	Revision No.	Issue Data 5/93	Drawing No. A12010104-11

DEFICIENCY FACTORS
0.12.01 .01.04 WASTE WATER TREATMENT PLANT

PROBABLE FAILURE POINTS

- Tank leakage due to age, excessive corrosion, physical damage, local environment.
- Pipe leakage due to internal corrosion.
- Inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network; blocked filters, pumping or control failures.

SYSTEM ASSEMBLIES/DEFICIENCIES

Influent Screens

Extreme Distortion, Damage:	Allows passage of large waste; blockage due to clogged screens.
Damaged Cleaner:	Failure of drive mechanism, worn guides, extreme wear or corrosion.
Damaged, Missing Fasteners:	Age, wear, poor maintenance.

pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked rotor.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, failed isolators.
Excessive Load:	Bearing wear, misalignment, failed internal relief, poor design.
Inadequate Capacity:	Low pressure, low flow caused by wear in impeller, failed internal relief, poor design.
Leakage in Packing or Mechanical Seal:	Normal wear, local environment.
Defective Bearings:	Age, improper lubrication, abuse, poor maintenance.
Severe Corrosion:	Normal aging, leakage, poor maintenance, local environment.

Comminutors

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked knives.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, failed isolators.
Excessive Load:	Bearing wear, misalignment, poor system design.
Inadequate Capacity:	Defective bars, knives, poor design.
Leakage in Packing or Mechanical Seal:	Normal wear, local environment.
Defective Bearings:	Age, improper lubrication, abuse.
Severe Corrosion:	Normal aging, leakage, poor maintenance, local environment.

DEFICIENCY FACTORS
0.12.01 .01.04 WASTE WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Grit Chambers

Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at manholes or other fittings.
Loose, Missing Fasteners:	Corrosion, damage.

Conveyors

Missing Parts:	Taken out for service, not returned.
Inoperative:	Corrosion, wear, physical damage, missing parts, damaged belts, screws.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress, vandalism.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Excessive Wear Chains:	Age, normal wear, improper lubrication.
Excessive Wear Guides:	Age, normal wear, improper lubrication.
Defective Reducer:	Age, normal wear, improper lubrication.
Loose, Missing Fasteners:	Corrosion, damage.
Leakage:	Worn or damaged covers, seals.
Distortion:	Overheating, physical abuse, loose fasteners.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charge.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, failed isolators.
Excessive Load:	Bearing wear, misalignment, poor design.
Corrosion:	Age, poor maintenance, local environment.

DEFICIENCY FACTORS
0.12.01 .01.04 WASTE WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES

Engines **(Continued)**

Compression Loss:	Defective rings or valves, cracked block, poor maintenance.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.
Battery Charger Defective:	Poor maintenance.
Battery Dead:	Lack of maintenance.

Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

Scrapers & Skimmers

Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, imbalance, misalignment, defective mounting brackets.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Excessive Wear Chains:	Age, normal wear, improper lubrication.
Excessive Wear Guides:	Age, normal wear, improper lubrication.

DEFICIENCY FACTORS
0.12.01 .01.04 WASTE WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES

Scrapers & Skimmers (Continued)

Defective Reducer:	Age, normal wear, improper lubrication.
Loose, Missing Fasteners:	Corrosion, damage.

Filters

Caked Bed:	Caused by normal use, but accelerated by improper cycling of filter controls.
Exhausted Filter Media:	Caused by normal use, but accelerated by improper cycling of filter controls.
Defective Spray Nozzles:	Usually blockage due to scaling in feed lines.
Tank, Pipe, or Fitting Leakage:	Age, physical damage, severe internal or external corrosion; gasket failure at manhole or other fittings.

Ponds & Reservoirs

Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
Leakage:	Severe corrosion, cracking, gasket failure.
Erosion of Banks:	Wave action of wind.

Sludge Drying Beds

Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
Leakage:	Severe corrosion, cracking, gasket failure.
Erosion of Banks:	Wave action of wind.

Piping & Fittings

Strainers Inaccessible:	Corroded fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.

DEFICIENCY FACTORS
0.12.01.01.04 WASTE WATER TREATMENT PLANT

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Defective Reliefs:	Missing, leaking, gagged.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.

Instrumentation

Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

Equipment Controls & Panels

Motor Starter Inoperative:	Overloaded, open coils, wear in linkage.
Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

DEFICIENCY FACTORS
0.12.01 .01.04 WASTE WATER TREATMENT PLANT

END OF SUBSECTION

0.12.01 .01.05 GAS DISTRIBUTION SYSTEM

DESCRIPTION

The typical Gas Distribution System provides gas preparation and transfer for use in heat and electrical generation equipment (boilers, furnaces, emergency generators). The system consists of storage tanks, strainers, and the connecting piping, fittings, valves, manholes, and supports. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15060)

The gas distribution system is normally buried underground, below the frost line. This helps protect against freezing and minimizes conflict with ground transportation, but also makes inspection and maintenance very difficult. The depth is at least 18 inches (special exceptions may apply). In some areas, the piping is placed in trenches, some of which are large enough for inspection access through manholes.

Gas pipe and fittings must comply with NFPA 54 National Fuel Gas Code. Piping for gas distribution is typically installed with “black iron” (seamless wrought steel), although other materials are allowed (metallic pipe, aluminum alloy, ductile iron, plastic, and brass pipe) in special circumstances. Cast iron is not allowed! Seamless copper tubing is frequently used at connections to storage tanks to facilitate tank changeovers. Distribution pipe sizes vary, generally in the range of 1 to 12 inches.

Fittings are made of compatible materials to minimize corrosion.

Piping for other than dry gas should be sloped not less than 1/4 inch in 15 feet to prevent traps.

Strainers are provided on the supply side of each control valve, pressure regulating valve, and burner connection.

Dielectric unions should be provided with appropriate end connections for the pipe material in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Piping susceptible to corrosion is wrapped or coated with an inert material.

Supports & Anchors (CSI 15140)

Underground piping is installed in trenches. The piping generally rests firmly on the bottom of the trench. Where piping is exposed, pipe hangers and supports are provided to minimize piping disturbance and to allow for expansion and contraction. They should be securely attached to foundation material at sufficiently close intervals.

Valves (CSI 15100)

Valves are used to switch service tanks, isolate gas system components for maintenance, and isolate terminal units. In addition, shut-off duty valves are typically provided at each branch connection to supply mains.

Regulating valves are used to control the flow of gas from the storage tanks or at service entrance piping to the terminal equipment. The distribution pressure may be as much as 50 psig, but must be less than 5 psig inside buildings, less than 10 psig for gas-air mixtures, and less than 20 psig for LP gas. Exceptions may be found in supplies to industrial processing plants, research buildings, and power plants.

0.12.01 .01.05 GAS DISTRIBUTION SYSTEM

Valves (CSI 15100) (Continued)

Overpressure protection is required on all systems, but may be accomplished through regulator design and installation. Relief valves are required in some supply systems (generally over 2 inch mains).

Manholes (CSI 02730)

Manholes are typically precast concrete rings positioned at critical connection points in the distribution system. They are essentially inspection and maintenance accesses found in systems with large pipe. They are located at key mechanical connections such as vent and isolation valving and expansion joints.

The lowest section is referred to as the base, channel, and bench, and serves to connect incoming pipe to outgoing. Riser rings (typically 48 inches) and grade rings are stacked above and joined with rubber gaskets. The top section is an eccentric cone matching a 24 inch diameter frame.

Older units may be built of brick or cast-in-place concrete. All units are fitted with access plates and ladders.

Compressed Gas Storage Tanks (CSI 15175)

Gas is usually supplied from an off-site main owned by a major utility, and local storage is not required. However, storage tanks are used in remote areas where a local gas distribution system is not available. In these installations, more than one tank will be provided and they will be installed above ground. They are usually installed outdoors to prevent accidental gas accumulation.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at branch tees and/or on the suction and discharge of each regulating valve, and on storage tanks. Temperature gauges are not usually provided.

Although metering is generally provided at the service entrance for billing purposes, they are sometimes located externally and at main branches. They should be readily accessible for examination, reading, replacement, and necessary maintenance.

Equipment Controls & panels (CSI 15950)

Few controls are used in the typical gas system except as mentioned under valving. The system is usually turned on and left to run continuously.

Some large installations may employ remote tank pressure and level indicators and alarms

DEFICIENCY FACTORS
0.12.01 .01.05 GAS DISTRIBUTION SYSTEM

PROBABLE FAILURE POINTS

- inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network, defective strainers, regulator failure.
- Piping leakage due to external corrosion, local environment, geological settlement.
- Tank leakage due to age, excessive corrosion, physical damage.

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining, geological settlement.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, corrosive backfill, lack of encapsulation, local environment.
Physical Damage:	Collapse/disturbance of backfill, inadequate support, vandalism.

Supports & Anchors

Missing:	Improper installation, poor maintenance, poor system design.
Improper Alignment:	Improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, poor maintenance, poor system design.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Fuel contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing, vandalism.
Poor Regulation:	Worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.

Manholes & Catch Basins

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment.
Physical Damage:	Collapsed, cracked.

DEFICIENCY FACTORS
0.12.01 .01.05 GAS DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Compressed Gas Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

Instrumentation

Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

Equipment Controls & Panels

Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance, local environment.

END OF SUBSECTION

0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

DESCRIPTION

Site Fuel Oil Storage and Distribution Systems are essentially the same as those discussed in Volume 8 Mechanical, Heating Systems. The components are simply larger and there is considerably more piping. The typical supply system provides fuel storage, preparation, and transfer for use in building heating and electrical generation equipment (boilers, furnaces, emergency generators). The system consists of storage tanks, transfer and circulating pumps, strainers and the connecting piping, fittings, valves, and supports. In some installations, heating the fuel oil is required to permit rapid firing in the utility equipment. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Storage Tanks (CSI 15175)

Tanks provide for the routine storage of fuel oil. In small installations, more than one tank will be provided and installed underground. Larger installations will employ several large capacity tanks installed above ground. Heavy oil storage tanks will usually include heating capability.

Storage Tanks typically have:

- Tank manhole(s) for periodic service and inspection
- Pipe connections for fill, supply, return, vent, gauging, and heating coils
- Ladders inside tank, anchored to top and bottom
- Heating coils
- Hot-wells
- Remote oil gauges
- Corrosion protection system (sacrificial elements)

Underground tanks are generally small, ranging from 2,000 to 20,000 gallons. Above ground tanks may range to 3 or 4 million gallons.

Above ground tanks must have retention dikes surrounding them with an adequate capacity to prevent contamination of the surrounding areas should a leak or spill occur. All tanks require leak detection and monitoring support.

pumps (CSI **15160)**

Pumps provide for the transfer of fuel to/from the storage tanks, allowing loading and distribution to consuming equipment. They may also facilitate maintenance of storage tank temperature by recirculating hot fuel oil.

Fuel pumps are typically single-stage, positive displacement rotary type with standard mechanical seals and built-in pressure relief bypasses.

Pumps should be arranged to provide easy access for periodic maintenance and repair.

Motors **(CSI** 15170)

Pumps are typically driven via a closed motor with coupling.

piping & Fittings **(CSI 15060)**

Fuel oil piping and fittings must comply with NFPA 31 Standard for the Installation of Oil Burning Equipment, Fuel oil piping is usually steel pipe or copper tubing. Fittings are made of compatible materials.

The minimum steel pipe size permitted is 3/4 inch. Steel pipe with threaded joints and fittings is typically used for 2 inch and smaller runs, and with welded joints for 2 1/2 inch and larger.

0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15060) (Continued)

Drawn copper tubing, Type L with wrought copper fittings and brazed joints for 2 inch and smaller is typically used above ground. Type K, annealed temper copper tubing for 2 inch and smaller without joints, is used for underground installations.

Supply, return, fill, and vent piping should be graded, typically at a uniform grade of 1/4 inch in 10 feet downward in the direction of the storage tank.

Flanges should be installed on valves, apparatus, and equipment having 2 1/2 inch and larger connections. Flanged joint surfaces should be parallel.

Unions should be installed in pipes 2 inches and smaller, adjacent to each valve, at final connections on each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices,

Dielectric unions should be provided with appropriate end connections for the pipe material in which installed (screwed, soldered, or flanged), that effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Duplex strainers are typically provided at the suction and discharge of the fuel oil transfer pumps to protect the pumps themselves and the sensitive control devices downstream.

Additional strainers are provided on the supply side of each control valve, pressure regulating valve, and oil burner connection.

Other devices include oil/water separators, surge absorbers, and sight flow indicators.

Valves (CSI 15100)

Valves are used to switch service tanks and isolate fuel system components for maintenance. In addition, shut-off valves are typically provided at each branch connection to supply mains.

Regulating valves are used to control the flow of water or steam through the storage tank heating coils, in-line heaters, and tracing lines. Drain valves should be installed at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

All valves should be installed in accessible locations, protected from physical damage. Valves should be tagged.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge of each pump or pump group. Temperature gauges are usually provided at terminal unit supply branches and on either side of the fuel oil heaters.

Level indication is usually provided for storage tanks, especially when located underground. Typically this is a remote hydraulic unit.

Supports & Anchors (CSI 15140)

Pipe hangers and supports are provided to support piping and allow for expansion and contraction. They should be securely attached to suitable foundations at sufficiently close intervals.

0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Insulation (CSI 15520)

Typically fuel oil piping and heaters are insulated to provide personnel protection and energy efficiency. This is especially true for heavy oils (#4 and #6). Some #2 fuel oil installations operate at a sufficiently low temperature to omit the insulation when run above ground. All underground piping is typically covered to minimize the corrosive effects of the soil and to minimize heat lost to the ground.

In-Line Heaters (CSI 15590)

Many fuel oils require preheating for proper combustion, usually near the burner assemblies. However, steam or hot water coils are also frequently provided in the storage tank hotwells. These are usually simple copper coils immersed directly in the oil.

Equlpmont Controls & panels (CSI 15950)

Few controls are used in the typical fuel oil system. (Generally metering is provided at the burner or emergency generator, covered under separate standards.) The system is usually turned on and left running through the season,

Pump control is performed via a typical motor assembly (motor, starter, and disconnect).

Fuel temperature controls are provided either through thermal bulb sensing and activation of an hydraulically controlled regulating valve or through thermostatic control of electric heating elements.

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

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DEFICIENCY FACTORS
0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

PROBABLE FAILURE POINTS

- Tank leakage due to age, excessive corrosion, physical damage, local environment.
- inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network; defective strainers, pumping failure.
- Pipe leakage due to internal corrosion, geological settlement.
- Loss of temperature control due to failed temperature sensors.

SYSTEM ASSEMBLIES/DEFICIENCIES

Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked gears.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, contamination, failed isolators, improper anchorage.
Excessive Load:	Bearing wear, misalignment, failed internal relief, poor system design.
inadequate Capacity:	Low pressure, low flow caused by wear in gears, failed internal relief.
Leakage in Packing or Mechanical Seal:	Normal wear.
Defective Bearings:	Age, improper lubrication, abuse.

DEFICIENCY FACTORS
0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps (Continued)

Severe Corrosion:	Normal aging, leakage, poor maintenance, local environment.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators, improper anchorage.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged :	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Piping & Fittings

Strainers Inaccessible:	Corroded fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Caused by use of incompatible materials, fuel contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.

Instrumentation

Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.

DEFICIENCY FACTORS
0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

PROBABLE FAILURE POINTS

- Tank leakage due to age, excessive corrosion, physical damage, local environment
- Inability of system to deliver rated capacity (flow and pressure) to terminal points due to internal scaling of the distribution network; defective strainers, pumping failure.
- Pipe leakage due to internal corrosion. geological settlement.
- Loss of temperature control due to failed temperature sensors.

SYSTEM ASSEMBLIES/DEFICIENCIES

Tanks	
Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.
pumps	
Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked gears.
Excessive Noise, Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, contamination, failed isolators, improper anchorage.
Excessive Load:	Bearing wear, misalignment, failed internal relief, poor system design.
Inadequate Capacity:	Low pressure, low flow caused by wear in gears, failed internal relief.
Leakage in Packing or Mechanical Seal:	Normal wear.
Defective Bearings:	Age, improper lubrication, abuse.

DEFICIENCY FACTORS
0.12.01.02.01 FUEL OIL STORAGE & DISTRIBUTION SYSTEM

END OF SUBSECTION

0.12.01.02.02 COAL HANDLING SYSTEM

DESCRIPTION

There are numerous varieties of Coal Handling Systems because each is designed for a specific site and purpose. The typical coal handling system stores and transfers coal for use in central heating and power generation equipment (boilers, furnaces, and generators). The system generally consists of storage facilities, hoppers and feeders, conveyors of various types, conveyor scales, pulverizers, exhaust and pressurization fans, controllers, and coal and air piping. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown, Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Storage Facilities

Coal stocked in storage piles is either active or reserve. In active coal piles, it is reclaimed in a relatively short period of time, usually one week or less. Reserve storage is a long-term supply of coal on an emergency basis. Coal in a reserve pile is compacted.

Enclosed or protected storage may be by silo, bunkers, or open-top bin. Silos for coal storage are usually single units with capacities up to 300 tons. Bunkers are of three types: framed steel with protected or unprotected steel plate sides and bottom, reinforced concrete, and parabolic suspension.

Open bins are not frequently seen because they must be protected by a roof and sometimes extended sidewalls.

Hoppers & Feeders

Hoppers and feeders are integral components of the system that deliver the coal to the conveyor system. The satisfactory operation of any conveyor depends on an even and continuous feed. The delivery rate of the hoppers and feeders must be closely matched with the conveyor performance. The system must be able to provide for a wide range of flow rates.

Conveyors

Conveyors are used for moving material from one point to another at the same or different elevations. Belt conveyors have proven to be exceptionally effective in coal handling systems. They are long wearing and designed to reduce maintenance to a minimum. The capacity may be several thousand tons per hour and the distance several miles. It may be horizontal, inclined, or a combination of both.

Screw or spiral conveyors are widely used for pulverized coal systems when the capacity is moderate, the path not too steep, and the distance not more than about 200 feet. This type of conveyor is readily made dust-tight by sealed cover plates. The components of a typical conveyor are:

- Drive motor
- Idlers (carrying and return)
- Controllers
- Traveling medium (belts, screw)
- supports

Conveyor Scales

Conveyor scales weigh and record the weight of the coal being carried on the conveyor system; they may be either continuous or batch weighers. Some continuous weighers function through constant volume and others through constant weight control, and are thus automatic feeaers as well as weighers.

0.12.01.02.02 COAL HANDLING SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Conveyor Scales (Continued)

Devices for controlling and monitoring the material weight and hopper bin level are very important. Generally, materials are weighed on the move with the weighing equipment in-line. If the device is dependent on gravimetric pull on the material being weighed, a measure of the counterbalance force can be combined with speed measurements into a direct measurement of rate of flow, and a device for totaling the weight as a function of time.

Non-gravimetric devices are not dependent on the force exerted on the material, but might be measured with a nuclear-radiation device, wherein the greater the quantity of material placed in the path of the beam, the greater the amount of absorption by the material. Properly calibrated, the readings from these devices may be combined with velocity measurements and the weight totaled as a function of time.

Pulverizers

Pulverizers are used to reduce coal to a fine particulate stage suitable for direct injection into a boiler, similar to the injection of gas and oil. Coal pulverizing equipment is generally based on rock and mineral-ore grinding machinery. Grinding is accomplished by impact, attrition, compression, or by a combination of two or more of these methods. The principal types of coal pulverizers may be classified under high, low, and medium speed.

- High Speed (above 225 rpm)
  - Impact mill
- Low speed (below 75 rpm)
  - Ball and race pulverizer
  - Roll and race pulverizer
  - Tube mill
- Medium Speed (75 - 225 rpm)
  - Ball and race pulverizer
  - Roll and race pulverizer
  - Bowl mill

Some coals are more difficult to pulverize than others. Grindability is expressed as an index showing the relative hardness of that coal compared with a standard coal chosen as 100 grindability. A coal is harder (easier) to grind if its grindability index is less (greater) than 100. The capacity of a pulverizer is directly related to the grindability index of the coal.

Pressurization Fans

Primary air is required for conveying the pulverized coal to the burners. In a pressure system, the primary fan handles clean air and is not subjected to abrasion by the pulverized coal. High efficiency fans can be used because the conditions permit efficient rotor design and high speed tips.

In a suction system, the exhauster must handle pulverized-coal-laden air. In this case, the fan housing must be designed to withstand a pressure of 200 psi in case of an explosion within the fan. Because the exhaust fan is subjected to excessive wear, a paddle wheel type of heavy construction is typically used.

Fan speed depends on the pressure requirements of the system, but is generally around 1800 rpm. The fans are usually independently driven, but in small cases, one motor may be used to drive the pulverizer and the fan.

0.12.01.02.02 COAL HANDLING SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Motors (CSI 15170)

Motors are usually used to drive the conveyors, pulverizers, and fans. In most cases, these are coupled, closed AC induction motors.

Steam Turbines

Large facilities may have steam turbines to drive the pulverizers and fans. There are many variations, but the most common for small auxiliary equipment is perhaps the single-stage, impulse turbine. These are relatively small, compact units with few moving parts.

Turbines are generally direct coupled to the unit. Operation is controlled by a turbine-mounted governor, either constant speed or constant pressure.

piping & Fittings (CSI 15090)

Piping and fittings are used to distribute the coal/air mixture from the pulverizer to the combustion air fan's damper. Piping must be designed and constructed to prevent hazardous concentrations of combustible gases that may exist under normal operation.

All fittings should be compatible with the type of piping material used to minimize corrosion induced by galvanic action.

Piping hangers and supports will be designed and installed in accordance with ANSI B31.1 Power Piping Code, Chapter 2, Part 5. Hangers and supports are provided to support piping and allow for expansion, contraction, and vibration. They should be securely attached to building construction at sufficiently close intervals.

For smooth flow, pulverized fuel piping should have bend radii of not less than one pipe diameter.

Equipment Controls & Panels (CSI 15950)

Many controls are used in the typical coal handling system.

Interlocks are provided between conveyor motors, scales, and pulverizers to monitor and regulate coal introduction to the boiler.

Hoppers and bins usually employ either weight or level limit controls.

Conveyor and pressurization fan motor controls are performed via a typical motor assemblies (motor, starter, and disconnect). Vari-speed units and variable frequency controls are employed to control the rate of coal transport.

0.12.01.02.02 COAL HANDLING SYSTEM

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DEFICIENCY FACTORS
0.12.01.02.02 COAL HANDLING SYSTEM

PROBABLE FAILURE POINTS

- Leakage in conveyor housings due to corrosion, physical damage, worn seals.
- Environmental pollution caused by component leakage.
- Inability of system to deliver rated capacity due to internal blockage of coal handling equipment.

SYSTEM ASSEMBLIES/DEFICIENCIES

Storage Facilities

Housing Leakage:	Failure of fasteners or welds, cracking, abuse.
Excessive Corrosion:	Leakage, poor maintenance, local environment.
Access Door, Plate Seals Leaking:	Physical abuse of seal, warped plate or door, cement breakdown.

Hoppers & Bins

Inoperative:	Corrosion, wear, physical damage, missing parts.
Housing Leakage:	Fastener or weld failure, cracking, abuse.
Excessive Corrosion:	Leakage, poor maintenance, local environment.
Access Door, Plate Seals Leaking:	Physical abuse of seal, warped plate or door, cement breakdown.

Conveyors

Missing Parts:	Taken out for service, not returned.
Inoperative:	Corrosion, wear, physical damage, missing parts, damaged belts, screws.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress, vandalism.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Excessive Wear Chains:	Age, normal wear, improper lubrication.
Excessive Wear Guides:	Age, normal wear, improper lubrication.
Defective Reducer:	Age, normal wear, improper lubrication.
Loose, Missing Fasteners:	Corrosion, damage.
Leakage:	Worn or damaged covers, seals.
Distortion:	Overheating, physical abuse, loose fasteners.

Conveyor Scales

Inoperative:	Corrosion, wear, physical damage, missing parts.

DEFICIENCY FACTORS
0.12.01 .02.02 COAL HANDLING SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Pulverizers

Inoperative:	Corrosion, wear, physical damage, missing parts.
Casing Leakage:	Corrosion, physical damage, loose fasteners.
Distortion:	Overheating, physical abuse, loose fasteners.
Excessive Corrosion:	Moisture in fuel, local environment.
Excessive Noise, Vibration:	Loose fasteners, worn bearings.
Defective Bearings:	Age, normal wear, improper lubrication.

pressurization Fans

Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, improper fuel mixing, local conditions
Casing Leakage:	Loose fasteners, corrosion, thermal stress.
Defective Bearings:	Age, normal wear, improper lubrication.
Mixing Dampers Inoperative:	Physical damage.

Motors

Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local conditions.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Turbines

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, rotor imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local conditions.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Casing Leakage:	Worn or damaged seals.

piping & Fittings

Excessive Corrosion:	Age, poor maintenance, leakage, local conditions.
Leakage:	Improper installation, corrosion.
Physical Damage:	Abuse, stress.

DEFICIENCY FACTORS
0.12.01.02.02 COAL HANDLING SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Rfflngs (Continued)

Tubes Blocked:	Excessive scale buildup.
Manhole, Handhole Leakage:	Defective seal, pitted seating surfaces.

Equipment Controls & panels

Housing Corrosion:	Age, poor maintenance, local conditions.
Bypassed Controls:	Damaged or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted, Burned:	Normal wear, overloading.
Motor Starter Inoperative:	Worn linkage, open coil, overloading.

DEFICIENCY FACTORS
0.12.01.02.02 COAL HANDLING SYSTEM

END OF SUBSECTION

0.12.01.02.03 BOILERS (CSI 15555)

DESCRIPTION

Many large facilities centralize their heat generation utilities and distribute the energy using a heating media (steam or high temperature water). They employ Boilers to produce the fluid heating media. The boiler converts a raw energy source (coal, wood, gas, oil, electricity) into heat and transfers this heat to the water passing through the boiler. The boiler employs controls to manage the rate of heat transfer.

Many site boilers are similar to those units found in and dedicated to individual buildings, as discussed in Volume 8, Section 0.08.03.02. However, they tend to be bigger and usually operate at higher pressures. Both locations use gas and oil firing. Coal firing is common in large, older installations, but is rarely used for small buildings anymore. Electric boilers are rarely used as site heat generators.

The typical site boiler consists of a casing; combustion chamber (furnace, fire box, flue) and heat exchange surfaces (shells and tubes); burners (for gas or oil firing); grates and stokers (for coal and other solid fuel firing); breeching and stacks (to remove gases); combustion air fans; boiler trim (control devices); major accessories like economizers, superheaters, soot blowers, blowdown separators, ash handling conveyors, scrubbers; control panels; pipe; and fittings. Some packaged units will also include pumps (oil and water) and air compressors mounted on the boiler itself.

Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Casing (CSI 15555)

The boiler casing is the primary gas containment device. It allows combustion to take place without excessive heat loss to the environment. It is typically made of steel, fabricated in a way to prevent air leakage. The interior wails of the casing are usually lined with refractory to provide insulation and to protect the casing from overheating.

Insulation is required on casing exteriors and shells to prevent surface temperatures above 120°F where contact is likely; 140°F otherwise.

Combustion Chambers (CSI 15555)

The combustion chamber is the area of the boiler in which the fuel is burned. Construction varies significantly, depending on the general design.

Most large commercial boilers are watertube boilers. The combustion chamber is literally a large compartment formed by the boiler casing and boiler tubes. Brickwork, baffles, and dampers are used to contain and direct the flow of combustion gases over the tubes and shells in the boiler.

Another class of boilers is firetube boilers. Older units in this class may employ a firebox similar to that used on the water tube units. Common examples are the horizontal return tube (HRT) boilers or the Scotch Marine design, which employs a long cylindrical steel tube as the primary combustion chamber. Baffles and end plates are used to direct the gas products through boiler tubes as opposed to over them.

Combustion chambers typically have access plates to allow inspection and servicing. On water tube boilers, they are built into the boiler casing. On the Scotch Marine design, the front and rear are constructed as large removable plates, usually hinged doors that allow access.

Doors and access plates on boilers should be sealed with heat-resistant gaskets.

Observation ports are usually located at each end of fuel-fired boilers to inspect flame conditions.

0.12.01.02.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Shells & Tubing (CSI 15555)

Most boilers employ one or more large shells and connected tubing to heat and contain the heated fluid. The construction of these heat exchange surfaces varies with boiler design.

In water-tube boilers, hot gases pass over the watertubes and the lower surface of the main shell (called the steam drum). The primary heating surface is the tubing, which externally connects the steam drum to smaller shells (mud drums) in an arrangement that promotes natural water circulation (convection) in the circuit. Some tubing may be partially insulated to control heat transfer and thus promote natural circulation.

In firetube boilers, there is generally only one shell (steam drum) and the tubes are installed horizontally within the drum. Gases leaving the combustion chamber pass through the inside of the tubes providing the primary heating. Baffles and endplates direct the gases in a pattern that promotes natural (convection) circulation on the waterside.

Before entering the tubing in an HRT unit, the gases heat the bottom of the main shell. In the Scotch Marine unit, the combustion chamber is mounted inside the main shell, and therefore the exterior surface of the combustion chamber is also a primary heat exchange surface.

When multiple shells are employed (watertube boilers), all are flooded but one (the steam drum). All have access plates (manholes or handholes) for inspection and servicing. The steam drum (or main drum if system is for high temperature water) is generally fitted with internal baffles to facilitate mixing, circulation, and screens to minimize carryover.

Breeching, Chimneys, Stacks **(CSI** 15575)

Exhaust gases leaving the boiler are controlled by breeching, chimneys, and stacks.

A breeching connects the boiler casing to a stack or chimney. It is typically made of sheet metal and has few if any fittings. In some installations, dampers will be mounted in the breeching to regulate draft. Some breechings will have barometric dampers to protect the breeching from over/under pressurization.

Chimneys and stacks are primarily used to direct the exhaust gases to the atmosphere. However, they also serve in many installations to provide combustion air flow through the boiler. Natural convection currents are created when heated air rises through the chimney/stack creating a partial vacuum in the combustion chamber. This “chimney effect” causes fresh combustion air to be induced into the boiler. This effect increases with chimney height.

Chimneys are generally masonry structures, and stacks are fabricated of sheet metal. Chimneys are usually lined with refractory. Stacks are frequently double-walled; i.e., they have a metal lining. Although important in both structures, dew point control is critical in stack temperatures because of its effect on stack corrosion.

Fittings on stacks/chimneys include:

- Barometric dampers
- Cleanout doors with gasketed and bolt-tightened inspection plate
- Guy bands
- Spark screens
- Bird barriers

0.12.01.02.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Fuel Burning/Heating Equipment (CSI **15556, 15557, 15558, 15561)**

There are three primary ways of producing heat in site boilers: with gas and oil burners, and with solid fuel (primarily coal) firing equipment.

Gas burners are typically simple rings supplied by a "gas train." The only moving part is generally an interlocked damper that regulates the amount of mixing air. These burners are typically high radiant multiport type burner, integral with front head of boiler, approved for operation with natural, manufactured, or mixed gas. Gas burners should have a gas pilot, premix type with automatic electric ignition, complete with electronic detector to monitor pilot so primary fuel valve cannot open until the pilot flame has been established.

Gas Burners typically provide:

- Air flow safety switch
- Controls and linkage for firing sequence
- Flame safeguard control
- Fuel air regulation damper and controller
- Gas cocks
- Gas electric ignition assembly
- Gas gauge
- Gas pressure regulator
- Gas volume control valve
- High and low gas pressure interlock
- Safety gas valves

Gas burner piping should include primary gas shutoff valve, motor operated with spring return, designed to start and stop gas burners and to close automatically in event of power failure, flame failure, or low water condition.

Oil-fired burners are the mainstay of most installations and are provided in various component combinations. Typically, a simple gun provides pressurized oil through a burner tip that induces atomization. Air is provided through a damper for primary mixing and combustion. Variations use steam or compressed air through the gun to improve atomization. These burners generally employ mechanical linkage that varies the amount of mixing air in conjunction with the amount of fuel oil supplied. Ignition is usually provided via a gas pilot, though a light oil (air atomized) pilot, or even hand firing may be used in some cases.

Oil burners should have an automatic electric ignition, complete with electronic detector to monitor pilot so the primary fuel valve cannot open until the pilot flame has been established.

Oil burners typically provide:

- Air flow safety switch
- Atomizing oil nozzles
- Controls and linkage for firing sequence
- Flame safeguard control
- Fuel-air regulation damper and controller
- Ignition assembly
- Integral oil pump
- Oil filter
- Oil metering control valve with adjustable cam operator
- Oil pressure regulating devices
- Oil solenoid valves
- Pressure gauges

Low pressure air for the oil atomizing system may be provided from a separate compressed air system. However, it is not unusual to find a self-contained air compressor as part of the burner assembly. It typically has a lube oil tank, oil level indicator, air inlet filter, and pressure gauges. In lieu of air, some boilers use steam to facilitate oil atomizing.

Some boilers will have combination gas/oil burners to combine low pressure air atomizing type for oil and high radiant multiport type for gas, for operation with commercial #2 fuel oil and natural, manufactured, or mixed gas.

0.12.01 .02.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fuel **Burning/Heating** Equipment (CSI **15556, 15557, 15558, 15561)** (Continued)

Coal-fired boilers can be generally classified as to their bed: fixed or traveling. Small boilers may have a fixed bed or grate on which the coal sits while burning. These units are hand loaded and fired. Combustion rate is controlled by raking/banking the coals on the bed and by varying the availability of combustion air via dampers.

Larger coal-fired boilers are fully automated. Mechanical hoppers, conveyors, and stokers are used to supply and distribute the coal to a traveling (motorized) grate in the combustion chamber. The coal is fired by auxiliary burners (gas or oil). Combustion is controlled by varying grate travel (speed), the loading rate, and draft.

Because not all of the fuel is burned, ash is produced in coal-fired boilers. In larger coal-fired boilers, this is dumped into an ash pit. Some boilers have ash hoppers and conveyors to remove the ash.

Stokers

Stokers are mechanical feeding devices used to inject solid fuel onto the grates in a boiler. Because of the greater flexibility in furnace design with pulverized coal and the trend toward larger boiler units, the demand for stokers is less. The practical steam output limit of boilers equipped with mechanical stokers is about 400,000 pounds per hour. When applicable, stokers are often preferred because of their greater operating range, capability of burning a wide range of solid fuels, and their lower power requirements.

Mechanical stokers can be classified in four main groups based on the method of introducing the fuel to the furnace:

- Chain grate and traveling grate stokers
- Spreader stokers
- Underfeed stokers
- Vibrating grate stokers

The spreader stoker is the most commonly used in the capacity range from 75,000 to 400,000 pounds per hour because it responds rapidly to load swings and can burn a wide range of fuels.

Underfeed stokers are primarily used for heating and for small industrial units of less than 30,000 pounds per hour.

Chain and traveling grate stokers, while still used in some areas, are being replaced with spreader and vibrating grate types.

Stokers are essentially motor-driven reciprocating rams located beneath a gravity bin. Forward motion forces the fuel onto the bed. The return motion creates a void that is filled by gravity from the overhead bin. Feed rate is controlled by varying motor speed or the stroke of the ram.

Stokers are frequently interlinked with the grates to control the overall fuel movement. Shakers are frequently included to move expended coal (ash and clinkers) into an ash pit for removal.

Ash **Conveyors**

Although small coal-fired boilers generally require manual unloading of the ash pits, most large units employ automated ash removal systems. The system is typically a simple motorized screw conveyor that transfers the ash to a hopper for disposal.

0.12.01.02.03 BOILERS (CSI **15555)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Boiler Trim (CSI 15570)

Boiler trim refers to the critical control devices mounted on the boiler, mostly on the main shell (steam drum).

High temperature water boiler trim should include:

- Boiler valves
  - stop and check valves
  - Y-type blowdown valves
- Low water cutoff
- Water relief valve
- Pressure and temperature gauges
- Operating and high-limit aquastats
- Burner controller

Low water cutoff for water boilers should be mounted on the side of boiler and wired into burner control circuit to prevent burner operation if boiler water falls below safe level.

Water relief valves on water boilers should be of type and size to comply with ASME Code requirements.

Pressure and temperature gauges for water boilers should be mounted on boiler with the temperature sensing element adjacent to the hot water outlet. Temperature controls to regulate burner operation for water boilers should be mounted with temperature sensing elements adjacent to hot water outlet.

Steam boiler trim should include:

- Boiler valves
  - stop and check valves
  - Y-type blowdown valves
  - surface blowdown valves
- Steam relief valve
- Low water cutoff
- Water column and pump control
- Pressure and temperature gauges
- Operating and limit controls
- Burner controller

Low water cutoffs should be an integral part of the boiler feed-water control, wired into burner control circuit to prevent burner operation if boiler water level falls below safe operating level.

An auxiliary low water cutoff typically provides a second low water cutoff, wired in series to the primary unit.

Water column should be complete with try-cocks, gauge glass set, and gauge glass and water column blowdown valves.

Feedwater pump control should be an integral part of the water column, selected to automatically actuate motor-driven feed-water pump to maintain boiler water level within normal limits,

Although the typical water level control is multiple float switches mounted in water columns, many other control devices are found in the field. Some units employ level probes for feed activation; others employ a variety of mechanical devices that sense the level and operate feed valves through mechanical linkage.

0.12.01 ■ O2.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Boiler Trim (CSI 15570) (Continued)

Water or steam safety valves should be provided for proper relieving capacity. This frequently requires multiple valves. They are set to relieve at 10 psi above operating pressure, and are installed on top of boilers with pipe discharge to floor drain for low-pressure service. Piping should discharge to outdoors for high-pressure service.

Stop and check valves are usually OS&Y construction with chain operation

Steam pressure gauges should be located on the front end of the boiler and include siphon, cock, and test connection. Range should suit operating pressure.

Steam pressure controls to regulate burner operation should be mounted near the water column, complete with high limit pressure control.

Superheater (CSI 15570)

A major boiler component is the superheater used where dry superheated steam is required by the system (typically where turbine generators are employed). If the boiler is used for heating only, a superheater is usually not installed.

The superheater is a heat exchanger mounted in the boiler casing that transfers heat from the combustion gases to the saturated steam leaving the steam drum. The superheater may get its heat from an independent combustion chamber, separated/shielded from the saturated side by water-tubes.

When employed, this device will usually be equipped with relief valves, isolation valves, and frequently with soot blowers.

Soot Blowers

On large oil and coal boilers, soot blowers are typically installed to periodically remove soot from the tube surfaces. These are typically combinations of a rotating head with a steam supply valve and are usually chain operated. Soot blowers may be installed on the boiler proper, on superheater tubing, the economizer, or the air heaters.

Air Heaters (CSI 15570)

A common major accessory is an air heater. This is a (finned coil) tubular heat exchanger installed in the exhaust gas ductwork. It uses the heat of the exhaust gases to preheat the incoming combustion air passing through the tubes, thus improving the overall boiler efficiency.

Economlter (CSI 15570)

A second major accessory is an economizer, a finned coil heat exchanger installed in the exhaust gas ductwork. It uses the heat of the exhaust gases to preheat the boiler feedwater, thus improving the overall boiler efficiency. It employs feedwater controls to regulate flow. Although it is desirable to extract as much heat as possible from the exhaust, care must be taken to prevent condensation in the stack.

When employed, this device will usually be equipped with relief valves, isolation valves, and frequently with soot blowers.

0.12.01.02.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Blowdown Separators (CSI 15570)

Boiler blowdown separators are required in most areas. They provide a staging area to prevent the discharge of highly concentrated, high temperature effluent from the boiler directly into the sewer. They are typically a small tank with a regulated water supply to cool and dilute the discharge. The drain should be connected to the sewer and vented outdoors. A regulated temperature sensing bulb should be mounted in the blowdown separator discharge. Backflow prevention devices are currently required between the separator and the water supply.

Combustion Air Fans (CSI 15880)

Combustion air is provided to boilers via two methods: forced (FD) and induced (ID) draft. In many cases, no special devices are required because an adequate draft is produced by the chimney effect of the stack or chimney. When present, this method is "induced." In other cases, assistance is required.

When a fan is used on the supply side of the combustion chamber to force air into the chamber, the draft is said to be forced. In this case, the casing is pressurized slightly. When a fan is employed in the exhaust system to evacuate the combustion products, the draft is said to be "induced." In this case, the casing is typically at a negative pressure.

Fan drives are usually motors, but large plants may employ steam turbines. Small units are belt-driven, and large units are coupled.

Combustion air flow can be controlled by varying damper positions and/or fan speeds. Instrumentation is typically used to measure draft and load and vary air flow accordingly. Dampers are typically interlocked with the fuel supply. On small boilers that cycle on/off, the air flow may be fixed.

Motors (CSI 15170)

Motors are usually used to drive the burner and fans. In most cases these are belt-driven, open AC induction motors (small boilers may use a direct-drive motor).

Steam Turbines

Large facilities may have steam turbines to drive the ID and/or FD fans. There are many variations, but the most common for small auxiliary equipment is perhaps the single-stage, impulse turbine. These are relatively small, compact units with few moving parts.

Turbines are generally direct coupled to the fan. Operation is controlled by a turbine-mounted governor, either constant speed or pressure.

Scrubbers

All boilers are required to meet environmental control requirements regarding emissions. In large heat-generating facilities, especially coal-fired units, this usually requires some type of exhaust filtration equipment. Many approaches have been used, and the group is loosely referred to as scrubbing equipment.

Dry bag houses provide rudimentary filtration. They employ large bag filters in a metal tower structure to extract relatively large particulate matter before the exhaust is passed to the atmosphere. Large units typically have shaker mechanisms and hoppers to allow for removal and disposal of the particulate waste.

0.12.01 .02.03 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Scrubbers (Continued)

Wet towers, or scrubbers, use liquid entrainment to remove particulate matter and undesirable gases for the exhaust. The exhaust is either sprayed with water or chemical solution or is forced through a bed of wetted filter media. The gas/liquid contact traps the particulate, and depending on the solution, dissolves some of the entrained gases. Like cooling towers, scrubbers are classified according to relative flow of liquid and air: cross flow, counter flow, and concurrent flow.

Electrostatic filters (precipitators) employ an electric field to ionize and collect exhaust particles. They employ high voltage discharge rods in the flow path that cause the ionization and large grounded collector plates that provide the collection surface.

Equipment Controls & Pands (CSI 15970)

Most boilers, regardless of type, employ many controls to match steam supply to demand and to ensure safe operations. All boiler controls must comply with "improved risk" criteria established in DOE 5480.7

Control panels for fuel-fired boilers provide electronic programming relays, burner and blower motor starters, and control switches. They typically include:

- Plug-in fuel modules and indicating lights for low water level, flame failure, fuel valve open, and load demand.
- Programming relay to control ignition timing and starting and stopping burner through pre-combustion purge and post- combustion purge, plus a flame scanner to shut down burner in event of ignition, pilot, or main flame failure.
- Manual-automatic selector switch and damper motor positioning switch to permit automatic firing in accordance with load demand, or manual control of firing rate at any desired point between low fire and maximum rating.

piping & Fittings (CSI 15060)

Piping and fittings for boilers include feedwater and fuel supplies, chemical makeup, blowdown lines, and the associated steam or water supply piping.

DOE requires all boiler room joints to valves and fittings larger than 1 1/4 inches be welded (or may be flanged to permit maintenance).

Oil and gas piping should provide shutoff valves and unions with sufficient clearance for burner removal and service.

Unions should be installed in pipes 2 inches and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

Strainers should be installed on the supply side of each control valve, pressure regulating valve, oil burner connection.

Flexible connectors should be installed at inlet and discharge connections to pumps, compressors, and other vibration producing equipment.

OTHER RELATED COMPONENTS

See the following subsections for related components:

DEFICIENCY FACTORS
0.12.01 .02.03 BOILERS (CSI 15555)

PROBABLE FAILURE POINTS

- Leakage in boilers tubes due to corrosion, overheating, embrittlement.
- Environmental pollution caused by burner and/or burner control failure.
- Inability of system to deliver rated capacity due to internal scaling of the boiler heating surfaces, plugged tubing leaks, burner/heating element failure, feedwater contamination, poor water supply.

SYSTEM ASSEMBLIES/DEFICIENCIES

Casing

Insulation Wet, Damaged, Missing:	Leaks, physical abuse, poor maintenance.
Leakage:	Fastener or weld failure; breakdown in internal refractory; cracking.
Blisters, Buckling:	Overheated metal, probable failure of the refractory lining.
Excessive Corrosion:	Leakage, poor maintenance, local environment.

Combustion Chambers

Damaged, Missing Refractory:	Overheating, poor flame control.
Baffles Distorted:	Overheating.
Flue Blistered, Buckled:	Overheating.
Access Door, Plate Seals Leaking:	Physical abuse of seal, warped plate or door, cement breakdown.

Shells & Tubing

Shell Blistered, Buckled:	Overheating, over pressurization.
Loose, Broken Fasteners:	Corrosion, stress, vibration.
Excessive Corrosion:	Poor chemical treatment, improper fuel burning.
Leakage:	Corrosion, heat fatigue, cutting by gas or steam, over pressurization.
Tubes Blocked:	Excessive scale buildup.
Tube Coating Damaged:	Cutting by combustion products.
Manhole, Handhole Leakage:	Defective seal, pitted seating surfaces.

Breeching, Chimneys, Stacks

Excessive Corrosion:	Poor gas temperature control, incomplete fuel burning, local environment.
Loose Fasteners:	Corrosion, thermal stresses.
Leaking Joints:	Physical abuse, corrosion, loose fasteners.
Damaged Masonry:	Thermal stresses, leakage.
Dampers Inoperative:	Corrosion, loose fasteners.
Leaks in Access Doors:	Damaged, dried out gaskets.

DEFICIENCY FACTORS
0.12.01.02.03 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Fuel **Burners/Heaters**

Gas Ring Distortion:	Overheating, physical abuse, loose fasteners.
Oil Burner Distortion:	Overheating, loose fasteners, physical abuse.
Mixing Dampers Inoperative:	Physical damage.
Burner Excessive Corrosion:	Poor temperature control, incomplete fuel burning, local environment.
Burner Excessive Noise, Vibration:	Loose fasteners, worn bearings.
Compressor - Excessive Noise, Vibration:	Loose fasteners, wear.
Coal Grate Damage:	Overheating, metal fatigue, corrosion.
Coal Grate Inoperative:	Failed drive/bearings.

Stokers

Ram Distortion:	Overheating, physical abuse, loose fasteners.
Excessive Corrosion:	Poor temperature control, incomplete fuel burning, local environment.
Excessive Noise, Vibration:	Loose fasteners, worn bearings.

Ash Conveyors

Missing Parts:	Taken out for service, not returned.
Inoperative:	Corrosion, wear, physical damage, missing parts, damaged belts, screws.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress, vandalism.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Excessive Wear Chains:	Age, normal wear, improper lubrication.
Excessive Wear Guides:	Age, normal wear, improper lubrication.
Defective Reducer:	Age, normal wear, improper lubrication.
Loose, Missing Fasteners:	Corrosion, damage.
Leakage:	Worn or damaged covers, seals.
Distortion:	Overheating, physical abuse, loose fasteners.

Boiler Trim

Valve Leakage:	Improper packing, corrosion.
Valve Inoperative:	Corrosion, damaged operating mechanism.
Valve Inadequate Seating:	Worn seat/disc, corrosion, scaling.

DEFICIENCY FACTORS
0.12.01 .02.03 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES

Boiler **Trim** (Continued)

Relief Valve Leakage:	Worn seat/disc, corrosion, scaling.
Gauges Missing:	Taken out for service, not replaced.
Gauges Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Gauges Inaccurate:	Corrosion or leakage in internal mechanism, wear, miscalibration.
Gauges Illegible:	Defaced by chemicals, corrosion, physical damage.
Low Water Cutoff Inoperative:	Bypassed, physical damage.
Water Column Leakage:	Corrosion, defective gaskets.
Level Controller Damage:	Physical abuse, corrosion.
Pressure/Temp Controls Inoperative:	Bypassed, physical damage.
Control Piping Leakage:	Corrosion, physical damage.
Control Piping Excessive Corrosion:	Leakage, local environment.

Superheater

Tubes Blistered, Buckled:	Overheating, over pressurization.
Loose, Broken Fasteners:	Corrosion, stress, vibration.
Excessive Corrosion:	Poor chemical treatment.
Leakage:	Corrosion, heat fatigue, cutting by gas or steam, over pressurization.
Tubes Blocked:	Excessive scale buildup.

Boot Blowers

Inoperative:	Corrosion, wear, physical damage, missing parts.
Excessive Corrosion:	Leakage, poor maintenance, local environment.
Leakage:	Corrosion, wear.

Air **Heater**

Coil Damage:	Physical abuse, wear.
Coil Leakage:	Corrosion.
Casing Leakage:	Corrosion, physical damage, loose fasteners.

Economizer

Coil Damage:	Physical abuse, wear.
Coil Leakage:	Corrosion, freezing.
Regulating Valve Inoperative:	Defective sensing element, corrosion.
Casing Leakage:	Corrosion, physical damage, loose fasteners.

DEFICIENCY FACTORS
0.12.01 .02.03 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Slowdown Separator	
Leakage:	Corrosion, thermal stress.
Regulating Valve inoperative:	Defective sensing element, corrosion.
Excessive Corrosion:	Poor maintenance, local conditions.
Combustion Air Fans	
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, improper fuel mixing, local conditions.
Casing Leakage:	Loose fasteners, corrosion, thermal stress.
Defective Bearings:	Age, normal wear, improper lubrication.
Motors	
Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment,
Excessive Corrosion:	Poor maintenance, local conditions.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Turbines	
Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, rotor imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local conditions.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Casing Leakage:	Worn or damaged seals.
Scrubbers	
Inoperative:	Damaged bags, excessive leakage, failed precipitator.
Excessive Noise, Vibration:	Shaker wear, damaged dampers, loose or missing fasteners.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Leakage:	Worn or damaged bags, housing damage.

DEFICIENCY FACTORS
0.12.01.02.03 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Equipment Controls & Panels

Housing Corrosion:	Age, poor maintenance, local conditions.
Bypassed Controls:	Damaged or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted, Burned:	Normal wear, overloading.
Motor Starter Inoperative:	Worn linkage, open coil, overloading.

piping & Fittings

Excessive Corrosion:	Age, poor maintenance, leakage, local conditions.
Leakage:	Improper installation, corrosion.
Physical Damage:	Abuse, stress.
Strainers Inoperative:	Corroded.

DEFICIENCY FACTORS
0.12.01 .02.03 BOILERS (CSI 15555)

END OF SUBSECTION

0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

DESCRIPTION

Many large facilities centralize their heat generation utilities and distribute the energy using Elevated Temperature Water as the conducting media. They employ boilers to either heat the water directly or to provide steam to converters for indirect heating. DOE Design Criteria stipulate a maximum supply temperature of 200ºF within a building's distribution system, but the site heating system may produce temperatures considerably above that. The upper limit is generally 450ºF due to related pressure limitations on piping and fittings. A high temperature water heating system is defined as one operating above 350ºF and designed for 300 psi. A medium temperature system operates between 250ºF and 350ºF and is designed for 125 to 150 psi.

The typical elevated temperature water system consists of converters, expansion tanks, circulating pumps, motors, turbines, and the connecting piping, fittings, valves, and supports. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Converters (CSI 15525)

Converters elevate incoming water temperature and restore recirculated water to supply demand temperature. The controlled supply temperature typically varies with such parameters as current indoor air temperature and ambient temperature.

A typical converter is a shell and tube heat exchanger, using one or more steam tube bundles as the heat source. The shell is usually large enough to act as a hot temperature water reservoir to allow for fluctuations in demand.

Pressurizing/Expansion Tanks (CSI 15175)

Variations in system water temperature cause a significant change in water volume. Variations in system pressure can result in water flashing and corresponding system hammer. Compensation for both of these events is provided by installing expansion tanks in the distribution system. A tank is typically provided at the circulating pump suction.

Expansion tanks usually have a sight glass for level monitoring. Pressure is typically maintained by using inert gas blankets in the expansion tank.

pumps (CSI 151 60)

Pumps circulate hot water throughout the distribution system to minimize wait time when hot water is required at a far point in the system.

Site heating water pumps are typically large, multi-stage, centrifugal pumps, and are generally pedestal-mounted units. They should be arranged to provide easy access for periodic maintenance and repair.

Motors (CSI 15170)

AC induction motors are normally used to drive the circulating pumps. Pedestal-mounted pumps are typically driven via rigid or flex coupled motors.

Some installations employ variable frequency drives to allow changes in motor speed to meet fluctuations in system flow demand.

0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Steam **Turbines**

Large facilities may have steam turbines to drive the circulating pumps. There are many variations, but the single-stage, impulse turbine is most common for small auxiliary equipment. These are relatively small, compact units with few moving parts.

Turbines are generally direct coupled to the pump. Operation is controlled by a turbine-mounted governor, either constant speed or pressure.

Piping **&** Fittings **(CSI** 15510)

Piping and fittings provide the distribution network for the high temperature water system.

The distribution system is normally installed underground, below the frost line. This helps protect against freezing and minimizes conflict with ground transportation, but also makes inspection and maintenance very difficult. DOE sometimes puts their distribution network above ground.

Underground piping is typically installed in tunnels or concrete trenches. However, there are many alternatives: factory-fabricated conduit systems, field-fabricated conduit, and poured envelope systems.

Most distribution piping is Schedule 40 steel pipe. Pipe sizes vary significantly, ranging from 4 to 12 inches. Larger sizes (up to 54 inches) may be used, but are uncommon.

Where soil is corrosive, underground pipe should be encapsulated, usually with a polyethylene film tube.

Because of significant changes in piping temperature, particular attention must be paid to the inclusion of expansion joints and loops in the distribution piping.

Mechanical fittings use rubber gaskets or elastomeric joints to improve reliability.

All fittings should be compatible with the type of piping material used in the system to minimize corrosion induced by galvanic action.

Strainers are typically provided at the suction of the water pumps to protect the pumps themselves.

Flexible connectors are usually used on the suction and discharge side of each base-mounted pump to minimize the effects of pump vibration.

Valves (CSI 15100)

Valves are primarily used to switch pumps and isolate converters and other components for maintenance. In addition, shut-off valves are typically provided at each branch connection to supply mains.

Drain valves are installed at low points in mains, branch lines, and elsewhere as required for system drainage; and vent valves are required at high points in the system.

Check valves are used on the discharge side of pump to prevent windmilling of idle pumps and to prevent reversal of system flow in the hot water circulation lines.

Regulating valves are used to control the flow of steam through the converter heating coils.

Relief valves are required on all water heating devices and pressurized tanks.

All valves should be installed in accessible locations, protected from physical damage. Valves should be tagged.

0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Supports & Anchors (CSI 15140)

Pipe hangers and supports are provided to support piping and allow for expansion and contraction. They should be securely attached to a solid foundation at sufficiently close intervals.

Insulation (CSI 15250)

Hot water piping and heaters should be insulated to provide personnel protection and energy efficiency. This is especially true for heating water where temperatures may reach 450ºF. Underground piping insulation not only provides for thermal efficiency, but also provides some corrosion protection, minimizes moisture infiltration, and protects against physical damage.

Insulating materials above ground include calcium silicate and fiberglass. In underground situations, additional materials include urethane foam, insulating concrete, clay pipe, and various hydrocarbon powders.

Manholes (CSI 02730)

Manholes are provided in underground distribution systems to permit access to valving and expansion joints and to inspect piping. They are typically precast concrete rings stacked at critical connection points in the distribution system. The lowest section is referred to as the base, channel, and bench and serves to support incoming and outgoing pipe. Riser rings (typically 48 inches) and grade rings are stacked above and joined with rubber gaskets. The top section is an eccentric cone matching a 24 inch diameter frame.

Older units may be built of brick or cast-in-place concrete. All units are fitted with access plates and ladders.

Instrumentation (CSI 15135)

Pressure gauges are typically provided at the suction and discharge of each pump or pump group. Temperature gauges are usually provided on large converters and expansion tanks and at branch lines and circulator pumps.

Equipment Controls & Panels (CSI 15950)

Few controls are required in the typical high temperature water distribution system. The system is usually turned on and left running during the heating season except for routine maintenance services and repairs.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect).

Water temperature controls are generally provided through thermal bulb sensing and modulation of a hydraulically controlled regulating valve on the converter or through controls on the boiler.

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

DEFICIENCY FACTORS
0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion, especially in hot water circuits where chemical reaction rate is greater.
- Pipe breakage due to poor design or maintenance of expansion loops.
- Inability of system to deliver rated capacity to terminal points due to internal scaling of the distribution network, defective control valve operation.
- Inadequate pressure at terminal points due to piping failures, poor pump performance.
- Inadequate temperature of hot water at terminal points due to heat losses in distribution lines, poor insulation, circulator and/or check valve failure.
- Inadequate temperature at terminal points due to insufficient heating capacity.

SYSTEM ASSEMBLIES/DEFICIENCIES

Converters

Inoperative:	Control failure, blocked tubing, open heating elements.
Inadequate Capacity:	Inability to maintain temperature due to tube blockage, scaling.
Overheating:	Failure of steam regulators.
Shell Distortion:	Blisters or bulges in the metal caused by overheating, fatigue, physical damage, loss of external support.

Pressuring/Expansion Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

DEFICIENCY FACTORS
0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment, failed isolators, improper anchorage.
Excessive Vibration:	Wear, imbalance, misalignment, failed isolators, improper anchorage.
Severe Corrosion:	Age, lack of maintenance, local environment.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment, poor system design.
Inadequate Capacity:	Low pressure, low flow caused by wear.

Motors

Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, imbalance, misalignment, failed isolators, improper anchorage.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Turbines

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, rotor imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Casing Leakage:	Worn or damaged seals.

Piping **& Fittings**

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.

DEFICIENCY FACTORS
0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

piping & Fittings (Continued)

Physical Damage:	Bent, broken, crimped, crushed.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.

Supports & Anchors

Missing:	Improper installation, poor maintenance.
Improper Alignment:	Improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, poor maintenance.

Insulation

Missing:	Never installed or taken off and not replaced.
Wet:	System leakage or external causes.
Damaged:	Physical abuse.

Manholes & Catch Basins

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment.
Physical Damage:	Collapsed, cracked.

Instrumentation

Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.

DEFICIENCY FACTORS
0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Equipment Controls & Panels (Continued)

Control Housing Corrosion:	Age, poor maintenance, local environment.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted, Burned:	Normal wear, overloading.
Missing:	Never installed or taken off and not replaced.

DEFICIENCY FACTORS
0.12.01.02.04 ELEVATED TEMPERATURE WATER DISTRIBUTION SYSTEM

END OF SUBSECTION

0.12.01 .02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

DESCRIPTION

Many large facilities centralize their heat generation utilities and distribute the energy using steam as the conducting media.

The typical Steam and Condensate System provides steam distribution to facility heat exchange devices, collection of condensate return and the preparation of condensate for recycling via the boiler feed system. The system consists of steam and condensate piping, steam traps, strainers, return tanks and pumps, deaerators and the connecting fittings, valves, and supports. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15520)

Piping and fittings provide the distribution and collection network for the steam and condensate return system.

The distribution system is normally buried underground, below the frost line. This helps protect against freezing and minimizes conflict with ground transportation, but also makes inspection and maintenance very difficult. DOE sometimes puts their distribution network above ground.

Underground piping is typically installed in tunnels or concrete trenches. However, there are many alternatives: factory-fabricated conduit systems, field-fabricated conduit, and poured envelope systems.

DOE requires that steam distribution piping be Schedule 40 with appropriate fittings; condensate and feed water piping should be Schedule 80. Most distribution piping is steel. Pipe sizes vary significantly, ranging from 4 to 24 inches. Larger sizes (up to 54 inches) may be used, but are uncommon.

Where soil is corrosive, underground pipe should be encapsulated, usually a polyethylene film tube.

Because of significant expansion and contraction in the piping systems due to variations in temperature, particular attention must be paid to the inclusion of expansion joints and loops in the distribution piping.

All joints to valves and fittings over 1 1/4 inches must be welded except in the boiler house, where flanges are used.

All fittings should be compatible with the type of piping materials used in the system to minimize corrosion induced by galvanic action.

Steam Traps (CSI 15525)

Traps are used to provide a seal between the relatively high pressure steam vapor on the consumption side of the system and the low pressure condensate and vapor on the return side. The trap prevents a short cycling of the steam through the system, while allowing steam that has given up its latent heat to return to the generator.

Steam traps are provided in many designs. Older units were inverted bucket traps that operate as a float mechanism to release the condensate when a sufficient level in the trap has been achieved. Impulse traps rely on pressure differentials to cycle a small plate covering outlet ports. Both types are susceptible to wear and corrosion, are prone to leaks, and are considered maintenance intensive. Newer traps have no moving parts, rely solely on port sizing, and are relatively maintenance free, susceptible only to blockage by scale.

0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Condensate Return Tanks (CSI 15175)

Condensate return tanks provide a collection point for condensate lines draining through gravity. They are necessarily located at low points in the system. Small units frequently incorporate dual condensate return pumps within the tank. Floats are provided to cycle pumps based on condensate level. Alternators are used to distribute pump wear.

On large distribution systems, multiple return tanks are usually distributed throughout the building. The discharge is routed to a common condensate return main.

The main condensate return tank is frequently used for mixing new makeup water. It is typically fitted with a water column, sight glass, and level control devices.

Deaerators

Deaerators serve to prepare water for feed service to the boilers. They are designed to preheat the water, provide de-oxygenation, and serve as feed storage. In a tight steam and condensate system (i.e., one with few fluid losses), the water in the deaerator is primarily condensate return.

Some manufacturers incorporate the deaerator and a main condensate return tank in a common shell.

The condensate return, mixed with any makeup feed water, is forced through spray nozzles into a steam chamber. The mild atomization and mixing with steam enhances heating and entrained oxygen release. Condensate falls to the bottom of the storage area, and non-condensable material rises through a vent condenser and escapes to the atmosphere. Mixing and separation are controlled by cones and baffles mounted in the deaerator.

pumps (CSI **15453)**

Pumps recirculate condensate back to the feed water system. They are typically used in site condensate return tanks, as transfer pumps between the main condensate return tank and the deaerator, and as boiler feed pumps.

Condensate return and transfer pumps operate at relatively low pressures. They are typically single-stage, centrifugal pumps.

Feed pumps must operate at relatively higher discharge pressures. In addition to single-stage centrifugal pumps for low pressure boilers, feed pumps also employ multi-stage centrifugal designs, and in larger plants, reciprocating steam pumps.

Motors **(CSI** 15170)

Most pumps are driven by open, AC induction, via a flexible coupling.

Storm **Turbines**

Large facilities may have steam turbines to drive the feed and condensate pumps. There are many variations, but the single stage, impulse turbine is the most common for small auxiliary equipment. These are relatively small, compact units with few moving parts.

Turbines are generally direct coupled to the pump. Operation is controlled by a turbine-mounted governor, either constant speed or pressure.

Valves (CSI **15100)**

Valves are primarily used to switch pumps and isolate tanks and other components for maintenance. In addition, shut-off valves are typically provided at each branch connection to supply mains.

0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Valves (CSI 15100)

Drain valves are installed at low points (drip legs) in mains, risers, branch lines, and elsewhere as required for system drainage; vent valves are required at high points in the system.

Check valves are used on the discharge side of pump to prevent windmilling of idle pumps.

Pressure regulating valves (PRV) are used to reduce main steam pressure to level required by distribution system devices. Pressure regulating valves are also used to control the flow of water and steam through the deaerator tank.

Relief valves are required on all reducing stations.

Instrumentation (CSI 15135)

Pressure gauges are typically provided at the discharge of each condensate transfer pump or pump group. Pressure gauges are also found on the deaerator and at the inlet and outlet of each PRV.

Temperature gauges are usually provided on the main condensate return tank and deaerator.

Supports & Anchors (CSI 15140)

Pipe hangers and supports are provided to support piping and allow for expansion and contraction. They should be securely attached to building construction at sufficiently close intervals.

Insulation (CSI 15250)

Steam and condensate piping and the deaerator should be insulated to provide personnel protection and energy efficiency.

Insulating materials above ground include calcium silicate and fiberglass. In underground situations, additional materials include urethane foam, insulating concrete, clay pipe, and various hydrocarbon powders.

Equipment Controls & Panels (CSI 15950)

Most of the control in a steam and condensate system is provided by mechanical regulating valves (PRVs and traps).

Condensate pump control is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the condensate return tank.

Transfer pump is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the deaerator.

Feed pump control is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the boiler water column.

Makeup water control is usually provided by a level sensor in the main condensate return tank (either a float mechanism or electric probes).

Because of the importance of the main condensate return tank and deaerator to system operation, each is usually equipped with level alarms.

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

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DEFICIENCY FACTORS
0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion, especially in the condensate circuit.
- Inadequate pressure at terminal points due to regulator failures.
- Excessive makeup requirements due to system leakage.

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Flfflngs

Physical Damage:	Bent, broken, crimped, crushed.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Leaks, local environment.
Strainers Inoperative:	Inaccessible due to corrosion, physical damage, internal clogging.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.

Steam Traps

Internal Leakage:	Failure of internal elements, wear, scale on seats.
External Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Leaks, local environment.

Condensate **Return** Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.

DEFICIENCY FACTORS
0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Deaerators

Inoperative:	Level control failure, defective pump.
Shell, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Severe Corrosion:	Age, lack of maintenance, leaks, local environment.
Access Plate Seal Leakage:	Defective gasket.
Spray Nozzle Defects:	Physical damage, corrosion, erosion.
Baffles, Cone, Tray Defects:	Physical damage, corrosion, erosion, missing fasteners.
Vent Condenser Defects:	Leakage, corrosion.

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment, failed isolators, poor anchorage.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Age, lack of maintenance, leaks, local environment.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment, poor system design.
Inadequate Capacity:	Low pressure, low flow caused by wear, poor system design,

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators, poor anchorage.
Excessive Corrosion:	Poor maintenance, leaks, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, leaks, local environment.

DEFICIENCY FACTORS
0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.
Instrumentation	
Missing:	Taken out for service, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Corrosion or leakage in internal mechanism, wear, miscalibration.
Illegible:	Defaced by chemicals, corrosion, physical damage.
Supports & Anchors	
Missing:	Improper installation, poor maintenance.
Improper Alignment:	Improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, poor maintenance.
Insulation	
Missing:	Never installed or taken off and not replaced.
Wet:	Caused by system leakage or external causes.
Damaged:	Physical abuse.
Equipment Controls & Panels	
Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Age, poor maintenance, local environment.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted, Burned:	Normal wear, overloading.

DEFICIENCY FACTORS
0.12.01.02.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM

END OF SUBSECTION

0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

DESCRIPTION

A Helical Rotary or Screw Type Chiller System removes heat from its associated chilled water system and rejects that heat to an associated condenser water system. It employs a refrigerant compression and expansion cycle where the compressive force is supplied by a device similar to a large, single-stage screw pump. The typical system consists of a rotary screw compressor, drive assembly, motor, a condenser, an economizer, an evaporator, a purge system, and the connecting piping, fittings, instrumentation, and controls. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Rotary Screw Compressors (CSI 15680)

Typical compressors consist of a large split casing enclosing multiple shafts, a main shaft, and a pair of star wheels or gate rotors. The main shaft is typically made of cast iron and is coupled to an external drive motor. The gate rotors are typically made of plastic and are driven by the action of the main rotor. The suction side of the compressor casing is piped to the system evaporator while the discharge side connects to the condenser.

Bearings are usually ball bearings and roller or needle bearings.

Most systems include unloading valves to control compressor loading.

Oil systems are sometimes provided to seal, cool, and lubricate the compressor and to activate the capacity control. Systems frequently come with an oil sump and an integral oil pump, usually gear-driven off the compressor shaft. A separate, electric oil pump is usually provided for system startup. There must be an oil heater (shutdown), cooler, and filter in these systems. However, the design of many rotary compressors is such that refrigerant can be used for sealing and cooling, and only a small amount of oil is required for bearing lubrication. This oil is injected directly into the refrigerant.

Drive Assemblies (CSI 15170)

External drive units are typically joined with the compressor using a flexible, steel spline coupling(s) and/or a gear transmission. The latter is usually a single or double helical gear assembly.

Some units are “semi-hermetic,” in which the motor is enclosed in the same casing as the compressor.

Motors (CSI 15170)

Most motors for external driven compressors are open AC induction motors, operating in a relatively narrow speed range. External drive motors are quite large and their bearings are usually lubricated with independent oilers.

Large units may employ independent fan cooling systems to remove heat generated by the motor. Particular attention must be paid to air filtration on all external units.

Internal drive motors (semi-hermetic units) share the same shaft as the compressor. In addition, refrigerant is often used for motor cooling, and the lubrication system is usually integral with the compressors.

0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Condensers (CSI 15740)

Condensers in a rotary screw chilling plant serve to condense the high pressure refrigerant gas. In this process, the latent heat of evaporization is conducted to the condenser water circuit.

Most condensers are shell and tube, gas to water heat exchangers. The condenser heads are usually designed for easy removal to permit annual cleaning. The gas side of the heat exchanger is fitted with over-pressure protection, usually a rupture disk vented to the building exterior. The top of the shell serves as a collection point for non-condensable gases. Fittings are provided for purging these gases manually or routing them to an automatic purging system.

Economizer (CSI 15880)

The evaporative section is separated from the condenser section by a metering device that controls refrigerant flow. This is typically a single floated operated valve. When more than one float operated valves are used in a separate chamber, it is called an economizer. The chamber is divided and a section is piped to an intermediate pressure stage/port of the compressor. The low pressure connection allows partial flashing and subcooling of the refrigerant, which effects an improvement in system efficiency.

Some systems may employ an orifice for metering control in lieu of the float valves.

Evaporators (CSI 15730)

Evaporators in a rotary screw chilling plant serve to evaporate the low pressure refrigerant gas. In this process, the latent heat of evaporization is conducted from the chilled water circuit.

Most evaporators are shell and tube, gas to water heat exchangers. The evaporator heads are usually designed for easy removal to permit routine inspection and cleaning.

The evaporator contains baffles or eliminators to minimize liquid entrainment in the compressor suction gas. The evaporator is normally independent of the condenser, frequently installed in an over-under arrangement, with the evaporator on the bottom. However, some arrangements will employ a common shell with internal flow dividers and independent heads. Evaporators are usually insulated with fiberglass to prevent condensation and improve efficiency.

Purge System (CSI 15680)

The purge system removes non-condensable gases that enter the refrigerant system through charging or through leaks during normal low pressure operations (as found in R-l 1 and R-l 13 systems).

Older systems employed an automatic purge valve (solenoid) and a simple vent condenser. Condensed refrigerant in the vent condenser was forced back to the evaporator by differential pressure. These systems allowed a lot of refrigerant to escape during venting.

A recovery type system consists of a small reciprocating air compressor, a shell and tube heat exchanger (condenser), a float tank, and controls. The compressor removes the gases from the top of the main condenser and discharges through the refrigerant cooled heat exchanger to the float chamber. The chamber is designed to permit refrigerant recycling while minimizing release during venting. A relief valve or pressure switch/solenoid valve combination is used to purge the non-condensable gases to the atmosphere.

CFC damage to the atmosphere has pushed the demand for improved purging systems. New chiller equipment (or retrofitted units) may have an independent refrigerant system just to recover gases from the primary system.

0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

piping **&** Fittings (CSI **15060)**

Most rotary screw chiller plants are either packaged systems or have the major components located close to one another. There is little refrigerant piping, simply the compressor to condenser, economizer, and evaporator connections. Because of the unique configurations involved, these are usually independent steel castings.

Piping for refrigerant controls and indicators is typically type ACR hard tubing.

Chilled and condenser water piping are covered in separate sections of this manual.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the condenser and evaporator pressure, the economizer (if included in the system), and oil pressure.

Multiple temperature gauges are provided on the evaporator and condenser to determine the amount of subcooling and the presence of excessive non-condensables.

Ammeters and voltmeters are provided to monitor system electrical load

Equipment Controls **& Panels** (CSI **15950)**

Rotary screw chiller systems usually include a master panel for all instrumentation and controls.

Compressor control is performed via a motor assembly (motor, starter, and disconnect). Old units sometimes employed a resistance bank and stepping controls for the motor speed adjustments.

Compressors frequently have oil pressure limits interlocked with the starter that can trip compressor operation.

Compressor cutout controls are also provided by low water temperature sensors (freezestats), flow controls (chilled water and condenser water flow switches), high condenser pressure switch, and motor overload.

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

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DEFICIENCY FACTORS
0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15680)

PROBABLE FAILURE POINTS

- Loss of system charge - leakage in seals and fittings due to wear, corrosion; failure of rupture disk due to over pressurization, condenser fouling.
- Bearing failure - loss of oil pressure due to wear of compressor parts, blockage in lubrication system, overheating of oil.
- Tube failure in heat exchanger due to thermal stress, fouling of tubes.
- Motor failure - insulation deteriorates due to excessive moisture, overloading of windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Compressors

Inoperative, Won't Turn:	Failed bearings, locked rotor.
Excessive Noise, Vibration:	Wear, imbalance, misalignment, failed isolators, improper anchorage.
Severe Corrosion:	Age, lack of maintenance, local environment.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment, poor system design.
Inadequate Capacity:	Low pressure, low flow caused by wear.
Oil Filter Inadequate:	Missing, damaged.
Oil Cooler Leakage:	Corrosion, physical damage.
Oil Cooler Blockage of Flow:	Corrosion, damaged coil fins.

Drive Assembly

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, gear imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Gears Worn:	Normal wear, improper lubrication, poor alignment.

Motors

Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.

DEFICIENCY FACTORS
0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 156801

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Condensers

Tube Sheet Distortion:	Blisters or bulges in the metal caused by fatigue, over pressurization, physical damage, loss of external support.
Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion.
Shell, Head Excessive Corrosion:	Poor maintenance, local environment.
Leaking Rupture Disk:	Over pressurization, vibration.

Economizers

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Poor maintenance, use of incompatible materials, local environment.
Poor Flow Regulation:	Defective float, worn orifice.

Evaporators

Tube Sheet Distortion:	Blisters or bulges in the metal caused by fatigue, over-pressurization, physical damage, loss of external support.
Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion.
Shell, Head Excessive Corrosion:	Poor maintenance, local environment.
Insulation Wet, Damaged, Missing:	Leakage, abuse, local environment, improper installation.

Purge System

Compressor Missing:	Taken out for service, not returned.
Compressor Inoperative, Won't Turn:	Failed bearings, locked rotor.
Compressor Excessive Noise:	Wear, imbalance, misalignment.
Compressor Excessive Vibration:	Wear, imbalance, misalignment.
Compressor Defective Bearing:	Age, normal wear, improper lubrication.
Severe Corrosion:	Age, lack of maintenance.
System Leakage:	Worn mechanical seal, defective packing.
Float Tank Inoperative:	Leakage, corrosion, defective float.

piping **& Fittings**

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broken, crimped, crushed.
Improper Wail Penetration:	Missing seals, flanges, escutcheons.

DEFICIENCY FACTORS
0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Instrumentation

Missing:	Taken out for service or repair, not replaced.
inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

Equipment Controls & Panels

Motor Starter Inoperative:	Overloaded, open coils, wear in linkage.
Relays Pitted, Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance, local environment.

DEFICIENCY FACTORS
0.12.01.03.01 ROTARY SCREW CHILLERS (CSI 15660)

END OF SUBSECTION

0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

DESCRIPTION

A site Chilled Water Distribution System supplies chilled water from a central plant to buildings and structures on the loop. It receives return (heated) water from the coils in air handlers and terminal cooling devices in the buildings and returns it to the central chilling plant for recooling. The system consists of circulating pumps, motors, and expansion tanks, and the connecting piping, fittings, valves, insulation, and supports. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

pumps (CSI 15540)

Chilled water pumps circulate chilled water throughout the distribution system. They are typically single-stage, single-entry, radial flow centrifugal pumps with a closed impeller. However, many feature variations depend on the specific application. These include multi-staging, double entry, axial flow, and open impellers.

Pumps are generally bronze fitted iron castings. The bronze is used for the impeller, shaft sleeves, and wear rings.

Newer pumps are fitted with mechanical seals, but a significant portion of the installed base continues to use packing.

Pumps should be arranged to provide easy access for periodic maintenance and repair.

Motors (CSI 15170)

Motors are used to drive the circulating pumps (though some large installations may use small turbine drives). These are typically open, AC induction motors flexible-coupled to the pump (normal when the unit is installed indoors).

Variations include closed motors, variable speed drives, synchronous motors, and alternative couplings (close, fluid, or eddy current).

Expansion Tanks (CSI 15175)

Variations in the system water temperature cause a significant change in water volume. Compensation is provided by installing expansion tanks in the distribution system. Typically, a tank is provided at the circulating pump suction.

Expansion tanks usually have a sight glass for level monitoring. Pressure is maintained either through a level control or a pressure regulating valve on the makeup water supply line.

Piping & Fittings (CSI 15411)

Piping and fittings provide the distribution network for the chilled water system.

Underground piping is installed in trenches. Suitably supported cradles and crowns are used to carry the pipe weight and to minimize disturbance.

DOE requires that chilled water distribution system piping be Schedule 40 with appropriate fittings.

All fittings should be compatible with the type of piping materials used in the system to minimize corrosion induced by galvanic action.

Dielectric Unions should be provided with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged) to effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

piping **& Fittings** (CSI 15411) (Continued)

Strainers are typically provided at the suction of the water pumps to protect the pumps themselves.

Flexible connectors are usually used on the suction and discharge side of each base-mounted pump to minimize the effects of pump vibration.

Valves (CSI 15100)

Valves are primarily used to switch pumps, isolate mains, branches, and other components for maintenance and repair. Main isolation valves are almost always rising stem gate valves. They are usually installed in manholes,

Drain valves are installed at low points in mains and elsewhere as required for system drainage. Vent valves are required at high points in the system.

Check valves are used on the discharge side of pump to prevent windmilling of idle pumps and to prevent reversal of system flow in the condenser water circulation lines.

All valves should be installed in accessible locations, protected from physical damage. Valves should be tagged.

Manholes (CSI 02730)

Manholes are typically precast concrete rings positioned at critical connection points in the distribution system. They are essentially inspection and maintenance accesses in systems with pipe 10 inches or larger. They are located at key mechanical connections such as vent and isolation valving and expansion joints. The lowest section is referred to as the base, channel, and bench and serves to connect incoming pipe to outgoing. Riser rings (typically 48 inches) and grade rings are stacked above and joined with rubber gaskets. The top section is an eccentric cone matching a 24 inch diameter frame.

Older units may be built of brick or cast-in-place concrete. All units are fitted with access plates and ladders.

Instrumentation (CSI 15135)

Pressure gauges are typically provided at the suction and discharge of each pump or pump group.

Supports & Anchors (CSI 15140)

Pipe hangers and supports are provided to support piping and allow for expansion and contraction. They should be securely attached to permanent construction at sufficiently close intervals.

Insulation (CSI 15250)

Chilled water piping should be insulated to reduce pipe surface condensation and provide energy efficiency.

Equipment Controls **& Panels** (CSI 15950)

Few controls are required in the typical site chilled water system. The system is usually started when HVAC systems are started annually and left to run continuously throughout the season.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Some pumps may employ a variable frequency controller to regulate speed.

0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

OTHER RELATED COMPONENTS

Refer to Mechanical, Volume 8, for additional deficiencies that may impact this system.

0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

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DEFICIENCY FACTORS
0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion.
- Inability of system to deliver rated capacity to buildings due to internal scaling of the distribution network; pumping failures.

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller.
Excessive Noise, Vibration:	Wear, imbalance, misalignment, failed isolators, improper anchorage.
Severe Corrosion:	Age, lack of maintenance, local environment.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment, poor system design.
inadequate Capacity:	Low pressure, low flow caused by wear.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment, failed isolators, improper anchorage.
Excessive Corrosion:	Poor maintenance, local environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Expansion Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support, local environment.
Corrosion:	Weathering, fuel contamination, local environment.
Excess Corrosion of Baffles, Supports:	Poor maintenance, extreme environmental conditions.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
External Leakage:	Severe internal or external corrosion, cracked concrete, split metal, gasket failure at fittings.
Loose, Missing Fasteners:	Corrosion, damage.
Leaking Heat Coil:	Thermal fatigue, corrosion.

DEFICIENCY FACTORS
0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

SYSTEM ASSEMBLIES/DEFICIENCIES

Expansion Tanks (Continued)	
Internal Corrosion:	Poor maintenance, inadequate venting, fuel contamination, heating coil leakage, local environment.
Tank, Pipe, Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Inadequate Pressure:	Failure of makeup valve, inert gas system.
Access Plate Seal Leakage:	Defective gasket.
Piping & Fittings	
Strainers Inaccessible:	Corroded fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
Physical Damage:	Bent, broken, crimped, crushed.
Valves	
Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, use of incompatible materials, local environment.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.
Manholes & Catch Basins	
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, lack of maintenance, local environment.
Physical Damage:	Collapsed, cracked.
Instrumentation	
Missing:	Taken out for service or repair, not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	Corrosion, physical damage.

DEFICIENCY FACTORS
0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Supports & Anchors

Missing:	Improper installation, poor maintenance.
Improper Alignment:	improper installation, poor maintenance.
Poor Allowance for Expansion:	Improper installation, poor maintenance.

Insulation

Missing:	Never installed or taken off and not replaced.
Wet:	Caused by system leakage or external causes.
Damaged:	Physical abuse.

Equipment Controls & panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Age, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted, Burned:	Normal wear, overloading.
Missing:	Removed for maintenance, never replaced.

DEFICIENCY FACTORS
0.12.01.03.02 CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)

END OF SUBSECTION

0.12.01.04.01 SWITCHYARDS (CSI 16200)

DESCRIPTION

The typical switchyard can be located above or below ground and is that part of the electrical distribution system used to interconnect several systems or subsystems. Although a switchyard is normally associated with a high Voltage transmission system, it may also be part of a medium Voltage subtransmission or distribution system. The switchyard may also contain ancillary systems such as structures, platforms, towers, maintenance buildings, low Voltage service and distribution systems and lighting systems. This complex assembly, normally referred to as the “switchyard,” is the result of good engineering and economic decisions.

SWITCHYARD EQUIPMENT

A typical listing of common switchyard equipment follows. The list does not address the ancillary systems that may be present and are the subject of Volume 9 of the CAS Program.

- Busway (Bus Duct)
- Communication Circuits
- Concrete Support Pads
- Conductors & Fittings
- Disconnects
- Lighting
- Lightning Protection & Surge Suppression
- Metering
- Precast Concrete Poles
- Raceway & Fittings
- Signal Circuits
- Steel Towers & Poles
- Switchgear
- Tower & Pole Foundations
- Utility Service Tunnels
- Utility Service Tunnels: Dampproofing/Waterproofing
- Wood Poles

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Busway (Bus Duct) (CSI **16465)**

A busway is a device consisting of a grounded metal enclosure containing factory-mounted, bare or insulated conductors that are usually copper or aluminum bars, rods, or tubes. A busway may be intended for a specific application and is so marked; it has a maximum rated Voltage of 600 Volts. A similar device used at Voltages larger than 600 is referred to as metal-enclosed bus and consists of three types: isolated phase, segregated phase, and nonsegregated phase. Isolated phase and segregated phase metal-enclosed bus are typically found in utility stations. Nonsegregated metal-enclosed bus is commonly used to connect transformers and switchgear and to interconnect switchgear lineups.

Communication Circuits (CSI **16700)**

A variety of equipment is an inherent part of communication circuits and includes, but is not limited to, the following:

- Fittings: Special components normally used to shield and/or protect the conductors used in a communication circuit. The fitting will sustain the characteristics of the communication circuit if such is required.
- Seals: Special fittings or materials used to secure the penetration of a barrier by communication circuits or to isolate one area from another area where communication circuits interrupt that isolation. The seal maintains the characteristics of the communication circuit if so required.
- Protectors: Items of equipment used to establish boundary conditions of Voltage and current permitted in the communication circuit; they are concerned primarily with isolating the communication device from excessive Voltage surges.

Concrete Support Pads (CSI **03300)**

See Electrical infrastructure (0.12.01.05) CAS Volume 12 for a description.

0.12.01 ■ O4.01 SWITCHYARDS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Conductors & Fittings (CSI 16120)

A material, usually in the form of a wire, cable, or bus bar, that is suitable for carrying an electric current. A conductor may be solid with or without insulation, or a stranded conductor with or without insulation and other coverings (single-conductor) or a combination of conductors insulated from one another (multiple conductor). Conductors may also be referred to as bundled, covered, grounded, insulated, shielded, line, and open conductors (see glossary for a description of each). Further, a conductor may be referred to as a cable (see glossary for a description). In addition, cables as conductors, have associated ancillary units or extensions. These ancillary units include spacer cable, messenger cable, cable termination, cable jacket, and cable sheath (see glossary for a description).

The conductors more common in switchyards and substations are a solid metal or tube type bus supported on insulators, noninsulated conductors supported by insulators, or insulated cable. Fittings include splices and terminations, and normally maintain conductor/cable characteristics in addition to meeting other requirements.

Disconnects (CSI 16200)

Disconnects are devices used to isolate one circuit section from another or to isolate a load from a source. Specific disconnect devices identified in this section are air break switches, circuit breakers, cutouts, isolation switches, circuit reclosers, oil switches, repeater cutouts, network protectors, and vacuum circuit breakers.

- Air Break Switches: Air break switches have both blade and stationary contacts equipped with arcing horns. These horns are pieces of metal between which an arc may form when opening an energized circuit. As the blade or movable contact moves away from the stationary contact its horn also moves, thus stretching an arc to a break point.
- Circuit Breakers: Circuit breakers are used to protect the switchyard and to connect and/or isolate the switchyard circuits in accordance with established parameters and operating conditions. The circuit breaker is normally an oil-filled device in high Voltage circuits. However, air circuit breakers and vacuum devices are also found. Vacuum circuit breakers differ from air circuit breakers in that the main contacts and interrupters are in a vacuum bottle and are not accessible for cleaning, repair, or adjustment. Indicators that reflect contact wear are sometimes provided.
- Circuit Recloser: A circuit recloser is a switch with additional ancillary devices. These additional devices monitor line current and at a predetermined value initiate action to open the switch; when the line current falls, the devices close the switch and restore the circuit. The additional ancillary devices are controllable to permit consideration of local or system conditions; the switch may be locked opened after one or more closures and the interrupt time is adjustable. The interrupting medium can be either oil or vacuum.
- Cutouts: Cutouts are fused devices used for protection and isolation in switching substations. Two types, the enclosed and the open link, are in general use today (the enclosed is more often found in distribution systems serving residential areas). Modern enclosed cutouts will drop “open” the fuse holder or an indicator after the fuse has melted on overcurrent, allowing a rapid “drive-by” status survey.

0.12.01 .04.01 SWITCHYARDS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Disconnects (CSI 16200) (Continued)

- Isolation Switches: Isolation switches are used to isolate a circuit or load from some other part of an electrical system. The isolation switch is designed to carry rated current at or below rated Voltage; however, the isolation switch is not designed nor rated to interrupt load current. Further, care must be exercised when isolation switches are operated due to the possibility of charging currents. (In one reported case, an unloaded, 50 mile, 132,000 Volt transmission line was found to have a charging current of 20 Amperes. A switch was opened and an arc of 132 feet was produced. Favorable oblique winds prevented a phase-to-phase short across a conductor spacing of 16 feet.)
- Network Protectors: Network protectors are air circuit breakers with specialized relays that sense network conditions and initiate appropriate circuit breaker action.
- Oil Switches: An oil switch is normally employed to protect from overloads, short circuit fault currents, and other abnormal conditions. The switch contacts are immersed in an oil that serves several functions. The oil is an insulator that tends to quench any arc formed during switch operation. The formation of an arc in an airtight tank pressurizes the tanks with vaporized oil, and this provides additional arc quenching.
- Repeater Cutouts: Repeater cutouts normally consist of two or more fused devices with additional ancillary devices, permitting several fused devices to be place in operation sequentially. Thus, if an overcurrent melts the first fuse, the cutout opens and mechanically places the next fused device into operation. This continues until all fused devices have been used or the overload condition has been removed.

Lighting (CSI 16600)

A lighting system converts electrical energy to energy in the visible frequency spectrum. The light system consists of the luminary and the necessary devices to connect the luminary to the low Voltage distribution system. The lighting system may be one using incandescent, fluorescent, or High Intensity Discharge (HID) equipment.

Lightning protection & Surge Suppression (CSI 16670)

A variety of equipment is used for Lightning Protection and Surge Suppression. Lightning protection may involve shielding the protected system by placing conductors with air terminals, connecting special devices to the electrical circuit being protected, or a combination of both. The shielding conductor and air terminals comply with NFPA 78 or an established engineering study for the protected system. Connected devices include, but are not limited to the following type of devices.

- Valve Arresters: Devices constructed with a non-linear resistive element in series with a spark gap and enclosed in a casing normally made of porcelain. Common non-linear elements are made of thyrite. Several devices may be constructed in series to meet the normal operational Voltages of the system(s).
- Expulsion Arresters: Devices with a spark gap connected in series with a hollow fiber tube. Gases created in the hollow tube are ejected in an explosive manner, which reduces follow-up current flow to a level interruptible by the spark gap.
- Choke Coils: Surge protection is achieved with choke coils, which offer a large reactance to the high frequency lightning-induced surge. The choke coil shunts the lightning-induced surge away from the protected apparatus to a strategically placed arrester.

0.12.01.04.01 SWITCHYARDS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Metering (CSI 18430)

Metering is a collection of devices such as Voltmeters, ammeters, switches, and ancillary devices used to measure various electrical parameters. Metering may be used to control the electrical system or to indicate selected parameters monitored by an operator. Ancillary metering devices may also be used for other control systems such as overcurrent or overvoltage relaying.

Precast Concrete Poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Raceway **&** Flfflngs (CSI 18110)

A raceway is an enclosed channel for holding wire, cables, or busbars. The more common forms of raceway include flexible and rigid conduit, tubing, and wireways. Fittings include bushings, locknuts, and conduit bodies.

Signal Circuits (CSI 18740)

Equipment used in signal circuits (as defined herein) are standard electrical devices and materials with additional use constraints. If power is not required to be limited to some established level then the circuit is rated as a Class 1 circuit. If Voltage and current are limited normally in accordance with NFPA standards, the circuit is rated as Class 2 or Class 3, and equipment and material rated for that class is used.

Steel Towers & Poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Switchgear (CSI 18425)

Switchgear assemblies include switches, circuit breakers, fuses, metering equipment, relays, and/or other forms of equipment to control the electric current distributed throughout an area. Switchgear is used in all Voltage ranges; however, it is frequently referred to as switchboard in the low Voltage range.

Tower **&** Pole Foundations (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Utility Service Tunnels (CSI 02300)

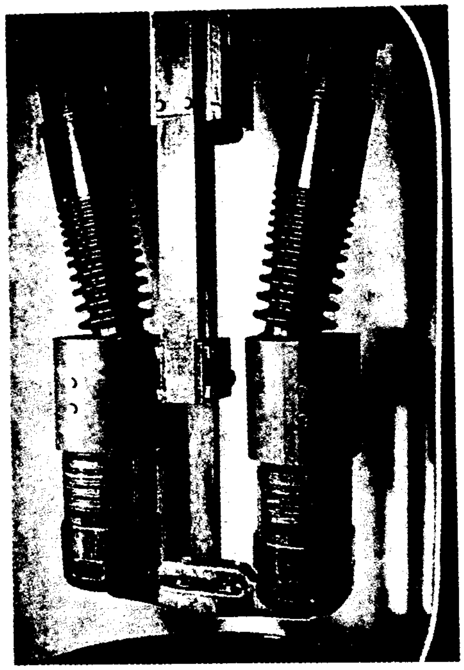
See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Utility Service Tunnels: **Dampproofing/Waterproofing** (CSI 02300)

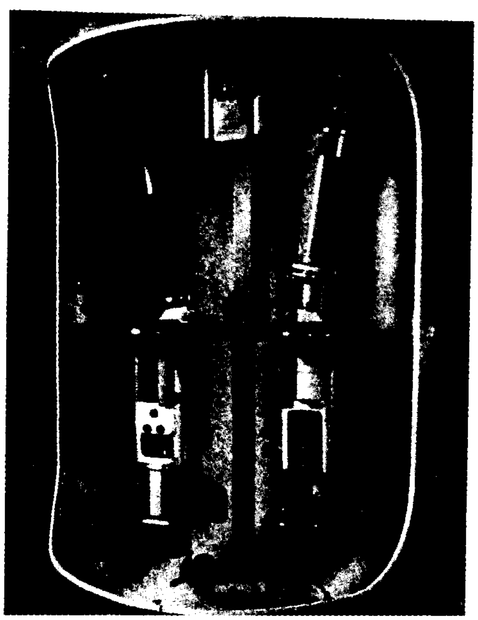
See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Wood Poles (CSI 02780)

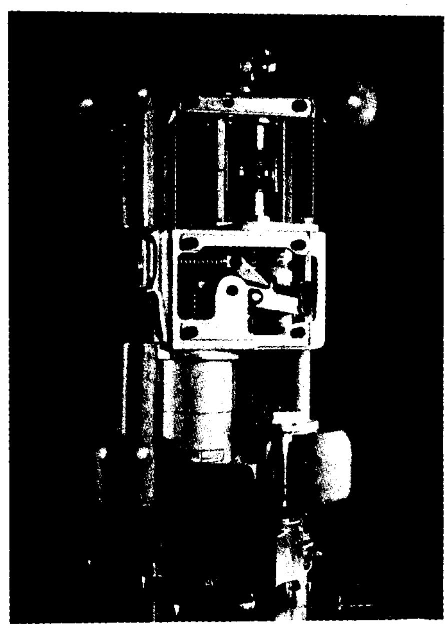
See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.



ORIGINAL CONFIGURATION:
ORIGINAL OIL CIRCUIT BREAKER



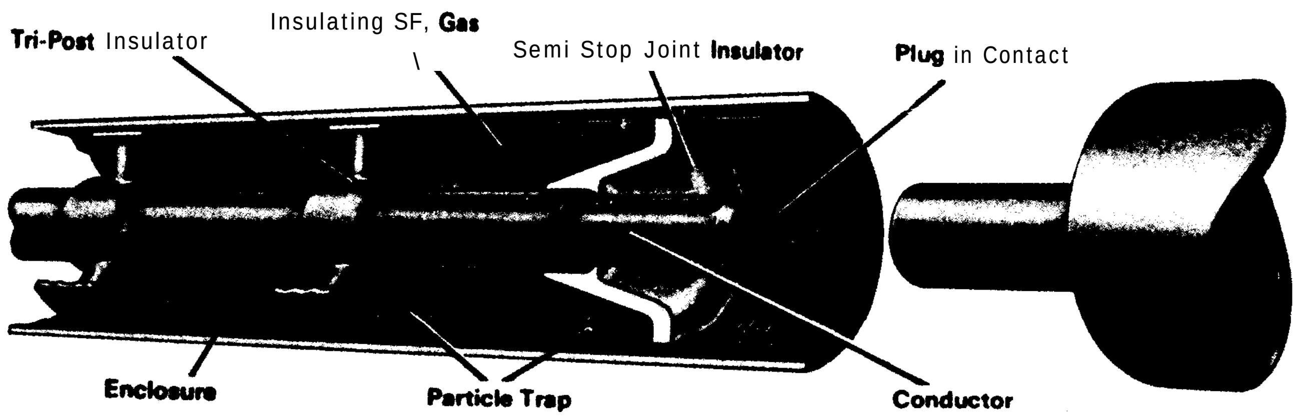
CURRENT CONFIGURATION:
VACUUM CIRCUIT BREAKER REPLACEMENT KIT



REPLACEMENT KIT:
CREATES VACUUM
CIRCUIT BREAKER REPLACEMENT KIT

SOURCE: ABB POWER T & D COMPANY INC. CATALOG 50-000

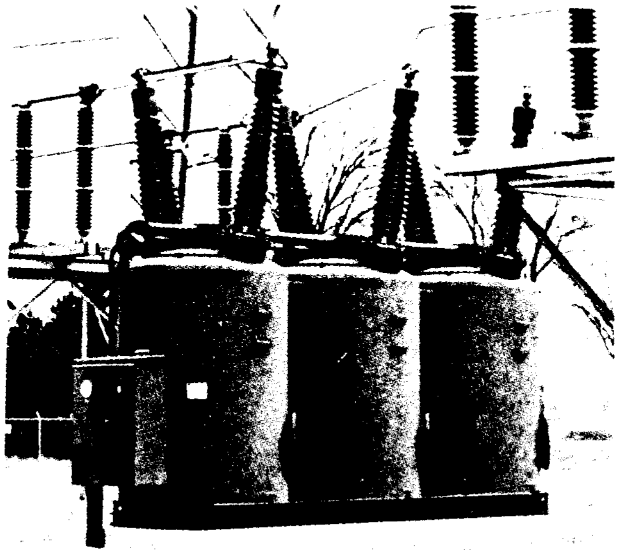
SYSTEM ASSEMBLY DETAILS-SITEWORK	CIRCUIT BREAKERS		
ELECTRICAL SWITCHYARDS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010401-1



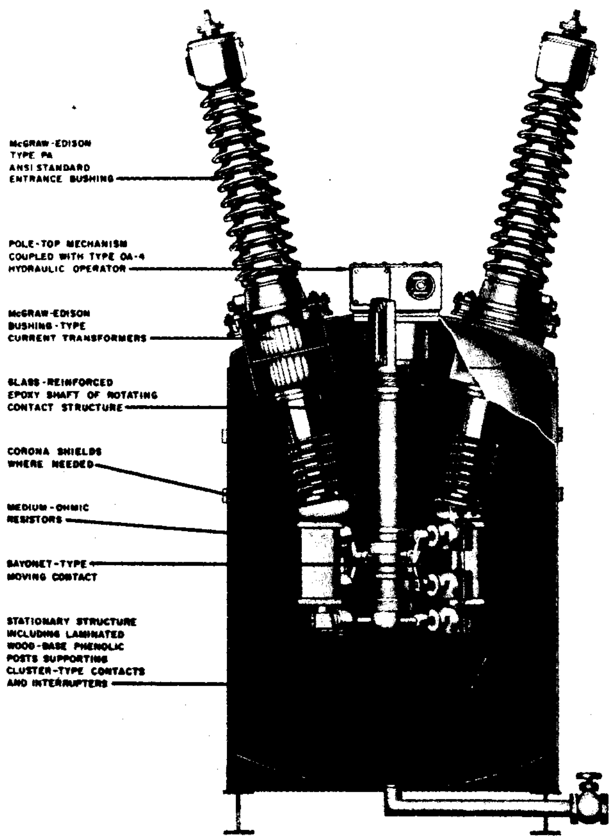
COMPRESSED GAS INSULATED TRANSMISSION BUS

SOURCE: ABB POWER T & D COMPANY INC. CATALOG 50-000

SYSTEM ASSEMBLY DETAILS-SITEWORK	BUS		
ELECTRICAL SWITCHYARDS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010401-2



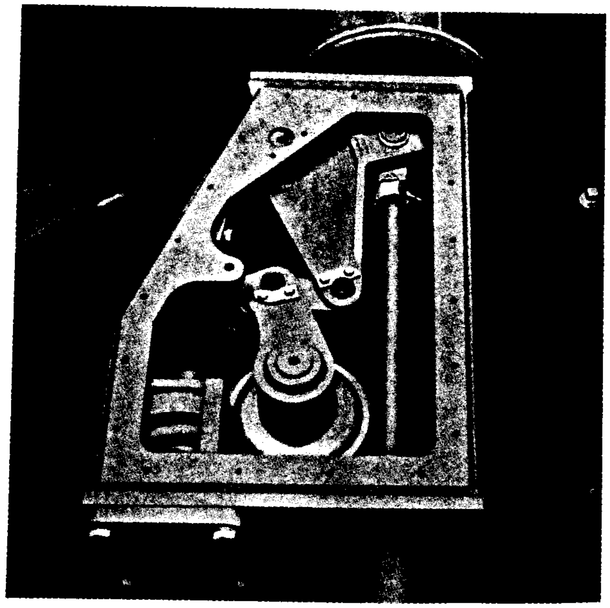
OIL CIRCUIT BREAKER



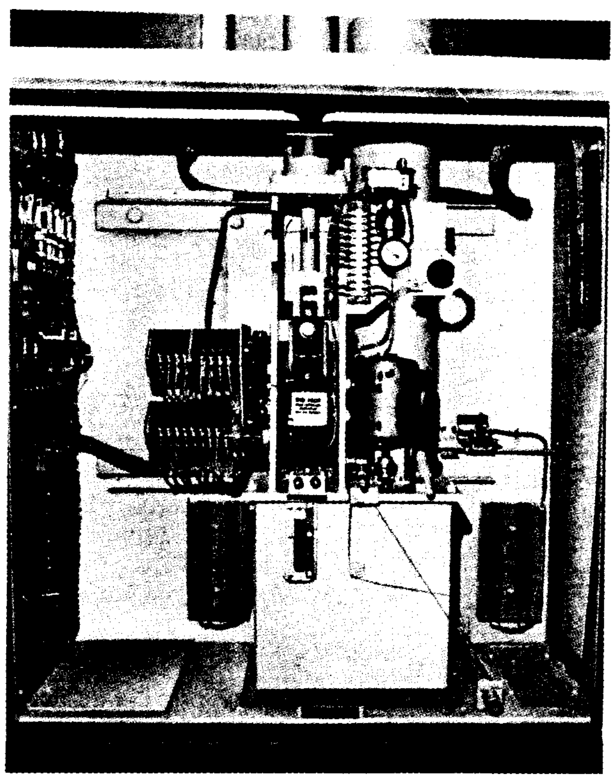
OIL CIRCUIT BREAKER CUTAWAY

SOURCE: McGRAW–EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIER'S CATALOG TRANSMISSION–DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	OIL CIRCUIT BREAKER		
ELECTRICAL SWITCHYARDS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010401-3



OIL CIRCUIT BREAKER POLE TOP MECHANISM



OIL CIRCUIT BREAKER OPERATING MECHANISM CONTROL CABINET

SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIER'S CATALOG TRANSMISSION-DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	OIL CIRCUIT BREAKER COMPONENTS		
ELECTRICAL SWITCHYARDS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010401-4

DEFICIENCY FACTORS
0.12.01.04.01 SWITCHYARDS (CSI 16200)

PROBABLE FAILURE POINTS

- Component grounding - components/devices are not adequately grounded or a grounding system is not in place.
- Device contacts - stationary and movable contacts are burned, pitted, or misaligned.
- Enclosures - not clean and moisture-free; oil leaks.
- Insulating liquid - does not meet criteria for continued use.
- Insulators - cracked, chipped, or have unacceptable surface contamination.
- Protective relays - malcalibrated when measured against manufacturer operation/-maintenance requirements. Inoperative on receipt of correct time-current signal.
- Splices - connections are not properly made or torqued.
- Switchgear - altered for new uses without revision of protective relaying engineering study.

SYSTEM ASSEMBLIES/DEFICIENCIES

Busway:	See CAS Volume 9 for deficiency factors.
Communication Circuits:	See CAS Volume 9 for deficiency factors for communication circuits.
Concrete Support Pads:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for concrete support pads.
Conductors & Fittings:	See CAS Volume 9 for deficiency factors for conductors and fittings.
Disconnects:	See CAS Volume 9 for deficiency factors for disconnects
Lighting:	See CAS Volume 9 for deficiency factors for lighting.
Lightning Protection & Surge Suppression:	See CAS Volume 9 for deficiency factors for lightning protection and surge suppression.
Metering:	See CAS Volume 9 for deficiency factors for metering.
Precast Concrete Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for precast concrete poles.
Raceway & Fittings:	See CAS Volume 9 for deficiency factors for raceway and fittings.
Signal Circuits:	See CAS Volume 9 for deficiency factors for signal circuits.
Steel Towers & Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for steel towers and poles.
Switchgear:	See CAS Volume 9 for deficiency factors for switchgear.
Tower & Pole Foundations:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for tower and pole foundations.
Utility Service Tunnels:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels.

DEFICIENCY FACTORS
0.12.01.04.01 SWITCHYARDS (CSI 16200)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Utilty Service Tunnels: Dampproofing/Waterproofing:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels: dampproofing/-waterproofing.
Wood Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for wood poles.

END OF SUBSECTION

0.12.01.04.02 SUBSTATIONS (CSI 16200)

DESCRIPTION

A typical transformer substation can be located above or below ground and is easily described as a switchyard with a transformer having primary and secondary protection, used to change an electrical system or subsystem Voltage. This description is adequate if one recognizes that the substation may consist of several transformers, and that primary and secondary protection are configured to provide protection for the individual transformers as well as the full substation. This complex assembly may also contain ancillary systems such as structures, platforms, towers, maintenance buildings, a low Voltage distribution system, and a lighting system. This complex assembly, normally referred to as the "substation," is the result of good engineering and economic decisions.

TRANSFORMER SUBSTATION EQUIPMENT

A typical listing of common transformer substation equipment follows. The list does not address the ancillary systems that may be present and are the subject of Volume 9 of the CAS Program.

- Busway (Bus Duct)
- Communication Circuits
- Concrete Support Pads
- Conductors & Fittings
- Disconnects
- Lighting
- Lightning Protection & Surge Suppression
- Metering
- Precast Concrete Poles
- Raceway & Fittings
- Signal Circuits
- Steel Towers & Poles
- Switchgear
- Tower & Pole Foundations
- Transformers
- Utility Service Tunnels
- Utility Service Tunnels: Dampproofing/Waterproofing
- Wood Poles

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Busway (Bus Duet) (CSI 16465)

A busway is a device consisting of a grounded metal enclosure containing factory-mounted, bare or insulated conductors that are usually copper or aluminum bars, rods, or tubes. A busway may be intended for a specific application and is so marked; it has a maximum rated Voltage of 600 Volts. A similar device used at Voltages larger than 600 is referred to as metal-enclosed bus and consists of three types: isolated phase, segregated phase, and nonsegregated phase. Isolated phase and segregated phase metal-enclosed bus are typically found in utility stations. Nonsegregated metal-enclosed bus is commonly used to connect transformers and switchgear and to interconnect switchgear lineups.

Communication Circuits (CSI 16700)

A variety of equipment is an inherent part of communication circuits and includes, but is not limited to, the following:

- Fittings: Special components normally used to shield and/or protect the conductors used in a communication circuit. The fitting will sustain the characteristics of the communication circuit if such is required.
- Seals. Special fittings or materials used to secure the penetration of a barrier by communication circuits or to isolate one area from another area where communication circuits interrupt that isolation. The seal maintains the characteristics of the communication circuit if so required.
- Protectors: Items of equipment used to establish boundary conditions of Voltage and current permitted in the communication circuit; they are concerned primarily with isolating the communication device from excessive Voltage surges.

0.12.01 ■ 4.02 SUBSTATIONS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Concrete Support Pads (CSI 03300)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Conductors & Fittings (CSI 18120)

A conductor is a material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current. A conductor may be solid with or without insulation, or a stranded conductor with or without insulation and other coverings (single-conductor) or a combination of conductors insulated from one another (multiple conductor). Conductors may also be referred to as bundled, covered, grounded, insulated, shielded, line, and open conductors (see glossary for a description of each). Further, a conductor may be referred to as a cable (see glossary for a description). In addition, cables as conductors, have associated ancillary units or extensions. These ancillary units include spacer cable, messenger cable, cable termination, cable jacket, and cable sheath (see glossary for a description).

The conductors more common in switchyards and substations are a solid metal or tube type bus supported on insulators, noninsulated conductors supported by insulators, or insulated cable. Fittings include splices and terminations, and normally maintain conductor/cable characteristics in addition to meeting other requirements.

Disconnects (CSI 16200)

Disconnects are devices used to isolate one circuit section from another or to isolate a load from a source. Specific disconnect devices identified in this section are air break switches, circuit breakers, cutouts, isolation switches, circuit reclosers, oil switches, repeater cutouts, network protectors, and vacuum circuit breakers.

- <u>Air Break Switches</u>: Air break switches have both blade and stationary contacts equipped with arcing horns. These horns are pieces of metal between which an arc may form when opening an energized circuit. As the blade or movable contact moves away from the stationary contact its horn also moves, thus stretching an arc to a break point.

- <u>Circuit Breakers</u>: Circuit breakers are used to protect the switchyard and to connect and/or isolate the switchyard circuits in accordance with established parameters and operating conditions. The circuit breaker is normally an oil-filled device in high Voltage circuits. However, air circuit breakers and vacuum devices are also found. Vacuum circuit breakers differ from air circuit breakers in that the main contacts and interrupters are in a vacuum bottle and are not accessible for cleaning, repair, or adjustment. Indicators that reflect contact wear are sometimes provided.

- <u>Circuit Recloser</u>: A circuit recloser is a switch with additional ancillary devices. These additional devices monitor line current and at a predetermined value initiate action to open the switch; when the line current falls, the devices close the switch and restore the circuit. The additional ancillary devices are controllable to permit consideration of local or system conditions; the switch may be locked opened after one or more closures and the interrupt time is adjustable. The interrupting medium can be either oil or vacuum.

- <u>Cutouts</u>: Cutouts are fused devices used for protection and isolation in switching substations. Two types, the enclosed and the open link, are in general use today (the enclosed is more often found in distribution systems serving residential areas). Modern enclosed cutouts will drop “open” the fuse holder or an indicator after the fuse has melted on overcurrent, allowing a rapid “drive-by” status survey.

0.12.01.04.02 SUBSTATIONS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Disconnects (CSI 16200) (Continued)

- Isolation Switches: Isolation switches are used to isolate a circuit or load from some other part of an electrical system. The isolation switch is designed to carry rated current at or below rated Voltage; however, the isolation switch is not designed nor rated to interrupt load current. Further, care must be exercised when isolation switches are operated due to the possibility of charging currents.
- Network Protectors: Network protectors are air circuit breakers with specialized relays that sense network conditions and initiate appropriate circuit breaker action.
- Oil Switches: An oil switch is normally employed to protect from overloads, short circuit fault currents, and other abnormal conditions. The switch contacts are immersed in an oil that serves several functions. The oil is an insulator that tends to quench any arc formed during switch operation. The formation of an arc in an airtight tank pressurizes the tanks with vaporized oil, and this provides additional arc quenching.
- Repeater Cutouts: Repeater cutouts normally consist of two or more fused devices with additional ancillary devices, permitting several fused devices to be place in operation sequentially. Thus, if an overcurrent melts the first fuse, the cutout opens and mechanically places the next fused device into operation. This continues until all fused devices have been used or the overload condition has been removed.

Lighting (CSI 16500)

A lighting system converts electrical energy to energy in the visible frequency spectrum. The light system consists of the luminary and the necessary devices to connect the luminary to the low Voltage distribution system. The lighting system may be one using incandescent, fluorescent, or High Intensity Discharge (HID) equipment.

Lightning protection & Surge Suppression (CSI 18870)

A variety of equipment is used for Lightning Protection and Surge Suppression. Lightning protection may involve shielding the protected system by placing conductors with air terminals, connecting special devices to the electrical circuit being protected, or a combination of both. The shielding conductor and air terminals comply with NFPA 78 or an established engineering study for the protected system. Connected devices include, but are not limited to the following type of devices.

- Valve Arresters: Devices constructed with a non-linear resistive element in series with a spark gap and enclosed in a casing normally made of porcelain. Common non-linear elements are made of thyrite. Several devices may be constructed in series to meet the normal operational Voltages of the system(s).
- Expulsion Arresters: Devices with a spark gap connected in series with a hollow fiber tube. Gases created in the hollow tube are ejected in an explosive manner, which reduces follow-up current flow to a level interruptible by the spark gap.
- Choke Coils: Surge protection is achieved with choke coils, which offer a large reactance to the high frequency lightning-induced surge. The choke coil shunts the lightning-induced surge away from the protected apparatus to a strategically placed arrester.

0.12.01.04.02 SUBSTATIONS (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Metering (CSI 18430)

Metering is a collection of devices such as Voltmeters, ammeters, switches, and ancillary devices used to measure various electrical parameters. Metering may be used to control the electrical system or to indicate selected parameters monitored by an operator. Ancillary metering devices may also be used for other control systems such as overcurrent or overvoltage relaying.

Precast Concrete Poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description

Raceway **& Fittings** (CSI 18110)

A raceway is an enclosed channel for holding wire, cables, or busbars. The more common forms of raceway include flexible and rigid conduit, tubing, and wireways. Fittings include bushings, locknuts, and conduit bodies.

Signal **Circuits** (CSI 18740)

Equipment used in signal circuits (as defined herein) are standard electrical devices and materials with additional use constraints. If power is not required to be limited to some established level then the circuit is rated as a Class 1 circuit. If Voltage and current are limited normally in accordance with NFPA standards, the circuit is rated as Class 2 or Class 3, and equipment and material rated for that class is used.

Steel lowers **&** poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Swltchgear (CSI 18425)

Switchgear assemblies include switches, circuit breakers, fuses, metering equipment, relays, and/or other forms of equipment to control or record the electric current distributed throughout an area. Switchgear is used in all Voltage ranges; however, it is referred to as switchboard in the low Voltage range.

lower **&** Pole Foundations (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Transformers (CSI 18320)

A device used to change the Voltage delivered to a load or to isolate a load electrically from its source. As used here, the term does not include units installed as part of some other device or load.

Utility Service Tunnels (CSI 02300)

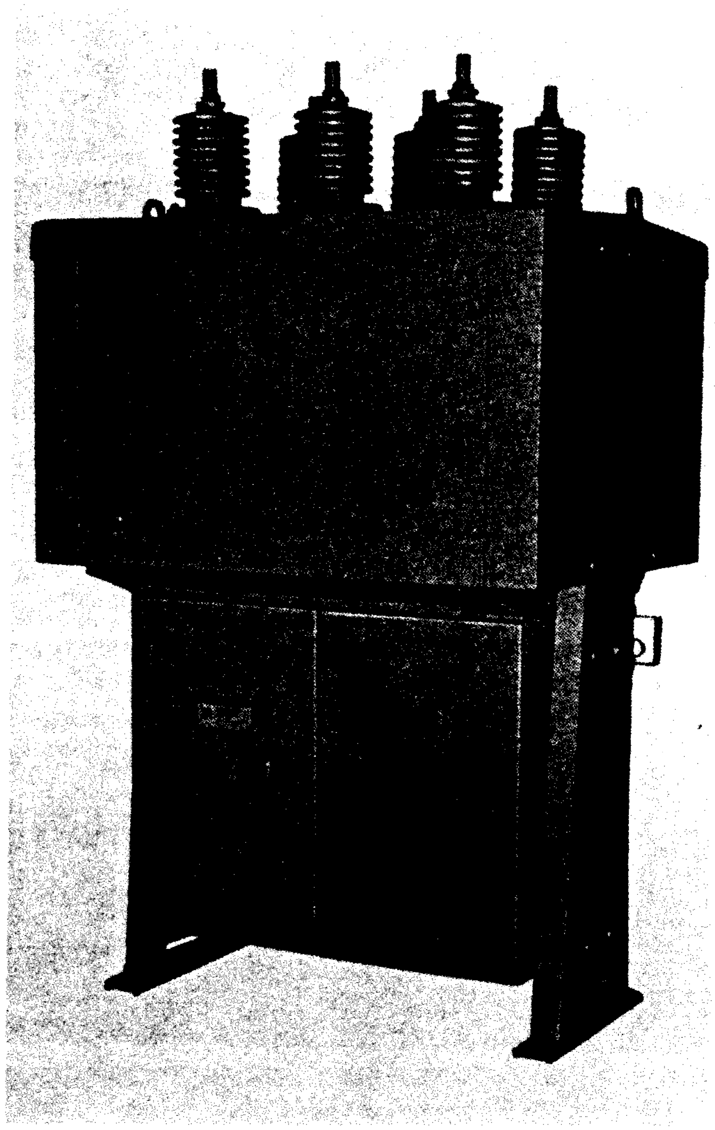
See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Utility Service Tunnels: **Dampproofing/Waterproofing** (CSI 02300)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

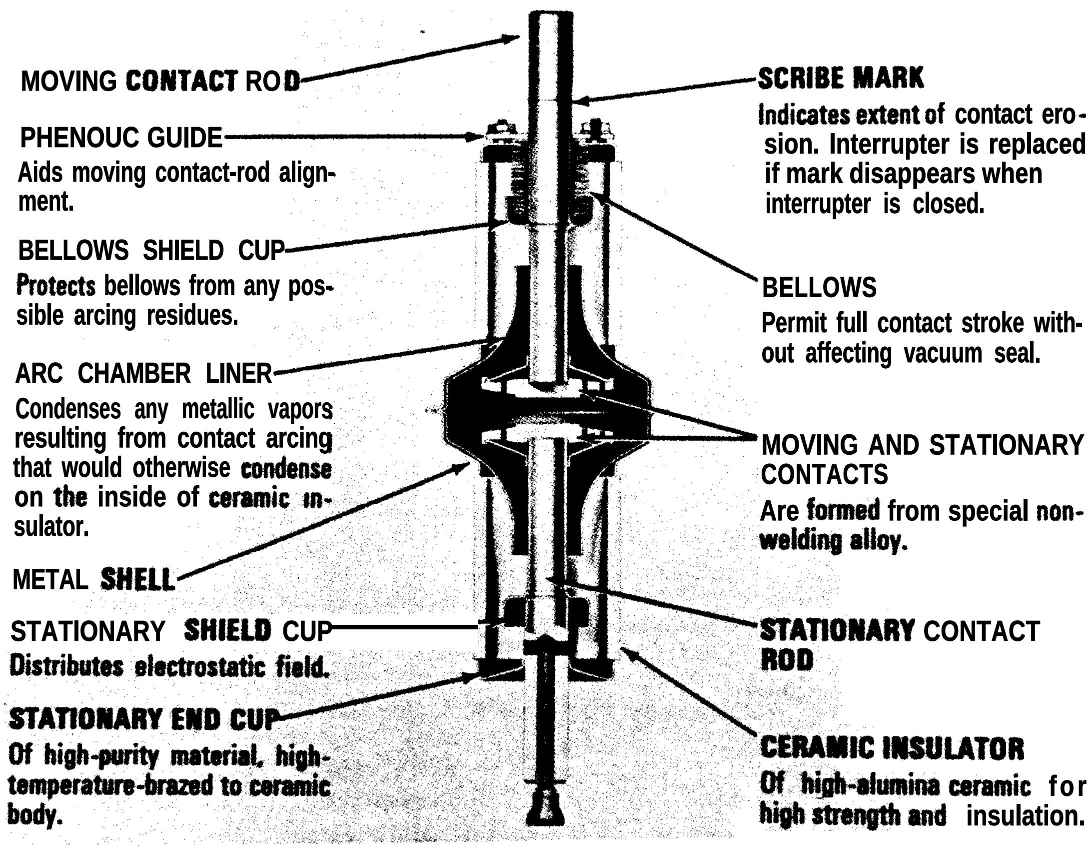
Wood Poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.



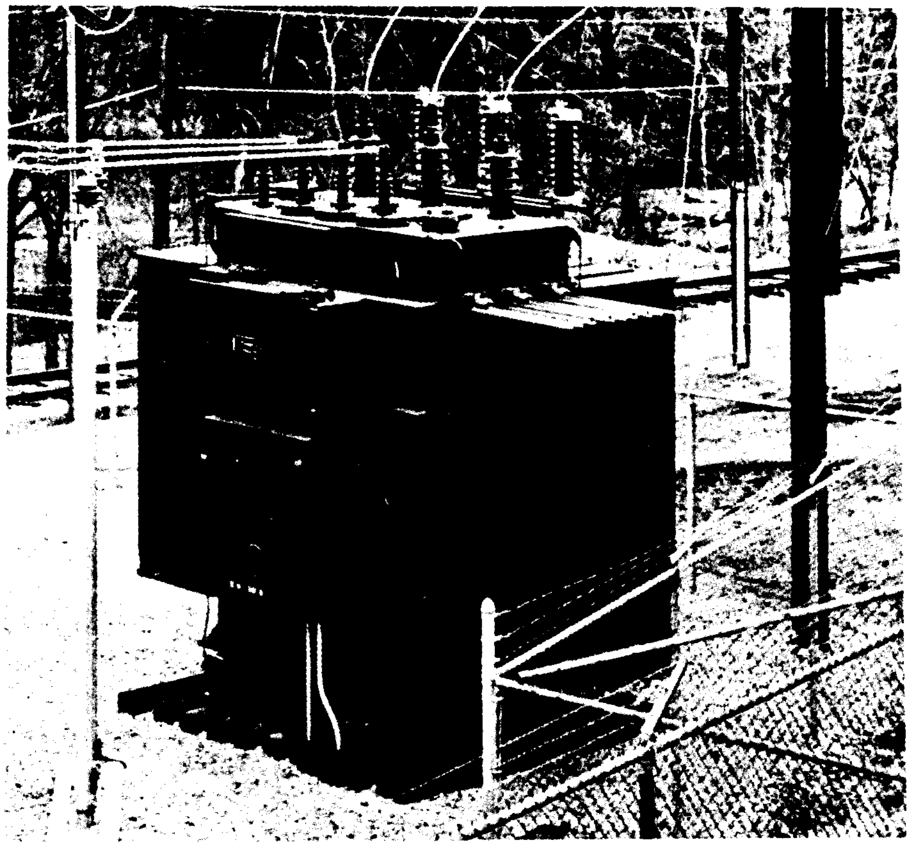
SOURCE: ABB POWER T&D COMPANY INC. CATALOG 50-000

SYSTEM ASSEMBLY DETAILS-SITEWORK	VACUUM CIRCUIT BREAKER		
ELECTRICAL SUBSTATIONS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010402-1



SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIER'S CATALOG TRANSMISSION-DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	VACUUM INTERRUPTER		
ELECTRICAL SUBSTATIONS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010402-2



SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIER'S CATALOG TRANSMISSION-DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TRANSFORMER		
ELECTRICAL SUBSTATIONS (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010402-3

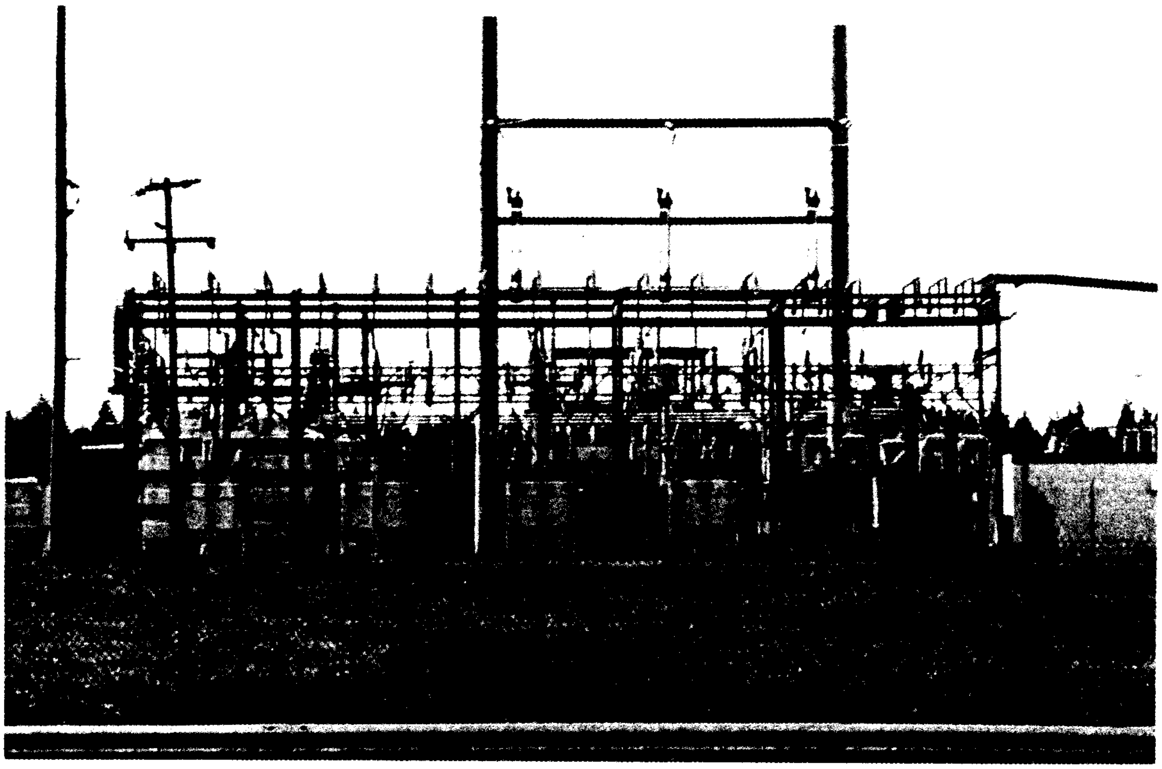


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	OUTDOOR SUBSTATION		
ELECTRICAL SUBSTATIONS (CSI 16310)	Revision No.	Issue Date 5/93	Drawing No. A12010402-4

DEFICIENCY FACTORS
0.12.01.04.02 SUBSTATIONS (CSI 16200)

PROBABLE FAILURE POINTS

- Component grounding - components/devices are not adequately grounded or a grounding system is not in place.
- Device contacts - stationary and movable contacts are burned, pitted or malaligned.
- Enclosures - not clean and moisture-free, oil leaks.
- Insulating liquid - does not meet criteria for continued use.
- Insulators - cracked, chipped, broken, or have unacceptable surface contamination.
- Protective relays - malcalibrated when measured against requirement. Inoperative on receipt of correct time-current signal.
- Switchgear - altered for new uses without revision of protective relaying engineering study.
- Transformer - overloaded.

SYSTEM ASSEMBLIES/DEFICIENCIES

Busway:	See CAS Volume 9 for deficiency factors for busway.
Communication Circuits:	See CAS Volume 9 for deficiency factors for communication circuits.
Concrete Support Pads:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for concrete support pads.
Conductors & Fittings:	See CAS Volume 9 for deficiency factors for conductors and fittings.
Disconnects:	See CAS Volume 9 for deficiency factors for disconnects,
Lighting:	See CAS Volume 9 for deficiency factors for lighting.
Lightning Protection & Surge Suppression:	See CAS Volume 9 for deficiency factors for lightning protection and surge suppression.
Metering:	See CAS Volume 9 for deficiency factors for metering.
Precast Concrete Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for precast concrete poles.
Raceway & Fittings:	See CAS Volume 9 for deficiency factors for raceway and fittings.
Signal Circuits:	See CAS Volume 9 for deficiency factors for signal circuits.
Steel Towers & Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for steel towers and poles.
Switchgear:	See CAS Volume 9 for deficiency factors for switchgear.
Tower & Pole Foundations:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for tower and pole foundations.
Transformers:	See CAS Volume 9 for deficiency factors for transformers.
Utility Service Tunnels:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels.

DEFICIENCY FACTORS
0.12.01 .04.02 SUBSTATIONS (CSI 16200)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Utility Service Tunnels: Dampproofing/Waterproofing:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels: dampproofing/-waterproofing.
Wood Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for wood poles.

END OF SUBSECTION

0.12.01 .04.03 OVERHEAD TRANSMISSION SYSTEM (CSI 16200)

DESCRIPTION

The typical overhead transmission system is that part of the electrical system that transports current from a source to a load using transmission lines placed on poles, platforms, or towers. The connection of the overhead transmission system to the source and the load is most often made through the use of switchyards and substations.

OVERHEAD TRANSMISSION SYSTEM EQUIPMENT

A typical listing of common overhead transmission system equipment follows. The list does not address the ancillary systems that may be present and are the subject of Volume 9 of the CAS Program.

- Communication Circuits
- Conductors & Fittings
- Disconnects
- Lighting
- Lightning Protection & Surge Suppression
- Metering
- Precast Concrete Poles
- Signal Circuits
- Steel Towers & Poles
- Switchgear
- Tower & Pole Foundations
- Wood Poles

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Communication Circuits **(CSI 16700)**

A variety of equipment is an inherent part of communication circuits and includes, but is not limited to, the following:

- Fittings: Special components normally used to shield and/or protect the conductors used in a communication circuit. The fitting will sustain the characteristics of the communication circuit if such is required.

- Seals. Special fittings or materials used to secure the penetration of a barrier by communication circuits or to isolate one area from another area where communication circuits interrupt that isolation. The seal maintains the characteristics of the communication circuit if so required.

- Protectors: Items of equipment used to establish boundary conditions of Voltage and current permitted in the communication circuit; they are concerned primarily with isolating the communication device from excessive Voltage surges.

Conductors **& Fittings (CSI** 16120)

Bare aluminum conductors are normally used in an overhead transmission system. Several types of aluminum conductors are used such as all aluminum, aluminum alloy, aluminum-steel reinforced, aluminum clad-steel reinforced, and aluminum-alloy reinforced. The different types of aluminum conductors are the result of a combination of conductor requirements such as high strength-to-weight ratio, sag characteristics, corrosion resistance, and high ampacity. Insulated cable is sometimes used for primary and secondary overhead distribution where limited space is available or desirable in rights-of-way. It is effective in preventing direct shorts and instantaneous flashovers when tree limbs and other objects make contact or are in very close proximity. The insulated cable is installed on insulators and is treated as a bare conductor. Fittings are those items of hardware used to terminate and protect a conductor by holding, guiding, or shielding the conductor from damage. Fittings normally maintain the cable characteristics in addition to meeting other requirements.

0.12.01.04.03 OVERHEAD TRANSMISSION SYSTEM **(CSI 16200)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Disconnects (CSI 16266)

Disconnects are devices used to isolate one circuit section from another or to isolate a load from a source. Specific disconnect devices identified in this section are air break switches, circuit breakers, cutouts, isolation switches, circuit reclosers, oil switches, repeater cutouts, network protectors, and vacuum circuit breakers.

- Air Break Switches: Air break switches have both blade and stationary contacts equipped with arcing horns. These horns are pieces of metal between which an arc may form when opening an energized circuit. As the blade or movable contact moves away from the stationary contact its horn also moves, thus stretching an arc to a break point.
- Circuit Breakers: Circuit breakers are used to protect the switchyard and to connect and/or isolate the switchyard circuits in accordance with established parameters and operating conditions. The circuit breaker is normally an oil-filled device in high Voltage circuits. However, air circuit breakers and vacuum devices are also found. Vacuum circuit breakers differ from air circuit breakers in that the main contacts and interrupters are in a vacuum bottle and are not accessible for cleaning, repair, or adjustment. Indicators that reflect contact wear are sometimes provided.
- Circuit Recloser: A circuit recloser is a switch with additional ancillary devices. These additional devices monitor line current and at a predetermined value initiate action to open the switch; when the line current falls, the devices close the switch and restore the circuit. The additional ancillary devices are controllable to permit consideration of local or system conditions; the switch may be locked opened after one or more closures and the interrupt time is adjustable. The interrupting medium can be either oil or vacuum.
- Cutouts: Cutouts are fused devices used for protection and isolation in switching substations. Two types, the enclosed and the open link, are in general use today (the enclosed is more often found in distribution systems serving residential areas). Modern enclosed cutouts will drop “open” the fuse holder or an indicator after the fuse has melted on overcurrent, allowing a rapid “drive-by” status survey.
- Isolation Switches: Isolation switches are used to isolate a circuit or load from some other part of an electrical system. The isolation switch is designed to carry rated current at or below rated Voltage; however, the isolation switch is not designed nor rated to interrupt load current. Further, care must be exercised when isolation switches are operated due to the possibility of charging currents.
- Network Protectors: Network protectors are air circuit breakers with specialized relays that sense network conditions and initiate appropriate circuit breaker action.
- Oil Switches: An oil switch is normally employed to protect from overloads, short circuit fault currents, and other abnormal conditions. The switch contacts are immersed in an oil that serves several functions. The oil is an insulator that tends to quench any arc formed during switch operation. The formation of an arc in an airtight tank pressurizes the tanks with vaporized oil, and this provides additional arc quenching.
- Repeater Cutouts: Repeater cutouts normally consist of two or more fused devices with additional ancillary devices, permitting several fused devices to be place in operation sequentially. Thus, if an overcurrent melts the first fuse, the cutout opens and mechanically places the next fused device into operation. This continues until all fused devices have been used or the overload condition has been removed.

0.12.01.04.03 OVERHEAD TRANSMISSION SYSTEM **(CSI 16200)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Ughtlng (CSI 16500)

A lighting system converts electrical energy to energy in the visible frequency spectrum. The light system consists of the luminary and the necessary devices to connect the luminary to the low Voltage distribution system. The lighting system may be one using incandescent, fluorescent, or High Intensity Discharge (HID) equipment.

Ughtning **Protection & Surge Suppression (CSI** 16670)

A variety of equipment is used for Lightning Protection and Surge Suppression. Lightning protection may involve shielding the protected system by placing conductors with air terminals, connecting special devices to the electrical circuit being protected, or a combination of both. The shielding conductor and air terminals comply with NFPA 78 or an established engineering study for the protected system. Connected devices include, but are not limited to the following type of devices.

- Valve Arresters: Devices constructed with a non-linear resistive element in series with a spark gap and enclosed in a casing normally made of porcelain. Common non-linear elements are made of **thyrite**. Several devices may be constructed in series to meet the normal operational Voltages of the system(s).
- Expulsion Arresters: Devices with a spark gap connected in series with a hollow fiber tube. Gases created in the hollow tube are ejected in an explosive manner, which reduces follow-up current flow to a level interruptible by the spark gap.
- Choke Coils: Surge protection is achieved with choke coils, which offer a large reactance to the high frequency lightning-induced surge. The choke coil shunts the lightning-induced surge away from the protected apparatus to a strategically placed arrester.

Metering (CSI **16430)**

Metering is a collection of devices such as Voltmeters, ammeters, switches, and ancillary devices used to measure various electrical parameters. Metering may be used to control the electrical system or to indicate selected parameters monitored by an operator. Ancillary metering devices may also be used for other control systems such as overcurrent or overvoltage relaying.

Precast Concrete polo8 (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Signal **Circuits** (CSI 16700)

Equipment used in signal circuits (as defined herein) are standard electrical devices and materials with additional use constraints. If power is not required to be limited to some established level then the circuit is rated as a Class 1 circuit. If Voltage and current are limited normally in accordance with NFPA standards, the circuit is rated as Class 2 or Class 3, and equipment and material rated for that class is used.

Steel Towers & Poles (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Switchgear (CSI 16425)

Switchgear assemblies include switches, circuit breakers, fuses, metering equipment, relays, and/or other forms of equipment to control the electric current distributed throughout an area. Switchgear is used in all Voltage ranges; however, it is referred to as switchboard in the low Voltage range.

0.12.01.04.03 OVERHEAD TRANSMISSION SYSTEM (CSI 16200)

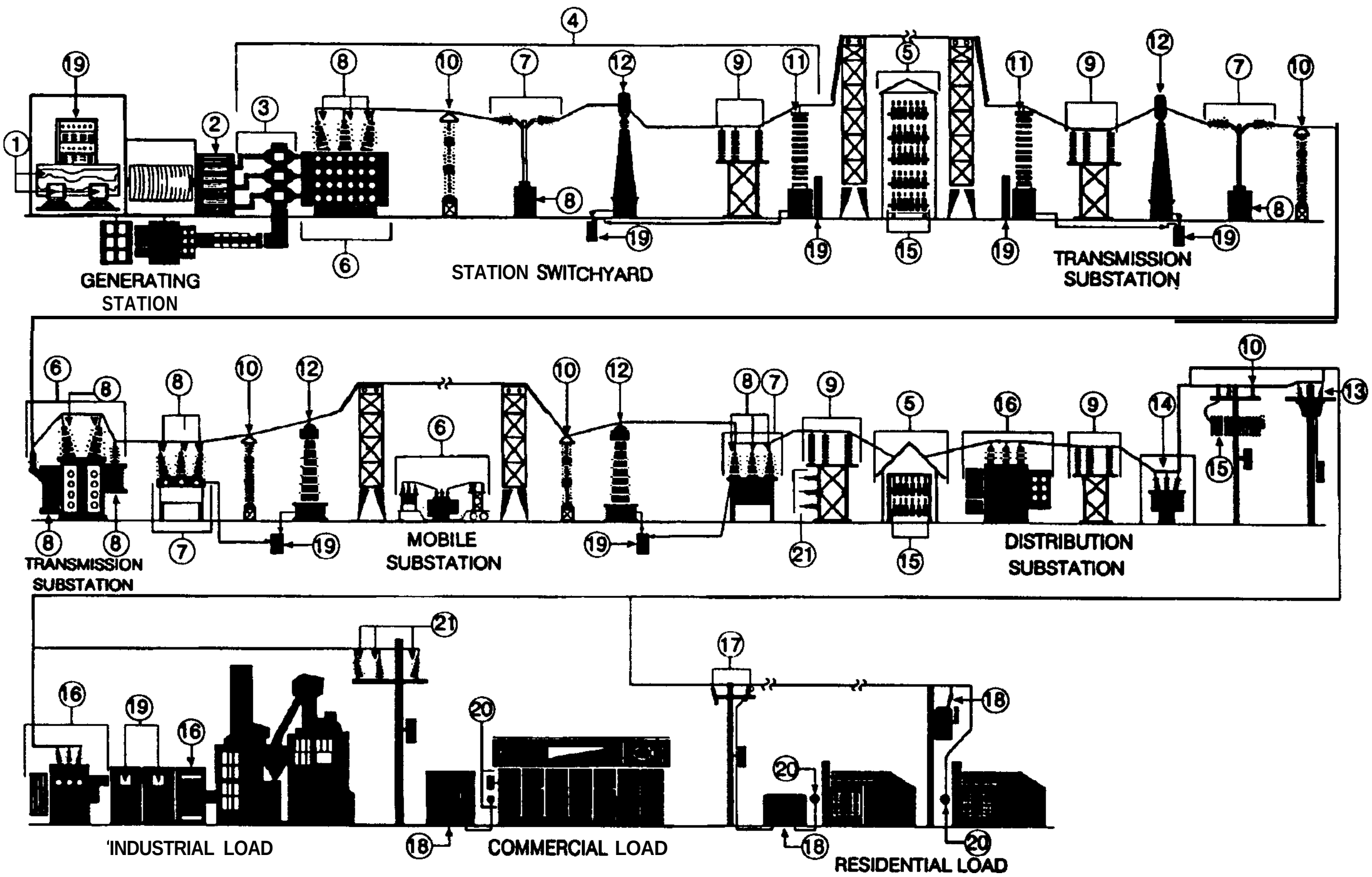
ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Tower & Polo Foundations (CSI 02780)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Wood Poles (CSI 02780)

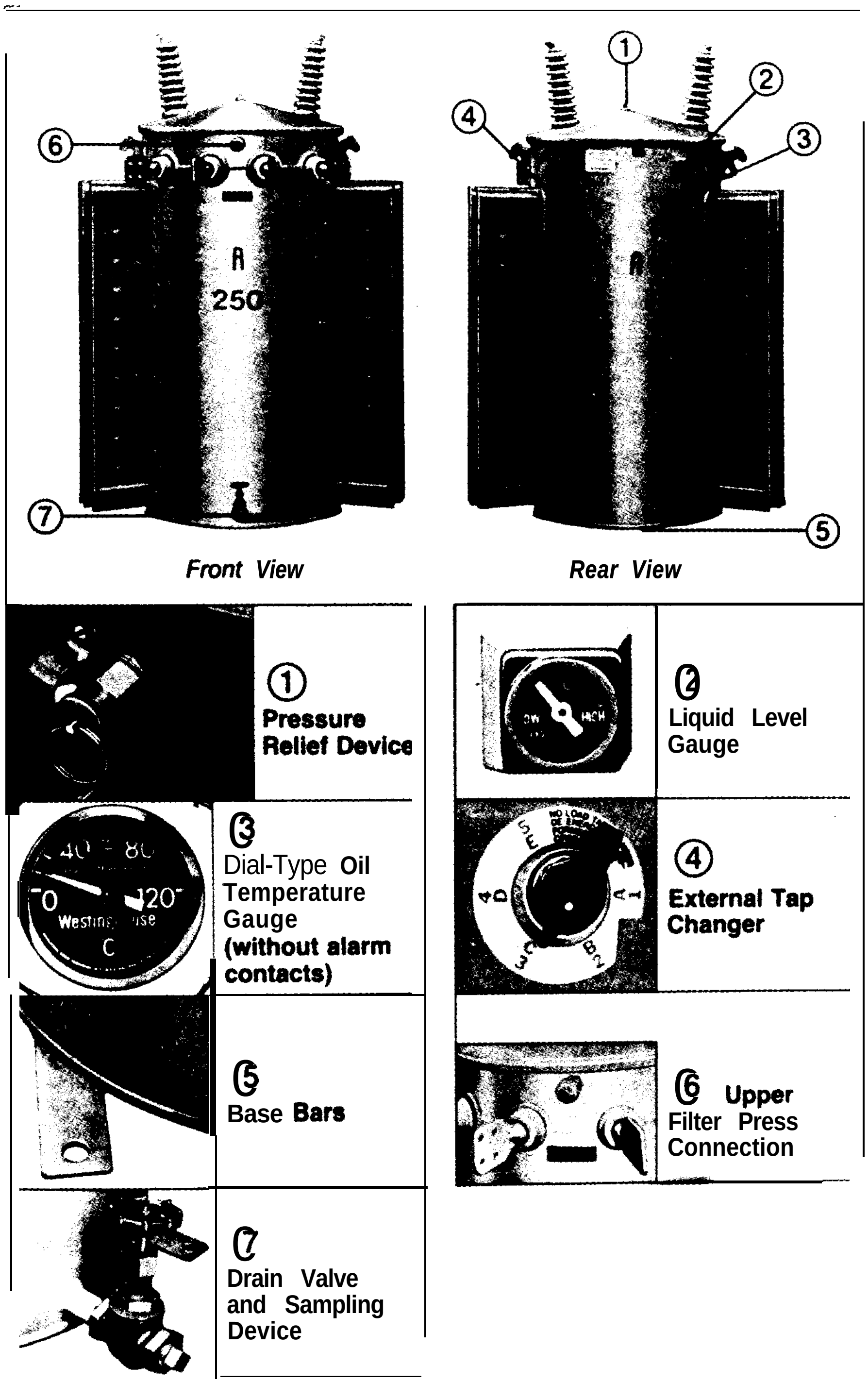
See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.



1. SYSTEM SOFTWARE AND STUDIES
2. HIGH VOLTAGE DIRECT CURRENT SYSTEMS
3. GAS INSULATED BUS
4. SUBSTATIONS
5. REACTIVE POWER COMPENSATION
6. POWER TRANSFORMERS
7. POWER CIRCUIT BREAKERS
8. POWER EQUIPMENT PARTS AND SERVICE
9. DISCONNECT SWITCHES
10. ARRESTERS
11. CAPACTIVE VOLTAGE TRANSFORMERS
12. OIL INSTRUMENT TRANSFORMERS
13. RECLOSERS
14. VACUUM BREAKERS
15. CAPACITORS
16. SMALLPOWERTRANSFORMERS
17. CUTOUTS
18. DISTRIBUTION TRANSFORMERS
19. RELAYS
20. METERING SYSTEMS
21. LOW VOLTAGE INSTRUMENT TRANSFORMERS

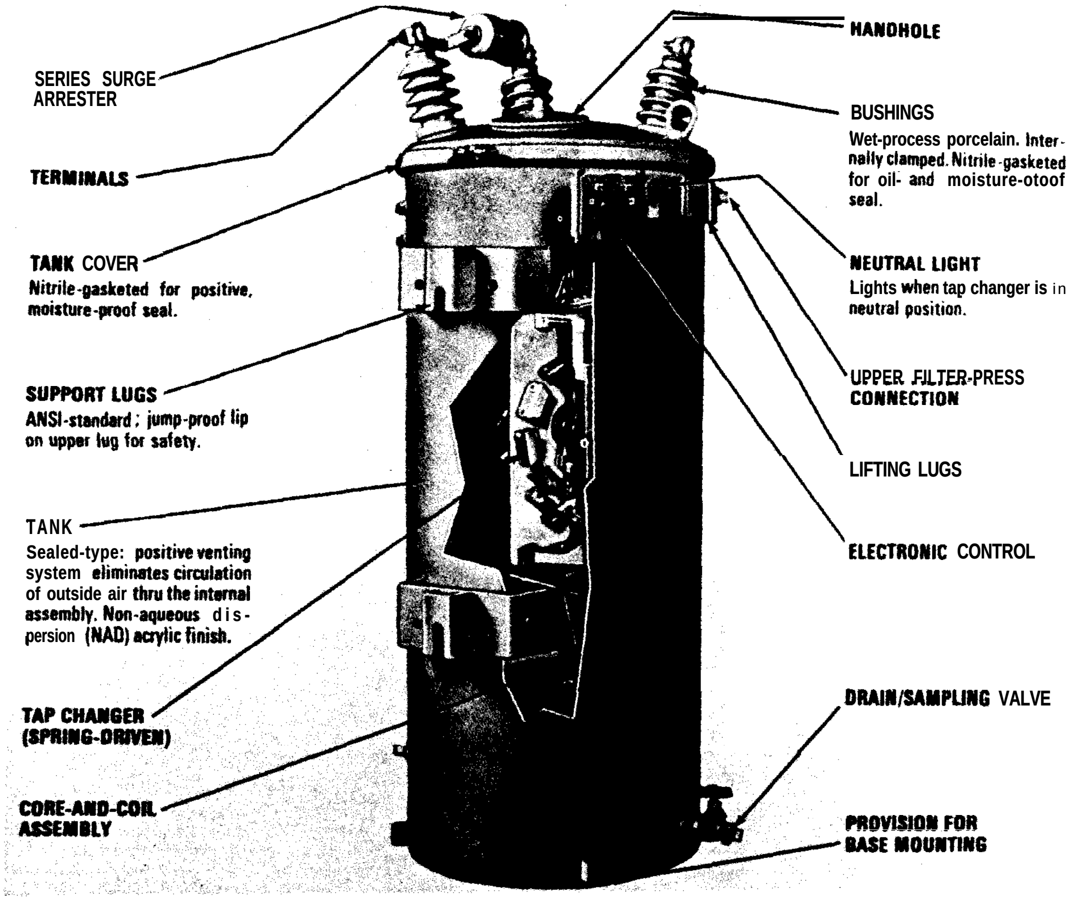
SOURCE: ABB POWER T&D COMPANY INC. CATALOG 50-000

SYSTEM ASSEMBLY DETAILS-SITE W ORK	POWER GENERATION AND DISTRIBUTION DIAGRAM		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-1



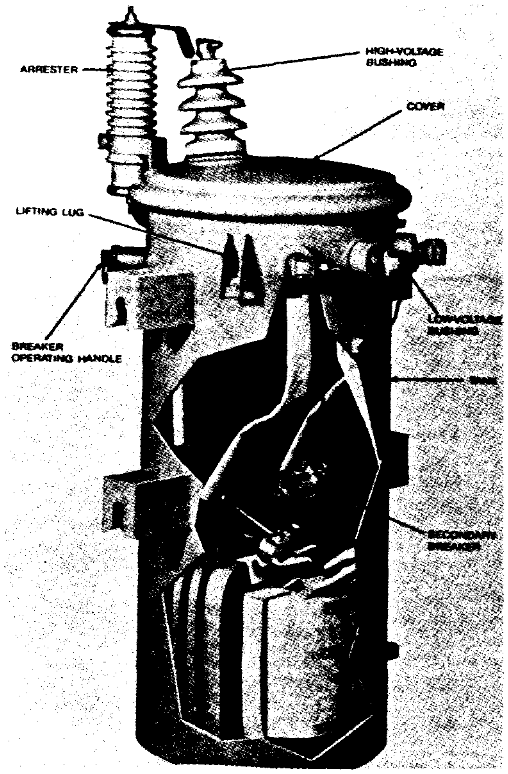
SOURCE: ABB POWER T&D COMPANY INC. CATALOG 50-000

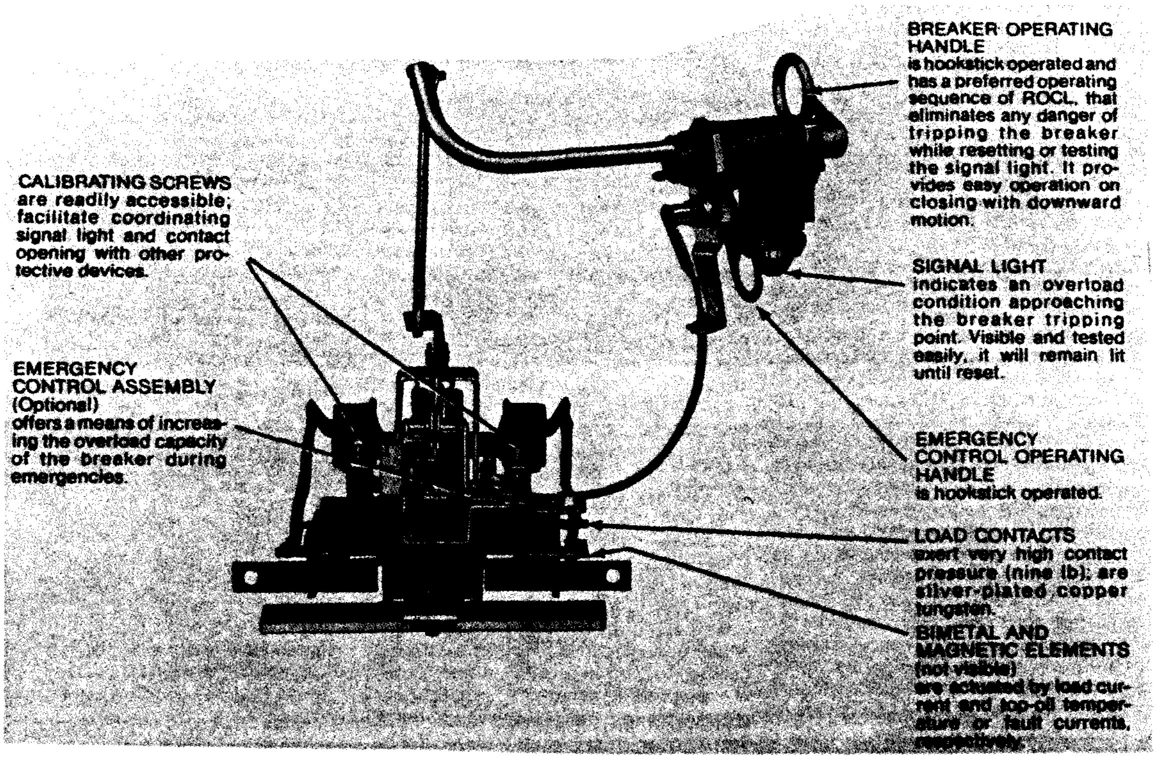
SYSTEM ASSEMBLY DETAILS-SITEWORK	POLE MOUNTED TRANSFORMER		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-2



SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIERS CATALOG TRANSMISSION-DISTRIBUTION

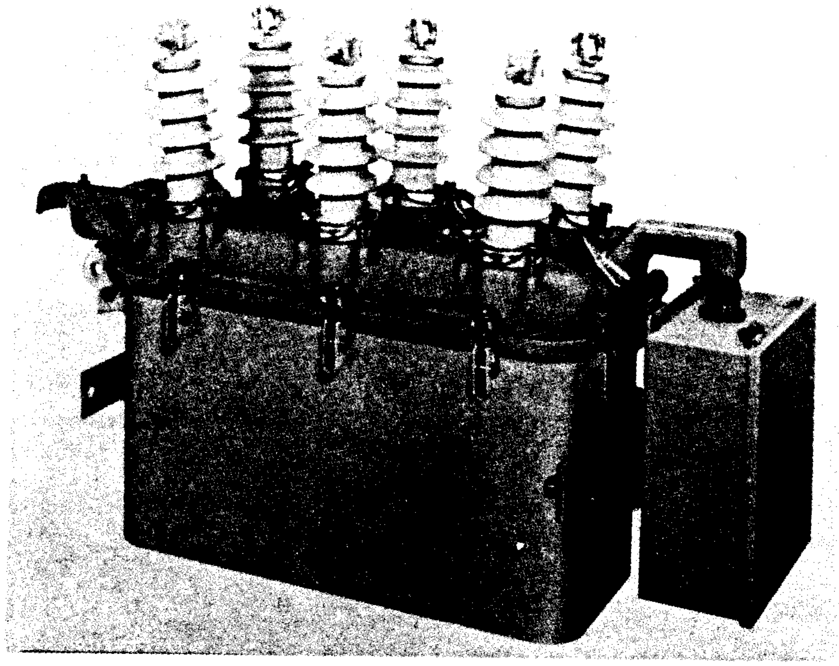
SYSTEM ASSEMBLY DETAILS-SITEWORK	VOLTAGE REGULATOR		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-3

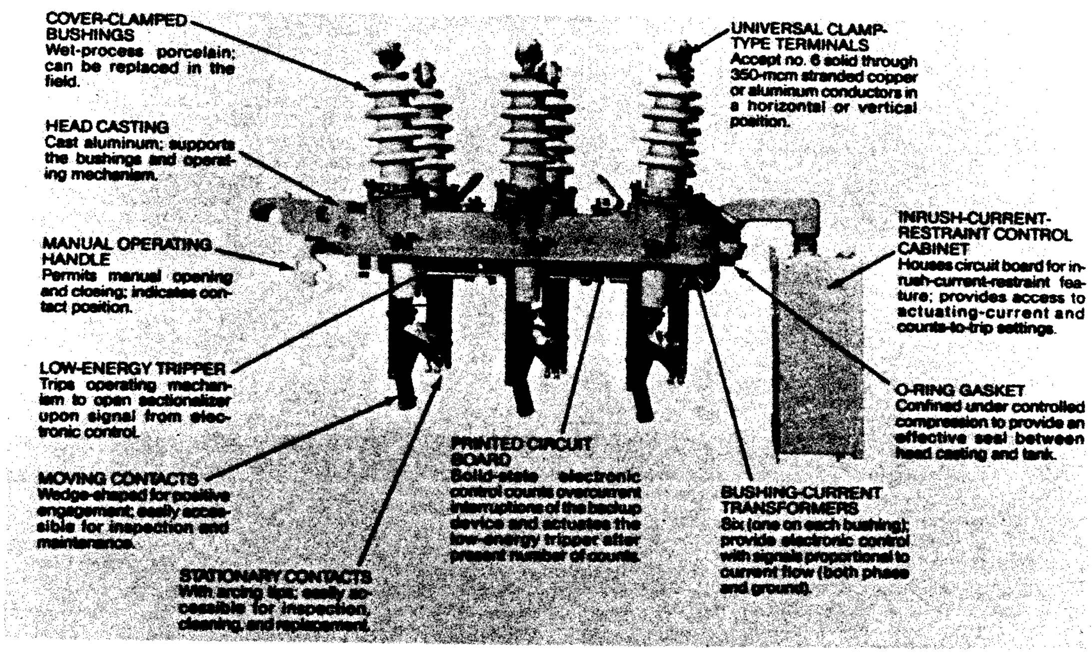




SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIERS CATALOG TRANSMISSION-DISTRIBUTION

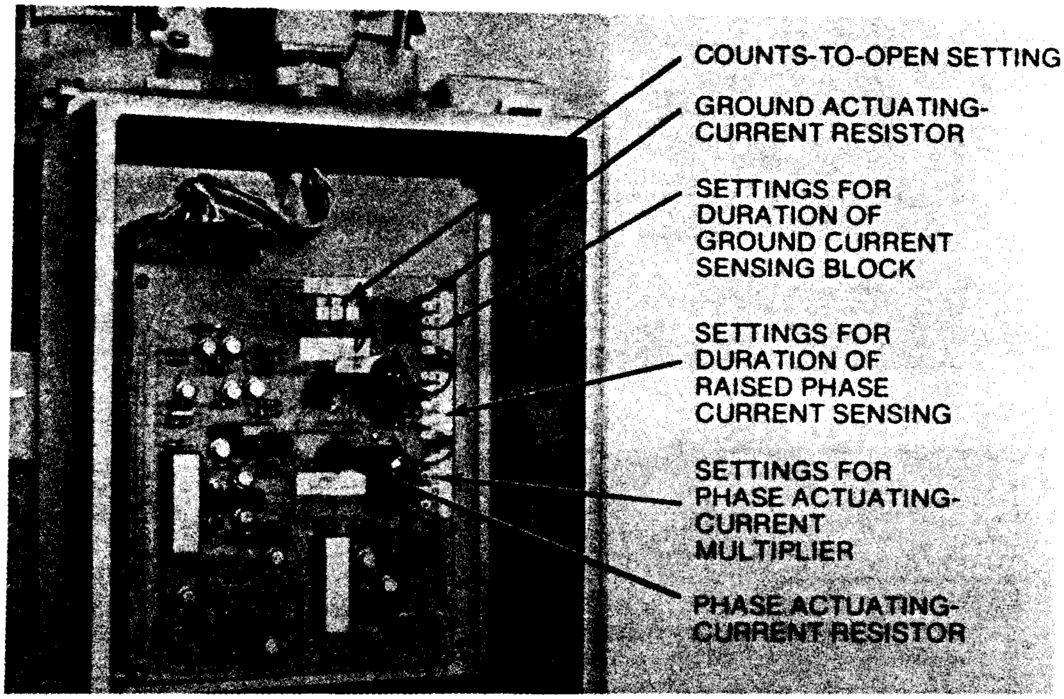
SYSTEM ASSEMBLY DETAILS-SITEWORK	TRANSFORMER		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-4





SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIERS CATALOG TRANSMISSION-DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	SECTIONALIZER		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-5



SOURCE: McGRAW-EDISON POWER SYSTEMS ELECTRICAL APPARATUS SPECIFIERS CATALOG TRANSMISSION-DISTRIBUTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	SECTIONALIZER CONTROL CABINET		
ELECTRICAL OVERHEAD TRANSMISSION SYSTEM (CSI 16200)	Revision No.	Issue Date 5/93	Drawing No. A12010403-6

DEFICIENCY FACTORS
0.12.01.04.03 OVERHEAD TRANSMISSION SYSTEM (CSI 16200)

PROBABLE FAILURE POINTS

- Component grounding - components/devices are not adequately grounded or a grounding system is not in place.
- Device contacts - stationary and movable contacts are burned, pitted, or malaligned.
- Enclosures - not clean and moisture-free, oil leaks.
- Insulating liquid - does not meet criteria for continued use.
- Insulators - cracked, chipped, broken, or have unacceptable surface contamination,
- Lightning arresters - cracked, chipped, broken, or have unacceptable surface contamination.
- Poles - rotting, leaning, and splitting. Poles have bird damage or are lightning damaged.
- Splices connections are not properly made or torqued.

SYSTEM ASSEMBLIES/DEFICIENCIES

Communication Circuits:	See CAS Volume 9 for deficiency factors for communication circuits.
Conductors & Fittings:	See CAS Volume 9 for deficiency factors for conductors and fittings.
Disconnects:	See CAS Volume 9 for deficiency factors for disconnects.
Lighting:	See CAS Volume 9 for deficiency factors for lighting.
Lightning Protection & Surge Suppression:	See CAS Volume 9 for deficiency factors for lightning protection and surge suppression.
Metering:	See CAS Volume 9 for deficiency factors for metering.
Precast Concrete Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for precast concrete poles.
Signal Circuits:	See CAS Volume 9 for deficiency factors for signal circuits.
Steel Towers & Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for steel towers and poles.
Switchgear:	See CAS Volume 9 for deficiency factors for switchgear.
Tower & Pole Foundations:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for tower and pole foundations.
Wood Poles:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for wood poles.

DEFICIENCY FACTORS
0.12.01.04.03 OVERHEAD TRANSMISSION SYSTEM (CSI 16200)

END OF SUBSECTION

0.12.01.04.04 UNDERGROUND TRANSMISSION SYSTEM (CSI 162001

DESCRIPTION

The typical underground transmission system transports current from a source to a load but is part of a subsurface network. The underground transmission system is not a common link in large networks due to the large burdens imposed. The underground system includes submarine systems and is often employed to bridge large water spans where the water span is used for navigational purposes.

Underground Transmission System Equipment

A typical listing of common underground transmission system equipment follows. The list does not address the ancillary support systems such as a low Voltage distribution system that may be present and are the subject of Volume 9 of the CAS Program.

- Communication Circuits
- Concrete Support Pads
- Conductors & Fittings
- Disconnects
- Lighting
- Lightning Protection & Surge Suppression
- Metering
- Raceway & Fittings
- Signal Circuits
- Utility Service Tunnels
- Utility Service Tunnels: Dampproofing/Waterproofing

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Communication Circuits (CSI 16700)

A variety of equipment is an inherent part of communication circuits and includes, but is not limited to, the following:

- Fittinas: Special components normally used to shield and/or protect the conductors used in a communication circuit. The fitting will sustain the characteristics of the communication circuit if such is required.
- Seals Special fittings or materials used to secure the penetration of a barrier by communication circuits or to isolate one area from another area where communication circuits interrupt that isolation. The seal maintains the characteristics of the communication circuit if so required.
- Protectors: Items of equipment used to establish boundary conditions of Voltage and current permitted in the communication circuit; they are concerned primarily with isolating the communication device from excessive Voltage surges.

Concrete Support Pads (CSI 03300)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Conductors & Fittings (CSI 16120)

These materials, usually in the form of a wire, cable, or bus bar, are suitable for carrying an electric current. A conductor may be solid with or without insulation, or a stranded conductor with or without insulation and other coverings (single-conductor) or a combination of conductors insulated from one another (multiple conductor). Conductors may also be referred to as bundled, covered, grounded, insulated, shielded, line, and open conductors (see glossary for a description of each). Further, a conductor may be referred to as a cable (see glossary for a description). In addition, cables as conductors, have associated ancillary units or extensions. These ancillary units include spacer cable, messenger cable, cable termination, cable jacket, and cable sheath (see glossary for a description).

0.12.01.04.04 UNDERGROUND TRANSMISSION SYSTEM (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS:

Conductors & Fittings (CSI 16120) (Continued)

The conductors more common in switchyards and substations are a solid metal or tube type bus supported on insulators, noninsulated conductors supported by insulators, or insulated cable. Fittings include splices and terminations, and normally maintain conductor/cable characteristics in addition to meeting other requirements.

Disconnects (CSI 16200)

Disconnects are devices used to isolate one circuit section from another or to isolate a load from a source. Specific disconnect devices identified in this section are air break switches, circuit breakers, cutouts, isolation switches, circuit reclosers, oil switches, repeater cutouts, network protectors, and vacuum circuit breakers.

- Air Break Switches: Air break switches have both blade and stationary contacts equipped with arcing horns. These horns are pieces of metal between which an arc may form when opening an energized circuit. As the blade or movable contact moves away from the stationary contact its horn also moves, thus stretching an arc to a break point.
- Circuit Breakers: Circuit breakers are used to protect the switchyard and to connect and/or isolate the switchyard circuits in accordance with established parameters and operating conditions. The circuit breaker is normally an oil-filled device in high Voltage circuits. However, air circuit breakers and vacuum devices are also found. Vacuum circuit breakers differ from air circuit breakers in that the main contacts and interrupters are in a vacuum bottle and are not accessible for cleaning, repair, or adjustment. Indicators that reflect contact wear are sometimes provided.
- Circuit Reclosers: A circuit recloser is a switch with additional ancillary devices. These additional devices monitor line current and at a predetermined value initiate action to open the switch; when the line current falls, the devices close the switch and restore the circuit. The additional ancillary devices are controllable to permit consideration of local or system conditions; the switch may be locked opened after one or more closures and the interrupt time is adjustable. The interrupting medium can be either oil or vacuum.
- Cutouts: Cutouts are fused devices used for protection and isolation in switching substations. Two types, the enclosed and the open link, are in general use today (the enclosed is more often found in distribution systems serving residential areas). Modern enclosed cutouts will drop "open" the fuse holder or an indicator after the fuse has melted on overcurrent, allowing a rapid "drive-by" status survey.
- Isolation Switches: Isolation switches are used to isolate a circuit or load from some other part of an electrical system. The isolation switch is designed to carry rated current at or below rated Voltage; however, the isolation switch is not designed nor rated to interrupt load current. Further, care must be exercised when isolation switches are operated due to the possibility of charging currents.
- Network Protectors: Network protectors are air circuit breakers with specialized relays that sense network conditions and initiate appropriate circuit breaker action.
- Oil Switches: An oil switch is normally employed to protect from overloads, short circuit fault currents, and other abnormal conditions. The switch contacts are immersed in an oil that serves several functions. The oil is an insulator that tends to quench any arc formed during switch operation. The formation of an arc in an airtight tank pressurizes the tank with vaporized oil and this provides additional arc quenching.

02.01.04.04 UNDERGROUND TRANSMISSION SYSTEM (CSI 16200)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Disconnects (CSI 16300) (Continued)

- Repeater Cutouts: Repeater cutouts normally consist of two or more fused devices with additional ancillary devices, permitting several fused devices to be place in operation sequentially. Thus, if an overcurrent melts the first fuse, the cutout opens and mechanically places the next fused device into operation. This continues until all fused devices have been used or the overload condition has been removed.

Lighting (CSI 16500)

A lighting system converts electrical energy to energy in the visible frequency spectrum. The light system consists of the luminary and the necessary devices to connect the luminary to the low Voltage distribution system. The lighting system may be one using incandescent, fluorescent, or High Intensity Discharge (HID) equipment.

Lightning Protection & Surge Suppression (CSI 16670)

A variety of equipment is used for Lightning Protection and Surge Suppression. Lightning protection may involve shielding the protected system by placing conductors with air terminals, connecting special devices to the electrical circuit being protected, or a combination of both. The shielding conductor and air terminals comply with NFPA 78 or an established engineering study for the protected system. Connected devices include, but are not limited to the following type of devices.

- Valve Arresters: Devices constructed with a non-linear resistive element in series with a spark gap and enclosed in a casing normally made of porcelain. Common non-linear elements are made of thyrite. Several devices may be constructed in series to meet the normal operational Voltages of the system(s).
- Expulsion Arresters: Devices with a spark gap connected in series with a hollow fiber tube. Gases created in the hollow tube are ejected in an explosive manner, which reduces follow-up current flow to a level interruptible by the spark gap.
- Choke Coils: Surge protection is achieved with choke coils, which offer a large reactance to the high frequency lightning-induced surge. The choke coil shunts the lightning-induced surge away from the protected apparatus to a strategically placed arrester.

Metering (CSI 16430)

Metering is a collection of devices such as Voltmeters, ammeters, switches, and ancillary devices used to measure various electrical parameters. Metering may be used to control the electrical system or to indicate selected parameters monitored by an operator. Ancillary metering devices may also be used for other control systems such as overcurrent or overVoltage relaying

Raceway & Fittings (CSI 16110)

A raceway is an enclosed channel for holding wire, cables, or busbars. The more common forms of raceway include flexible and rigid conduit, tubing, and wireways. Fittings include bushings, locknuts, and conduit bodies.

Signal Circuits (CSI 16700)

Equipment used in signal circuits (as defined herein) are standard electrical devices and materials with additional use constraints. If power is not required to be limited to some established level then the circuit is rated as a Class 1 circuit. If Voltage and current are limited normally in accordance with NFPA standards, the circuit is rated as Class 2 or Class 3, and equipment and material rated for that class is used.

0.12.01.04.04 UNDERGROUND TRANSMISSION SYSTEM **(CSI 16200)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Utility **Service Tunnels** (CSI **02300)**

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

Utility **Service Tunnels: Dampproofing/Waterproofing** (CSI 02300)

See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for a description.

DEFICIENCY FACTORS
0.12.01 .04.04 UNDERGROUND TRANSMISSION SYSTEM (CSI 16200)

PROBABLE FAILURE POINTS

- Component grounding - components/devices are not adequately grounded or a grounding system is not in place.
- Device contacts - stationary and movable contacts are burned, pitted, or malaligned.
- Enclosures - not clean and moisture-free, oil leaks.
- Insulating liquid - does not meet criteria for continued use.
- Insulators - cracked, chipped, broken, or have unacceptable surface contamination.
- Lightning arresters - cracked, chipped, broken, or have unacceptable surface contamination.
- Raceway - not clean and moisture-free.
- Splices - connections are not properly made or torqued.

SYSTEM ASSEMBLIES/DEFICIENCIES

Communication Circuits:	See CAS Volume 9 for deficiency factors for communication circuits,
Concrete Support Pads:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for concrete support pads.
Conductors & Fittings:	See CAS Volume 9 for deficiency factors for conductors and fittings.
Disconnects:	See CAS Volume 9 for deficiency factors for disconnects,
Lighting:	See CAS Volume 9 for deficiency factors for lighting.
Lightning Protection & Surge Suppression:	See CAS Volume 9 for deficiency factors for lightning protection and surge suppression.
Metering:	See CAS Volume 9 for deficiency factors for metering.
Raceway & Fittings:	See CAS Volume 9 for deficiency factors for raceway and fittings.
Signal Circuits:	See CAS Volume 9 for deficiency factors for signal circuits.
Utility Service Tunnels:	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels.
Utility Service Tunnels: **Dampproofing/Waterproofing:**	See Electrical Infrastructure (0.12.01.05) CAS Volume 12 for deficiency factors for utility service tunnels: **dampproofing/-** waterproofing.

DEFICIENCY FACTORS
0.12.01.04.04 UNDERGROUND TRANSMISSION SYSTEM (CSI 16200)

END OF SUBSECTION

0.12.01.05.01 STEEL TOWERS & POLES (CSI 05000)

DESCRIPTION

Steel towers and pole structures are designed to support electrical transmission lines, radio and television antennas, radar and microwave equipment, floodlights, etc. The ease of steel fabrication combined with its durability are key factors, especially for exposed high tension lines that must be elevated considerably above the topography. Some of its desirable qualities include great strength and stiffness, durability, workability, and reliability. Steel is non-combustible, unaffected by fungi or insects, and dimensionally stable. The disadvantage of most steel products is corrosion. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Steel Towers & Poles (CSI 05000)

Steel towers are composed of hot-rolled or cold-formed shapes. These are mostly angles, although other shapes may also be used. The members are bolted together to form a lattice truss. Tower members may be hot-dip galvanized to obtain resistance to corrosion, or they may be fabricated from weathering steel requiring no corrosion protection. Steel poles are welded from plates. Pole shapes vary from circular to multi-sided polygonal.

Connections:

The ASTM A39A Type 0 bolts are the most common fasteners used for steel towers. High-strength and weathering-steel bolts are also covered by this specification.

High-strength bolts may be specified with friction type or bearing type connections with threads included or excluded from the shear plane.

Welded connections are generally governed by the American Welding Society document D1.1-88 Structural Welding Code, Steel. Field welded connections are not normally used for steel poles.

OTHER RELATED COMPONENTS

See the following subsections within this manual for related components.

0.12.01.05.01 STEEL TOWERS & POLES (CSI 05000)

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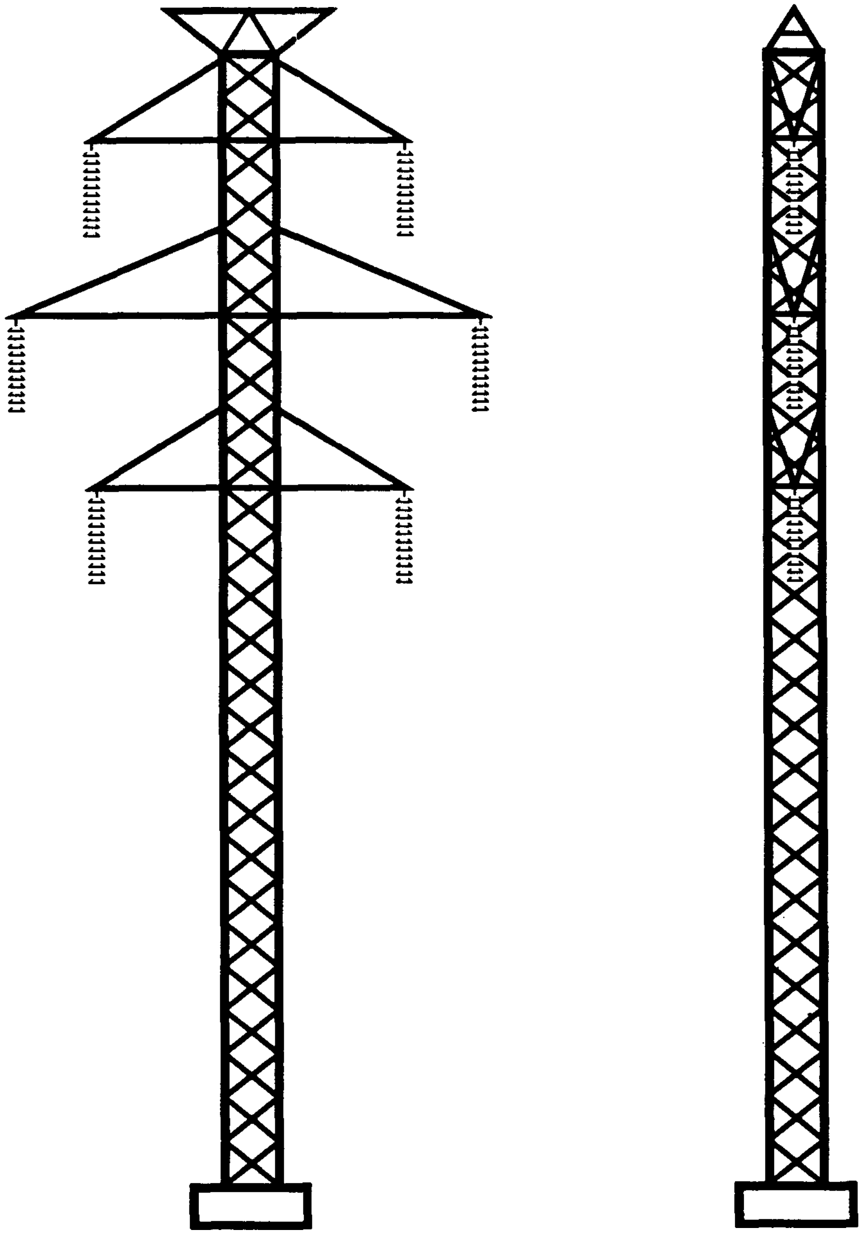
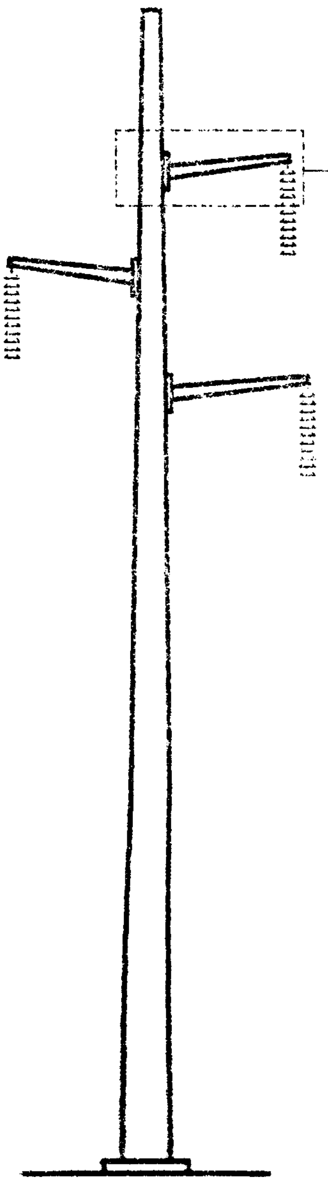
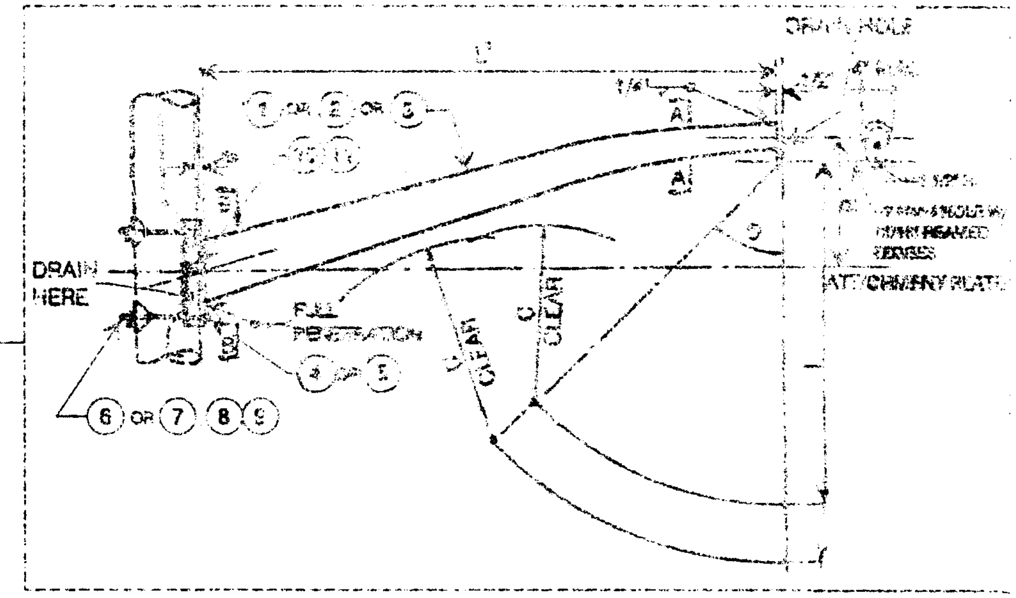
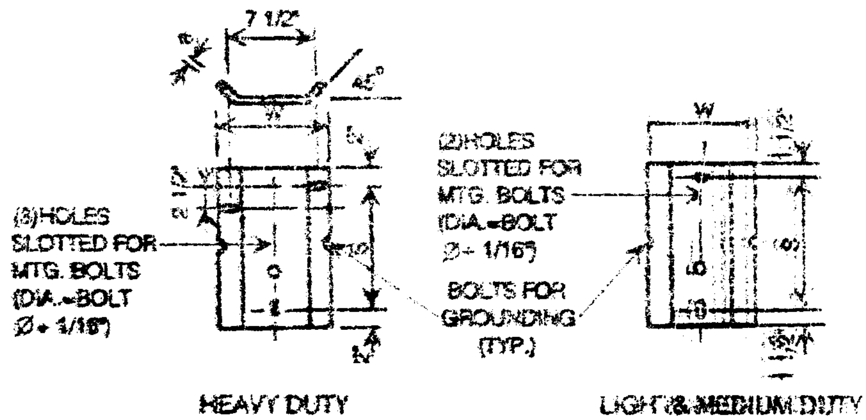


SYSTEM ASSEMBLY DETAILS-SITEWORK	STEEL TOWER		
UTILITY SUPPORT STRUCTURES STEEL TOWERS AND POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing Mo. A12010501-1

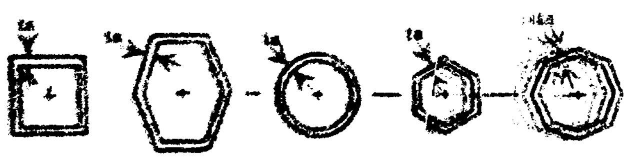




ONE-CIRCUIT 138-kV
STEEL TRANSMISSION POLE



SECTION B-B
(BASE PLATE DETAILS)



SECTION A-A
(TYPICAL ARMS)

SYSTEM ASSEMBLY DETAILS-SITEWORK	STEEL POLE STRUCTURE		
UTILITY SUPPORT STRUCTURES STEEL TOWERS AND POLES (CSI 02780)	Revision No.	Issue Date	Drawing No.
		5/93	A02010501-2

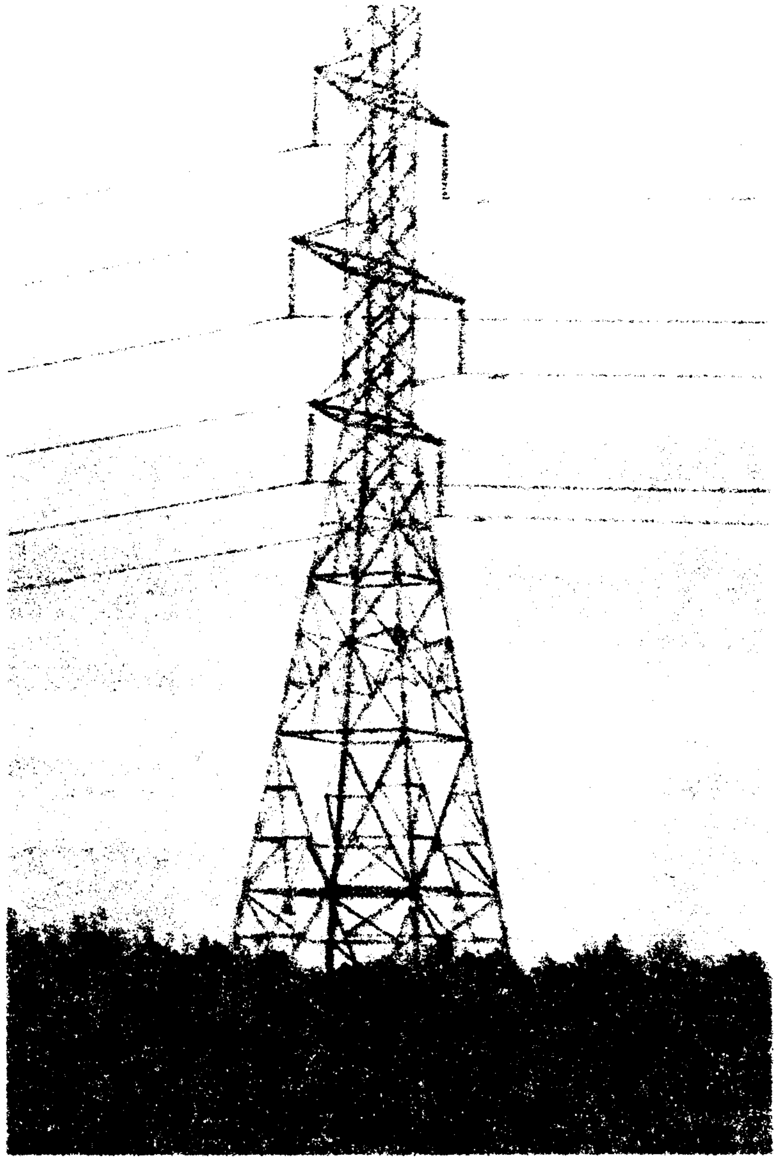


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	STEEL TOWER		
UTILITY SUPPORT STRUCTURES STEEL TOWERS AND POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. A12010501-3

DEFICIENCY FACTORS
0.12.01.05.01 STEEL TOWERS & POLES (CSI 05000)

PROBABLE FAILURE POINTS

- Steel corrosion is an electrochemical process that occurs in the presence of air and moisture.
- Cracked or broken welds caused by stress, settlement/movement, poor materials, or improper construction.
- Loose connections caused by vibration, temperature changes, or improper tightness.
- Impact damage caused by objects striking or impacting the surface.

SYSTEM ASSEMBLIES/DEFICIENCIES

Steel

Corrosion:	A chemical or electrochemical reaction that converts the metal into oxides, carbonates, and/or sulfides.
Damaged Welds:	Cracked or broken welds caused by stresses, poor materials, or improper construction.
Fatigue Cracking:	Repetitive, cyclic loading occurring at stresses at or below allowable design values.
Impact Damage:	Depressions, dents, or buckled surface from objects striking or impacting the surface.
Lamellar Tearing:	A separation within the steel strains induced by hot welds shrinking as they cool.
Loose Connections:	Impact, vibration, fatigue loading, or incorrect tightness.
Loss of Protective Coating/Paint:	Chalking, peeling, chipping, blistering, or deterioration.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out of its designed position in one or more directions. This includes out-of-plumb towers and poles and out-of-level crossarms.

DEFICIENCY FACTORS
0.12.01.05.01 STEEL TOWERS & POLES (CSI 05000)

END OF SUBSECTION

0.12.01.05.02 PRECAST CONCRETE POLES **(CSI 03400)**

DESCRIPTION

Precast methodology involves concrete items fabricated off-site. Precast poles are either reinforced or prestressed in a manufacturer/casting plant and then shipped to the project site. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Precast Concrete Poles (CSI 03400)

Precast and prestressed concrete elements permit a wide variety of engineering solutions. The feasibility of using prestressed elements will often depend on a manufacturing plants accessibility to the site. Prestressed concrete elements are of little advantage for short spans, but can be used to advantage for long spans with all types of construction. Precast has the greatest advantage when identical members are to be cast, because the same forms can be used several times. In addition to using the same forms, precast concrete has other advantages:

- Control of the concrete quality.
- Smoother surfaces.
- Less storage space is needed.
- Concrete member can be cast under all weather conditions.
- Better protection for curing.
- Weather conditions do not affect erection.
- Faster erection time.

Test cylinders should be made at the same time as the precast concrete and cured in the same manner.

Reinforced Precast Concrete (CSI 03400)

Because concrete in itself has limited resistance to tensile and shear stress, a composite of materials is necessary to take advantage of the maximum compatibility of the ingredients in the composite.

Reinforcing steel should be placed in accordance with engineers requirements. Laps, tying, and hook positioning should conform to the ACI codes. Concrete covering over steel reinforcement is critical because of the protection afforded the steel.

The cross-sectional area of the reinforcing should not be reduced in any way because the tensile capacity of the reinforcing materials is specified to conform to ACI 318.

OTHER RELATED COMPONENTS

Refer to Substructure, Volume 2, for additional deficiencies that may impact this system.

0.12.01.05.02 PRECAST CONCRETE POLES (CSI 03400)

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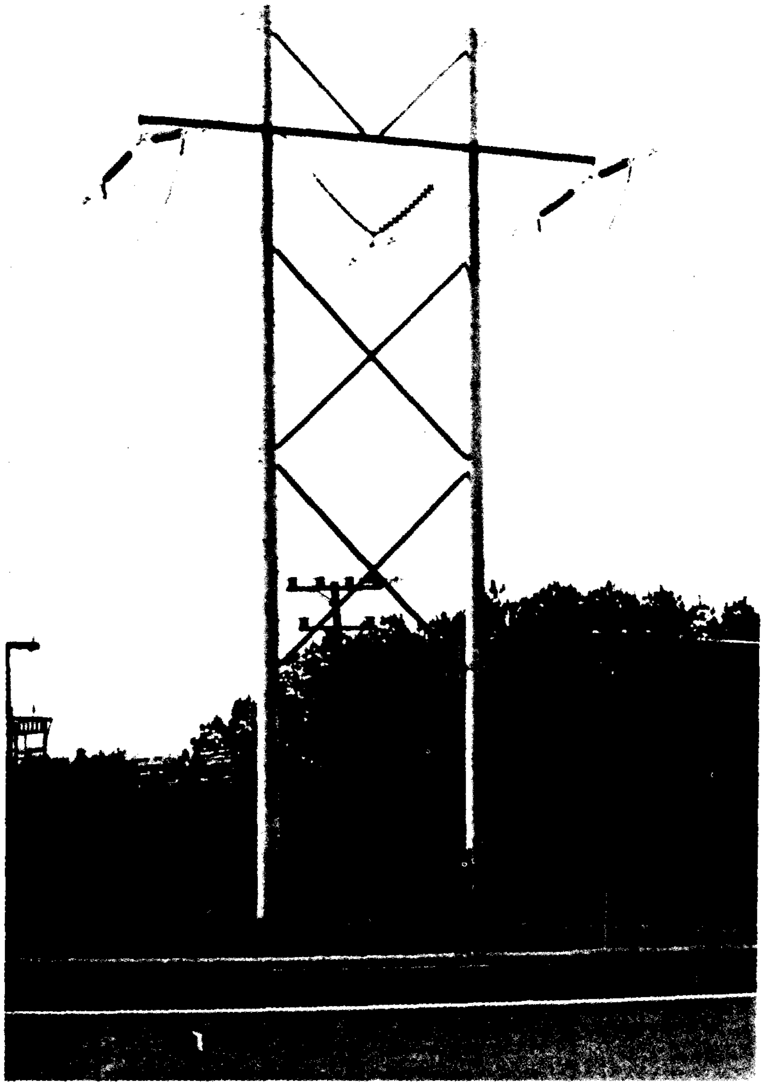

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	CONCRETE POLES		
UTILITY SUPPORT STRUCTURES PRECAST CONCRETE POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. A12010502-1

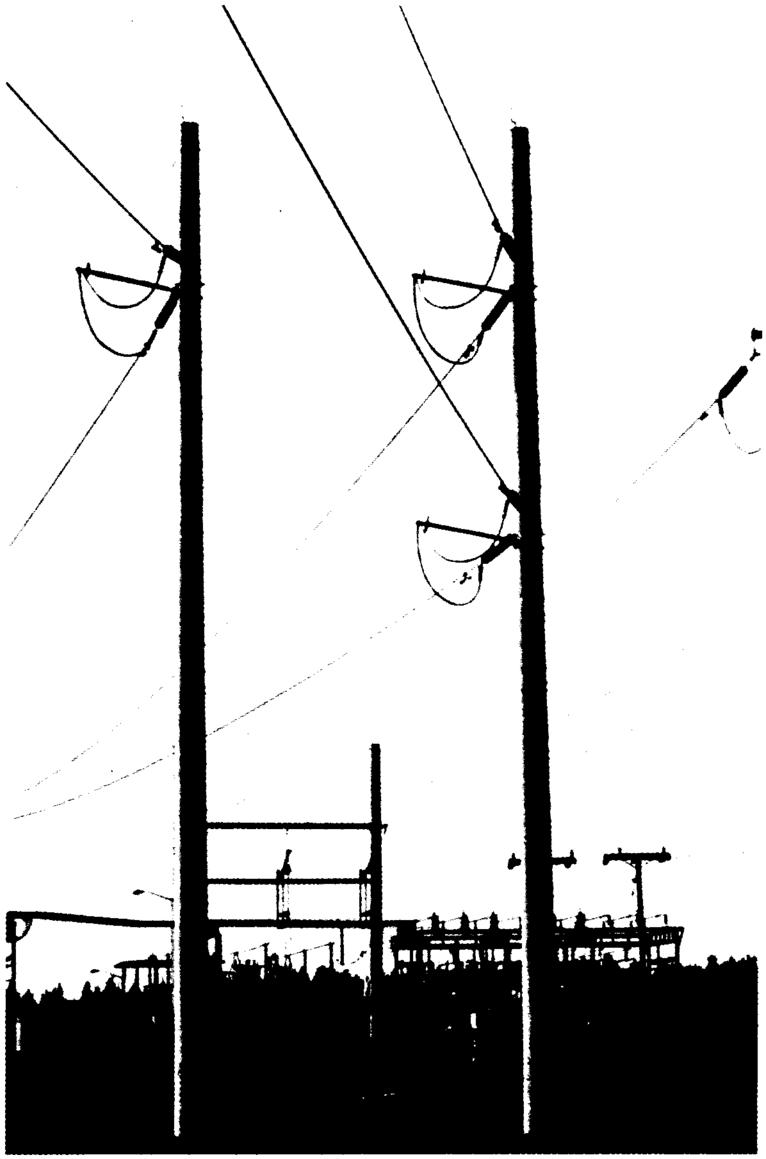

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITE WORK	CONCRETE POLES		
UTILITY SUPPORT STRUCTURES PRECAST CONCRETE POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. A12010502-2

DEFICIENCY FACTORS
0.12.01.05.02 PRECAST CONCRETE POLES (CSI 03400)

PROBABLE FAILURE POINTS

- Reinforcement corrosion is an electro-chemical process that occurs in the presence of air and moisture.
- Construction overloads induced during construction or storage can be far more severe than those experienced in the lifetime of the structure. These conditions may occur at early ages when the concrete is most susceptible to damage, and often results in cracks.
- The effects of improper design and/or detailing range from poor appearance to lack of serviceability to catastrophic failure.
- Externally applied loads induce tensile stress, which results in cracks. Current ACI 318 design procedures use reinforcing steel, not only to carry the tensile forces, but also to control crack distribution and width.

SYSTEM ASSEMBLIES/DEFICIENCIES

Corrosion of Rebar:	The oxidation or eating away of the metal rebar by chemical or electrochemical action after prolonged exposure to moisture.
Cracks (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Inadequate finishing and curing. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Thermal changes (subjected to temperature extremes, such as from freeze/thaw cycles). Stress concentration. Structural design. Accidents from overload, vibration, fatigue, and earthquake.
Holes (Small & Large):	Inadequate construction and design. Impact damage.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out of its design position. This includes out-of-plumb poles and bent crossarms.
Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions.
Staining:	Surface discoloration from a foreign substance or material.
Surface Deterioration:	Chemical reactions.

DEFICIENCY FACTORS
0.12.01.05.02 PRECAST CONCRETE POLES (CSI 03400)

END OF SUBSECTION

0.12.01.05.03 WOOD POLES (CSI 06000)

DESCRIPTION

Wood poles are used to support electrical conductors and equipment for overhead power distribution systems and may be used in single units or in pairs. Associated appurtenances include crossarms, support hardware, and anchoring devices. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Wood poles are used for medium voltage power distribution support. At the upper end of the medium voltage range, they may be used in tandem to obtain proper overhead conductor spacing. Two poles are connected by a crossarm allowing greater spacing of conductors than with a crossarm on a single wood pole.

Wood poles used to support large transformers may be used in tandem to obtain adequate strength. To provide an elevated platform for installation of transformers or other heavy items of electrical equipment, two poles are connected by crossarms with decking.

Wood Poles (CSI 06000)

Wood poles used in electrical power distribution range in sizes up to 100 feet, but in general range between 30 and 50 feet. Wood poles are available in five strength classes: the class is selected based on pole loading. Wood poles are pressure treated for protection against environmental deterioration and insect infestation.

Crossarms (CSI 06000)

Poles used for medium voltage distribution generally have one or more crossarms to support insulators, arrestors, fused cutouts, etc. Crossarms are secured to the pole by means of bolts, braces, and other hardware.

Support **Hardware** (CSI 06000)

Generally, poles are equipped with mounting brackets to support electrical equipment. These brackets provide structural connection points for equipment such as transformers, capacitors, etc.

Anchors (CSI 06000)

Wood poles are buried in the earth to an appropriate depth to provide support for the pole, its appurtenances, and electrical equipment. Additional support is provided by guy wires and anchors used to offset lateral forces of overhead conductors. Push poles, in lieu of guy wires, are used when location does not permit guy wires. Push poles provide force in compression, whereas guy wires provide force in tension.

OTHER RELATED COMPONENTS

See the following subsections for related components:

0.12.01.05.03 WOOD POLES (CSI 06000)

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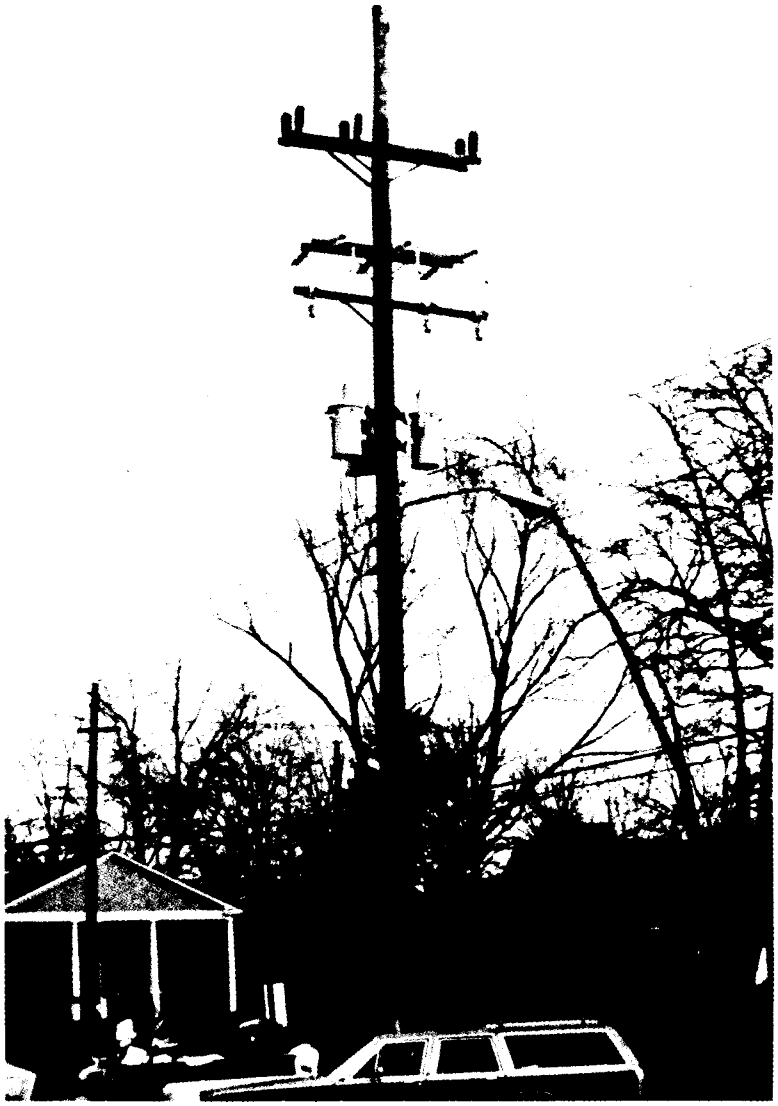


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	WOOD POLE		
UTILITY SUPPORT STRUCTURES WOOD POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. A12010503-1

DEFICIENCY FACTORS
0.12.01.05.03 WOOD POLES (CSI 06000)

PROBABLE FAILURE POINTS

- Termite and boring insect damage causing breakdown of structural integrity.
- Decay (rot) due to fungi, mildew, dry rot causing surface deterioration.
- Fire damage or charred surfaces causing flaking or surface breakdown.
- Splitting or checking caused by stress, settlement/movement, poor materials, or improper construction.
- Impact damage caused by objects striking or impacting the surface.
- Attachment hardware corrosion caused by an electro-chemical process that occurs in the presence of air and moisture.
- Excessive loading or unbalanced loading may cause failure.
- Loose connections caused by vibration, temperature changes, or improper tightness.

SYSTEM ASSEMBLIES/DEFICIENCIES

Wood Poles

Burned, Charred Surface:	Damage from fire or excessive heat on surface.
Cracking:	Cracking, usually structural in nature, that results in tearing, ripping, or splitting.
Dry Rot, Decay:	Breakdown of structural integrity from mold, mildew, or dry rot.
Impact Damage, Denting:	Depressions, punctures, or buckled surface from objects striking or impacting the pole.
Insect Damage:	Holes, cracks, or punctures from burrowing insects.
Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the pole out-of-plumb.
Splitting:	Surface splitting or tearing.
Staining:	Surface discoloration from a foreign substance or material.

Crossarm

Burned, Charred Surface:	Damage from fire or excessive heat on surface.
Cracking:	Cracking, usually structural in nature, that results in tearing, ripping, or splitting.
Dry Rot, Decay:	Breakdown of structural integrity from mold, mildew, or dry rot.
Impact Damage, Denting:	Depressions, punctures, or buckled surface from objects striking or impacting with the crossarm.
Insect Damage:	Holes, cracks, or punctures from burrowing insects.
Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface.

DEFICIENCY FACTORS
0.12.01.05.03 WOOD POLES **(CSI 06000)**

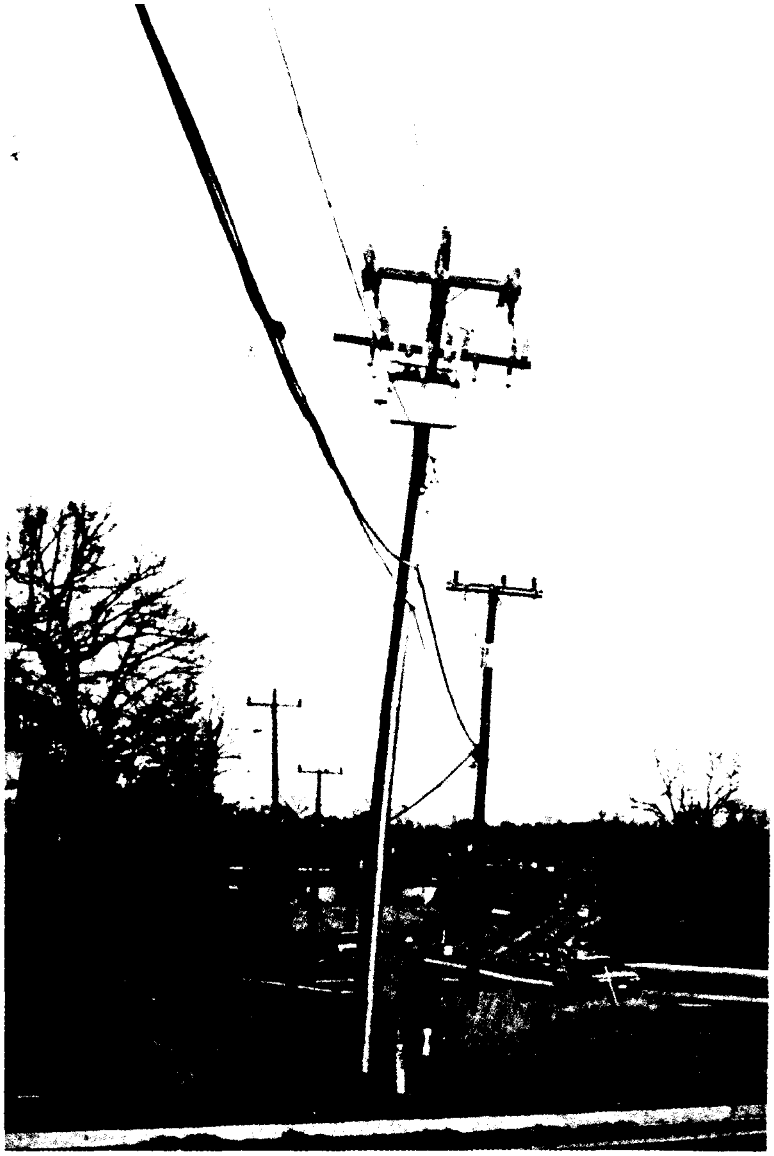
SYSTEM ASSEMBLIES/DEFICIENCIES

Crossarm (Continued)

Out-of-Alignment:	Bowing, deflection, or other movement that brings the crossarm out of level in one or more directions.
Splitting:	Surface splitting or tearing.
Staining:	Surface discoloration from a foreign substance or material.

Anchors & Hardware

Insufficient Anchors, Connections:	Broken, damaged, loose, corroded, or missing anchorage or fasteners caused by vibration, excessive deflection, impact, or improper tightness.



DEFICIENCY-LEANING

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	WOOD POLE DEFICIENCY		
UTILITY SUPPORT STRUCTURES WOOD POLES (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. D12010503-1

DEFICIENCY-LEANING

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	WOOD POLE DEFICIENCY		
UTILITY SUPPORT STRUCTURES WOOD POLES (CSI 02780)	Revision No.	issue Date 5/93	Drawing No. D12010503-2

DEFICIENCY FACTORS
0.12.01.05.03 WOOD POLES **(CSI 06000)**

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DEFICIENCY FACTORS
0.12.01.05.03 WOOD POLES (CSI 06000)

END OF SUBSECTION

0.12.01.05.04 TOWER & POLE FOUNDATIONS (CSI 03000)

DESCRIPTION

Foundations are the structural elements that spread and transmit loads directly to the soil. The most common types of foundations for steel towers and poles are concrete caissons. Concrete and wood poles are usually anchored into soil by direct embedment without concrete foundations, using the excavated soil, crushed stone or sand, or both, for backfill. Caissons are constructed by placing concrete in an excavated or augured hole in the ground. This type of caisson is usually exposed. Concrete caisson design is based on physical properties of specified cement, admixtures, uniformity in mixing and placing technique, curing methods, and other quality control factors. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Cast-In-Place Concrete (CSI 02300)

Concrete placed in forms at its final location. Concrete is a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate. In Portland cement concrete, the binder is a mixture of Portland cement and water. ACI publications 318 "Building Code Requirements for Reinforced Concrete" and 301 "Specifications for Structural Concrete for Buildings" have indicated a preference for specifying the proportioning and design of mixes by other than prescriptive methods.

Design mixes that provide the most common normal weight concrete:

- 4000-psi, 28 day compressive strength water/cement ratio; 0.44 max
- 3500-psi, 28 day compressive strength water/cement ratio; 0.51 max
- 3000-psi, 28 day compressive strength water/cement ratio; 0.58 max
- 2500-psi, 28 day compressive strength water/cement ratio; 0.67 max

Concrete Reinforcement (CSI **03200)**

Bars, wires, strands, and other slender members embedded in concrete in such a manner that the reinforcement and the concrete act together to resist forces. Reinforcement must be accurately located to ensure proper cover and to reduce the chance of loss or corrosion of structural section of reinforcing steel. When concrete is deposited against the earth for footings and other principal structural members, there should be at least 3 inches of concrete between the steel and the earth. Follow ACI 318 publication "Building Code Requirements for Reinforced Concrete."

Support for Reinforcement (Chairs, Spacers, & Bolsters) (CSI 03250)

Chairs are small metal or plastic supports for reinforcing steel. The support is used to maintain the proper positioning during concrete placement. Spacers are used in the same fashion as chairs to maintain proper positioning during concrete pours. Concrete bolsters are a continuous wire bar support used to support bars in the bottom of footings. The top wire is usually corrugated at 1 inch centers to hold the bar in position.

Admixtures (CSI 03370)

An ingredient other than cement, aggregate, or water that is added to a concrete or mortar mix to affect the physical or chemical characteristics of the concrete. The most common admixtures affect the plasticity, air entrainment, and curing time.

Air-Entrainment Agents:

- Provide a more workable material.
- Definitely used when concrete surface will be exposed to freeze/thaw cycles.

0.12.01.05.04 TOWER & POLE FOUNDATIONS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Admixtures (CSI 03370) (Continued)

Retarder & Densifying Agents:

- Retard the set; suggested in warm weather to reduce cracking due to rapid set-up.
- Increase the workability of the mix.
- Allow for delayed finishing, resulting in less permeable concrete.

Accelerator:

- Useful in winter (cold weather concreting).
- Useful when working to seal against the water-flow.
- Should be used sparingly because the admixture tends to increase shrinkage.

OTHER RELATED COMPONENTS

See the following subsections for related components:

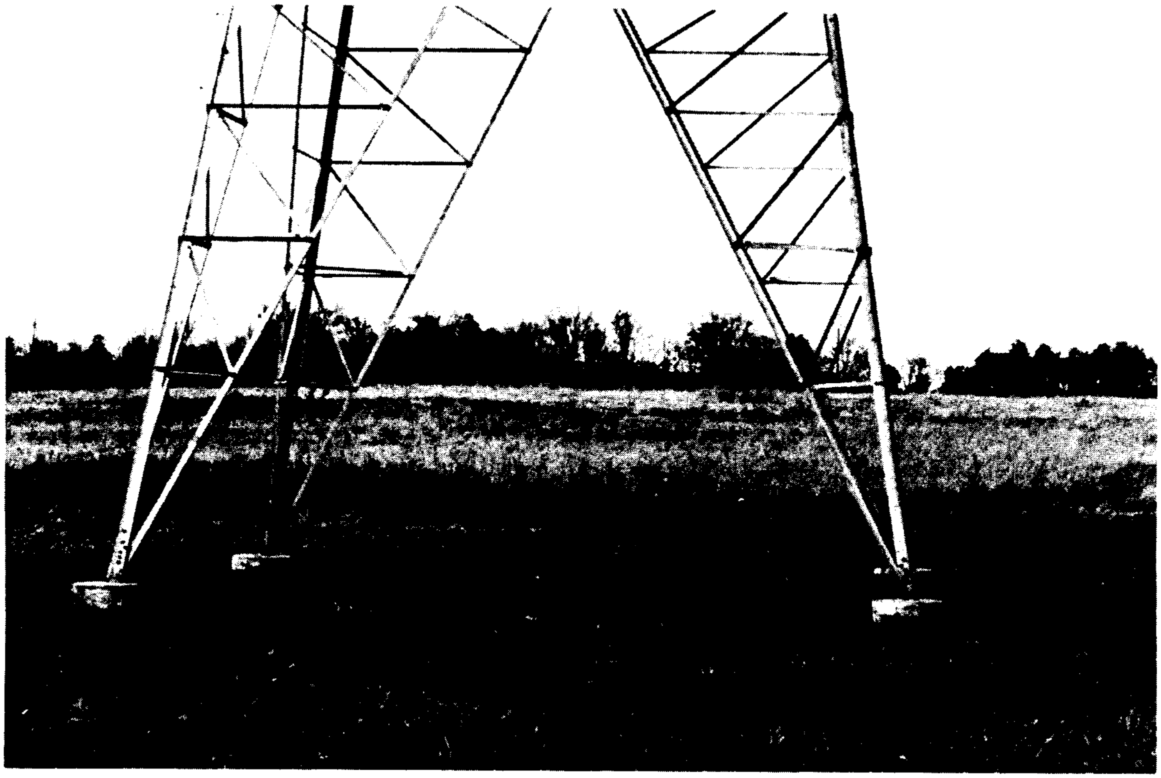
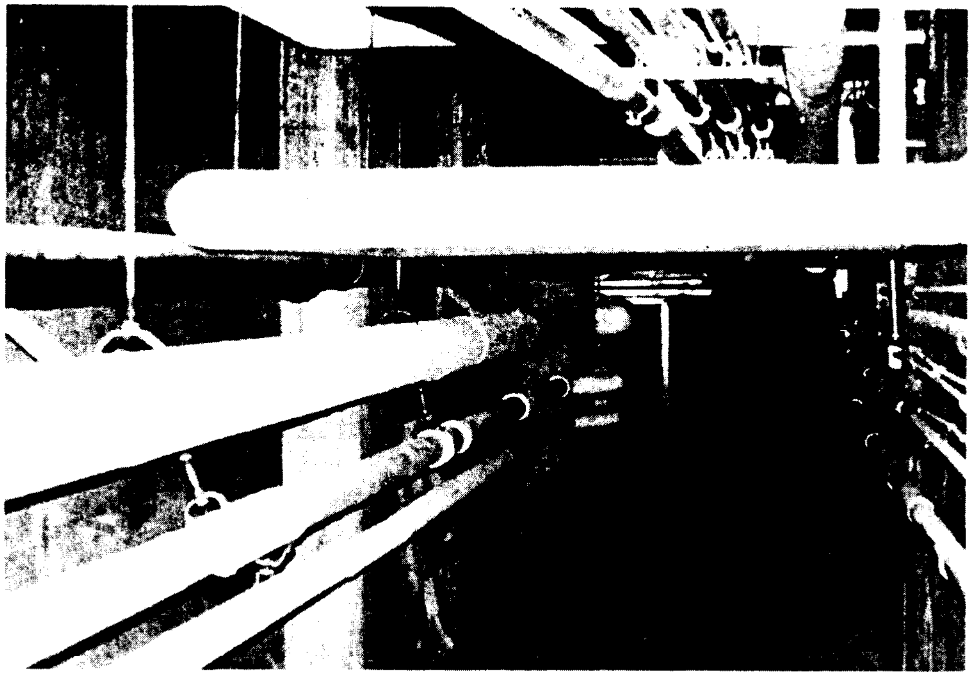


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TOWER FOUNDATION		
UTILITY SUPPORT STRUCTURES TOWER AND POLE FOUNDATIONS (CSI 02780)	Revision No.	Issue Date 5/93	Drawing No. A12010504-1



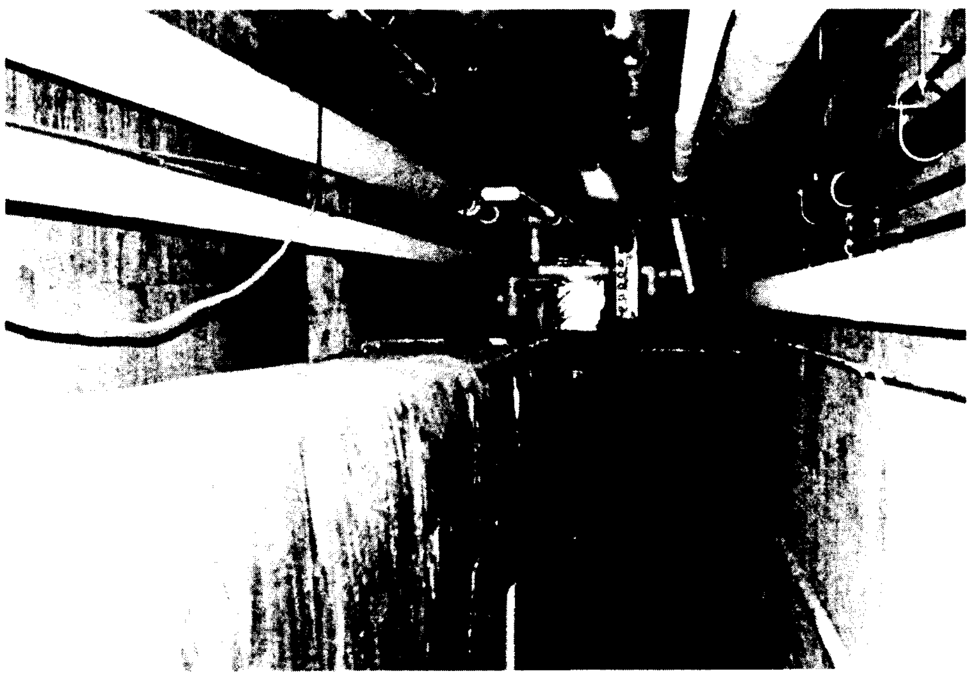


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	UTILITY SERVICE TUNNELS		
UTILITY SUPPORT STRUCTURES UTILITY SERVICE TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A120105051

DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

PROBABLE FAILURE POINTS

- Lack of curing will increase the degree of cracking within a concrete structure.
- Reinforcement corrosion is an electro-chemical process that occurs in the presence of air and moisture.
- The weathering processes that can cause cracking include 1) freezing and thawing, 2) wetting and drying, and 3) heating and cooling.
- A number of deleterious chemical reactions may result in concrete cracks. These reactions may be due to the aggregate used to make the concrete or materials that come into contact with the concrete after it has hardened or cured.
- A wide variety of poor construction practices can result in cracking in concrete or masonry structures, especially adding water to concrete to improve workability. Added water has the effect of reducing strength, increasing deformation, and increasing ultimate drying shrinkage.
- Overloads induced during construction can be far more severe than those experienced in the lifetime of the structure. Unfortunately, these conditions may occur at early ages when the concrete or masonry is most susceptible to damage, and often results in cracks.
- The effects of improper design and/or detailing range from poor appearance to lack of serviceability to catastrophic failure.
- Externally applied loads induce tensile stresses that result in cracks. Current ACI 318 design procedures use reinforcing steel, not only to carry the tensile forces, but also to control both an adequate crack distribution and width.
- Improper compaction or soft spots in the grade resulting in uneven settling or slippage.
- Hydrostatic pressure from groundwater ranging from cracks to total failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Concrete

Alkali-Aggregate Expansion:	Chemical reaction between aggregate and cement paste.
Corrosion of Rebar:	The oxidation or eating away of the metal rebar by chemical or electrochemical action after prolonged exposure to moisture.
Cracks (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Inadequate finishing and curing. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Thermal changes (subjected to temperature extremes, such as from freeze/thaw cycles). Stress concentration. Structural design. Accidents from overload, vibration, fatigue, and earthquake.
Eff lorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Form Scabbing:	Form oil improperly applied.
Holes (Small & Large):	Inadequate construction and design. Impact damage.
Leaching:	Process of separating liquids from solid materials by allowing them to percolate into surrounding soil.

DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

SYSTEM ASSEMBLIES/DEFICIENCIES

Concrete (Continued)

Mortar, Joint Material Missing, Eroded:	Deteriorated or damaged joints that have fallen out or worn down. Excessive joint movement.
Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb or not level in one or more directions.
Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions.
Staining:	Surface discoloration from a foreign substance or material.
Surface Deterioration:	Crazing from surface shrinkage more rapid than interior of concrete mass. Too high a slump. Too rich a mix. Poor timing on finishing. Too rapid absorption of moisture. Cavitation from water or liquid action over surface. Chemical reactions.

Masonry

Cracks (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Inadequate finishing and curing. Vertical or horizontal cracking. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Surface cracking. Thermal changes (subjected to temperature extremes, such as from freeze/thaw cycles). Stress concentration from excessive loads. Step cracking. Accidents from overload, vibration, fatigue, and earthquake. Shear cracking.
Surface Deterioration:	Cavitation from water or liquid action over surface. Chemical reactions causing surface breakdown.
Holes (Small & Large):	Inadequate construction and design. Impact damage.
Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb or not level in one or more directions.
Mortar, Joint Material Missing, Eroded:	Deteriorated or damaged mortar/grout joints that have fallen out or worn down. Excessive joint movement.
Staining:	Surface discoloration from a foreign substance or material.
Efflorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.

DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

SYSTEM ASSEMBLIES/DEFICIENCIES

Masonry (Continued)

Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
Damaged/Missing Sections:	Broken, damaged, cracked, or missing units or sections.

Stone

Cracks (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Inadequate finishing and curing. Vertical or horizontal cracking. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Surface cracking. Thermal changes (subjected to temperature extremes, such as from freeze/thaw cycles). Stress concentration from excessive loads. Step cracking. Accidents from overload, vibration, fatigue, and earthquake. Shear cracking.
Damaged/Missing Sections:	Broken, damaged, cracked, or missing units or sections.
Efflorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Holes (Small & Large):	Inadequate construction and design. Impact damage.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
Mortar, Joint Material Missing, Eroded:	Deteriorated or damaged mortar/grout joints that have fallen out or worn down. Excessive joint movement.
Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface usually results from excessive moisture.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb or not level in one or more directions.
Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions.
Staining:	Surface discoloration from a foreign substance or material.
Surface Deterioration:	Cavitation from water or liquid action over surface. Chemical reactions causing surface breakdown.

DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

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PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	CONCRETE EFFLORESCENCE		
UTILITY SUPPORT STRUCTURES UTILITY SERVICE TUNNELS (CSI 03000)	Revision No.	issue Date 5/93	Drawing No. D12010505-1

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	CONCRETE CRACKING/EFFLORESCENCE		
UTILITY SUPPORT STRUCTURES UTILITY SERVICE TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. D12010505-2

DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

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DEFICIENCY FACTORS
0.12.01.05.05 UTILITY SERVICE TUNNELS (CSI 03000)

END OF SUBSECTION

0.12.01.05.06 UTILITY SERVICE TUNNELS: **DAMPPROOFING/WATERPROOFING** (CSI 07000)

DESCRIPTION

Concrete and masonry structures are designed and built to (1) contain water within the structure, or (2) maintain dry conditions within the structure when it is subject to water conditions on the outside. Because most tunnel walls and slabs leak water by hydration, they are not always completely impermeable to water. However, dampproofing/waterproofing is used to prevent moisture penetration. Because concrete and masonry may develop cracks after placement, it is sometimes necessary to cover the surface with a barrier material to meet these requirements.

Protective barrier systems are required to protect concrete and masonry from deterioration when exposed to chemicals. In some cases, a barrier is required to prevent chemicals from being contaminated when they contact a concrete surface. In this guide, they will be identified as a waterproofing barrier system and a dampproofing barrier system. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

Waterproofing barrier systems treat surface or structural systems to prevent water passage under hydrostatic pressure.

Dampproofing barrier systems treat a surface or structural systems to resist water passage in the absence of hydrostatic pressure.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Waterproofing (CSI 07100)

Waterproofing is normally used to prevent leakage of water into, through, or out of concrete or masonry under hydrostatic pressure. If freeze/thaw conditions exist or if water is carrying aggressive chemicals that attack reinforcing steel or concrete, the waterproofing barrier will be used to prevent leakage into the concrete or masonry. If a dry surface is required for applying coatings, waterproofing could be used to prevent moisture from leaving the concrete. Waterproofing is also used to minimize unsightly carbonates or efflorescence.

Positive side barrier systems are placed on the same side as the applied hydrostatic pressure. Negative side barrier systems are placed on the side opposite to the applied hydrostatic pressure.

Waterstops (CSI 03250)

A waterstop is a thin sheet of metal, rubber, or other material inserted across a joint to obstruct the water seeping through the joint. Usually formed from rubber in a dumbbell shape with fins cast into the concrete during the concrete pour or inserted into pockets formed by specially shaped masonry units.

0.12.01.05.06 UTILITY SERVICE TUNNELS: **DAMPPROOFING/WATERPROOFING** (CSI 07000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Waterstops (CSI 03250) (Continued)

Comparison of Positive or **Negative Side** Waterproofing Barriers

Negative Side Waterproofing	Positive Side Waterproofing
Advantages	Advantages
Concrete may remain moist eliminating drying, shrinkage, and cracking	Water is prevented from entering concrete
Inspection and repair possible and economical after backfill	Dried concrete is protected from freeze/thaw damage
No additional excavation costs for application or repair	Corrosion protection if aggressive chemicals are present
Disadvantages	Disadvantages
No freeze/thaw protection	Membrane inaccessible if sandwiched or backfilled
No corrosion protection if aggressive chemicals are present	Repairs are difficult
May have to stop moisture flow to install the system	Additional excavation costs for installation of membrane
	Damage possible during backfill

Membrane Waterproofing (CSI 07100)

Membrane waterproofing is the most reliable barrier type for preventing water under a hydrostatic head from entering an underground structure. When used in conjunction with good design, high quality concrete, admixtures, and hydrostatic pressure reduction by designed drainage (surface tile, drainage fabric, wellpoints, etc.), membrane waterproofing should reduce water leakage problems.

Waterproofing membranes have varying permeability coefficients (perms). Traditionally, waterproofing barriers consist of multiple layers of bituminous-saturated felt or fabric cemented together with hot-applied coal tar pitch or asphalt for positive side applications. There are also cold-applied systems that use multiple asphaltic mastic and glass fabric applications. A number of other positive side waterproofing barriers can be selected, including cold-applied systems, (such as elastomeric membrane barriers), cementitious membranes, modified bituminous materials, and bentonite-based materials. For negative side waterproofing, cementitious membranes or metallic oxide waterproofing materials can be used. The number of coats or plys, thickness, and the types of materials will vary with the job conditions.

Types of Waterproofing Barrier Systems:

- Hot-applied bituminous-reinforced
- Hot-applied bituminous-nonreinforced
- Prefabricated bituminous
- Prefabricated nonbituminous
- Cold-applied bituminous-nonreinforced
- Cold-applied nonbituminous-reinforced
- Cold-applied nonbituminous-nonreinforced
- Cementitious barriers

0.12.01.05.06 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING (CSI 07000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Hot-Applied Bituminous Barrier Materials (CSI 07100)

The materials used for hot-applied systems are bituminous substances of either coal tar pitch or asphalt derived from petroleum. The bitumens (coal tar pitch and asphalt) used in hot-applied systems have very little strength within themselves. Fabrics and felts act as reinforcement to withstand the strains of expansion, contraction, temperature changes, vibration, and building movement.

Felts (CSI 07100)

Used in a waterproofing system, felts are usually the same as those used for roofing purposes. Cotton fabrics weigh a minimum of 10 oz. per square yard and have a long record of use. Glass fabric is the strongest in use, having a minimum tensile strength of 75 lb. per inch of width. Jute (treated burlap) is sometimes used because of its coarse texture. All of the fabrics are available in a variety of widths ranging from 3 to 48 inch.

Cold-Applied Bituminous Barrier Materials (CSI 07100)

These materials may use bituminous and/or elastomeric materials that may be built-up in a manner similar to hot-applied systems, applied as a liquid to form a membrane, or may be factory-fabricated into sheets or rolls and then joined in the field to form the barrier system. Cold bituminous systems use asphalt emulsions or solvent cut-back asphaltic mastics and are reinforced with fabric. These mastics and emulsions have little strength within themselves. The fabric acts as a reinforcement in the same manner as in hot-applied systems.

Liquid-Applied Elastomeric Barrier Materials (CSI 07120)

Elastomeric materials are liquids that are applied by means of squeegee, roller, brush, trowel, or spray. When cured, they form a film resistant to water and many other chemicals, With some of these materials, the manufacturer may require reinforcement with glass fabric. An elastomer is defined in ASTM D1566 as a “macromolecular material that returns rapidly to approximately the initial dimensions and shape after substantial deformation by a weak stress and release of the stress.” Liquid-applied membranes are formulated as single- or multiple-component products such as neoprene (polychloroprene), neoprene-bituminous blends, polyurethane, polyurethane-bituminous blends, and epoxy-bituminous blends.

Dampproofing (CSI 07150)

Dampproofing is a treatment of a surface or structure to resist water passage in the absence of hydrostatic pressure. Dampproofing barrier systems are used to perform the same functions as a waterproofing system, but cannot be used to protect against water under pressure. A drainage system may be required to prevent the development of a head of water. Dampproofing is a low-cost system because the material thickness is relatively low and minimum surface preparation is required. A dampproofing barrier system will minimize water vapor transmission through concrete that is not subjected to a continuous or intermittent head of water.

OTHER RELATED COMPONENTS

Refer to Foundations and Footings, Volume 1, for additional deficiencies that may impact this system.

0.12.01.05.06 UTILITY SERVICE TUNNELS: **DAMPPROOFING/WATERPROOFING** (CSI 07000)

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DEFICIENCY FACTORS
0.12.01.05.06 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING (CSI 07000)

PROBABLE FAILURE POINTS

- Efflorescence is a deposit of salts on a surface, that having emerged in solution from within concrete or masonry and are deposited by evaporation. Also, soluble salts of various kinds, chiefly sulfates, may be carried by water into the concrete from the soil or other environmental source.
- Water may be forced through tunnel walls or roof slab by hydrostatic pressure, water vapor gradient, capillary action, or any combination of these.
- Acids, some salt solutions, and water (depending on purity and temperature) will react with The Calcium Hydroxide in the hydrated Portland cement binder of concrete or mortar to form water-soluble reaction products resulting in material disintegration.
- Chemical or salt solutions penetrating concrete or masonry are likely to cause localized reinforcing steel corrosion. Rust results in expansive pressures that cause deterioration of the concrete or masonry near the steel. A protective barrier may be factory-applied to reinforcing steel before use and/or a waterproofing barrier may be applied to the positive side of the concrete.

SYSTEM ASSEMBLIES/DEFICIENCIES

Membrane/Coating

Loose Adhesive, Bubbles:	Adhesive breakdown causing slippage, loose areas, or membrane pop-up.
Fishmouths, Open Seams:	Seams opening or puckering from adhesive breakdown allowing water penetration.
Holes, Penetrations, Leaks:	Impact or chemical reaction damage causing missing membrane or barrier areas.
Surface Deterioration:	Ultraviolet light, chemical reaction, or weathering.
Blistering:	Surface condition usually caused by chemical reaction causing surface dimpling or puckering.
Surface Splitting:	Ripping or tearing from excess substrate movement.
Alligatoring/Cracking:	Random surface cracking from weathering or ultraviolet light.

DEFICIENCY FACTORS
0.12.01.05.06 UTILITY SERVICE TUNNELS:
DAMPPROOFING/WATERPROOFING (CSI 07000)

END OF SUBSECTION

0.12.01.05.07 CONCRETE SUPPORT PADS (CSI 03000)

DESCRIPTION

Support pads are used to support electrical equipment and to transfer equipment loads to the soil. They are generally rectangular prisms of concrete larger in lateral dimensions than the unit of equipment it supports. Shapes other than rectangular are possible. The concrete support pad design is created not only by specific formwork, but is also based on physical properties of specified cement, admixtures, uniformity in mixing and placing technique, curing methods, and other quality control factors. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Cast-in-Place Concrete (CSI 03300)

Concrete placed in forms at its final location. Concrete is a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate. In Portland cement concrete, the binder is a mixture of Portland cement and water. ACI publications 318 “Building Code Requirements for Reinforced Concrete” and 301 “Specifications for Structural Concrete for Buildings” have indicated a preference for specifying the proportioning and design of mixes by other than prescriptive methods.

Design mixes that provide the most common normal weight concrete:

- 4000-psi, 28-day compressive strength water/cement ratio; 0.44 max
- 3500-psi, 28 day compressive strength water/cement ratio; 0.51 max
- 3000-psi, 28 day compressive strength water/cement ratio; 0.58 max
- 2500-psi, 28 day compressive strength water/cement ratio; 0.67 max

Formwork (CSI 03100)

The total assembly/component member of support for freshly placed concrete, including the mold or sheathing that contacts it, all supporting members, hardware, and necessary bracing. ACI standard 347 “Recommended Practice for Concrete Formwork” provides recommended practices for materials, applications, and specifications for forming systems including oiling formwork to prevent concrete from adhering.

Types of Formwork Materials:

- Dimension Lumber
- Plywood
- Steel
- Aluminum & Magnesium
- Plastics
- Reinforced Plastics
- Masonite
- Planking

Concrete Reinforcement (CSI 03200)

Bars, wires, strands, and other slender members embedded in concrete in such a manner that the reinforcement and the concrete act together in resisting forces. Reinforcement must be accurately located to ensure proper cover and to reduce the chance of loss or corrosion of structural section of reinforcing steel. When concrete is deposited against the earth for support pads, there should be at least 3 inches of concrete between the steel and the earth. Follow ACI 318 publication “Building Code Requirements for Reinforced Concrete.”

0.12.01.05.07 CONCRETE SUPPORT PADS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Support for Reinforcement (Chairs, Spacers & Bolsters) (CSI 03250)

Chairs are small metal or plastic supports for reinforcing steel. The support is used to maintain the proper positioning during concrete placement. Spacers are used in the same fashion as chairs to maintain proper positioning during concrete pours. Concrete bolsters are a continuous wire bar support used to support bars in the bottom of footings. The top wire is usually corrugated at 1 inch centers to hold the bar in position.

Admixtures (CSI 03370)

An ingredient other than cement, aggregate, or water that is added to a concrete mix to affect the physical or chemical characteristics of the concrete. The most common admixtures affect the plasticity, air entrainment, and curing time.

Air-Entrainment Agents:

- Provide a more workable material.
- Definitely used when concrete surface will be exposed to freeze/thaw cycles.

Retarder & Densifying Agents:

- Retard the set; suggested in warm weather to reduce cracking due to rapid set-up.
- Increase the workability of the mix.
- Allow for delayed finishing, resulting in less permeable concrete.

Accelerator:

- Useful in winter (cold weather concreting).
- Useful when working to seal against the water-flow.
- Should be used sparingly because the admixture tends to increase shrinkage.

Granular Base (CSI 03300)

Evenly graded mixture of fine and course aggregates to provide, when compacted, a smooth and even surface below support pads.

OTHER RELATED COMPONENTS

Refer to Foundations and Footings and Substructure, Volume 1 and 2, for additional deficiencies that may impact this system.

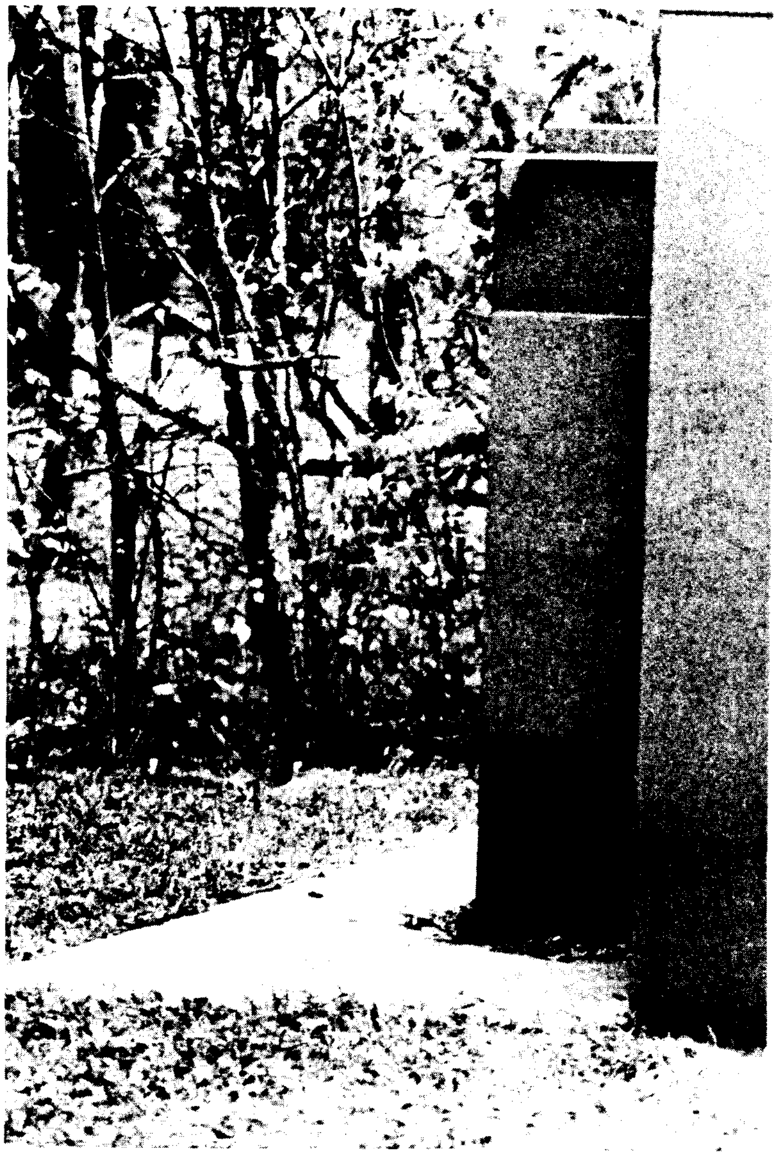
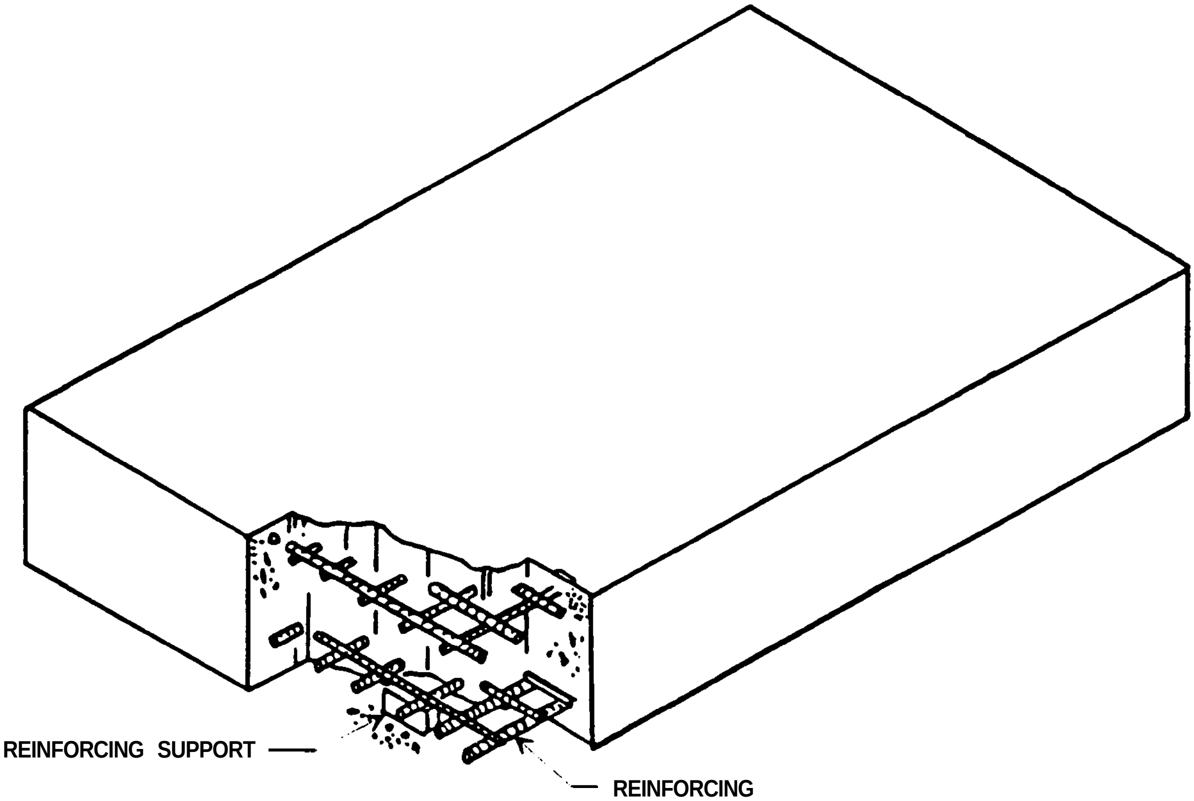
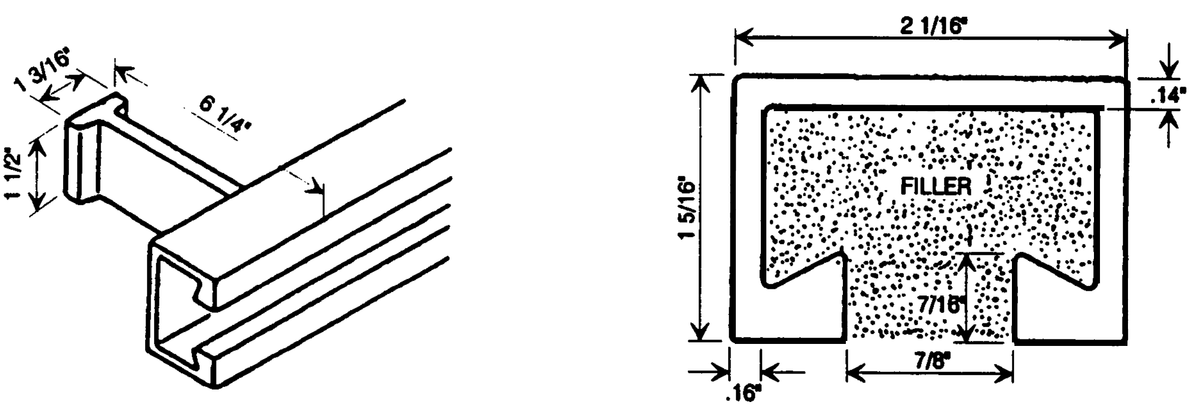


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TRANSFORMER PAD		
UTILITY SUPPORT STRUCTURES CONCRETE SUPPORT PADS (CSI 03300)	Revision No.	Issue Date 5/93	Drawing No. A12010507-1

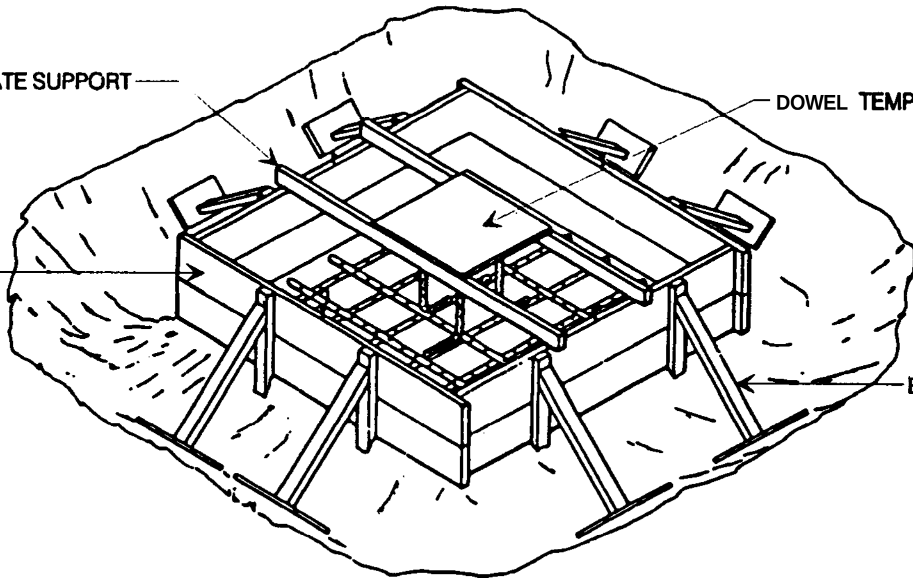


CONCRETE SUPPORT PAD



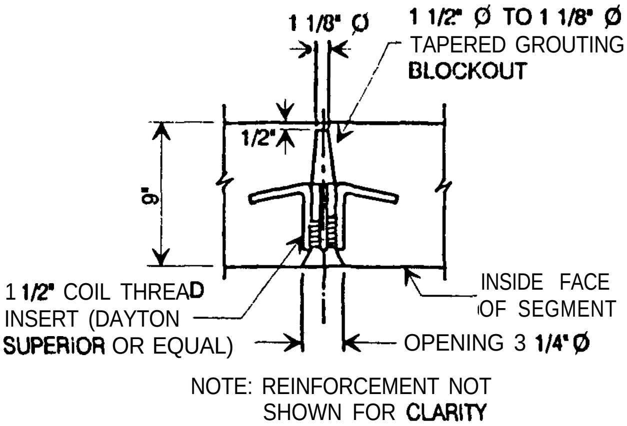
ANCHOR CHANNEL

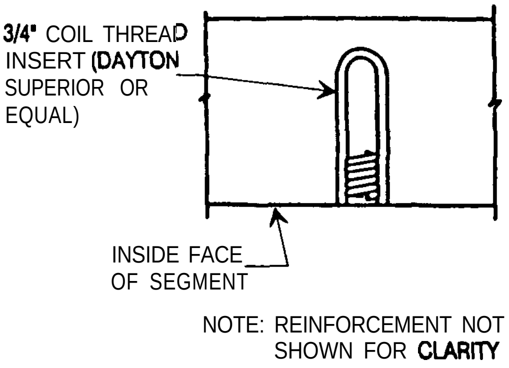
SYSTEM ASSEMBLY DETAILS-SITEWORK	SUPPORT PADS		
ELECTRICAL INFRASTRUCTURE CONCRETE SUPPORT PADS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A12010507-2

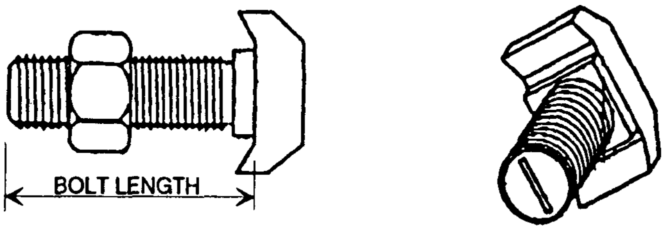


TYPICAL FORMWORK

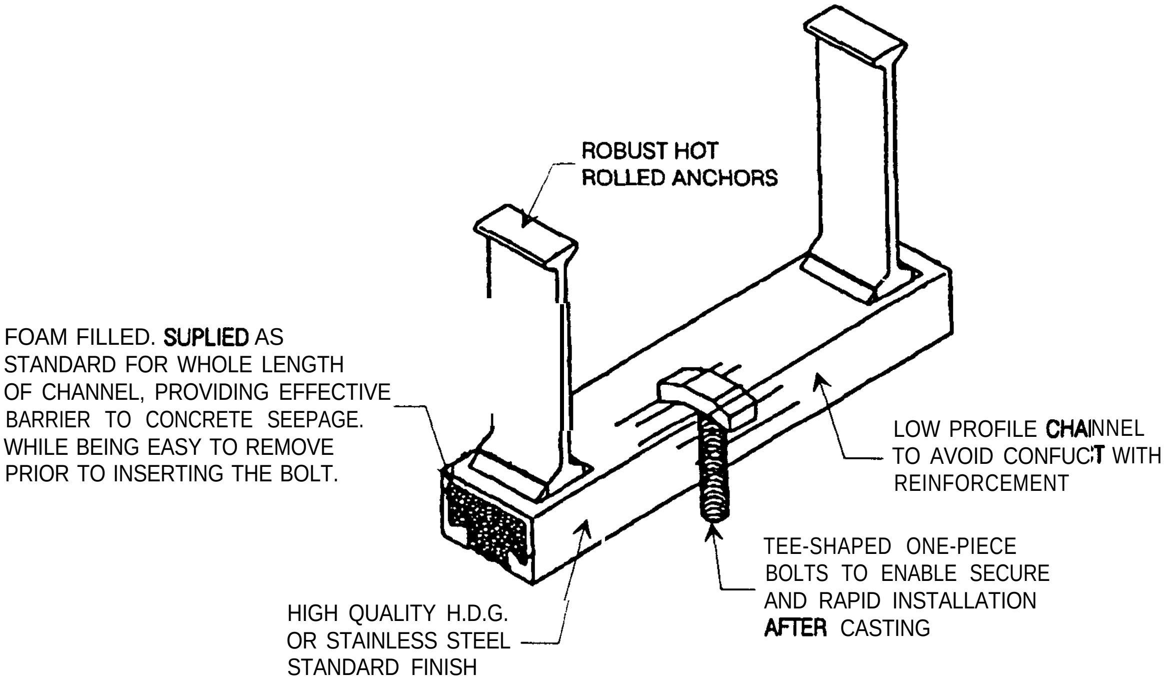
SYSTEM ASSEMBLY DETAILS-SITEWORK	SUPPORT PAD FORMWORK		
UTILITY SUPPORT STRUCTURES CONCRETE SUPPORT PADS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A12010507-3







HOOK HEAD BOLT



SYSTEM ASSEMBLY DETAILS-SITEWORK	CONCRETE ANCHORING ACCESSORIES		
UTILITY SUPPORT STRUCTURES CONCRETE SUPPORT PAD S (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A12010507-4

DEFICIENCY FACTORS
0.12.01.05.07 CONCRETE SUPPORT PADS (CSI 03000)

PROBABLE FAILURE POINTS

- Lack of curing will increase the degree of cracking within a concrete structure.
- Reinforcement corrosion caused by an electro-chemical process that occurs in the presence of air and moisture.
- The weathering processes that can cause cracking include (1) freezing and thawing, (2) wetting and drying, and (3) heating and cooling.
- A number of deleterious chemical reactions may result in concrete cracks. These reactions may be due to the aggregate used to make the concrete or materials that come into contact with it after it has hardened or cured.
- A wide variety of poor construction practices can result in cracking in concrete structures, especially adding water to concrete to improve workability. Added water has the effect of reducing strength, increasing deformations, and increasing ultimate drying shrinkage.
- Overloads induced during construction can be far more severe than those experienced in the lifetime of the structure. Unfortunately, these conditions may occur at early ages when the concrete is most susceptible to damage, and often results in cracks.
- The effects of improper design and/or detailing range from poor appearance to lack of serviceability to catastrophic failure.
- Externally applied loads induce tensile stresses that result in concrete cracks. Current ACI 318 design procedures use reinforcing steel, not only to carry the tensile forces, but also to control both crack distribution and width.
- Improper compaction or soft spots in the grade resulting in uneven settling or equipment slippage.
- Hydrostatic pressure from groundwater resulting in heaving or movement of the structure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Alkali-Aggregate Expansion:	Chemical reaction between aggregate and cement paste.
Cracks (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Inadequate finishing and curing. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Thermal changes (subjected to temperature extremes, such as from freeze/thaw cycles). Stress concentration. Structural design. Accidents from overload, vibration, fatigue, and earthquake.
Surface Deterioration:	Crazing from shrinkage more rapid than interior of concrete mass. Too high a slump. Too rich a mix. Poor timing on finishing. Too rapid adsorption of moisture. Cavitation from water or liquid action over surface. Chemical reactions.
Holes (Small & Large):	Inadequate construction and design. Impact damage.
Form Scabbing:	Form oil improperly applied.
Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions.
Leaching:	Process of separating liquids from solid materials by allowing them to percolate into surrounding soil.

DEFICIENCY FACTORS
0.12.01.05.07 CONCRETE SUPPORT PADS (CSI 03000)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb or not level in one or more directions.
Staining:	Surface discoloration from a foreign substance or material.
Eff lorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Moss, Algae Growth:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Corrosion of Rebar:	The oxidation or eating away of the metal rebar by chemical or electrochemical action after prolonged exposure to moisture.

END OF SUBSECTION

0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

DESCRIPTION

Pavement provides a stable but flexible surface that transfers and distributes loads to the earth or other supporting structure (such as a bridge or overpass). Design and construction varies significantly, depending on local factors such as weather and volume and type of traffic. The most common construction methods are easily recognized by their wearing surface (eg., asphalt, concrete, brick, or stone), but there many variations in the application techniques not readily apparent during an inspection.

Although the major system components vary with the method, generally road profiles include a subbase, a base, and a wearing course. In addition there may be a binder course, vapor barriers, geotextile fabrics. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Subbase (CSI 02200)

Roadwavs:

The subbase refers to the earth (grade) or structure on which the pavement system is applied. Although not technically part of the pavement system per se, the subbase condition has a direct impact on the functionality and life expectancy of the pavement.

The subbase must be stable. Loss of support or shifts in the load distribution within the subbase can lead to excessive pavement movement. This causes (paving system) fatigue resulting in cracks, course delamination, and possible collapse.

Where needed, subbase stabilization may be achieved by direct mixing of additives or the application of a geotextile fabric. These common additives are cement, bituminous cutback, and lime. The additive choice depends on the silt and clay content of the soil. After mixing, the soil is compacted and left to cure.

The geotextile fabric utilization is an alternative method of achieving stabilization. It is typically a woven polyethylene of various weights applied directly over the subbase. On sloping elevations, additional erosion controls may be required. In addition to geotextile fabrics, other controls may include: shrubbery, ground cover, and grass; biodegradable plastic netting; organic, wood, or stone mulch; rip rap stone.

Walkways:

As with roadways a stable subbase is required. The usual method includes compacting the grade to 90% of existing undisturbed grade.

Base (CSI 02200)

Roadwavs:

The base course transfers the load from the wearing course to the subbase. It is a single layer of material that varies in type of material and thickness. Base design is dependent on the subbase structural capabilities. The weaker (lower bearing value) the subbase, the greater the required capabilities (thickness and flexural strength) of the base.

Base materials include gravel aggregate, sand, concrete, or some combination of material. For bituminous or asphaltic bitumin concrete pavement, the base aggregate material's flexural strength can be improved by mixing in bitumen and/or separating the base material from the subbase with a geotextile fabric. The latter approach has the benefit of preventing "pumping" or mixing of the subbase material with the base.

0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Base (CSI 02200)

Roadways (Continued):

For concrete pavement, the strength of the base is improved with the use of reinforcing bars or wire mesh in the mix. Size and type of reinforcing again depends on the structural subbase capability.

Walkwavs:

The base material for walkways is commonly a gravel aggregate (4 to 6 inches deep) although sand, concrete, or some other combination may be used.

Wearing Course (CSI 02500)

The wearing course is the top surface of the pavement system and is generally considered the maintainable portion. Although it may be perceived of as a single layer, the wearing course may consist of several courses, that bind together to form a replaceable unit. These are referred to as the leveling course, the binding course, and the surface course. Usually, the wearing course consists of multiple layers whenever the thickness is greater than 2 inches. The wearing surface transmits the traffic load to the base (provides support), takes the abrasive action of the traffic (provides longevity), and provides a non-slip surface for the traffic.

The most common wearing surface (for roads) is asphaltic bitumen concrete, and is usually applied directly over a granular base course. It consists of mineral aggregates mixed with asphaltic bituminous materials. The aggregates are broken stone and slag, crushed or uncrushed gravel, sand, and mineral fillers. The bituminous materials bind the aggregates and prevent moisture from penetrating the surface. Another widely used wearing surface for roads is concrete. It is applied directly over a gravel base and uses reinforcing bar or wire mesh to improve its strength. (As noted reinforcing will vary based on overall road structural capability.)

Walkwavs:

The most common wearing surface for walkways is concrete; It is applied directly over a gravel base and uses wire mesh to improve its strength. Bituminous asphalt is the second most common material employed. More decorative surfaces such as cobblestone, random stone, or brick may be used for small walks, patios, plazas, etc. These may be set on a concrete bed and grouted or may be set on a sand bed. When sand is employed, the bricks or stones are “grouted” with sand and tamped.

Curbs & Expansion Joints (CSI 02500)

In all pavement (including sidewalks), allowance must be made for the effects of expansion and contraction. This is typically achieved by forming the pavement in sections and placing spacers or expansion joints between the sections.

Curbs are primarily used to channel water runoff from the pavement to the drainage system. Providing a manufactured channel minimizes pavement erosion. Curbs are also used to demark the end of the pavement area to prevent or minimize traffic movement to unpaved areas.

Curbs may be either precast, cast-in-place concrete, formed of bituminous concrete, stone, or masonry.

DEFICIENCY FACTORS
0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

PROBABLE FAILURE POINTS

- Erosion of subbase causing support failure with associated pavement cracks, breaks, chips.
- Weathering of wearing course with associated potholes, alligatoring, surface cracks.

SYSTEM ASSEMBLIES/DEFICIENCIES

Subbase

Erosion:	Penetration of water into system causing runoff of material.
Collapse:	Voids caused by improper compaction, erosion, contraction during a thaw cycle.
Heaving:	Expansion of moisture during a freeze cycle

Base

Erosion:	Penetration of water into system causing runoff of material.
Collapse:	Voids caused by improper compaction, erosion, contraction during a thaw cycle/
Heaving:	Expansion of moisture during a freeze cycle.

Wearing Course

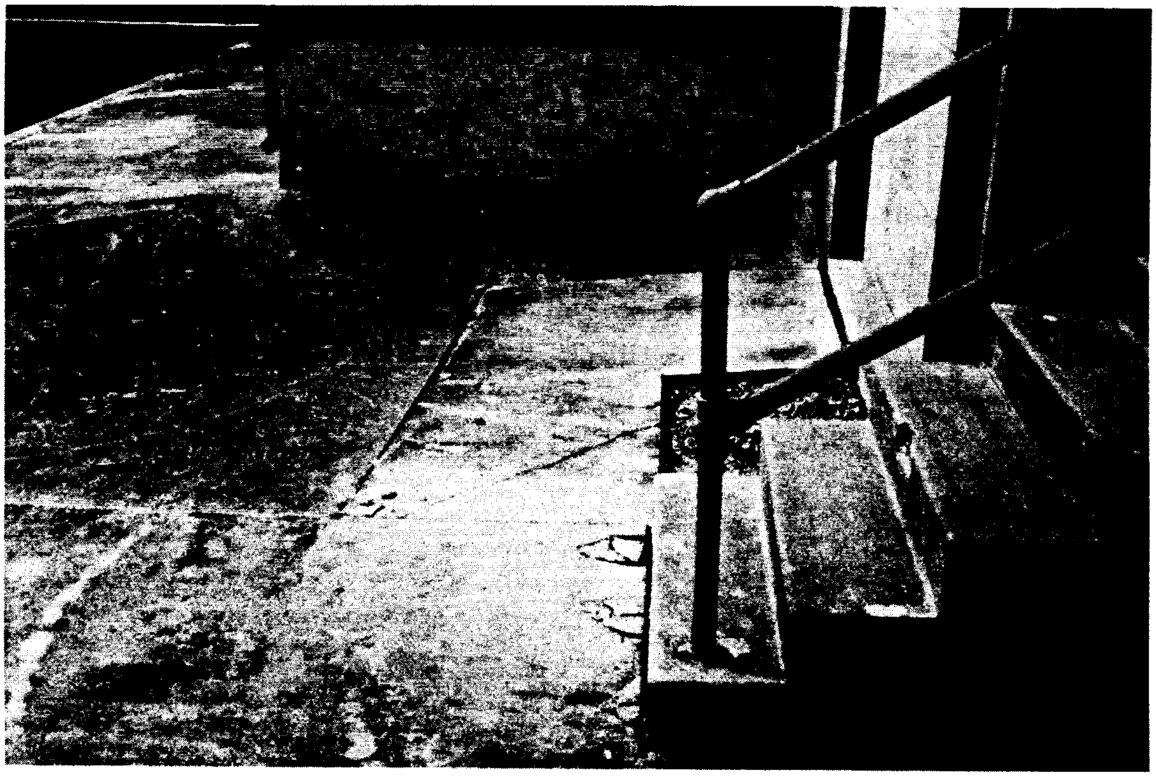
Erosion:	Penetration of water into system causing runoff of material; freeze/thaw cycles.
Potholes:	Penetration of water into system causing runoff of material; freeze/thaw cycles.
Collapse:	Voids caused by improper compaction, erosion, contraction during a thaw cycle.
Heaving:	Expansion of moisture during a freeze cycle.
Surface Raveling:	Improper design; inadequate asphalt.
Longitudinal or Transverse Cracks:	Shrinkage of subgrade, frost action.
Localized Cracks (alligatoring, mapping, blocking):	Lack of support, settling, deformation, loss of volatiles, embriiement.
Shrinkage Cracking:	Improper mixtures.
Hardening:	Brittleness of the binder, loss of resiliency due to exposure.
Stripping:	Breakup of the surface due to insufficient binder or improper application (wet).
Rutting:	Overload of pavement.
Slippage:	Improper curing of prime coats, tack coats; dirt not removed during application.

DEFICIENCY FACTORS
0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Curbs & Expansion Joints

Cracking/Spalling:	Improper design, impact damage and/or reinforcing oxidation.
Missing Sections:	Improper installation, impact damage.
Heaving:	Uneven settling between curb subbase and paving subbase.
Physical Damage:	Abuse by traffic.
Weathering:	Normal effects of the environment.



CRACKING OF SIDEWALK DUE TO UNSTABLE SOIL

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	UNSTABLE SOIL AT SIDEWALK AND CRACKING		
PAVING ROADWAYS/WALKWAYS WALK (CSI 02520)	Revision No.	Issue Date 5/93	Drawing No. D1202-1

CRACKING OF SIDEWALK DUE TO UNSTABLE SOIL

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	UNSTABLE SOIL AT SIDEWALK AND CRACKING		
PAVING ROADWAYS/WALKWAYS WALK (CSI 02520)	Revision No.	Issue Date 5/93	Drawing No. D1202-2

WATER PONDING AT LOW POINT OF ENTRY

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	LOWPOINT AT ENTRY		
PAVING ROADWAYS/WALKWAYS WALK (CSI 02520)	Revision No.	Issue Date 5/93	Drawing No. D1202-3

CRACKING AND DETERIORATION

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	CONCRETE CURB CRACKING AND DETERIORATION		
PAVING ROADWAYS/WALKWAYS ROAD (CSI 02520)	Revision No.	Issue Date 5/93	Drawing No. D1202-4

SUNKEN PARKING LOT DUE TO UNSTABLE SOIL

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	UNSTABLE SOIL AT PARKING LOT		
PAVING ROADWAYS/WALKWAYS PARKING (CSI 02545)	Revision No.	Issue Date 5/93	Drawing No. D1202-5

DEFICIENCY FACTORS
0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

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DEFICIENCY FACTORS
0.12.02 PAVING ROADWAYS/WALKWAYS (CSI 02500)

END OF SUBSECTION

0.12.03 TUNNELS (CSI 02300)

DESCRIPTION

This section addresses tunnel construction and configuration. Tunnel structures are used to guide traffic (vehicular, pedestrian, utility) under water or earth. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

General Construction

For tunnel fabrication, various construction materials and techniques are employed. Tunnel components may include construction materials such as masonry, concrete (cast-in-place and prestressed), and steel. General foundation, substructure, and superstructure information is found in Volumes 1, 2, and 3, respectively. The following information pertains to tunnels only.

Tunnel Construction & Type:

- Shield Tunnel - In soft, unstable soil, tunnel construction consists of steel shields (circular), driven through the ground and then excavated. Substrate conditions requiring shield tunnels include weak non-cohesive soil (sand, silt, loose gravel), weak plastic soils, clays and soils (clays), under water pressure.
- Rock Tunnels - Rock tunnels are cut through stable rock and can only be excavated by drilling and blasting. After the tunnel has been cleared, liners are used to stabilize and provide interior finishes. Liner types include masonry (Ashlar, brick), concrete (usually cast-in-place), and timber supports with solid lagging. (This last method used primarily for rail tunnels.) Highway tunnels are usually lined with ceramic tile. (See Sidewall Finishes in this section further information.)
- Sunken Tube Tunnels - Sunken tube tunnels are usually employed to cross bodies of water. They consist of tube sections (concrete or steel construction) designed in convenient lengths which are fabricated on dry docks, ship yards, or temporary construction sites located near the tunnel site. After completion, sections are towed by barge to location and placed in prepared tunnel trenches. These trenches are essential for tube tunnel construction. Because of this, soil must be of adequate cohesion to support stable trench slope walls to accommodate tube sections.

Arch/Circular Tunnel:

- Brick/Masonry Arch Tunnel - Brick tunnel construction was used extensively in early transit and railway systems. In the United States, this type of construction was generally limited to subways by the jack-arch method (the best examples of this construction can be found in older underground tunnels, most notably in Boston and New York). These tunnels, constructed by cut-and-cover techniques, were composed of steel framing spaced approximately 8 feet on-center for walls and 4 feet on-center for roof sections. The spaces between the steel framing were filled with brick in an arch shape. The brick and ceiling vaults are usually 24 inches thick and are covered with pitch on the exterior (outside) for waterproofing. Railway tunnels were designed as large arches, forming the entire tunnel structure. Depending on the depth of burial, these tunnels are generally 24 to 30 inches thick and are waterproofed with pitch on the exterior surface.

0.12.03 TUNNELS (CSI 023001

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

General Construction (Continued)

- Concrete Arch Tunnel - Today, concrete is now extensively used in arch tunnel design. Concrete arches are pored over forms in an arched shape. The arches are from 12 to 24 inches thick and are waterproofed on the exterior surface.

Concrete arches require less frequent maintenance than most materials, but certain failures can occur. For example, leakage through concrete arches is caused by cracks in the concrete and in rare cases, porosity of the concrete. These cracks may be caused by settlement, excessive floor loading, temperature expansion and contraction in structural members, or poor materials and workmanship in the original construction. Arch interior surfaces should be inspected quarterly for structural cracks, open soft joints, settlement, efflorescence, stains, and deterioration of paint or other covering.

<u>Circular Tunnels</u>:

- Circular tunnel structures consist of pre-cast concrete segments (similar to sunken tube tunnel construction). The void between the concrete liner and the earth is normally filled with gravel packing or grout.
- Segmental Steel Lined Tunnels - In segmental steel-lined tunnels, the steel liner acts as the exterior walls, floor, and roof of the tunnel, and the flanges of the liner plate act as the steel framing or ribs. The void between the steel liner and the earth is normally filled with gravel packing or grout.
- Utility and Sewer Tunnels - For utility tunnels and sewers (also rapid transit tunnels) that require shallow depth (35 to 45), cut and cover is the preferred method of construction. Such tunnels are usually designed as a rigid frame box structure constructed within a well-ordered trench with steel bracing supporting the side walls. In open areas, sloping trenches may be used. It should be noted that when slabs are used, each slab may serve a different function as described below:

    Roof supporting the earth at the top of a tunnel

    Ceiling forming the floor of an upper air duct

    Roadway slab forming the roof of the lower air duct

In all three functional classifications, slabs are continuous horizontal components of concrete with steel reinforcement.

<u>Tunnel Finishes</u>:

All tunnels, except those mined through stable rock substrate, require a structural lining. In most cases, the tunnel lining interior surface will also serve as the finish. Highway tunnels are the exception: tile is usually placed over the interior lining face. Additionally, for ventilation purposes, interior surfaces of rail and highway tunnels must be smooth to minimize air turbulence and consequent friction loss. Common finish materials include:

- Cast-in-Place Concrete - The ceiling slab consists of reinforced concrete 4 to 6 inches thick, which usually span transversely between the tunnel walls and supports. Interior spans vary, and composite concrete and structural beams or steel stringers, located between hangers 4 to 12 feet on-center, provide the main support. See Volume 3 Superstructure for more detailed information concerning cast-in-place concrete construction and assembly data.

0.12.03 TUNNELS (CSI 02300)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

General Construction

Tunnel Finishes (Continued):

- Metal Panel Ceiling - Usually consisting of cold-formed steel or aluminum panel filled with concrete, metal pan ceilings are widely used in highway tunnels. Panels vary in thickness from 2 to 4 inches, and are usually 6 to 13 feet long and 1 1/2 to 2 1/2 feet wide. Porcelain finishes are often applied to panel soffits and sides. These ceilings are usually supported by means of hangers, string supports, and frames.
- Veneered Ceilings - Veneer finish is directly applied to the structural tunnel lining; ceramic tile is the most common. (Where suspended ceiling is not required, tile is installed after the structural lining is in place.) Other veneer finishes include metal panels, paints, and specialty coatings. For more information concerning ceramic tile and other Finishes, see Volume 6 Interior Construction.
- Sidewall Finishes - As with ceiling finishes, the tunnel's structural lining (interior face) usually constitutes the wall finish. Paint, ceramic tile, and cast concrete patterns (coffer, vault, etc.) are employed in highway tunnels. It should be noted, as with ceiling finishes, that sidewalls must be smooth to avoid ventilation and reduce friction loss. For more detailed information concerning these finishes, see Volume 4 Exterior Finishes and Volume 6 Interior Finishes & Construction.
- Sidewalks - Tunnel sidewalks provide emergency means of pedestrian egress, and utility conduits are enclosed within the sidewalk construction assembly. For subaqueous vehicular tunnels, a raised sidewalk and ledge are often provided. This raised sidewalk is ideal for circular or arch tunnels because of its greater room for utility conduits and pull boxes. Construction materials are primarily cast-in-place concrete. See Volume 2, Substructure for additional concrete information concerning cast-in-place construction.

Tunnel Ventilation:

All vehicular tunnels require ventilation. Although natural ventilation is adequate for short length tunnels, (50 feet or less) longer, more heavily traveled tunnels are provided mechanical ventilation systems based on the length and traffic volume expected. For naturally vented tunnels, meteorological conditions, combined with the piston effect of moving traffic, are sufficient. Natural ventilation can be portal to portal or portal to shaft (for bi-directional traffic, intermediate shaft combined with portals is the most effective method).

Longitudinal ventilation involves removing and/or adding air at a limited number of points creating a longitudinal air flow. Injection type longitudinal system is used frequently in rail tunnels. This method is most effective in unidirectional tunnels, because uniform air velocity avoids concentrating contaminants. The longitudinal system, with an additional shaft used for bi-directional tunnels, is similar, but air flow is induced mechanically by fans. Peak contaminants are pulled into the shaft area.

For longer tunnels, a semi-transverse ventilation method is used. A fan-induced flow is often used to provide uniform contaminant movement throughout the tunnel. This method avoids any harmful noxious gas concentrations. For larger tunnels, a full transverse system is employed, which combines a full exhaust duct with the supply type semi-transverse system to achieve a uniform supply air and vitiated air distribution.

- Ventilation Equipment - Ventilation is supplied mechanically by an engineered system containing a series of fans, motors, dampers, distribution ducts, and facilities to house them. Fan types include axial flow, centrifugal, and propeller fans. For detailed information concerning these fans see Volume 8 Mechanical.

0.12.03 TUNNELS (CSI 02300)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

General Construction

Tunnel Ventilation (Continued):

- Environmental Monitoring System - To monitor environmental conditions, several systems are provided including carbon monoxide analyzing and visibility monitoring equipment. Other systems are used to control fans (see Volume 8 Mechanical), closed circuit TV, etc.

  The carbon monoxide analyzer samples tunnel air and determines the CO concentration in the tunnel environment. The primary analyzers include the Catalytic Reaction type, which uses chemical reaction to particulate samples, and the Non-dispersive infrared type, which uses two infrared beams (one passing through a sample cell and one through an inert cell for comparison). Pumps are critical to the operation of these devices and must be strong enough to draw the sample from the sample point to the device in less than 3 minutes. Pump types include turbine, positive displacement, and diaphragm (most common). See Volume 8 Mechanical Systems for additional pump information.

  Visibility detectors measure the visibility of tunnel air by the light-scattering principle. This comparison method uses a dual cell device (one being a calibrated optic the other containing the tunnel air sample).

- Railroad Tunnel Ventilation - In railroad tunnels, the most important environmental hazards involve heat generation and contaminants produced by diesel engine locomotives. Although contaminant problems are similar to those found in vehicular traffic tunnels, instead of carbon monoxide, oxides of nitrogen are primary toxin. As pointed out in the Handbook of Tunnel Engineering, “The exhaust gases are emitted from the top of most diesel electric locomotives. This creates a phenomena which aids the ventilation of any railroad tunnel. The stratification effect created in the crown of the tunnel and in the annular space by the temperature gradients remains stable, and thus a percentage of the exhaust gas contaminants will remain in the crown of the tunnels and not interact with the train. Tests have shown that about only 45 percent of the emitted exhaust gases descend from the tunnel crown to interact with the air in the spaces at the sides of the locomotives.” Ventilation methods previously described use this phenomenon to aid in removing contaminants.

Drainage System:

Tunnel drainage can be accommodated by either a gravity flow or pumped system. For continuous grade tunnels, gravity is sufficient provided water can be collected and disposed of at the tunnel end(s). Tunnels that change grade require pumping system to control drainage. The tunnel roadway drainage system can be either open or closed. The open type contains gutter recessed into the curb. This system, however, may propagate fuel fires. A closed system eliminates this risk because drainage flow enter inlets at curb lines, then passes through a closed gravity flow system. Inlets located on both sides are usually between 50 and 75 feet apart. See Volume 8 Mechanical for detailed information concerning system components.

Electrical Systems:

The tunnel’s electrical distribution includes primary supply, transformers, switchgears, control equipment, and distribution wiring. tight systems include general tunnel lighting and emergency light and fire/smoke detection systems. See Volume 9 Electrical for detailed information concerning these systems.

0.12.03 TUNNELS (CSI 023001

OTHER RELATED COMPONENTS

Refer to Foundations and Footings, Substructure, Superstructure, Exterior Closure, Interior Finishes and Construction, Mechanical, and Electrical, Volumes 1, 2, 3, 4, 6, 8, and 9 respectively, for additional deficiencies that may impact this system.

0.12.03 TUNNELS **(CSI 02300)**

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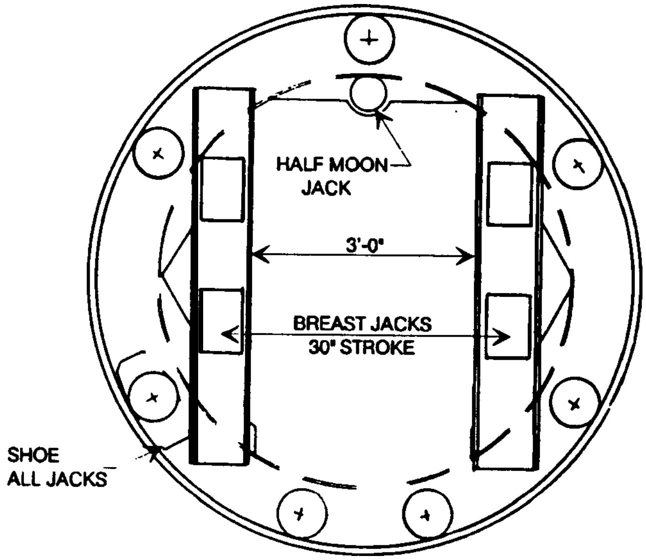
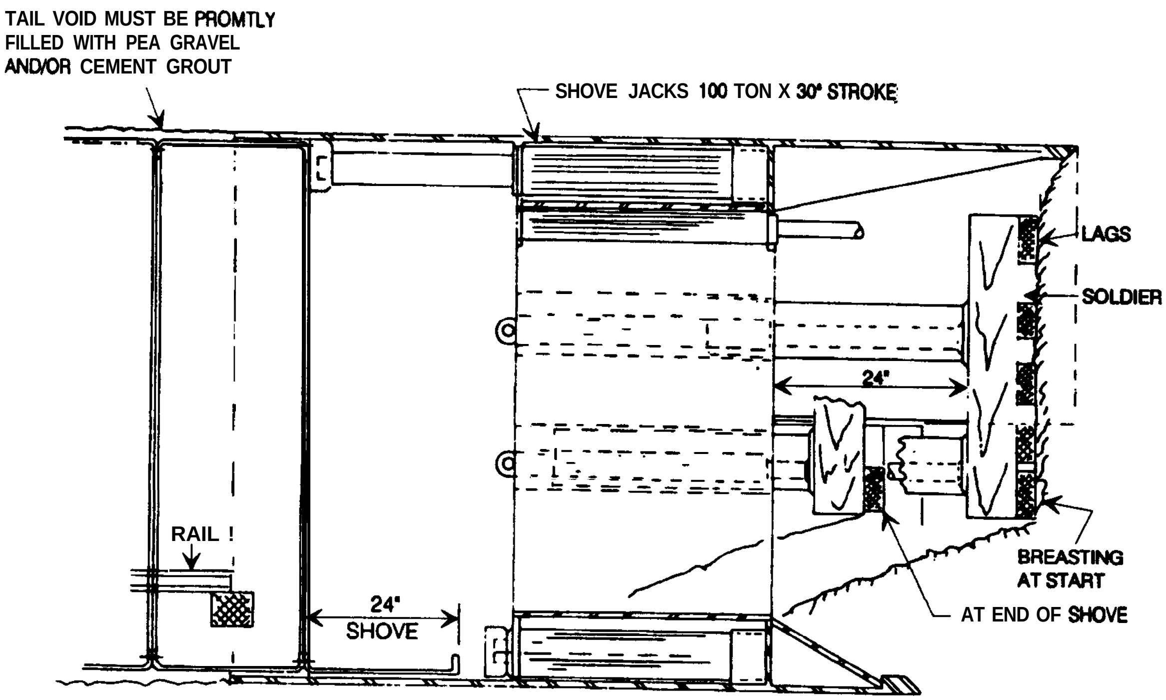


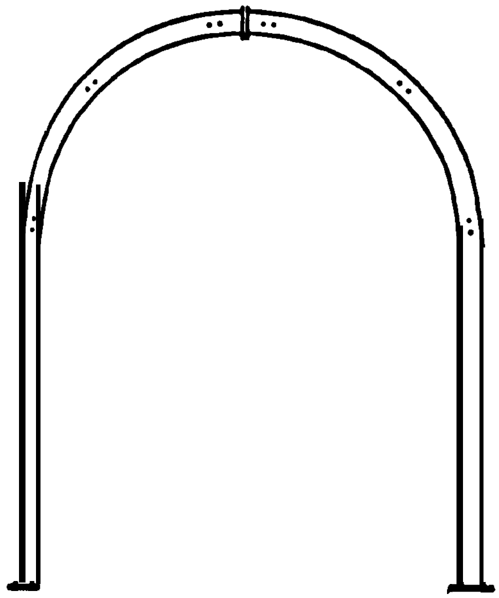
VIEW OF TAIL



TUNNEL SHIELD FOR 84" O.D. LINER PLATES

SMALL TUNNEL SHIELD FOR RAILROAD CROSSING

SYSTEM ASSEMBLY DETAILS-SITEWORK	SHIELD TUNNEL SECTION		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-1



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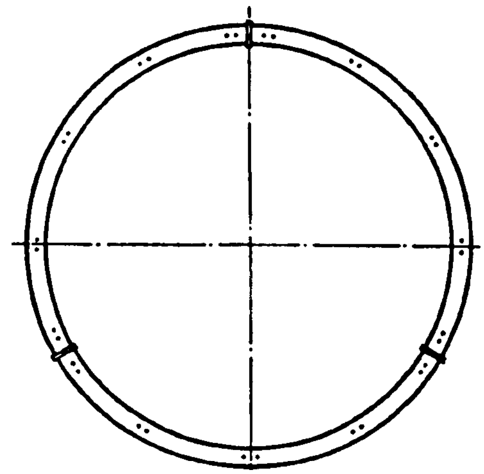
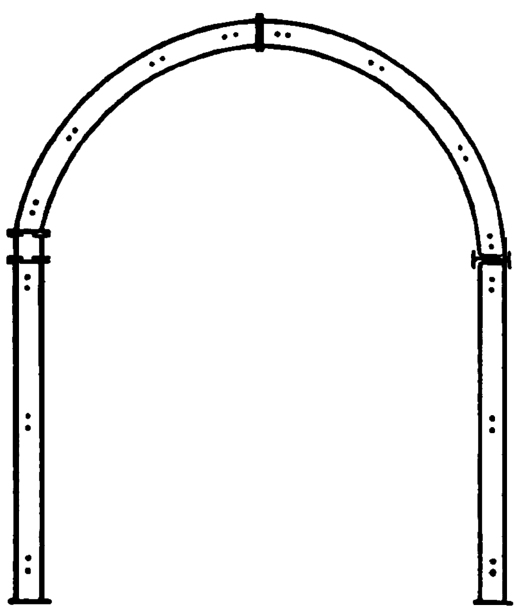
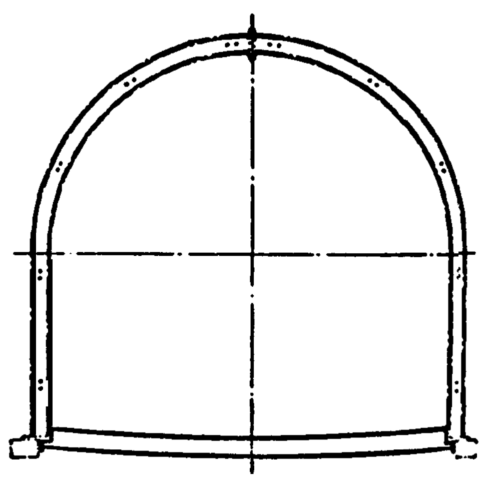


FULL CIRCLE RIB TYPE

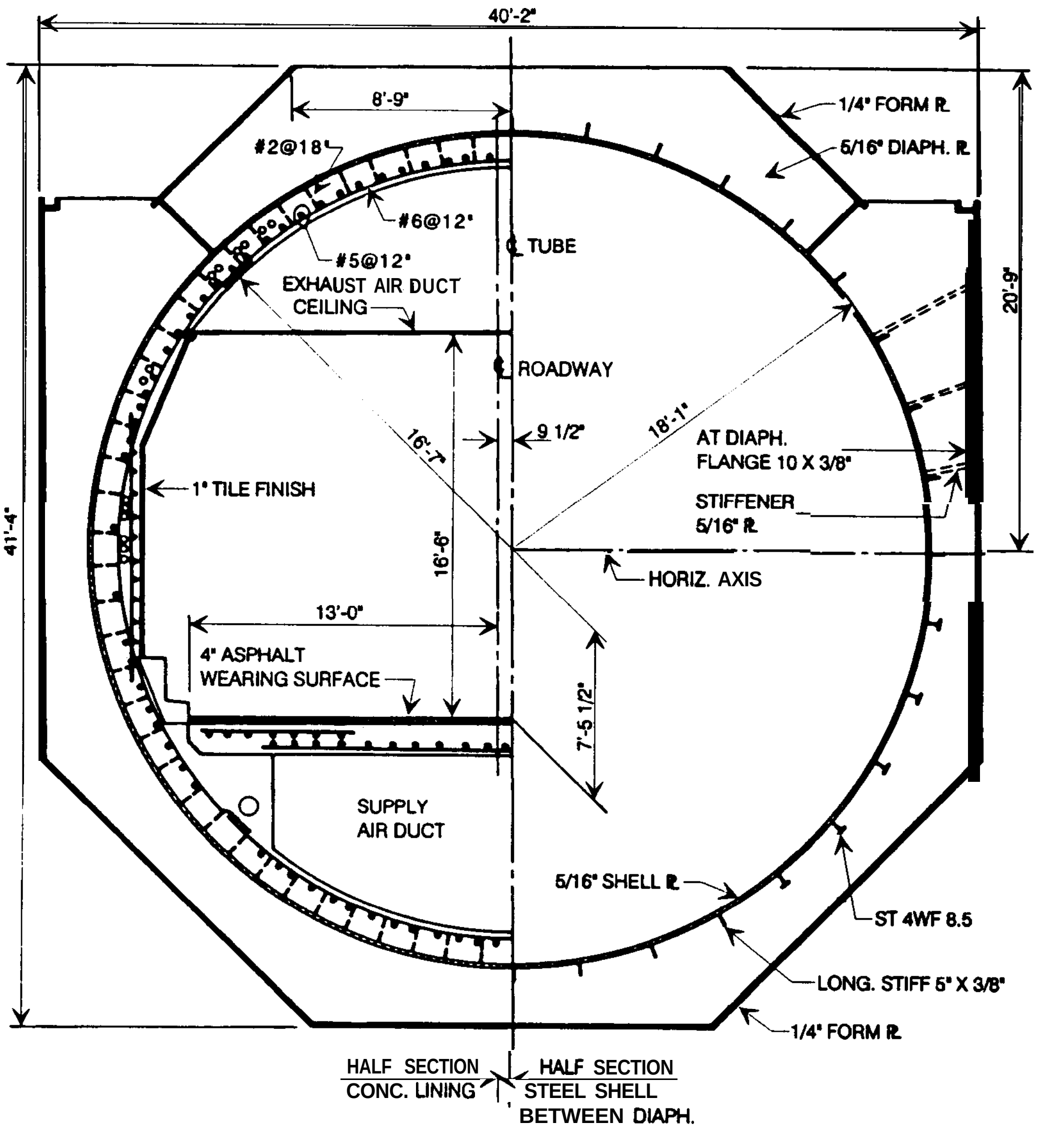


RIB, WALL PLATE AND POST TYPE

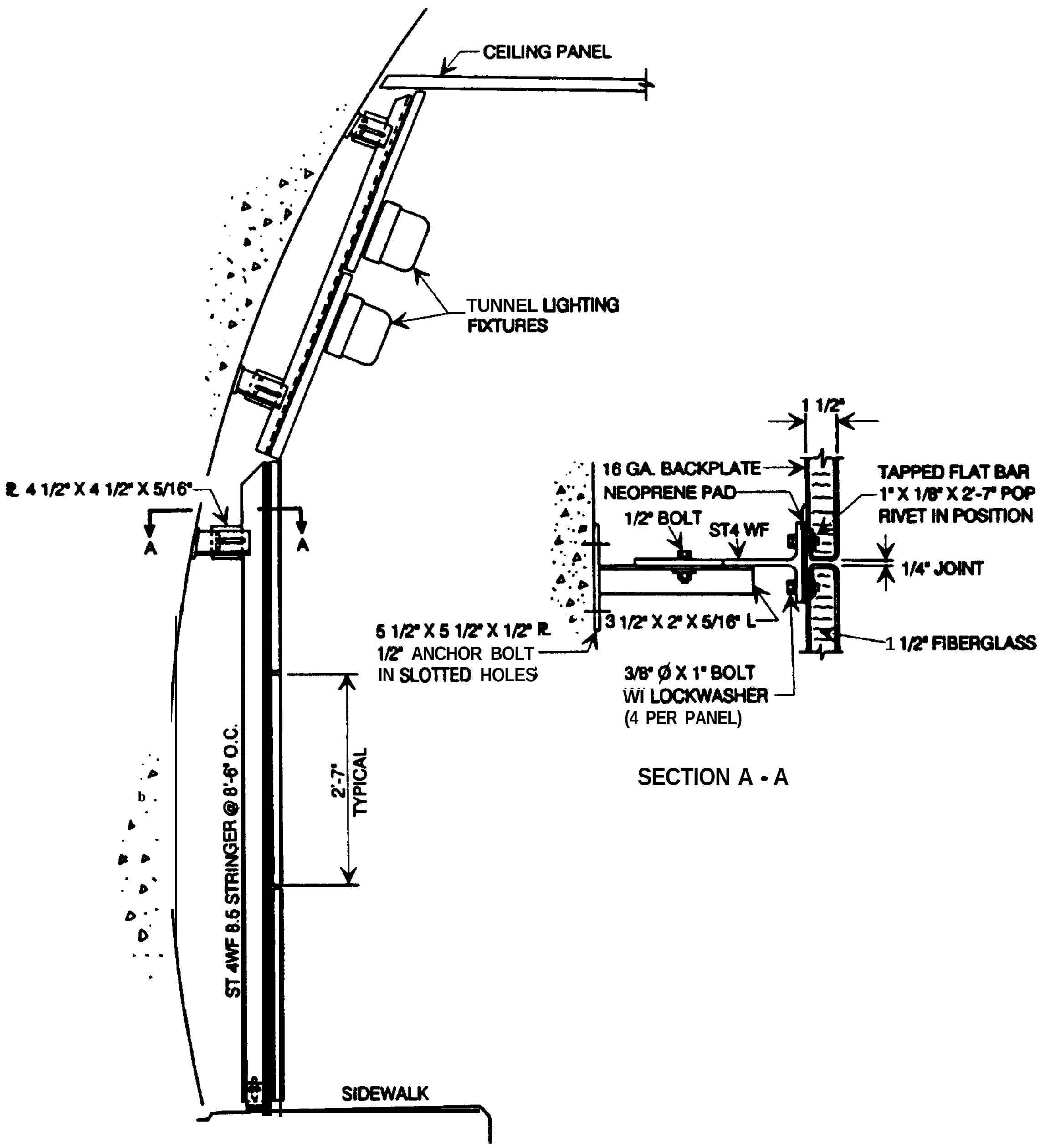


INVERT STRUT

SYSTEM ASSEMBLY DETAILS-SITEWORK	ROCK TUNNEL LINER		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-2

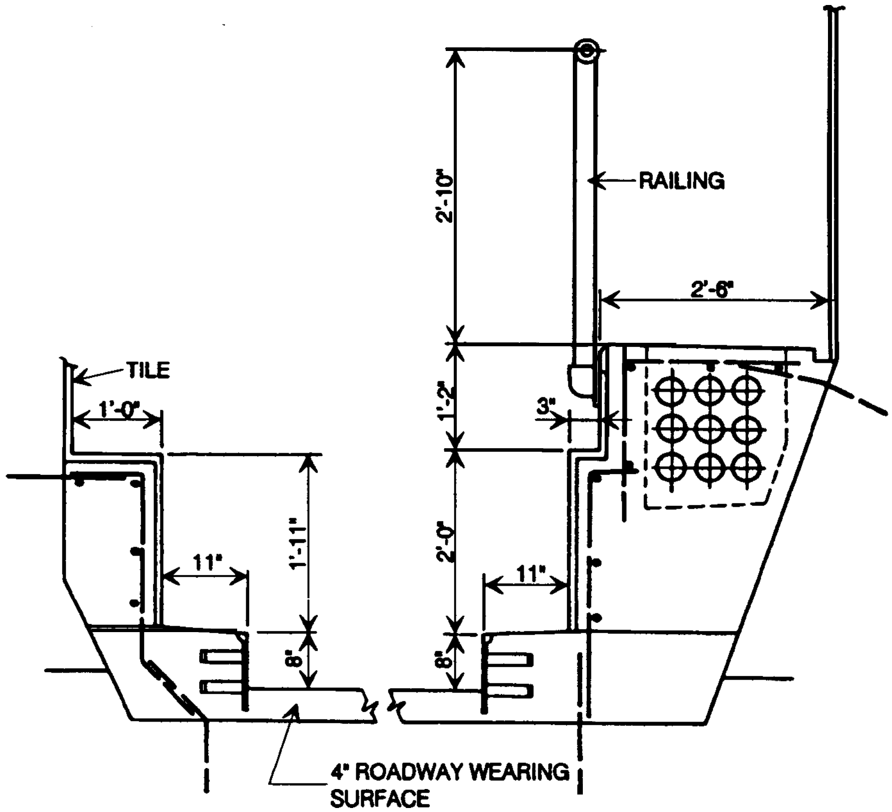


SYSTEM ASSEMBLY DETAILS-SITEWORK	SUNKEN TUBE TUNNEL		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-3

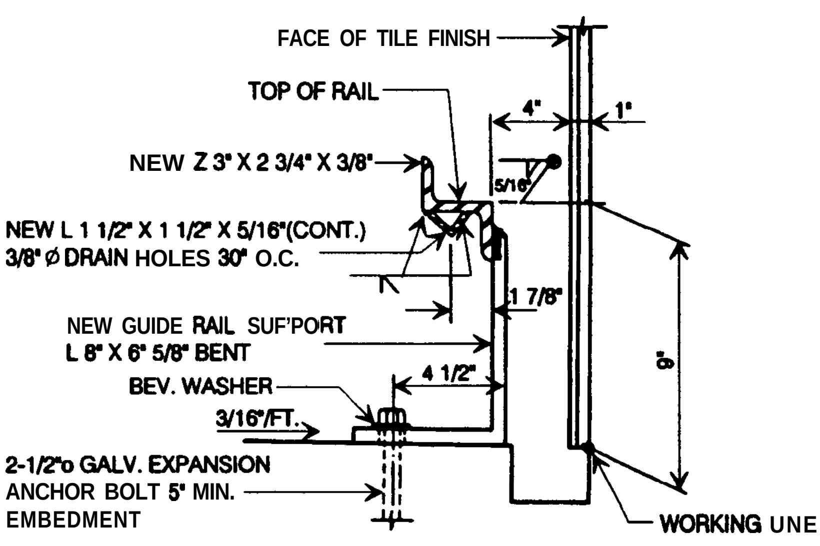


FURRED-OUT METAL WALL PANEL

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL FINISHING		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-4

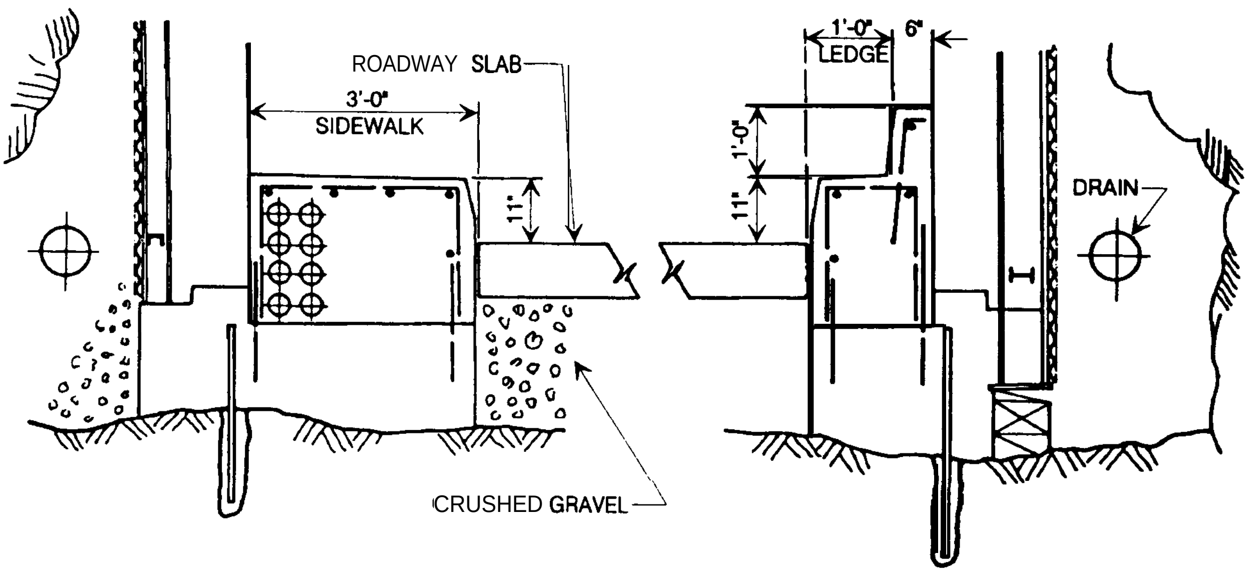


SUBAQUEOUS TUNNEL SIDEWALK



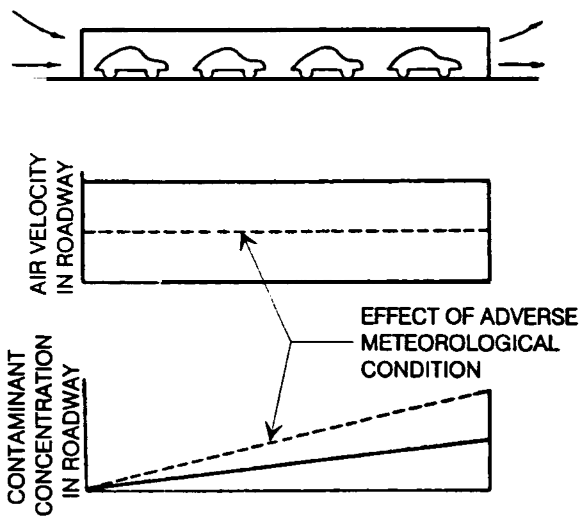
SIDEWALK PATROL CAR GUIDE RAIL

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL FINISHING		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-5



ROCK TUNNEL SIDEWALK

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL SIDEWALK		
TUNNELS (CSI 03000)	Revision No.	Issue Date 5/93	Drawing No. A1203-6



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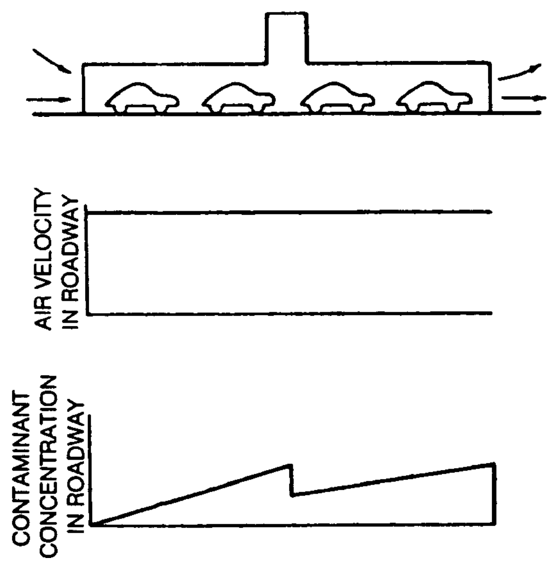
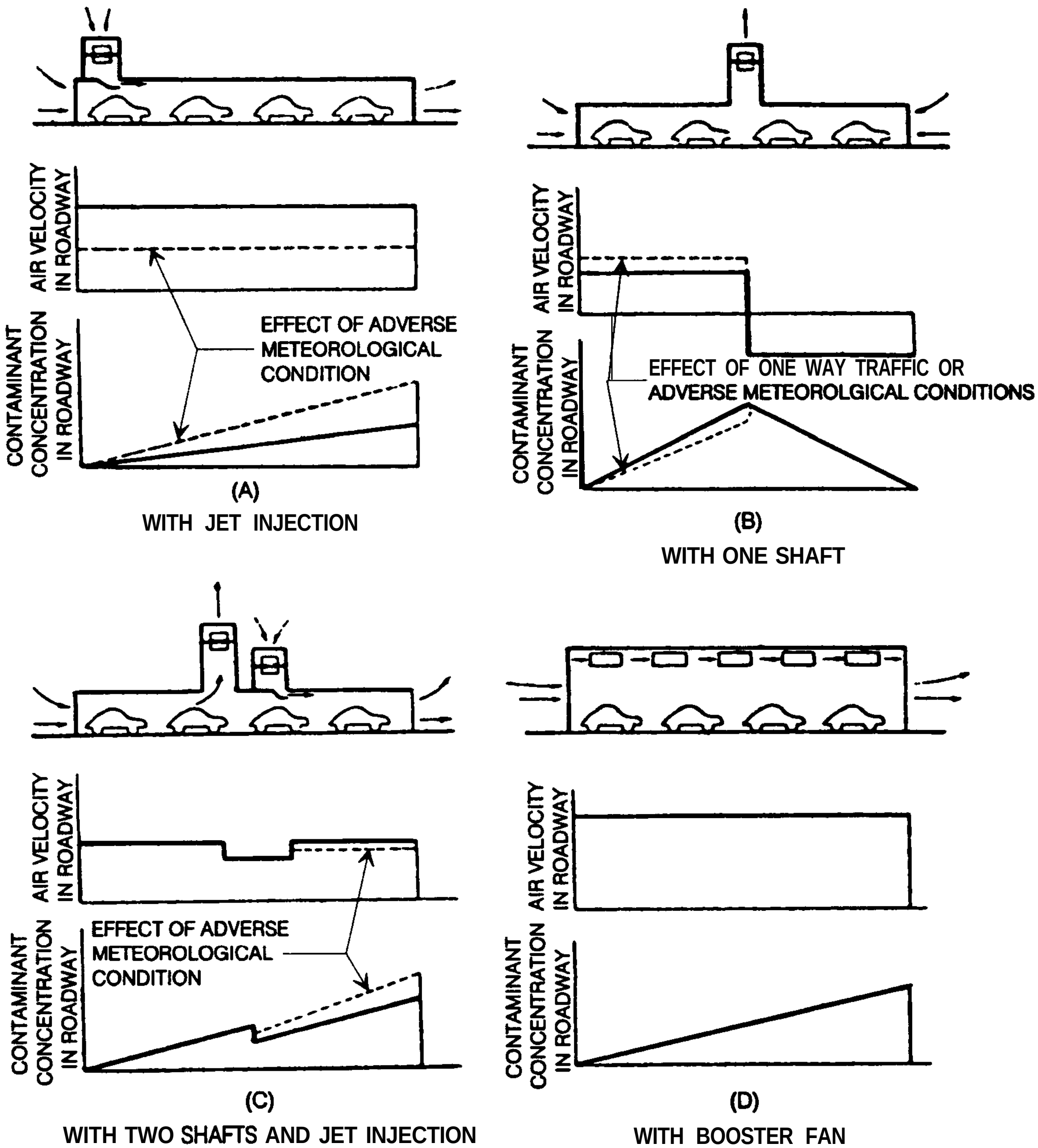


(B)

WITH CENTER SHAFT

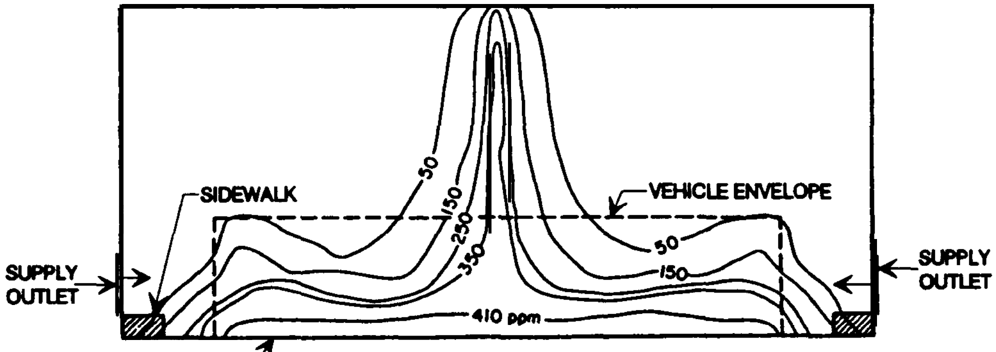
NATURAL VENTILATION SYSTEMS

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-7

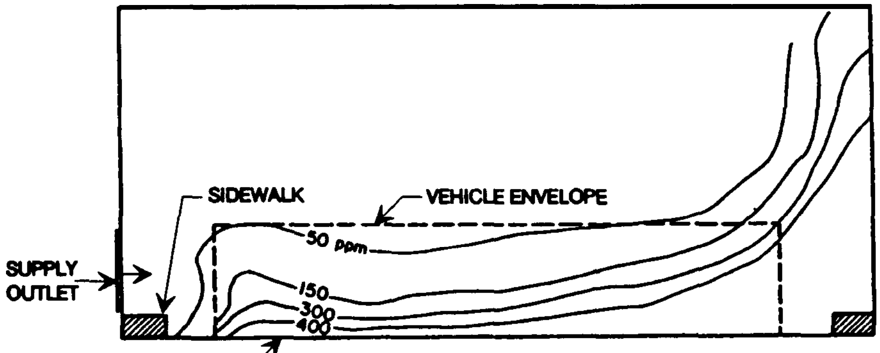


LONGITUDINAL VENTILATION SYSTEMS

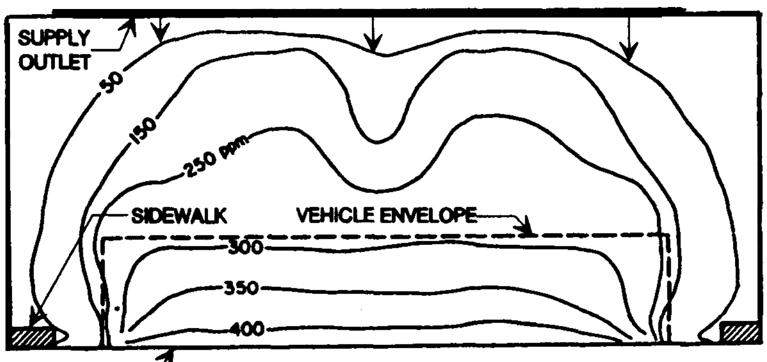
SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-8



TWO SIDE SUPPLY

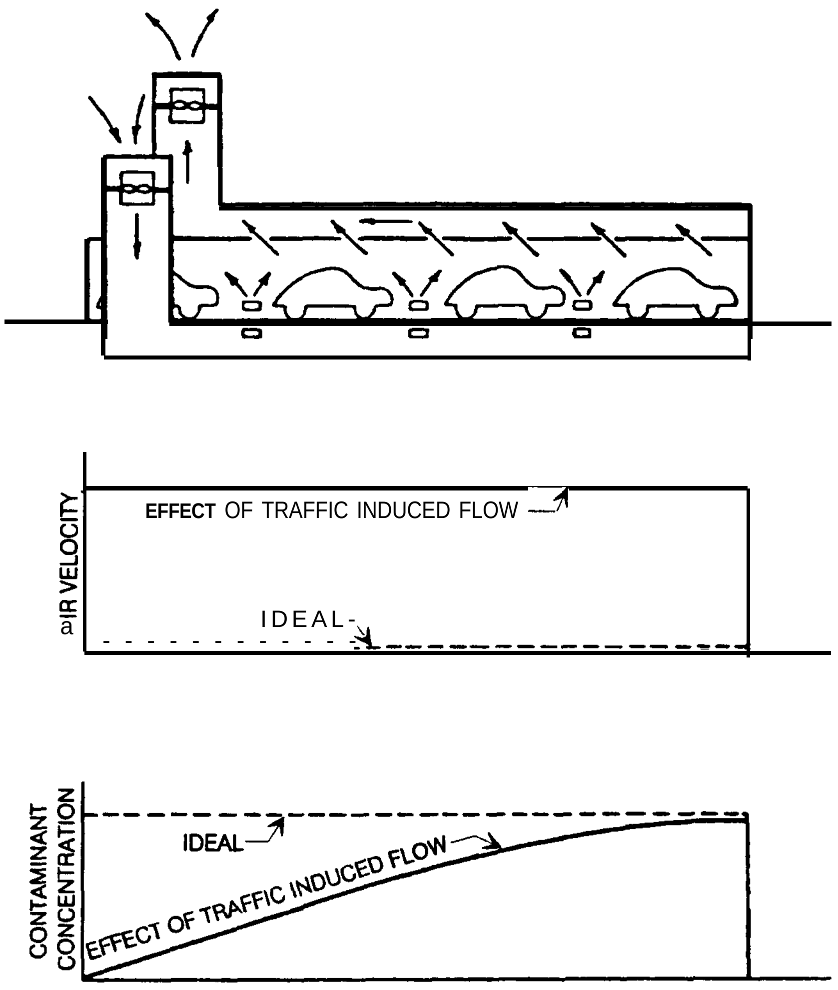


ONE SIDE SUPPLY



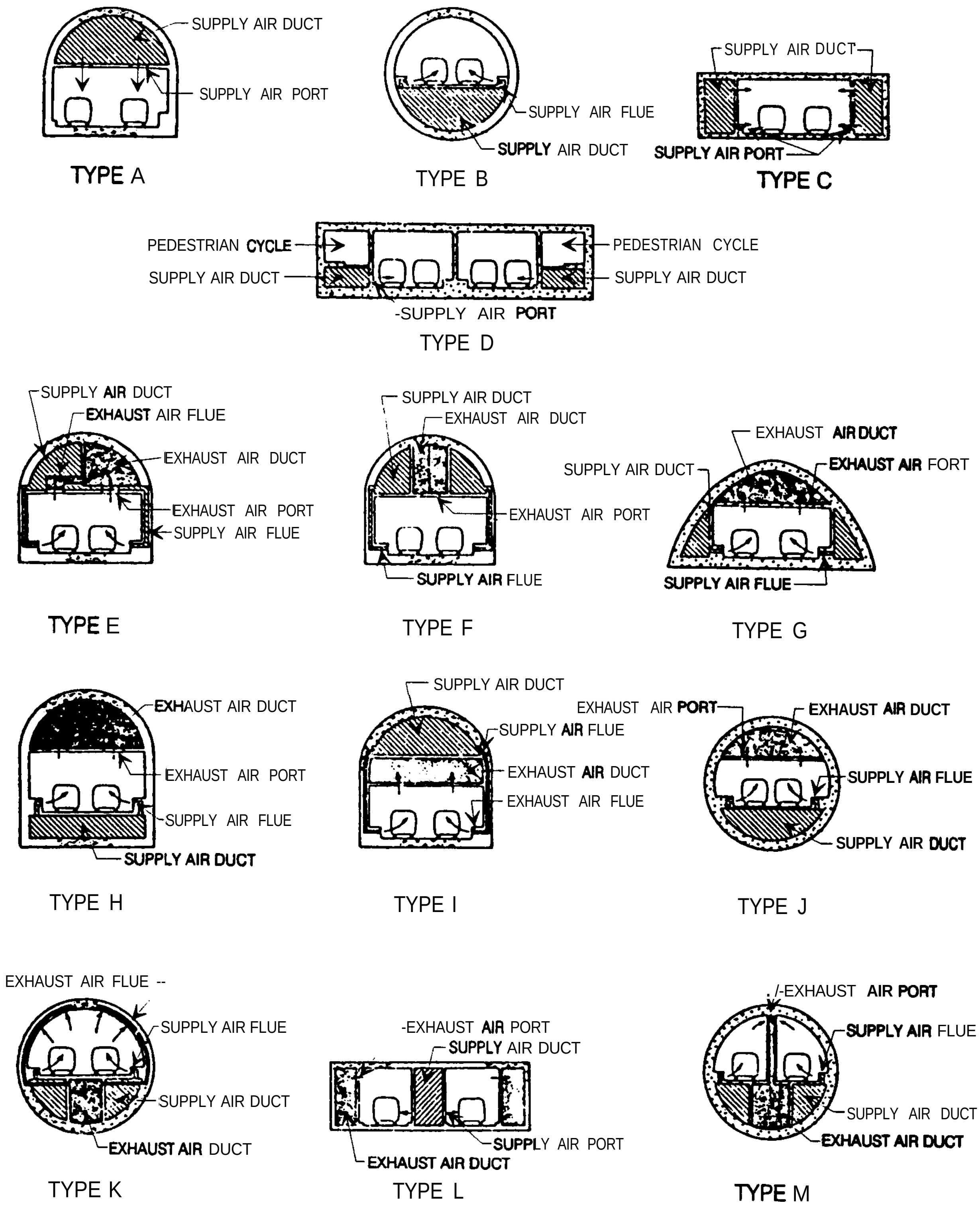
OVERHEAD SUPPLY

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-9



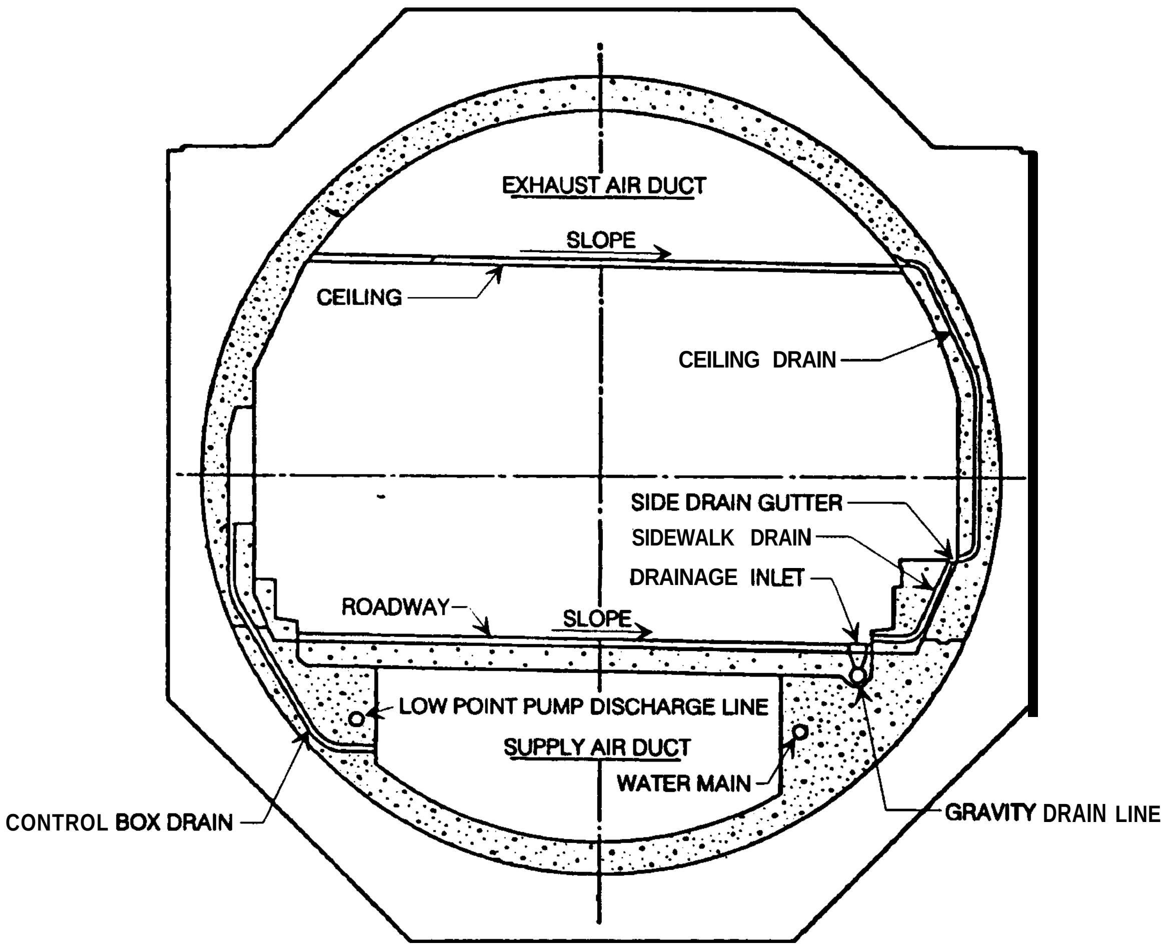
TRANSVERSE VENTILATION SYSTEMS

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-10



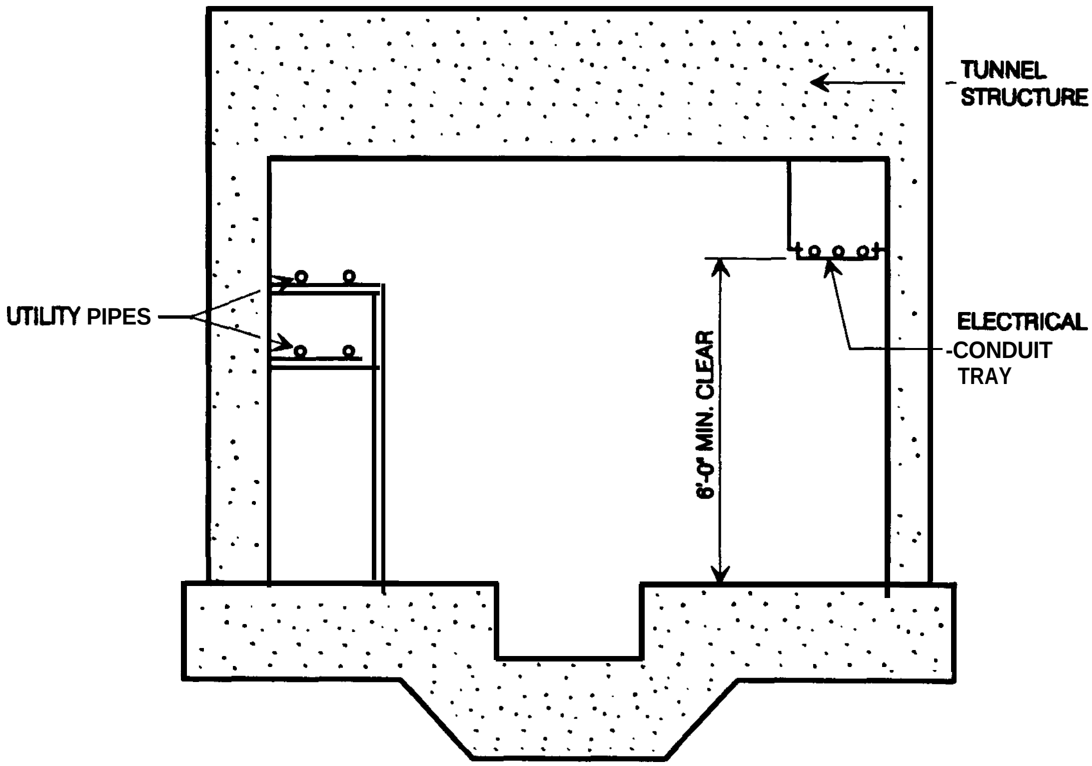
TYPICAL TUNNEL CROSS-SECTIONS WITH VENTILATION CONFIGURATIONS

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-11



CROSS-SECTION OF SUBAQUEOUS TUNNEL SHOWING MISCELLANEOUS DRAINS

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-12



SECTION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TUNNEL VENTILATION		
TUNNELS (CSI 15000)	Revision No.	Issue Date 5/93	Drawing No. A1203-13

DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

PROBABLE FAILURE POINTS

- Panel or tile separation from substrate.
- Reflective cracking from structural movement of substrate.
- Corrosion or rust of the surface material.
- Corrosion or rust hanger rods and fasteners.
- Damaged, broken, cracked, or missing panels or tiles.
- Deterioration or breakdown of expansion/control joints resulting in water penetration.
- Damaged, broken, or missing joint sections.
- Water penetration through surface flaws or joints.
- Lack of curing will increase the degree of cracking within a concrete structure.
- Reinforcement corrosion is an electro-chemical process that occurs in the presence of air and moisture.
- The weathering processes that can cause cracking include (1) freezing and thawing, (2) wetting and drying, and (3) heating and cooling.
- A number of deleterious chemical reactions may result in concrete cracks. These reactions may be due to the aggregate used to make the concrete or materials that come into contact with it after it has hardened or cured.
- A wide variety of poor construction practices can result in cracking in concrete structures, especially adding water to concrete to improve workability. Added water has the effect of reducing strength, increasing settlement, and increasing ultimate drying shrinkage.
- Overloads induced during construction can be far more severe than those experienced in the lifetime of the structure. Unfortunately, these conditions may occur at early ages when the concrete is most susceptible to damage, and often results in cracks.
- The effects of improper design and/or detailing range from poor appearance to lack of serviceability to catastrophic failure.
- Externally applied loads induce tensile stress that result in cracks. Current ACI 318 design procedures use reinforcing steel, not only to carry the tensile forces, but also to control both an adequate crack distribution and width.
- Improper compaction or soft spots in the grade resulting in uneven footing settlement.
- Hydrostatic pressure from groundwater resulting in heaving or movement of the structure.
- Spalling or surface deterioration resulting from adverse environmental conditions.
- Cracking or structural movement including creep.
- Separation of segments.
- Surface corrosion or rust resulting in weakened structural integrity.
- Reinforcing steel corrosion or rust resulting in spalling.
- Damaged, broken, cracked, or missing units such as brick or sections.

DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

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DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

SYSTEM ASSEMBLIES/DEFICIENCIES

Metal Panels

Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb (or not level) in one or more directions.
Surface Deterioration:	Crazing, small surface cracks, or surface corrosion and breakdown due to weather, pressure, or other actions.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
Staining:	Surface discoloration from a foreign substance or material.
Plant Growth Moss, Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Damaged, Missing Sections:	Broken, damaged, cracked, or missing units or sections.
Corrosion, Rust:	The oxidation or eating away of a metal or other material by chemical or electrochemical action after prolonged exposure.
Joint Separation:	Separation of lap joints.
Punctures, Holes, Tears:	Holes, punctures, or tears in surface caused by missing fasteners, corrosion, or roof traffic.
Impact Damage, Denting:	Depressions, punctures, or buckled surface from objects striking or impacting surface.

Tile

Weathering:	Changes in color, texture, strength, chemical composition, or other properties of a natural (slate) or artificial (concrete) material due to age and weathering.
Spalling:	Flaking, scaling of tile caused by aging, weathering (freeze/thaw) and/or defective material.
Damaged, Missing Tile:	Broken, cracked, or missing tile exposing substrate.
Loose Tile:	Failing adhesive.

Concrete

Uneven Settlement:	Improper compaction of backfill and weak or loose spots in grade causing sinking and slipping of footing. Usually indicated by grade change and wall or substructure movement.
Uplift, Hydrostatic Pressure:	Upward movement of footings from external pressures or hydrostatic pressure. Hydrostatic pressure results from water pressure on the structure. Results are usually evident by slab movement or wall cracking with water or moisture penetration.
Lateral Movement:	Shifting caused by external forces such as hydrostatic pressure or ground movement.

DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Concrete

Surface Deterioration:	Crazing, small surface cracks, or surface corrosion and breakdown due to weather, pressure, or other actions.
Foundation Wall Cracking:	Stress or shear cracking; diagonal or step cracking resulting from footing slipping or movement.
Spalling:	Concrete fragments broken from the surface caused by reinforcement corrosion.
Settlement:	Sinking of solid particles in fresh concrete, after placement and before initial set.
Exposed Reinforcement:	Insufficient steel cover. Concrete quality. Calcium chloride overused as admixture.
Alkali-Aggregate Expansion:	Chemical reaction between aggregate and cement paste causing separation and bond break-up.
Cavitation:	Rapid movement of water or other liquids across the surface.
Cracking (Active & Dormant):	Construction movement, settlement, shrinkage around reinforcement. Setting due to inadequate finishing and curing. Chemical reactions, such as corrosion. Physical reactions, such as drying shrinkage. Thermal changes (subjected to temperature extremes, such as from freezing and thawing cycles). Stress concentration. Structural design. Accidents from overload, vibration, fatigue, and earthquake.
Crazing:	Surface shrinkage more rapid than interior of concrete mass. Too high a slump. Too rich a mix. Poor timing on finishing. Too rapid absorption of moisture.
Holes (Small & Large):	Chemical reaction. Inadequate construction and design.
Form Scabbing:	Form oil improperly applied.
Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb (or not level) in one or more directions.
Delamination:	Loosening or separation of laminar surface concrete.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
Staining:	Surface discoloration from a foreign substance or material.
Efflorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Plant Growth Moss/Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Damaged, Missing Sections:	Broken, damaged, cracked, or missing units or sections.

DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Concrete

Corrosion of Rebar:	The oxidation or eating away of the metal rebar by chemical or electrochemical action after prolonged exposure.
Improper, Insufficient Anchorage:	Broken, damaged, loose, corroded, or missing anchorage or fasteners.

Segmental Steel

Out-of-Alignment:	Bowing, deflection, or other movement that brings the surface out-of-plumb (or not level) in one or more directions.
Cracking:	Cracking, usually structural in nature, that results in tearing, ripping, or shearing of the material. Cracks can be random, horizontal, vertical, or diagonal.
Surface Deterioration:	Crazing, small surface cracks, or surface corrosion and breakdown due to weather, pressure, or other actions.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
Staining:	Surface discoloration from a foreign substance or material.
Joint Separation:	Separation of lap joints.
Punctures, Holes, Tears:	Holes, punctures, or tears in surface caused by missing fasteners, corrosion, or roof traffic.
Impact Damage, Denting:	Depressions, punctures, or buckled surface from objects striking or impacting surface.
Metal Fatigue:	Loss of structural integrity and weakening of material from stress cracks, torquing, or bending.
Plant Growth Moss, Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Damaged, Missing Sections:	Broken, damaged, cracked, or missing units or sections.
Corrosion, Rust:	The oxidation or eating away of a metal or other material by chemical or electrochemical action after prolonged exposure.

Masonry

Spalling:	Fragment flakes from the surface due to weather, pressure, or other actions. Usually results in roughly circular depressions.
Bowing:	Deflection or other movement that brings the surface out-of-plumb (or not level) in one or more directions.
Mortar, Joint Material Missing, Eroded:	Deteriorated or damaged mortar joints that have fallen out or worn down.

DEFICIENCY FACTORS
0.12.03 TUNNELS (CSI 02300)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Masonry

Cracking:	Cracking, usually structural in nature, that results in tearing, ripping, or shearing of the material. Cracks can be random, horizontal, vertical, or diagonal.
Surface Deterioration:	Crazing, small surface cracks, or surface corrosion and breakdown due to weather, pressure, or other actions.
Inadequate Expansion Joint:	Lack of expansion or control joints resulting in surface cracking from stresses.
insufficient, Clogged Weepholes:	Blocked or closed weepholes or improper number preventing drainage of trapped water.
Staining:	Surface discoloration from a foreign substance or material.
Eff lorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Plant Growth Moss, Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Damaged, Missing Sections:	Broken, damaged, cracked, or missing units or sections.
Corrosion of Rebar:	The oxidation or eating away of the metal rebar by chemical or electrochemical action after prolonged exposure.
Improper, Insufficient Anchorage:	Broken, damaged, loose, corroded, or missing anchorage or fasteners.

END OF SUBSECTION

0.12.04.01 TRACKWORK (CSI 02450)

DESCRIPTION

This narrative and the following details describe railways. Railways, or railway facilities as defined here, are the trackwork structure from the rails down to the ballast, turnouts, and other special trackwork; signal equipment, power rail, or catenary system (if applicable), and other appurtenances associated with the above; including grade crossings, bumping posts, signal poles, and signal boxes. Power rail and catenary systems will not be included in the detailed inspection breakdown below, as these items are not anticipated to be encountered in DOE facilities.

The trackwork facilities to be inspected vary by location. The following inspection procedures and description apply primarily to relatively low speed trackwork located in railway yards, sidings, and depots. Trackwork in these areas generally consist of conventional wood tie track in ballast with tie plates and cut spikes. Concrete or steel ties are occasionally used in railway trackwork; these will be described briefly as information.

The signals and communications system (see section 0.12.04.02), in the absence of a power rail or catenary system, generally consists of all the electric and electromechanical devices on the railway. Items to be considered for inspection include signal indicators, transformers, relays, bonding and signal wires, switch machines, grade crossing signals, and trackside communications equipment. Minor exceptions to this definition include switch heaters and electric rail lubricators, which are normally considered to be trackwork items.

Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Major trackwork components are divided into the following groupings, for convenience of inspection:

- Rails
- Rail Joints
- Ties
- Rail Fasteners
- Ballast
- Turnouts & Special Trackwork

Appendix B includes definitions provided by the American Railway Engineering Association (AREA) for trackwork as supplementary information to that given below.

Rails

Rails are the continuous steel guideways that actually support the vehicle wheels. Rails are manufactured as special steel sections; the wheels contact and ride on the top portion of the rail, termed the rail head. The thinner middle portion of the rail section is the rail web which connects the rail head to its base. The rail base is sufficiently wide (5 to 6 inches) to provide a stable foundation. Rail sections are usually classified by weight (pounds per yard) and standard design section, usually indicated as raised or stamped letters on one side of the rail web. Examples of this identification are "132 RE," "100 RA," or "130 PS."

0.12.04.01 TRACKWORK (CSI 02450)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Rail Joints

Rails are generally manufactured in 39 foot lengths and are joined together at the ends by either welds or bolts; jointed connections use splice (joint) bars.

Rail Welds:

Rail welds are used to fuse rail ends in lieu of jointed rail joints. Long strings of rail joined in this manner are termed continuous welded rail (CWR) or simply welded rail. Welds are ground flush to the rail head and are difficult to detect; however, weld metal is normally left on the rail web end base and this 1/8 to 1/2 inch upset metal indicates the location of a rail weld.

Rail Bolted Joints:

Rail ends are generally connected by bolted joints in yard and industrial tracks. The components of a rail joint are two joint bars on both sides of the rail web held together by large track bolts with square nuts and spring washers. A specialized insulated bolted rail joint is used to electrically isolate rail sections, especially at turnouts, for signaling purposes.

Insulated Rail Joints:

An insulated rail joint electrically isolates two rails by use of an insulating post between the two rail ends, insulation between rails and joint bars, and insulated bushings between the joint bolts and rail/joint bar holes. The insulation material is usually fiberglass or other fiber insulating material. Some insulated joints use an additional epoxy adhesive to strengthen the joint; this is known as a bonded, insulated joint.

Compromise Joints:

Different rail sections often are of different heights or configuration. Compromise joints are used to join these different rail sections. Either special joint bars or offset welds are used for this purpose.

Bolts:

The rail bolt assembly consists of a 7/8 to 1 1/8 inch heat-treated track bolt with a square nut and heavy spring washer. The spring washer is sometimes referred to as a lock washer and is essential for maintaining tension on the bolt threads to prevent track nuts loosening under operating conditions.

Ties

In general, ties (or crossties) are a transverse component under the rail that is embedded in the ballast section. Their function is to support the rail vertically and laterally, maintain proper track gauge, and distribute the vehicle wheel loads across a wider area of the ballast.

Wood Ties (or Crossties):

Ties are manufactured from the heartwood portions of selected wood species and are usually treated with creosote preservative. Typical length is 8 feet 6 inches, and cross-sections are typically either 6 x 8 inches or 7 x 9 inches.

Concrete & Steel Ties:

Reinforced concrete and steel ties are also occasionally used in railway freight service, which incorporate an integral rail fastener system using rail spring clips or rigid bolted rail clips.

0.12.04.01 TRACKWORK (CSI 02450)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Rail Fasteners

Rail fasteners are used to hold the rail to the tie. Older practices included spiking rails directly onto the tie. Modern higher wheel loads require tie plate to spread the loading to a larger tie surface area and to provide additional support for the rail base. Trackwork using wood ties, cut spikes, and AREA standard tie plates are anticipated for most locations, but other tie and fastening systems in relatively common use are included for information purposes.

Spikes or Cut Spikes:

The term "spike" without qualification invariably refers to a 6 inch long, square cut spike in accordance with AREA standards. The head of a cut spike is shaped to provide an increased bearing area on the rail base or tie plate when installed properly. In a typical application for wood ties with tie plates, one spike is driven at the rail base on the gauge and field sides, and a second pair of spikes is driven at the plate ends to provide tie plate anchorage resulting in a total of 4 spikes per tie plate. Spikes are the major component in preventing rail and tie plate movement during train operation.

Screw Spikes.

Screw spikes, also known as lag screws, are drive spikes with a very coarse thread pattern. These spikes have increased holding power compared to the cut spike, and are sometimes used instead of cut spikes where sharp curve or other severe conditions warrant their use. Screw spikes are often used for turnout plates. They are easily differentiated from the cut spike by their square, lag bolt head.

Tie Plates:

Tie plates distribute the vertical wheel loads to the tie as well as assist in holding the rail in position. Modern tie plates tilt the rail slightly toward the gauge of the track (1:40 cant) to improve rail wear characteristics. Most tie plates are of AREA standard design and may be either single or double shoulder. The most likely tie plate that will be encountered is the double shoulder, 8 hole configuration.

Elastic Rail Clips:

Instead of holding the rail in place with spikes, some rail fasteners utilize an elastic clip arrangement. The most common type is the Pandrol "pretzel" rail clip. A specially designed tie plate is required for an elastic rail clip on wood ties. This type of rail clip is almost always used on concrete ties.

Rail Anchors:

Rail anchors are attached to the base of the rail and are set against the ties to prevent movement of rail (rail creep) due to thermal expansion or rail traffic. These are generally used on welded rail track.

Ballast

Ballast is the material that supports the crossties, holds it in place in track, and provides drainage by means of its high porosity. It generally consists of large crushed stone with high angularity which tends to lock the ballast in place. In general, preferred ballast material is granite, trap rock, or other igneous crushed aggregate. Limestone, slag, and cinders may also be used as ballast due to economics or availability, but are less desirable. It is noted that limestone ballast has been found to be unacceptable for use with concrete ties.

0.12.04.01 TRACKWORK (CSI 02450)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Turnouts & Special **Trackwork**

The major components of a turnout are the switch, closure rails, frog, guard rails, rail fasteners, timbers, and ballast. Other special trackwork includes rail crossings and bridge guard rails. Rail fasteners, ballast, and turnout timbers are subject to the probable failure points illustrated in the Trackwork section. Other special trackwork items may occasionally be encountered, including rail crossings or bridge guard rails.

Turnouts are used to divert rail vehicles from one track to another. Turnouts are classified as left hand, right hand, or equilateral, defined by the direction of the diverting move when standing at the switch point. Turnouts are also classified by their frog numbers, which are determined by the rate that the rail offset increases per unit length of track behind the frog point. Major components of a turnout are the switch, closure rails, frog, and guard rails. These components of the turnout are briefly described below. Descriptions for the more detailed portions of the turnout are given by the AREA definitions in Appendix B. Turnout limits are often defined by the beginning and end of the long crosstie timbers characteristically used in turnout construction.

Switch:

The switch points are connected to each other by switch rods, and both switch points slide in tandem on slide plates to permit rolling stock wheels to be routed in either the straight or curved direction. A connecting rod is attached to a hand operated or electric switch throwing mechanism (not shown) which physically moves the switch points. Switch points are planed to a thin section at the point of switch and fits tightly against the stock rail to assure a smooth transition from stock rail to switch rail. The heel block is at the end of the switch point and maintains proper rail separation (usually 6 1/4 inches) at what is known as the heel of switch.

Closure Rails:

Closure rails are the two rails that extend from the heel of the switch to the frog in a turnout.

Frog:

The frog is the component of the turnout that permits the vehicle wheel to cross two intersecting rails, All turnouts have one frog for this purpose. the end of the frog toward the switch is termed the toe of frog and the opposite end is the heel of frog. the actual point of switch, usually known as simply the point of frog, is the location where the frog point is 1/2 inch wide. This point is often marked in the frog casting. Wing rails are at the outside of the frog point and wheels must transfer from the wing rail to frog point and vice versa to negotiate the frog.

Guard Rails:

Guard rails are located at frogs on both outer rails. Their purpose is to prevent vehicle wheel flanges from striking the frog point and possibly being routed in the wrong direction. Guard rails are usually 9 to 13 feet in length. Special plates and spacer blocks between the running rail and guard rail maintain a proper flangeway and provide structural stability. Some frogs do not use an outer guard rail, but have a raised casting at the wing rails to provide the guarding function. These are known as self-guarded frogs and are often used in low-speed track.

Switch Point Guard:

This is a “miniature” guard rail mounted on the field side of the stock rail at the point of switch. It is used in low-speed track to prevent excessive wear to switch points.

Crossover:

Two turnouts arranged to permit vehicle routing between two parallel tracks.

0.12.04.01 TRACKWORK (CSI 02450)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Turnouts & Special Trackwork (Continued)

Rail Crossing:

Sometimes referred to as a crossing diamond, this assembly permits rails to cross at track intersections. It consists of four rigid frogs often termed crossing frogs to differentiate them from turnout frogs.

Double Crossover:

A double crossover consists of four turnouts, with a crossing diamond in the center of the configuration, that permits universal vehicle movements between two parallel tracks. This is used in place of two separate crossovers where space is limited.

Derail.

A derail is a device installed on siding tracks or other locations where inadvertent movement of rolling stock could create a dangerous condition by fouling main line tracks or moving into areas occupied by working personnel. The derail can be set to shunt the vehicle wheels off the rails where this protection is warranted.

Road Crossings:

Road crossings permit highway vehicles to cross the track. Several road crossing types are commonly used:

- Stone
- Asphalt
- Rail Guarding
- Timber & Asphalt
- Full Timber
- Rubber
- Concrete

Stone crossings are used at temporary or low-grade access roads. Asphalt crossing with formed flangeways are also used on low-volume roadways. An improved variation of the asphalt crossing uses separate rails to form flangeways. Timber and asphalt crossings use timber headers on both sides of the rails to provide a smoother ride. Full timber crossings provide a timber roadway surface for the entire width of the track. Rubber and concrete road crossings are premium systems using prefabricated panels fastened to the ties or wedged into the trackwork rails.

Rail Lubricators:

On relatively sharp curves, rail lubricators are used to apply a grease or heavy oil compound on the gauge side of the rail during the passage of trains. The passing vehicle wheel deposits the grease on the rail, which lubricates the track and reduces wear. The rail lubricator is normally identified by a rail mounted wiping bar, grease reservoir, and grease deposits in the track gauge.

0.12.04.01 TRACKWORK (CSI 02450)

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DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

PROBABLE FAILURE POINTS

TRACKWORK

- The rail is excessively worn, contains external or internal cracks, has head corrugations or engine burn damage, is excessively corroded, or is otherwise structurally compromised from its original section and condition. (Modern rails rarely exhibit these defects when new, but rail welds occasionally fracture or show a profile dip after a short period in service.)
- Ties can have excessive splits, severe bows, rotted, burned, plate cut, spike killed, or otherwise unable to perform its function of holding the rail fasteners securely in place.
- Ballast, subballast, and subgrade deficiencies can all result in profile problems in the rail. Failure points specific to ballast are fouling (contamination by dirt or fines), missing or washed-out ballast, frost heave, and tie/ballast separation. Extremely deficient ballast or subgrade problems can result in excessive movement of the track under load.

TURNOUTS & SPECIAL TRACKWORK

- Switch points can be chipped or worn, the points may not rest firmly against the stock rail, the points may not throw properly, the throwing mechanism may be defective, switch rods may be bent or loose, and the stock rail braces or switch heel bolts may be loose or missing.
- Closure rails can have the same defects as trackwork rail in the previous section.
- The frog point and wing rail are subject to severe wear conditions. The frog rails or casting can fracture, and the bolts are frequently loose or missing.
- The guard rail may become worn or cracked, and the bolted assemblies or special rail fasteners in this area are often loose or missing.
- These consist of four frogs and have the same failure points as the turnout frog.
- Bridge Guard Rails may be missing or the guard rail spikes may be loose or nonexistent,

OTHER TRACKWORK COMPONENTS

- The casting of sliding point derails may become cracked and the throwing mechanism can become inoperable. Switch point derails have the same failure points as turnout switches.

SYSTEM ASSEMBLY/DEFICIENCIES

TRACKWORK

Rails

Broken Base:	A fracture occurring in the rail base.
Compound Fissure:	A progressive fracture originating in a horizontal split head that turns up or down in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the rail length.
Corrosion Damage:	Surface rust and corrosion affects rail head (usually found only in unused track), rail web, and particularly the rail base (at tie plates).
Corrugation:	A repeated wavelike pattern on the rail's running surface.
Crushed Head:	A flattening or crushing down of the rail head.
Detail Fracture:	A progressive fracture originating at or near the surface of the rail head.
End Batter:	See Rail Joint, End Batter

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

SYSTEM ASSEMBLY/DEFICIENCIES

TRACKWORK

Rails (Continued)

Engine Burn Fractures:	A progressive fracture originating in spots where driving wheels have slipped on top of the rail.
Excessive Metal Flow:	Metal flow (particularly on curves) at the rail head causing rail metal to move to the gauge or field side of the rail head. This condition is common on the inside rail of curved track, especially when super-elevation is present.
Excessive Rail Wear:	Wear on the gauge and top of the rail head. A general rule of thumb is that rail should be replaced after the loss of 25% of the rail head area.
Rail Flaking:	A progressive horizontal separation on the running surface near the gauge corner, often accompanied by scaling or chipping. Appearance in Track: Shallow depressions with irregular edges and horizontal hairline cracks resembling small slivers occurring on the running surface near the gauge corner. Generally flaking will occur within 1/4 inch of the corner of the rail.
Head & Web Separation:	A fracture longitudinally separating the head and web of the rail at the fillet under the head.
Horizontal Split Head:	A horizontal defect originating inside of the rail head.
Ordinary Break (or Broken Rail):	A rail breaking transversely, either square or angular, due to sudden rupture.
Piped Rail:	A vertical split, usually in the web, due to failure of the shrinkage cavity sides in the ingot which did not unite during rolling.
Rail Base Fractures:	Fractures at spike locations and severe pitting are indications of excessive corrosion.
Rail Shelling:	A thin (usually 3/8 inch depth or less) shell-like piece of surface metal separated from the parent rail metal, generally at the gauge corner. The appearance on the rail is either as a black spot or metal broken away at the gauge corner.
Rail Slivers:	A thin, tapered mass of metal from the surface of the head, web, or base of a rail. Appearance in Track: Thin slivers on the surface of the rail head and parallel to the rail length.
Split Web:	A horizontal crack in the web.
Transverse Defect:	Fracture in the rail head that is seen as a transverse separation. This is sometimes seen as an extended crack from severe rail shelling.
Transverse Fissure:	A transverse fracture substantially at a right angle to the length of the rail. This is usually an internal rail defect, unobservable during a standard visual inspection.

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 024501

SYSTEM ASSEMBLY/DEFICIENCIES

TRACKWORK

Rails (Continued)

Vertical Split Head:	A vertical split through or near the middle of the head, and extending into or through it. Often only a small crack on the top of the rail head or at the head/web fillet is visible.
Weld Failure:	Cracks, piping, or other metal separation in the rail web at the weld location. Cracks extending into the rail head are more serious and indicate a potential full rail break.
Wheel Burn:	Rail scarred on the running surface by the friction of slipping locomotive wheels. Also known as an engine burn.

Rail Joints

Bolt Hole Break:	A rail web fracture that develops in any direction from a bolt hole.
Dipped Weld:	A small dip or depression on the rail top or gauge at the weld location.
Excessive Rail Gap:	Rail gap excessive, or rail ends vertically mismatched.
Improper Bolt Pattern:	A deviation from the alternating bolt pattern.
Loose/Broken Joint Bars:	Cracks occur between bolt holes or at the center of the bar. Loose bars due to wear at the contact surfaces, incorrect joint bar size, or the wrong type of track bolt.
Loose/Missing Bolts:	Bolted rail joints may have loose or missing bolts, loose or cracked joint bars, bolt hole cracks in the rail, and rail end batter (a profile dip in the rail ends). Insulated rail joints may have the same defects plus defects in the rail insulation or joint adhesive.
Loose/Missing Joint Bar Bolts:	Loose or missing bolts are usually due to a nut loosening or a deteriorated or missing spring washer.
Rail End Batter:	Damage caused by wheels striking the rail ends; rail head is worn at the rail or the rail end is bent downward.

Ties

Broken Tie:	Tie breaks usually occur at the center or under the rail.
Burnt Tie:	Burnt tie defects are the same as for decayed ties.
Decayed Tie:	A decayed tie will appear to have a “hollowed out” appearance and is extremely soft when probed with an awl or pick. Extensive decay or rot in the tie plate areas are considered to be defects.
Derailment Damage:	The wheel flange will cut a notch in wood ties during derailment. Concrete ties are more prone to show cracking or crushing on the ties surface. In wood ties, a single flange cut is not necessarily a defect, but if the tie plate area is damaged or if tie breaking occurs (see Broken Tie), then affected ties are considered to be derailment damaged.

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

SYSTEM ASSEMBLIES/DEFICIENCIES

TRACKWORK

lies (Continued)

Plate Cut Tie:	Under load, the tie plate eventually cuts into the tie. A gap between the edge of a tie plate and the edge of the notched tie often indicates lateral tie plate movement.
Spike Killed:	Repeated installation of tie plates and spikes in the same tie create a number of spike holes under the tie plate, eventually causing loose spikes.
Splits:	Large splits, or splits that cause loosening of spikes at the tie plates are classified as a defect.
Warped Tie:	A tie warp, especially in the horizontal direction, is not a notable defect. The only significant warping defect is a vertical or twisting warp that does not allow the tie to be properly seated in ballast. This causes unacceptable deflection under loading.

Rail **Fasteners**

Incorrect Spike Installation:	At least two spikes must be installed per tie plate. On other types of rail fasteners, rail clips must be installed on both sides of the rail. Incorrect spiking pattern under the rail base resulting in a rail break. In angle bar joints, spikes should not be installed in the slotted portion of the bar.
Missing/Loose, Spikes & Clips:	Spikes and rail clips missing or loose. Tie plates and plate shims can crack. Poor fastener or tie conditions can cause the tie and rail to separate, resulting in a low tie and excessive rail deflection.
Broken, Loose or Missing Spikes:	Broken, loose, or missing spikes and/or lag screws.
Cracked or Corroded Tie Plates:	Cracked or excessive corrosion.
Cracked or Missing Track Shims:	Shims cracked or missing portions resulting in a loose tie plate.

Ballast

Missing or washed out Ballast Shoulder:	Missing or washed out. At least 6 inches of ballast is required beyond the end of ties.
Fouled Ballast/Pumping Track:	Excessive ballast fouling, vertical separation of ties from the plate or rail, a visible gap between ties and ballast (hanging ties), and excessive movement of the rail and tie under load. The last item is usually not possible to determine during a conventional track inspection.
Contaminated Subgrade:	Fouling (contamination by dirt or fines), missing or washed-out ballast, frost heave, and tie/ballast separation.
Track Dip:	Frost heave, subgrade or drainage problems, and/or defective ballast.

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

SYSTEM ASSEMBLIES/DEFICIENCIES

TRACKWORK

Ballast (Continued)

Washout:	Ballast erosion causing loss of track bed and creating a change in track profile.

TURNOUTS & SPECIAL TRACKWORK

Switch

Loose/Missing Bolts:	Bolts at the stock rail may be loose or missing, especially at the switch heel.
Loose Points:	The switch point should be seated tightly against the stock rail. A gap in the switch point (loose points) can indicate that a switch is out of adjustment or that the switch rod is defective.
Loose Rail Braces:	The outside stock rail braces are loose or missing.
Cracked/Loose Switch Heel:	Heel block is loose, cracked.
Inoperable/Damaged Switch Machine:	The switch machine may not throw properly, the connecting rod can be bent or out of adjustment, or the locking mechanisms may be broken or missing.
Corroded Switch Plates:	The switch plate may be corroded or not lubricated. This causes the switch to throw stiffly. Switch plates may also become loose.
Chipped/Worn Switch Points:	Switch points can be broken or chipped. In older trackwork, it is common to see switch point ends ground back several inches from their original position.

Closure **Rails**

Damaged Closure Rails:	Have the same defects as other trackwork rail, except that the plates are subject to high vehicle forces and should be checked for loose spikes or plate cutting.

Frog

Cracked Casting or Frog Rail:	Cracking can occur in the casting, especially at the frog heel area.
Damaged or worn Frog Point:	The point can show excessive wear or chipping.
Loose/Missing Bolts:	Bolts are often loose or missing.
Worn Wing Rail:	Should have an even profile and not be excessively worn or grooved.

Guard **Rails**

Missing/Broken Guard Rails:	Missing, cracked, loose, or excessively worn.
Corroded Rails:	The rail will probably have heavy surface rust; however, this is only significant at the rail base spike locations.
Loose/Missing Spikes:	Spikes may be loose, missing, or corroded.

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

SYSTEM ASSEMBLIES/DEFICIENCIES

TURNOUTS & SPECIAL TRACKWORK (Continued)

Rail Crossings

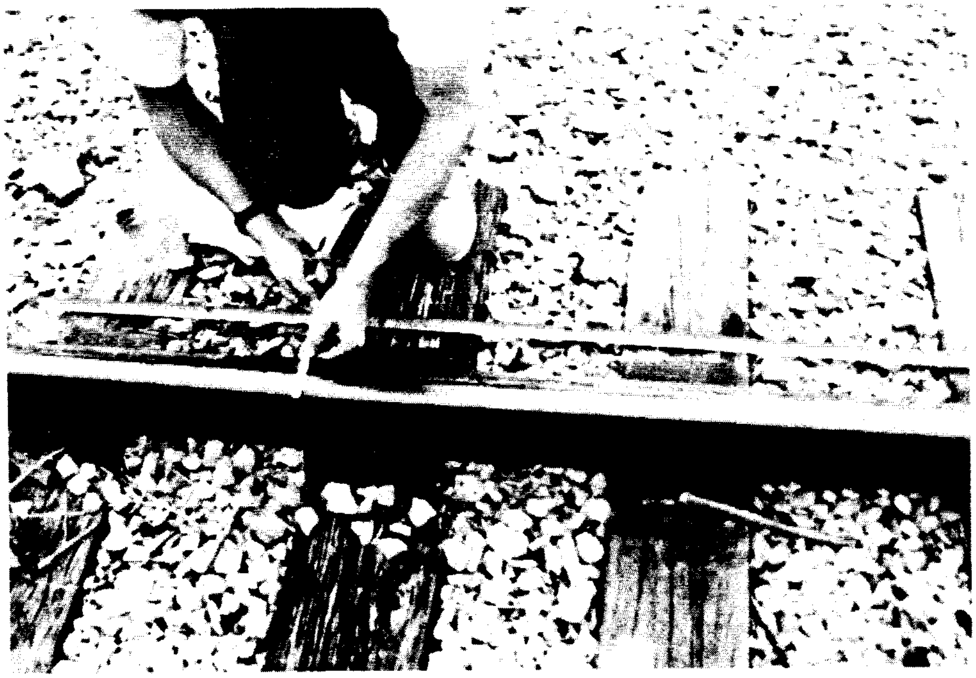
Defective or Improper Rail Crossings:	Major components and defects are similar to the turnout frog. Crossing frog areas should be checked closely for loose components and pumping track, which are inherent problems with these assemblies.

Derails

Cracked Sliding Derails:	Cracked and/or split rail usually caused by a defect in casting process.
Loose/Deteriorated Derail Road Crossings:	Rutted or irregular road surface, flangeway protection may loosen, deteriorate, fill with debris, or otherwise become fouled.
Flowed Metal Rail:	A rolling out of the metal on the top of the rail head, with no breaking down on the underside of the head.
Inoperable/Damaged Throwing Mechanism:	The throwing mechanism may not operate smoothly or the connecting rods may be bent or out of adjustment. Most derails have a locking provision to prevent accidental operation fo the derail. These may be broken or missing.
Chipped/Worn,Switch Point Derails:	Switch points can be broken or chipped. In older trackwork, it is common to see swtich point ends ground back several inches from thier original position.

Road Crossings

Damaged Crossing Surface:	The asphalt, concrete, timber, or rubber surface can deteriorate and develop potholes and other surface irregularities. Rubber and timber surfaces can become mismatched, separated, or have raised leg screws.
Fouled Flangeways:	The formed flangeways, especially in asphalt crossings, can become fouled with debris or the flangeway corners can crack or crumble. The flangeway protection may also loosen.
Fouled/Loose Field Crossing Panels:	See Flangeways for Deficiency.
Loose/Corroded Frog Plates:	Special tie plates are used in frog areas. These can become loose or heavily corroded.
Loose/Missing Lag Screws:	The long lag screws used to hold down rubber and timber road crossing components can back out above the crossing surface.



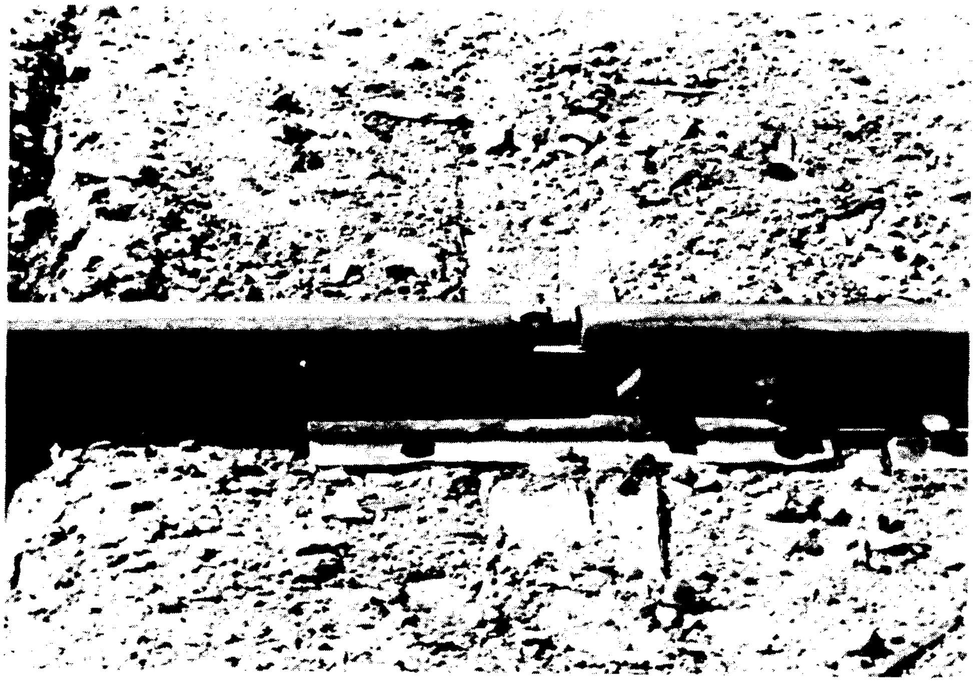
VERTICAL SPLIT HEAD IN TRACK

BROKEN RAIL HEAD AT JOINT, LOOSE BOLTS, NON-STANDARD
TIE PLATES AND DEFECTIVE TIES

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. 0120401-I

TORCH CUT RAIL

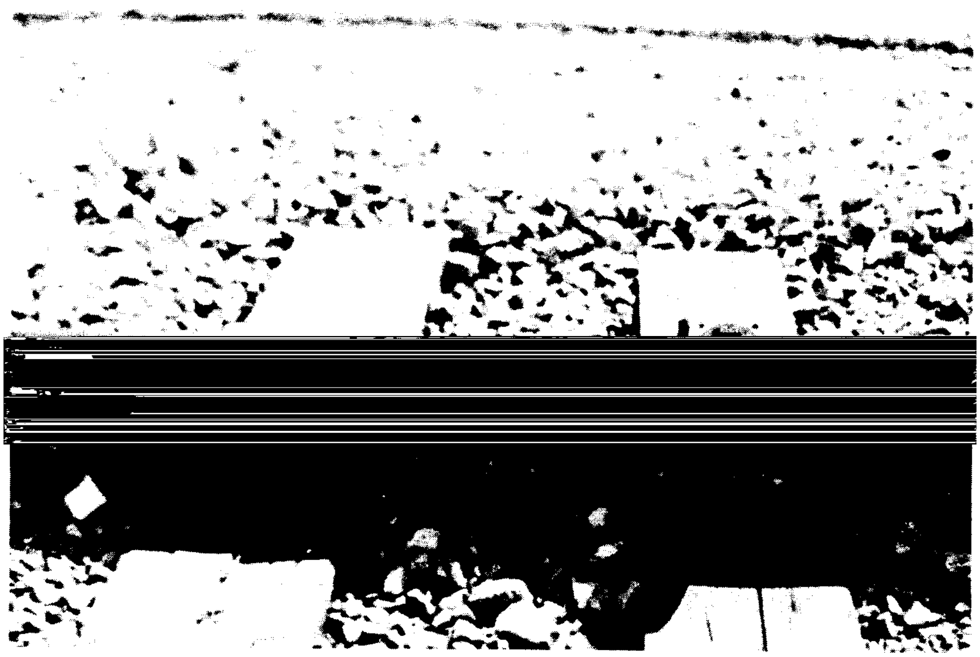


RAIL PULLAPART AND MISSING BOLTS

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	**RAIL COMPONENT DEFICIENCIES**		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-2

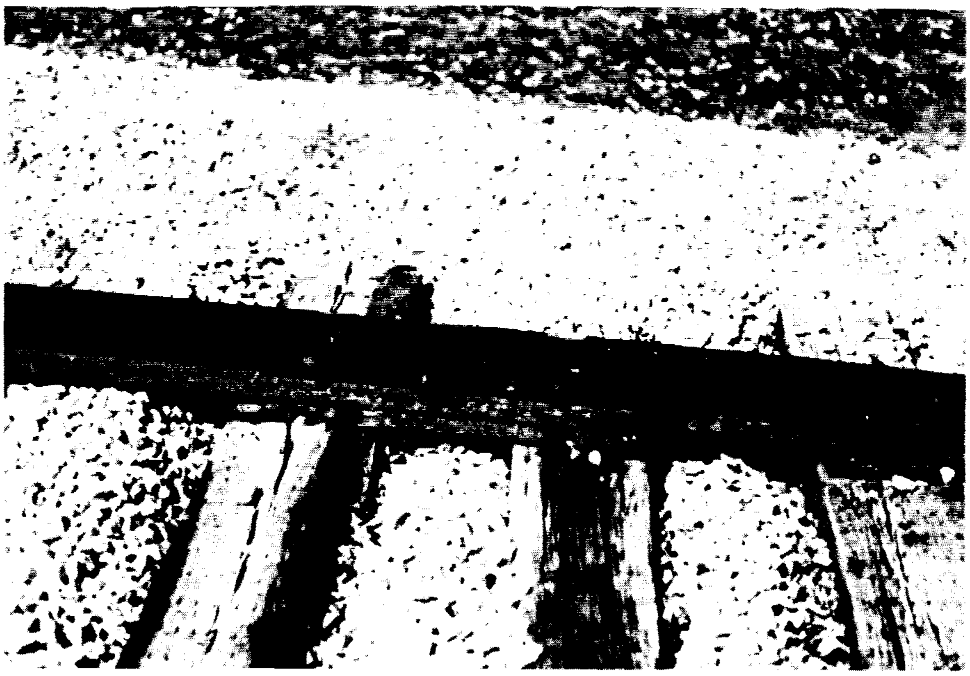
RAIL PULLAPART. NO RAIL ANCHORS AND DEFECTIVE TIES



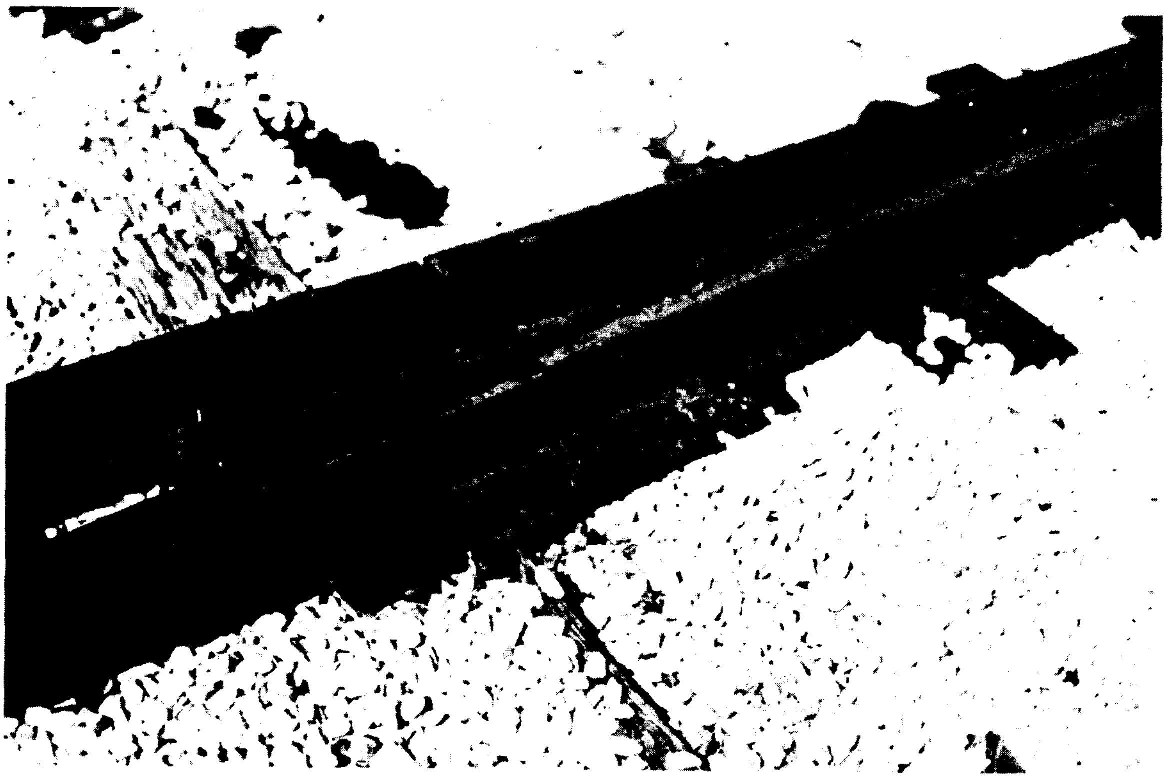
TYPICAL WIDE GAP RAIL JOINTS AND BATTERED ENDS

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-3



MISSING BOLTS AND DEFECTIVE TIES

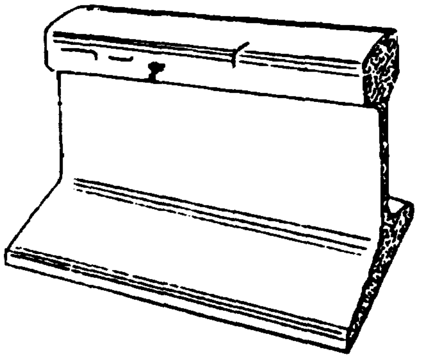


MISSING BOLTS/SWINGING JOINT AT FROG

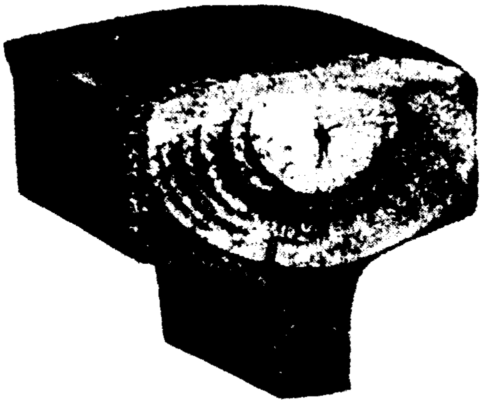
PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAIL WAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-4

TRANSVERSE FISSURE,
SHOWING RAPID GROWTH



APPEARANCEOFTRANSVERSEDEFECTS
(EXCEPT ENGINE BURN FRACTURE)IN TRACK

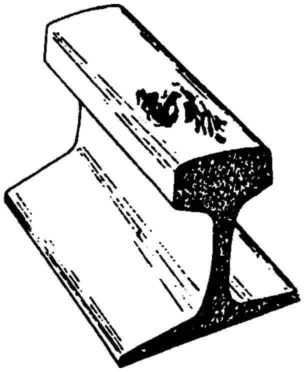


TRANSVERSE FISSURE,
SHOWING SUDDEN GROWTH

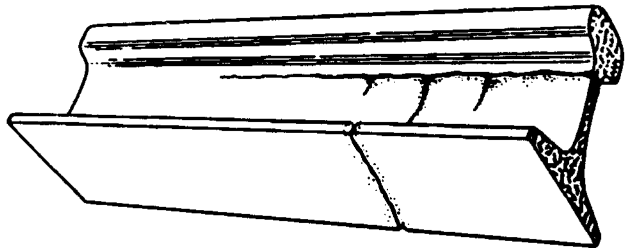
TRANSVERSE DEFECT

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-5



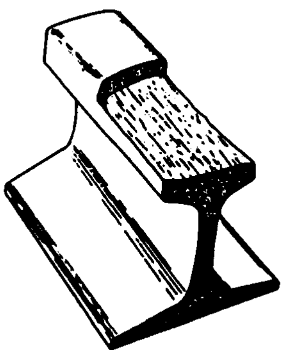
APPEARANCE OF
ENGINE BURN IN TRACK



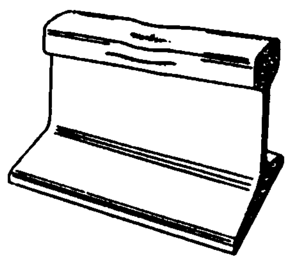
APPEARANCEOFAHEAD
AND SEPARATION IN TRACK

ENGINE BURN

HEAD AND WEB SEPARATION



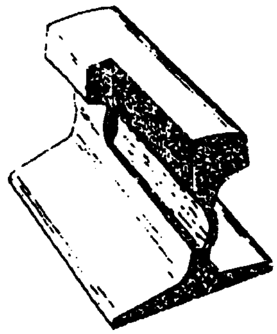
GENERAL APPEARANCE
OF A HORIZONTAL SPLIT HEAD



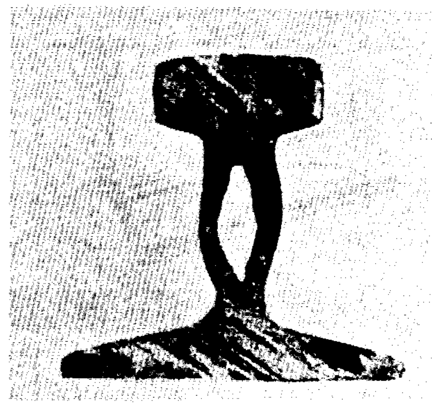
APPEARANCE OF A
HORIZONTAL SPLIT HEAD IN TRACK

HORIZONTAL SPLIT HEAD

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-6

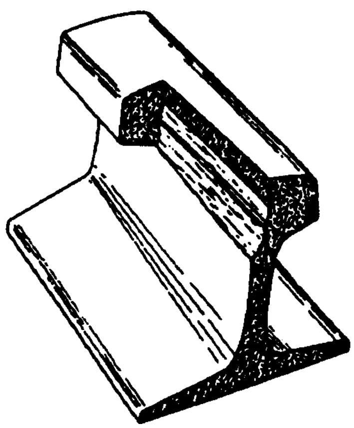


GENERAL APPEARANCE
OF PIPED RAIL

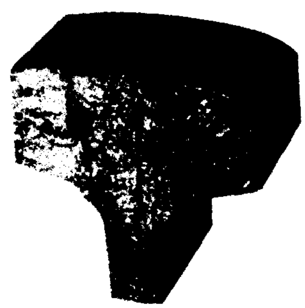


PIPED RAIL

PIPED RAIL



GENERAL APPEARANCE
OF A VERTICAL SPLIT HEAD

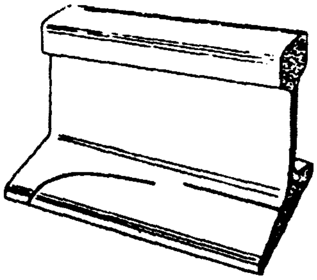


VERTICAL HEAD WITH
SPLIT EXTENDING INTO WEB

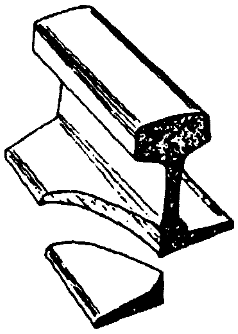
VERTICAL SPLIT HEAD

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-7

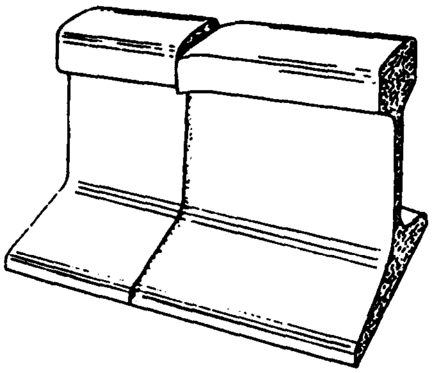


APPEARANCE OF A
BROKEN BASE IN TRACK



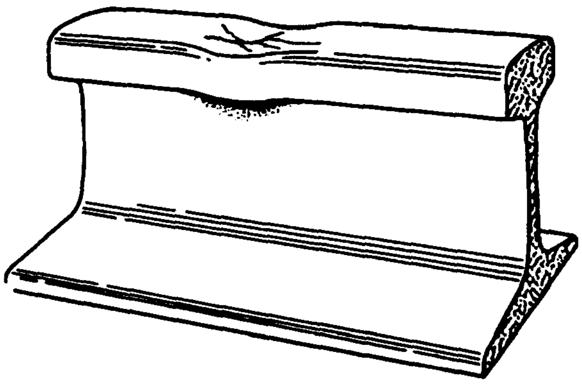
GENERAL APPEARANCE
OF A BROKEN BASE

BROKEN BASE



APPEARANCE OF A SQUARE
OR ANGULAR BREAK IN TRACK

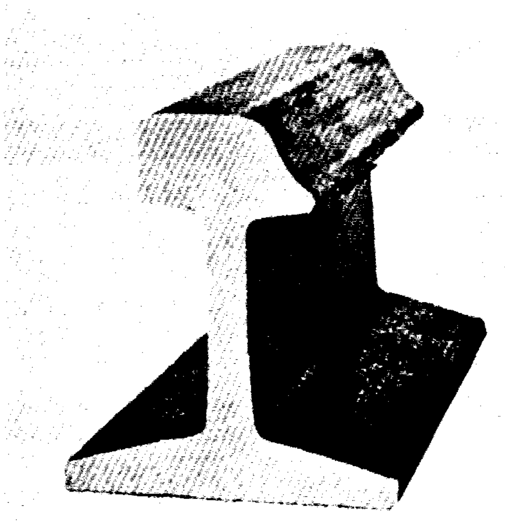
ORDINARY BREAK



APPEARANCE OF A
CRUSHED HEAD IN TRACK

CRUSHEDHEAD

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-8



CURVE WORN RAIL

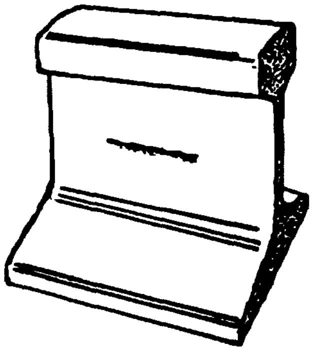
BATTERED END

CLOSE-UP OF SHELLY SPOT ON GAUGE SIDE OF RAIL HEAD

SHEELY RAIL

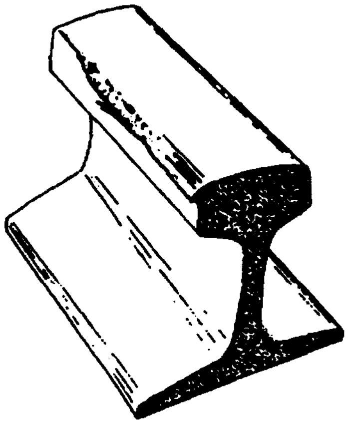
PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-9



APPEARANCE OF A
SPLIT WEB IN TRACK

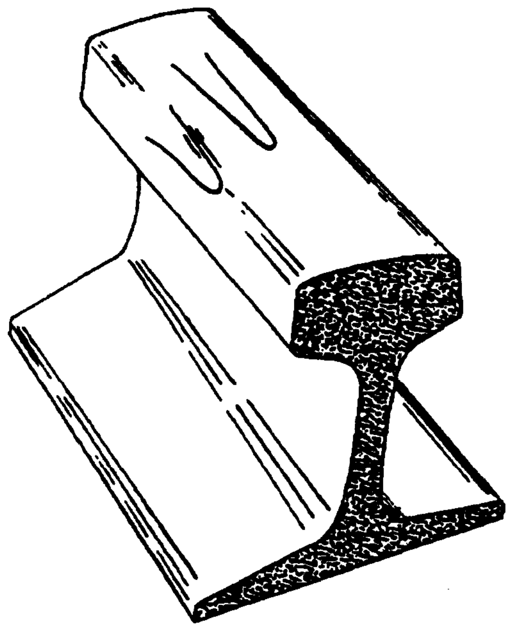
SPLIT WEB



APPEARANCE OF A FLOW IN TRACK

FLOWED RAIL

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	RAIL COMPONENT DEFICIENCIES		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-10



A SLIVER IS THE SEPARATION OF A THIN, TAPERED MASS OF METAL FROM THE SURFACE OF THE HEAD, WEB, OR BASE OF A RAIL. SLIVERS ARE NOT CRITICAL DEFECTS.

APPEARANCE OF TRACK: THIN SLIVERS ON THE SURFACE OF THE RAIL HEAD AND PARALLEL TO THE RAIL LENGTH, SIMILIAR TO WOOD SLIVERS.

<table>
<tr><td>SYSTEM ASSEMBLY
DEFICIENCY DETAILS-SITEWORK</td><td colspan="3">GENERAL APPEARANCE OF SLIVERS</td></tr>
<tr><td rowspan="2">RAILWAYS
TRACKWORK
(CSI 14900)</td><td>Revision No.</td><td>Issue Date</td><td>Drawing No.</td></tr>
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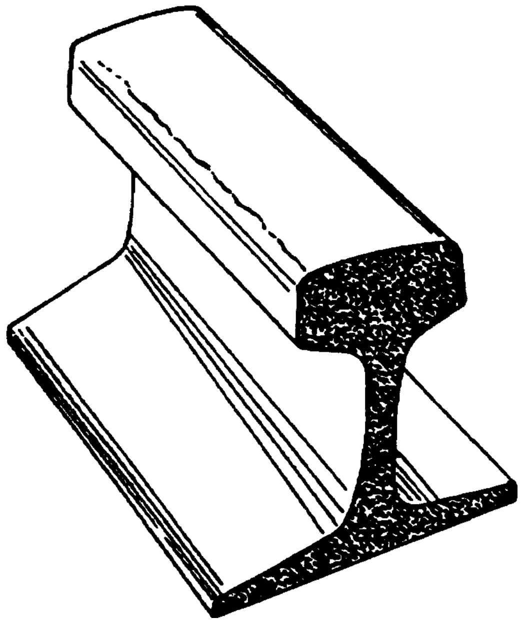

A PROGRESSIVE HORIZONTAL SEPARATION ON THE RUNNING SURFACE NEAR THE GAGE CORNER, OFTEN ACCOMPANIED BY SCALING OR CHIPPING. FLAKING SHOULD NOT BE CONFUSED WITH SHELLING, AS FLAKING OCCURS ONLY ON THE RUNNING SURFACE NEAR THE GAGE CORNER AND IS NOT AS DEEP AS SHELLING. FLAKING IS NOT A CRITICAL DEFECT.

SYSTEM ASSEMBLY DEFICIENCY DETAILS-SITEWORK	GENERAL APPEARANCE OF FLACKING		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. D120401-12

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

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DEFICIENCY FACTORS
0.12.04.01 TRACKWORK **(CSI 02450)**

END OF SUBSECTION

0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

DESCRIPTION

The typical railway electrical signal system is a complex assembly used for the operation of a relatively automatic, “fail-safe” train control system. This signal system is designed to accommodate numerous factors that include size and quantity of rail units handled. This section addresses the more common components found in most systems. This section does not address actual operation of the railway electrical signal system.

Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

RAILWAY ELECTRICAL SIGNAL SYSTEM EQUIPMENT

Types of equipment found in typical railway electrical signal systems include but are not limited to the following:

- Conductors & Fittings
- Disconnects
- Luminaires
- Signal Circuits
- Switch Heater
- Switch Machine
- Transformers

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Conductors & Flfflngt (CSI 16120)

Conductors and fittings employed in railway electrical signal systems normally involve use of the rails as well as insulated conductors and bonding conductor. The rails are designed and fabricated to carry loads in addition to serving as an electrical conductor. Most insulated conductors are used for control wiring. Bonding wires are special applications of conductors welded to the web or head of the rail to ensure electrical conductivity across bolted rail joints or at various turnout components.

Disconnects (CSI 16440)

A device used to disconnect a load from a source or generate a signal such as a relay. In rail systems this disconnect may be in the form of an auxiliary device to a track switch used to alter track paths. Such auxiliaries would include trip stop switches. A relay is an electro-mechanical device that opens and closes contacts in an electrical system. One of the more common uses in a railway electrical signal system is control of luminaires of block signaling systems. The relays may be described also as track, A-C track, and rotor type A-C.

Lumlnalres (CSI 16520)

Lighting devices (signal heads or signal lamps) used to provide a visual signal of stop and go track conditions for rail equipment and to provide a visual stop signal for track crossings by personnel and non-track equipment.

Signal Systems

Signal systems consist of signal heads, wire, cable, conduit, rail joint bonds, relay cases, rail trips, compressed air piping, bootleg boxes, timers, and track switch machine interlocking.

Switch Heater (CSI 16850)

A device that prevents freeze-up, due to inclement weather, of switching devices used in the control of rolling stock.

0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

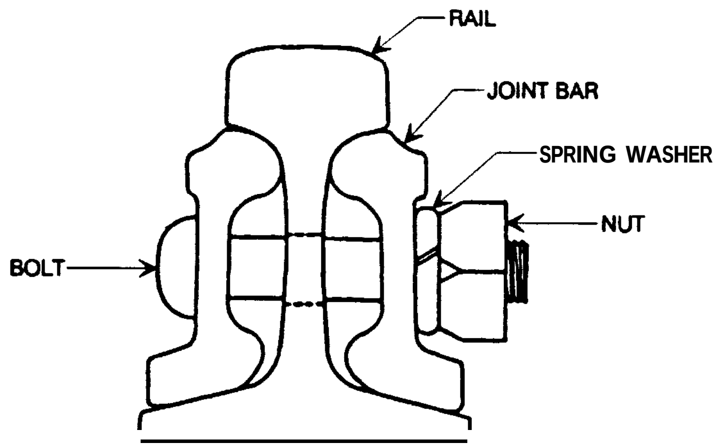
ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Switch Machine

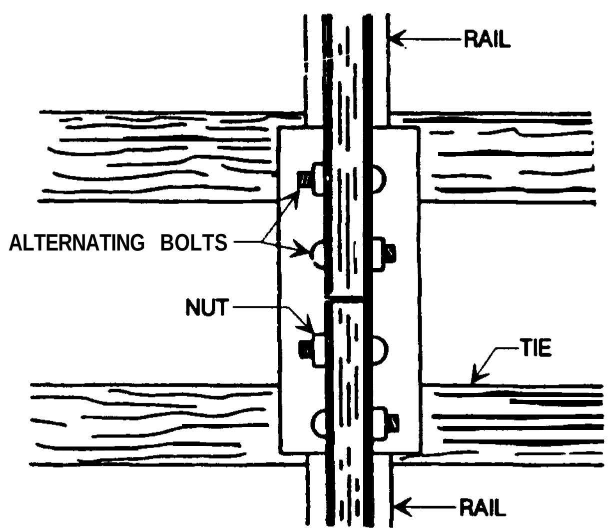
A switch machine is an electromechanical device that operates the turnout switch points via a connecting rod.

Transformers (CSI 16460)

A device that steps down, steps up, limits or isolates AC voltages and currents. The transformer(s) provide the necessary electrical energy for operation of the railway electrical signal system to include luminaires. Reactors are a special device used to provide an impedance in the railway electrical signal system to limit current flow. Reactors are key elements to ensure adequate electrical energy for pickup and dropout of control relays.



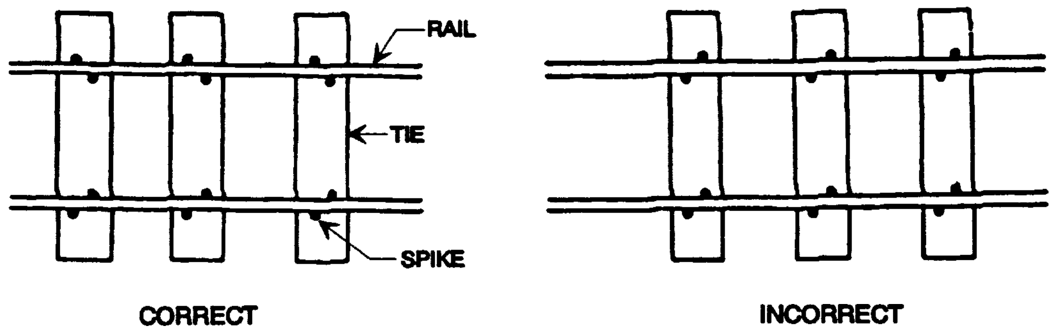
SECTION



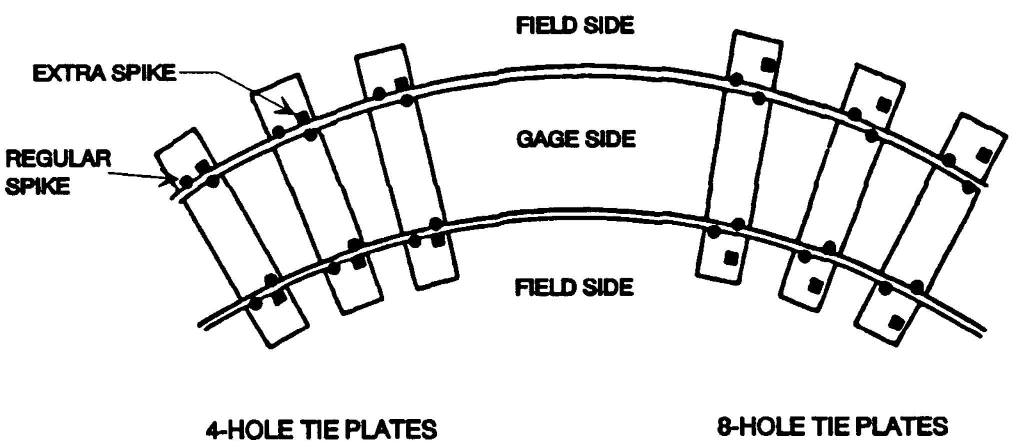
PLAN VIEW

PROPER BOLT INSTALLATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-1

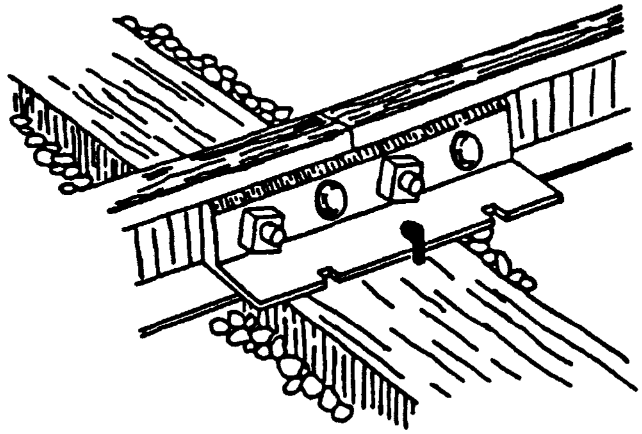


SPIKING PATTERN FOR TANGENTS AND CURVES LESS THAN 4 DEGREES

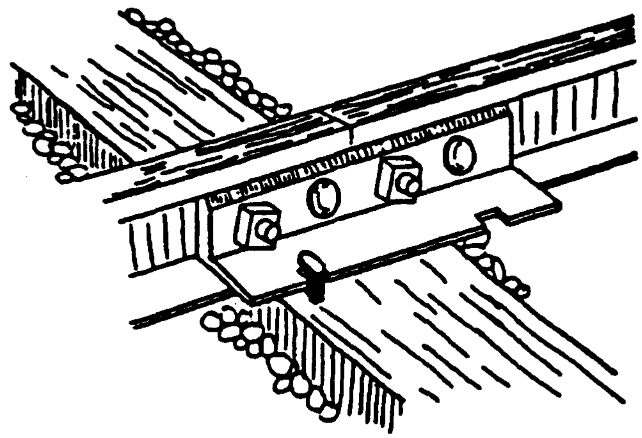


SPIKING PATTERN FOR CURVES 4 DEGRESS AND GREATER

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-2

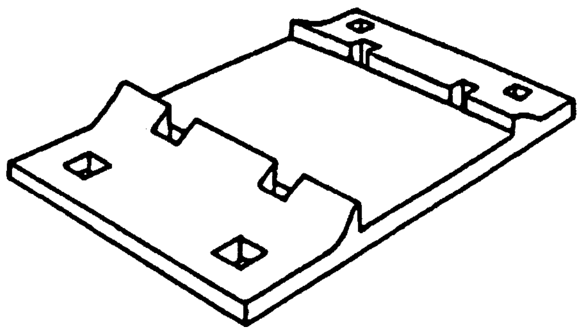


CORRECT

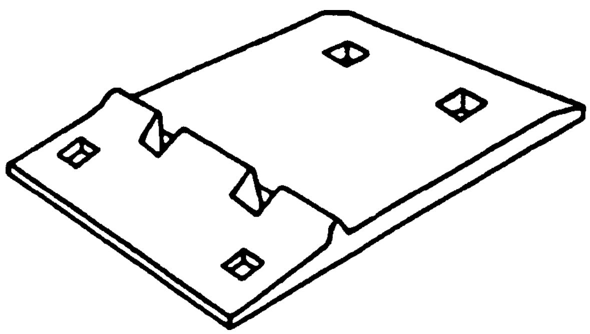


INCORRECT

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	issue Date 5/93	Drawing No. A120401-3

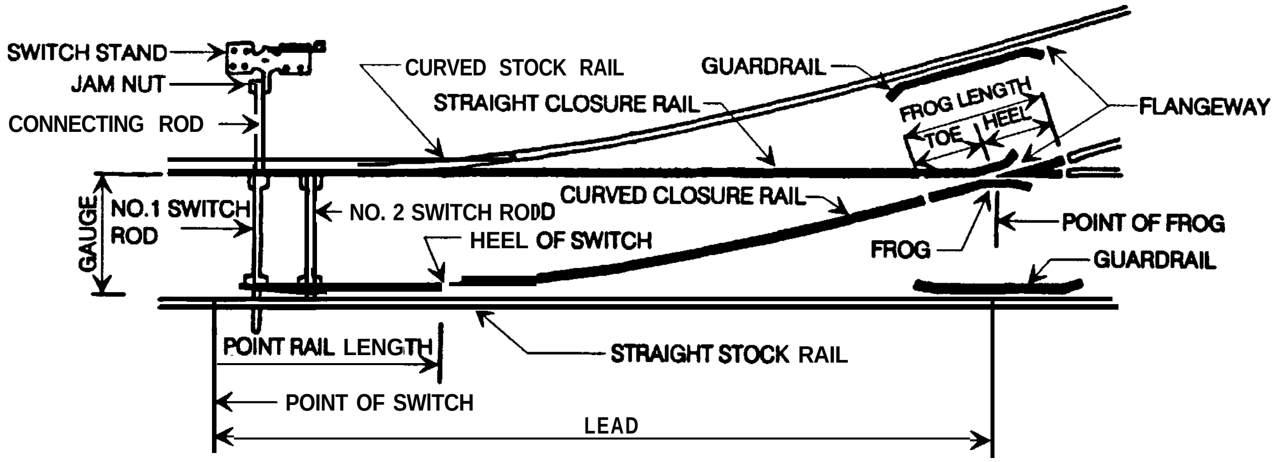


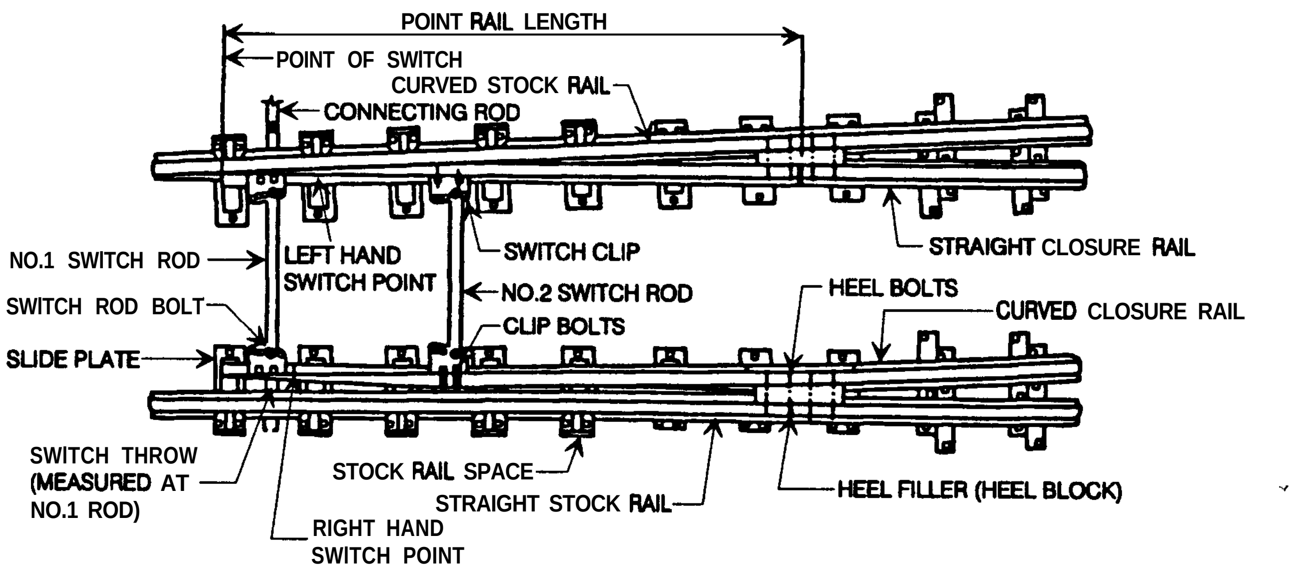
DOUBLE SHOULDER TIE PLATE



SINGLE SHOULDER TIE PLATE

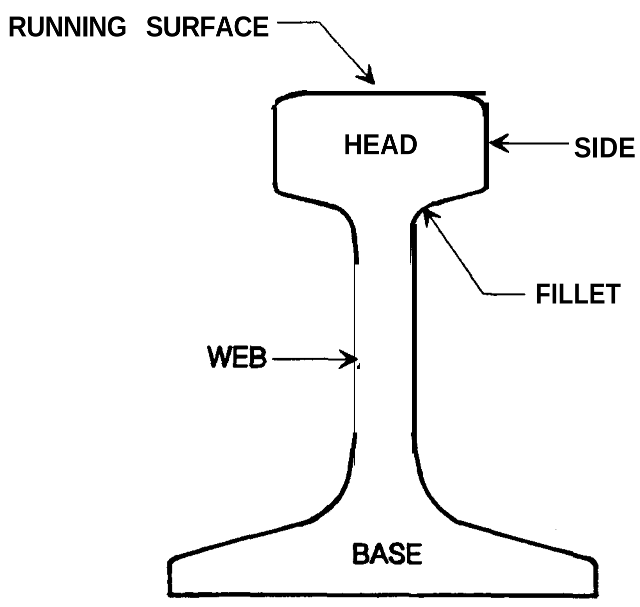
SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-4





PARTS OF A TURNOUT

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-5

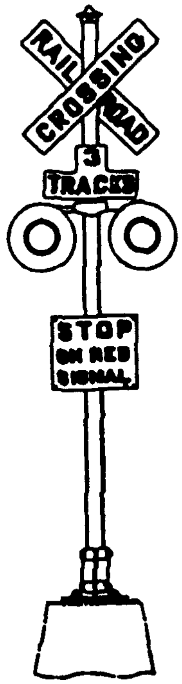


SYSTEM ASSEMBLY DETAILS-SITEWORK	RAIL STRUCTURE		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-6

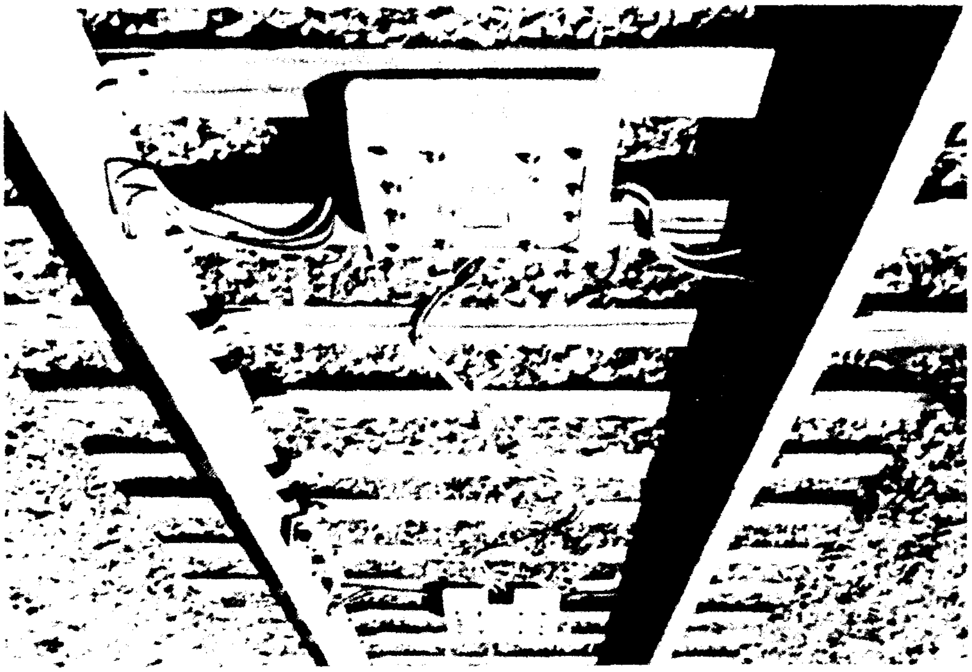
50-DEGREE SIGN

90-DEGREE SIGN

SYSTEM ASSEMBLY DETAILS-SITEWORK	HIGHWAY CROSSING SIGNS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	issue Date 5/93	Drawing No. A120401-7



SYSTEM ASSEMBLY DETAILS-SITEWORK	HIGHWAY CROSSING SIGNS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issua Date 5/93	Drawing No. A120401-8



SYSTEM ASSEMBLY DETAILS-SITEWORK	IMPEDANCE BOND		
RAILWAYS SIGNALS AND COMMUNICATIONS (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120402-1

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

PROBABLE FAILURE POINTS

- Ballast Resistance - Exceeds minimum or maximum value.
- Broken Rail - Non-bonded joint or broken bond wire.
- Flood Detector - Motion inhibited by flora.
- Insulated Joints - Shorted
- Luminaire/Signal Lamp - Inoperative
- Switch Heater - inoperative
- Switch Machine - Inoperative
- Track Relay - Inoperative
- Unused Track - Oxide inhibition/high impedance

SYSTEM ASSEMBLIES/DEFICIENCIES

Conductors & Fittings

Improper Cable/Conductor:	Ampacity not properly rated. Bimetallic connectors not used as required. Broken wire strands. Burned, melted, discolored conductor material. Defective or deficient cable/conductor penetrations. High splice temperature. Improper bending radius. Improper insulation Voltage. Improper splice materials used. Improper termination. Improper trench. Improperly made splice. Inappropriate for application. Insulation inappropriate for application. Insulation improperly removed. Insulation is burned, charred, discolored, or other physical damage. Insulation resistance less than one megOhm per each kiloVolt of rating. Insulation unraveled, frayed, brittle, or other physical damage. Nicked or ringed conductor. Not properly bundled or trained. Not properly connected to device. Not properly derated for installation. Not properly supported. Not protected physically. Unauthorized splice.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Conductors & Fittings (Continued)

Improper Fitting/Device:	Exposed conductors. Improper for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Disconnects

Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Heater:	Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative heater element. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.
Defective Pressure Relief:	High internal pressure. No internal pressure.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension. inadequately torqued at termination. inappropriate for application. Inconsistent time delays.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Disconnects

Improper Control Wiring (Continued):	Incorrect overcurrent protection. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. Insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
improper Disconnect:	Adjustable settings misadjusted. Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage. Contacts bent or not aligned. Defective phase barriers. Does not sustain rated current per NEMA AB4-1991. Does not trip on instantaneous overcurrent per NFPA 708. Handle broken, bent, or other physical deformity. High conductor, lug temperature. High contact resistance. Improper application. improper switch time. Improperly sized. Improperly wired. Interlock broken, missing, or inoperative. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. No engineering study to support adjustable settings. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Series trip device missing, broken, or inoperative. Shunt trip device missing, broken, or inoperative. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored. Terminals, contact blocks, bus bar and connectors loose, burned, or discolored. Time-delay overcurrent trip not per manufacturer's specifications.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI **16700)**

SYSTEM **ASSEMBLIES/DEFICIENCIES**

Disconnects

Improper Disconnect (Continued):	UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, misaligned, or other physical deformity. Not secured to mounting surface. Insufficient work space. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Oil leaks. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Improper Fuse Unit:	Fuse clips bent, malaligned, discolored, or other physical damage. Improper fuse type used. Improperly sized. Poor fuse to clip contact. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
Improper Insulating Liquid:	Contaminated internal device. Low insulation resistance. Low liquid level. Oil does not meet criteria of NFPA 708. Pressure leak.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Protective Relay:	Cover loose, missing, broken, chipped, cracked, or other physical damage. Current, Voltage, and time pick-up/drop-out values not per manufacturer's specifications. Housing chipped, cracked, broken, or other physical damage. Improper application. Improperly wired. Inoperative. Malcalibrated.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Disconnects

Improper Protective Relay (Continued):	Missing and/or out-of-date calibration tag. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. Not clean and moisture-free. Not secured to mounting surface. No engineering study to support adjustable setting. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored.
Inaccurate Metering:	Terminals loose, broken, missing, burned, discolored, or corroded. Calibration standard not established. Defective or inoperative sensor or transducer. Metering device inadequately sized. Metering device not calibrated.
Improper Mount:	Device not secured to mount. Device mounting surface chipped, cracked, broken, or other physical damage. Dirty, oily, greasy, or other surface contamination. Mounting structure inadequate. Mounting structure not secured to mounting surface. Not aligned.

Lighting

Defective Ballast:	Corroded, rusted, dented, or other physical damage. Defective capacitor. Dirty, oily, greasy, or other surface contamination. Improper and/or inadequate line voltage. Inappropriate for application. Inoperative thermal protector. inoperative. Missing. Noisy. Not adequately secured. Not properly grounded. Oil leakage. Transformer coils discolored, burned, or other signs of high temperature.
Defective Battery Charger:	Abnormal output. Corroded, rusted, dented, or other physical damage. Inappropriate for application. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Indicator meter inoperative or missing. Inoperative.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS **&** COMMUNICATIONS **(CSI 16700)**

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Defective Battery Charger (Continued):	Noisy. Not adequately secured. Not clean and moisture-free. Test switch inoperative or missing. Top, bottom, or side cover missing.
Defective Battery/Application:	Corroded terminal. Cracked case. Flame arrestor missing or broken. Improper liquid level. Inoperative. Insufficient ampacity. Liquid leakage. No emergency shower readily available. No eyewash readily available. No protective personnel gear available. Not properly marked. Not properly ventilated. Not securely attached to mounting surface. Overcharged. Pressure release vent inoperative. Rack(s) unstable, uneven, or inaccessible. Undercharged. Ventilation obstructed or clogged.
Defective Control Module:	Circuit boards improperly installed and/or connected Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Dimmer Switch:	Dirty, oily, greasy, or other surface contamination. Discolored, burned, or other signs of high temperature. Inadequate capacity. Inoperative. Missing, cracked, or broken components. Noisy. Not adequately secured. Not properly grounded.
Defective Fixture Hanger:	Inappropriate for application. Missing, broken, corroded, or other physical damage. Not adequately secured to mounting surface.
Defective Fixture Wiring:	Bundled or trained inappropriately. Improper splice. Inadequately torqued at termination. Inappropriate for application.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Defective Fixture Wiring (Continued):	Insulation charred, burned, or discolored. insulation improperly removed from conductor. Insulation less than one megohm per each kiloVolt of rating. Insulation nicked, cut, cracked, or other physical damage. Splice(s) improperly insulated. Unauthorized splice.
Defective Globe:	Dirty, oily, greasy, or other surface contamination. Inappropriate for application or location. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Lamp:	Blackening at end of arc tube. Broken or cracked arc tube. Dirty, oily, greasy, or other surface contamination. Ignitor inappropriate for application. Ignitor inoperative. Improper burning position. Inadequate base to socket contact pressure. Inappropriate for application. Inoperative. Low light output level. Missing, cracked, chipped, or other damage.
Defective Lens:	Dirty, oily, greasy, or other surface contamination. Inappropriate for application. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Reflector:	Dirty, oil, greasy, or other surface contamination. Inappropriate for application. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Safety Guard:	Inappropriate for application. Not adequately secured. Missing, broken, or other damage.
Defective Socket:	Dirty, oily, greasy, or other surface contamination. Inadequate socket contact pressure. Inadequate termination. Missing, cracked, chipped, or other damage. Not adequately secured. Pitted, burned, or discolored.
Improper Housing:	Corroded, rusted, dented, or other physical damage. Enclosure not secured to mounting surface. Missing. Not accessible. Not adequate for application or location. Not clean and moisture-free. Not grounded properly.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS **(CSI 16700)**

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Improper Housing (Continued):	Not securely attached to mounting surface. Top, bottom, or side cover missing. Unused openings not covered or plugged. Vent defective or nonoperative. Ventilation obstructed or clogged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Signal Circuits

Deficient Penetration:	Approved seals not used in boundaries.
Improper Cable/Conductor:	Ampacity not properly rated. Bimetallic connectors not used as required. Broken wire strands. Burned, melted, discolored conductor material. Defective or deficient cable/conductor penetrations. High splice temperature. Improper bending radius. Improper insulation voltage. Improper splice materials used. Improper termination. Improper trench. Improperly made splice. Inappropriate for application. Insulation inappropriate for application. Insulation improperly removed. Insulation is burned, charred, discolored, or other physical damage. Insulation resistance less than one megOhm per each kiloVolt of rating. Insulation unraveled, frayed, brittle, or other physical damage. Nicked or ringed conductor. Not properly bundled or trained. Not properly connected to device. Not properly derated for installation. Not properly supported. Not protected physically. Unauthorized splice.
Improper Fitting:	Exposed conductors. Improper fitting for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Signal Circuits (Continued)

Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Overcurrent Device:	Interchangeable devices used in signal circuits. No engineering study for adjustable settings. Not of proper size. Not properly located for signal circuit application. Overcurrent device exceeds 167 percent of signal circuit source rating. Signal circuit conductors less than 14AWG not properly protected.
improper Power Supply:	Not durably marked for class and rating. Parallel connection of unlisted power supplies.
Improper Rating:	Maximum non-transformer source output exceeds 2500 Volt-Amperes. System exceeds 30 Volts and 1000 Volt-Amperes to load.
Defective Crossing Signals:	Crossing arm broken or missing. Inoperable. Signals do not reset properly after actuation. Signals do not actuate properly. Warning bell missing or inoperable.

Switch **Heater**

Defective Heater:	Damaged. Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative. Not energized. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.
Improper Cable/Conductor:	Ampacity not properly rated. Bimetallic connectors not used as required. Broken wire strands. Burned, melted, discolored conductor material. Defective or deficient cable/conductor penetrations. High splice temperature. Improper bending radius. Improper insulation voltage. Improper splice materials used. Improper termination. Improper trench. Improperly made splice. Inappropriate for application. Insulation inappropriate for application. Insulation improperly removed.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Heater

Improper Cable/Conductor: (Continued)	Insulation resistance less than one megOhm per each kiloVolt of rating. Insulation is burned, charred, discolored, or other physical damage. Insulation unraveled, frayed, brittle, or other physical damage. Nicked or ringed conductor. Not properly bundled or trained. Not properly connected to device. Not properly derated for installation. Not properly supported. Not protected physically. Unauthorized splice.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pickup or dropout point. Improper termination. Inadequate fuse/connection tension. Inadequately torqued at termination. Inappropriate for application. Inconsistent time delays. Incorrect fuse installed. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
Improper Disconnect:	Adjustable settings misadjusted. Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage. Contacts bent or not aligned. Defective phase barriers. Does not sustain rated current per NEMA AB4-1991. Does not trip on instantaneous overcurrent per NFPA 70B. Handle broken, bent, or other physical deformity. High conductor, lug temperature. High contact resistance. Improper application. Improper switch time.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Heater

Improper Disconnect (Continued):	Interlock broken, missing, or inoperative. Improperly sized. Improperly wired. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. No engineering study to support adjustable settings. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Series trip device missing, broken, or inoperative. Shunt trip device missing, broken, or inoperative. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored. Terminals, contact blocks, bus bar, and connectors loose, burned, or discolored. Time-delay overcurrent trip not per manufacturer's specifications. UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Not secured to mounting surface. Interlock broken, missing, or inoperative. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Oil leaks. Pedestal mounting surface chipped, broken, or other physical damage. Unused openings not covered or plugged. Vent defective or nonoperative. Ventilation obstructed.
Improper Equipment Protection:	Improper or inadequate primary protection device. Improper or inadequate secondary protection device. Improper or inadequate differential protection device. No engineering study to support protection scheme.
improper Installation:	Conductor or cable not appropriate for installation. Conductor or cable not listed. Conductors not trained or bundled for ventilation.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS **&** COMMUNICATIONS (CSI 16700)

SYSTEM **ASSEMBLIES/DEFICIENCIES**

Switch Heater

Improper Installation (Continued):	Hanger not adequately secured to structure. Improper joint. Inadequate grounding. Inadequate ventilation. Missing vertical run hardware. No bushing or equivalent protection. Not adequately protected from severe physical damage. Not adequately secured to mounting surface. Not appropriate for location, Not clearly and permanently marked where required. Not properly spaced from combustible materials. Not secured within three feet of end of run. Unauthorized conductor present. Unused openings not covered or plugged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Switch **Machine**

Defective Bearings:	High temperature. Rough or irregular rotation. Leaking seals. Improper bearing. Noisy.
Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Contactor:	Arc suppression components broken, eroded, cracked, or missing. Broken strands in braided shunts. Coil discolored, burned, or other sign of high temperature. Coil inoperative at 85% of rated Voltage. Contact pressure not per manufacturer's specifications. Contacts burned, pitted, or other physical damage. Contacts not properly aligned. Control circuits improperly connected. Dash pot inoperative, broken, or missing. Device sticks magnetically. Drum contacts inadequately torqued. High contact resistance. Improper fluid in dash pot. Improper rolling action of drum contacts. Improper size. Indicator lamps inoperative.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS **(CSI 16700)**

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Defective Contactor (Continued):	Indicator lens missing, cracked, or broken. Missing, loose, broken, or corroded hardware. No engineering study to support thermal trip device rating. Noisy. Plugging relays dirty or other contamination. Pushbuttons not labeled. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Rheostat contact surface corroded, oxidized, uneven, or other physical defect. Rheostat holding coil missing or inoperative. Rheostat ventilation impeded. Terminals, contact blocks, bus bars, and connectors loose or discolored. Thermal trip device wrong size.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Pressure Relief:	High internal pressure. No internal pressure.
Defective Switch Machine:	Detector rod broken, missing, or out of adjustment. Inoperable. Loose or broken wiring. Operating rod broken, missing, or out of adjustment. Overloaded motor. Relays out of adjustment, pitted, or burned.
Improper Fitting:	Exposed conductors. Improper fitting for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS **&** COMMUNICATIONS **(CSI** 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Improper Control Wiring (Continued):
- Inadequately torqued at termination.
- Inappropriate for application.
- Inconsistent time delays.
- Incorrect overcurrent protection.
- Indicator lamps inoperative.
- Indicator lens missing, cracked, or broken.
- Inoperative.
- Inoperative interlock.
- Insulation charred, burned, or discolored.
- Insulation improperly removed from conductor.
- No engineering study to support installed fuse.
- Splices improperly insulated.
- Terminal boards improperly installed.
- Unauthorized splice.

Improper Disconnect:
- Adjustable settings misadjusted.
- Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage.
- Contacts bent or not aligned.
- Defective phase barriers.
- Does not sustain rated current per NEMA AB4-1991.
- Does not trip on instantaneous overcurrent per NFPA 70B.
- Handle broken, bent, or other physical deformity.
- High conductor, lug temperature.
- High contact resistance.
- Improper application.
- Improper switch time.
- Improperly sized.
- Improperly wired.
- Interlock broken, missing, or inoperative.
- Movable contacts bent, malaligned, or other physical deformity.
- Movable contacts pitted, burned, or discolored.
- No engineering study to support adjustable settings.
- Not accessible.
- Not adequate for application.
- Not clean and moisture-free.
- Not grounded properly.
- Not secured to mounting surface.
- Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
- Series trip device missing, broken, or inoperative.
- Shunt trip device missing, broken, or inoperative.
- Stationary contacts bent, malaligned, or other physical deformity.
- Stationary contacts pitted, burned, or discolored.
- Terminals, contact blocks, bus bar and connectors loose, burned, or discolored.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Improper Disconnect (Continued):	Time-delay overcurrent trip not per manufacturer's specifications. UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, misaligned, or other physical deformity. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Oil leaks. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Imoroper Equipment Protection:	Improper or inadequate primary overcurrent device. Improper or inadequate secondary overcurrent device. No engineering study to support protection scheme. Incorrect calibration of protective devices or sensors. Improper or inadequate differential protection. Time delay suppression devices missing, broken, or inoperative.
Improper Fuse Unit:	Fuse clips bent, malaligned, discolored, or other physical damage. Improper fuse type used. Improperly sized. Poor fuse to clip contact. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Motor Application:	Inappropriate starting system. Improper motor size. Improper rotation. Improper speed. Improper connection of bimetallic elements. Improper winding connections.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine (Continued)

Improper Mount:	Device not secured to mount. Device mounting surface chipped, cracked, broken, or other physical damage. Dirty, oily, greasy, or other surface contamination. Mounting structure inadequate. Mounting structure not secured to mounting surface. Not aligned.
Improper Rotor/Stator:	Bent, scored, or other damage to rotor shaft. Burned, charred, or other signs of high temperature. Damaged internal and/or external cooling fan. Noisy laminations. Non-uniform air gap. Open turns or coils. Shorted turns or coils. Splice insulation unraveled, brittle, cracked, or other damage. Unbalanced rotor assembly.

Transformers

Contaminated Transformer:	Contaminated coils and core.
Damaged Metering:	Device inoperative. Metering device broken or other physical damage. Tampering of metering device or circuit.
Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Heater:	Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative heater element. Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Transformers (Continued)

Defective Pressure Relief:	High internal pressure. No internal pressure.
Defective Transformer:	Cooling fans inoperative. Corona. Inadequate rating. Low insulation resistance. Low liquid level. Noisy. Pressure leak. Shorted or open coil or winding. Tap changer inoperative.
Defective Ventilation:	High operating temperature. Ventilation inlets clogged. Ventilation obstructed. Location not adequately ventilated.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension. Inadequately torqued at termination. Inappropriate for application. Inconsistent time delays. Incorrect overcurrent protection. indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. Insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, malaligned, or other physical deformity. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Transformers

Improper Enclosure (Continued):	Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Oil leaks. Pedestal mounting surface chipped, broken, or other physical damage. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Improper Equipment Protection:	Improper or inadequate primary overcurrent device. Improper or inadequate secondary overcurrent device. No engineering study to support protection scheme. Incorrect calibration of protective devices or sensors. Improper or inadequate differential protection. Time delay suppression devices missing, broken, or inoperative.
Improper Insulating Liquid:	Contaminated internal device. Low insulation resistance. Low liquid level. Oil does not meet criteria of NFPA 70B. Pressure leak.
improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Inaccurate Metering:	Calibration standard not established. Defective or inoperative sensor or transducer. Metering device inadequately sized. Metering device not calibrated.

END OF SUBSECTION

0.12.05 FOUNTAINS & POOLS (CSI 02776)

DESCRIPTION

Fountains are artificially produced jet streams of water that enhance the characteristics of their surroundings; pools are usually a small and rather deep body of fresh water. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/COMPONENT

Fountains & Pools (CSI 02776)

In liner fabrication, one or more layers of fabric scrim, either nylon or polyester, may be laminated between two layers of sheet to produce a reinforce membrane. When a scrim is not used, the sheet is called unsupported or unreinforced.

A scrim helps reduce the amount of streaking, which improves the liner's dimensional stability. In addition, with scrim reinforcement, the liner resists punctures and tears and is able to vent trapped air and gas.

The scrim is often as important as the seam. Under some conditions, a scrim-reinforced sheet is essential. Where there is a high groundwater table or where soil decomposition produces methane gas, air or gas pockets can form under the liner. Under these conditions, scrim reinforcement is needed to prevent the liner from ballooning and to permit venting.

A good liner material must have the following properties:

- Weather resistance: must be resistant to ozone, oxygen, and ultraviolet light.
- Low temperature flexibility.
- Crack resistance.
- Abrasion resistance.
- The ability to produce strong field seams.
- Hypalon liners are flexible, resilient, and can conform to irregular as well as nominal shapes. As with any material, hypalon liners should be installed by experienced contractors. The ability to resist the effluent should be determined for each job.

<u>Liner Properties</u>:

Some advantages of liners are:

- Leakproof when properly installed.
- Flexible and resilient over a wide temperature range.
- Excellent aging and weathering characteristics (depending on liner material, application procedures, products contained).
- Resist mildew, mold, and fungus.
- Resist attack from a variety of chemicals.
- Accepted for use with potable water.

OTHER RELATED COMPONENTS

Refer to Foundations and Footings, Substructure, and Mechanical, Volumes 1, 2, and 8 for additional deficiencies that may impact this system.

0.12.05 FOUNTAINS & POOLS (CSI 02776)

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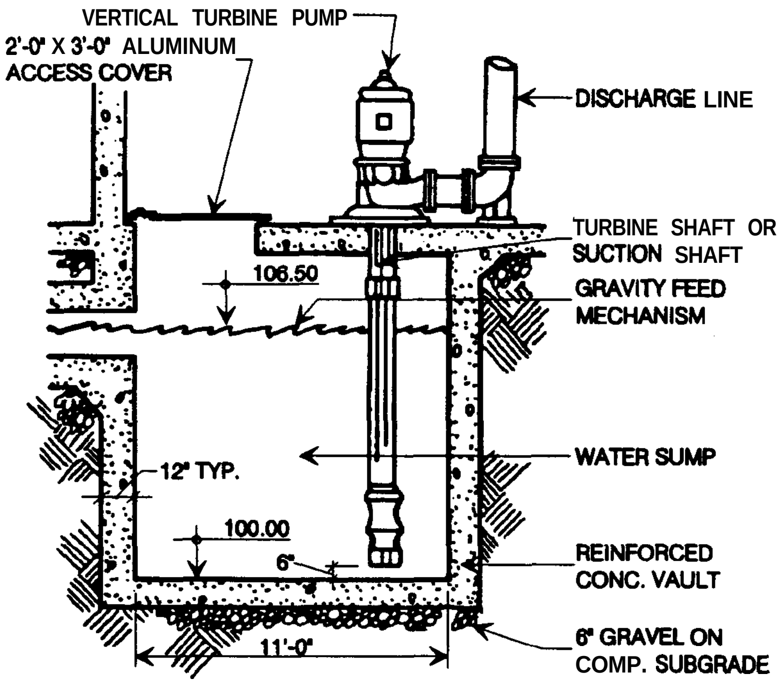
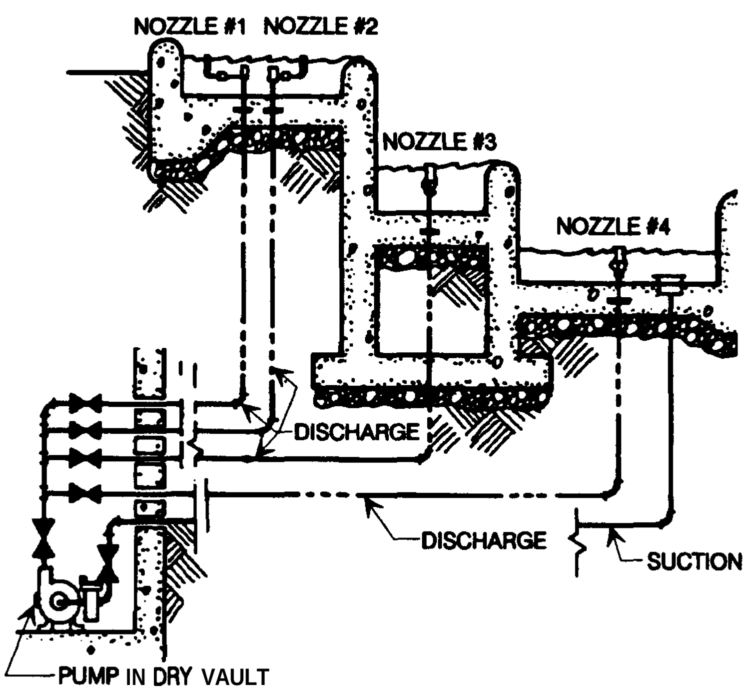


VERTICAL TURBINE PUMP



DRY CENTRIFUGAL PUMP

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL PUMPING SYSTEMS FOR FOUNTAINS		
FOUNTAINS AND POOLS (CSI 02820)	Revision No.	Issue Date 5/93	Drawing No. A1205-1

DEFICIENCY FACTORS
0.12.05 FOUNTAINS & POOLS (CSI 02776)

PROBABLE FAILURE POINTS

- Fountain and/or pool liner deterioration.
- Pump failure.
- Lack of curing will increase the degree of cracking within a concrete structure
- The weathering processes that can cause cracking include 1) freezing and thawing, 2) wetting and drying, and 3) heating and cooling.
- A number of deleterious chemical reactions may result in concrete cracks. These reactions may be due to the aggregate used to make the concrete or materials that come into contact with it after it has hardened.
- A wide variety of poor construction practices can result in cracking.

SYSTEM ASSEMBLIES/DEFICIENCIES

Spatting:	Concrete fragments broken from the surface, caused by reinforcement corrosion.
Exposed Reinforcing:	Insufficient steel cover. Concrete quality. Calcium chloride overused as admixture.
Cavitation:	Rapid movement of water or other liquids across the surface.
Staining:	Surface discoloration from a foreign substance or material.
Efflorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Plant Growth Moss, Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Cracks:	Caused by foundation/footing settlement.
Impact Damage:	Depressions, dents, or buckled surface from objects striking or impacting the surface.

DEFICIENCY FACTORS
0.12.05 FOUNTAINS & POOLS (CSI 02776)

END OF SUBSECTION

0.12.06 SECURITY GATES & FENCES (CSI 02830)

DESCRIPTION

Fences are used for a variety of purposes. Chain-link fences are typically used for security fencing, serve as a physical demarcation of a security area and obstruct illegal entry. Chain-link fencing consists of steel mesh fabric, gates, posts, rails and braces, and accessories. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fabric (CSI 02830)

Wire fabric is typically 11 gauge galvanized steel mesh with openings not larger than 2 inches.

Tvpes of Wire Fabric:

I Zinc-coated steel
II Aluminum-coated steel
III Aluminum-coated alloy
IV Polyvinyl Chloride (PVC) coated over Zinc- or Aluminum-coated steel

Fences (CSI 02830)

Fence construction has several major components: support framework including post rails and braces, fabric wire, gates (manual and powered), security components (eg., barbed, razor, and concertina) placed at top. Additionally, high security area fencing may be electrical or attached to a remote monitoring station used to prevent and/or detect possible illegal intrusion into security zones. Overall fence height, excluding barbed wire topping, usually exceeds 7 feet, but may vary in height when enclosing less critical sites.

Gates (CSI 02830)

Gates are the movable portion of the fencing used to control vehicle and pedestrian traffic. Typically motorized gates are used for vehicle access points; they are designed to operate manually during power outages. To operate normally, electrical continuity must be maintained across all gate openings. Gates are fabricated of the same materials and finishes as the fence framework. Generally, fabric for gates is the same as fabric for fences. Gates may be single leaf or double leaf, hinged, or sliding.

Types of Chainlink Fence Gates:

I Single Swing
II Double Swing
III Single Cantilever Sliding
IV Double Cantilever Sliding
V Single Overhead Sliding
VI Double Overhead Sliding
VII Vertical Lift

Mesh Size in Inches:

1 inch (9 & 11 wire gauge size only)
1 3/4 inch
2 inch
2 1/2 inch

Wire Gauae Sizes:

11 Gauge = 0.120 inch
9 Gauge = 0.146 inch
6 Gauge = 0.192 inch

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Gates (CSI 02830) (Continued)

Fabric Heiaht in Inches & Feet:

36 inches - 3 feet
42 inches - 3 1/2 feet
48 inches - 4 feet
60 inches - 5 feet
72 inches - 6 feet
84 inches - 7 feet
96 inches - 8 feet
120 inches - 10 feet
144 inches - 12 feet

Posts, Rails, & Braces (CSI 02830)

Posts, rails, and braces provide structural integrity and support fencing fabric and gates. Chain-link fencing is typically fastened to pipe type posts, rails, and bracing. Pipe specification include:

Class 1 - Steel Pipe:

- Grade A - Hot-dip zinc-coated after fabrication with 1.8 ounces of zinc per square foot of coated surface area.
- Grade B - Hot-dip zinc-coated with 0.9 ounces of zinc per square foot of external coated surface area. The interior surface is hot-dip zinc-coated or zinc rich painted to a minimum thickness of three mils.

Size - Outside diameter multiplied bv (x) minimum wall thickness in inches:

SP1- 1.1600Dx0.111
SP2 - 1.900 OD x 0.120
SP3 - 2.375 OD x 0.130
SP4 - 2.875 OD x 0.160
SP5 - 4.000 OD x 0.226
SP6 - 6.625 OD x 0.280
SP7 - 8.625 OD x 0.322

Class 2 - Aluminum Pipe:

Size - Outside diameter in inches x weiaht per foot of lenath (lb/ft):

AP1- 1.629 OD x 0.786 lb/ft
AP2 - 1.869 OD x 0.940 lb/ft
AP3 - 2.351 OD x 1.264 lb/ft
AP4 - 2.846 OD x 2.004 lb/ft
AP5 - 3.960 OD x 3.151 lb/ft
AP6 - 6.559 OD x 6.564 lb/ft
AP7 - 8.625 OD x 9.878 lb/ft

Class 3 - Formed Steel Sections:

Size - Outside dimensions in inches x weiaht per foot of lenath (lb/ft):
FS1- 1.625 by 1.250 x 1.35 lb/ft
FS2 - 1.875 by 1.625 x 2.40 lb/ft
FS3 - 2.250 by 1.700 x 2.78 lb/ft
FS4 - 3.500 by 3.500 x 5.10 lb/ft

Class 4 - Steel H-Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

SH1- 2.25 by 1.70 x 3.43 lb/ft

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Posts, Rails, & Braces (CSI 02830) (Continued)

Class 5 - Aluminum H-Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

AH1 - 1.875 by 1.565 x 0.91 lb/ft
AH2 - 2.250 by 2.000 x 1.22 lb/ft

Class 6 - Steel Square Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

SS1 - 2.00 by 2.00 x 2.60 lb/ft
SS2 - 2.50 by 2.50 x 5.10 lb/ft

Class 7 - Aluminum Square Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

AS1 - 2.50 by 2.50 x 1.25 lb/ft
AS2 - 3.00 by 3.00 x 1.40 lb/ft
AS3 - 3.00 by 3.00 x 2.45 lb/ft

Posts must be compatible with fence heights and are typically concreted in place. “Terminal Posts” refers to end, corner, and pull posts. “Line Posts” are vertical posts installed between terminal posts, and “Gate Posts” refers to posts supporting the weight of the gates.

TABLE ONE
Posts of class 1 steel pipe, grades A and B

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	SP3
	over 6 ft	SP4
Line	up to 6 ft	SP2
	up to 8 ft	SP3
	over 8 ft	SP4
	Gate Leaf Widths	
Gate	up to 6 ft	SP4
	up to 13 ft	SP5
	up to 18 ft	SP6
	up to 23 ft	SP7

TABLE TWO
Posts of class 2 aluminum pipe

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	AP3
Line	up to 6 ft	AP2
	up to 8 ft	AP3
	Gate Leaf Widths	
Gate	up to 13 ft	AP5
	up to 18ft	AP6
	up to 23 ft	AP7

TABLE THREE
Posts of class 3 formed steel section

Post Type	Fabric Heights	Size
Line	up to 8 ft	FS2
Terminal	over 8 ft	FS3
	All Heights	FS4

TABLE FOUR
Posts of class 4 steel H-section

Post Type	Fabric Heights	Size
Line	All Heights	SH1

TABLE FIVE
Posts of class 5 aluminum H-section

Post Type	Fabric Heights	Size
Line	All Heights	AH2

TABLE SIX
Posts of class 6 steel square section

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	SS1
	over 6 ft	SS2
	Gate Leaf Widths	
Gate	up to 6 ft	ss2

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Posts, Rails, & Braces (CSI 02830) (Continued)

TABLE SEVEN
Posts of class 7 aluminum square section

Post Type	Fabric Heights	Size
Terminal	up to 6 ft over 6 ft	AS1 AS3
	Gate Leaf Widths	
Gate	up to 6 ft	AS2

Braces are provided for gate posts and each terminal post, and double bracing is used when fabric height is greater than 9 feet.

Posts, braces, and other structural members are located on the inside of the secured perimeter. Once in place, all hardware is peened over or spot welded to prevent easy removal.

Accessories (CSI 02830)

Rail caps are used on the exposed ends of post to exclude moisture. Caps have a ring or hole for the passage of the top rail. Caps are typically formed steel or aluminum alloy.

Rail and brace ends are used on the ends of top and bottom rails and braces to exclude moisture and provide for post anchoring. Rail and brace ends are typically formed steel or aluminum alloy.

Rail sleeves are used to allow for expansion and contraction of the rails and are made of the same material.

Wire ties and clips are used to attach the fabric to the line posts, top and bottom rails, or tension wires. When attaching fabric to line posts, spacing should not be greater than 15 inches. When attaching to rails or tension wire, the spacing shall not exceed 24 inches. Wire ties and clips should be the same size and material as the fabric.

Brace and tension bands are used to secure rail and brace ends to terminal posts and tension bars with fabric to terminal posts. Spacing of tension bands are at 15 inch intervals or less. Brace and tension bands are typically made of steel.

Tension bars are used where the fabric meets the terminal posts. Tension bars are threaded through the fabric and attached to the terminal posts with tension bands. Tension bars are made of steel and of a continuous length compatible with the height of the fence.

Tension wire is used at the bottom of the fence to provide rigidity.

Truss rods are installed diagonally with the brace; they have adjustable turnbuckles to maintain the proper tension.

Barbed wire is installed across the top of the fencing, typically with 4 point barbs at spacings of 3 or 5 inches. Fencing is usually topped by three or more strands of barbed wire mounted on single or double arms. Barbed wire, as with fabric, may be galvanized or aluminized finish for steel, and mill-finished aluminum. Aluminum barbed wire is furnished with solid aluminum barbs. Barb tape coils are being used with increased frequency for high-security or detention facilities. Coils have razor-sharp barbs and are far more effective as a deterrent (both physical and psychological) than barbed wire (should conform to DOE/Federal Security Requirements). Grounding and security contact points for electrified fences are provided from power feeds (usually underground).

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Accessories (CSI 02830) (Continued)

Barbed wire arms may be attached to or be an integral part of the line post caps. Typical arms are:

- Single vertical
- Single 45-degree
- Vee-type with two arms at 45 degrees to vertical

Bolts, nuts, and washers are galvanized steel or aluminum alloy.

OTHER RELATED COMPONENTS

Refer to Exterior Closures, Volume 4, for additional deficiencies that may impact this system.

0.12.08 SECURITY GATES & FENCES (CSI 02830)

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DEFICIENCY FACTORS
0.12.06 SECURITY GATES **&** FENCES (CSI 02830)

PROBABLE FAILURE POINTS

- Gate sagging and misalignment caused by insufficient gate post bracing, loose mounting hardware, loose or broken gate members caused by vehicular impact.
- Fabric sagging caused by insufficient bracing, improper installation, loose or missing tie wires.
- Fence post leaning caused by poor footing, broken post, improper installation.
- Washout under fencing caused by soil erosion.
- Corrosion of structural members, fabric, and accessories due to weathering.
- Loose, missing, or broken accessories caused by improper installation, vehicular impact, or weathering.

SYSTEM ASSEMBLY/DEFICIENCIES

Fa **bric**

Fabric Sagging:	Insufficient bracing, loose or missing tie wires, missing/broken rail or tension wire, or improper installation.
Fabric Split, Torn:	Vehicular impact, vandalism, improper wire size, or improper installation.
Corrosion:	Breaks in protective coating allowing moisture to get at base metal, or use of improper materials.

Gates

Gate Sagging, or Misaligned:	Loose or broken mounting hardware, broken structural members on gate, gate post leaning due to insufficient bracing, or damage caused by vehicular impact.
Gate Doesn't or is Hard to Open, Close:	Swinging gate; loose or broken mounting hardware, lack of lubrication on hinges.
Binding:	Insufficient bracing or loose/broken structural members.
Sliding, Lifting Gate:	Loose or broken mounting hardware, lack of lubrication of rollers, obstruction in track, loose or broken structural members, binding caused by insufficient bracing.
Malfunctioning, Electrically Operated Gate:	Operator missing, broken, or out-of-adjustment.
Gate Opens Too Far:	Gate stop broken or missing, electrical operator out of adjustment.
Gate Swings Back When Opened:	Gate keeper missing or broken.
Gate Corroded:	Protective coating missing or damaged, improper materials used.

DEFICIENCY FACTORS
0.12.06 SECURITY GATES & FENCES (CSI 02830)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Posts, Rails, & Braces

Posts Broken:	Vehicular impact, improper size piping.
Posts Leaning:	Vehicular impact, inadequate foundation size, excessive tension, insufficient bracing, or improper installation.
Rail Sagging:	Missing or broken wire ties, rail sleeves broken, missing, or broken caps.
Braces Loose:	Insufficient tension, missing or broken truss rod, or missing or broken tie wires.
Corrosion:	Protective coating missing or damaged, improper materials used.

Accessories

Corrosion:	Protective coating missing or damaged, improper materials used.

END OF SUBSECTION

DEFICIENCY FACTORS
0.12.04.01 TRACKWORK **(CSI 02450)**

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DEFICIENCY FACTORS
0.12.04.01 TRACKWORK (CSI 02450)

END OF SUBSECTION

0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

DESCRIPTION

The typical railway electrical signal system is a complex assembly used for the operation of a relatively automatic, “fail-safe” train control system. This signal system is designed to accommodate numerous factors that include size and quantity of rail units handled. This section addresses the more common components found in most systems. This section does not address actual operation of the railway electrical signal system.

Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

RAILWAY ELECTRICAL SIGNAL SYSTEM EQUIPMENT

Types of equipment found in typical railway electrical signal systems include but are not limited to the following:

- Conductors & Fittings
- Disconnects
- Luminaires
- Signal Circuits
- Switch Heater
- Switch Machine
- Transformers

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Conductors & Flfflngt (CSI 16120)

Conductors and fittings employed in railway electrical signal systems normally involve use of the rails as well as insulated conductors and bonding conductor. The rails are designed and fabricated to carry loads in addition to serving as an electrical conductor. Most insulated conductors are used for control wiring. Bonding wires are special applications of conductors welded to the web or head of the rail to ensure electrical conductivity across bolted rail joints or at various turnout components.

Disconnects (CSI 16440)

A device used to disconnect a load from a source or generate a signal such as a relay. In rail systems this disconnect may be in the form of an auxiliary device to a track switch used to alter track paths. Such auxiliaries would include trip stop switches. A relay is an electro-mechanical device that opens and closes contacts in an electrical system. One of the more common uses in a railway electrical signal system is control of luminaires of block signaling systems. The relays may be described also as track, A-C track, and rotor type A-C.

Lumlnalres (CSI 16520)

Lighting devices (signal heads or signal lamps) used to provide a visual signal of stop and go track conditions for rail equipment and to provide a visual stop signal for track crossings by personnel and non-track equipment.

Signal Systems

Signal systems consist of signal heads, wire, cable, conduit, rail joint bonds, relay cases, rail trips, compressed air piping, bootleg boxes, timers, and track switch machine interlocking.

Switch Heater (CSI 16850)

A device that prevents freeze-up, due to inclement weather, of switching devices used in the control of rolling stock.

0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

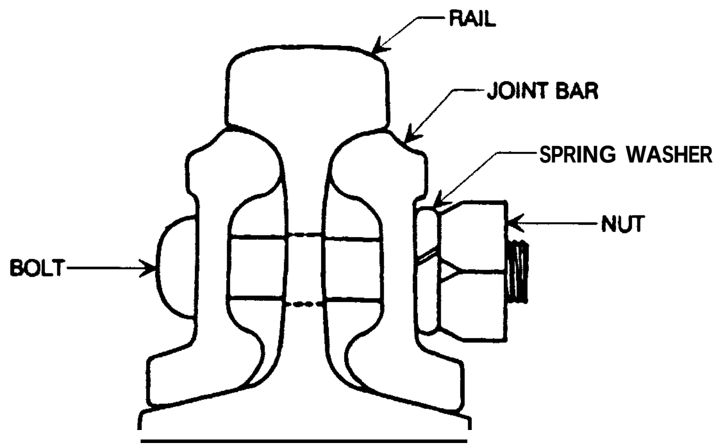
ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Switch Machine

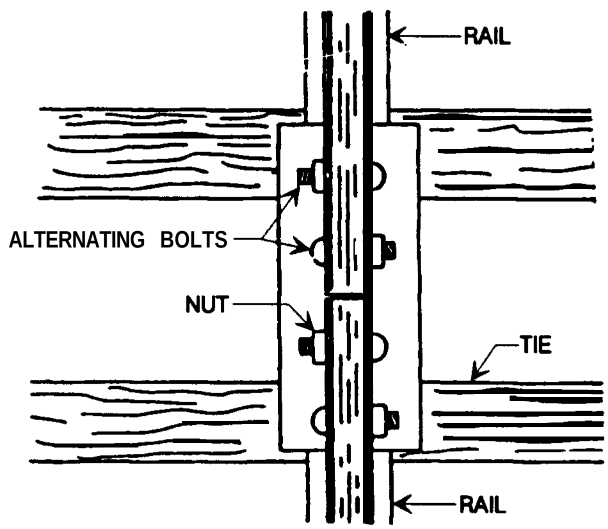
A switch machine is an electromechanical device that operates the turnout switch points via a connecting rod.

Transformers (CSI 16460)

A device that steps down, steps up, limits or isolates AC voltages and currents. The transformer(s) provide the necessary electrical energy for operation of the railway electrical signal system to include luminaires. Reactors are a special device used to provide an impedance in the railway electrical signal system to limit current flow. Reactors are key elements to ensure adequate electrical energy for pickup and dropout of control relays.



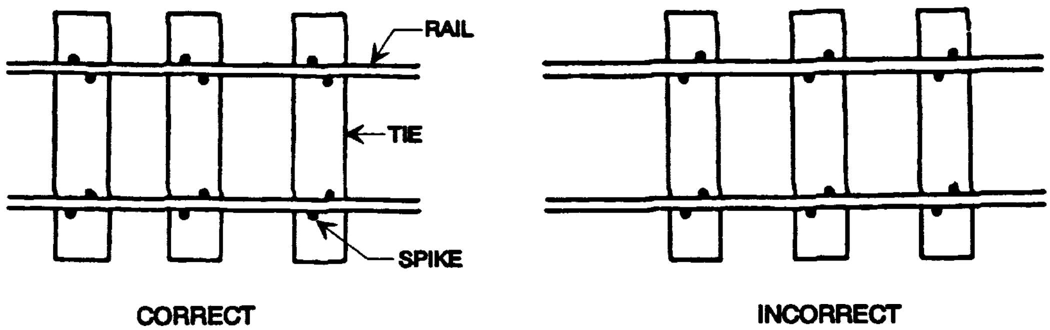
SECTION



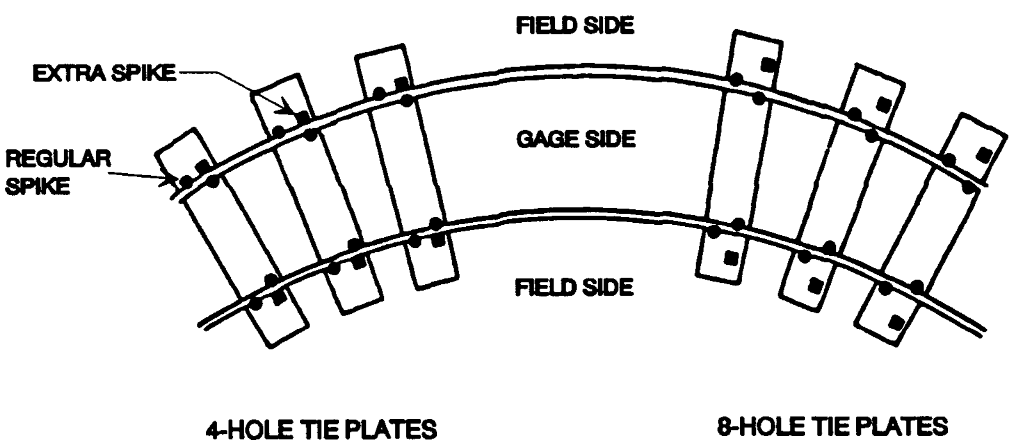
PLAN VIEW

PROPER BOLT INSTALLATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-1

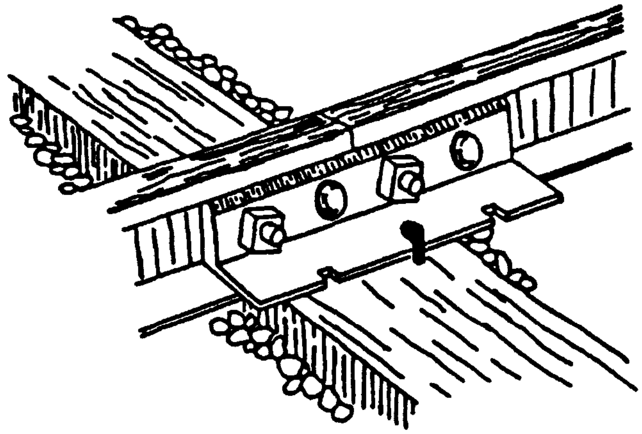


SPIKING PATTERN FOR TANGENTS AND CURVES LESS THAN 4 DEGREES

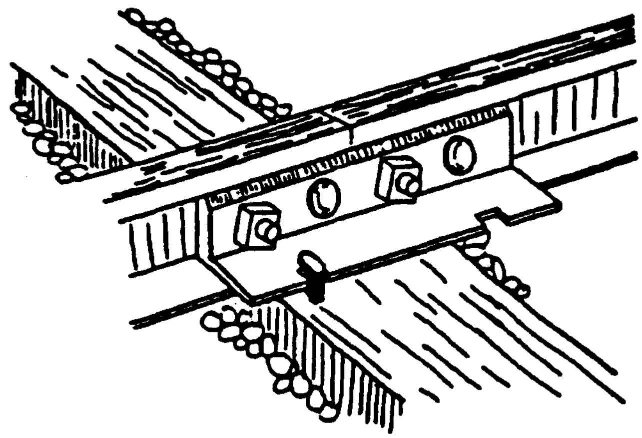


SPIKING PATTERN FOR CURVES 4 DEGRESS AND GREATER

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-2

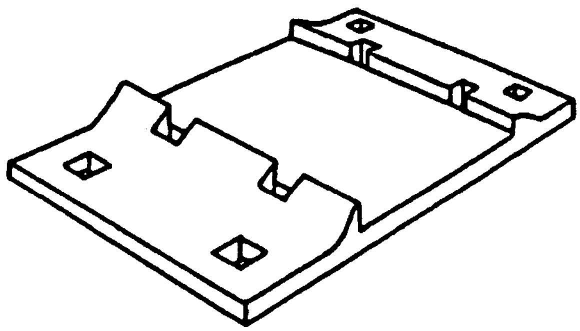


CORRECT

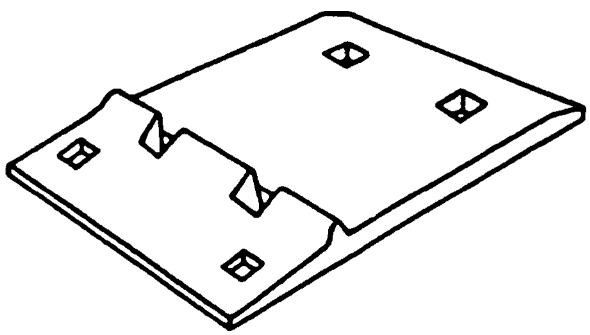


INCORRECT

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	issue Date 5/93	Drawing No. A120401-3

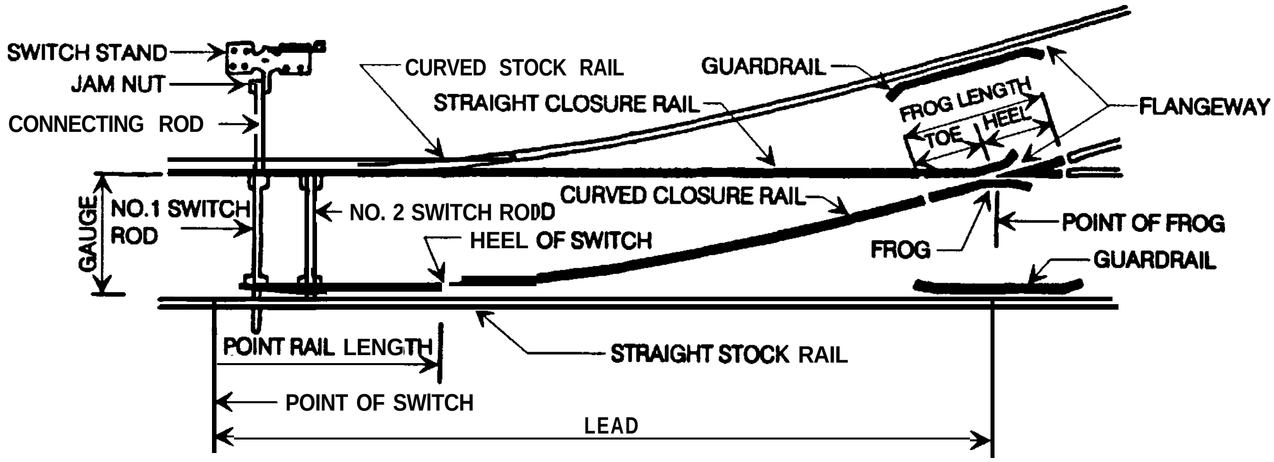


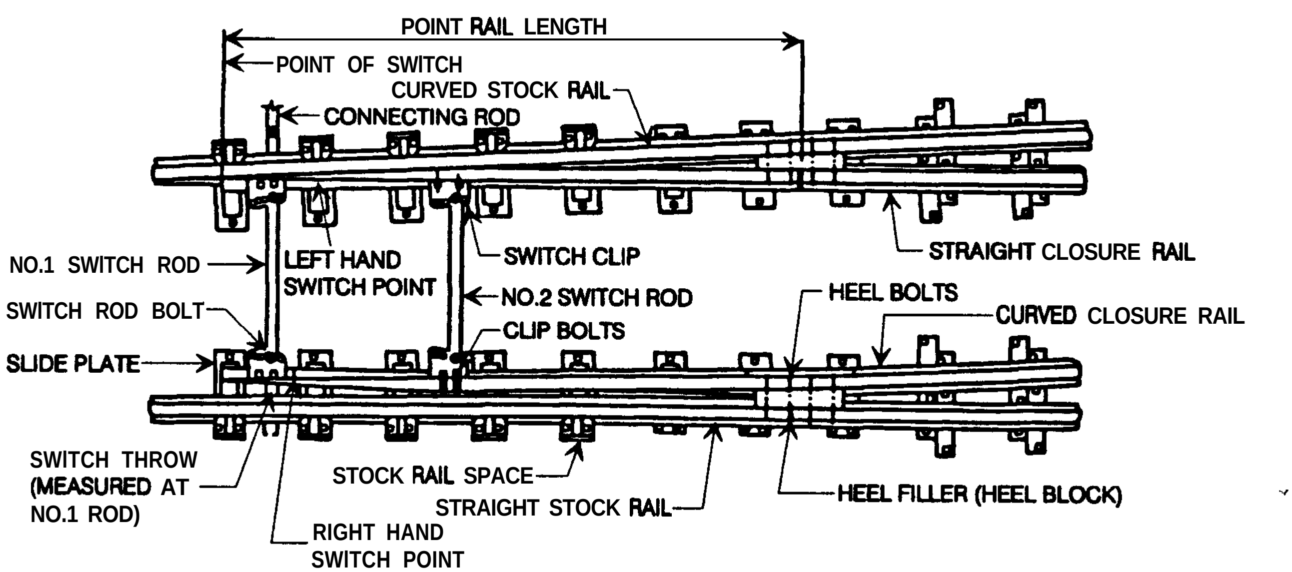
DOUBLE SHOULDER TIE PLATE



SINGLE SHOULDER TIE PLATE

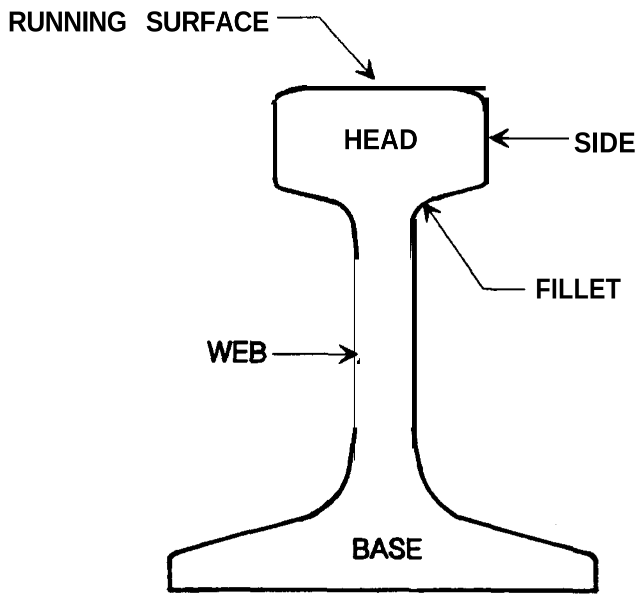
SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-4





PARTS OF A TURNOUT

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL RAIL COMPONENTS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-5

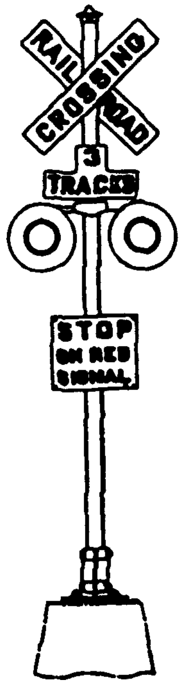


SYSTEM ASSEMBLY DETAILS-SITEWORK	RAIL STRUCTURE		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120401-6

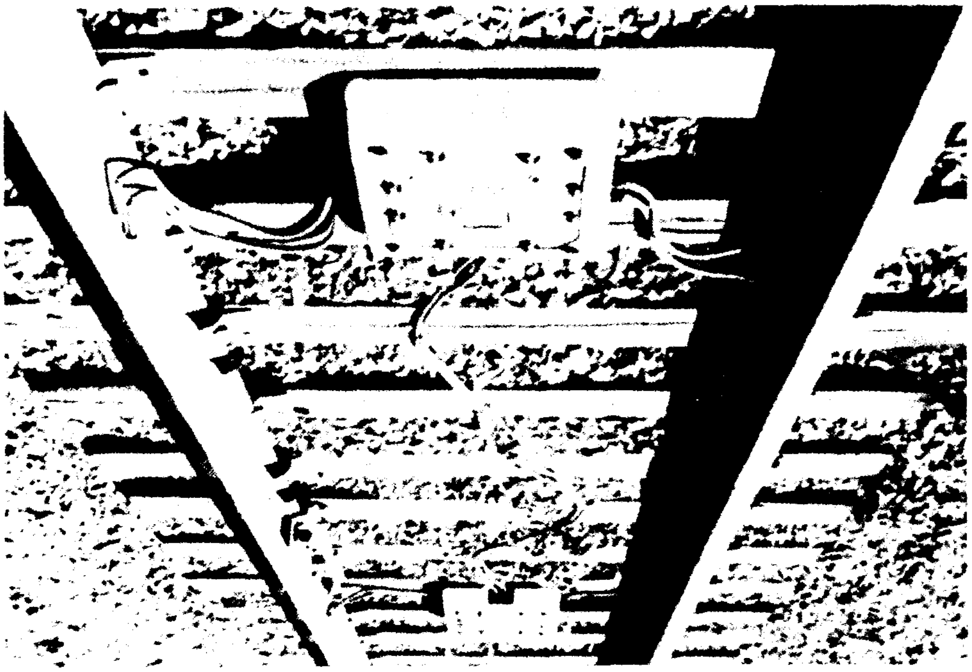
50-DEGREE SIGN

90-DEGREE SIGN

SYSTEM ASSEMBLY DETAILS-SITEWORK	HIGHWAY CROSSING SIGNS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	issue Date 5/93	Drawing No. A120401-7



SYSTEM ASSEMBLY DETAILS-SITEWORK	HIGHWAY CROSSING SIGNS		
RAILWAYS TRACKWORK (CSI 14900)	Revision No.	Issua Date 5/93	Drawing No. A120401-8



SYSTEM ASSEMBLY DETAILS-SITEWORK	IMPEDANCE BOND		
RAILWAYS SIGNALS AND COMMUNICATIONS (CSI 14900)	Revision No.	Issue Date 5/93	Drawing No. A120402-1

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

PROBABLE FAILURE POINTS

- Ballast Resistance - Exceeds minimum or maximum value.
- Broken Rail - Non-bonded joint or broken bond wire.
- Flood Detector - Motion inhibited by flora.
- Insulated Joints - Shorted
- Luminaire/Signal Lamp - Inoperative
- Switch Heater - inoperative
- Switch Machine - Inoperative
- Track Relay - Inoperative
- Unused Track - Oxide inhibition/high impedance

SYSTEM ASSEMBLIES/DEFICIENCIES

Conductors & Fittings

Improper Cable/Conductor:

Ampacity not properly rated.
Bimetallic connectors not used as required.
Broken wire strands.
Burned, melted, discolored conductor material.
Defective or deficient cable/conductor penetrations.
High splice temperature.
Improper bending radius.
Improper insulation Voltage.
Improper splice materials used.
Improper termination.
Improper trench.
Improperly made splice.
Inappropriate for application.
Insulation inappropriate for application.
Insulation improperly removed.
Insulation is burned, charred, discolored, or other physical damage.
Insulation resistance less than one megOhm per each kiloVolt of rating.
Insulation unraveled, frayed, brittle, or other physical damage.
Nicked or ringed conductor.
Not properly bundled or trained.
Not properly connected to device.
Not properly derated for installation.
Not properly supported.
Not protected physically.
Unauthorized splice.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Conductors & Fittings (Continued)

Improper Fitting/Device:	Exposed conductors. Improper for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Disconnects

Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Heater:	Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative heater element. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.
Defective Pressure Relief:	High internal pressure. No internal pressure.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension. inadequately torqued at termination. inappropriate for application. Inconsistent time delays.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Disconnects

Improper Control Wiring (Continued):	Incorrect overcurrent protection. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. Insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
improper Disconnect:	Adjustable settings misadjusted. Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage. Contacts bent or not aligned. Defective phase barriers. Does not sustain rated current per NEMA AB4-1991. Does not trip on instantaneous overcurrent per NFPA 708. Handle broken, bent, or other physical deformity. High conductor, lug temperature. High contact resistance. Improper application. improper switch time. Improperly sized. Improperly wired. Interlock broken, missing, or inoperative. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. No engineering study to support adjustable settings. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Series trip device missing, broken, or inoperative. Shunt trip device missing, broken, or inoperative. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored. Terminals, contact blocks, bus bar and connectors loose, burned, or discolored. Time-delay overcurrent trip not per manufacturer's specifications.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI **16700**)

SYSTEM **ASSEMBLIES/DEFICIENCIES**

Disconnects

Improper Disconnect (Continued):	UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, misaligned, or other physical deformity. Not secured to mounting surface. Insufficient work space. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Oil leaks. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Improper Fuse Unit:	Fuse clips bent, malaligned, discolored, or other physical damage. Improper fuse type used. Improperly sized. Poor fuse to clip contact. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
Improper Insulating Liquid:	Contaminated internal device. Low insulation resistance. Low liquid level. Oil does not meet criteria of NFPA 708. Pressure leak.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Protective Relay:	Cover loose, missing, broken, chipped, cracked, or other physical damage. Current, Voltage, and time pick-up/drop-out values not per manufacturer's specifications. Housing chipped, cracked, broken, or other physical damage. Improper application. Improperly wired. Inoperative. Malcalibrated.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Disconnects

Improper Protective Relay (Continued):	Missing and/or out-of-date calibration tag. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. Not clean and moisture-free. Not secured to mounting surface. No engineering study to support adjustable setting. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored.
Inaccurate Metering:	Terminals loose, broken, missing, burned, discolored, or corroded. Calibration standard not established. Defective or inoperative sensor or transducer. Metering device inadequately sized. Metering device not calibrated.
Improper Mount:	Device not secured to mount. Device mounting surface chipped, cracked, broken, or other physical damage. Dirty, oily, greasy, or other surface contamination. Mounting structure inadequate. Mounting structure not secured to mounting surface. Not aligned.

Lighting

Defective Ballast:	Corroded, rusted, dented, or other physical damage. Defective capacitor. Dirty, oily, greasy, or other surface contamination. Improper and/or inadequate line voltage. Inappropriate for application. Inoperative thermal protector. inoperative. Missing. Noisy. Not adequately secured. Not properly grounded. Oil leakage. Transformer coils discolored, burned, or other signs of high temperature.
Defective Battery Charger:	Abnormal output. Corroded, rusted, dented, or other physical damage. Inappropriate for application. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Indicator meter inoperative or missing. Inoperative.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Defective Battery Charger (Continued):	Noisy. Not adequately secured. Not clean and moisture-free. Test switch inoperative or missing. Top, bottom, or side cover missing.
Defective Battery/Application:	Corroded terminal. Cracked case. Flame arrestor missing or broken. Improper liquid level. Inoperative. Insufficient ampacity. Liquid leakage. No emergency shower readily available. No eyewash readily available. No protective personnel gear available. Not properly marked. Not properly ventilated. Not securely attached to mounting surface. Overcharged. Pressure release vent inoperative. Rack(s) unstable, uneven, or inaccessible. Undercharged. Ventilation obstructed or clogged.
Defective Control Module:	Circuit boards improperly installed and/or connected Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Dimmer Switch:	Dirty, oily, greasy, or other surface contamination. Discolored, burned, or other signs of high temperature. Inadequate capacity. Inoperative. Missing, cracked, or broken components. Noisy. Not adequately secured. Not properly grounded.
Defective Fixture Hanger:	Inappropriate for application. Missing, broken, corroded, or other physical damage. Not adequately secured to mounting surface.
Defective Fixture Wiring:	Bundled or trained inappropriately. Improper splice. Inadequately torqued at termination. Inappropriate for application.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Defective Fixture Wiring (Continued):	Insulation charred, burned, or discolored. insulation improperly removed from conductor. Insulation less than one megohm per each kiloVolt of rating. Insulation nicked, cut, cracked, or other physical damage. Splice(s) improperly insulated. Unauthorized splice.
Defective Globe:	Dirty, oily, greasy, or other surface contamination. Inappropriate for application or location. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Lamp:	Blackening at end of arc tube. Broken or cracked arc tube. Dirty, oily, greasy, or other surface contamination. Ignitor inappropriate for application. Ignitor inoperative. Improper burning position. Inadequate base to socket contact pressure. Inappropriate for application. Inoperative. Low light output level. Missing, cracked, chipped, or other damage.
Defective Lens:	Dirty, oily, greasy, or other surface contamination. Inappropriate for application. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Reflector:	Dirty, oil, greasy, or other surface contamination. Inappropriate for application. Missing, cracked, chipped, or other damage. Not adequately secured.
Defective Safety Guard:	Inappropriate for application. Not adequately secured. Missing, broken, or other damage.
Defective Socket:	Dirty, oily, greasy, or other surface contamination. Inadequate socket contact pressure. Inadequate termination. Missing, cracked, chipped, or other damage. Not adequately secured. Pitted, burned, or discolored.
Improper Housing:	Corroded, rusted, dented, or other physical damage. Enclosure not secured to mounting surface. Missing. Not accessible. Not adequate for application or location. Not clean and moisture-free. Not grounded properly.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS **(CSI 16700)**

SYSTEM ASSEMBLIES/DEFICIENCIES

Lighting

Improper Housing (Continued):	Not securely attached to mounting surface. Top, bottom, or side cover missing. Unused openings not covered or plugged. Vent defective or nonoperative. Ventilation obstructed or clogged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Signal Circuits

Deficient Penetration:	Approved seals not used in boundaries.
Improper Cable/Conductor:	Ampacity not properly rated. Bimetallic connectors not used as required. Broken wire strands. Burned, melted, discolored conductor material. Defective or deficient cable/conductor penetrations. High splice temperature. Improper bending radius. Improper insulation voltage. Improper splice materials used. Improper termination. Improper trench. Improperly made splice. Inappropriate for application. Insulation inappropriate for application. Insulation improperly removed. Insulation is burned, charred, discolored, or other physical damage. Insulation resistance less than one megOhm per each kiloVolt of rating. Insulation unraveled, frayed, brittle, or other physical damage. Nicked or ringed conductor. Not properly bundled or trained. Not properly connected to device. Not properly derated for installation. Not properly supported. Not protected physically. Unauthorized splice.
Improper Fitting:	Exposed conductors. Improper fitting for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Signal Circuits (Continued)

Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Overcurrent Device:	Interchangeable devices used in signal circuits. No engineering study for adjustable settings. Not of proper size. Not properly located for signal circuit application. Overcurrent device exceeds 167 percent of signal circuit source rating. Signal circuit conductors less than 14AWG not properly protected.
improper Power Supply:	Not durably marked for class and rating. Parallel connection of unlisted power supplies.
Improper Rating:	Maximum non-transformer source output exceeds 2500 Volt-Amperes. System exceeds 30 Volts and 1000 Volt-Amperes to load.
Defective Crossing Signals:	Crossing arm broken or missing. Inoperable. Signals do not reset properly after actuation. Signals do not actuate properly. Warning bell missing or inoperable.

Switch **Heater**

Defective Heater:	Damaged. Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative. Not energized. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.
Improper Cable/Conductor:	Ampacity not properly rated. Bimetallic connectors not used as required. Broken wire strands. Burned, melted, discolored conductor material. Defective or deficient cable/conductor penetrations. High splice temperature. Improper bending radius. Improper insulation voltage. Improper splice materials used. Improper termination. Improper trench. Improperly made splice. Inappropriate for application. Insulation inappropriate for application. Insulation improperly removed.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Heater

Improper Cable/Conductor: (Continued)	Insulation resistance less than one megOhm per each kiloVolt of rating. Insulation is burned, charred, discolored, or other physical damage. Insulation unraveled, frayed, brittle, or other physical damage. Nicked or ringed conductor. Not properly bundled or trained. Not properly connected to device. Not properly derated for installation. Not properly supported. Not protected physically. Unauthorized splice.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pickup or dropout point. Improper termination. Inadequate fuse/connection tension. Inadequately torqued at termination. Inappropriate for application. Inconsistent time delays. Incorrect fuse installed. Indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
Improper Disconnect:	Adjustable settings misadjusted. Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage. Contacts bent or not aligned. Defective phase barriers. Does not sustain rated current per NEMA AB4-1991. Does not trip on instantaneous overcurrent per NFPA 70B. Handle broken, bent, or other physical deformity. High conductor, lug temperature. High contact resistance. Improper application. Improper switch time.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Heater

Improper Disconnect (Continued):	Interlock broken, missing, or inoperative. Improperly sized. Improperly wired. Movable contacts bent, malaligned, or other physical deformity. Movable contacts pitted, burned, or discolored. No engineering study to support adjustable settings. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Series trip device missing, broken, or inoperative. Shunt trip device missing, broken, or inoperative. Stationary contacts bent, malaligned, or other physical deformity. Stationary contacts pitted, burned, or discolored. Terminals, contact blocks, bus bar, and connectors loose, burned, or discolored. Time-delay overcurrent trip not per manufacturer's specifications. UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Not secured to mounting surface. Interlock broken, missing, or inoperative. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Oil leaks. Pedestal mounting surface chipped, broken, or other physical damage. Unused openings not covered or plugged. Vent defective or nonoperative. Ventilation obstructed.
Improper Equipment Protection:	Improper or inadequate primary protection device. Improper or inadequate secondary protection device. Improper or inadequate differential protection device. No engineering study to support protection scheme.
improper Installation:	Conductor or cable not appropriate for installation. Conductor or cable not listed. Conductors not trained or bundled for ventilation.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM **ASSEMBLIES/DEFICIENCIES**

Switch Heater

Improper Installation (Continued):	Hanger not adequately secured to structure. Improper joint. Inadequate grounding. Inadequate ventilation. Missing vertical run hardware. No bushing or equivalent protection. Not adequately protected from severe physical damage. Not adequately secured to mounting surface. Not appropriate for location, Not clearly and permanently marked where required. Not properly spaced from combustible materials. Not secured within three feet of end of run. Unauthorized conductor present. Unused openings not covered or plugged.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.

Switch **Machine**

Defective Bearings:	High temperature. Rough or irregular rotation. Leaking seals. Improper bearing. Noisy.
Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Contactor:	Arc suppression components broken, eroded, cracked, or missing. Broken strands in braided shunts. Coil discolored, burned, or other sign of high temperature. Coil inoperative at 85% of rated Voltage. Contact pressure not per manufacturer's specifications. Contacts burned, pitted, or other physical damage. Contacts not properly aligned. Control circuits improperly connected. Dash pot inoperative, broken, or missing. Device sticks magnetically. Drum contacts inadequately torqued. High contact resistance. Improper fluid in dash pot. Improper rolling action of drum contacts. Improper size. Indicator lamps inoperative.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS **(CSI 16700)**

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Defective Contactor (Continued):	Indicator lens missing, cracked, or broken. Missing, loose, broken, or corroded hardware. No engineering study to support thermal trip device rating. Noisy. Plugging relays dirty or other contamination. Pushbuttons not labeled. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts. Rheostat contact surface corroded, oxidized, uneven, or other physical defect. Rheostat holding coil missing or inoperative. Rheostat ventilation impeded. Terminals, contact blocks, bus bars, and connectors loose or discolored. Thermal trip device wrong size.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Pressure Relief:	High internal pressure. No internal pressure.
Defective Switch Machine:	Detector rod broken, missing, or out of adjustment. Inoperable. Loose or broken wiring. Operating rod broken, missing, or out of adjustment. Overloaded motor. Relays out of adjustment, pitted, or burned.
Improper Fitting:	Exposed conductors. Improper fitting for application. Insert broken, cracked, missing, or other damage. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, cracked, loose, or other damage. Unused openings not covered or plugged.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS **&** COMMUNICATIONS **(CSI** 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Improper Control Wiring (Continued):
- Inadequately torqued at termination.
- Inappropriate for application.
- Inconsistent time delays.
- Incorrect overcurrent protection.
- Indicator lamps inoperative.
- Indicator lens missing, cracked, or broken.
- Inoperative.
- Inoperative interlock.
- Insulation charred, burned, or discolored.
- Insulation improperly removed from conductor.
- No engineering study to support installed fuse.
- Splices improperly insulated.
- Terminal boards improperly installed.
- Unauthorized splice.

Improper Disconnect:
- Adjustable settings misadjusted.
- Arc suppression devices broken, cracked, missing, tracked, chipped, or other physical damage.
- Contacts bent or not aligned.
- Defective phase barriers.
- Does not sustain rated current per NEMA AB4-1991.
- Does not trip on instantaneous overcurrent per NFPA 70B.
- Handle broken, bent, or other physical deformity.
- High conductor, lug temperature.
- High contact resistance.
- Improper application.
- Improper switch time.
- Improperly sized.
- Improperly wired.
- Interlock broken, missing, or inoperative.
- Movable contacts bent, malaligned, or other physical deformity.
- Movable contacts pitted, burned, or discolored.
- No engineering study to support adjustable settings.
- Not accessible.
- Not adequate for application.
- Not clean and moisture-free.
- Not grounded properly.
- Not secured to mounting surface.
- Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
- Series trip device missing, broken, or inoperative.
- Shunt trip device missing, broken, or inoperative.
- Stationary contacts bent, malaligned, or other physical deformity.
- Stationary contacts pitted, burned, or discolored.
- Terminals, contact blocks, bus bar and connectors loose, burned, or discolored.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine

Improper Disconnect (Continued):	Time-delay overcurrent trip not per manufacturer's specifications. UnderVoltage trip missing, broken, maladjusted, or inoperative.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, misaligned, or other physical deformity. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible. Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Oil leaks. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Imoroper Equipment Protection:	Improper or inadequate primary overcurrent device. Improper or inadequate secondary overcurrent device. No engineering study to support protection scheme. Incorrect calibration of protective devices or sensors. Improper or inadequate differential protection. Time delay suppression devices missing, broken, or inoperative.
Improper Fuse Unit:	Fuse clips bent, malaligned, discolored, or other physical damage. Improper fuse type used. Improperly sized. Poor fuse to clip contact. Resistance less than one megOhm per each kiloVolt of rating between poles and/or from poles to non-energized parts.
Improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Improper Motor Application:	Inappropriate starting system. Improper motor size. Improper rotation. Improper speed. Improper connection of bimetallic elements. Improper winding connections.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Switch Machine (Continued)

Improper Mount:	Device not secured to mount. Device mounting surface chipped, cracked, broken, or other physical damage. Dirty, oily, greasy, or other surface contamination. Mounting structure inadequate. Mounting structure not secured to mounting surface. Not aligned.
Improper Rotor/Stator:	Bent, scored, or other damage to rotor shaft. Burned, charred, or other signs of high temperature. Damaged internal and/or external cooling fan. Noisy laminations. Non-uniform air gap. Open turns or coils. Shorted turns or coils. Splice insulation unraveled, brittle, cracked, or other damage. Unbalanced rotor assembly.

Transformers

Contaminated Transformer:	Contaminated coils and core.
Damaged Metering:	Device inoperative. Metering device broken or other physical damage. Tampering of metering device or circuit.
Defective Bushing/Insulator:	Cable clamp loose, missing, broken, corroded, burned, or other physical damage. Dirty, oily, greasy, or other surface contamination. Missing, cracked, chipped, or other damage. Not adequately secured. Oil leakage. Tracked or carbonized.
Defective Control Module:	Circuit boards improperly installed and/or connected. Inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, cracked, chipped, corroded, burned, or other damage to components and/or circuit boards. Not clean and moisture-free.
Defective Heater:	Heater not adequately secured to mounting surface. Improper conductors from source. Improper temperature in device enclosure. Inoperative heater element. Heater element resistance to ground less than one megOhm per each kiloVolt of rating. Sensing device broken, missing, or inoperative. Sensing device malcalibrated.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Transformers (Continued)

Defective Pressure Relief:	High internal pressure. No internal pressure.
Defective Transformer:	Cooling fans inoperative. Corona. Inadequate rating. Low insulation resistance. Low liquid level. Noisy. Pressure leak. Shorted or open coil or winding. Tap changer inoperative.
Defective Ventilation:	High operating temperature. Ventilation inlets clogged. Ventilation obstructed. Location not adequately ventilated.
Improper Control Wiring:	Bimetallic connectors not used as required. Bundled and trained inappropriately. Control circuits improperly connected. Control wiring insulation resistance less than one megOhm per each kiloVolt of rating. Improper sensor pick-up or drop-out point. Improper termination. Inadequate fuse/connection tension. Inadequately torqued at termination. Inappropriate for application. Inconsistent time delays. Incorrect overcurrent protection. indicator lamps inoperative. Indicator lens missing, cracked, or broken. Inoperative. Inoperative interlock. Insulation charred, burned, or discolored. Insulation improperly removed from conductor. No engineering study to support installed fuse. Splices improperly insulated. Terminal boards improperly installed. Unauthorized splice.
Improper Enclosure:	Corroded, rusted, dented, or other physical damage. Dirty, missing, or inappropriate filters. Gaskets missing, damaged, malaligned, or other physical deformity. Interlock broken, missing, or inoperative. Loose, broken, damaged, corroded, or missing fastening hardware. Missing, broken, damaged, or inoperative security device. No curbing or berm for oil containment. Not accessible.

DEFICIENCY FACTORS
0.12.04.02 SIGNALS & COMMUNICATIONS (CSI 16700)

SYSTEM ASSEMBLIES/DEFICIENCIES

Transformers

Improper Enclosure (Continued):	Not adequate for application. Not clean and moisture-free. Not grounded properly. Not secured to mounting surface. Oil leaks. Pedestal mounting surface chipped, broken, or other physical damage. Unused openings not covered or plugged. Ventilation openings defective, nonoperative, obstructed, or not properly guarded.
Improper Equipment Protection:	Improper or inadequate primary overcurrent device. Improper or inadequate secondary overcurrent device. No engineering study to support protection scheme. Incorrect calibration of protective devices or sensors. Improper or inadequate differential protection. Time delay suppression devices missing, broken, or inoperative.
Improper Insulating Liquid:	Contaminated internal device. Low insulation resistance. Low liquid level. Oil does not meet criteria of NFPA 70B. Pressure leak.
improper Marking:	Nameplate missing or illegible. Missing or insufficient data.
Inaccurate Metering:	Calibration standard not established. Defective or inoperative sensor or transducer. Metering device inadequately sized. Metering device not calibrated.

END OF SUBSECTION

0.12.05 FOUNTAINS & POOLS (CSI 02776)

DESCRIPTION

Fountains are artificially produced jet streams of water that enhance the characteristics of their surroundings; pools are usually a small and rather deep body of fresh water. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/COMPONENT

Fountains & Pools (CSI 02776)

In liner fabrication, one or more layers of fabric scrim, either nylon or polyester, may be laminated between two layers of sheet to produce a reinforce membrane. When a scrim is not used, the sheet is called unsupported or unreinforced.

A scrim helps reduce the amount of streaking, which improves the liner's dimensional stability. In addition, with scrim reinforcement, the liner resists punctures and tears and is able to vent trapped air and gas.

The scrim is often as important as the seam. Under some conditions, a scrim-reinforced sheet is essential. Where there is a high groundwater table or where soil decomposition produces methane gas, air or gas pockets can form under the liner. Under these conditions, scrim reinforcement is needed to prevent the liner from ballooning and to permit venting.

A good liner material must have the following properties:

- Weather resistance: must be resistant to ozone, oxygen, and ultraviolet light.
- Low temperature flexibility.
- Crack resistance.
- Abrasion resistance.
- The ability to produce strong field seams.
- Hypalon liners are flexible, resilient, and can conform to irregular as well as nominal shapes. As with any material, hypalon liners should be installed by experienced contractors. The ability to resist the effluent should be determined for each job.

<u>Liner Properties</u>:

Some advantages of liners are:

- Leakproof when properly installed.
- Flexible and resilient over a wide temperature range.
- Excellent aging and weathering characteristics (depending on liner material, application procedures, products contained).
- Resist mildew, mold, and fungus.
- Resist attack from a variety of chemicals.
- Accepted for use with potable water.

OTHER RELATED COMPONENTS

Refer to Foundations and Footings, Substructure, and Mechanical, Volumes 1, 2, and 8 for additional deficiencies that may impact this system.

0.12.05 FOUNTAINS & POOLS (CSI 02776)

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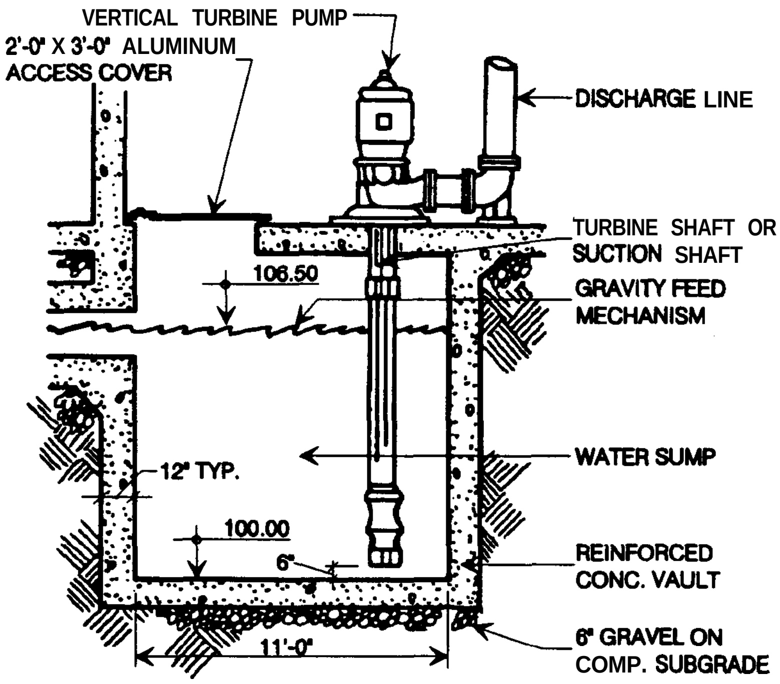
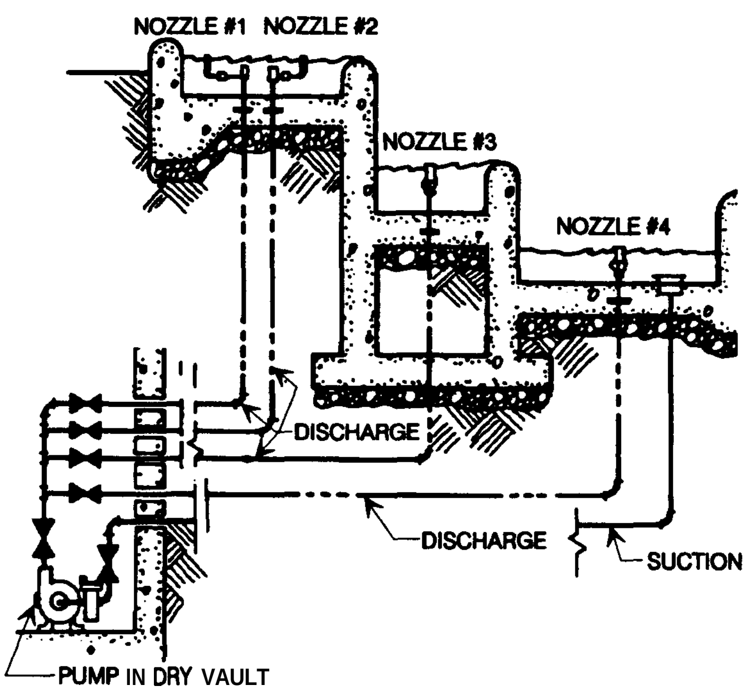


VERTICAL TURBINE PUMP



DRY CENTRIFUGAL PUMP

SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL PUMPING SYSTEMS FOR FOUNTAINS		
FOUNTAINS AND POOLS (CSI 02820)	Revision No.	Issue Date 5/93	Drawing No. A1205-1

DEFICIENCY FACTORS
0.12.05 FOUNTAINS & POOLS (CSI 02776)

PROBABLE FAILURE POINTS

- Fountain and/or pool liner deterioration.
- Pump failure.
- Lack of curing will increase the degree of cracking within a concrete structure
- The weathering processes that can cause cracking include 1) freezing and thawing, 2) wetting and drying, and 3) heating and cooling.
- A number of deleterious chemical reactions may result in concrete cracks. These reactions may be due to the aggregate used to make the concrete or materials that come into contact with it after it has hardened.
- A wide variety of poor construction practices can result in cracking.

SYSTEM ASSEMBLIES/DEFICIENCIES

Spatting:	Concrete fragments broken from the surface, caused by reinforcement corrosion.
Exposed Reinforcing:	Insufficient steel cover. Concrete quality. Calcium chloride overused as admixture.
Cavitation:	Rapid movement of water or other liquids across the surface.
Staining:	Surface discoloration from a foreign substance or material.
Efflorescence:	A whitish powdery deposit of soluble salts brought to the surface by moisture that leaves residue after evaporating.
Plant Growth Moss, Algae:	The growth of plant life such as moss or algae over the surface, usually from excessive moisture.
Cracks:	Caused by foundation/footing settlement.
Impact Damage:	Depressions, dents, or buckled surface from objects striking or impacting the surface.

DEFICIENCY FACTORS
0.12.05 FOUNTAINS & POOLS (CSI 02776)

END OF SUBSECTION

0.12.06 SECURITY GATES & FENCES (CSI 02830)

DESCRIPTION

Fences are used for a variety of purposes. Chain-link fences are typically used for security fencing, serve as a physical demarcation of a security area and obstruct illegal entry. Chain-link fencing consists of steel mesh fabric, gates, posts, rails and braces, and accessories. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fabric (CSI 02830)

Wire fabric is typically 11 gauge galvanized steel mesh with openings not larger than 2 inches.

Tvpes of Wire Fabric:

I Zinc-coated steel
II Aluminum-coated steel
III Aluminum-coated alloy
IV Polyvinyl Chloride (PVC) coated over Zinc- or Aluminum-coated steel

Fences (CSI 02830)

Fence construction has several major components: support framework including post rails and braces, fabric wire, gates (manual and powered), security components (eg., barbed, razor, and concertina) placed at top. Additionally, high security area fencing may be electrical or attached to a remote monitoring station used to prevent and/or detect possible illegal intrusion into security zones. Overall fence height, excluding barbed wire topping, usually exceeds 7 feet, but may vary in height when enclosing less critical sites.

Gates (CSI 02830)

Gates are the movable portion of the fencing used to control vehicle and pedestrian traffic. Typically motorized gates are used for vehicle access points; they are designed to operate manually during power outages. To operate normally, electrical continuity must be maintained across all gate openings. Gates are fabricated of the same materials and finishes as the fence framework. Generally, fabric for gates is the same as fabric for fences. Gates may be single leaf or double leaf, hinged, or sliding.

Types of Chainlink Fence Gates:

I Single Swing
II Double Swing
III Single Cantilever Sliding
IV Double Cantilever Sliding
V Single Overhead Sliding
VI Double Overhead Sliding
VII Vertical Lift

Mesh Size in Inches:

1 inch (9 & 11 wire gauge size only)
1 3/4 inch
2 inch
2 1/2 inch

Wire Gauae Sizes:

11 Gauge = 0.120 inch
9 Gauge = 0.146 inch
6 Gauge = 0.192 inch

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Gates (CSI 02830) (Continued)

Fabric Heiaht in Inches & Feet:

36 inches - 3 feet
42 inches - 3 1/2 feet
48 inches - 4 feet
60 inches - 5 feet
72 inches - 6 feet
84 inches - 7 feet
96 inches - 8 feet
120 inches - 10 feet
144 inches - 12 feet

Posts, Rails, & Braces (CSI 02830)

Posts, rails, and braces provide structural integrity and support fencing fabric and gates. Chain-link fencing is typically fastened to pipe type posts, rails, and bracing. Pipe specification include:

Class 1 - Steel Pipe:

- Grade A - Hot-dip zinc-coated after fabrication with 1.8 ounces of zinc per square foot of coated surface area.
- Grade B - Hot-dip zinc-coated with 0.9 ounces of zinc per square foot of external coated surface area. The interior surface is hot-dip zinc-coated or zinc rich painted to a minimum thickness of three mils.

Size - Outside diameter multiplied bv (x) minimum wall thickness in inches:

SP1- 1.1600Dx0.111
SP2 - 1.900 OD x 0.120
SP3 - 2.375 OD x 0.130
SP4 - 2.875 OD x 0.160
SP5 - 4.000 OD x 0.226
SP6 - 6.625 OD x 0.280
SP7 - 8.625 OD x 0.322

Class 2 - Aluminum Pipe:

Size - Outside diameter in inches x weiaht per foot of lenath (lb/ft):

AP1- 1.629 OD x 0.786 lb/ft
AP2 - 1.869 OD x 0.940 lb/ft
AP3 - 2.351 OD x 1.264 lb/ft
AP4 - 2.846 OD x 2.004 lb/ft
AP5 - 3.960 OD x 3.151 lb/ft
AP6 - 6.559 OD x 6.564 lb/ft
AP7 - 8.625 OD x 9.878 lb/ft

Class 3 - Formed Steel Sections:

Size - Outside dimensions in inches x weiaht per foot of lenath (lb/ft):
FS1- 1.625 by 1.250 x 1.35 lb/ft
FS2 - 1.875 by 1.625 x 2.40 lb/ft
FS3 - 2.250 by 1.700 x 2.78 lb/ft
FS4 - 3.500 by 3.500 x 5.10 lb/ft

Class 4 - Steel H-Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

SH1- 2.25 by 1.70 x 3.43 lb/ft

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Posts, Rails, & Braces (CSI 02830) (Continued)

Class 5 - Aluminum H-Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

AH1 - 1.875 by 1.565 x 0.91 lb/ft
AH2 - 2.250 by 2.000 x 1.22 lb/ft

Class 6 - Steel Square Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

SS1 - 2.00 by 2.00 x 2.60 lb/ft
SS2 - 2.50 by 2.50 x 5.10 lb/ft

Class 7 - Aluminum Square Sections:

Size - Outside dimensions in inches x weight per foot of length (lb/ft):

AS1 - 2.50 by 2.50 x 1.25 lb/ft
AS2 - 3.00 by 3.00 x 1.40 lb/ft
AS3 - 3.00 by 3.00 x 2.45 lb/ft

Posts must be compatible with fence heights and are typically concreted in place. "Terminal Posts" refers to end, corner, and pull posts. "Line Posts" are vertical posts installed between terminal posts, and "Gate Posts" refers to posts supporting the weight of the gates.

TABLE ONE
Posts of class 1 steel pipe, grades A and B

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	SP3
	over 6 ft	SP4
Line	up to 6 ft	SP2
	up to 8 ft	SP3
	over 8 ft	SP4
	Gate Leaf Widths	
Gate	up to 6 ft	SP4
	up to 13 ft	SP5
	up to 18 ft	SP6
	up to 23 ft	SP7

TABLE TWO
Posts of class 2 aluminum pipe

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	AP3
Line	up to 6 ft	AP2
	up to 8 ft	AP3
	Gate Leaf Widths	
Gate	up to 13 ft	AP5
	up to 18ft	AP6
	up to 23 ft	AP7

TABLE THREE
Posts of class 3 formed steel section

Post Type	Fabric Heights	Size
Line	up to 8 ft	FS2
Terminal	over 8 ft	FS3
	All Heights	FS4

TABLE FOUR
Posts of class 4 steel H-section

Post Type	Fabric Heights	Size
Line	All Heights	SH1

TABLE FIVE
Posts of class 5 aluminum H-section

Post Type	Fabric Heights	Size
Line	All Heights	AH2

TABLE SIX
Posts of class 6 steel square section

Post Type	Fabric Heights	Size
Terminal	up to 6 ft	SS1
	over 6 ft	SS2
	Gate Leaf Widths	
Gate	up to 6 ft	ss2

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Posts, Rails, & Braces (CSI 02830) (Continued)

TABLE SEVEN
Posts of class 7 aluminum square section

Post Type	Fabric Heights	Size
Terminal	up to 6 ft over 6 ft	AS1 AS3
	Gate Leaf Widths	
Gate	up to 6 ft	AS2

Braces are provided for gate posts and each terminal post, and double bracing is used when fabric height is greater than 9 feet.

Posts, braces, and other structural members are located on the inside of the secured perimeter. Once in place, all hardware is peened over or spot welded to prevent easy removal.

Accessories (CSI 02830)

Rail caps are used on the exposed ends of post to exclude moisture. Caps have a ring or hole for the passage of the top rail. Caps are typically formed steel or aluminum alloy.

Rail and brace ends are used on the ends of top and bottom rails and braces to exclude moisture and provide for post anchoring. Rail and brace ends are typically formed steel or aluminum alloy.

Rail sleeves are used to allow for expansion and contraction of the rails and are made of the same material.

Wire ties and clips are used to attach the fabric to the line posts, top and bottom rails, or tension wires. When attaching fabric to line posts, spacing should not be greater than 15 inches. When attaching to rails or tension wire, the spacing shall not exceed 24 inches. Wire ties and clips should be the same size and material as the fabric.

Brace and tension bands are used to secure rail and brace ends to terminal posts and tension bars with fabric to terminal posts. Spacing of tension bands are at 15 inch intervals or less. Brace and tension bands are typically made of steel.

Tension bars are used where the fabric meets the terminal posts. Tension bars are threaded through the fabric and attached to the terminal posts with tension bands. Tension bars are made of steel and of a continuous length compatible with the height of the fence.

Tension wire is used at the bottom of the fence to provide rigidity.

Truss rods are installed diagonally with the brace; they have adjustable turnbuckles to maintain the proper tension.

Barbed wire is installed across the top of the fencing, typically with 4 point barbs at spacings of 3 or 5 inches. Fencing is usually topped by three or more strands of barbed wire mounted on single or double arms. Barbed wire, as with fabric, may be galvanized or aluminized finish for steel, and mill-finished aluminum. Aluminum barbed wire is furnished with solid aluminum barbs. Barb tape coils are being used with increased frequency for high-security or detention facilities. Coils have razor-sharp barbs and are far more effective as a deterrent (both physical and psychological) than barbed wire (should conform to DOE/Federal Security Requirements). Grounding and security contact points for electrified fences are provided from power feeds (usually underground).

0.12.06 SECURITY GATES & FENCES (CSI 02830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Accessories (CSI 02830) (Continued)

Barbed wire arms may be attached to or be an integral part of the line post caps. Typical arms are:

- Single vertical
- Single 45-degree
- Vee-type with two arms at 45 degrees to vertical

Bolts, nuts, and washers are galvanized steel or aluminum alloy.

OTHER RELATED COMPONENTS

Refer to Exterior Closures, Volume 4, for additional deficiencies that may impact this system.

0.12.08 SECURITY GATES & FENCES (CSI 02830)

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DEFICIENCY FACTORS
0.12.06 SECURITY GATES & FENCES (CSI 02830)

PROBABLE FAILURE POINTS

- Gate sagging and misalignment caused by insufficient gate post bracing, loose mounting hardware, loose or broken gate members caused by vehicular impact.
- Fabric sagging caused by insufficient bracing, improper installation, loose or missing tie wires.
- Fence post leaning caused by poor footing, broken post, improper installation.
- Washout under fencing caused by soil erosion.
- Corrosion of structural members, fabric, and accessories due to weathering.
- Loose, missing, or broken accessories caused by improper installation, vehicular impact, or weathering.

SYSTEM ASSEMBLY/DEFICIENCIES

Fabric

Fabric Sagging:	Insufficient bracing, loose or missing tie wires, missing/broken rail or tension wire, or improper installation.
Fabric Split, Torn:	Vehicular impact, vandalism, improper wire size, or improper installation.
Corrosion:	Breaks in protective coating allowing moisture to get at base metal, or use of improper materials.

Gates

Gate Sagging, or Misaligned:	Loose or broken mounting hardware, broken structural members on gate, gate post leaning due to insufficient bracing, or damage caused by vehicular impact.
Gate Doesn't or is Hard to Open, Close:	Swinging gate; loose or broken mounting hardware, lack of lubrication on hinges.
Binding:	Insufficient bracing or loose/broken structural members.
Sliding, Lifting Gate:	Loose or broken mounting hardware, lack of lubrication of rollers, obstruction in track, loose or broken structural members, binding caused by insufficient bracing.
Malfunctioning, Electrically Operated Gate:	Operator missing, broken, or out-of-adjustment.
Gate Opens Too Far:	Gate stop broken or missing, electrical operator out of adjustment.
Gate Swings Back When Opened:	Gate keeper missing or broken.
Gate Corroded:	Protective coating missing or damaged, improper materials used.

DEFICIENCY FACTORS
0.12.06 SECURITY GATES & FENCES (CSI 02830)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

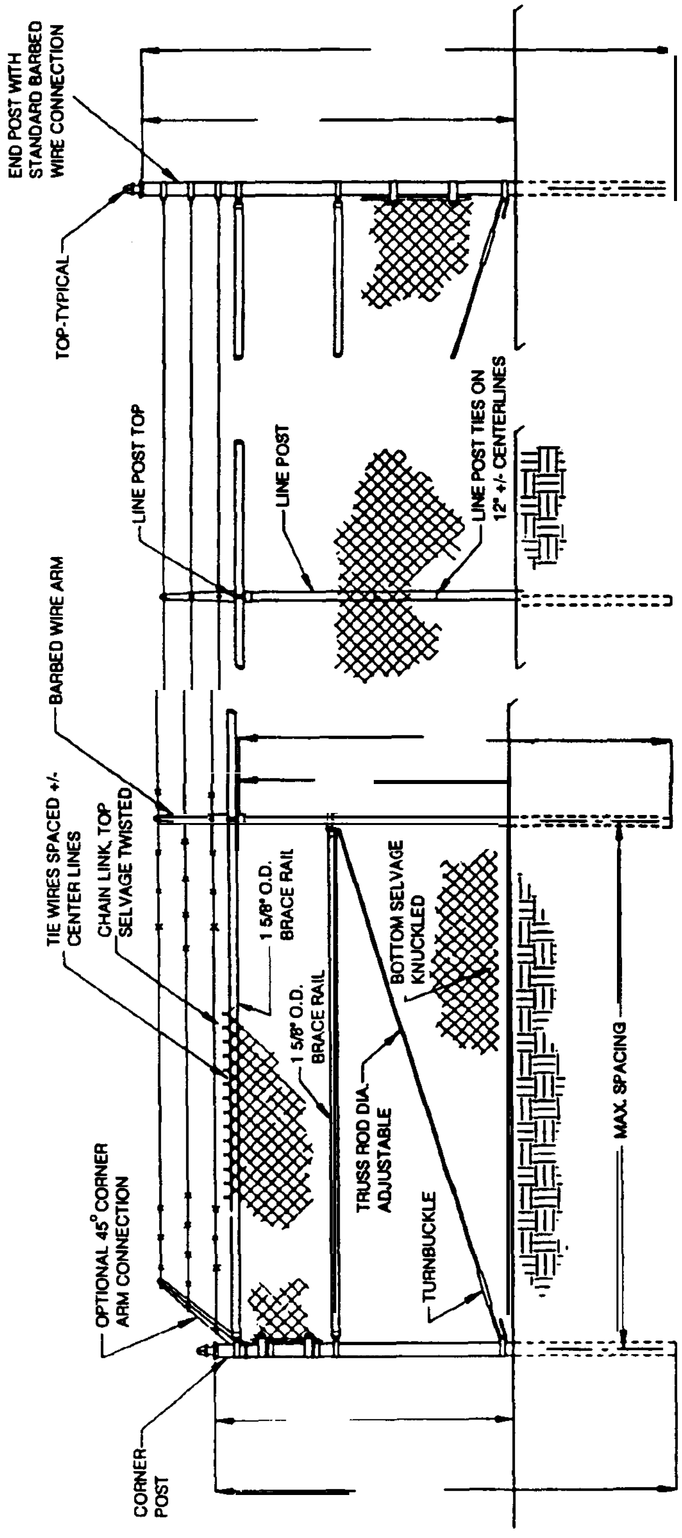
Posts, Rails, & Braces

Posts Broken:	Vehicular impact, improper size piping.
Posts Leaning:	Vehicular impact, inadequate foundation size, excessive tension, insufficient bracing, or improper installation.
Rail Sagging:	Missing or broken wire ties, rail sleeves broken, missing, or broken caps.
Braces Loose:	Insufficient tension, missing or broken truss rod, or missing or broken tie wires.
Corrosion:	Protective coating missing or damaged, improper materials used.

Accessories

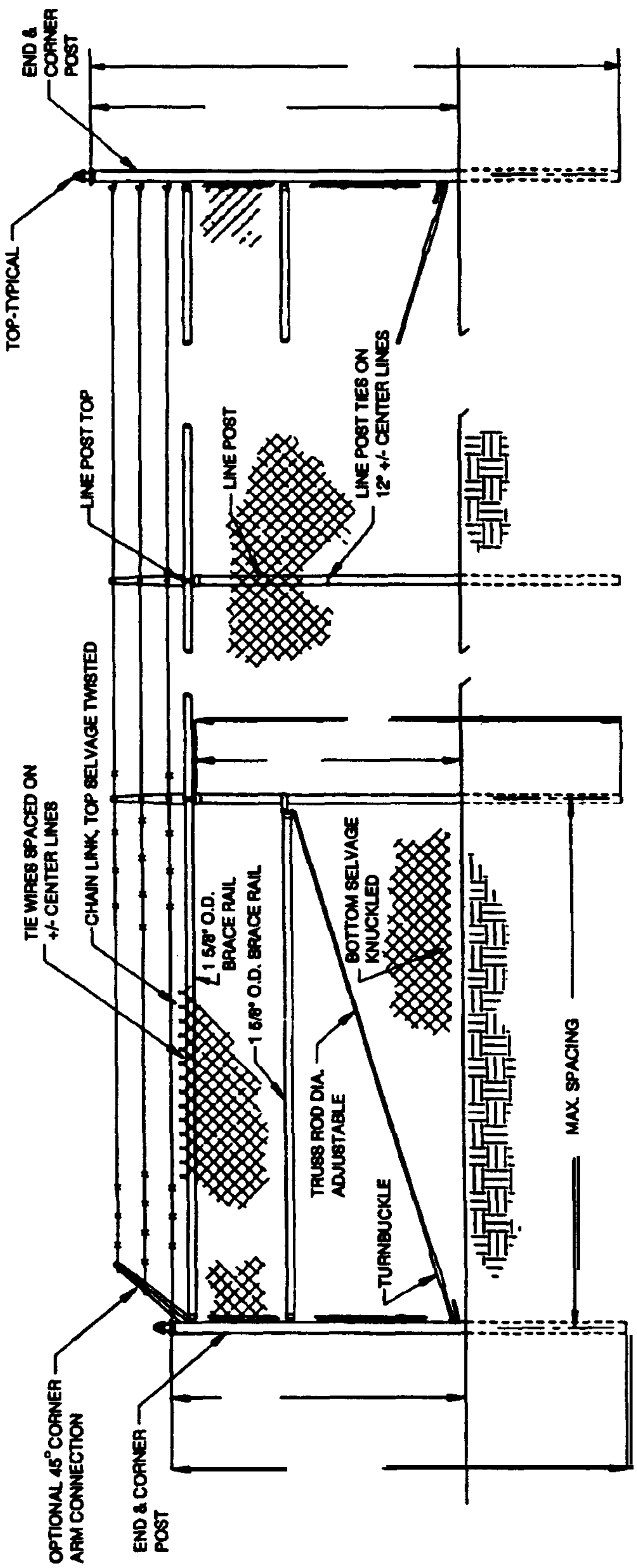
Corrosion:	Protective coating missing or damaged, improper materials used.

END OF SUBSECTION



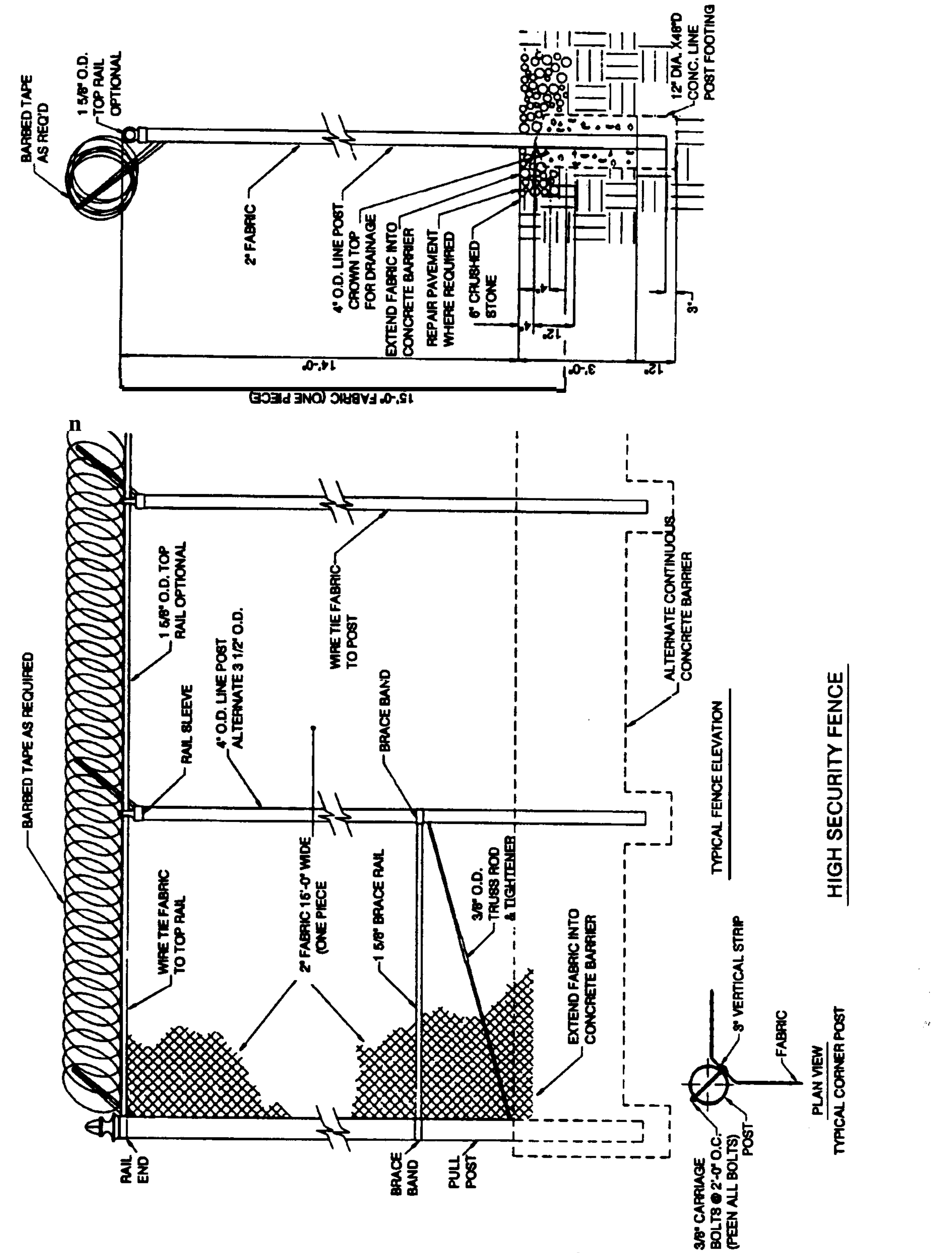
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	SECURITY FENCE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-1



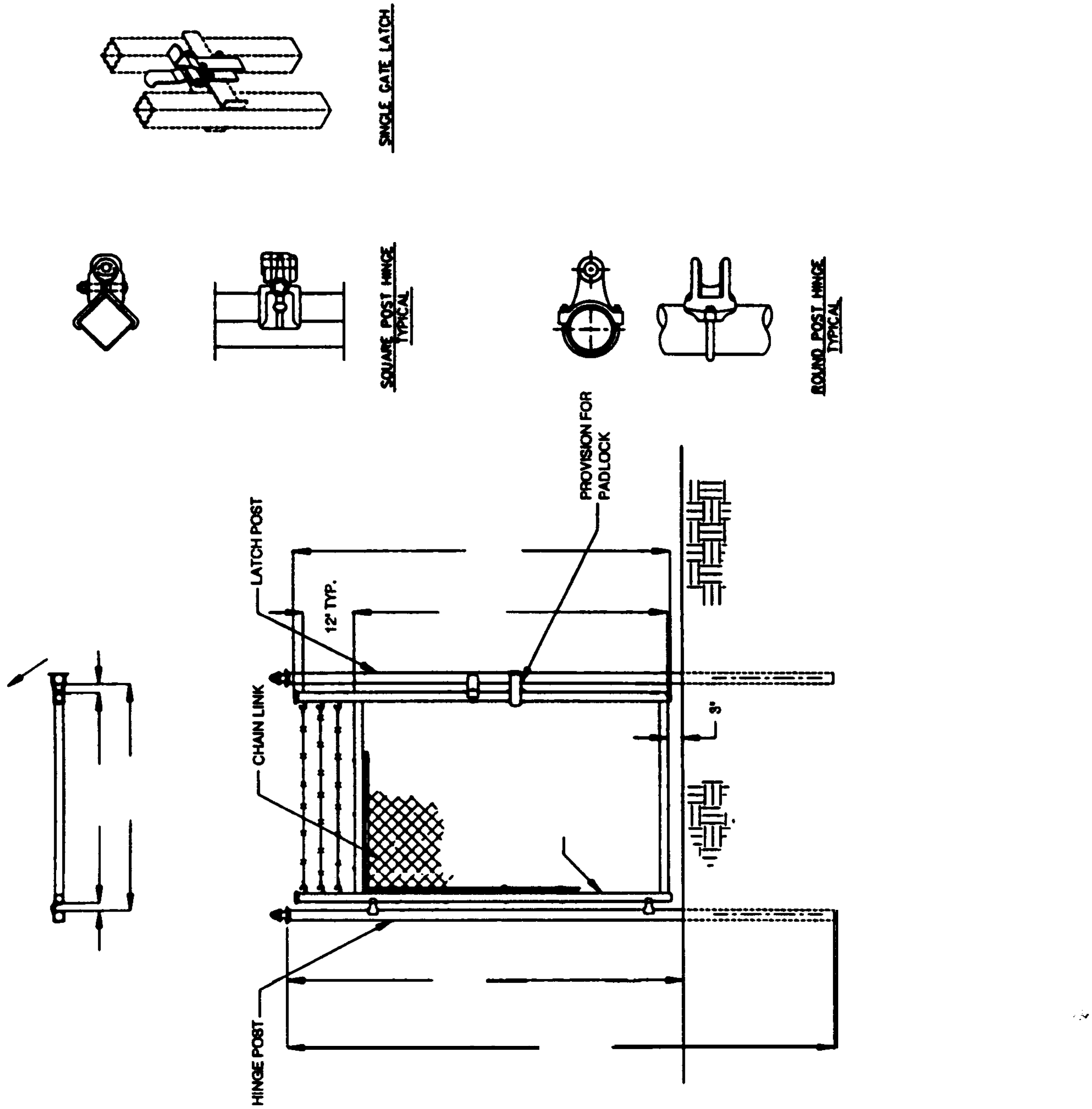
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	SECURITY FENCE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-2



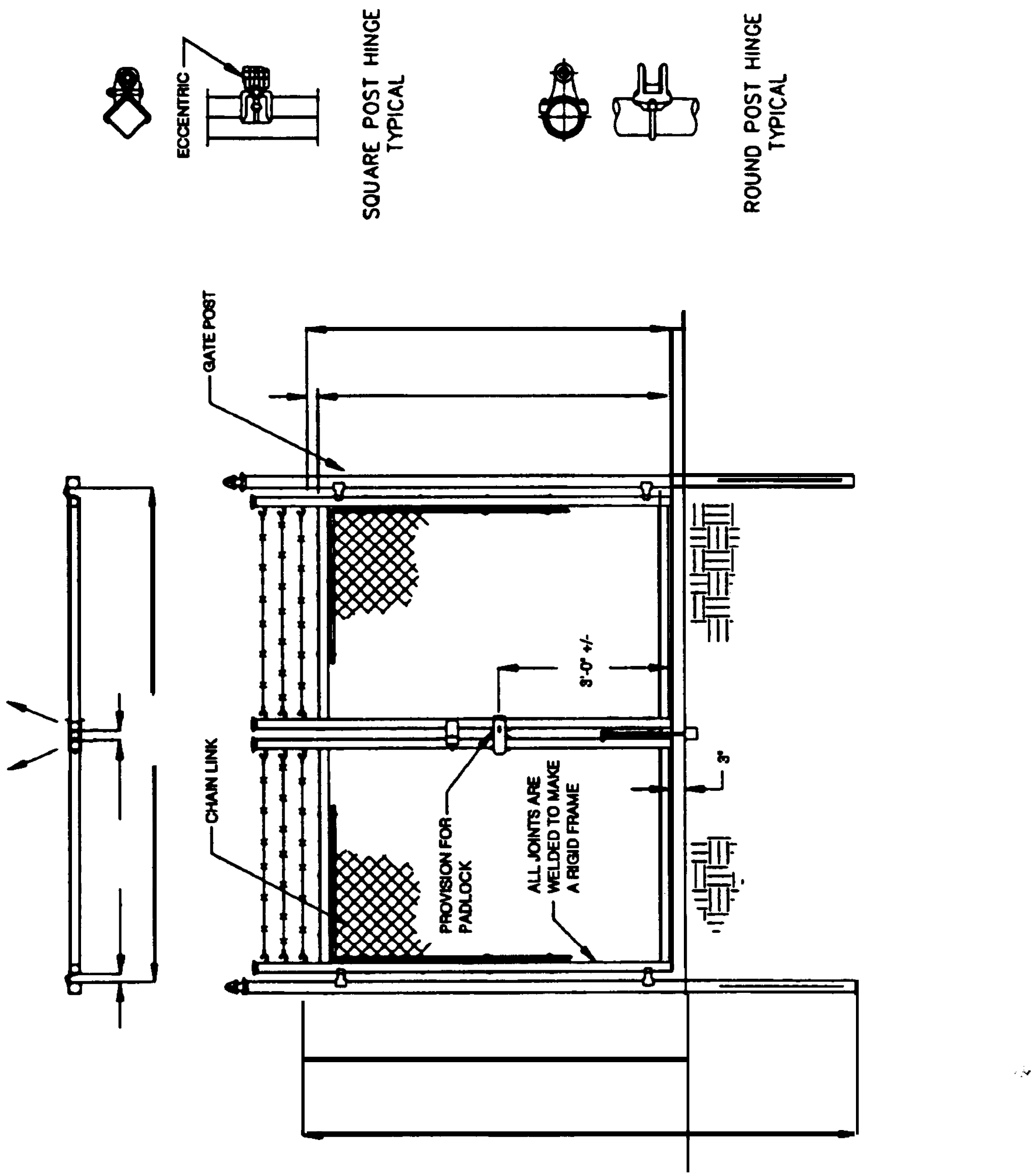
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	HIGH SECURITY FENCE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-3



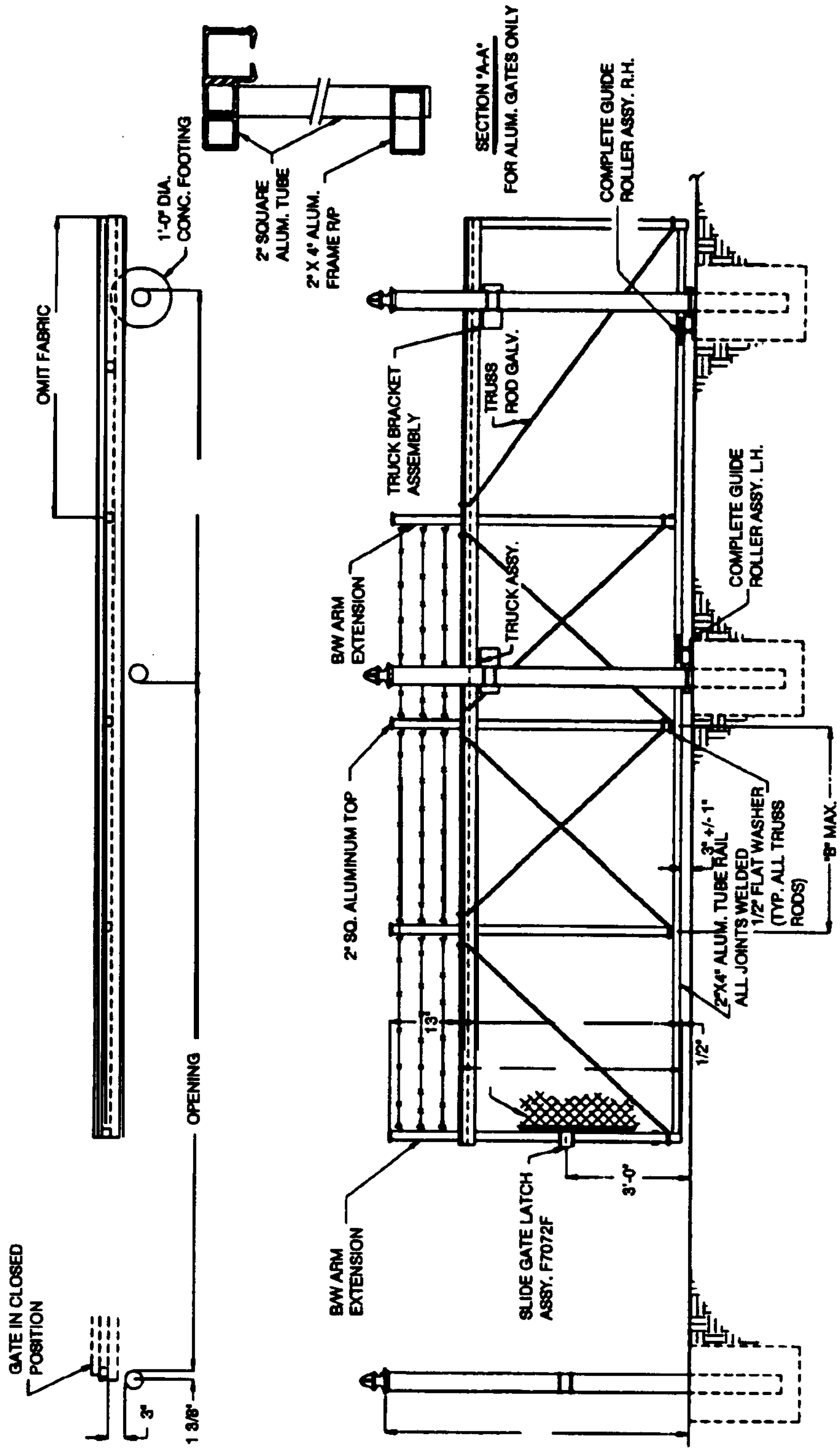
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	SINGLE SWING GATE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-4



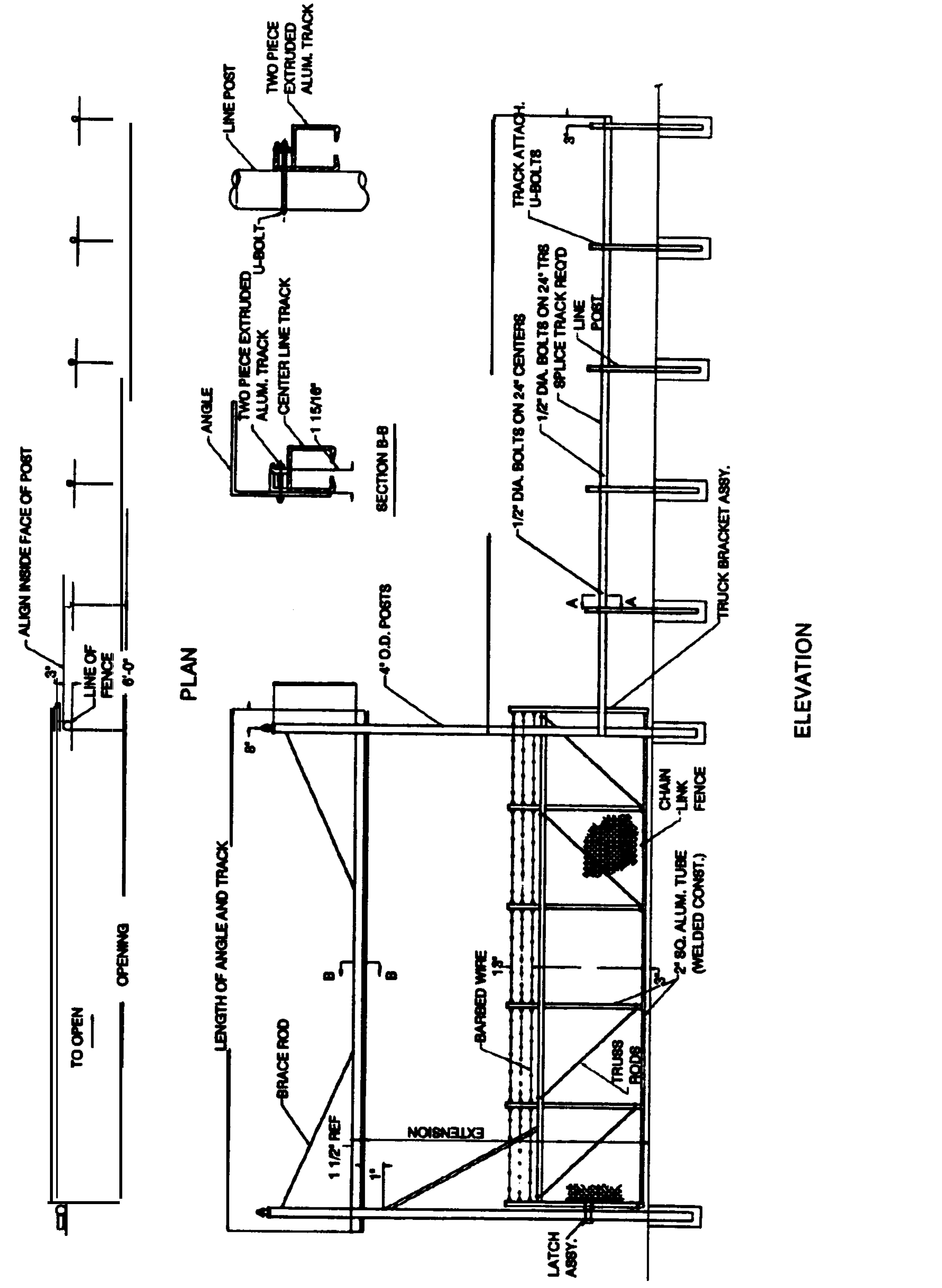
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITE WORK	DOUBLE SWING GATE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-5



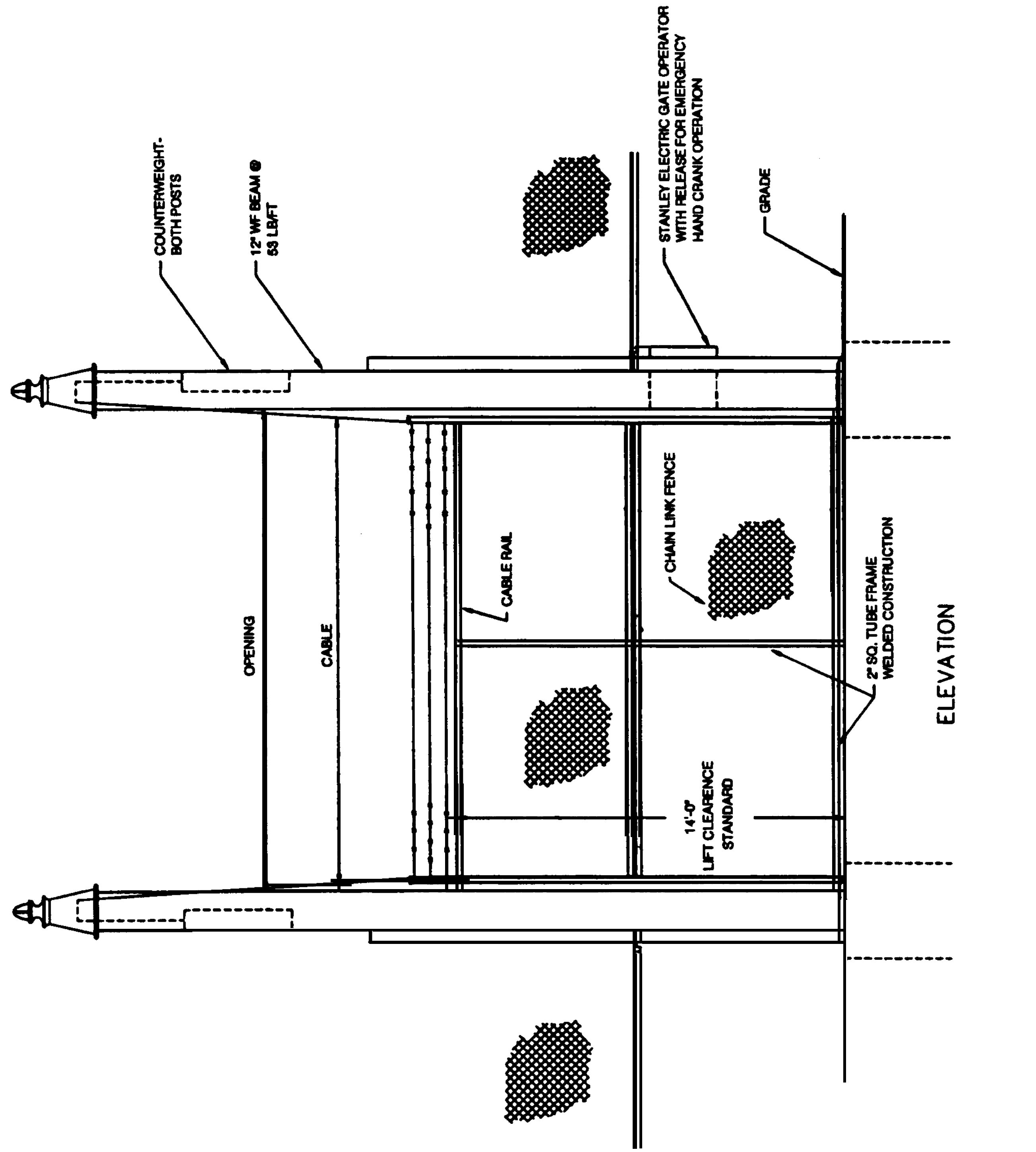
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	CANTILEVER SLIDING GATE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-6



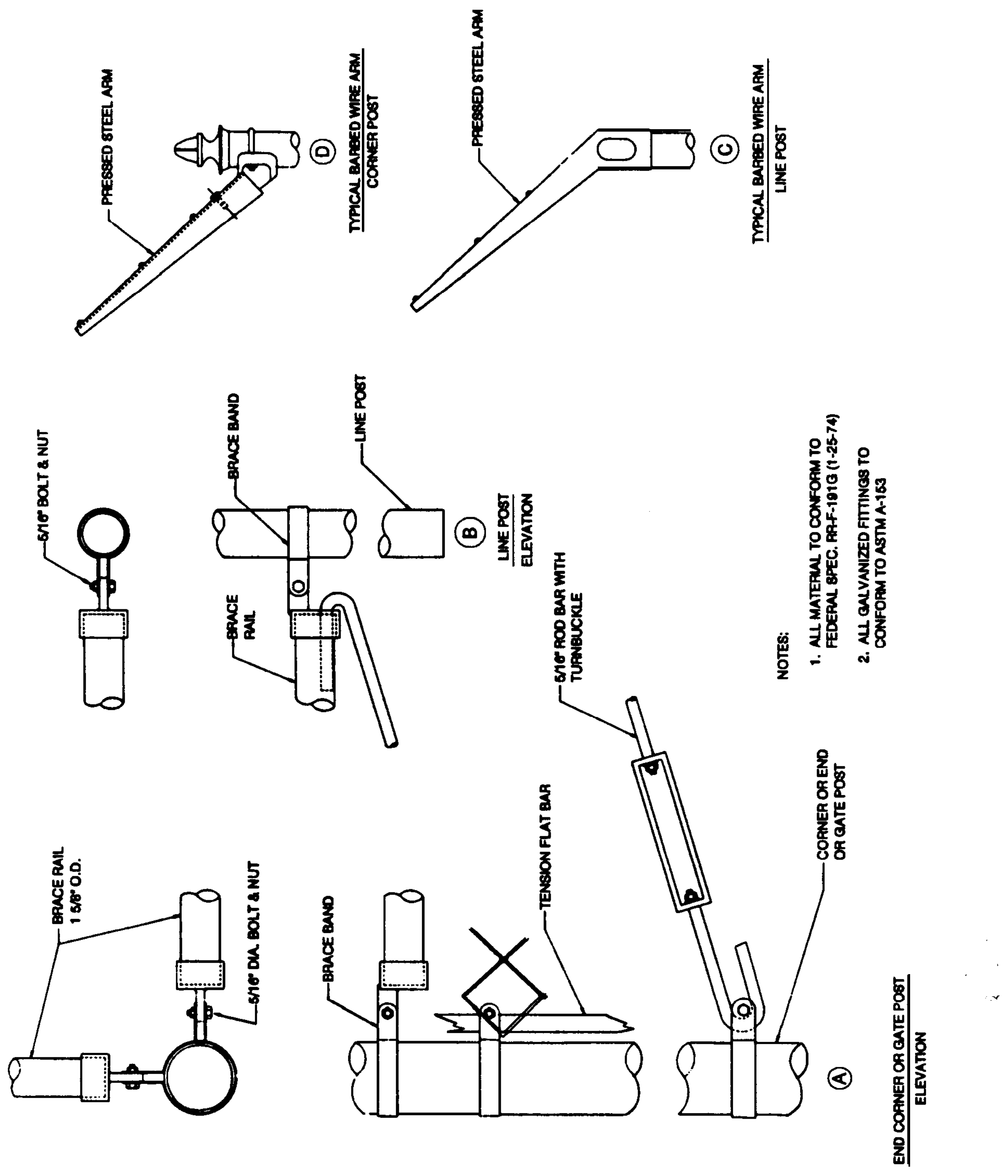
SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	OVERHEAD SLIDING GATE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	**Revision** No.	**Issue Date** 5/93	**Drawing** No. A1206-7



SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	VERTICAL LIFT GATE AND ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-8



SOURCE: ANCHOR FENCE COMPANY, INC., MANUFACTURERS CUT SHEETS

SYSTEM ASSEMBLY DETAILS-SITEWORK	FENCE ACCESSORIES		
SECURITY GATES AND FENCES (CSI 02831)	Revision No.	Issue Date 5/93	Drawing No. A1206-9

0.12.07 LANDSCAPING (CSI 02900)

DESCRIPTION

In today's heightened concern for environmental issues, the question of good landscaping and its maintenance is increasingly important. Although "landscaping" can include a broad set of variables, for the purpose of this manual, landscaping is defined as the area immediately adjacent (200 feet) to a facility, as well as "common" grounds maintained between facilities. This does not Include natural preserves; reforested areas, or parklands. Site appurtenances including roads, walk, site lighting, etc. are covered under separate headings.

A good maintenance program includes, pruning, spraying, fertilizing, and mulching. Pruning involves shaping trees and shrubs by removing excess growth. This is only done to the degree necessary to balance the top of the tree to the roof system. A tree should be kept to is natural shape as much as possible. All pruning should be done vertically to the direction of growth.

Spraying, to control disease and insect infestation, is usually done in the early spring before the tree is in bud. Generally, one or two sprayings are required during the growing season (but may require more depending on specific climatic conditions). Fertilizing, either liquid or solid, is used in the spring of each year. Good and rapid growth are the results of fertile soil. Fertilizers containing a large proportion of nitrogen are desirable because nitrogen is the element contributing to most plant growth.

Mulching is the practice of covering the ground around tree trunks and plant beds with a substance to prevent weed growth, soil erosion, and to retain moisture. Materials used for mulching included shredded/chunk tree materials, peat moss, peanut shells, and compost.

Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Landscaping (CSI 02900)

Soils provide an ideal balance of mechanical and chemical properties required for native plants grown under natural conditions. However, most landscape work involves plantings that are not native or are grown under soil and climatic conditions that are not entirely natural to the site.

Plants require air, water, and nutrients; these requirements must be in an available form and in proper balance. The ideal soil holds nearly equal amounts of air and water and a rich supply of nutrients. Plants, except for the acid-loving species, generally prefer a slightly acid to neutral soil condition in the pH range of 6 to 7.

The best method to determine soil conditions is by testing the soil. Specifications can then tailor the soil preparation requirements to overcome deficiencies. In familiar areas where soil conditions are known, general measures that produce good planting results are often specified without tests.

It is advisable when working in unfamiliar areas, not only to make preliminary tests, but also to consult local experts. Extreme soil conditions (particularly extreme alkalinity) usually require extensive and costly measures.

Topsoils (CSI 02920)

Soils in humid climates will tend to be leached of nutrients, and if originally forested, will be on the acid side. Areas that originally contained high grass will have deep topsoils rich in humus and nutrients, usually neutral or slightly alkaline, and may need little to no initial soil preparation. Drier areas, originally covered by short grass, will be shallower and less rich. Arid areas in the west, while generally well supplied with nutrients due to lack of leaching, will have little humus and will tend toward extreme alkalinity. Irrigation will make nutrients available and compensate for lack of humus, but drastic initial measures may be required to overcome the alkalinity.

0.12.07 LANDSCAPING (CSI 02900)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Topsoils (CSI 02920) (Continued)

Good soil structure is permeable to roots, air, and water, not only in the upper layer of topsoil, but also in the lower layer of subsoil. If subsoil is not permeable (dense clay, for example), deep cultivation and addition of soil amendments to lighten the subgrade may be required, unless irrigation and regular fertilization are economically feasible.

The addition of partially decayed animal or vegetable matter as a soil amendment is a kind of magic answer for most soils. Humus makes heavy soils more permeable, and allows lighter soils to hold moisture, thereby aiding the air-water balance of the soil.

Humus is available in the form of animal manure, compost, leaf mold, and waste products, such as spent hops and cotton-seed meal. However, the prime source of bulk humus is peat obtained from decayed mosses and sedges. Sawdust and ground bark are also available in some areas, but require nitrogen to initiate decay.

Mulches (CSI 02930)

Primary mulch functions include preventing weed growth, surface erosion, and moisture evaporation, along with maintaining more uniform soil temperatures. Inorganic materials, such as gravel and crushed stone, can also function as a mulch and as a decorative surface treatment.

Fertilizers (CSI 02930)

The primary nutrients required for most plants are nitrogen, phosphorous, and potash typically listed in that order (i.e., 5-10-5 fertilizer is 5 percent nitrogen (N), 10 percent phosphorous (P), and 5 percent potassium (K)). Other elements such as hydrogen, oxygen, calcium, sodium, sulfur, and magnesium are normally present or derived from air and water.

- Nitrogen is essential to the protoplasm or living substance of plant cells and vital to growth, particularly of foliage. For this reason, heavy applications are required for lawns to stimulate leaf and stem growth. Trees, shrubs, and other plants that should mature normally do not require heavy nitrogen fertilization.
- Phosphorus aids root growth and maturing of plants. If it is deficient, plants are stunted, flowers and fruits are retarded, and foliage is dull.
- Potassium increases resistance of plants to disease and inclement weather. Most soils, except those in very sandy areas, contain enough potassium, and the small amounts found in most complete fertilizers are adequate.

lawns & Grasses (CSI 02930)

Grasses constitute a very large family of plants comprising some 600 species, about 40 of which are suitable for establishing lawns.

Some of the finest lawns, particularly bentgrasses, require inordinate amounts of time and money to establish and maintain good turf. Northern type lawns, such as bluegrass, will be difficult to carry through hot summers if grown in southern, subtropical grass areas. In areas with extreme soil or moisture conditions, species tolerant to extreme conditions should be considered.

Heavily shaded areas are not conducive to establishing good lawns even if shade-tolerant species are planted. If planted under the drip-line of large trees, frequent applications of fertilizer must be applied to compensate for tree root feeding. A better solution is to plant a dense stand of a shade-tolerant species of ground cover.

0.12.07 LANDSCAPING (CSI 02900)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Lawns & Grasses (CSI 02930) (Continued)

Vegetative Planting:

- Lawns established from living plant material, rather than from seed, may be required for southern species such as Zoysia, St. Augustine grass, Centipede grass, and for many of the northern creeping bent species. Such species must be established by vegetative plantings (sod, plugs, springs, or stolons).
- Sod is the most effective if an instant lawn is required, and is the best solution for steep slopes (15 to 30% slope).
- Minimum spacings for spring and plug planting are based on relative rates of growth. Slower growing species, such as Zoysia, may take two years to establish a uniform turf unless initial spacing is relatively close.

Seed Planting:

- Lawns may be seeded as a single grass species or a mixture. The southern species available from seed are generally planted as a single species, as lawn establishment is relatively rapid. Northern lawn species (and growing conditions) lead to slower establishment, mixtures containing nurse grasses (to prevent erosion and discourage early weed growth) are more common.
- Mixed species should be compatible in color, texture, and maintenance requirements; and be suited to growing conditions, such as amount of sunlight, moisture requirements, drainage, etc.
- Nurse grasses, such as Redtop, are quick growing, but do not establish a good permanent turf. They are valuable in mixtures with slower growing species to provide fast initial coverage. However, nurse grass species will tend to take over if they comprise too large a percentage of the total mixture; 20 percent is considered to approach this point.
- Grasses suitable for lawns in cool, humid regions are Kentucky Bluegrass, Red Fescue, Alta Fescue, Bentgrass, Redtop, and Ryegrass. Grasses suitable for warm, humid regions are Bermuda, Centipede, Carpet grass, St. Augustine grass, and Zoysia. St. Augustine grass will withstand salt spray, as it is naturally a seashore grass.
- Buffalo, Grama, and Crested Wheat (Fairway strain) grasses are extremely drought-tolerant and suitable for dry areas where little or no watering is anticipated. Red Fescue, Zoysia, Bermuda, and Centipede grasses are more drought-tolerant than Kentucky Bluegrass, Bentgrass, Carpet grass, and St. Augustine grass. In dry areas where irrigation (or sprinklers) will be installed, Kentucky Bluegrass and Bentgrass do well in cooler areas and Bermuda in warmer areas.

Well-drained soil conditions are required by Kentucky Bluegrass, Fed Fescue, Bermuda, Centipede, Grama, Buffalo, and Crested Wheat grasses.

Relatively high fertility is required by Kentucky Bluegrass, Bermuda, and Bentgrasses. Lower levels of fertility are tolerated by Red Fescue, Zoysia, Carpet, Centipede, St. Augustine, Grama, Buffalo, and Crested Wheat grasses.

Red Fescue, Roughstalk Bluegrass, St. Augustine grass, and Zoysia do well in shade. Bent and Centipede grasses require more sun. Kentucky Bluegrass, Bermuda, Carpet, Grama, Buffalo, and Crested Wheat grasses require full sunlight.

0.12.07 LANDSCAPING (CSI 029001

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Ground Cover (CSI 02950)

Dichondra is a broadleafed plant, not a grass, and is used in the milder parts of California and Arizona for a green, soft, ground-hugging lawn cover. It does not grow well in coastal areas subject to fog or where average winter temperatures drop below 25°F. A light sandy loam soil is preferred. Dichondra is compatible with Bermuda grass and has a longer growing period. Under conditions of shade, combined with frequent feedings and no traffic, Dichondra will grow to a lush, big-leafed stand, unless mowed. However, the more traffic it gets, the smaller, tighter, and more compact the leaves will grow, reducing mowing frequency.

Other plants that form a flat, ground-hugging mat that can be walked on and mowed are sometimes used for lawn effects similar to Dichondra. Phyla nodiflora (Lippia repens) is good in desert areas of extreme sun and heat and suitable for large areas and steep slopes. Irish moss (Aranaria verna caespetosa) tolerates sub-zero temperatures, acid soils, and sun or medium shade, but is best confined to small, level areas.

Like trees and shrubs, ground covers should be selected to fit the climate and terrain to be planted. Relative hardiness, tolerances for sun, part shade, full shade, and dry, poor, or acid soils should be considered. In addition, the rate of coverage, ability to grow on steep slopes, and the effect in large or small plantings may require consideration.

Trees & Shrubs (CSI 02950)

Trees and shrubs, dug from native stands or established plantings, are designated as "collected stock," and if required, should be so identified and requirements for them must be inserted in the text. Growth cannot be expected to be as uniform for native stock as for more carefully controlled nursery-grown stock. Control of quality is therefore more difficult, unless sources are designated, or in the case of specimen stock, if specific trees for shrubs are designated to be collected.

ASI Z60.1 provides for balled and burlapped (B&B) or bare rooted deciduous trees and shrubs, and the text includes options for all stock to be either B&B or bare rooted, or for a mixture. Container-grown stock should be considered an alternate form of bailed stock applicable to smaller trees and shrubs.

The terms "deciduous" and "evergreen" can be confusing. Deciduous refers to plants that shed all their leaves at the end of the growing season and remain leafless during the winter, or dormant period. Evergreens maintain green foliage, such as coniferous and broadleaf. However, not all conifers (plants bearing seeds in a cone) are evergreen: larches and bald cypress lose their foliage. Broadleaf evergreens comprise a wide range of plants that have broad leaves rather than needle-like leaves and retain green leaves during winter.

DEFICIENCY FACTORS
0.12.07 LANDSCAPING (CSI 02900)

PROBABLE FAILURE POINTS

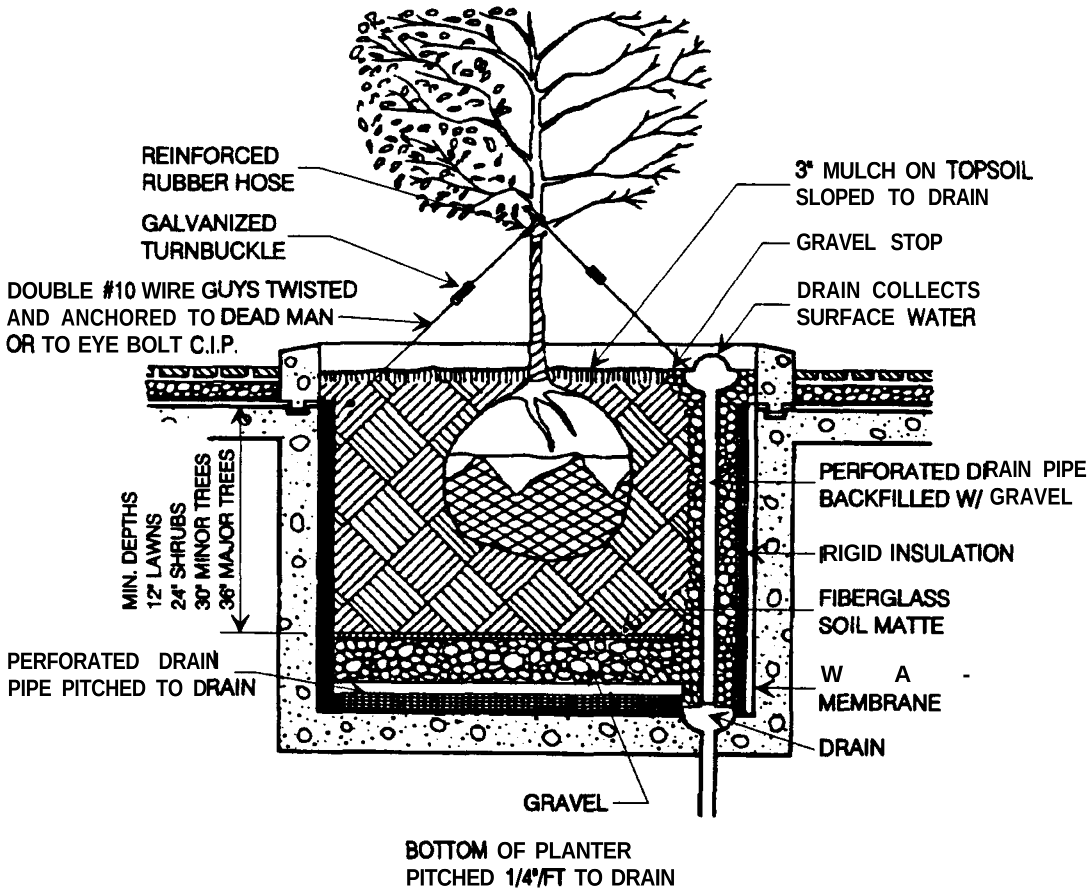
- Improper surface and subsurface drainage causes massive soil shifting resulting in soil erosion.
- Minimal wind is required to start the movement of soil particles resulting in wind erosion
- Water erosion may result from an uncontrolled flow of water down a slope not protected by a ground cover or adequate mulch. Most erosion is caused by scour.
- Grass diseases are caused by deviations in normal, local, environmental conditions
- Insect damage caused by sucking insects, which obtain their food by destoying the plant tissue and sucking the sap: and chewing insects, which bite off and eat portions of the plant.

SYSTEM ASSEMBLIES/DEFICIENCIES

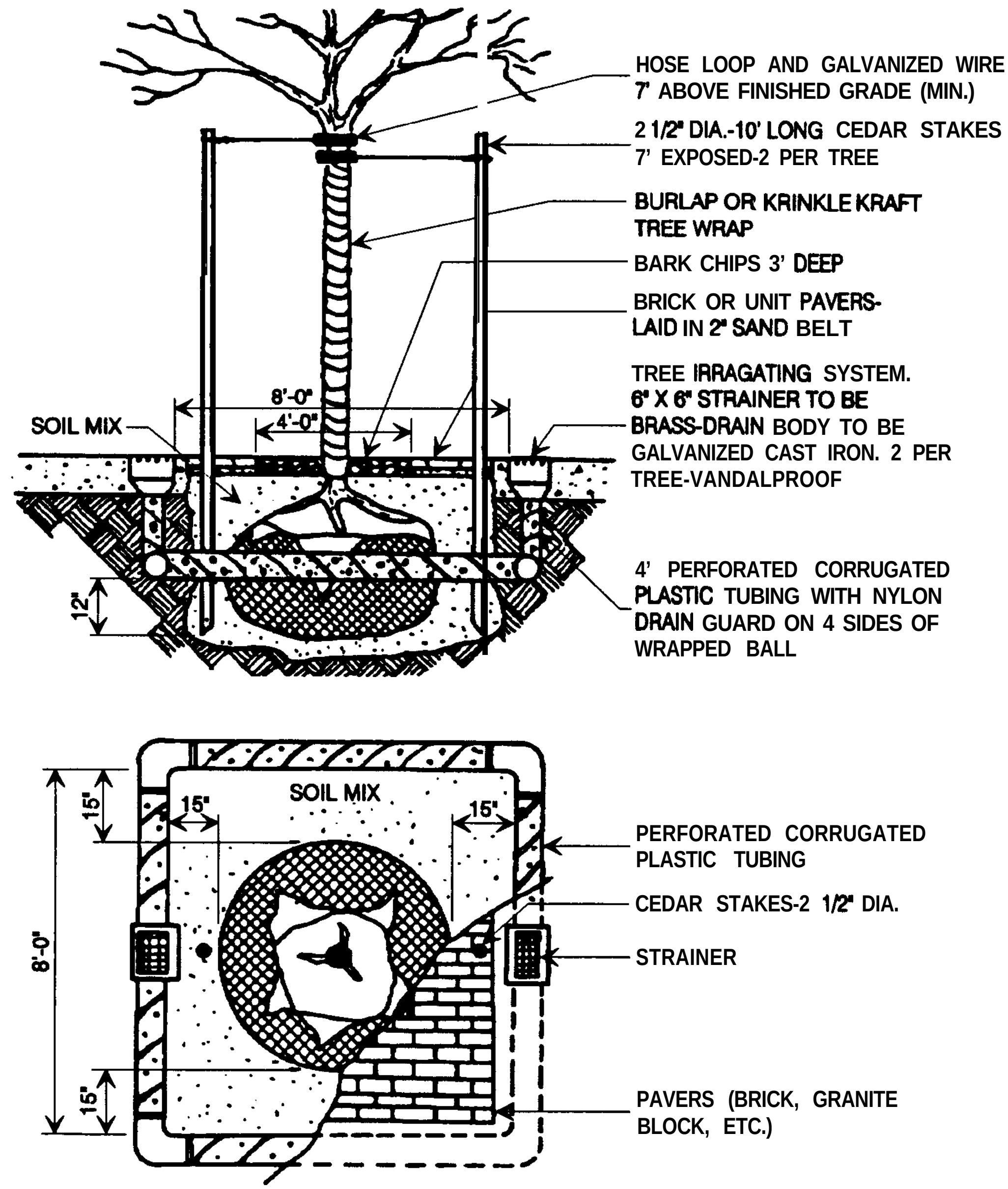
Erosion:	Natural agents such as wind and water, or can result from human activities (eg., uncontrolled pedestrian and vehicular traffic).
Improper Drainage:	Improper drainage slopes, lack of swales, or inadequate landscaping.
Insect Damage:	Plant-eating and/or disease-carrying insects.
Tree, Grass Diseases:	Organisms or agents such as fungi, bacteria, and viruses.
Wind/Ice Storm Damage:	Broken limbs, lose of vegetation, leaning or toppling of tree

DEFICIENCY FACTORS
0.12.07 LANDSCAPING (CSI 02900)

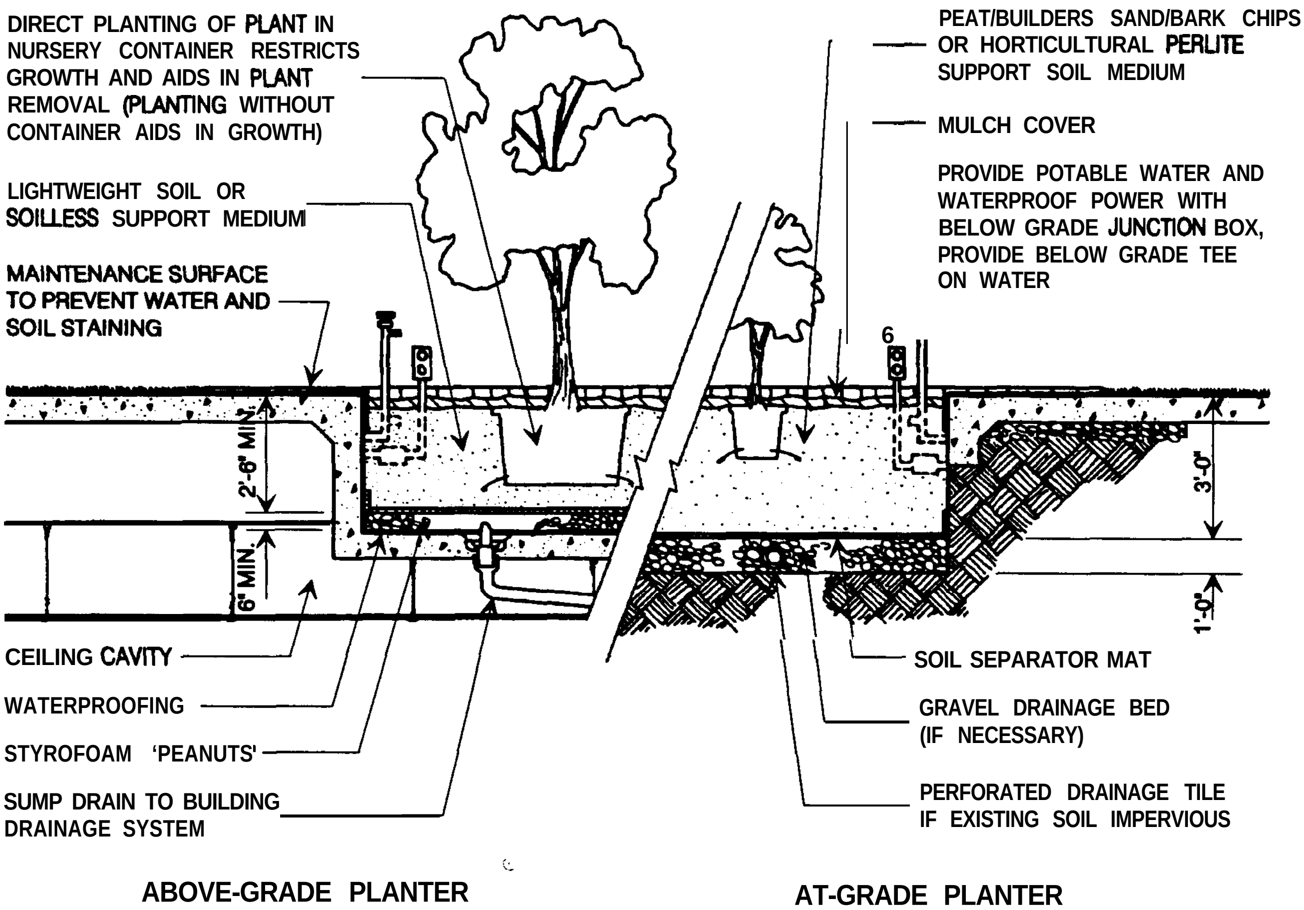
END OF SUBSECTION



SYSTEM ASSEMBLY DETAILS-SITEWORK	ROOFTOP PLANTER DETAIL		
LANDSCAPING (CSI 02900)	Revision No.	Issue Date 5/93	Drawing No. A1207-1



SYSTEM ASSEMBLY DETAILS-SITEWORK	TREE IN PAVEMENT DETAIL		
LANDSCAPING (CSI 02900)	Revision No.	Issue Date 5/93	Drawing No. A1207-2



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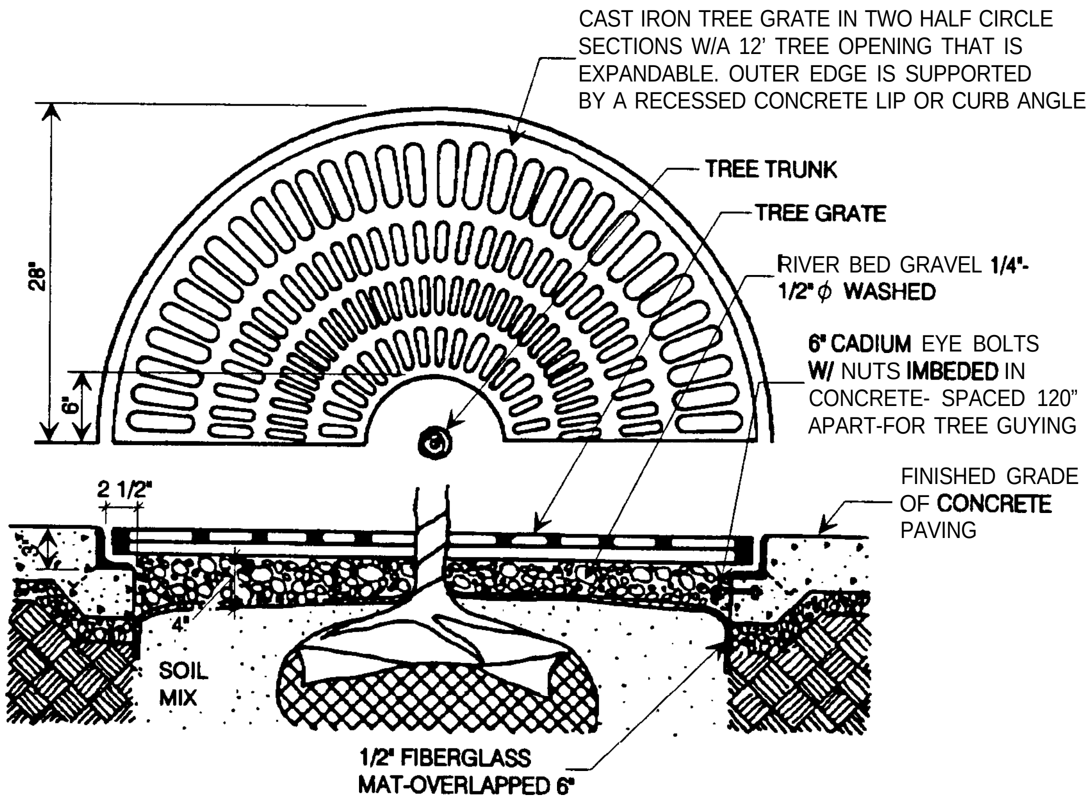

SYSTEM ASSEMBLY DETAILS-SITEWORK	TREE GRATE DETAIL		
LANDSCAPING (CSI 02900)	Revision No.	Issue Date 5/93	Drawing No. A1207-4

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

DESCRIPTION

A bridge's function is to span an obstacle and to enhance trafficability. Generally bridges are referred to according to their use; i.e., pedestrian, highway, or railroad. The type of superstructure and substructure further describe the bridge.

Bridges vary in size and complexity from simple timber trestle and stringer bridges to multispan arch or suspension bridges. A bridge system consists of multiple components of varying materials depending on the design. Typical superstructure components include: deck (structural), primary members and secondary members. Typical deck components include: wearing surface, curbs, sidewalks, railings, scuppers, and gratings. Typical substructure components include: abutments, anchor bolt pads, pedestals, solid piers, cap beams, pier columns, footings, and piles. Miscellaneous components include: lighting standards, lighting fixtures, sign structures, utilities, and utility support components. Graphic assembly details that follow illustrate general assembly/component types only and are not meant as a definitive, exhaustive, in-depth system breakdown. Field conditions will vary and are subject to project type, local requirements, and facility design.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Bridge Types (CSI **03000, 04000, 05000, 06000)**

There are five basic types of bridges:

- Girder Bridges - Flexure or bending between vertical supports is the main structural action in this type. They may be further subdivided into simple, continuous, and suspended-and-cantilevered spans.
- Rigid Frame Bridges - In this type, the longitudinal girders are made structurally continuous with the vertical or inclined supporting members by moment-carrying joints; flexure with some axial force is the main structural action in this type.
- Arches - The loads are transferred to the foundations by arches as the main structural element; axial compression in the arch rib is the main structural action, combined with some bending. The horizontal thrust at the ends is resisted either by the foundations or by a tie running longitudinally for the full span length; the latter type is called a tied or a bow-string arch.
- Cable-Stayed Bridges - The main longitudinal girders are supported by a few or many ties in the vertical or near-vertical plane, which are hung from one or more tall towers and are usually anchored at the bottom to the girders.
- Suspension Bridges - The bridge deck is suspended from cables stretched over the gap to be bridged, anchored to the ground at two ends and passing over tall towers erected at or near the two edges of the gap.

The first three types and the deck structure of the last two types may be either solid-web girders or truss (lattice) girders.

Because of the steel shortage in the postwar years, prestressed concrete became the more prevalent choice for long-span structures.

Today, prestressed, post-tensioned reinforced concrete structures have been combined successfully in major bridges that incorporate the integration of precasting and erection (i.e., segmental). The design concepts of this technique, as well as other conventional methods, are described in detail in this text.

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Bridge Types (CSI 03000, **04000, 05000, 06000)** (Continued)

The major advantage in the use of concrete for bridges is the wide variation that can be achieved in form. This flexibility, however, does not limit its exclusive use for all major structures. Because of factors like the ratio of dead to live load, depth constraints, availability of material, and labor costs, steel structures may be cost-effective and must be considered as a possible alternative. Many major bridge projects today include alternate designs (steel and -- ncretej with appropriate working drawings for use in bidding.

The range in span of bridge types varies. As illustrated below, steel and concrete can be used for many bridge types.

General reinforced concrete bridges can consist of decks, T-beams, or cells. Combinations of these types and precasting these elements can enhance their versatility. Concrete section types may consist of the following:

- Composite spread box
- Composite box
- Composite AASHO-PCI standard sections
- Type I 30-45 ft span
- Type II 40-60 ft span
- Type III 55-80 ft span
- Type IV 70-1 60 ft span
- Type V 90-l 20 ft span
- Type VI 11 O-l 40 ft span
- Composite/Tee 40-60 ft
- Channel 20-40 ft
- Solid slab
- Voided slab
- Single box
- Double box

Although these elements are standardized, the engineer can modify the geometry to accommodate the bridge under design.

Abutments (CSI **03000, 04000)**

An abutment is a substructure unit loaded at the end of a bridge. Its function is to provide end support for the bridge and to retain the approach embankment. In addition to supporting the bridge, it also provides a transition from the road, footpath, or railroad track to the bridge.

Abutments typically have a joint between the header and the bridge deck that serves as an expansion joint and provides for a smooth transition between the wearing surfaces.

Bearings, Anchor Bolts, Pads:

A superstructure element that provides an interface between the superstructure and the substructure. Bearings, anchor bolts, and pads are used to transmit vertical loads from the structural deck to the abutment while allowing horizontal forces due to material expansion and contraction caused by changes in temperature to dissipate without causing structural damage. Bearing types used include: fixed steel, steel rocker, steel or bronze sliding plate, steel roller, and pot bearings. Pads are generally elastomeric, Fabreeka, and Teflon/steel.

Bridae Seats & Pedestals:

Bridge seats and pedestals are located on the stem or breastwall. Each stringer of the structural deck uses a bridge seat or pedestal to transmit loads from the bearing or pad to the abutment mass. Brrdge seats are usually made of concrete but, masonry, timber, and steel are also used. Pedestals are usually made of concrete, but masonry and steel have been used in the past.

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Abutments (CSI **03000, 04000)** (Continued)

Backwall:

The topmost portion of an abutment above the eievation of the bridge seat, functioning primarily as a retaining wall with a live load surcharge. Typical backwalls are made of concrete, but masonry, steel, and timber can be used as construction materials.

Stem (Breast-wall):

The portion of an abutment between the wings and beneath the bridge seat; the breast wall supports the superstructure loads and retains the approach fill. The stem or breastwall also consolidates and transmits the loads to the footings and piles. Generally, the stem is made of either reinforced or unreinforced concrete, but stone, masonry, steel, and wood can be used. In some cases, a stem is not used because the bridge seats are directly supported by footings.

Wingwalls:

Wingwalls are abutment exteriors but do not carry bridge loads; their function is to retain backfill material. Wingwalls typically follow the topography and are built with reinforced concrete, stone, masonry, steel, or timber sheeting or cribbing.

Footings & Piles (CSI 03300)

Footings and piles maintain the abutment's alignment and grade. In some cases, pilings are not used when footings provide sufficient support. Footings are generally made of reinforced concrete, and piles can be made of concrete, steel, or timber.

Piers (CSI **03300, 04000, 05000)**

The pier is a substructure unit that provides intermediate support for the bridge when multiple spans are required. The subcomponents of a pier are similar to abutment subcomponents. For example, the bearing pads, bearing, and anchor bolts serve the same function, as do pedestals, footings, and piles.

Loads from the superstructure are transmitted through the pedestals to a pier cap or beam. Loads are further transmitted to the footings or piles by many types of structures, including solid piers or pier columns.

Superstructure

The superstructure consists of the following subcomponents: structural deck, primary and secondary members. The superstructure is designed to carry dead and live loads associated with the deck and transmit those loads to the substructure (abutments and piers).

The structural deck carries the load associated with the wearing surface to the primary structural members. The deck is usually made of concrete, steel grating, or timber.

Primary structural members of the superstructure are as follows:

- Stringers
- Girders
- Floor beams
- Main trusses
- Jack arches
- Box girders
- Rigid frames
- Cables and suspenders on suspension bridges
- Filled arches
- Arch ribs, spandrel columns and spandrel walls
- Portions of box culverts
- Plates or members welded to the above members
- Pipes
- Connections between primary members

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Superstructure (Continued)

Primary members are usually constructed with the following materials:

- Concrete
- Prestressed concrete
- Stone
- Brick
- Steel
- Aluminum
- Wrought iron
- Cast iron
- Wire rope
- Timber

Secondary members are usually constructed of metal or concrete. Their function is to provide support or bracing for the primary structural members. The more common secondary members are:

- Lateral bracing
- Lacing bars, stay plates, and tie plates on trusses
- Girder knee braces

Deck

The deck subcomponents do not carry loads. Loads are carried by the structural deck, a subcomponent of the superstructure. Deck components include the wearing surface, curbs, sidewalks and fascias, railings and parapets, scuppers, and gratings.

Wearing Surface:

The surface in direct contact with the live loads. When the wearing surface is monolithic with the structural deck, only the surface that vehicles bear on is rated. When the wearing course is separate from the structural deck, the full thickness of the wearing course is considered. In some cases, the deck and structural deck are synonymous in that it is a monolithic deck surface that not only carries load, but is used as the wearing surface. Typical types of wearing surfaces are:

- Asphalt overlays
- Portland cement concrete overlays

Portland cement concrete decks with monolithic wearing surface:

- Steel grating
- Timber

Curbs.

A short barrier paralleling the side limit of the roadway to guide the movement of vehicle wheels and safeguard construction and pedestrian traffic existing outside the roadway from collision with vehicles and their loads.

Curbs are provided in conjunction with sidewalks and safety walks and are usually constructed of reinforced concrete, granite, timber, or steel plate.

Sidewalks and fascia are provided for pedestrian traffic over highway bridges. Sidewalks can be designed as an overlay and treated as a wearing surface or structural element. Typical construction materials include concrete, timber, metal, and masonry.

Railings & Parapets

A fence-like construction built at the outermost edge of the roadway or the sidewalk portion of a bridge to protect pedestrians and vehicles.

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Railings & Parapets (Continued)

Railings and parapets are placed along the extreme edges of the deck to provide protection for traffic and pedestrians. Typical construction materials include steel, aluminum, concrete, timber, and masonry.

Utilities

Utilities that support the bridge operation include lighting standards, lighting fixtures, sign structures, and miscellaneous utilities that either support the bridge operation or use the bridge to span an obstacle. For example, gas, water, electric, telephone, and sewage distribution systems are sometimes attached to the bridge structure to span the same obstacle.

Lighting standards are the structural elements that attach the light fixtures to the bridge, including the connections. The light fixture includes the bulb housing, bulb, and lens.

Sign structures include the structural element that holds the sign in place and the sign. Electrical wiring and conduit to the sign and lighting structures are also included in their respective subcomponents.

Drainage (CSI 07000)

The ability of the approach drainage system to prevent water from running onto the bridge and its ability to remove water from the bridge and approach roadway.

Scuppers are located along the curb to provide drainage for the deck. If it is not desirable to allow water to free fall, scuppers are tied into downspouts to divert water to a desirable location. In some cases, gratings are used in lieu of scuppers.

Embankment

The approach embankment is the fill material required to bring the existing ground line up to the proposed grade for the roadway subgrade. The embankment foundation is the material below the original ground surface that supports the embankment.

OTHER RELATED COMPONENTS

Refer to Footing and Foundations, Substructure, and Superstructure, Volumes 01, 02, and 03 for additional deficiencies that may impact this system.

0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

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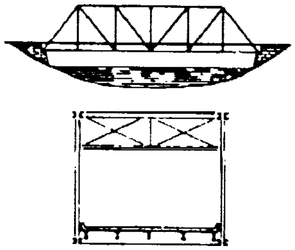
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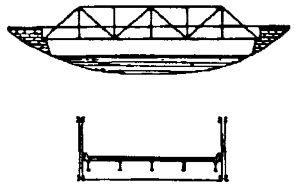
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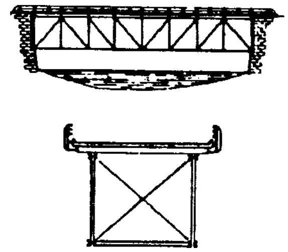
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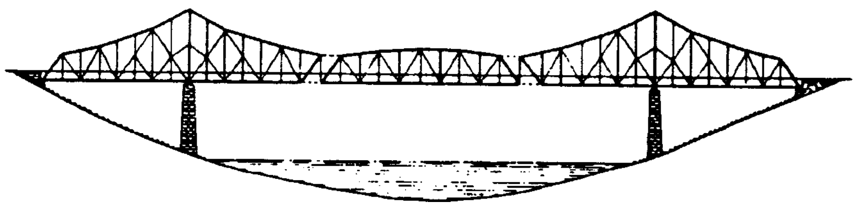
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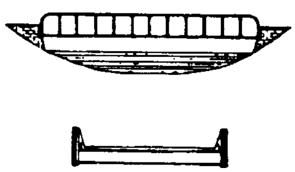
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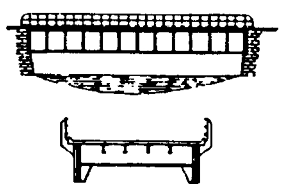
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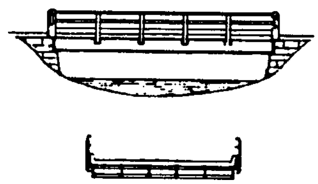
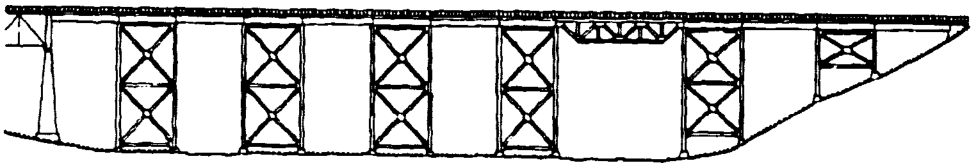
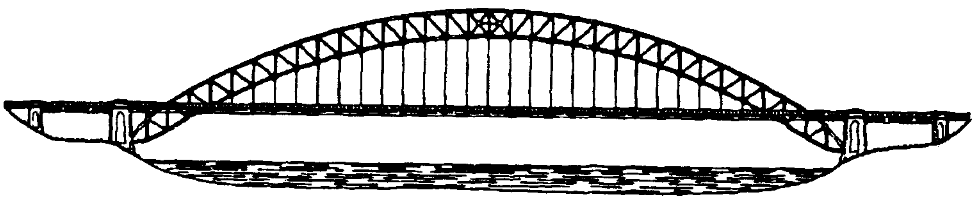

I BEAM


SUSPENSION

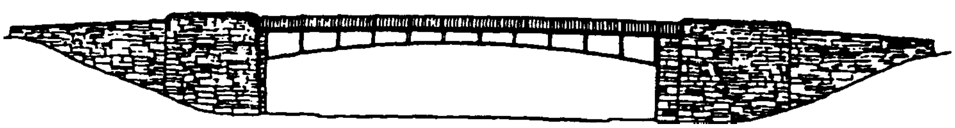
SYSTEM ASSEMBLY DETAILS-SITEWORK	GENERAL BRIDGE TYPES		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-1



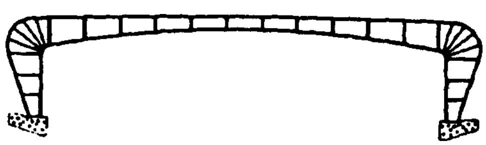
STEEL VIADUCT



THROUGH-ARCH TRUSS

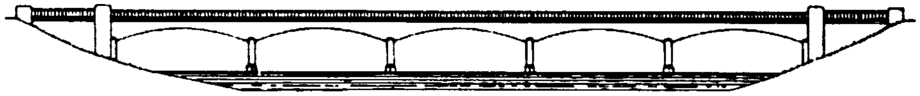


RIGID FRAME-STEEL

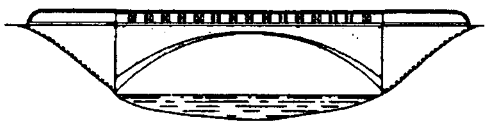


RIGID FRAME
(STEEL GIRDER ELEMENT)

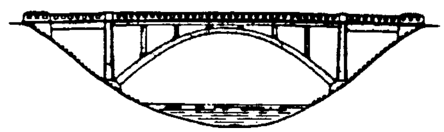
SYSTEM ASSEMBLY DETAILS-SITEWORK	GENERAL BRIDGE TYPES		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-2



CONTINUOUS GIRDER



SPANDREL-FILLED ARCH



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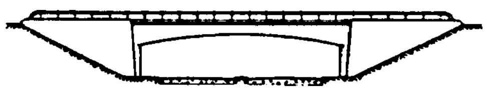
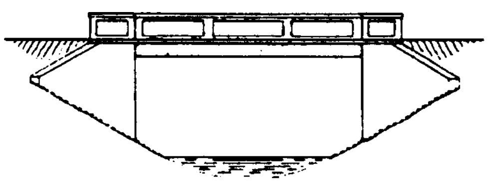
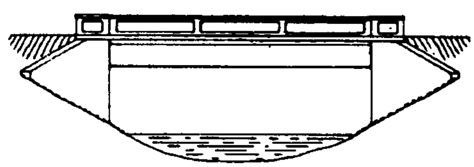


RIGID FRAME-CONCRETE



SLAB SECTION

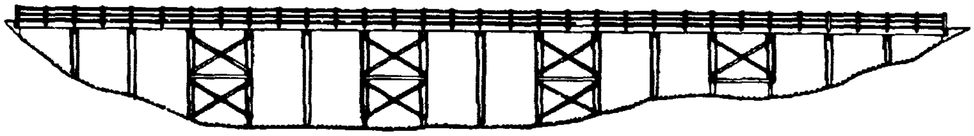
CONCRETE SLAB (PLAIN)



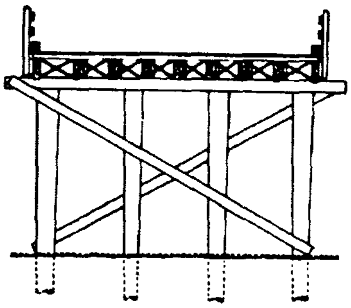
T-BEAM SECTION

CONCRETE T-BEAM

SYSTEM ASSEMBLY DETAILS-SITEWORK	**GENERAL BRIDGE TYPES**		
BRIDGES AND ABUTMENTS (CSI 02500)	**Revision No.**	**issue Date** 5/93	**Drawing No.** A1208-3



TIMBER TRESTLE



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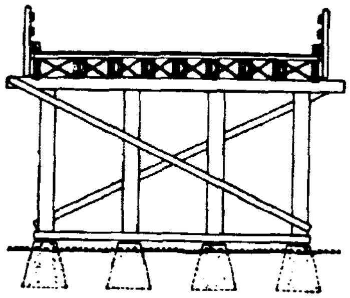

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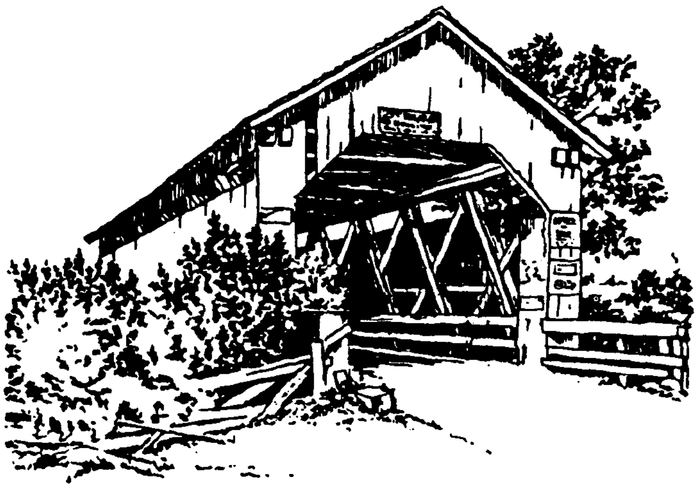
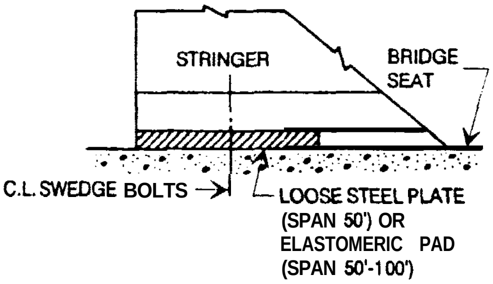


COVERED BRIDGE

SOURCE: AASHTO MANUAL FOR BRIDGE MAINTENANCE 1987

SYSTEM ASSEMBLY DETAILS-SITEWORK	GENERAL BRIDGE TYPES		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-4



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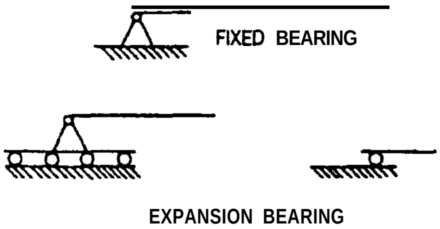

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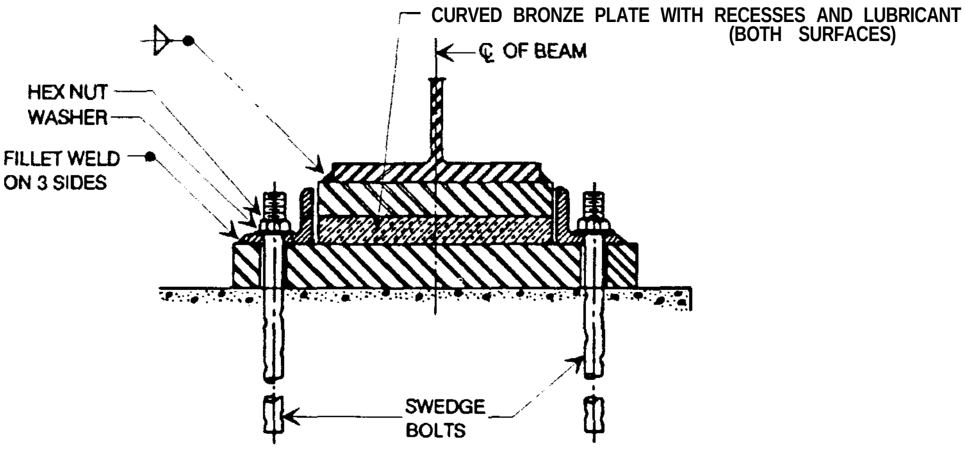
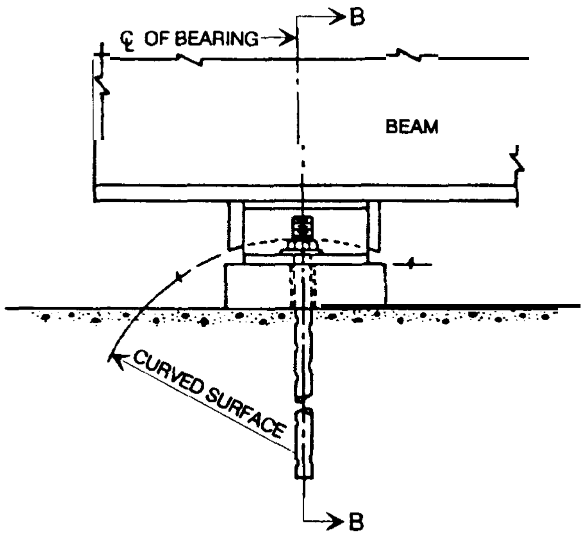


SECTION B-B



SLIDE EXPANSION BEARING

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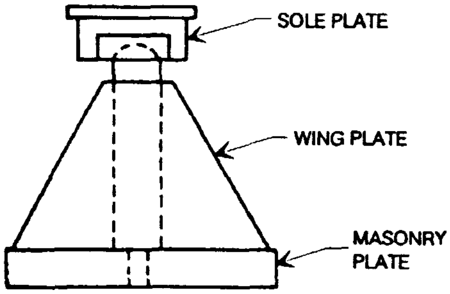
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	issue Date 5/93	Drawing No. A1208-5



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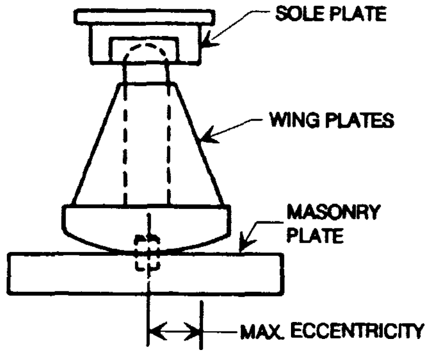

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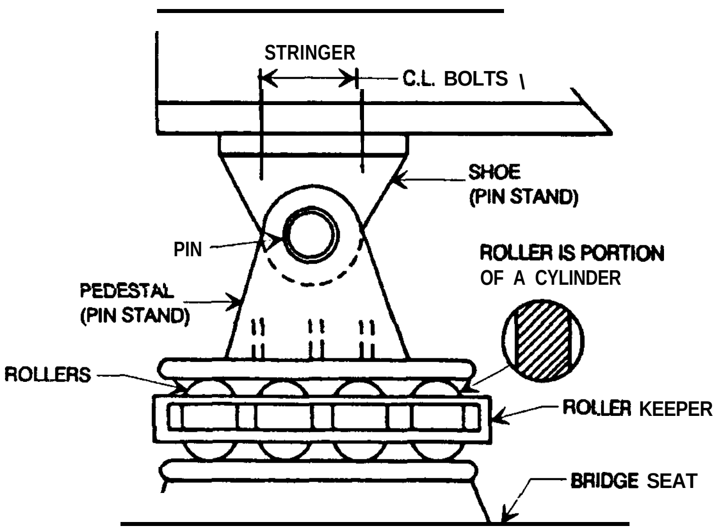
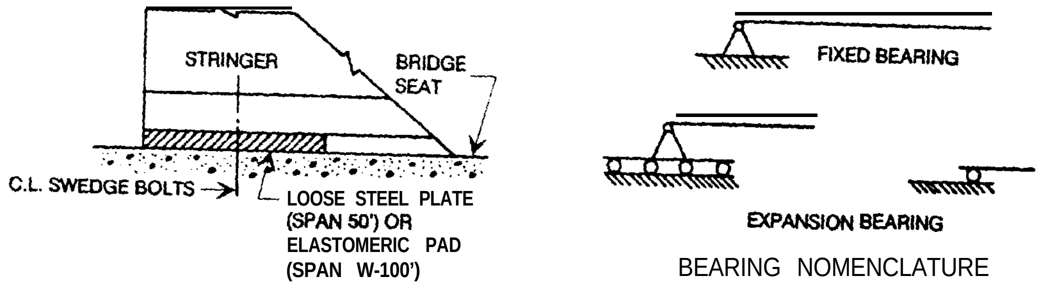


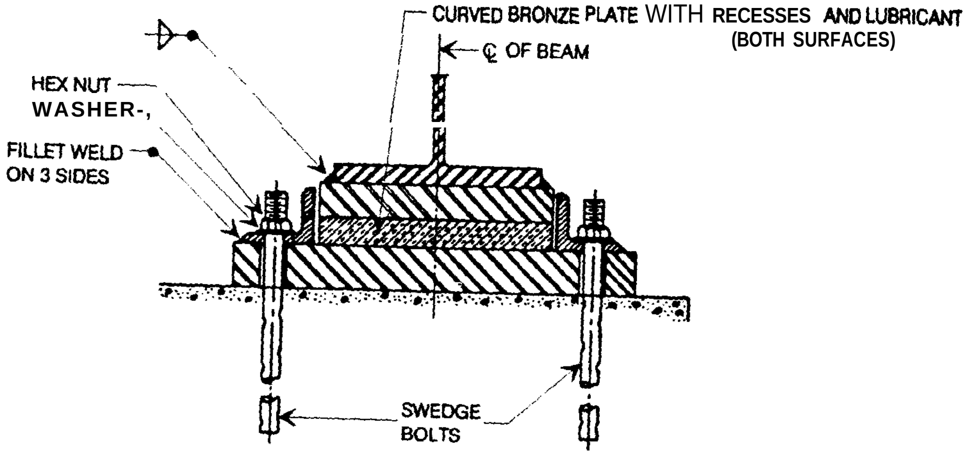
ROLLER EXPANSION BEARING

SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE BEARINGS		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-6

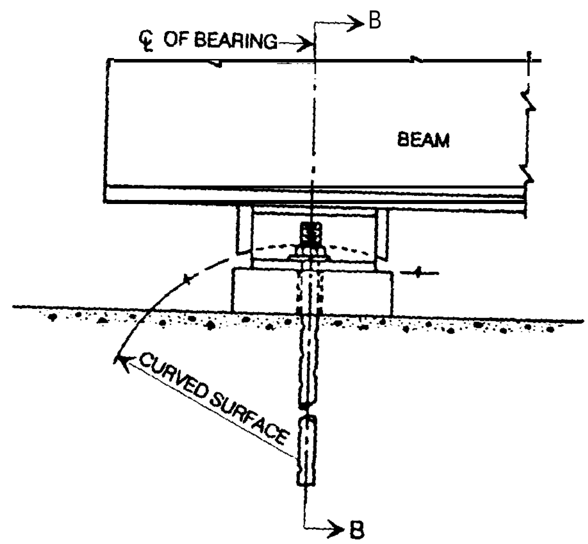


SIMPLE EXPANSION BEARING

BEARING NOMENCLATURE



SECTION B-B



SLIDE EXPANSION BEARING

SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE BEARINGS		
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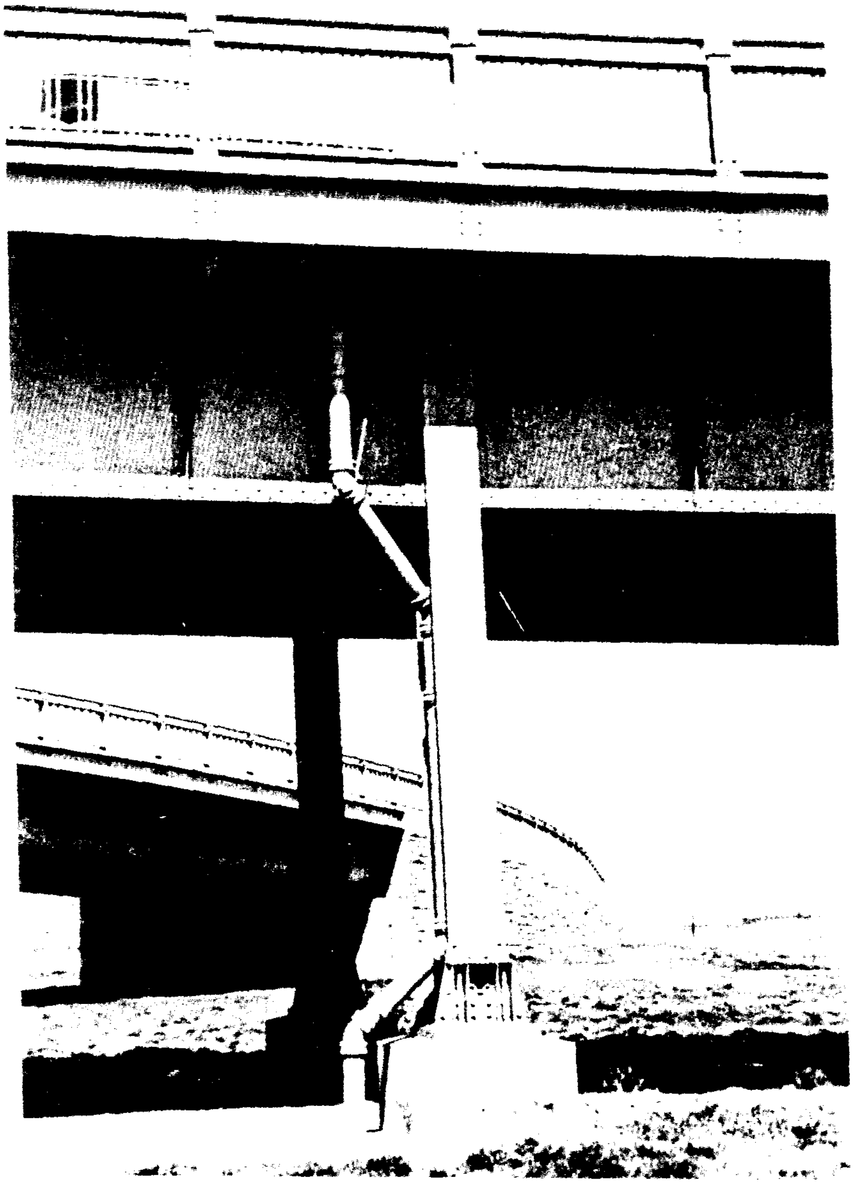

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PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	SCUPPER DRAIN PIPE		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-8

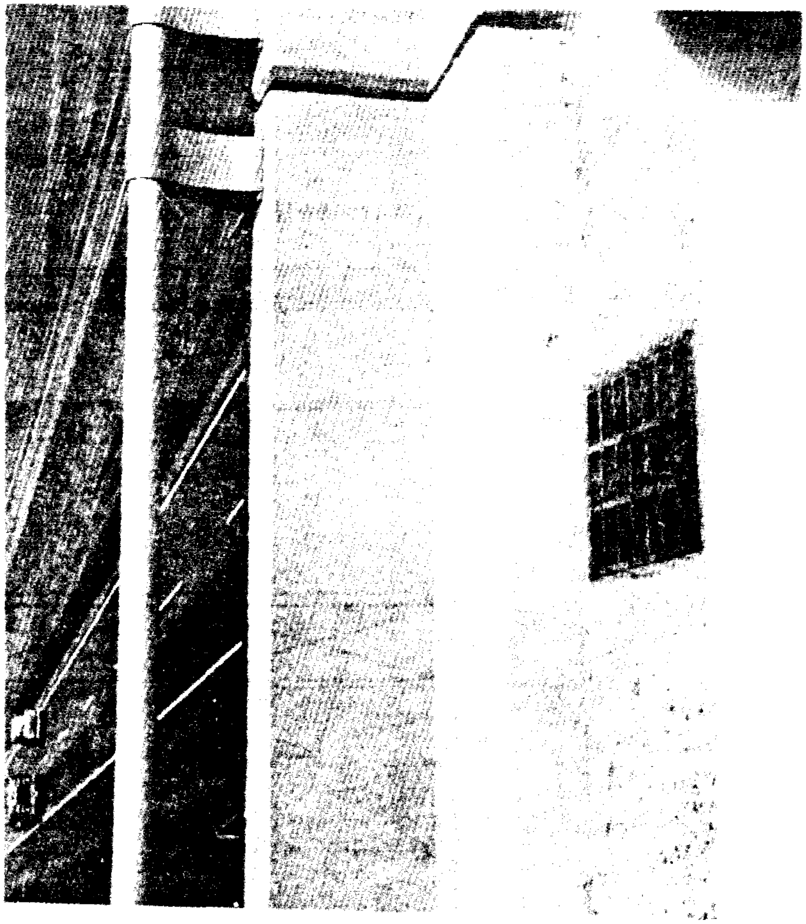
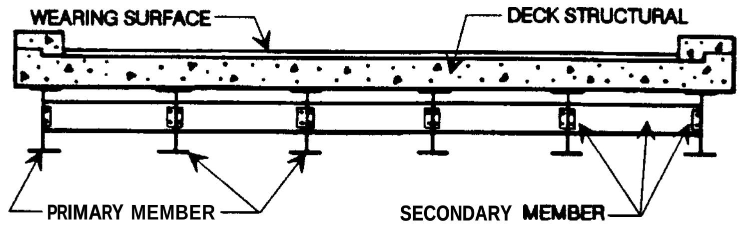


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE SCUPPER		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-9

STRINGER SPAN

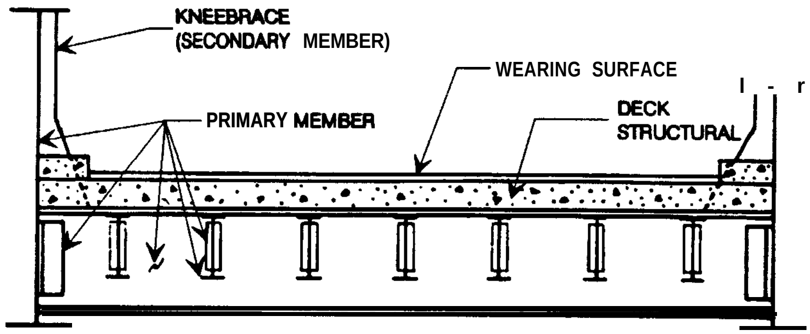
PRIMARY MEMBER	SECONDARY MEMBER
STRINGER	DIAPHRAGM



STRINGER SPAN

GIRDER SPAN

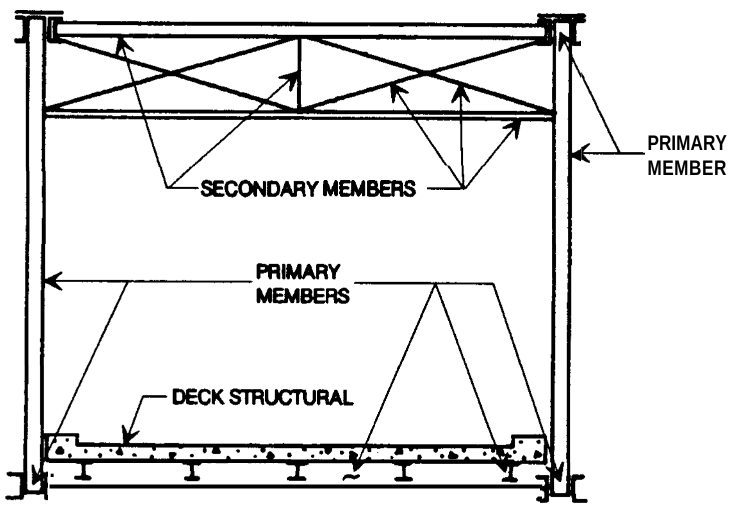
PRIMARY MEMBER	SECONDARY MEMBER
STRINGERS FLOORBEAMS GIRDERS STR./FLBM. CONN. FLBM./GIR. CONN.	KNEE BRACES



GIRDER SPAN

TRUSS SPAN

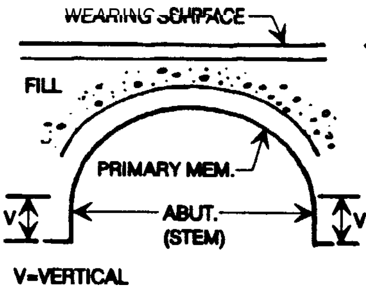
PRIMARY MEMBER	SECONDARY MEMBER
TRUSS TRUSS CONNECTION FLOORBEAMS TRUSS/FLBM. CONN. STRINGER STR./FLBM. CONN.	PORTALS LACING BARS BATTERN PLATES STAY PLATES DIAGONAL BRACING



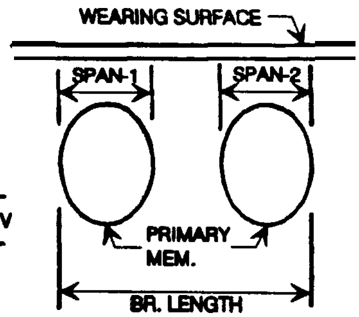
TRUSS SPAN

SOURCE: BRIDGE INSPECTION MANUAL-82, DEVELOPED BY, STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION, STRUCTURES DESIGN AND CONSTRUCTION DIVISION, INVENTORY AND INSPECTION UNIT, INSPECTION SUBUNIT

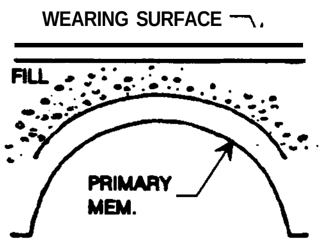
SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE TYPES		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-10



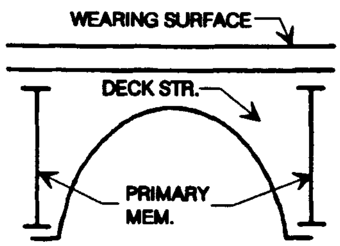
FILLED ARCH
TYPE-2



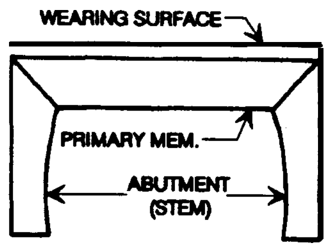
PARALLEL PIPES



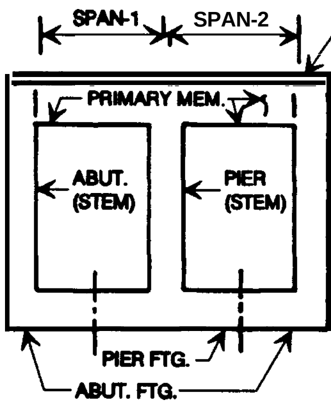
FILLED ARCH
TYPE-1



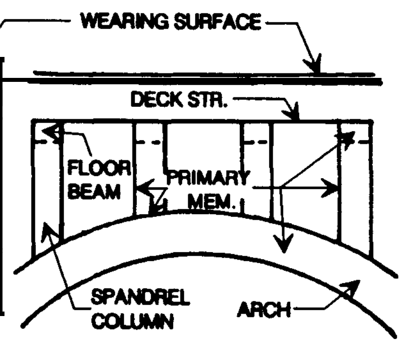
JACK ARCH
(TRANS. SECT.)



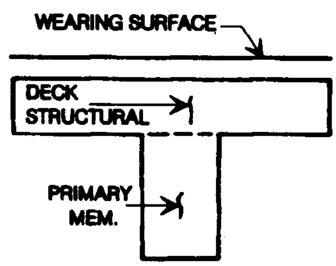
RIGID FRAME



DOUBLE BOX
CULVERT



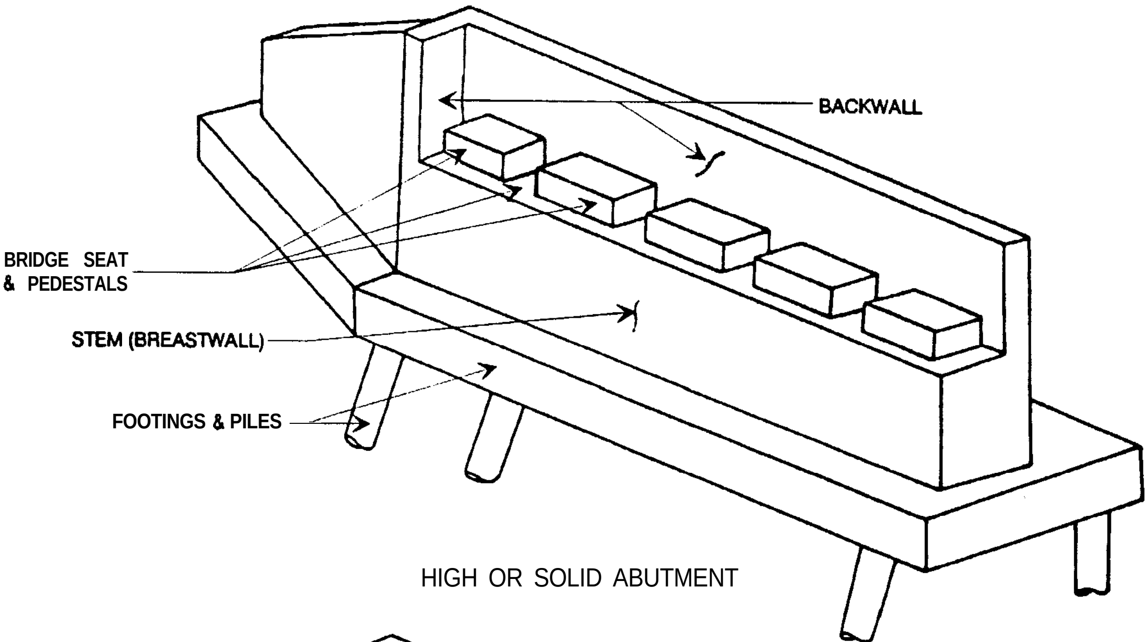
SPANDREL ARCH



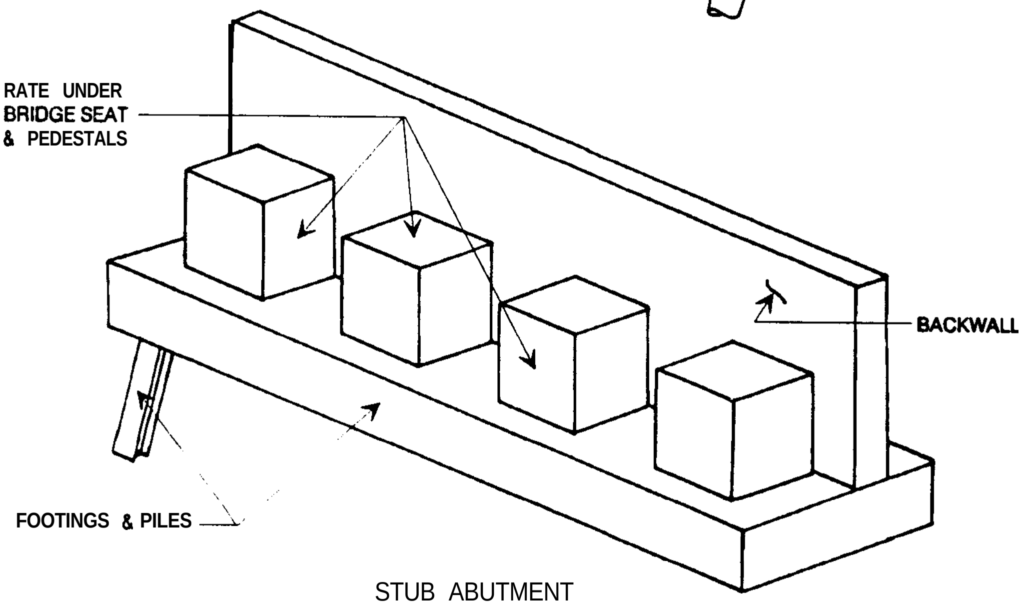
CONCRETE T-BEAM

SOURCE: BRIDGE INSPECTION MANUAL-82, DEVELOPED BY, STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION, STRUCTURES DESIGN AND CONSTRUCTION DIVISION, INVENTORY AND INSPECTION UNIT, INSPECTION SUBUNIT

SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE TYPES		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-11



HIGH OR SOLID ABUTMENT



STUB ABUTMENT
(WINGWALLS NOT SHOWN)

SYSTEM ASSEMBLY DETAILS-SITEWORK	BRIDGE ABUTMENT		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-12

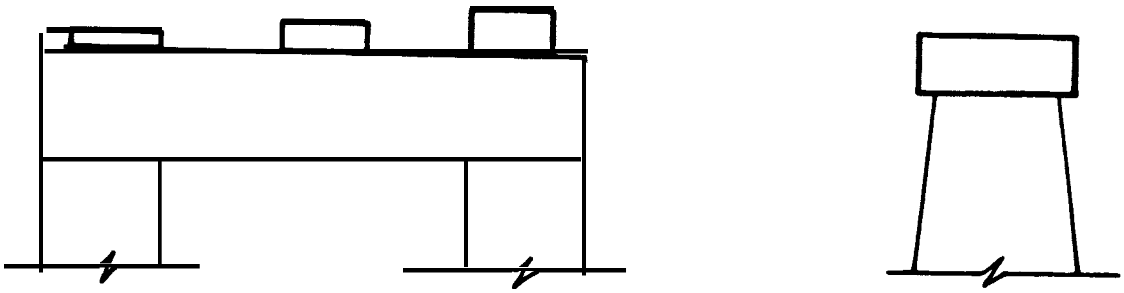
APPROVAL PENDING

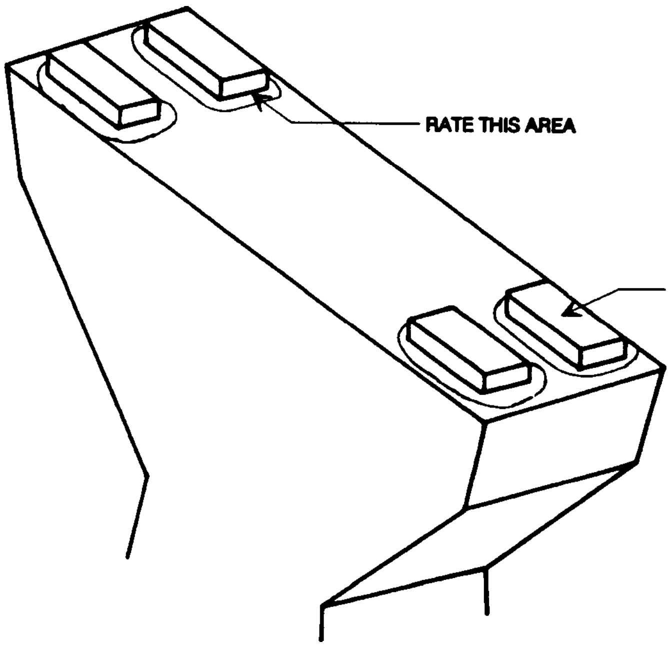
APPROVAL PENDING

PHOTO ILLUSTRATION

SOURCE: BRIDGE INSPECTION MANUAL-82, DEVELOPED BY, STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION, STRUCTURES DESIGN AND CONSTRUCTION DIVISION, INVENTORY AND INSPECTION UNIT, INSPECTION SUBUNIT

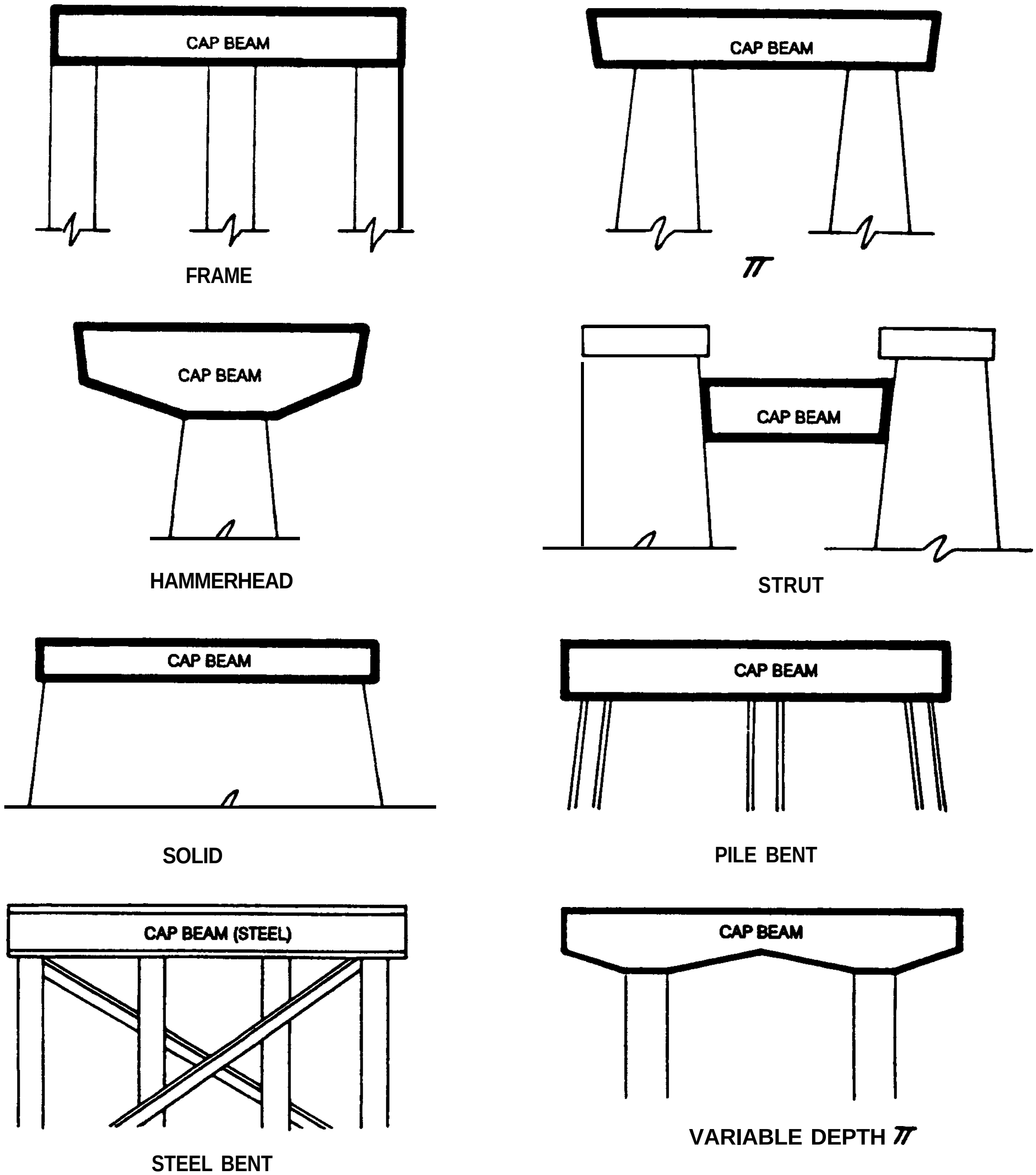
SYSTEM ASSEMBLY DETAILS-SITEWORK	ABUTMENT WINGWALL		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-13



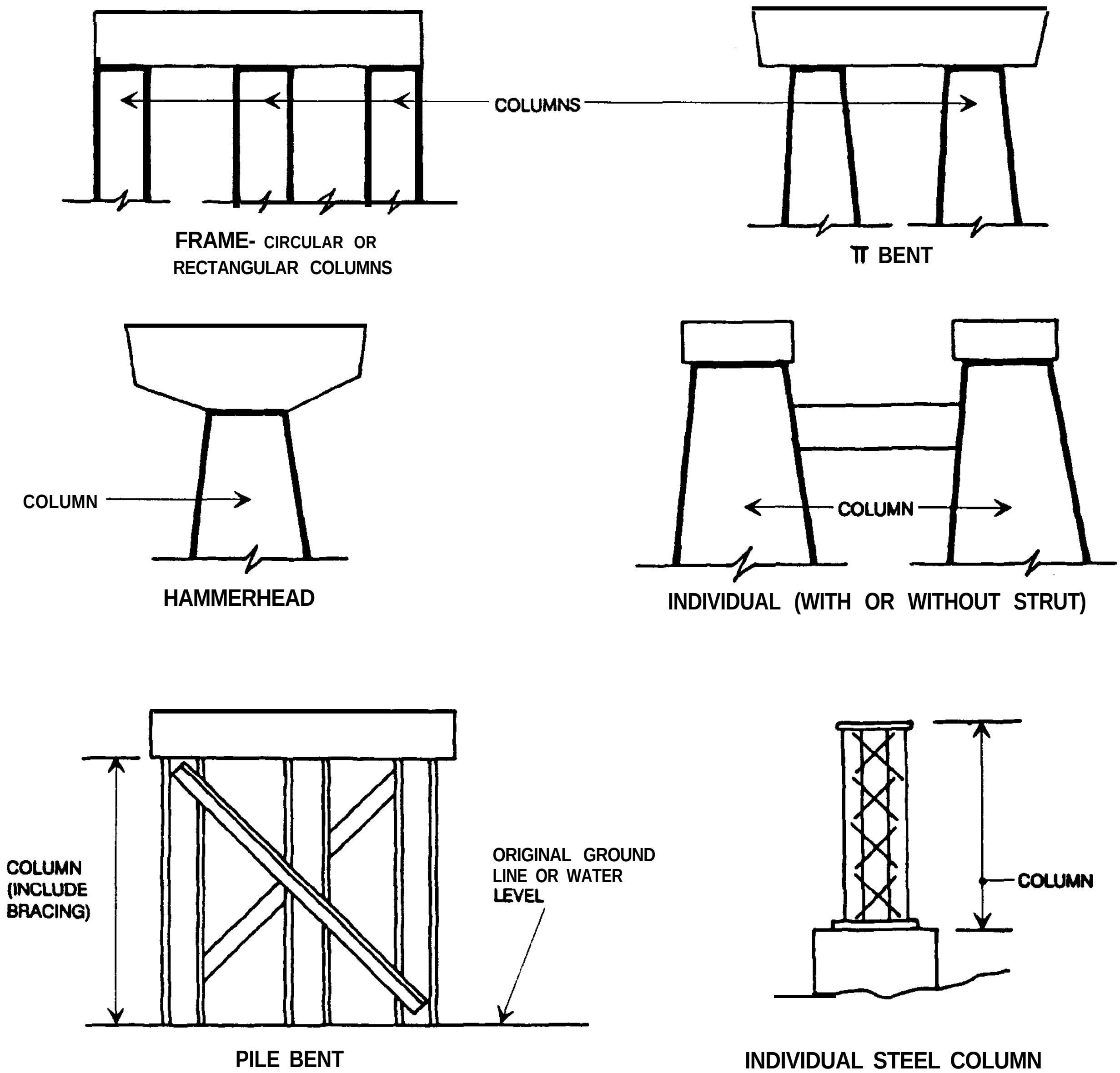


SOURCE: BRIDGE INSPECTION MANUAL-82, DEVELOPED BY, STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION, STRUCTURES DESIGN AND CONSTRUCTION DIVISION, INVENTORY AND INSPECTION UNIT, INSPECTION SUBUNIT

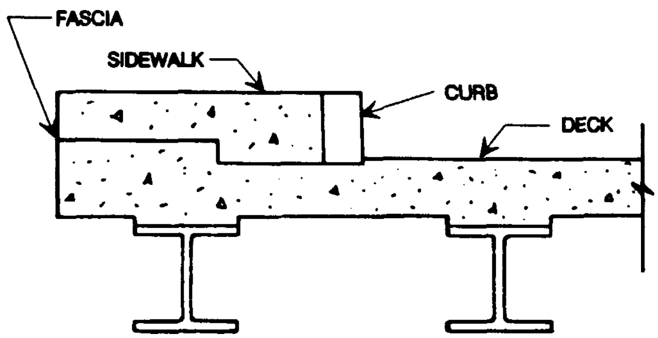
SYSTEM ASSEMBLY DETAILS-SITEWORK	TYPICAL BRIDGE PEDESTALS		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-14



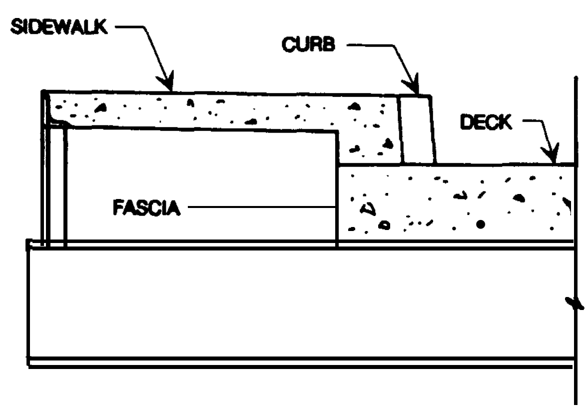
SYSTEM ASSEMBLY DETAILS-SITEWORK	CAP BEAMS		
BRIDGES AND ABUTMENTS (CSI 02500)	**Revision** No.	**Issue Date** 5/93	**Drawing** No. A1208-15



SYSTEM ASSEMBLY DETAILS-SITEWORK	PIER COLUMNS		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-16



CONCRETE OVERLAY SIDEWALK



CONCRETE STRUCTURAL SIDEWALK

SYSTEM ASSEMBLY DETAILS-SITEWORK	SIDEWALK AND FASCIA		
BRIDGES AND ABUTMENTS (CSI 02500)	Revision No.	Issue Date 5/93	Drawing No. A1208-17

DEFICIENCY FACTORS
0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

PROBABLE FAILURE POINTS

- Scaling due to expansive forces of freeze-thaw cycles, poor drainage, poor materials, or improper construction.
- Spalling due to corrosion of reinforcing steel or inferior aggregate.
- Cracking due to forces of freeze-thaw cycles, settlement/movement, poor drainage, poor materials, or improper construction.
- Reinforcement corrosion caused by an electro-chemical process that occurs in the presence of air and moisture.
- Mechanical wear caused by abrasion, accelerated by dirt and debris or studded tires.
- Ponding caused by poor drainage due to accumulation of dirt and debris, which clogs the drain system.
- Open joints caused by failure of or lack of joint sealant permitting moisture to penetrate.
- Damage caused by vehicular impact or floating debris.
- Erosion caused by the constriction of flow at the bridge site, meandering stream geometry, stream bed material, the bank material, and pier size.

SYSTEM ASSEMBLIES/DEFICIENCIES

Abutments

Scaling:	Expansive forces of freeze-thaw cycles, poor drainage, poor materials, and improper construction.
Spalling:	Corrosion of reinforcing material or inferior aggregate.
Deterioration of Timber Piles, or Structural Members:	Marine borers that tunnel into and hollow out the inside of timber members for food or shelter.
Cavities Under Footings:	Erosion of materials by weather and water leading to settlement or movement.
Cracking:	Freeze-thaw cycles, settlement/movement, poor drainage, poor materials, or improper construction.
Deterioration:	Alternate wet-dry conditions at the water line.
Corrosion:	Air and moisture attacking bare metal due to cracking and chipping of protective coating.
Damage:	Vehicular impact or floating debris.
Debris:	Buildup caused by weather, rising/falling water levels.
Frozen Bearing:	Corrosion, debris buildup, misposition.
Rot of Timber Components:	Weathering, alternate wet-dry conditions, and boring insects.

Piers

Scaling:	Expansive forces of freeze-thaw cycles, poor drainage, poor materials, and improper construction.
Spalling:	Corrosion of reinforcing material or inferior aggregate.

DEFICIENCY FACTORS
0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

SYSTEM ASSEMBLY/DEFICIENCIES

Piers (Continued)

Cavities Under Footings:	Erosion of materials by weather and water leading to settlement or movement.
Cracking:	Freeze-thaw cycles, settlement/movement, poor drainage, poor materials, or improper construction.
Deterioration:	Alternate wet-dry conditions at the water line.
Corrosion:	Air and moisture attacking bare metal due to cracking and chipping of protective coating.
Damage:	Vehicular impact or floating debris.
Debris:	Buildup caused by weather, rising/falling water levels.

Superstructure

Scaling:	Expansive forces of freeze-thaw cycles, poor drainage, poor materials, and improper construction.
Spalling:	Corrosion of reinforcing material or inferior aggregate.
Cracking:	Freeze-thaw cycles, settlement/movement, poor drainage, poor materials, improper construction, or deterioration of reinforcement steel due to lack of cathodic protection.
Corrosion:	Air and moisture attacking bare metal due to cracking and chipping of protective coating.
Damage:	Vehicular impact or floating debris.
Cracked, Broken Welds:	Stress, settlement/movement, poor materials, improper construction.
Rot of Timber Components:	Weathering, alternate wet-dry conditions, and boring insects.

Decks

Scaling:	Expansive forces of freeze-thaw cycles, poor drainage, poor materials, and improper construction.
Spalling:	Corrosion of reinforcing material or inferior aggregate.
Cracking:	Due to freeze-thaw cycles, settlement/movement, poor drainage, poor materials, improper construction, or deterioration of reinforcement steel due to lack of cathodic protection.
Corrosion:	Air and moisture attacking bare metal due to cracking and chipping of protective coating.
Cracked, Broken Welds:	Stress, settlement/movement, poor materials, improper construction.
Alligator Cracking (Asphalt Surface):	Excessive deck deflection or material drying out.
Mechanical Wear:	Abrasion, accelerated by dirt and debris or studded tires.
Ponding:	Poor drainage due to accumulation of dirt and debris which clogs the drain system.

DEFICIENCY FACTORS
0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

SYSTEM ASSEMBLY/DEFICIENCIES

Decks (Continued)

Open Joints:	Failure of or lack of joint sealant permitting moisture to penetrate.
Decay of Wood Surfaces:	Moisture penetrating around nails, bolt holes, notches, cracks, and end grain.
Curb Damage, Misalignment:	Vehicular impact.
Loose Anchor Bolts:	Vibration and temperature changes.

Utilities

Damage:	Vehicular impact, floating debris, wind, and vandalism.
Broken Piping, Conduit:	Vibration, settle/movement, corrosion, impact.
Loose Anchor Bolts:	Vibration and temperature changes
Cracking:	Freeze-thaw cycles, settlement/movement, poor drainage, poor materials, or improper construction.
Corrosion:	Air and moisture attacking bare metal due to cracking and chipping of protective coating.
Cracked, Broken Welds:	Stress, settlement/movement, poor materials, vibration, improper construction.
Missing Signs, Lights:	Taken out for service or repair and not returned, vandalism.
Loose, Missing Electrical Cover Plates:	Taken off for service not tightened, vandalism.
Pipe Leakage:	Corrosion, breaks, cracks, looseness.
Broken, Missing Pipe, Cable Supports:	Vibration, corrosion, settlement/movement, impact, improper construction.

DEFICIENCY FACTORS
0.12.08 BRIDGES & ABUTMENTS (CSI 03000)

END OF SUBSECTION

INSPECTION METHODS

GENERAL

Unlike previous volumes that have dealt with building systems and their associated primary disciplines (i.e., Volumes 1 through 6: Architectural Systems, Volumes 7 and 8: Mechanical Systems, and Volume 9 Electrical), Volume 12 SiteWork contains systems that involve all disciplines. Subsection 0.12.01 covers mechanical and electrical utility distribution systems, and 0.12.01.05, 0.12.02 through 0.12.08 handle civil/structural infrastructure items. It should be noted however, that many of these systems have as components systems addressed in the previous volumes. Where this situation occurs, the reader will be given references to the appropriate volume: only inspection data unique to the SiteWork system shall be listed in Volume 12. For example, pumps are part of the water treatment plant, but guide sheets for inspecting general pumps are found in Volume 8 Mechanical Guide sheets. For pumps unique to water treatment plants only will be listed in this volume.

INSPECTION METHODS

END OF SUBSECTION

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Water Treatment Plant inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Air Compressors	GSS 0.08.01 .01
Engines	GSS 0.08.01.04
Equipment Controls..	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories..	GSS 0.08.01.08
Pumps..	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Water Conditioners	GSS 0.08.01.14
Concrete Tanks..	GSS 0.12.01 .01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
NON STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Air Compressors..	GSNS 0.08.01 .01
Engines	GSNS 0.08.01.04
Equipment Controls..	GSNS 0.08.01.05
Motors..	GSNS 0.08.01.07
Pipe & Accessories..	GSNS 0.08.01.08
Pumps..	GSNS 0.08.01.09
Storage Tanks..	GSNS 0.08.01.12
Water Conditioners..	GSNS 0.08.01.14
Concrete Tanks..	GSNS 0.12.01.01
Conveyors (Belt, Bucket, Screw).	GSNS 0.12.01.02

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Concrete Tanks	GSS 0.12.01 .01
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Concrete Tanks	GSNS 0.12.01 .01
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Sewage & Drainage Collection System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Concrete Tanks	GSS 0.12.01 .01
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Concrete Tanks..	GSNS 0.12.01 .01
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01 .10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Waste Water Treatment Plant inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Motor-Generators	GSS 0.07.01.06
Air Compressors	GSS 0.08.01.01
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Water Conditioners	GSS 0.08.01.14
Concrete Tanks	GSS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Motor-Generators	GSNS 0.07.01.06
Air Compressors	GSNS 0.08.01.01
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Water Conditioners	GSNS 0.08.01.14
Concrete Tanks	GSNS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general site Gas Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Equipment Controls..	GSS 0.08.01.05
Pipe & Accessories..	GSS 0.08.01.08
Compressed Gas Storage Tanks..	GSS 0.08.01.03
Manholes..	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Equipment Controls..	GSNS 0.08.01.05
Pipe & Accessories..	.GSNS 0.08.01.08
Compressed Storage Tanks	GSNS 0.08.01.03
Manholes..	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01 .10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Fuel Oil Storage & Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Coal Handling System inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Ductwork & Accessories	GSS 0.08.05.02
Fans	GSS 0.08.05.03
Concrete Tanks	GSS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
Dust Collector	GSS 0.12.01.03
Pulverizer	GSS 0.12.01.05
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe &Accessories	GSNS 0.08.01.08
Ductwork & Accessories	GSNS 0.08.05.02
Fans	GSNS 0.08.05.03
Concrete Tanks	GSNS 0.12.01 .01
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02
Dust Collector	GSNS 0.12.01.03
Pulverizer	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide general Boilers inspection.

Assembly/Component	Control Number
STANDARD	
Air Compressors	GSS 0.08.01 .01
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories..	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Boilers, Fuel-Fired	GSS 0.08.03.01
Burners	GSS 0.08.03.03
Ductwork & Accessories..	GSS 0.08.05.02
Fans..	GSS 0.08.05.03
Dust Collector	GSS 0.12.01.03
Scrubbers..	GSS 0.12.01.07
Steam Turbines	GSS 0.12.01.08
Stoker	GSS 0.12.01.09
NON-STANDARD	
Air Compressors	GSNS 0.08.01 .01
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Boilers, Fuel-Fired	GSNS 0.08.03.01
Burners	GSNS 0.08.03.03
Ductwork & Accessories	GSNS 0.08.05.02
Fans	GSNS 0.08.05.03
Dust Collector	GSNS 0.12.01.03
Scrubbers	GSNS 0.12.01.07
Steam Turbines	GSNS 0.12.01.08
Stoker	GSNS 0.12.01.09

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Elevated Temperature Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Steam Distribution & Condensate Return System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Tanks & Sumps	GSS 0.08.01.13
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Tanks & Sumps	GSNS 0.08.01.13
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide general Rotary Screw Chillers inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Condensers	GSS 0.08.04.03
Liquid Coolers	GSS 0.08.04.06
Rotary Screw Chillers	GSS 0.12.01.06
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Condensers	GSNS 0.08.04.03
Liquid Coolers	GSNS 0.08.04.06
Rotary Screw Chillers	GSNS 0.12.01.06

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Chilled Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of Switchyards.

Assembly/Component	Control Number
STANDARD	
Busway	GSS 0.09.01.02.01
Communication Circuits	GSS 0.09.03.02
Concrete Support Pads..	GSS 0.12.01.05.07
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects..	GSS 0.09.01.02.03
Lighting..	GSS 0.09.02.01
Lightning Protection & Surge Suppression..	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Switchboard/Switchgear	GSS 0.09.02.09
Tower & Pole Foundations	GSS 0.12.01.05
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Busway..	GSNS 0.09.01.02.01
Communication Circuits	GSNS 0.09.03.02
Concrete Support Pads..	GSNS 0.12.01.05.07
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression..	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Switchboard/Switchgear	GSNS 0.09.02.09
Tower & Pole Foundations	GSNS 0.12.01.05
Utility Service Tunnels	GSNS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSNS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of Substations.

Assembly/Component	Control Number
STANDARD	
Busway	GSS 0.09.01.02.01
Communication Circuits	GSS 0.09.03.02
Concrete Support Pads	GSS 0.12.01.05.07
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Switchboard/Switchgear	GSS 0.09.02.09
Tower & Pole Foundations	GSS 0.12.01.05
Transformers	GSS 0.09.01.02.11
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Busway	GSNS 0.09.01.02.01
Communication Circuits	GSNS 0.09.03.02
Concrete Support Pads	GSNS 0.12.01.05.07
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Switchboard/Switchgear	GSNS 0.09.02.09
Tower & Pole Foundations	GSNS 0.12.01.05
Transformer	GSNS 0.09.01.02.11
Utility Service Tunnels	GSNS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSNS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of an Overhead Transmission System.

Assembly/Component	Control Number
STANDARD	
Communication Circuits	GSS 0.09.03.02
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Tower & Pole Foundations	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Communication Circuits	GSNS 0.09.03.02
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Tower & Pole Foundations	GSS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of an Underground Transmission System.

Assembly/Component	Control Number
STANDARD	
Communication Circuits	GSS 0.09.03.02
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05
NON-STANDARD	
Communication Circuits	GSNS 0.09.03.02
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits	GSNS 0.09.03.10
Utility Service Tunnels	GSN S 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05

END OF SUBSECTION

INSPECTION METHODS - STANDARD

MECHANICAL GUIDE SHEETS

Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general component inspection. Sheets have been developed for each major assembly/component as shown in TABLE ONE below:

TABLE ONE

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE TANKS
CONTROL NUMBER: GSS 0.12.01 .01

APPLICATION

This guide applies to concrete and masonry tanks used in site utility systems such as water and waste-water treatment. This guide may be used for inspections of the masonry aspects of mixing tanks, settling tanks, aeration tanks, filters, chlorine contact tanks, flocculation tanks, and similar concrete structures.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Air Compressors
- Pipe & Accessories
- Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general exterior appearance of tank. Note sediment, algae growth, and other substances that may contribute to deterioration of the tank surfaces.
2. Check panel surfaces for crazing (small hairline cracks caused by over finishing, freeze-thaw cycles, poor aggregate).
3. Inspect panels for cracking (longitudinal, transverse and diagonal) and corner breaks (caused by load cycling). Note depths of cracks.
4. Check panels near joints for parallel cracking or pop-outs (caused by temperature swings, freeze-thaw cycles).
5. Check for faulting (uneven levels) at joints and cracks caused by settlement, loss of support sections.
6. Inspect joints for shattering or buckling (caused for inadequate expansion space).
7. Check joint seals for damage (missing sealant, extrusion, hardening of filler, loss of bond to concrete).
8. Check tank exterior surfaces (especially corners) for damage caused by traffic, equipment movement.
9. Inspect all previous repairs. Check for continued or repeated damage and growth.
10. Note excessive corrosion of all metal work (stairs, ladders, handrails, guard rails, etc.).
11. Check entire unit for loose fasteners.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONVEYORS (Belt, Bucket, Screw)
CONTROL NUMBER: GSS 0.12.01.02

APPLICATION

This guide applies to material handling conveyors (no personnel carriers) used in site utilities to convey coal, ash, sludge, trash, and similar products between storage and processing equipment.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Drive Assemblies
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of conveyor. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of conveyor surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. On closed conveyors, check for indications of damaged cover seals (air noise, dust, fluid leaks). .
6. On open conveyors, check primary transport media (belt, buckets, flights, screw) for missing parts and proper operation. Note distortion or binding in operating mechanisms.
7. Check chains, belts, fasteners, etc. for looseness, missing components.
8. Inspect local controls and indicators for damage/proper operation.
9. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

INSPECTION METHODS . STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: DUST COLLECTORS
CONTROL NUMBER: GSS 0.12.01.03

APPLICATION

This guide applies to dust collectors, fabric arrestors, electrostatic precipitators, and similar dry process equipment typically used in large heating plants to control particulate emissions to the atmosphere.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:
- Fans
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the collector. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of collector surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals (air noise, dust, fluid leaks).
6. Check accessible bags/collector tubes for damage (tears, gouges, etc.).
7. Inspect damper/valve operators for damage, loose or missing fasteners.
8. Inspect local controls and indicators for damage/proper operation.
9. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: MANHOLES
CONTROL NUMBER: GSS 0.12.01.04

APPLICATION

This guide applies to manholes used to access underground piping, conduit, valves, and related equipment as found in site distribution systems. (Covers the manhole only, not the contained equipment.)

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Underground Pipe & Accessories
- Air Compressors
- Sumps and Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Manholes to include visual survey, examination of system records, and analysis. Points include:

1. Inspect general appearance of manhole cover and retaining ring. Note corrosion buildup on exposed surfaces (metal covers) or cracking and spalling (concrete covers).
2. Check grade of cover; ensure sufficient to prevent excess water from entering manhole.
3. Check access ladder for damage (loose or missing rungs, severe corrosion, improper anchoring).
4. Check all masonry for cracking, spalling, loose mortar.
5. Note signs of any infiltration through masonry or joint seals.
6. Check piping/conduit connections for signs of settlement.
7. Check conduit end plates and coatings for corrosion, damage.
8. Check conduit vents and drains for proper operation.
9. Check for proper drainage and signs of flooding.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS
CONTROL NUMBER: GSS 0.12.01.05

APPLICATION

This guide applies to coal pulverizers used to crush coal for use in firing of boilers.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:
- Boilers
- Conveyors
- Motors
- Scales
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the pulverizer. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of pulverizer surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, damaged or distorted supportss and anchors.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals and duct connections (air noise, dust).
6. Inspect local controls and indicators for damage/proper operation.
7. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS
CONTROL NUMBER: GSS 0.12.01.05

APPLICATION

This guide applies to coal pulverizers used to crush coal for use in firing of boilers.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repa basis.

CONCURRENT ACTIONS

Inspect associated:
- Boilers
- Conveyors
- Motors
- Scales
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of syst records, and analysis. Points include:

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1. Check general appearance of the pulverizer. Note poor housekeeping, leakage, etc. that m contribute to the accelerated deterioration of pulverizer surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, damaged or distorte supportss and anchors.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals and duct connections (air noise, dust).
6. Inspect local controls and indicators for damage/proper operation.
7. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

INSPECTION METHODS - STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SCRUBBERS
CONTROL NUMBER: GSS 0.12.01.07

APPLICATION

This guide applies to scrubbers, wet towers, and similar wet process equipment typically used in large heating plants to control particulate emissions to the atmosphere.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Fans
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the scrubber. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of scrubber surfaces.
2. Check exposed surfaces for excessive corrosion.
3. inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals (air noise, dust, fluid leaks)..
6. Inspect damper/valve operators for damage, loose or missing fasteners.
7. Inspect local controls and indicators for damage/proper operation.
8. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEAM TURBINES
CONTROL NUMBER: GSS 0.12.01.08

APPLICATION

This guide applies to small steam turbines used to drive auxiliary equipment such as pumps, fans and compressors in large central heating plants. It includes related components (fittings, valves, traps, governors, insulation, etc.).

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Pumps
- Fans
- Compressors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Steam Turbines to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the turbine. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of turbine surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Examine turbine shaft at seal areas; check for leakage, scoring.
6. Check governor and throttle valve for signs of leakage.
7. Check governor /throttle linkage for wear, loose fasteners..
8. Check bearings for indications of damage (seals, lock rings, air noise, dust, fluid leaks.
9. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

INSPECTION METHODS - STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STOKERS
CONTROL NUMBER: GSS 0.12.01.09

APPLICATION

This guide applies to the portion of stokers and related components installed external to the boiler and employed to inject coal (or other solid fuels) into site boilers. The grate portion (fixed or traveling) of the stoker is covered under the boilers, Fuel-Fired Guide Sheet.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Pulverizers
- Blowers
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Stokers to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the stoker. Note poor housekeeping, lube leakage, etc. that may contribute to the accelerated deterioration of stoker surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Examine exposed sections of rams (underfeed stokers) - check for scoring, pitting, heat damage.
6. Check drive linkage for wear, loose fasteners.
7. Check bearings for indications of damaged (seals, lock rings, or cover seals (air noise, dust, fluid leaks) .).
8. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

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INSPECTION METHODS - STANDARD

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INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND PIPING
CONTROL NUMBER: GSS 0.12.01 .10

APPLICATION

This guide applies to all underground piping used to convey chilled water, high temperature water, steam, condensate return, gas, fuel oil, etc. and includes related components (fittings, valves, expansion joints, supports, etc.) installed as part of a site infrastructure.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Manholes
- Pumps
- Motors

INSPECTION ACTIONS

Condition Asset Survey of Underground Piping to include visual survey and analysis. Points include:

1. Check general appearance of visible portions of the system through manholes, conduit accesses, trench plates, etc.
2. Note severe corrosion or erosion of piping surfaces.
3. Check for pipe leakage at exposed locations (especially at joints and couplings).
4. Note signs of leakage for direct buried piping (dead grass above piping, erosion of soil, cave-ins, gas leak testing).
5. Note piping distortion (bent, sagging, crimped, crushed).
6. Check piping expansion joints for leaks, loose fasteners., room for expansion.
7. Check pipe supports, cradles, aanchors, and hangers for defects (loose, missing fasteners; improper alignment; improper allowance for expansion).
8. Record defects in piping insulation (missing, damaged, wet).
9. Note any valve stem leakage (improper packing adjustment, worn or missing packing).
10. Check valves for damage (cracked housing, bent stem).
11. Examine all regulators - check for proper adjustment and smooth operation.
12. Check instrumentation (gauges, meters) for proper operation. Note damage, defects, inaccuracies, illegible, leakage, missing components.
13. Test cathodic protection system (ensure that allrectifiers and other sources of impressed current are operational).
14. Measure infiltration to sewer system (flag point - greater than 5,000-8,000 gpd/inch-mile).
15. Measure water loss from water distribution system (flag point - greater than 15% loss).

TOOLS & MATERIALS

1. Standard Inspection Tools - Mechanical
2. Flow monitoring equipment
3. Gas leak detector

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INSPECTION METHODS - STANDARD

ELECTRICAL GUIDE SHEETS

The following guide sheets provide a general overview of the standard inspection methods and requirements used to provide an analysis of the electrical utility distribution system. Sheets have been developed for each major component or device as shown in TABLE TWO:

TABLE TWO

Assembly/Component	Control Number	Page #
STANDARD		
Switchyards..	GSS 0.12.01.04.01	3.2-25
Substations	GSS 0.12.01.04.02	3.2-29
Overhead Transmission System..	GSS 0.12.01.04.03	3.2-33
Underground Transmission System..	GSS 0.12.01.04.04	3.2-37

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS
CONTROL NUMBER: GSS 0.12.01.04.01

APPLICATION

This guide applies to all Switchyard assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of switchyard assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Leaning
6.6 Not adequate for application
6.7 Loose, broken, damaged, corroded, or missing hardware
6.8 Inadequate mounting structure
6.9 Mounting structure not adequately secured to mounting surface
6.10 Not adequately secured to mount

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS (Continued)
CONTROL NUMBER: GSS 0.12.01.04.01

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

8.0 LIGHTNING PROTECTION & SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

9.0 METERING
If encountered, inspect metering accordance with guide sheet GSS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

16.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

17.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

18.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS
CONTROL NUMBER: GSS 0.12.01.04.02

APPLICATION

This guide applies to all Substation assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of substation assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductcrs and fittings other than control are encountered, inspect in accordance with guide sheet GSS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Leaning
6.6 Not adequate for application
6.7 Loose, broken, damaged, corroded, or missing hardware
6.8 Inadequate mounting structure
6.9 Mounting structure not adequately secured to mounting surface
6.10 Not adequately secured to mount

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS (Continued)
CONTROL NUMBER: GSS 0.12.01 .04.02

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

8.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

9.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

16.0 TRANSFORMERS
If encountered, inspect transformers in accordance with guide sheet GSS 0.09.01.02.11.

17.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

18.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

19.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: OVERHEAD TRANSMISSION SYSTEM
CONTROL NUMBER: GSS 0.12.01.04.03

APPLICATION

This guide applies to all overhead transmission systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of overhead transmission systems provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

2.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, in accordance with guide sheet GSS 0.09.01.02.02.

3.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

4.0 INSULATORS
4.1 Missing, cracked, chipped, or other damage
4.2 Tracked or carbonized
4.3 Dirty, oily, greasy, or other surface contamination
4.4 Not adequately secured
4.5 Leaning
4.6 Not adequate for application
4.7 Loose, broken, damaged, corroded, or missing hardware
4.8 Inadequate mounting structure
4.9 Mounting structure not adequately secured to mounting surface
4.10 Not adequately secured to mount

5.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

6.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: OVERHEAD TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSS 0.12.01.04.03

PHYSICAL DEFICIENCIES

7.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

8.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

9.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

10.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

11.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

12.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM
CONTROL NUMBER: GSS 0.12.01.04.04

APPLICATION

This guide applies to all underground transmission systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of underground transmission systems provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulator-y deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

2.0 CONCRETE SUPPORT PADS

If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

3.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, in accordance with guide sheet GSS 0.09.01.02.02.

4.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

5.0 INSULATORS
5.1 Missing, cracked, chipped, or other damage
5.2 Tracked or carbonized
5.3 Dirty, oily, greasy, or other surface contamination
5.4 Not adequately secured
5.5 Leaning
5.6 Not adequate for application
5.7 Loose, broken, damaged, corroded, or missing hardware
5.8 Inadequate mounting structure
5.9 Mounting structure not adequately secured to mounting surface
5.10 Not adequately secured to mount

6.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSS 0.12.01.04.04

PHYSICAL DEFICIENCIES

7.0 LIGHTNING PROTECTION & SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

8.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

9.0 RACEWAY & FITTINGS
If encountered, inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

10.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

11.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

12.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS - STANDARD

UTILITY SUPPORT STRUCTURES GUIDE SHEETS

The following Guide Sheets provide a general overview of inspection methods and requirements used to provide a general Utility Support Structures inspection. Sheets have been developed for each major type and associated assembly components as follows:

TABLE THREE

Assembly/Component	Control Number	Page #
STANDARD		
Steel Towers & Poles	GSS 0.12.01.05.01	3.2-35
Precast Concrete Poles	GSS 0.12.01.05.02	3.2-37
Wood Poles	GSS 0.12.01.05.03	3.2-39
Tower & Pole Foundations	GSS 0.12.01.05.04	3.2-41
Utility Service Tunnels	GSS 0.12.01.05.05	3.2-43
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05.06	3.2-45
Concrete Support Pads	GSS 0.12.01.05.07	3.2-47

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEEL TOWERS & POLES
CONTROL **NUMBER: GSS 0.12.01.05.01**

APPLICATION

This guide applies to all steel towers and poles.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies.
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations for any sign of damage or deterioration that may be related to steel tower or pole deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Steel Towers and Poles to include visual survey, examination of construction records, and analysis. Points include:

1. Check general appearance for any stress-related conditions. Determine type of stress as tension (pulling force), which causes stretching and cracking; compression (pushing or crushing force), which causes crushing; shear (slicing action), which causes diagonal or perpendicular to the member cracks or breakage from point of maximum load or shear; and bending (combination of tension and compression), which causes cracking. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for uneven settlement by observing ground conditions.
3. Check for improper design and construction conditions that can cause deficiencies.
4. Check bearing plates for proper bearing, anchorage, and deterioration.
5. Check for exposure conditions, specifically chemical attack (i.e., is surface material resistant to process contamination), impact exposure, staining and rust, corrosion, surface deterioration, operation or misuse of material, and extent of each.
6. Check all previous repairs and patches for any possible failures or deterioration.
7. Check for improper or damaged welds and "Lamellar" tearing of weld joints.
8. Check bolted connections to verify that bolts are properly tightened.
9. Check condition of anchorage to verify that anchorage is intact, in place, and properly tightened.
10. Perform stress analysis. Stress analysis consists of documenting the location, pattern, depth, and width of cracks.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Permanent Ink Marker
3. Tape - Masking or Duct
4. Vernier Calipers
5. Level

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INSPECTION METHODS • STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PRECAST CONCRETE POLES
CONTROL NUMBER: GSS 0.12.01.05.02

APPLICATION

This guide applies to all Precast Concrete Poles.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies,
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations for any signs of damage or deterioration that may be related to cast-in-place concrete pole deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Precast Concrete Beams to include visual survey, examination of building records, and analysis. Points include:

1. Check general appearance for any stress-related conditions. Determine type of stress as tension (pulling force), which causes cracking and usually no spalling; compression (pushing or crushing force), which causes crushing or spalling; shear (slicing action), which causes diagonal or perpendicular to the member cracking from point of maximum load or shear; and bending (combination of tension and compression), which causes cracking with no spalling. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for uneven settlement by observing ground conditions.
3. Check for improper design and construction conditions that can cause deficiencies such as cracking and surface deterioration.
4. Check for exposure conditions, specifically chemical attack (i.e., is surface material resistant to process contamination), freeze-thaw action, impact exposure, staining and rust, dusting, surface deterioration, pitting, spalling, operation or misuse of material, and extent of each.
5. Check all previous repair and patches for any possible cracking or deterioration.
6. Check for any exposed reinforcement and extent for rust or deterioration.
7. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between two cracked surfaces. Determine if crack is active or dormant by the following steps.
   a. Mark the end of the crack and check after a few days to see if crack has extended past mark. Note direction.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PRECAST CONCRETE POLES (Continued)
CONTROL NUMBER: GSS 0.12.01.05.02

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Permanent Ink Marker
3. Tape - Masking or Duct
4. Pins or Nails
5. Vernier Calipers
6. Level

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES
CONTROL NUMBER: GSS 0.12.01.05.03

APPLICATION

This guide applies to wood poles used in electrical power distribution systems.

SPECIAL INSTRUCTIONS

1. Review all operating history documentation prior to the inspection process.
2. Consult a licensed structural engineer for significant deficiencies.

CONCURRENT ACTIONS

1. Inspection of electrical equipment associated with wood poles, including line hardware, switches, grounding, etc.
2. Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of wood poles provide an input to the analysis of functional and physical deficiencies of an electrical power distribution system. Because the system exists and is not in a construction process, regulatory deficiencies associated with installation of wood poles are not addressed.

1. Check general appearance for any stress-related conditions. Determine type of stress as: tension (pulling force), which causes tearing or ripping; compression (pushing or crushing force), which causes crushing; shear (slicing action), which causes splitting and delamination; and bending (combination of tension and compression), which causes cracking or splitting. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for improper design and construction conditions that can cause deficiencies such as cracking and surface deterioration.
3. Check for exposure conditions, specifically chemical attack, freeze-thaw action, impact exposure, efflorescence, staining, dry rot, surface deterioration, decay, splitting, or misuse of material, and extent of each.
4. Check all previous repairs and patches for any possible cracking or deterioration.
5. Check for improperly designed or placed anchorage components. Verify that anchorage is intact and properly tightened.
6. Check for improper tension in guy wires.
7. Check for any splitting, cracking, or deterioration of the surface.
8. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between cracked surfaces.
9. Sound pole using hammer; check for proper tonal quality. This is a qualitative analysis not a quantitative one. A “dead” thud is a sign of interior deterioration.
10. Check that all mounting hardware (nut, bolt, clevis, brace; etc.) is free of corrosion.
11. Check for loose hardware connections. Crossarm hardware tightness may be difficult to verify around energized power conductors.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES (Continued)
CONTROL NUMBER: GSS 0.12.01.05.03

TOOLS & MATERIALS

1. Binoculars
2. Spotting Telescope
3. Standard and Phillips head screwdrivers - various sizes
4. Tape Measure
5. Permanent Ink Marker
6. Pins or nails
7. Vernier Calipers
8. Hammer
9. Flashlight
10. Level

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TOWER & POLE FOUNDATIONS
CONTROL NUMBER: GSS 0.12.01.05.04

APPLICATION

This guide applies to all tower and pole foundations.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Refer to references and glossaries as needed.

CONCURRENT ACTIONS

Inspect towers or poles for any signs of damage or deterioration that may be traced to foundation deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Tower and Pole Foundations to include visual survey, examination of building records, and analysis. Since Tower and Pole Foundations are normally hidden from direct view, the condition of adjacent systems must be surveyed. Points include:

1. Check for surface deterioration in the form of cracking, spalling, pop-outs, or separations if applicable.
2. Check for exposure conditions, specifically chemical attack and freeze-thaw action, causing excessive movement or surface deterioration.
3. Check for improper, unbalanced, or overloading conditions that can cause fatigue or failure.
4. Check for uneven settlement by observing condition of existing grade.
5. Check for corrosion of rebar and degree of damage.
6. Check all previous repairs and patches for any possible cracking or deterioration.
7. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between two cracked surfaces. Determine if a crack is active or dormant by doing the following steps:
   a. Mark the end of the crack and check after a few days to see if crack has extended past mark. Note direction.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Tape Measure
3. Permanent Ink Marker
4. Tape - Masking or Duct
5. Pins or Nails
6. Vernier Calipers
7. Level

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INSPECTION METHODS

GENERAL

Unlike previous volumes that have dealt with building systems and their associated primary disciplines (i.e., Volumes 1 through 6: Architectural Systems, Volumes 7 and 8: Mechanical Systems, and Volume 9 Electrical), Volume 12 SiteWork contains systems that involve all disciplines. Subsection 0.12.01 covers mechanical and electrical utility distribution systems, and 0.12.01.05, 0.12.02 through 0.12.08 handle civil/structural infrastructure items. It should be noted however, that many of these systems have as components systems addressed in the previous volumes. Where this situation occurs, the reader will be given references to the appropriate volume: only inspection data unique to the SiteWork system shall be listed in Volume 12. For example, pumps are part of the water treatment plant, but guide sheets for inspecting general pumps are found in Volume 8 Mechanical Guide sheets. For pumps unique to water treatment plants only will be listed in this volume.

INSPECTION METHODS

END OF SUBSECTION

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Water Treatment Plant inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Air Compressors	GSS 0.08.01.01
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Water Conditioners	GSS 0.08.01.14
Concrete Tanks	GSS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
NON STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Air Compressors	GSNS 0.08.01.01
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Water Conditioners	GSNS 0.08.01.14
Concrete Tanks	GSNS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Concrete Tanks	GSS 0.12.01 .01
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Concrete Tanks	GSNS 0.12.01 .01
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Sewage & Drainage Collection System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Concrete Tanks	GSS 0.12.01 .01
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Concrete Tanks..	GSNS 0.12.01 .01
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01 .10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Waste Water Treatment Plant inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Motor-Generators	GSS 0.07.01.06
Air Compressors	GSS 0.08.01.01
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Water Conditioners	GSS 0.08.01.14
Concrete Tanks	GSS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Motor-Generators	GSNS 0.07.01.06
Air Compressors	GSNS 0.08.01.01
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Water Conditioners	GSNS 0.08.01.14
Concrete Tanks	GSNS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general site Gas Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Equipment Controls..	GSS 0.08.01.05
Pipe & Accessories..	GSS 0.08.01.08
Compressed Gas Storage Tanks..	GSS 0.08.01.03
Manholes..	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Equipment Controls..	GSNS 0.08.01.05
Pipe & Accessories..	.GSNS 0.08.01.08
Compressed Storage Tanks	GSNS 0.08.01.03
Manholes..	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01 .10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Fuel Oil Storage & Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Storage Tanks	GSS 0.08.01.12
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Storage Tanks	GSNS 0.08.01.12
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Coal Handling System inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Ductwork & Accessories	GSS 0.08.05.02
Fans	GSS 0.08.05.03
Concrete Tanks	GSS 0.12.01.01
Conveyors (Belt, Bucket, Screw)	GSS 0.12.01.02
Dust Collector	GSS 0.12.01.03
Pulverizer	GSS 0.12.01.05
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe &Accessories	GSNS 0.08.01.08
Ductwork & Accessories	GSNS 0.08.05.02
Fans	GSNS 0.08.05.03
Concrete Tanks	GSNS 0.12.01 .01
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02
Dust Collector	GSNS 0.12.01.03
Pulverizer	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide general Boilers inspection.

Assembly/Component	Control Number
STANDARD	
Air Compressors	GSS 0.08.01 .01
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories..	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Boilers, Fuel-Fired	GSS 0.08.03.01
Burners	GSS 0.08.03.03
Ductwork & Accessories..	GSS 0.08.05.02
Fans..	GSS 0.08.05.03
Dust Collector	GSS 0.12.01.03
Scrubbers..	GSS 0.12.01.07
Steam Turbines	GSS 0.12.01.08
Stoker	GSS 0.12.01.09
NON-STANDARD	
Air Compressors	GSNS 0.08.01 .01
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Boilers, Fuel-Fired	GSNS 0.08.03.01
Burners	GSNS 0.08.03.03
Ductwork & Accessories	GSNS 0.08.05.02
Fans	GSNS 0.08.05.03
Dust Collector	GSNS 0.12.01.03
Scrubbers	GSNS 0.12.01.07
Steam Turbines	GSNS 0.12.01.08
Stoker	GSNS 0.12.01.09

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Elevated Temperature Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01 .10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSN S 0.08.01.08
Pumps	GSNS 0.08.01.09
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Steam Distribution & Condensate Return System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Tanks & Sumps	GSS 0.08.01.13
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Tanks & Sumps	GSNS 0.08.01.13
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide general Rotary Screw Chillers inspection.

Assembly/Component	Control Number
STANDARD	
Drive Assemblies	GSS 0.07.01.02
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Condensers	GSS 0.08.04.03
Liquid Coolers	GSS 0.08.04.06
Rotary Screw Chillers	GSS 0.12.01.06
NON-STANDARD	
Drive Assemblies	GSNS 0.07.01.02
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Condensers	GSNS 0.08.04.03
Liquid Coolers	GSNS 0.08.04.06
Rotary Screw Chillers	GSNS 0.12.01.06

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general Chilled Water Distribution System inspection.

Assembly/Component	Control Number
STANDARD	
Engines	GSS 0.08.01.04
Equipment Controls	GSS 0.08.01.05
Motors	GSS 0.08.01.07
Pipe & Accessories	GSS 0.08.01.08
Pumps	GSS 0.08.01.09
Manholes	GSS 0.12.01.04
Underground Piping	GSS 0.12.01.10
NON-STANDARD	
Engines	GSNS 0.08.01.04
Equipment Controls	GSNS 0.08.01.05
Motors	GSNS 0.08.01.07
Pipe & Accessories	GSNS 0.08.01.08
Pumps	GSNS 0.08.01.09
Manholes	GSNS 0.12.01.04
Underground Piping	GSNS 0.12.01.10

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of Switchyards.

Assembly/Component	Control Number
STANDARD	
Busway	GSS 0.09.01.02.01
Communication Circuits	GSS 0.09.03.02
Concrete Support Pads	GSS 0.12.01.05.07
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Switchboard/Switchgear	GSS 0.09.02.09
Tower & Pole Foundations	GSS 0.12.01.05
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels:	
Dampproofing/Waterproofing	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Busway	GSNS 0.09.01.02.01
Communication Circuits	GSNS 0.09.03.02
Concrete Support Pads	GSNS 0.12.01.05.07
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Switchboard/Switchgear	GSNS 0.09.02.09
Tower & Pole Foundations	GSNS 0.12.01.05
Utility Service Tunnels	GSNS 0.12.01.05
Utility Service Tunnels:	
Dampproofing/Waterproofing	GSNS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of Substations.

Assembly/Component	Control Number
STANDARD	
Busway	GSS 0.09.01.02.01
Communication Circuits	GSS 0.09.03.02
Concrete Support Pads	GSS 0.12.01.05.07
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Switchboard/Switchgear	GSS 0.09.02.09
Tower & Pole Foundations	GSS 0.12.01.05
Transformers	GSS 0.09.01.02.11
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Busway	GSNS 0.09.01.02.01
Communication Circuits	GSNS 0.09.03.02
Concrete Support Pads	GSNS 0.12.01.05.07
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Switchboard/Switchgear	GSNS 0.09.02.09
Tower & Pole Foundations	GSNS 0.12.01.05
Transformer	GSNS 0.09.01.02.11
Utility Service Tunnels	GSNS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSNS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of an Overhead Transmission System.

Assembly/Component	Control Number
STANDARD	
Communication Circuits	GSS 0.09.03.02
Conductors & Fittings	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting	GSS 0.09.02.01
Lightning Protection & Surge Suppression	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Signal Circuits	GSS 0.09.03.10
Steel Towers & Poles	GSS 0.12.01.05
Tower & Pole Foundations	GSS 0.12.01.05
Wood Poles	GSS 0.12.01.05
NON-STANDARD	
Communication Circuits	GSNS 0.09.03.02
Conductors & Fittings	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting	GSNS 0.09.02.01
Lightning Protection & Surge Suppression	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Signal Circuits	GSNS 0.09.03.10
Steel Towers & Poles	GSNS 0.12.01.05
Tower & Pole Foundations	GSS 0.12.01.05
Wood Poles	GSNS 0.12.01.05

GUIDE SHEET CROSS REFERENCE TABLES

GUIDE SHEETS

The following Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general inspection of the components of an Underground Transmission System.

Assembly/Component	Control Number
STANDARD	
Communication Circuits	GSS 0.09.03.02
Conductors & Fittings..	GSS 0.09.01.02.02
Disconnects	GSS 0.09.01.02.03
Lighting..	GSS 0.09.02.01
Lightning Protection & Surge Suppression..	GSS 0.09.03.08
Metering	GSS 0.09.02.04
Raceway & Fittings	GSS 0.09.01.02.08
Signal Circuits	GSS 0.09.03.10
Utility Service Tunnels	GSS 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05
NON-STANDARD	
Communication Circuits	GSNS 0.09.03.02
Conductors & Fittings..	GSNS 0.09.01.02.02
Disconnects	GSNS 0.09.01.02.03
Lighting..	GSNS 0.09.02.01
Lightning Protection & Surge Suppression..	GSNS 0.09.03.08
Metering	GSNS 0.09.02.04
Raceway & Fittings	GSNS 0.09.01.02.08
Signal Circuits..	GSNS 0.09.03.10
Utility Service Tunnels	..GSN S 0.12.01.05
Utility Service Tunnels: Dampproofing/Waterproofing	GSS 0.12.01.05

END OF SUBSECTION

INSPECTION METHODS - STANDARD

MECHANICAL GUIDE SHEETS

Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general component inspection. Sheets have been developed for each major assembly/component as shown in TABLE ONE below:

TABLE ONE

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE TANKS
CONTROL NUMBER: GSS 0.12.01 .01

APPLICATION

This guide applies to concrete and masonry tanks used in site utility systems such as water and waste-water treatment. This guide may be used for inspections of the masonry aspects of mixing tanks, settling tanks, aeration tanks, filters, chlorine contact tanks, flocculation tanks, and similar concrete structures.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Air Compressors
- Pipe & Accessories
- Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general exterior appearance of tank. Note sediment, algae growth, and other substances that may contribute to deterioration of the tank surfaces.
2. Check panel surfaces for crazing (small hairline cracks caused by over finishing, freeze-thaw cycles, poor aggregate).
3. Inspect panels for cracking (longitudinal, transverse and diagonal) and corner breaks (caused by load cycling). Note depths of cracks.
4. Check panels near joints for parallel cracking or pop-outs (caused by temperature swings, freeze-thaw cycles).
5. Check for faulting (uneven levels) at joints and cracks caused by settlement, loss of support sections.
6. Inspect joints for shattering or buckling (caused for inadequate expansion space).
7. Check joint seals for damage (missing sealant, extrusion, hardening of filler, loss of bond to concrete).
8. Check tank exterior surfaces (especially corners) for damage caused by traffic, equipment movement.
9. Inspect all previous repairs. Check for continued or repeated damage and growth.
10. Note excessive corrosion of all metal work (stairs, ladders, handrails, guard rails, etc.).
11. Check entire unit for loose fasteners.

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONVEYORS (Belt, Bucket, Screw)
CONTROL NUMBER: GSS 0.12.01.02

APPLICATION

This guide applies to material handling conveyors (no personnel carriers) used in site utilities to convey coal, ash, sludge, trash, and similar products between storage and processing equipment.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:
- Drive Assemblies
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of conveyor. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of conveyor surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. On closed conveyors, check for indications of damaged cover seals (air noise, dust, fluid leaks). .
6. On open conveyors, check primary transport media (belt, buckets, flights, screw) for missing parts and proper operation. Note distortion or binding in operating mechanisms.
7. Check chains, belts, fasteners, etc. for looseness, missing components.
8. Inspect local controls and indicators for damage/proper operation.
9. Check for excessive noise or vibration in components.

TOOLS & MATERIALS

Standard Inspection Tools - Mechanical

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: DUST COLLECTORS
CONTROL NUMBER: GSS 0.12.01.03

APPLICATION

This guide applies to dust collectors, fabric arrestors, electrostatic precipitators, and similar dry process equipment typically used in large heating plants to control particulate emissions to the atmosphere.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Fans
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the collector. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of collector surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals (air noise, dust, fluid leaks).
6. Check accessible bags/collector tubes for damage (tears, gouges, etc.).
7. Inspect damper/valve operators for damage, loose or missing fasteners.
8. Inspect local controls and indicators for damage/proper operation.
9. Check for excessive noise or vibration in components.

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: MANHOLES
CONTROL NUMBER: GSS 0.12.01.04

APPLICATION

This guide applies to manholes used to access underground piping, conduit, valves, and related equipment as found in site distribution systems. (Covers the manhole only, not the contained equipment.)

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Underground Pipe & Accessories
- Air Compressors
- Sumps and Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Manholes to include visual survey, examination of system records, and analysis. Points include:

1. Inspect general appearance of manhole cover and retaining ring. Note corrosion buildup on exposed surfaces (metal covers) or cracking and spalling (concrete covers).
2. Check grade of cover; ensure sufficient to prevent excess water from entering manhole.
3. Check access ladder for damage (loose or missing rungs, severe corrosion, improper anchoring).
4. Check all masonry for cracking, spalling, loose mortar.
5. Note signs of any infiltration through masonry or joint seals.
6. Check piping/conduit connections for signs of settlement.
7. Check conduit end plates and coatings for corrosion, damage.
8. Check conduit vents and drains for proper operation.
9. Check for proper drainage and signs of flooding.

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS
CONTROL NUMBER: GSS 0.12.01.05

APPLICATION

This guide applies to coal pulverizers used to crush coal for use in firing of boilers.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Conveyors
- Motors
- Scales
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the pulverizer. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of pulverizer surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, damaged or distorted supportss and anchors.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals and duct connections (air noise, dust).
6. Inspect local controls and indicators for damage/proper operation.
7. Check for excessive noise or vibration in components.

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS
CONTROL NUMBER: GSS 0.12.01.05

APPLICATION

This guide applies to coal pulverizers used to crush coal for use in firing of boilers.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repa basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Conveyors
- Motors
- Scales
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of syst records, and analysis. Points include:

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1. Check general appearance of the pulverizer. Note poor housekeeping, leakage, etc. that m contribute to the accelerated deterioration of pulverizer surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Inspect accessible structure. Note loose or missing fasteners, damaged or distorte supportss and anchors.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals and duct connections (air noise, dust).
6. Inspect local controls and indicators for damage/proper operation.
7. Check for excessive noise or vibration in components.

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GUIDE SHEET

SYSTEM/COMPONENT: SCRUBBERS
CONTROL NUMBER: GSS 0.12.01.07

APPLICATION

This guide applies to scrubbers, wet towers, and similar wet process equipment typically used in large heating plants to control particulate emissions to the atmosphere.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Fans
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the scrubber. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of scrubber surfaces.
2. Check exposed surfaces for excessive corrosion.
3. inspect accessible structure. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Check for indications of damaged cover seals (air noise, dust, fluid leaks)..
6. Inspect damper/valve operators for damage, loose or missing fasteners.
7. Inspect local controls and indicators for damage/proper operation.
8. Check for excessive noise or vibration in components.

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GUIDE SHEET

SYSTEM/COMPONENT: STEAM TURBINES
CONTROL NUMBER: GSS 0.12.01.08

APPLICATION

This guide applies to small steam turbines used to drive auxiliary equipment such as pumps, fans and compressors in large central heating plants. It includes related components (fittings, valves, traps, governors, insulation, etc.).

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Pumps
- Fans
- Compressors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Steam Turbines to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the turbine. Note poor housekeeping, leakage, etc. that may contribute to the accelerated deterioration of turbine surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Examine turbine shaft at seal areas; check for leakage, scoring.
6. Check governor and throttle valve for signs of leakage.
7. Check governor /throttle linkage for wear, loose fasteners..
8. Check bearings for indications of damage (seals, lock rings, air noise, dust, fluid leaks.
9. Check for excessive noise or vibration in components.

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INSPECTION METHODS - STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STOKERS
CONTROL NUMBER: GSS 0.12.01.09

APPLICATION

This guide applies to the portion of stokers and related components installed external to the boiler and employed to inject coal (or other solid fuels) into site boilers. The grate portion (fixed or traveling) of the stoker is covered under the boilers, Fuel-Fired Guide Sheet.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Pulverizers
- Blowers
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Stokers to include visual survey, examination of system records, and analysis. Points include:

1. Check general appearance of the stoker. Note poor housekeeping, lube leakage, etc. that may contribute to the accelerated deterioration of stoker surfaces.
2. Check exposed surfaces for excessive corrosion.
3. Note loose or missing fasteners, support member damage or distortion.
4. Note loose, missing, or damaged covers and guards.
5. Examine exposed sections of rams (underfeed stokers) - check for scoring, pitting, heat damage.
6. Check drive linkage for wear, loose fasteners.
7. Check bearings for indications of damaged (seals, lock rings, or cover seals (air noise, dust, fluid leaks) .).
8. Check for excessive noise or vibration in components.

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GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND PIPING
CONTROL NUMBER: GSS 0.12.01 .10

APPLICATION

This guide applies to all underground piping used to convey chilled water, high temperature water, steam, condensate return, gas, fuel oil, etc. and includes related components (fittings, valves, expansion joints, supports, etc.) installed as part of a site infrastructure.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Manholes
- Pumps
- Motors

INSPECTION ACTIONS

Condition Asset Survey of Underground Piping to include visual survey and analysis. Points include:

1. Check general appearance of visible portions of the system through manholes, conduit accesses, trench plates, etc.
2. Note severe corrosion or erosion of piping surfaces.
3. Check for pipe leakage at exposed locations (especially at joints and couplings).
4. Note signs of leakage for direct buried piping (dead grass above piping, erosion of soil, cave-ins, gas leak testing).
5. Note piping distortion (bent, sagging, crimped, crushed).
6. Check piping expansion joints for leaks, loose fasteners., room for expansion.
7. Check pipe supports, cradles, aanchors, and hangers for defects (loose, missing fasteners; improper alignment; improper allowance for expansion).
8. Record defects in piping insulation (missing, damaged, wet).
9. Note any valve stem leakage (improper packing adjustment, worn or missing packing).
10. Check valves for damage (cracked housing, bent stem).
11. Examine all regulators - check for proper adjustment and smooth operation.
12. Check instrumentation (gauges, meters) for proper operation. Note damage, defects, inaccuracies, illegible, leakage, missing components.
13. Test cathodic protection system (ensure that allrectifiers and other sources of impressed current are operational).
14. Measure infiltration to sewer system (flag point - greater than 5,000-8,000 gpd/inch-mile).
15. Measure water loss from water distribution system (flag point - greater than 15% loss).

TOOLS & MATERIALS

1. Standard Inspection Tools - Mechanical
2. Flow monitoring equipment
3. Gas leak detector

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INSPECTION METHODS - STANDARD

ELECTRICAL GUIDE SHEETS

The following guide sheets provide a general overview of the standard inspection methods and requirements used to provide an analysis of the electrical utility distribution system. Sheets have been developed for each major component or device as shown in TABLE TWO:

TABLE TWO

Assembly/Component	Control Number	Page #
STANDARD		
Switchyards	GSS 0.12.01.04.01	3.2-25
Substations	GSS 0.12.01.04.02	3.2-29
Overhead Transmission System	GSS 0.12.01.04.03	3.2-33
Underground Transmission System	GSS 0.12.01.04.04	3.2-37

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS
CONTROL NUMBER: GSS 0.12.01.04.01

APPLICATION

This guide applies to all Switchyard assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of switchyard assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Leaning
6.6 Not adequate for application
6.7 Loose, broken, damaged, corroded, or missing hardware
6.8 Inadequate mounting structure
6.9 Mounting structure not adequately secured to mounting surface
6.10 Not adequately secured to mount

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS (Continued)
CONTROL NUMBER: GSS 0.12.01.04.01

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

8.0 LIGHTNING PROTECTION & SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

9.0 METERING
If encountered, inspect metering accordance with guide sheet GSS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

16.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

17.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

18.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS
CONTROL NUMBER: GSS 0.12.01.04.02

APPLICATION

This guide applies to all Substation assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of substation assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductcrs and fittings other than control are encountered, inspect in accordance with guide sheet GSS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Leaning
6.6 Not adequate for application
6.7 Loose, broken, damaged, corroded, or missing hardware
6.8 Inadequate mounting structure
6.9 Mounting structure not adequately secured to mounting surface
6.10 Not adequately secured to mount

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS (Continued)
CONTROL NUMBER: GSS 0.12.01 .04.02

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

8.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

9.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

16.0 TRANSFORMERS
If encountered, inspect transformers in accordance with guide sheet GSS 0.09.01.02.11.

17.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

18.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

19.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: OVERHEAD TRANSMISSION SYSTEM
CONTROL NUMBER: GSS 0.12.01.04.03

APPLICATION

This guide applies to all overhead transmission systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of overhead transmission systems provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

2.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, in accordance with guide sheet GSS 0.09.01.02.02.

3.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

4.0 INSULATORS
4.1 Missing, cracked, chipped, or other damage
4.2 Tracked or carbonized
4.3 Dirty, oily, greasy, or other surface contamination
4.4 Not adequately secured
4.5 Leaning
4.6 Not adequate for application
4.7 Loose, broken, damaged, corroded, or missing hardware
4.8 Inadequate mounting structure
4.9 Mounting structure not adequately secured to mounting surface
4.10 Not adequately secured to mount

5.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

6.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: OVERHEAD TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSS 0.12.01.04.03

PHYSICAL DEFICIENCIES

7.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

8.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSS 0.12.01.05.02.

9.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

10.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSS 0.12.01.05.01.

11.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSS 0.12.01.05.04.

12.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSS 0.12.01.05.03.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM
CONTROL NUMBER: GSS 0.12.01.04.04

APPLICATION

This guide applies to all underground transmission systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of underground transmission systems provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulator-y deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSS 0.09.03.02.

2.0 CONCRETE SUPPORT PADS

If encountered, inspect concrete support pads in accordance with guide sheet GSS 0.12.01.05.07.

3.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, in accordance with guide sheet GSS 0.09.01.02.02.

4.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSS 0.09.01.02.03.

5.0 INSULATORS
5.1 Missing, cracked, chipped, or other damage
5.2 Tracked or carbonized
5.3 Dirty, oily, greasy, or other surface contamination
5.4 Not adequately secured
5.5 Leaning
5.6 Not adequate for application
5.7 Loose, broken, damaged, corroded, or missing hardware
5.8 Inadequate mounting structure
5.9 Mounting structure not adequately secured to mounting surface
5.10 Not adequately secured to mount

6.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSS 0.09.02.01.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSS 0.12.01.04.04

PHYSICAL DEFICIENCIES

7.0 LIGHTNING PROTECTION & SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSS 0.09.03.08.

8.0 METERING
If encountered, inspect metering in accordance with guide sheet GSS 0.09.01.02.04.

9.0 RACEWAY & FITTINGS
If encountered, inspect raceway and fittings in accordance with guide sheet GSS 0.09.01.02.08.

10.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSS 0.09.03.10.

11.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSS 0.12.01.05.05.

12.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSS 0.12.01.05.06.

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Binoculars (10x)
5. Spotting Scope (20x)

INSPECTION METHODS - STANDARD

UTILITY SUPPORT STRUCTURES GUIDE SHEETS

The following Guide Sheets provide a general overview of inspection methods and requirements used to provide a general Utility Support Structures inspection. Sheets have been developed for each major type and associated assembly components as follows:

TABLE THREE

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEEL TOWERS & POLES
CONTROL **NUMBER: GSS 0.12.01.05.01**

APPLICATION

This guide applies to all steel towers and poles.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies.
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations for any sign of damage or deterioration that may be related to steel tower or pole deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Steel Towers and Poles to include visual survey, examination of construction records, and analysis. Points include:

1. Check general appearance for any stress-related conditions. Determine type of stress as tension (pulling force), which causes stretching and cracking; compression (pushing or crushing force), which causes crushing; shear (slicing action), which causes diagonal or perpendicular to the member cracks or breakage from point of maximum load or shear; and bending (combination of tension and compression), which causes cracking. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for uneven settlement by observing ground conditions.
3. Check for improper design and construction conditions that can cause deficiencies.
4. Check bearing plates for proper bearing, anchorage, and deterioration.
5. Check for exposure conditions, specifically chemical attack (i.e., is surface material resistant to process contamination), impact exposure, staining and rust, corrosion, surface deterioration, operation or misuse of material, and extent of each.
6. Check all previous repairs and patches for any possible failures or deterioration.
7. Check for improper or damaged welds and "Lamellar" tearing of weld joints.
8. Check bolted connections to verify that bolts are properly tightened.
9. Check condition of anchorage to verify that anchorage is intact, in place, and properly tightened.
10. Perform stress analysis. Stress analysis consists of documenting the location, pattern, depth, and width of cracks.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Permanent Ink Marker
3. Tape - Masking or Duct
4. Vernier Calipers
5. Level

INSPECTION METHODS - STANDARD

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INSPECTION METHODS • STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PRECAST CONCRETE POLES
CONTROL NUMBER: GSS 0.12.01.05.02

APPLICATION

This guide applies to all Precast Concrete Poles.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies,
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations for any signs of damage or deterioration that may be related to cast-in-place concrete pole deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Precast Concrete Beams to include visual survey, examination of building records, and analysis. Points include:

1. Check general appearance for any stress-related conditions. Determine type of stress as tension (pulling force), which causes cracking and usually no spalling; compression (pushing or crushing force), which causes crushing or spalling; shear (slicing action), which causes diagonal or perpendicular to the member cracking from point of maximum load or shear; and bending (combination of tension and compression), which causes cracking with no spalling. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for uneven settlement by observing ground conditions.
3. Check for improper design and construction conditions that can cause deficiencies such as cracking and surface deterioration.
4. Check for exposure conditions, specifically chemical attack (i.e., is surface material resistant to process contamination), freeze-thaw action, impact exposure, staining and rust, dusting, surface deterioration, pitting, spalling, operation or misuse of material, and extent of each.
5. Check all previous repair and patches for any possible cracking or deterioration.
6. Check for any exposed reinforcement and extent for rust or deterioration.
7. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between two cracked surfaces. Determine if crack is active or dormant by the following steps.
   a. Mark the end of the crack and check after a few days to see if crack has extended past mark. Note direction.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PRECAST CONCRETE POLES (Continued)
CONTROL NUMBER: GSS 0.12.01.05.02

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Permanent Ink Marker
3. Tape - Masking or Duct
4. Pins or Nails
5. Vernier Calipers
6. Level

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES
CONTROL NUMBER: GSS 0.12.01.05.03

APPLICATION

This guide applies to wood poles used in electrical power distribution systems.

SPECIAL INSTRUCTIONS

1. Review all operating history documentation prior to the inspection process.
2. Consult a licensed structural engineer for significant deficiencies.

CONCURRENT ACTIONS

1. Inspection of electrical equipment associated with wood poles, including line hardware, switches, grounding, etc.
2. Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of wood poles provide an input to the analysis of functional and physical deficiencies of an electrical power distribution system. Because the system exists and is not in a construction process, regulatory deficiencies associated with installation of wood poles are not addressed.

1. Check general appearance for any stress-related conditions. Determine type of stress as: tension (pulling force), which causes tearing or ripping; compression (pushing or crushing force), which causes crushing; shear (slicing action), which causes splitting and delamination; and bending (combination of tension and compression), which causes cracking or splitting. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for improper design and construction conditions that can cause deficiencies such as cracking and surface deterioration.
3. Check for exposure conditions, specifically chemical attack, freeze-thaw action, impact exposure, efflorescence, staining, dry rot, surface deterioration, decay, splitting, or misuse of material, and extent of each.
4. Check all previous repairs and patches for any possible cracking or deterioration.
5. Check for improperly designed or placed anchorage components. Verify that anchorage is intact and properly tightened.
6. Check for improper tension in guy wires.
7. Check for any splitting, cracking, or deterioration of the surface.
8. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between cracked surfaces.
9. Sound pole using hammer; check for proper tonal quality. This is a qualitative analysis not a quantitative one. A “dead” thud is a sign of interior deterioration.
10. Check that all mounting hardware (nut, bolt, clevis, brace; etc.) is free of corrosion.
11. Check for loose hardware connections. Crossarm hardware tightness may be difficult to verify around energized power conductors.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES (Continued)
CONTROL NUMBER: GSS 0.12.01.05.03

TOOLS & MATERIALS

1. Binoculars
2. Spotting Telescope
3. Standard and Phillips head screwdrivers - various sizes
4. Tape Measure
5. Permanent Ink Marker
6. Pins or nails
7. Vernier Calipers
8. Hammer
9. Flashlight
10. Level

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TOWER & POLE FOUNDATIONS
CONTROL NUMBER: GSS 0.12.01.05.04

APPLICATION

This guide applies to all tower and pole foundations.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Refer to references and glossaries as needed.

CONCURRENT ACTIONS

Inspect towers or poles for any signs of damage or deterioration that may be traced to foundation deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Tower and Pole Foundations to include visual survey, examination of building records, and analysis. Since Tower and Pole Foundations are normally hidden from direct view, the condition of adjacent systems must be surveyed. Points include:

1. Check for surface deterioration in the form of cracking, spalling, pop-outs, or separations if applicable.
2. Check for exposure conditions, specifically chemical attack and freeze-thaw action, causing excessive movement or surface deterioration.
3. Check for improper, unbalanced, or overloading conditions that can cause fatigue or failure.
4. Check for uneven settlement by observing condition of existing grade.
5. Check for corrosion of rebar and degree of damage.
6. Check all previous repairs and patches for any possible cracking or deterioration.
7. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between two cracked surfaces. Determine if a crack is active or dormant by doing the following steps:
   a. Mark the end of the crack and check after a few days to see if crack has extended past mark. Note direction.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Tape Measure
3. Permanent Ink Marker
4. Tape - Masking or Duct
5. Pins or Nails
6. Vernier Calipers
7. Level

INSPECTION METHODS - STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES
CONTROL NUMBER: GSS 0.12.01.05.03

APPLICATION

This guide applies to wood poles used in electrical power distribution systems.

SPECIAL INSTRUCTIONS

1. Review all operating history documentation prior to the inspection process.
2. Consult a licensed structural engineer for significant deficiencies.

CONCURRENT ACTIONS

1. inspection of electrical equipment associated with wood poles, including line hardware, switches, grounding, etc.
2. Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of wood poles provide an input to the analysis of functional and physical deficiencies of an electrical power distribution system. Because the system exists and is not in a construction process, regulatory deficiencies associated with installation of wood poles are not addressed.

1. Check general appearance for any stress-related conditions. Determine type of stress as: tension (pulling force), which causes tearing or ripping; compression (pushing or crushing force), which causes crushing; shear (slicing action), which causes splitting and delamination; and bending (combination of tension and compression), which causes cracking or splitting. Buckling is a form of bending, most visible at the outermost fibers of the member. Bending is usually associated with a high failure rate.
2. Check for improper design and construction conditions that can cause deficiencies such as cracking and surface deterioration.
3. Check for exposure conditions, specifically chemical attack, freeze-thaw action, impact exposure, efflorescence, staining, dry rot, surface deterioration, decay, splitting, or misuse of material, and extent of each.
4. Check all previous repairs and patches for any possible cracking or deterioration.
5. Check for improperly designed or placed anchorage components. Verify that anchorage is intact and properly tightened.
6. Check for improper tension in guy wires.
7. Check for any splitting, cracking, or deterioration of the surface.
8. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between cracked surfaces.
9. Sound pole using hammer; check for proper tonal quality. This is a qualitative analysis not a quantitative one. A “dead” thud is a sign of interior deterioration.
10. Check that all mounting hardware (nut, bolt, clevis, brace; etc.) is free of corrosion.
11. Check for loose hardware connections. Crossarm hardware tightness may be difficult to verify around energized power conductors.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UTILITY SERVICE TUNNELS (Continued)
CONTROL NUMBER: GSS 0.12.01.05.05

INSPECTION ACTIONS

9. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between cracked surfaces. Determine if crack is active or dormant by the following steps:
   a. Mark the end of the crack and check after a few days to see if crack has extended past mark. Note direction.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkle) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Tape Measure
3. Permanent Ink Marker
4. Tape - Masking or Duct
5. Pins or Nails
6. Vernier Calipers
7. Level
8. Flashlight (Recommend Explosion-proof)

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UTILITY SERVICE TUNNELS
CONTROL NUMBER: GSS 0.12.01.05.05

APPLICATION

This guide applies to all utility service tunnel systems including concrete, brick maso masonry, and CMU.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service ca basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies.
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect dampproofing/waterproofing. (GSS 0.12.01.05.06)

INSPECTION ACTIONS

Condition Assessment Survey of Utility Service Tunnels to include visual survey, exami structure records, and analysis. Points include:

1. Check for overall water tightness including presence, location, and duration of a leaks. Verify any historical information concerning leaks. Leaks can signify c excessive hydrostatic pressures.
2. Check general appearance for any stress-related conditions. Determine type of s tension (pulling force), which causes cracking and usually no spalling; compression (or crushing force), which causes crushing or spalling; shear (slicing action), which diagonal or stepped cracking from point of maximum load or shear; and (combination of tension and compression), which causes cracking with no spalling. I is a form of bending, most visible at the outermost fibers of the member. Bending is associated with a high failure rate.
3. Check for uneven settlement by observing condition of existing grade on exterior.
4. Check for uplift or presence of hydrostatic pressure causing upward movement of grade.
5. Check for exposure conditions, specifically chemical attack (i.e., is surface material r to process contamination), freeze-thaw action, impact exposure, efflorescence, staini rust, dusting, surface deterioration, operation or misuse of material, and extent of each.
6. Check all previous repairs and patches for any possible cracking or deterioration.
7. Check for any exposed reinforcement and extent of rust or deterioration.
6. Check all sealant, expansion/contraction joints, or mortar joints for deterioration or cr which will allow water penetration.

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INSPECTION METHODS • STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE SUPPORT PADS
CONTROL NUMBER: GSS 0.12.01.05.07

APPLICATION

This guide applies to all Concrete Support Pads including reinforced, non-reinforced, and associated components.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Refer to references and glossaries as needed.

CONCURRENT ACTIONS

1. Inspect the supported equipment for any signs of damage or deterioration that may be traced to support pad deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Concrete Support Pads to include visual survey, examination of building records and analysis. Points include:

1. Check general appearance of support pad for any stress-related conditions. Determine type of stress as tension, compression, shear, bending or buckling.
2. Check for uneven settlement by observing condition of existing grade on exterior and condition of pad surface.
3. Perform stress analysis and monitor cracking to determine if cracks are active or dormant. Stress analysis consists of documenting the location, pattern, depth and width, presence of foreign materials, and elevation differences between two cracked surfaces. Determine if crack is active or dormant by the following steps.
   a. Mark the end of the crack and check over time to determine if cracks are active or dormant.
   b. Place a notched piece of tape across the crack. Wait for a period of a month or more. If tape tears or compresses (wrinkles) the crack is active, and if the tape shows no apparent change the crack is dormant.
   c. Apply pins and gauge points on either side of crack. Measure distance between points at regular intervals with vernier calipers to determine the extent of movement.
4. Check for exposure conditions, specifically chemical attack and freeze-thaw action.
5. Check all previous repairs and patches for any possible cracking or deterioration.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. Tape Measure
3. Permanent Ink Marker
4. Tape - Masking or Duct
5. Pins or Nails
6. Vernier Calipers
7. Level

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INSPECTION METHODS - STANDARD

ARCHITECTURAL/CIVIL GUIDE SHEETS

The following Guide Sheets provide a general overview of inspection methods and requirements used to provide a general inspection. Sheets have been developed for each major type and associated assembly components as follows:

TABLE FOUR

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PAVING ROADWAYS/WALKWAYS
CONTROL NUMBER: GSS 0.12.02

APPLICATION

This guide applies to concrete and bituminous pavement used in site roadways, parking lots, and walkways.

SPECIAL INSTRUCTIONS

This is a general inspection, and specific deficiencies should be handled on a service or repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Drainage Systems

INSPECTION ACTIONS

Site Subsystems CAS includes visual survey, examination of system records, and analysis. Points include:

1. Check general exterior appearance of pavement - note discoloration, vegetation growth, and other substances that may contribute to deterioration of the pavement.
2. Inspect visible portions of subbase. Note signs of erorion - penetration of water into system causing runoff of material; voids caused by improper compaction , erosion, contraction during a thaw cycle.
3. Inspect visible portion of base. Note signs of erosion - penetration of water into system causing runoff of material; collapse - voids caused by improper compaction , erosion, contraction during a thaw cycle.
4. Check pavement for heaving - lifting of material due to freeze cycle.
5. Inspect wearing surfaces for cracking (longitudinal, transverse, diagonal, alligatoring, mapping, blocking) and corner breaks (caused by load cycling). Note depths of cracks.
6. Check concrete surfaces for corner or joint spalling, popouts, crazing.
7. Note potholes - number and severity.
8. Check wearing surface for ravelling, hardening, stripping, rutting and slippage.
9. Check wearing surface smoothness - note depressions, patches, utility cuts.
10. Check wearing surfaces for lane or shoulder drop.
11. Check pavement near joints for parallel cracking or popouts (caused by temperature swings - freeze-thaw cycles).
12. Check for faulting (uneven levels) at joints and cracks, caused by settlement, loss of support sections.
13. Inspect joints for shattering or buckling (caused for inadequate expansion space).
14. Check joint seals for damage (missing sealant, extrusion, hardening of filler, loss of bond to concrete).
15. Check pavement surfaces (especially curbing) for damage caused by traffic, equipment movement.
16. Inspect all previous repairs - check for continued or repeated damage and growth.

TOOLS & MATERIALS

Standard Tools - Basic

INSPECTION METHODS - STANDARD

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INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TUNNELS
CONTROL NUMBER: GSS 0.12.03

APPLICATION

This guide applies to all Tunnel Structural Systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other historical documentation prior to initiating the inspection process.
2. Schedule this inspection to coincide with scheduled maintenance activities.
3. Observe established safety procedures during the inspection.
4. This is a general inspection, deficiencies should be handled on a service call or repair order basis.

CONCURRENT ACTIONS

1. Inspect tunnel mechanical systems.
2. Inspect tunnel electrical systems.
3. Inspect tunnel roadway and walks.
4. Inspect tunnel drainage system.

INSPECTION ACTIONS

Condition Assessment Survey of Tunnel structural systems to include visual examination and analysis. Points include:

1. Check for overall water tightness including presence, location, and duration of any water leaks.
2. Check for locations or presence of dampness and/or stains. Note location and determine type of stain and cause.
3. Check all previous repairs and patches for cracking or deterioration.
4. Check all construction joints for unevenness, warping, or buckling.
5. Check general appearance and condition of sealants for cracking, deterioration, or deformation.
6. Check for loose damaged or missing fasteners.
7. Check for damage caused by impact, weather, or vandalism.
8. Check painted surfaces for peeling, cracking, or chalking.
9. Check steel members for corrosion.
10. Check for cracked and corroded welds.
11. Check for signs of settlement or movement.
12. Check for debris buildup along curbs.
13. Check concrete for scaling, cracking, spalling, or deterioration.
14. Check for buckling of steel members.
15. Check for signs of improper or poor drainage, eg., ponding water, buildup in drains.
16. Check for spalls and delamination.
17. Check for misalignment of steel members.

TOOL & MATERIALS

Standard Tools - Basic

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TRACKWORK
CONTROL NUMBER: GSS 0.12.04.01

APPLICATION

This guide applies to all types of Trackwork and associated work. The failure of trackwork components, especially loose spikes and rail fasteners, are often difficult to determine during a routine visual inspection. Rail and turnout wear is gradual, as is the deterioration of the overall trackwork system after maintenance or renewal. Since the ultimate object of the trackwork system is to hold the rails securely in its proper horizontal and vertical alignment, the measurement of certain portions of the track geometry are made during inspection to determine whether the end objectives of the trackwork construction are being achieved. The most important of these in a standard inspection is checking rail gauge and cross-level (see Appendix B for definitions) at regular intervals. A calibrated track gauge rod is used to take these measurements quickly and accurately. FRA track geometry criteria is usually based on 31 foot intervals. In turnouts, flangeways and switch-throw distance is usually measured.

The importance of taking the above geometric measurements is not only the determination of whether the track passes minimum safety criteria, but also it is an important indicator of the wear and deterioration of applicable trackwork components.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review existing rail documentation.
3. Use extreme care when working around rail and rail tunnels.
4. This is a general inspection, and deficiencies should be handled on a service call or repair basis.

CONCURRENT ACTIONS

1. Inspect running rails.
2. Inspect rail joints.
3. Inspect ties.
4. Inspect tie plates or rail fasteners.
5. Inspect ballast.
6. Inspect turnouts, rail crossings, and other special trackwork

INSPECTION ACTIONS

Condition Assessment Survey of Railways and Rolling Stock to include visual survey, examination of building records, and analysis. Points include:

1. Check for corrosion or broken rails.
2. Check rail for engine burn or end batter.
3. Check for a piped rail or split web.
4. Check for any traverse defects (eg. compound fissure, traverse fissure, or detail fractures).
5. Check joint bar for cracks.
6. Inspect jointing to ensure that each joint is bolted with at least two bolts in each rail.
7. Check bolts for tightness.
8. Check joints for excessive openings.
9. Check fasteners and the plates for cracks.
10. Check spikes to ensure the proper size for the plates are used.
11. Check fasteners for correct spiking pattern.
12. Inspect for loose or missing fasteners.

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TRACKWORK (Continued)
CONTROL NUMBER: GSS 0.12.04.01

INSPECTION ACTIONS

13. Check fasteners for correct striking pattern.
14. Check tie for splits or deformations.

TOOLS & MATERIALS

Standard Tools - Basic

INSPECTION METHODS ▪ STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS
CONTROL NUMBER: GSS 0.12.04.02

APPLICATION

This guide applies to signal systems that are used to provide electrical energy to an electrical railway signal system. This guide does not apply to the operation of electrical railway signal systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiation of the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to the inspection process.
4. Observe all established safety procedures during the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment survey and evaluation of railway electrical signal systems provide an input to the analysis of functional and physical deficiencies of that assembly. Since the assembly exists and is not in a construction process; regulatory deficiencies associated with installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 CABLE/CONDUCTOR
1.1 Inappropriate for application
1.2 Insulation burned, charred, or other damage
1.3 Splice insulation unraveled, brittle, cracked, or other damage
1.4 Unauthorized splice
1.5 Not properly connected to device
1.6 Insulation improperly removed from conductor
1.7 Bimetallic connectors not used as required
1.8 Not properly bundled or trained

2.0 FITTING

3.0 BEARINGS
3.1 High bearing temperature as measured in thermographic test
3.2 Rough or irregular bearing during rotation as measured in vibration analysis
3.3 Leaking seals

4.0 MOUNT
4.1 Dirty or other internal or external surface contamination
4.2 Not properly secured to mounting structure
4.3 Mounting structure inadequate
4.4 Unit not adequately secured to mount

5.0 HEATER
5.1 Inadequate temperature in device enclosure
5.2 Excessive temperature in device enclosure
5.3 Not adequately secured to mounting surface

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS (Continued)
CONTROL NUMBER: GSS 0.12.04.02

PHYSICAL DEFICIENCIES

5.0 HEATER
5.4 Improper conductors from source

6.0 MARKING
6.1 illegible
6.2 Damaged or missing dataplate

7.0 DISCONNECT
7.1 Blades bent or not aligned
7.2 Handle broken, bent, or other physical deformity
7.3 Inadequate size
7.4 Blade clip bent, malaligned or other physical deformity
7.5 Clips pitted, burned or discolored
7.6 Blades pitted, burned or discolored
7.7 Improperly wired
7.8 Not accessible
7.9 Improper application
7.10 Improperly sized
7.11 No engineering study to support adjustable settings
7.12 High conductor-breaker lug temperature as measured in thermographic test

8.0 LIGHTNING PROTECTION/SURGE PROTECTION DEVICES
Lightning protection devices or surge suppressors encountered in the inspection of this equipment will be inspected in accordance with guide sheet GSS 0.09.03.08.

9.0 CONTROL WIRING
9.1 Inappropriate for application
9.2 Bundled and trained inappropriately
9.3 Terminal boards improperly installed
9.4 Insulation charred, burned or discolored
9.5 Splices improperly insulated
9.6 Unauthorized splice
9.7 Insulation improperly removed from conductor
9.8 Bimetallic connectors not used as required

10.0 BUSHING/INSULATOR
10.1 Tracked or carbonized
10.2 Missing, cracked, chipped or other damage
10.3 Dirty, oily, greasy or other surface contamination

11.0 METERING
Metering encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.04.

12.0 TRANSFER SWITCH, ELECTRICAL
Transfer switches encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.10.

13.0 ENCLOSURE
13.1 Not adequate for application
13.2 Corroded, rusted, dented or other physical damage

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS (Continued)
CONTROL NUMBER: GSS 0.12.04.02

PHYSICAL DEFICIENCIES

13.0 ENCLOSURE
13.3 Not secured to mounting surface
13.4 Unused openings not covered or plugged
13.5 Not grounded properly
13.6 Pedestal mounting surface chipped, cracked, broken or other physical damage
13.7 Not accessible
13.8 Vent defective/nonoperative
13.9 Not clean and moisture free

14.0 FUSE UNIT
14.1 Improperly sized
14.2 Improper fuse type used
14.3 Fuse clips bent, malaligned, discolored or other physical damage
14.4 Poor fuse to clip contact as measured using thermographic test

15.0 LUMINAIRES
Luminaires encountered in the inspection will be inspected in accordance with guide sheet GSS 0.09.02.01.

16.0 REACTORS
Reactors encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.11.

17.0 TRANSFORMERS
Transformers encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.11.

18.0 BONDS
18.1 Case loose or broken
18.2 Damaged or missing
18.3 Defective or inoperative

19.0 MOTOR CONTROL CENTERS
Motor control centers encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.06.

20. SWITCH MACHINES
20.1 Detector rod broken, missing, or out of adjustment
20.2 Inoperable
20.3 Loose or broken wiring
20.4 Operating rod broken, missing or out of adjustment
20.5 Overloaded motor
20.6 Relays out of adjustment, pitted or burned contacts

21.0 SIGNAL SYSTEMS
21.1 Inappropriate for application
21.2 Insulation burned, charred or other damage
21.3 Splice insulation unraveled, brittle, cracked, or other damage
21.4 Unauthorized splice
21.5 Not properly connected to device
21.6 Insulation improperly removed from conductor

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS (Continued)
CONTROL NUMBER: GSS 0.12.04.02

PHYSICAL DEFICIENCIES

21 .0 SIGNAL SYSTEMS
21.7 Bimetallic connectors not used as required
21.8 Not properly bundled or trained

TOOLS & MATERIALS

1. Light, portable
2. Infrared camera
3. Stepladder
4. Stroboscope

INSPECTION METHODS . STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: FOUNTAINS & POOLS
CONTROL NUMBER: GSS 0.12.05

APPLICATION

This guide applies to all Fountains and Pools.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Review any as-builts and other data to determine locations, types, and construction.
3. Consult a licensed structural engineer for significant deficiencies.
4. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations and footings and substructure for any other signs of damage or deterioration that may be related to Fountains and Pools deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Fountains and Pools to include visual survey, examination of building records, and analysis. Points include:

1. Check for corrosion of metal components.
2. Check concrete for cracking, scaling, spalling, or deterioration.
3. Check wooden members, if applicable, for insect damage, rot, softness, splitting, or bulging.
4. Check for damage caused by vehicular impact, weather, or vandalism.
5. Check for missing or broken components.
6. Check for signs of settlement or movement.
7. Check for cracked or corroded welds.
8. Check for loose, damaged, or missing fasteners.
9. Observe lifts and levelers with the passage of loads for excessive deflection or unusual noises.
10. Check painted surfaces for peeling, chipping, cracking.
11. Check for damaged, missing, or nonfunctional lighting fixtures.
12. Check electrical connections for tightness.
13. Check for fluid leaks if applicable.
14. Check drains for buildup of debris.
15. Check all previous repairs and patches for cracking or deterioration.
16. Check all joints for deterioration or cracking.

TOOLS & MATERIALS

Standard Tools - Basic

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SECURITY GATES & FENCES
CONTROL NUMBER: GSS 0.12.06

APPLICATION

This guide applies to Chainlink Security Gates and Fences.

SPECIAL INSTRUCTIONS

1. Review manufacturer's or installers instructions.
2. Review historical documentation prior to initiating inspection.
3. This is a general inspection, deficiencies should be handled on a service or repair call basis.
4. Use extreme care when working around chainlink fabric or barbed wire.

CONCURRENT ACTIONS

1. Annual Preventive Maintenance tasks.

INSPECTION ACTIONS

Condition Assessment Survey of Security Gates and Fences to include visual inspection and analysis. Points include:

1. Check for corrosion of fabric, framework, and accessories.
2. Check for sagging, split, or torn fabric.
3. Checked for sagging or broken barbed wire.
4. Check for missing or broken components.
5. Check all hardware for tightness.
6. Check all posts for rigidity and plumb.
7. Check for washouts under fencing or digging by animals.
8. Check for damage caused by impact, weather, or vandalism.
9. Check for plant growth infringing on fencing.

TOOLS & MATERIALS

Standard Tools - Basic

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: LANDSCAPING
CONTROL NUMBER: GSS 0.12.07

APPLICATION

This guide applies to Landscaping to include lawns, planting beds, shrubbery, and trees.

SPECIAL INSTRUCTIONS

1. This is a general inspection, and deficiencies should be handled on a service call or repair basis.
2. Schedule this inspection during dry conditions.
3. Review historical documentation prior to inspection to identify prior problem areas.

CONCURRENT ACTIONS

1. Inspect walkways.
2. Inspect parking lots.
3. Inspect gates and fences.
4. Inspect fountains and pools.

INSPECTION ACTIONS

Condition Assessment Survey of Landscaping to include visual survey, examination of building records, and analysis. Points include:

1. Check for proper drainage.
2. Check for signs of erosion caused by wind, water, heavy traffic, etc.
3. Check for signs of disease in grass, shrubs, and trees.
4. Check for signs of insect infestation or damage in grass, shrubs, and trees.
5. Check for signs of rotting in trees,
6. Check lawns for proper mowing, edging, and trimming.
7. Check planting beds for weeds and proper mulching.

TOOLS & MATERIALS

Standard Tools - Basic

INSPECTION METHODS - STANDARD

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INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: BRIDGES & ABUTMENTS
CONTROL NUMBER: GSS 0.12.08

APPLICATION

This guide applies to bridges and abutments.

SPECIAL INSTRUCTIONS

1. This is a general inspection, deficiencies should be handled on a service call or repair basis.
2. Review as-builts and other historical documentation prior to initiating the inspection process.
3. Refer to glossary and references as needed.

CONCURRENT ACTIONS

Inspect foundations and footings, substructure, and superstructure for any other signs of damage or deterioration that may be related to bridge deficiencies.

INSPECTION ACTIONS

Condition Assessment Survey of Bridges and Abutments to include visual survey, examination of building records, and analysis. Points include:

Abutments:

1. Check for bearing corrosion or displacement.
2. Check for sheared anchor bolts. NOTE: This is done by striking each bolt with a heavy hammer.
3. Check for cracked and corroded welds.
4. Check concrete for cracking, scaling, spalling, or deterioration.
5. Check timber, if applicable, for insect damage, rot, softness, splitting, or bulging.
6. Check for signs of settlement or movement.
7. Check for erosion or scour.
8. Check for damage caused by vehicular impact or floating debris.
9. Check for debris buildup.

Piers:

1. Check for bearing corrosion or displacement.
2. Check for sheared anchor bolts. NOTE: This is done by striking each bolt with a heavy hammer.
3. Check for cracked or corroded welds.
4. Check hangers for cracks and tightness.
5. Check concrete for scaling, spalling, cracking, or deterioration.
6. Check for signs of settlement or movement.
7. Check for debris buildup.
8. Check metal members for corrosion.
9. Check for loose, damaged, or missing fasteners.
10. Check timber, if applicable, for insect damage, rot, softness, splitting, or bulging.
11. Check for erosion or scour.
12. Check for damage caused by floating debris.
13. Check for buckling of steel members.

INSPECTION METHODS - STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: BRIDGES &ABUTMENTS (Continued)
CONTROL NUMBER: GSS 0.12.08

INSPECTION ACTIONS

Superstructure:

1. Check concrete for cracking, scaling, spalling, or deterioration.
2. Check for corrosion of metal members.
3. Check grating for broken welds, rivets, and alignment.
4. Check timber, if applicable, for insect damage, rot, softness, splitting, or bulging.
5. Observe decks with live load passage for excessive deflection and unusual noises.
6. Check for damage caused by floating debris.
7. Check for debris buildup.
8. Check for signs of stress or improper alignment.
9. Check for peeling, cracking, or excessive chalking or paint.

Utilities:

1. Checking for cracking, scaling, spalling, or deterioration of concrete supports.
2. Check for cracking or corrosion of metal supports.
3. Check for loose, damaged, or missing fasteners.
4. Check for damage caused by impact, weather, or vandalism.
5. Check for missing or non-functional lighting fixtures.
6. Check for damaged, missing, or non-functional road signs.
7. Check pipes and ducts for leaks, cracks, breaks, and corrosion.
8. Check electrical wiring for loose connections.
9. Check junction boxes for moisture and covers in place.
10. Check all hangers for tightness, corrosion, breaks, cracks, and rigidity.

TOOLS & MATERIALS

Standard Tools - Basic

INSPECTION METHODS - NON-STANDARD

MECHANICAL GUIDE SHEETS

Guide Sheets provide a general overview of the inspection methods and requirements used to provide a general component inspection. Sheets have been developed for each major assembly/component as shown in TABLE FIVE below:

TABLE FIVE

Assembly/Component	Control Number	Page #
NONSTANDARD		
Conveving		
Drive Assemblies	GSNS 0.07.01.02	Volume 7
Motor-Generators	GSNS 0.07.01.06	Volume 7
Mechanical - Plumbing		
Air Compressors	GSNS 0.08.01.01	Volume 8
Compressed Gas Storage Tanks	GSNS 0.08.01.03	Volume 8
Engines	GSNS 0.08.01.04	Volume 8
Equipment Controls	GSNS 0.08.01.05	Volume 8
Motors	GSNS 0.08.01.07	Volume 8
Pipe & Accessories	GSNS 0.08.01.08	Volume 8
Pumps	GSNS 0.08.01.09	Volume 8
Storage Tanks	GSNS 0.08.01.12	Volume 8
Tanks & Sumps	GSNS 0.08.01.13	Volume 8
Water Conditioners	GSNS 0.08.01.14	Volume 8
Mechanical - Heating		
Boilers, Fuel-Fired	GSNS 0.08.03.01	Volume 8
Burners	GSNS 0.08.03.03	Volume 8
Mechanical - Cooling		
Condensers	GSNS 0.08.04.03	Volume 8
Liquid Coolers	GSNS 0.08.04.06	Volume 8
Mechanical - Ventilating		
Ductwork & Accessories	GSNS 0.08.05.02	Volume 8
Fans	GSNS 0.08.05.03	Volume 8
Mechanical - SiteWork		
Concrete Tanks	GSNS 0.12.01.01	3.2-71
Conveyors (Belt, Bucket, Screw)	GSNS 0.12.01.02	3.2-73
Dust Collectors	GSNS 0.12.01.03	3.2-75
Manholes	GSNS 0.12.01.04	3.2-77
Pulverizers	GSNS 0.12.01.05	3.2-79
Rotary Screw Chillers	GSNS 0.12.01.06	3.2-81
Scrubbers	GSNS 0.12.01.07	3.2-83
Steam Turbines	GSNS 0.12.01.08	3.2-85
Stokers	GSNS 0.12.01.09	3.2-87
Underground Piping	GSNS 0.12.01.10	3.2-89

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE TANKS
CONTROL NUMBER: GSNS 0.12.01 .01

APPLICATION

This guide applies to all non-standard inspection procedures for concrete and masonry tanks used in site utility systems such as water and waste-water treatment. This guide may be used for inspections of the masonry aspects of mixing tanks, settling tanks, aeration tanks, filters, chlorine contact tanks, flocculation tanks, and similar concrete structures.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Air Compressors
- Pipe & Accessories
- Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Perform standard tank inspection. Check general operation and note erratic performance.
2. Check for unusual noises, vibration, or leaks; note location.

Shutdown of Unit:

3. Secure all influent to tank.
4. Drain or pump out tank as needed to fully empty it.
5. Flush tank to remove sediment, etc. and fully expose all surfaces.
6. Turn off, lock out, and tag out all electrical devices.
7. Isolate unit mechanically by securing and tagging all related valves.

Shutdown Inspection:

8. Check general interior appearance of tank. Note sediment, algae growth, and other substances that may contribute to surface deterioration.
9. Check for tears, gouges, and other physical defects in liner if present.
10. Check masonry surfaces for crazing (small hairline cracks caused by over finishing, freeze-thaw cycles, poor aggregate).
11. Inspect masonry for cracking (longitudinal, transverse, and diagonal) and corner breaks (caused by load cycling). Note crack depths.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE TANKS (Continued)
CONTROL NUMBER: GSNS 0.12.01 .01

INSPECTION ACTIONS

Shutdown Inspection:

12. Check masonry near joints for parallel cracking or pop-outs (caused by temperature swings, freeze-thaw cycles).
13. Check for masonry faulting (uneven levels) at joints and cracks caused by settlement, loss of support sections.
14. Inspect masonry joints for shattering or buckling (caused by inadequate expansion space).
15. Check joint seals for damage (missing sealant, extrusion, hardening of filler, loss of bond to concrete).
16. Inspect all previous masonry repairs for continued or repeated damage and growth.
17. Check internal baffling, weir valves, and similar level or flow control devices for loose or missing fasteners, wear, damage, impairments to operation.
18. Cycle mechanical flow control devices to check for binding, erratic operation.
19. Check skimmers and scrapers (in clarifiers, aeration, or settling tanks) for loose or missing fasteners, wear, damage, impairments to operation.
20. Cycle skimmers and scrapers to check for binding, erratic operation.
21. Inspect guides, rollers for wear and other damage.
22. Check clearances between skimmers and scrapers and the tank surfaces. Note damage to devices and or tank caused by improper clearances.
23. Note excessive corrosion of all metal work (stairs, ladders, handrails, guard rails, sump strainers, filters, etc.).
24. Check stairs, ladders, handrails, guard rails, sump strainers, filters, etc. for loose or missing fasteners, damage.
25. Check internal piping for excessive corrosion, signs of leakage.

Return to Operation:

26. Inspect interior of internal piping, for excessive scaling, pitting, etc.
27. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
28. Ensure all guards and covers have been reinstalled.
29. Notify affected personnel and obtain permission to place unit back in service.
30. Restore valving to normal position.
31. Remove lockouts and restore unit to service.
32. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONVEYORS (Belt, Bucket, Screw)
CONTROL NUMBER: GSNS 0.12.01.02

APPLICATION

This guide applies to all non-standard inspection procedures for material handling conveyors (no personnel carriers) used in site utilities to convey coal, ash, sludge, trash, and similar products between storage and processing equipment.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Drive Assemblies
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Check operation of all controls. Note erratic performance.
2. Check for noise and vibration. Note location.

Shutdown of Unit:

3. Turn off unit and lock out disconnect,
4. Tag out all electrical devices.

Shutdown Inspection:

5. Open guards and covers; check condition of cover seals (cuts, missing sections, etc.).
6. Check interior of conveyor housing for excessive corrosion, damage.
7. (Screw) Inspect full length of screw for damaged sections, excessive corrosion.
8. (Screw) Check clearances between screw and housing. Note excessive variance from specs.
9. (Belt) Inspect full length of belt for damaged sections, excessive wear, holes, etc.
10. (Belt) Check clearances between belt and housing. Note excessive variance from specs.
11. Inspect guides, rollers for wear, and other damage.
12. (Bucket/Flights) Inspect all buckets and flights for damaged sections, excessive corrosion, holes.
13. (Bucket/Flights) Check clearances between buckets/flights and housing. Note excessive variance from specs.
14. (Bucket/Flights) Check carrier chains and sprockets for excessive wear, damage, missing links.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONVEYORS (Belt, Bucket, Screw) (Continued)
CONTROL NUMBER: GSNS 0.12.01.02

INSPECTION ACTIONS

Shutdown Inspection:

15. Check all bearings for excessive wear or damage. Note seal damage, missing seals, loose or missing locking rings, improper lubrication.
16. Check all guide rails for wear, loose fasteners..
17. Check conveyor supports and anchors for loose or missing fasteners, corrosion.
18. Check electrical conduit, cables, pendants, etc. for wear, damage, loose fasteners..

Return to Operation:

19. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
20. Ensure all guards and covers have been reinstalled.
21. Notify affected personnel and obtain permission to place unit back in service.
22. Remove lockout on disconnect and restore unit to service.
23. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONVEYORS (Belt, Bucket, Screw)
CONTROL NUMBER: GSNS 0.12.01.02

APPLICATION

This guide applies to all non-standard inspection procedures for material handling conveyo personnel carriers) used in site utilities to convey coal, ash, sludge, trash, and similar pro between storage and processing equipment.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affectec equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a syst shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:
- Drive Assemblies
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of syster records, and analysis. Points include:

Prior to Shutdown:

1. Check operation of all controls. Note erratic performance.
2. Check for noise and vibration. Note location.

Shutdown of Unit:

3. Turn off unit and lock out disconnect.
4. Tag out all electrical devices.

Shutdown Inspection:

5. Open guards and covers; check condition of cover seals (cuts, missing sections, etc.).
6. Check interior of conveyor housing for excessive corrosion, damage.
7. (Screw) Inspect full length of screw for damaged sections, excessive corrosion.
8. (Screw) Check clearances between screw and housing. Note excessive variance from specs.
9. (Belt) Inspect full length of belt for damaged sections, excessive wear, holes, etc.
10. (Belt) Check clearances between belt and housing. Note excessive variance from specs.
11. Inspect guides, rollers for wear, and other damage.
12. (Bucket/Flights) Inspect all buckets and flights for damaged sections, excessive corrosion, holes.
13. (Bucket/Flights) Check clearances between buckets/flights and housing. Note excessive variance from specs.
14. (Bucket/Flights) Check carrier chains and sprockets for excessive wear, damage, missing links.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: DUST COLLECTORS (Continued)
CONTROL NUMBER: GSNS 0.12.01.03

INSPECTION ACTIONS

Return to Operation:

17. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
18. Ensure all guards and covers have been reinstalled.
19. Notify affected personnel and obtain permission to place unit back in service.
20. Restore utility service (compressed air, water).
21. Remove lockout on disconnect and restore unit to service.
22. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: MANHOLES
CONTROL NUMBER: GSNS 0.12.01.04

APPLICATION

This guide applies to all non-standard inspection procedures for manholes used to access underground piping, conduit, valves, and related equipment as found in site distribution systems. (Covers the manhole only, not the contained equipment.)

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:
- Underground Pipe & Accessories
- Air Compressors
- Sumps & Pumps
- Motors
- Equipment Controls

INSPECTION ACTIONS

There are no non-standard inspection actions required for manholes.

TOOLS & MATERIALS

Standard Tools - Mechanical

INSPECTION METHODS - NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS
CONTROL NUMBER: GSNS 0.12.01.05

APPLICATION

This guide applies to all non-standard inspection procedures for coal pulverizers used to crush coal for use in firing of boilers.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Conveyors
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Pulverizers to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Check operation of all controls. Note erratic performance.
2. Check for noise and vibration. Note location.

Shutdown of Unit:

3. Turn off unit and lock out disconnect.
4. Tag out all electrical devices.
5. Secure flow (air and coal) and any utilities (compressed air, water, etc.) to pulverizer.
6. Tag all supply valves and dampers.

Shutdown Inspection:

7. Open access plates and covers; check condition of seals (cuts, missing sections, etc.).
8. Check interior of pulverizer housing for excessive corrosion, damage.
9. Check grinding elements (balls, rolls, bowls, etc.) for pitting, corrosion, excessive wear.
10. Inspect races (or discs) for pitting, corrosion, excessive wear.
11. Check internal drive (gears, worms, etc.) for broken or excessively worn teeth.
12. Check all bearings for damage, excessive wear, missing seals, improper lube.
13. Inspect dampers, butterfly valves for worn guides, tight seating, binding in operation.
14. Inspect damper, butterfly valve operators for cylinder leakage, worn or distorted linkage.
15. Check pulverizer supports and anchors for loose or missing fasteners, corrosion.
16. Check electrical conduit, cables, pendants, etc. for wear, damage, loose fasteners.
17. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PULVERIZERS (Continued)
CONTROL NUMBER: GSNS 0.12.01.05

INSPECTION ACTIONS

Return to Operation:

18. Ensure all guards and covers have been reinstalled.
19. Notify affected personnel and obtain permission to place unit back in service.
20. Restore utility service (compressed air, water).
21. Remove lockout on disconnect and restore unit to service.
22. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS . NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: ROTARY SCREW CHILLERS
CONTROL NUMBER: GSNS 0.12.01.06

APPLICATION

This guide applies to non-standard inspection procedures for all rotary screw refrigeration compressors and related components (fittings, integral pumps, valves, strainers, insulation, etc.) installed as components in Cooling Chiller systems.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Motors
- Piping & Accessories
- Condensers
- Liquid Coolers

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Verify load on unit.
2. Move load controller set point to obtain maximum load.
3. Monitor pressure and temperature gauges and compare against rating data.
4. Move load controller set point to obtain minimum load.
5. Monitor pressure and temperature gauges and compare against rating data.
6. Perform vibration analysis on compressor at maximum, minimum, and 50% load.

Shutdown of Unit:

7. Turn off unit and lock out disconnect.
8. Tag out all electrical devices.
9. Isolate unit mechanically by securing valves on associated components.
10. Tag out all secured valves.

Shutdown Inspection:

11. Draw sample from oil reservoir and send to laboratory for wear analysis.
12. Use oil-dry nitrogen to test unit for leaks at shaft seals (external drives only).
13. Pull and inspect oil pump.
14. Check oil pump gears for excessive or uneven wear.
15. Check magnetic strainer for indications of ferrous wear products.
16. Check exposed drive shafting for cracks, fatigue, corrosion; check suspicious areas with dye penetrant.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: ROTARY SCREW CHILLERS (Continued)
CONTROL NUMBER: GSNS 0.12.01.06

INSPECTION ACTIONS

Shutdown inspection:

17. Check drive shaft bearing thrust and run-out clearances (compare with manufacturer's spec and machine history).
18. Open and inspect drive reducer; check gears for excessive or uneven wear.
19. Check gears for cracks, fatigue, corrosion; check suspicious areas with dye penetrant.
20. Check coupling for wear, damage, loose fasteners.
21. Check coupling for misalignment.

Return to Operation:

22. Close all casings; ensure new seals are employed.
23. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
24. Ensure that all guards and covers have been reinstalled.
25. Notify affected personnel and obtain permission to place unit back in service.
26. Restore valving to normal position.
27. Remove lockout on disconnect and restore unit to service.
28. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SCRUBBERS
CONTROL NUMBER: GSNS 0.12.01.07

APPLICATION

This guide applies to all non-standard inspection procedures for scrubbers, wet towers, and similar wet process equipment typically used in large heating plants to control particulate emissions to the atmosphere.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Inspection should be scheduled when system is not in use.
3. Notify affected personnel and obtain permission to take unit out-of-service.
4. Obtain necessary tools, equipment, and materials.
5. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Fans
- Motors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Site Subsystems to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Check operation of all controls. Note erratic performance.
2. Check for noise and vibration. Note location.

Shutdown of Unit:

3. Turn off unit and lock out disconnect.
4. Tag out all electrical devices.
5. Secure air flow (exhaust gases) and all utilities (compressed air, water, etc.) to scrubber.
6. Tag all supply valves and dampers.

Shutdown Inspection:

7. Open access plates and covers; check condition of seals (cuts, missing sections, etc.).
8. Check interior of scrubber housing for excessive corrosion, damage.
9. Check distributors (nozzles, trays) for damage, corrosion, loose or missing fasteners.
10. Check eliminators (separators, demisters) for damage corrosion, loose or missing fasteners.
11. Check fill (packing, absorbent) for collapse, blockage.
12. Check liquid level and makeup controls for damage, corrosion. Cycle to check smooth operation.
13. Inspect dampers, valves for worn guides, tight seating, binding in operation.
14. Inspect damper, valve operators for cylinder leakage, worn or distorted linkage.
15. Check scrubber supports and anchors for loose or missing fasteners, corrosion.
16. Check electrical conduit, cables, pendants, etc. for wear, damage, loose fasteners.

INSPECTION METHODS - **NON-STANDARD**

GUIDE SHEET

SYSTEM/COMPONENT: SCRUBBERS (Continued)
CONTROL NUMBER: GSNS 0.12.01.07

INSPECTION ACTIONS

Return to Operation:

17. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
18. Ensure all guards and covers have been reinstalled.
19. Notify affected personnel and obtain permission to place unit back in service.
20. Restore utility service (compressed air, water).
21. Remove lockout on disconnect and restore unit to service.
22. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEAM TURBINES
CONTROL NUMBER: GSNS 0.12.01.08

APPLICATION

This guide applies to all non-standard inspection procedures for small steam turbines used to drive auxiliary equipment such as pumps, fans and compressors in large central heating plants including related components (fittings, valves, traps, governors, insulation, etc.).

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Review manufacturer's or installer's instructions.
3. Inspection should be scheduled when system is not in use.
4. Notify affected personnel and obtain permission to take unit out-of-service.
5. Obtain necessary tools, equipment, and materials.
6. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Pumps
- Fans
- Compressors
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Steam Turbines to include visuai survey, examination of system records, and analysis. Points include:

Shutdown of Unit:

1. Isolate related blowers, fans, compressors.
2. Tag out all electrical devices.

Shutdown Inspection:

3. Open turbine housing.
4. Check interior walls for erosion, corrosion, physical damage.
5. Examine stationary nozzles for worn, loose, or damaged nozzles.
6. Examine turbine rotor for worn or loose nozzles, loose or damaged shrouding.
7. Check equalizing ports for blockage.
8. Examine rotor in seal area for wear, scoring.
9. Examine control valve seats and poppets for steam cutting, wear.
10. Check operating linkage of throttle, governor, safety trips for wear, distortion, binding.
11. Close housing.
12. Check axial and radial shaft clearances.

Return to Service:

13. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.
14. Ensure that all parts, guards and covers have been reinstalled.
15. Notify affected personnel and obtain permission to place unit back in service.
16. Remove lockout on disconnect and restore unit to service.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEAM TURBINES (Continued)
CONTROL NUMBER: GSNS 0.12.01.08

INSPECTION ACTIONS

Return to Service:

17. Remove tags from all devices.

TOOLS & MATERIALS

1. Non Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STOKERS
CONTROL NUMBER: GSNS 0.12.01.09

APPLICATION

This guide applies to all non-standard inspection procedures for the portion of stokers and related components installed external to the boiler and employed to inject coal (or other solid fuels) into site boilers. The grate portion (fixed or traveling) of the stoker is covered under the Boilers, Fuel-Fired Guide Sheet.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Review manufacturer's or installer's instructions.
3. Inspection should be scheduled when system is not in use.
4. Notify affected personnel and obtain permission to take unit out-of-service.
5. Obtain necessary tools, equipment, and materials.
6. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

Inspect associated:

- Boilers
- Pulverizers
- Blowers
- Equipment Controls

INSPECTION ACTIONS

Condition Asset Survey of Stokers to include visual survey, examination of system records, and analysis. Points include:

Prior to Shutdown:

1. Check operation of all controls. Note erratic performance.
2. Check for noise and vibration. Note location.

Shutdown of Unit:

3. Turn off unit and lock out disconnect.
4. Tag out all electrical devices.
5. Block off supplies to feed hoppers. Tag all unit:;

Shutdown Inspection:

6. Open access plates and covers; condition of seals (cuts, rnissing sections, etc.).
7. Check interior of stoker housing (hopper and feeder) for excessive corrosion, damage.
8. (Overfeed) Inspect feed plate and drive for corrosion, damage, wear, distortion.
9. (Overfeed) Inspect spreader (thrower) for corrosion, damage, wear, distortion.
10. (Underfeed) Inspect ram drive linkage for worn or damaged parts.
11. (Underfeed) Inspect vibrating grate linkage for worn or damaged parts.
12. Check all bearings for wear, damage, improper lube.
13. Ensure that all tools, equipment, and materials used for inspection have been removed from the unit.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STOKERS (Continued)
CONTROL NUMBER: GSNS 0.12.01.09

INSPECTION ACTIONS

Return to Operation:

14. Ensure that all guards and covers have been reinstalled.
15. Notify affected personnel and obtain permission to place unit back in service.
16. Restore utility service (compressed air, water).
17. Remove lockout on disconnect and restore unit to service.
18. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND PIPING
CONTROL NUMBER: GSNS 0.12.01.10

APPLICATION

This guide applies to all non-standard inspection procedures for all underground piping used to convey chilled water, high temperature water, steam, condensate return, gas, fuel oil, etc. and includes related components (fittings, valves, expansion joints, supports, etc.) installed as part of a site infrastructure.

SPECIAL INSTRUCTIONS

1. Review mechanical and electrical plans to determine systems and areas affected by equipment/system outage.
2. Notify affected personnel and obtain permission to take section out-of-service.
3. Obtain necessary tools, equipment, and materials.

CONCURRENT ACTIONS

1. Perform standard inspection of Underground Piping and Accessories
2. Inspect associated:
   - Manholes
   - Pumps
   - Motors

INSPECTION ACTIONS

Condition Asset Survey of Site Underground Piping Systems to include "dig up" surveys, testing, examination of system records, and analysis. Inspection of underground gas piping should be performed on a sampling basis, at one foot/mile for each soil type and where any suspicious readings have been derived from leak testing. Inspection of underground steam/hot water piping should be performed where standard inspections have indicated possible leakage. Points include:

Prior to Shutdown:

1. Select section for testing.
2. Check operation of all related controls. Note erratic performance.
3. Perform leak detection tests.

Shutdown of Unit:

4. Isolate section (lockout valves) to be inspected; tag out all related valves.
5. Disconnect, lockout and tag out all electrical devices.

Shutdown Inspection:

6. (Gas) Expose a 1 foot section of pipe per mile of run.
7. (Gas) Examine pipe surfaces; measure and record depth of pitting.
8. (Steam/Hot Water) Expose a 2 foot section of pipe above heat loss, high erosion areas.
9. (Steam/Hot Water) Examine insulation, joints, and pipe surfaces; measure and record depth of pitting.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND PIPING (Continued)
CONTROL NUMBER: GSNS 0.12.01 .10

INSPECTION ACTIONS

Return to Operation:

10. Perform pressure test on 20% of direct buried conduit sections that have been in service for 5 or more years.
11. Ensure that all tools, equipment, and materials used for inspection have been removed from the inspection areas.
12. Ensure that all insulation, backfill, and covers have been properly reinstalled.
13. Notify affected personnel and obtain permission to place unit back in service.
14. Remove lockouts on disconnects and valves and restore unit to service.
15. Remove tags from all devices.

TOOLS & MATERIALS

1. Non-Standard Tools - Mechanical
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

ELECTRICAL GUIDE SHEETS

The following Guide Sheets provide a general overview of the non-standard inspection methods and requirements used to provide detailed analysis of the electrical utility distribution system. Sheets have been developed for each major component or device as shown in TABLE SIX:

TABLE SIX

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS
CONTROL NUMBER: GSNS 0.12.01.04.01

APPLICATION

This guide applies to non-standard inspection procedures for all Switchyard assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of switchyard assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSNS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSNS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSNS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSNS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSNS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Not adequate for application
6.6 Loose, broken, damaged, corroded, or missing hardware
6.7 Inadequate mounting structure
6.8 Mounting structure not adequately secured to mounting surface
6.9 Not adequately secured to mount

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SWITCHYARDS (Continued)
CONTROL NUMBER: GSNS 0.12.01.04.01

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSNS 0.09.02.01

8.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSNS 0.09.03.08.

9.0 METERING
If encountered, inspect metering in accordance with guide sheet GSNS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSNS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSNS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSNS 0.09.03.10.

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSNS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSNS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSNS 0.12.01.05.04.

16.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSNS 0.12.01.05.05.

17.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSNS 0.12.01.05.06.

18.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSNS 0.12.01.05.03.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS
CONTROL NUMBER: GSNS 0.12.01.04.02

APPLICATION

This guide applies to all non-standard inspection procedures for all Substation assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of substation assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT

Inspect busway/busduct in accordance with guide sheet GSNS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS

If encountered, inspect communication circuits in accordance with guide sheet GSNS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS

If encountered, inspect concrete support pads in accordance with guide sheet GSNS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS

If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSNS 0.09.01.02.02.

5.0 DISCONNECTS

Inspect disconnects in accordance with guide sheet GSNS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Not adequate for application
6.6 Loose, broken, damaged, corroded, or missing hardware
6.7 Inadequate mounting structure
6.8 Mounting structure not adequately secured to mounting surface
6.9 Not adequately secured to mount

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS (Continued)
CONTROL NUMBER: GSNS 0.12.01.04.02

PHYSICAL DEFICIENCIES

7.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSNS 0.09.02.01.

8.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSNS 0.09.03.08.

9.0 METERING
If encountered, inspect metering in accordance with guide sheet GSNS 0.09.01.02.04.

10.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSNS 0.12.01.05.02.

11.0 RACEWAY & FITTINGS
Inspect raceway and fittings in accordance with guide sheet GSNS 0.09.01.02.08.

12.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSNS 0.09.03.10.

13.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSNS 0.12.01.05.01.

14.0 SWITCHBOARDS (SWITCHGEAR)
Inspect switchboards/switchgear in accordance with guide sheet GSNS 0.09.01.02.09.

15.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSNS 0.12.01.05.04.

16.0 TRANSFORMERS
If encountered, inspect transformers in accordance with guide sheet GSNS 0.09.01.02.11.

17.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSNS 0.12.01.05.05.

18.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofing in accordance with guide sheet GSNS 0.12.01.05.06.

19.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSNS 0.12.01.05.03.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SUBSTATIONS
CONTROL NUMBER: GSNS 0.12.01.04.02

APPLICATION

This guide applies to all non-standard inspection procedures for all Substation assemblies.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of substation assemblies provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 BUSWAY/BUSDUCT
Inspect busway/busduct in accordance with guide sheet GSNS 0.09.01.02.01.

2.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSNS 0.09.03.02.

3.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSNS 0.12.01.05.07.

4.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSNS 0.09.01.02.02.

5.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSNS 0.09.01.02.03.

6.0 INSULATORS
6.1 Missing, cracked, chipped, or other damage
6.2 Tracked or carbonized
6.3 Dirty, oily, greasy, or other surface contamination
6.4 Not adequately secured
6.5 Not adequate for application
6.6 Loose, broken, damaged, corroded, or missing hardware
6.7 inadequate mounting structure
6.8 Mounting structure not adequately secured to mounting surface
6.9 Not adequately secured to mount

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: OVERHEAD TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSNS 0.12.01.04.03

PHYSICAL DEFICIENCIES

7.0 METERING
If encountered, inspect metering in accordance with guide sheet GSNS 0.09.01.02.04.

8.0 PRECAST CONCRETE POLES
Inspect precast concrete poles in accordance with guide sheet GSNS 0.12.01.05.02.

9.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSNS 0.09.03.10.

10.0 STEEL TOWERS & POLES
If encountered, inspect steel towers and poles in accordance with guide sheet GSNS 0.12.01.05.01.

11.0 TOWER & POLE FOUNDATIONS
If encountered, inspect tower and pole foundations in accordance with guide sheet GSNS 0.12.01.05.04.

12.0 WOOD POLES
If encountered, inspect wood poles in accordance with guide sheet GSNS 0.12.01.05.03.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM
CONTROL NUMBER: GSNS 0.12.01.04.04

APPLICATION

This guide applies to non-standard inspection procedures for all underground transmission systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiating the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to initiating the inspection process.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment and evaluation of underground transmission systems provides an analysis of functional and physical deficiencies of an electrical system. Because the system exists and is not in a construction process, regulatory deficiencies associated with assembly installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 COMMUNICATION CIRCUITS
If encountered, inspect communication circuits in accordance with guide sheet GSNS 0.09.03.02.

2.0 CONCRETE SUPPORT PADS
If encountered, inspect concrete support pads in accordance with guide sheet GSNS 0.12.01.05.07.

3.0 CONDUCTORS & FITTINGS
If conductors and fittings other than control are encountered, inspect in accordance with guide sheet GSNS 0.09.01.02.02.

4.0 DISCONNECTS
Inspect disconnects in accordance with guide sheet GSNS 0.09.01.02.03.

5.0 INSULATORS
5.1 Missing, cracked, chipped, or other damage
5.2 Tracked or carbonized
5.3 Dirty, oily, greasy, or other surface contamination
5.4 Not adequately secured
5.5 Not adequate for application
5.6 Loose, broken, damaged, corroded, or missing hardware
5.7 Inadequate mounting structure
5.8 Mounting structure not adequately secured to mounting surface
5.9 Not adequately secured to mount

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UNDERGROUND TRANSMISSION SYSTEM (Continued)
CONTROL NUMBER: GSNS 0.12.01.04.04

PHYSICAL DEFICIENCIES

6.0 LIGHTING
If encountered, inspect in accordance with guide sheet GSNS 0.09.02.01.

7.0 LIGHTNING PROTECTION &SURGE SUPPRESSION
If encountered, inspect in accordance with guide sheet GSNS 0.09.03.08.

8.0 METERING
If encountered, inspect metering in accordance with guide sheet GSNS 0.09.01.02.04.

9.0 RACEWAY & FITTINGS
If encountered, inspect raceway and fittings in accordance with guide sheet GSNS 0.09.01.02.08.

10.0 SIGNAL CIRCUITS
If encountered, inspect signal circuits in accordance with guide sheet GSNS 0.09.03.10.

11.0 UTILITY SERVICE TUNNELS
If encountered, inspect utility service tunnels in accordance with guide sheet GSNS 0.12.01.05.05.

12.0 UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
If encountered, inspect utility service tunnels: dampproofing/waterproofingin accordance with guide sheet GSNS 0.12.01.05.06.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

UTILITY SUPPORT STRUCTURES GUIDE SHEETS

The following Guide Sheets outline an overview of inspection methods and requirements used in providing a general non-standard inspection. For these non-standard inspections, it is assumed that all standard inspections will be completed to determine non-standard methodology. (However, non-standard methods may be implemented as a non-contingent option.) Non-standard Guide Sheets have been developed for each major assembly type and associated assembly components as follows:

TABLE SEVEN

INSPECTION METHODS - NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: STEEL TOWERS & POLES
CONTROL NUMBER: GSNS 0.12.01.05.01

APPLICATION

This guide applies to non-standard inspection procedures for all Steel Towers and Poles.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to glossary and references as needed.
3. It is recommended that such non-standard inspection be performed under the supervision of a licensed structural engineer. Based on his review of standard inspection results the following tests and analyses may be recommended (can include all or some of the tests listed below).

CONCURRENT ACTIONS

1. Inspect foundations for any signs of damage or deterioration that may be related to steel tower or pole deficiencies.
2. Complete inspection requirements listed in GSS 0.12.01.05.01.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.01 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine degree of deterioration and material thickness.
3. Perform Magnetic test to determine material thickness and cracks.
4. Perform Radiography (X-Ray) testing to detect cracking and material defects/deficiencies.
5. Perform Electrical Resistivity test to determine material thickness and degree of corrosion or deterioration.
6. Perform Microwave Absorption Scanning to determine material defects. This is a relatively new method still under development.
7. Perform dye penetrant test to determine extent of cracking.
a. Perform Acoustic Emission test to determine stress points and material deformations. This is a difficult test requiring dynamic loading conditions.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PRECAST CONCRETE POLES
CONTROL NUMBER: GSNS 0.12.01.05.02

APPLICATION

This guide applies to non-standard inspection procedures for all Precast Concrete Poles.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to glossary and references as needed.
3. It is recommended that such non-standard inspection be performed under the supervision of a licensed structural engineer; based on his review of standard inspection results, the following tests and analyses may be recommended (can include all or some of the tests listed below).

CONCURRENT ACTIONS

1. Inspect foundations for any signs of damage or deterioration that may be related to precast concrete pole deficiencies.
2. Complete inspection requirements listed in GSS 0.12.01.05.02.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.02 and/or as directed, proceed to non-standard. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Surface Hardness testing or Maturity Concept Analysis to determine material condition and locate possible defects/deficiencies within the material.
3. Take core samples to determine condition or strength of the material. Patch sample holes immediately. Use great care when performing this work and consult a licensed structural engineer before proceeding.
4. Perform infrared or Nuclear Analysis testing to determine if water or moisture is present, indicating general location of cracks or breaks.
5. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine degree of deterioration and material thickness.
6. Perform Magnetic test to determine material thickness and reinforcement location.
7. Perform Electrical Resistivity test to determine moisture content, material thickness, and degree of corrosion or deterioration.
6. Perform Radiography (X-Ray) testing to detect cracking, internal defects/deficiencies.
9. Perform Microwave Absorption Scanning to determine moisture content and material defects. This is a relatively new method still under development.
10. Perform Acoustic Emission test to determine stress points and material deformations. This is a difficult test requiring dynamic loading conditions.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: WOOD POLES
CONTROL NUMBER: GSNS 0.12.01.05.03

APPLICATION

This guide applies to all non-standard inspection procedures for wood poles used in electrical power distribution systems.

SPECIAL INSTRUCTIONS

1. Review all operating history documentation prior to the inspection process.
2. Consult a licensed structural engineer for significant deficiencies.

CONCURRENT ACTIONS

1. Inspection of electrical equipment associated with wood poles, including line hardware, switches, grounding, etc.
2. Annual preventive maintenance tasks.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.03, and/or as directed, proceed to non-standard inspections.

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Ultrasonic Pulse Velocity test to locate defects within the material to determine degree of deterioration.
3. Perform Radiography (X-Ray) testing to detect cracking and material defects/deficiencies.
4. Perform Infrared or Nuclear Analysis testing to determine physical condition of material by locating breaks or cracks.
5. Perform Microwave Absorption Scanning to determine material defects, This is a relatively new method still under development.
6. Perform Acoustic Emission test to determine stress points and material deformations. This is a difficult test requiring dynamic loading conditions.
7. Take core samples to determine condition or strength of the material. Patch sample holes immediately.
8. Check tightness of all attachment hardware using a calibrated torque wrench.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS . NON-STANDARD

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INSPECTION METHODS . NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TOWER & POLE FOUNDATIONS
CONTROL NUMBER: GSNS 0.12.01.05.04

APPLICATION

This guide applies to non-standard inspection procedures for all non-standard inspections of all tower and pole foundations.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to references and glossaries as needed.
3. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

1. Inspect towers or poles for any signs of damage or deterioration that may be traced to foundation deficiencies.
2. Complete inspection requirements listed in GSS 0.12.01.05.04.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.04 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine the degree of deterioration and material thickness.
3. Perform Maturity Concept Analysis to determine strength and capacity of in-situ concrete.
4. Take core samples to determine condition or strength of the material. Patch sample holes immediately.
5. Perform Acoustic Emission test to determine stress points, cracks, or strained surfaces.
6. Perform Magnetic test to determine thickness and position of reinforcement.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS • NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UTILITY SERVICE TUNNELS
CONTROL NUMBER: GSNS 0.12.01.05.05

APPLICATION

This guide applies to non-standard inspection procedures for all non-standard inspections of utility service tunnel systems, including concrete, brick masonry, stone masonry, or CMU.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Consult a licensed structural engineer for significant deficiencies.
3. Refer to glossary and references as needed.

CONCURRENT ACTIONS

1. Inspect dampproofing/waterproofing.
2. Complete inspection requirements listed in GSS 0.12.01.05.05.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.05 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Infrared or Nuclear Analysis testing to determine if water or moisture is present, indicating cracks, breaks, and general location.
3. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine the degree of deterioration and material thickness.
4. Take core samples to determine condition or strength of the material. Patch sample holes immediately.
5. Perform Magnetic test to determine material thickness and reinforcement location.
6. Perform Electrical Resistivity test to determine moisture content, material thickness, and degree of corrosion.
7. Perform Surface Hardness testing or Maturity Concept Analysis to determine material condition and locate possible defects/deficiencies within the material.
8. Perform Acoustic Emission test or Microwave Absorption Scanning if conditions allow. Both methods are relatively new, and results are questionable.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: UTILITY SERVICE TUNNELS: DAMPPROOFING/WATERPROOFING
CONTROL **NUMBER:** **GSNS** 0.12.01.05.06

APPLICATION

This guide applies to all non-standard inspections of all dampproofing and waterproofing systems.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations and types.
2. Refer to glossary and references as needed.
3. This is an invasive inspection, and should be performed in conjunction with a system shutdown and overhaul. Specific deficiencies should be handled on a repair call basis.

CONCURRENT ACTIONS

1. Inspect utility service tunnels.
2. Complete inspection requirements listed in GSS 0.12.01.05.06.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.06 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. If possible, excavate or expose surface and perform Infrared or Nuclear Analysis testing to determine if water or moisture is present, indicating general location of cracks or breaks.
3. If possible, excavate or expose surface and perform Electrical Resistivity test or Microwave Absorption Scanning to determine if water or moisture is present and moisture content of material, indicating general location of cracks or breaks.

TOOLS & MATERIALS

1. **Standard** Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: CONCRETE SUPPORT PADS
CONTROL NUMBER: GSNS 0.12.01.05.07

APPLICATION

This guide applies to non-standard inspection procedures for all Concrete Support Pads, including reinforced, non-reinforced, and associated components.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to references and glossaries as needed.

CONCURRENT ACTIONS

1. Inspect the supported pads for any signs of damage or deterioration that may be related to or result in support pad deficiencies.
2. Complete inspection requirements listed in GSS 0.12.01.05.07.

INSPECTION ACTIONS

Based on results of GSS 0.12.01.05.07 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine the degree of deterioration and material thickness.
3. Take core samples to determine condition or strength of the material. Patch sample holes immediately.
4. Perform Magnetic test to determine material thickness and reinforcement location.
5. Perform Electrical Resistivity test to determine moisture content, material thickness and degree of corrosion.
6. Perform Surface Hardness testing or Maturity Concept Analysis to determine material condition and locate possible defects/deficiencies within the material.
7. Perform Acoustic Emission test or Microwave Absorption Scanning if conditions allow. Both methods are relatively new, and results are questionable.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

ARCHITECTURAL/CIVIL GUIDE SHEETS

The following Guide Sheets provide a general overview of the non-standard inspection methods and requirements used to provide a detailed analysis of these systems. Sheets have been developed for each major component or device as shown in TABLE EIGHT:

TABLE EIGHT

Assembly/Component	Control Number	**Page #**
NON-STANDARD		
Paving Roadways/Walkways	GSNS 0.12.02	3.2-119
Tunnels	GSNS 0.12.03	3.2-121
Railways		
Trackwork	GSNS 0.12.04.01	3.2-123
Signals & Communications	GSNS 0.12.04.02	3.2-125
Fountains & Pools	GSNS 0.12.05	3.2-129
Security Gates & Fences	GSNS 0.12.06	3.2-131
Landscaping	GSNS 0.12.07	3.2-133
Bridges & Abutments	GSNS 0.12.08	3.2-135

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: PAVING ROADWAYS/WALKWAYS
CONTROL NUMBER: GSNS 0.12.02

APPLICATION

This guide applies to concrete and bituminous pavement used in site roadways, parking lots, and walkways.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to glossary and references as needed.

CONCURRENT ACTIONS

1. Inspect associated Drainage Systems.
2. Complete inspection requirements listed in GSS 0.12.02.

INSPECTION ACTIONS

Based on results of GSS 0.12.02 and/or as directed proceed to non-standard inspection. Points to include:

1. Perform deflection measurements using pulse loading methods, static load testing such as Benkelman Beam, vibrating steady-state force devices such as Dynaflect, or impulse loading testing with a "falling weight deflecto-meter." This data requires processing and analysis to generate remaining life, limitations on loading, and rehabilitation or overlay requirements.
2. Perform skid resistance measurements for safety considerations.
3. Perform roughness or ride quality measurements with profilometers or dynamic devices.
4. Perform Core testing to determine exact layer thickness.
5. Perform Marshall Stability testing on asphalt concrete cores as well as penetation and viscosity tests. These tests require laboratory analysis.
6. Perform Indirect Tensile Strength and/or Compressive Strength tests on concrete core samples. These tests require laboratory analysis.
7. Perform Ground Penetration Radar testing to locate defects or voids in topping and base layers. This testing is still under development.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TUNNELS
CONTROL NUMBER: GSNS 0.12.03

APPLICATION

This guide applies to all non-standard inspections of utility service tunnel systems, including concrete, brick masonry, stone masonry, or CMU.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Consult a licensed structural engineer for significant deficiencies.
3. Refer to glossary and references as needed.

CONCURRENT ACTIONS

1. Inspect dampproofing/waterproofing.
2. Complete inspection requirements listed in GSS 0.12.03.

INSPECTION ACTIONS

Based on results of GSS 0.12.03 and/or as directed, proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Infrared or Nuclear Analysis testing to determine if water or moisture is present, indicating cracks or breaks and general location.
3. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine the degree of deterioration and material thickness.
4. Take core samples to determine condition or strength of the material. Patch sample holes immediately.
5. Perform Magnetic test to determine material thickness and reinforcement location.
6. Perform Electrical Resistivity test to determine moisture content, material thickness, and degree of corrosion.
7. Perform Surface Hardness testing or Maturity Concept Analysis to determine material condition and locate possible defects/deficiencies within the material.
8. Perform Acoustic Emission test or Microwave Absorption Scanning if conditions allow. Both methods are relatively new, and results are questionable.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TRACKWORK
CONTROL NUMBER: GSNS 0.12.04.01

APPLICATION

This guide applies to all non-standard procedures for trackwork, turnouts and special trackwork systems, as well as associated work.

SPECIAL INSTRUCTIONS

1. The descriptions below describe general inspection procedures, that are usually performed by specialized personnel or railway contractors.
2. Deficiencies should be handled on a service call or repair basis.
3. Before conducting any non-standard test, existing railway test documentation should be reviewed. Pertinent information should be made available to test personnel.
4. Use extreme care when working on or near live track.
5. Tracks under inspection should be temporarily removed from service whenever possible.

CONCURRENT ACTIONS

Complete standard inspection items listed in GSS 0.12.04.

INSPECTION ACTIONS

The requirements for non-standard inspection items are normally expected to result from the results of the standard inspection as described in GSS 0.12.04. Recurrent or premature failures may require the performance of one or more or the following non-standard tests. This list is not intended to be inclusive, but represent some of the more common specialty tests available.

1. Perform Ultrasonic or Inductive Rail Testing - Often known as Sperry rail testing, after the largest company that performs this service, a rail car equipped with a series of ultrasonic probes (the original equipment utilized long induction coils) travels along the track and is able to detect both external and internal rail defects.
2. Perform Ultrasonic Rail/Weld Test - Specific rail locations can be tested by probable ultrasonic equipment for internal defects. One use for this test is where several rail welds are observed to have visually failed and internal inspection of the remaining welds is desired.
3. Ultrasonic Testing, Special Trackwork - Ultrasonic pulses are sent through material to be tested, such as a frog casting. The reflection velocity and pulse dispersion characteristics is used to determine deterioration or defects size as well as material thickness.
4. Manual Switch Machine Operation - Often included as a standard test, the manual switch machine is thrown in both directions to check for ease of operation and whether both switch points close properly.
5. Ballast/Coring Samples - Samples of ballast and/or subgrade material are taken and sent to a testing laboratory. Tests are conducted to determine percentage of fines, gradation and classification of subgrade, and susceptibility of ballast to mechanical or chemical degradation. When determining ballast fouling and profile deterioration causes, other probable causes should be investigated before this procedures most notably drainage deficiencies.
6. Rail Profile - When rail is severely worn on the top or gauge side, rail profiles (sections) are taken to determine rate of water and probable remaining life. Although there is no rail mounted automatic measurement equipment available for this work, simpler manual measurements with calipers or similar equipment is often more cost effective.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: TRACKWORK (Continued)
CONTROL NUMBER: GSNS 0.12.04.01

INSPECTION ACTIONS

7. Special Trackwork Measurements - Standard turnout inspection includes measurements of gauge, switch point gap, and flangeway depth. More detailed measurements of the special trackwork components may be necessary where excessive or unusual wear and defects are observed.
8. Clearances - Proper horizontal and vertical clearances are essential to the operation and safety of the railway. Specialized clearance cars exist for checking the clearance envelope, but standard survey equipment is normally employed for individual locations.
9. Surveying or Stringlining - Where the geometric alignment is in question for equipment speed or other purposes, the standard inspection gauge and cross level measurements must be supplemented with survey data. Common plane survey equipment is used to check the vertical or horizontal alignment in question. Stringlining is a similar and faster method of determining the track degree of curvature by measuring the midordinates of successive string chords, usually 62 feet in length, stretched along the inside gauge of curved rail.
10. Load/ Dynamic Testing - Where trackwork components show evidence of movement or looseness, the problem area is observed under dynamic conditions; i.e., under loading from a locomotive or train.
11. Grease Test - If there is a question about whether wheel flanges are contacting certain portions of a rail or special trackwork, grease or bitumen is placed on the surface in question and trains are operated over the track. This is most commonly used at switch points, frog points, and guard rails, usually as a result of problems detected during standard inspections.
12. Brinell Hardness - Where the hardness of rails or special trackwork components are in question due to wear, metal flow or corrugation, hardness testing is sometimes indicated. Component hardness is usually checked against surrounding undefective areas of AREA Manual standards, if applicable.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS
CONTROL NUMBER: GSNS 0.12.04.02

APPLICATION

This guide applies to signal systems that are used to provide electrical energy to an electrical railway electrical signal system. This guide does not apply to the operation of signal systems.

SPECIAL INSTRUCTIONS

1. Review as-builts and other documentation to ensure that all interlocks are known prior to initiation of the inspection process.
2. Schedule this inspection to coincide with programmed maintenance activities to minimize system interruption and downtime.
3. Review all operating history documentation prior to the inspection process.
4. Observe all established safety procedures during the inspection process.
5. The inspected unit must be deenergized during this inspection.

CONCURRENT ACTIONS

Annual preventive maintenance tasks.

INSPECTION ACTIONS

Condition assessment survey and evaluation of railway electrical signal and communication systems provide an input to the analysis of functional and physical deficiencies of that assembly. Since the assembly exists and is not in a construction process; regulatory deficiencies associated with installation are not addressed.

PHYSICAL DEFICIENCIES

1.0 CABLE/CONDUCTOR
1.1 Insulation resistance less than one megOhm as measured in insulation resistance test
1.2 Ballast resistance less than established criteria for ballast application
1.3 Ballast resistance less than established criteria for rail-to-rail resistance criteria

2.0 FITTING

3.0 BEARINGS
3.1 Improper bearing

4.0 MOUNT
4.1 Bent or misshapen

5.0 HEATER
5.1 Sensing device broken, missing or inoperative
5.2 Sensing device malcalibrated when measured against standard
5.3 Inadequate heater resistance to ground when measured by insulation resistance test
5.4 Heater inoperative

6.0 MARKING

7.0 DISCONNECT
7.1 Interlock broken, missing or inoperative as measured in protective device test
7.2 Mechanical trip broken, misadjusted or inoperative as measured in protective device test

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS (Continued)
CONTROL NUMBER: GSNS 0.12.04.02

PHYSICAL DEFICIENCIES

7.0 DISCONNECT
7.3 Contacts burned, pitted, discolored or other physical damage as measured in protective device test
7.4 Adjustable settings misadjusted as measured in protective device test
7.5 Does not trip on overcurrent in accordance with NFPA 70B as measured in protective device test
7.6 UnderVoltage trip missing, broken, maladjusted or inoperative as measured in protective device test
7.7 Resistance less than one megOhm between poles and/or from poles to non-energized parts as measured in insulation resistance test
7.8 Individual pole resistance does not meet manufacturer's specifications as measured in contact resistance test
7.9 Time current characteristics not per manufacturer's specifications as measured in protective device test
7.10 Does not sustain rated current in accordance with NFPA 70B as measured in sustained current test
7.11 Shunt trip device missing, broken or inoperative as measured in protective device tset
7.12 Series trip device missing, broken or inoperative as measured in protective device test
7.13 Arc suppression device broken, cracked, missing, tracked, chipped or other physical damage

8.0 LIGHTNING PROTECTION/SURGE PROTECTION DEVICES
Lightning protection devices or surge suppressors encountered in the inspection of this equipment will be inspected in accordance with guide sheet GSNS 0.09.03.08.

9.0 CONTROL WIRING
9.1 Control wiring insulation less than one megOhm per kiloVolt of rating when measured by insulation resistance test
9.2 Inadequately torqued at termination
9.3 Time delays inconsistent when measured with timer
9.4 Improper sensor pickup or dropout value when measured against standard
9.5 Interlock inoperative

10.0 BUSHING/INSULATOR
10.1 Not adequately torqued to mounting surface

11.0 METERING
Metering encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.04.

12.0 TRANSFER SWITCH
Transfer switches encountered in the inspection of this device will be inspected in accordance with guide sheet GSNS 0.09.01.02.10.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SIGNALS & COMMUNICATIONS (Continued)
CONTROL **NUMBER:** **GSNS 0.12.04.02**

PHYSICAL DEFICIENCIES

13.0 ENCLOSURE
13.1 Interlock broken, missing or inoperative as measured in protective test

14.0 FUSE UNIT
14.1 Resistance less than one megOhm between poles and/or from poles to non-energized parts as measured in insulation resistance test

15.0 LUMINAIRES
Luminaires encountered in the inspection of this device will be inspected in accordance with guide sheet GSNS 0.09.02.01.

16.0 REACTORS
Reactors encountered in the inspection of this device will be inspected in accordance with guide sheet GSNS 0.09.01.02.11.

17.0 TRANSFORMERS
Transformers encountered in the inspection of this device will be inspected in accordance with guide sheet GSS 0.09.01.02.11.

18.0 BONDS
18.1 Defective or inoperative

19.0 MOTOR CONTROL CENTERS
Motor control centers encountered in the inspection of this device will be inspected in accordance with guide sheet GSNS 0.09.01.02.06.

20. SWITCH MACHINES
20.1 Detector rod broken, missing, or out of adjustment
20.2 Inoperable
20.3 Loose or broken wiring
20.4 Operating rod broken, missing or out of adjustment
20.5 Overloaded motor
20.6 Relays out of adjustment, pitted or burned contacts

21.0 SIGNAL SYSTEMS
21.1 Inoperative
21.2 Insulation burned, charred or other damage
21.3 Splice insulation unraveled, brittle, cracked, or other damage
21.4 Unauthorized splice
21.5 Not properly connected to device
21.6 Insulation improperly removed from conductor
21.7 Bimetallic connectors not used as required
21.8 Not properly bundled or trained
21.9 Insulation resistance less than one megOhm as measured in insulation resistance test

TOOLS & MATERIALS

1. **Standard** Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: FOUNTAINS & POOLS
CONTROL NUMBER: GSNS 0.12.05

APPLICATION

This guide applies to non-standard inspection procedures for all Fountains and Pools.

SPECIAL INSTRUCTIONS

1. Review any as-builts and other data to determine locations, types, and construction.
2. Refer to glossary and references as needed.
3. It is recommended that such non-standard inspection be performed under the supervision of a licensed structural engineer. Based on his review of standard inspection results the following tests and analyses may be recommended (can include all or some of the tests listed below).

CONCURRENT ACTIONS

1. Inspect foundations and footings, substructure, and exterior closure for any other signs of damage or deterioration that may be related to Fountain and Pool deficiencies.
2. Complete inspection requirements listed in GSS 0.12.05.

INSPECTION ACTIONS

Based on results of GSS 0.12.05 and/or as directed proceed to non-standard inspections. Points include:

1. Perform an environmental data analysis to determine the effects of external environmental conditions.
2. Perform Surface Hardness testing or Maturity Concept Analysis to determine material condition and locate possible defects/deficiencies within the material.
3. Take core samples to determine condition or strength of the material. Patch sample holes immediately. Use great care when performing this work and consult a licensed structural engineer before proceeding.
4. Perform Infrared or Nuclear Analysis testing to determine if water or moisture is present, indicating general location of cracks or breaks.
5. Perform Ultrasonic Pulse Velocity test to locate defects within the material and to determine the degree of deterioration and material thickness.
6. Perform Magnetic test to determine material thickness and reinforcement location.
7. Perform Electrical Resistivity test to determine moisture content, material thickness, and degree of corrosion or deterioration.
8. Perform Radiography (X-Ray) testing to detect cracking, internal defects, and deficiencies.
9. Perform Microwave Absorption Scanning to determine moisture content and material defects. This is a relatively new method still under development.
10. Perform Acoustic Emission test to determine stress points and material deformations. This is a difficult test requiring dynamic loading conditions.

TOOLS & MATERIALS

1. Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS . NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: SECURITY GATES & FENCES
CONTROL NUMBER: GSNS 0.12.06

APPLICATION

This guide applies to all non-standard inspection procedures for Chainlink Security Gates and Fences.

SPECIAL INSTRUCTIONS

1. Review manufacturer's or installers instructions.
2. Review historical documentation prior to initiating inspection.
3. Inspection should be scheduled during period of least traffic volume.
4. Establish traffic control in accordance with established safety procedures.
5. Use extreme care when working around chainlink fabric and barbed wire.

CONCURRENT ACTIONS

1. Annual preventive maintenance tasks.
2. Accomplish Standard Methods Inspection.

INSPECTION ACTIONS

Condition Assessment Survey of Security Gates and Fences to include visual inspection and analysis. Points include:

1. Open and close gate manually, noting ease of movement, binding.
2. Check control operation for opening and closing electrically if applicable.
3. Open and close gate electrically (if applicable) noting operation of operator and limit switches.
4. Check gate operator, if applicable; chain for excessive slack and lubrication; belts for tension and condition; clutch adjustment; sprockets for tightness; limit switches for adjustment.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

INSPECTION METHODS - NON-STANDARD

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: LANDSCAPING
CONTROL NUMBER: GSNS 0.12.07

APPLICATION

This guide applies to all non-standard inspection procedures for Landscaping.

SPECIAL INSTRUCTIONS

1. Schedule this inspection during dry conditions.
2. Review historical documentation prior to inspection to identify prior problem areas.
3. It is recommended that such non-standard inspections be performed under the supervision of a Horticulturist. Based on his/her review of standard inspection results, the following tests and analyses may be recommended (can include all or some of the tests listed below).

CONCURRENT ACTIONS

1. Inspect walkways.
2. Inspect parking lots.
3. Inspect gates and fences.
4. Inspect fountains and pools.
5. Complete inspection requirements listed in GSS 0.12.08.

INSPECTION ACTIONS

Based on results of GSS 0.12.08 and/or as directed, proceed to non-standard inspections. Points include:

1. Take soil samples for analysis to determine needed amendments and fertilizer materials to bring soil to desired standards.
2. Take samples from grass, shrubs, and trees as required for analysis to determine type of disease or infestation present and required corrective action.
3. Perform environmental data analysis to determine the effects of the local environment on the landscape.

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

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INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: BRIDGES & ABUTMENTS
CONTROL NUMBER: GSNS 0.12.08

APPLICATION

This guide applies to all non-standard inspection procedures for Bridges and Abutments.

SPECIAL INSTRUCTIONS

1. Review as-builts and other historical documentation prior to initiating the inspection process.
2. Schedule this inspection during a time period of least traffic volume.
3. Establish traffic control in accordance with established procedures.
4. Observe safety procedures during the inspection process.

CONCURRENT ACTIONS

1. Scheduled Preventive Maintenance Tasks.
2. Accomplish the Standard Inspection.

INSPECTION ACTIONS

Condition Assessment Survey of Bridges and Abutments to include visual survey, examination of building records, and analysis. Points include:

Abutments:

1. Check for cracked and corroded welds; check suspicious areas with dye-penetrant.
2. Check for erosion or scour, using divers to check areas below water level.
3. Check for damage caused by impact or floating debris; check areas below water line using divers.

Piers:

1. Check for cracked and corroded welds; check suspicious areas with dye-penetrant.
2. Check for erosion or scour, using divers to check areas below water level.
3. Check for damage caused by impact or floating debris; check areas below water line using divers.
4. Check hangers for cracks and tightness; check suspicious areas with dye-penetrant.

Decks:

1. Check asphalt, if applicable, for cracking, pot holes, rutting, and drying out.
2. Check concrete for scaling, spalling, cracking, and rutting.
3. Check steel grating, if applicable, for broken welds and rivets; check suspicious areas with dye-penetrant.
4. Check timber, if applicable, for insect damage, rot, wear, splitting, or other damage.
5. Checks curbs for damage, alignment, proper anchorage, and corrosion.
6. Check sidewalks for deterioration, cracking, scaling, and spalling.
7. Check railings and parapets for spalling, scaling, cracking, corrosion, and impact damage.
8. Check for loose, damaged, or missing fasteners.
9. Check painted surfaces for peeling, cracking, chipping, and corrosion.
10. Check drainage system for proper operation by flushing with water and noting any ponding.
11. Check for debris buildup along the curb.

Utilities:

Check for cracked or broken welds; check suspicious areas with dye-penetrant.

INSPECTION METHODS - NON-STANDARD

GUIDE SHEET

SYSTEM/COMPONENT: BRIDGES & ABUTMENTS (Continued)
CONTROL NUMBER: GSNS 0.12.08

TOOLS & MATERIALS

1. Non-Standard Tools - Basic
2. As required for the type of test being performed

END OF SUBSECTION

DATA COLLECTION METHODS

GENERAL

The heart of the CAS System is built around the hand-held data collection device and the CAIS software that supports it. As discussed in the Introduction, this is a "new way" of seeing and recording specific standardized information. Several phases are involved in the CAS inspection process. They include:

PHASE 1 PRESURVEY

- Facility managers review assets and assign each an Asset Determinant Factor (ADF) to define the level and type of inspection to be accomplished (see Subsection 1 .1 for definition).
- Facility managers assign specific assets to CAS inspectors.
- The CAS Inspector reviews existing asset data (including as-builts and past repair reports) and the Work Breakdown Structure (WBS) systems requiring inspection, which are then subdivided as necessary. (For example, a large roof may be subdivided into four (4) WBS items such as North, South, East and West sections.)
- The inspector establishes the Inspection Units (IU) to be surveyed based on the WBS (or multiple WBS). IUs may also be added in the field.
- Facility manager and/or staff downloads asset data into the hand-held data collection device.

PHASE 2 SURVEY

- Conduct CAS inspection.
- Upload data into PC-based CAIS.
- Review raw data "universal" reports.

PHASE 3 **POSTSURVEY**

- Correct data, as necessary, issue final "universal" report, and create other required reports for facility managers.
- Data and reports are created and issued through DOE hierarchy (see Introduction).

DATA COLLECTION METHODS

ENTERING DATA: DATA COLLECTION MENU

SURVEY STEP: LOGIN SCREEN 1.0

The screen contains identification data including the inspector's name, ID number, and discipline to be inspected. This data may be input or preloaded. From this screen, several information and help pop-up aids can be accessed. Help functions would provide screen-specific instructions, and information functions would list special management instructions and/or schedules specifically for the inspector.

SURVEY STEP: ASSET IDENTIFICATION SCREEN 2.0

Asset identification including class, type, ADF number (see subsection 1.1 for ADF description), and asset ID numbers are captured on this screen. Pop-up screens with preformatted picklists (for type and class) are provided for the inspector's review and selection. Additional support screens include ASSET DIMENSIONS indicating key elements required for inspection (such as asset gross square footage, perimeter, height, etc.); and ASSET DESCRIPTION for recording asset name and address. Such information would be entered (or verified) by the inspector prior to the actual asset CAS inspection.

SURVEY STEP: WBS SELECTION SCREEN 3.0

This screen displays the preselected systems and WBS listings based on the ADF selected for the particular asset. Although all WBS assemblies for a system will be listed, the inspector selects only assemblies applicable to the specific asset. For example, although all system 0.05 Roof WBS categories are listed, the inspector would eliminate all non-applicable categories by "de-selecting" non-applicable items, Once this process is complete, the inspector can re-sort the included WBS items. Columns are also provided that indicate the survey status for each WBS item.

At this point, the inspector can subdivide the WBS. For example, the inspector may elect to split a large roof into four sections, each as a separate WBS, or isolate a pump from a WBS containing several pumps. This feature will allow the inspector to logically build his survey based on the unique properties and requirements of each asset.

Finally, while most WBS structuring will be accomplished prior to the CAS inspection, WBS subdivision can also be done in the field.

DATA COLLECTION METHODS

ENTERING DATA: DATA COLLECTION MENU (Continued)

SURVEY STEP: INSPECTION UNIT (IU) SELECTION SCREEN 4.0

While screen 3.0 defines the WBS structure, screen 4.0 concerns selecting the IU for each WBS category. In the CAIS software, the base CAS (see subsection 1 .1 for definition) is preset at the assembly level for all systems. For example, a WBS Roof System, Built-up Membrane Roofing (0.05.01), is set at the assembly level. At this point the inspector would select the type of assembly based on a preselected picklist. (Such a picklist at the assembly level might include various roof assembly groupings; eg., 3 to 5-ply asphalt with gravel coating and composite insulation.) If a more detailed inspection is required, the inspector would "de-select" the base CAS assembly level by crossing through the LVL Box "Assy." This action would bring up the next level "component." In our roof example, this would mean that the inspector would now assess the membrane, flashing, and insulation as separate components. As with the assembly level, the inspector would choose a type from a selected picklist for each component. Although IUs are usually determined prior to the survey, multiple IUs may also be developed during the inspection. For example, a WBS of the south quadrant built-up roof may be divided into two IUs (eg., sw corner and remaining roof) if the inspector chooses to highlight and isolate some abnormal conditions from the main IU.

Additional information developed on this screen would include the percentage of WBS served by the IU, the estimated quantity (this figure will also be independently generated by CAIS status (see subsection 1.1), estimated life remaining useful without repair (WOR), and estimated age.

SURVEY STEP: DEFICIENCY ASSESSMENT SCREEN 4.1

With the WBS and IU established, the inspector now conducts the CAS inspection for each WBS IU. As the inspector surveys the asset, a preformatted picklist containing all deficiencies that may affect the particular WBS IU is reviewed. The default setting shows a zero in each coverage block, indicating no deficiencies. As the survey proceeds, the inspector "de-selects" this normal setting by entering a percentage of coverage under condition categories listed (light, moderate, severe, and fail). For example, inspector entries for WBS roofing, IU built-up membrane, deficiency "splitting" of 10% light, 0% moderate, 0% severe, 0% fail, would be interpreted by CAIS software as 90% normal, and light splitting occurring over 10% of the membrane. If the inspector cannot determine the condition using standard inspection methods, he can indicate the need for a non-standard inspection (NSIP) by de-selecting the "NO" in the NSIP column. To complete the inspection, the aforementioned procedures would be carried out for each deficiency noted by the inspector.

DATA COLLECTION METHODS

ENTERING DATA: DATA COLLECTION MENU (Continued)

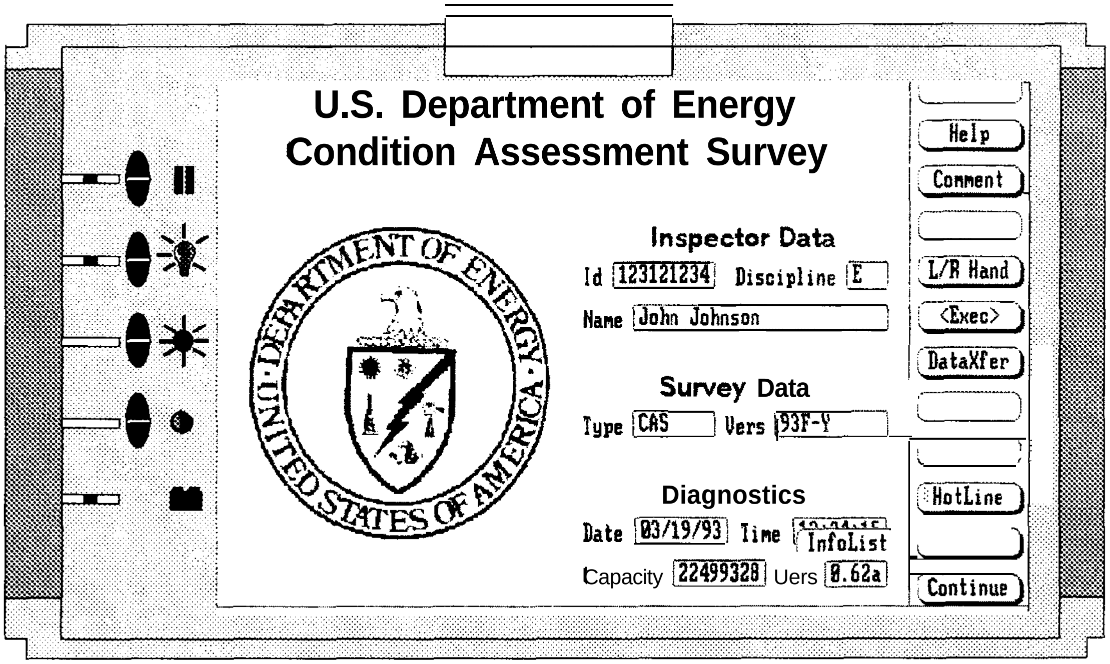
SURVEY STEP: SUMMARY CONDITION ASSESSMENT SCREEN 5.0

This final screen summarizes the WBS IU in three major categories: urgency, purpose, and condition. In each category, the inspector will call up a picklist and select the category he feels is most appropriate for the WBS IU surveyed. (For the purpose category, the inspector may select multiple headings.) Additionally, the inspector may elect to enter an estimated cost and/or quantity. (This is optional as CAIS will generate these data based on the inspector's survey information.) The inspector will also enter an estimated remaining life post-repair. As an option, a work order may be generated based on the CAS survey information. This option is generated by selecting the WORK ORDER function key and filling out pertinent data. Finally, the inspector may choose to describe the repair more fully by selecting the REPAIR CHARACTER key.

After completing all WBS IUs, the CAS inspection for the system is complete. This procedure is repeated for each applicable system. Once all systems for the asset are complete, the information is uploaded to the PC-based CAIS program for data analysis and report generation.

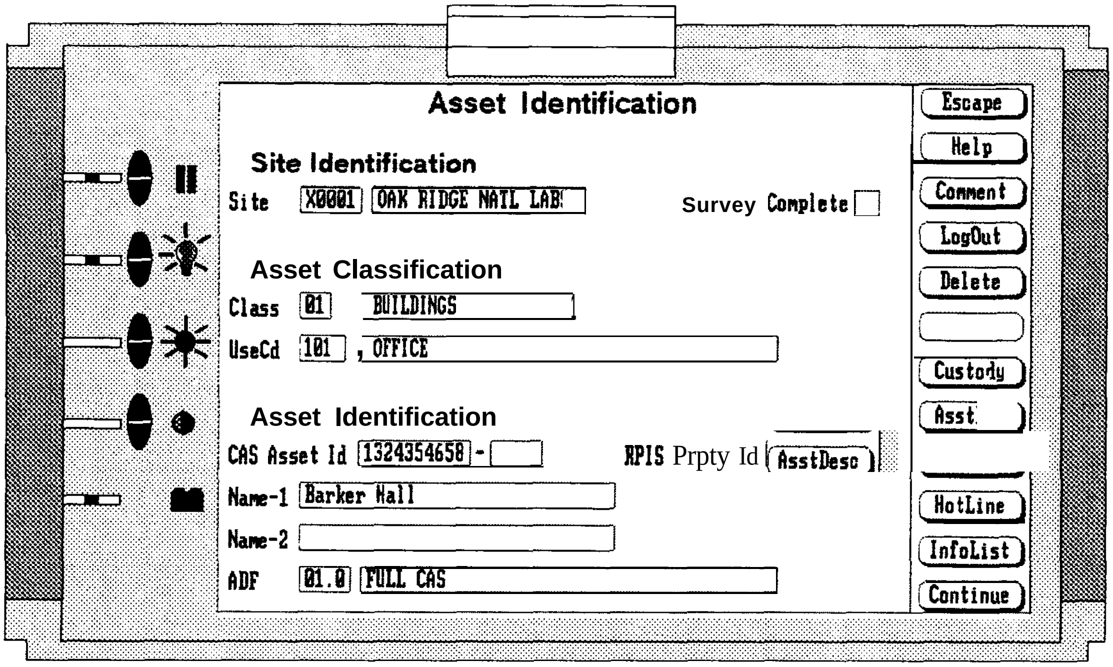
In the remainder of this subsection, actual data screens, as they will appear to the inspector, are displayed to illustrate a typical inspection. As previously noted, five main screens are used in the system supported by numerous "pop-up" lists, information, comment, and other auxiliary screens. In our examples, main screens are numbered 1.0 - 5.0; secondary screens are labeled 1.1, 1.2, etc.; and general support screens use the series 99.0. Key inspector actions on each screen are highlighted. Support function keys are listed below these main functions.

SURVEY STEP **LOGIN** **Screen 1 .0**



SCREEN	ACTION	COMMENT
1.0	1. Enter Name and Employee Id #	May be preloaded for security
	2. Tap "Discipline" title for picklist, cursor select or enter by pen	Picklist preformatted A=Arch, C=Site/Civil, E=Elec, M=Mech
	3. Tap "Type" and "Vers" title under Survey Data for picklist cursor select or enter by pen	Picklist preformatted for type of survey to be performed and version date for record
	4. Diagnostics data is system generated and for information purposes only	N/A
	5. Press (Continue) to go to Screen 2.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information.
(Help)	**Press** to bring **up** screen help	**Screen 99.1**
(Comment)	Press to bring up screen for entering inspector comments	Screen 99.2
(LH/RH)	Press to change screen between Left or Right Hand use	**N/A**
(<Exec>)	Press to exit to the Grid System Menu	This option can be password protected
(DataXfer)	Press to transfer data to site computer	Used for data **upload/download** procedures
(Hotline)	Press for important contacts and telephone numbers	Screen 99.3
(InfoList)	**Press** to bring up information/directions **preloaded** for inspector	Screen 99.4

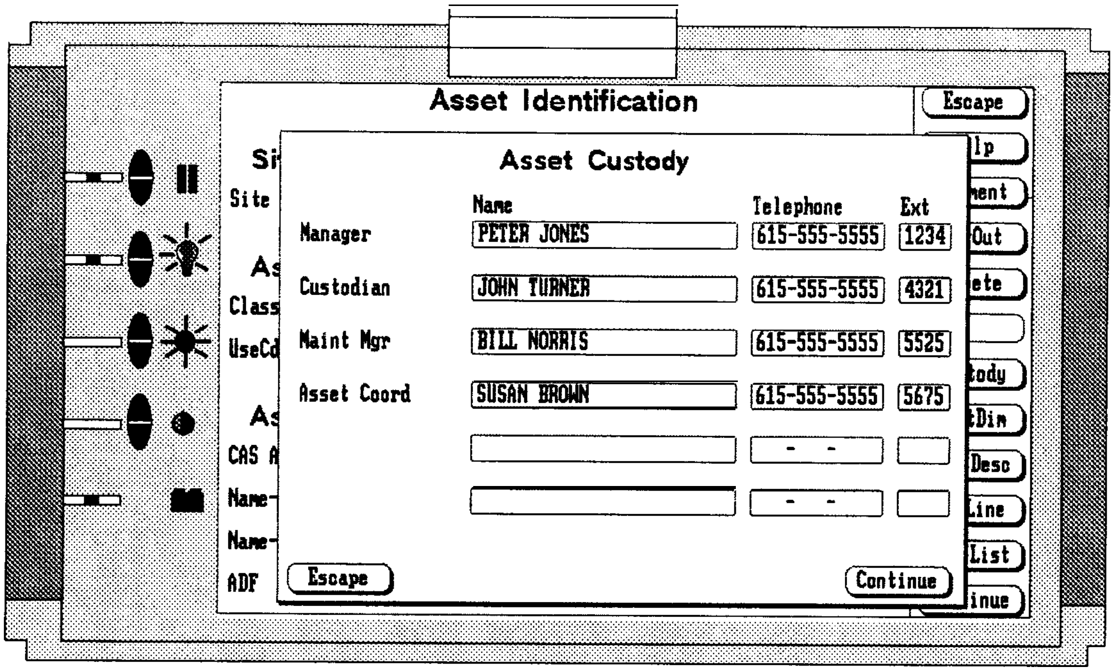
SURVEY STEP ASSET IDENTIFICATION Screen 2.0



SCREEN	ACTION	COMMENT
2.0	1. Tap "Site" title for picklist Cursor select or enter by pen	Picklist can be preloaded, site code appears automatically to match name selected
	2. Tap "Class" title for picklist Cursor select or enter by pen or skip to item 4	Picklist preformatted based on RPIS categories
	3. Tap "Use Cd" title for picklist Cursor select or enter by pen or skip to item 4	Picklist preformatted based on RPIS categories
	4. Enter Asset Identification information by selecting "CAS Asset Id" corresponding "RPIS Prpty Id" and "Name-1 or Name-2" will be generated	This data can be preloaded
	5. Enter a Split Asset by creating an extension to "CAS Asset ID" and selecting a new name	This data can be preloaded or created by inspector
	6. Enter Asset Determinant Factor "ADF" provided by Site Mgr.	Determined by Site Manager prior to survey
	7. Press box next to Survey Complete upon completion of Asset Survey	N/A
	8. Press (Continue) to go to Screen 3.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 1.0	By pressing (Escape) information is not verified and any changes made are lost
(Help)	Press to bring up screen help	Screen 99.1
(Comment)	Press to bring up screen for entering inspector comments	Screen 99.2
(Logout)	Press to save all data entered and leave survey	N/A
(Custody)	Press to bring up asset contact names	Screen 2.1 Thii data can be preloaded
(AssetDim)	Press to bring up screen for entering or verifying key asset dimensions	Screen 2.2 This data can be preloaded
(AssetDes)	Press to bring up screen for entering or verifying asset name, address and descriptions	Screen 2.3 This data can be preloaded
(HotLine)	Press for important contacts and telephone numbers	Screen 99.3
(InfoList)	Press to bring up information/directions preloaded for inspector	Screen 99.4

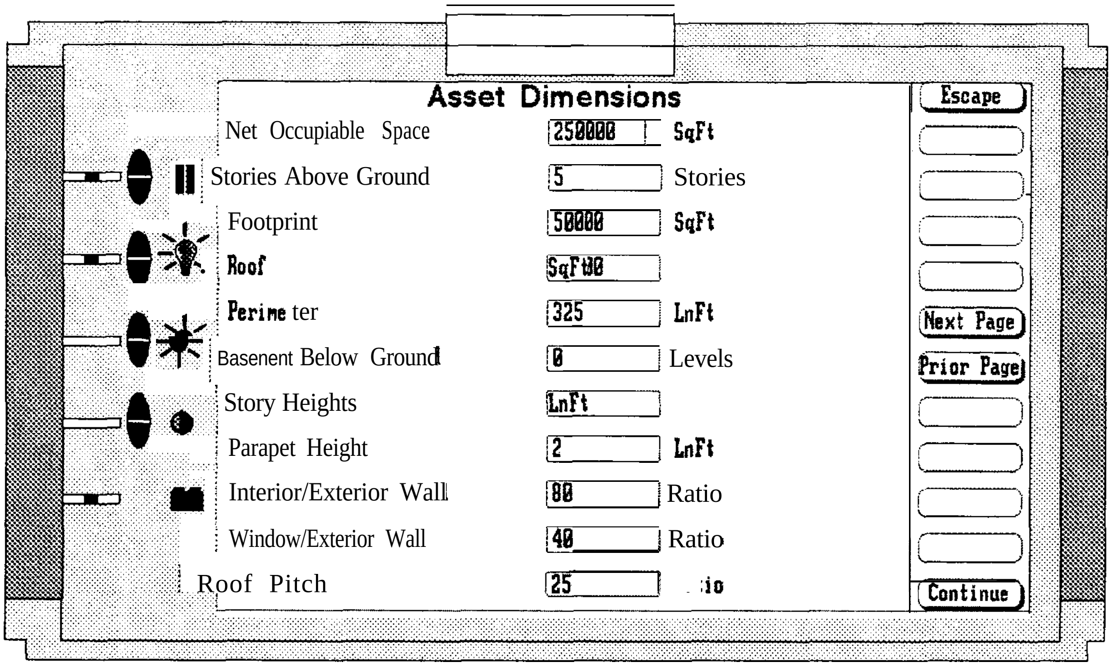
SURVEY STEP ASSET CUSTODY SCREEN

Screen 2.1



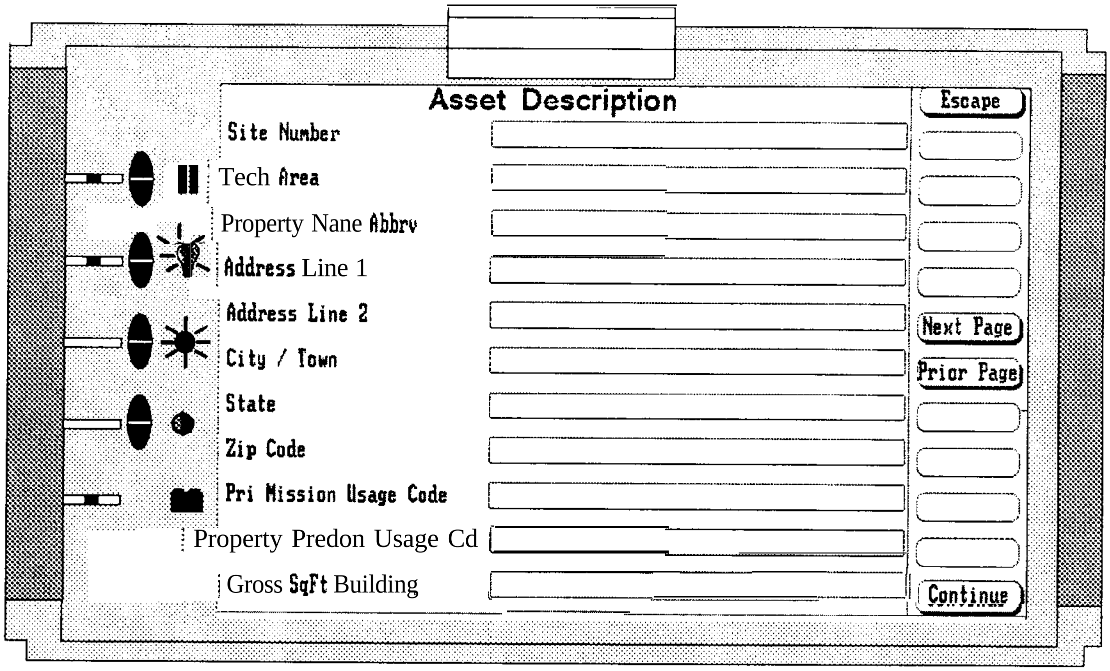
SCREEN	ACTION	COMMENT
2.1	1. Pop up window displays important names and numbers for asset. Cross through data and make any changes	Data can be either preloaded or inspector generated.
	2. Press (Continue) to return to Screen 2.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information.
(Escape)	Press to return to Screen 2.0	3y pressing- inform&ii is not verified and any changes made am lost.

SURVEY STEP ASSET DIMENSIONS Screen **2.2**



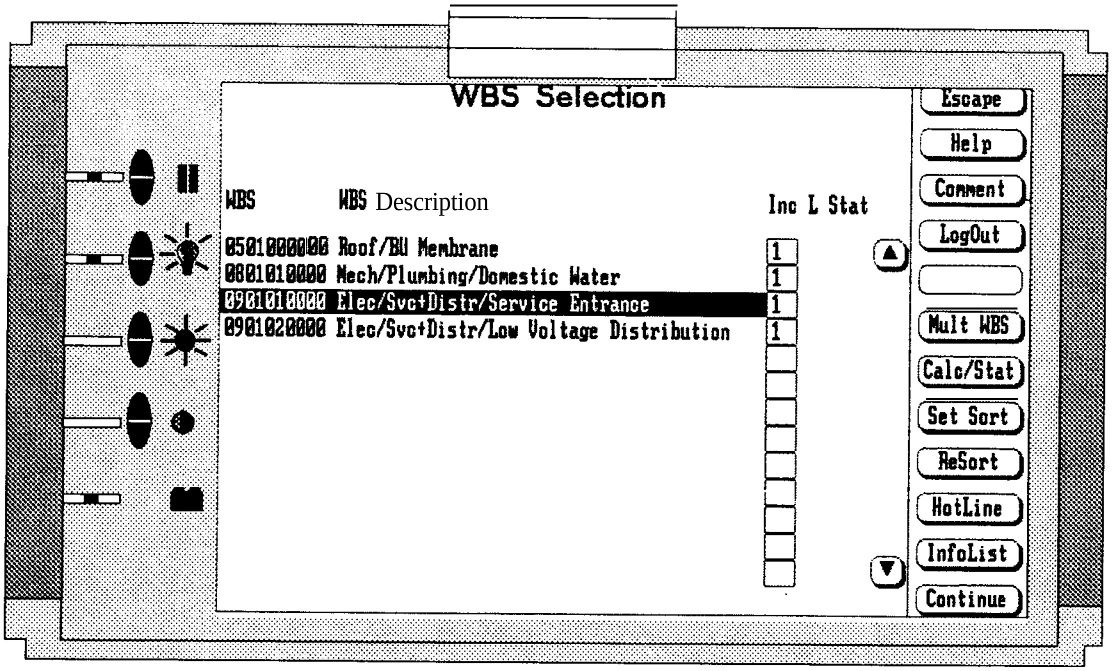
SCREEN	ACTION	COMMENT
2.2	1. Screen displays important dimension related to the asset verify data or cross through data and make any changes	Data can be either preloaded or inspector generated.
	2. Press (Continue) to return to Screen 2.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information.
(Escape)	Press to **return** to **Screen** 2.0	By **pressing** (Escape) **information** is not **verified** and any changes made **are** lost.
(NextPage)	**Press** to bring up **next screen** of important dimensions	Data can **be either preloaded** or inspector **generated.**
(PriorPage)	**Press** to **return** to previous **asset** dimension **screen**	Data can **be either preloaded** or inspector generated.

SURVEY STEP ASSET DESCRIPTION Screen 2.3



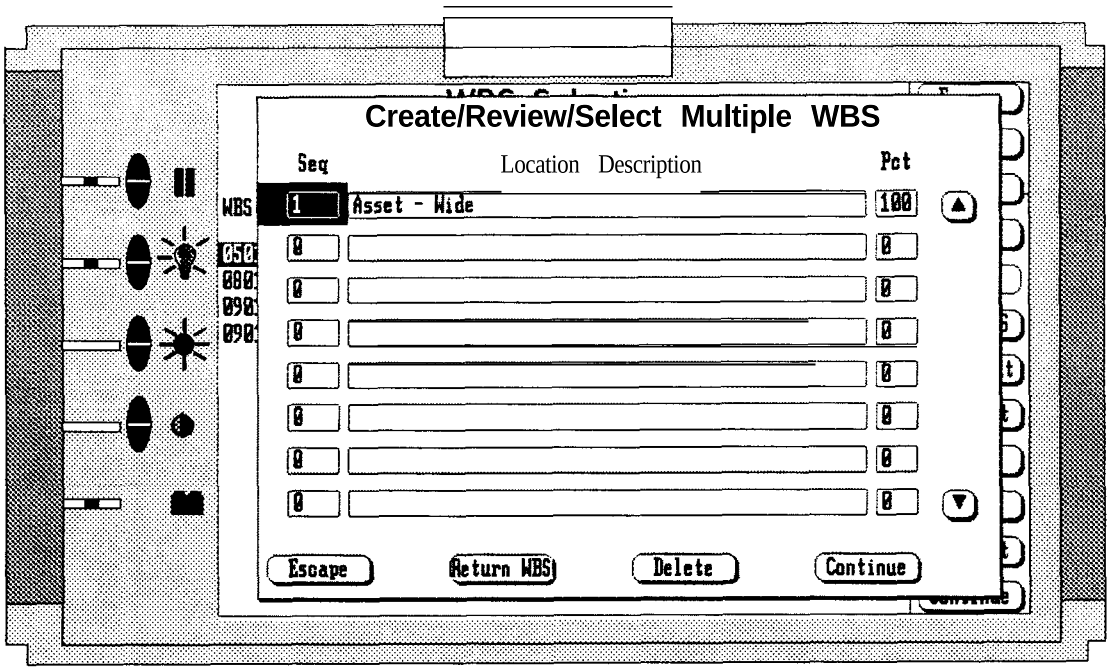
SCREEN	ACTION	COMMENT
2.3	1. Screen displays important asset description information verify data or cross through and make changes	Data can be either preloaded or inspector generated
	2. Press (Continue) to return to Screen 2.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 2.0	By pressing (Escape) information is not verified and any changes made are lost
(NextPage)	Press to bring up **next** screen of important descriptions	Data can be either preloaded or inspector generated
(PriorPage)	Press to return to previous asset description screen	Data can be either preloaded or inspector generated

SURVEY STEP WBS SELECTION Screen 3.0



SCREEN	ACTION	COMMENT
3.0	1. Select WBS item to inspect from picklist	Picklist preformatted and is presorted by ADF numbers. Columns at end of WBS list show: "inc" (included) by sort order 1,2,3...; "M" (multiple items); and "Stat" (Status) (In Progress, Complete, or Not Started [*])
	2. All WBS for ADF included on screen; cross through number in "inc" column to deselect	By crossing through "inc" number, WBS item is deselected
	3. Press (Continue) to go to Screen 4.0	By pressing (Continue) information is verified and inspections units under the selected WBS are loaded
(Escape)	Press to return to Screen 2.0	By pressing (Escape) information is not verified and any changes made are lost.
(Help)	Press to bring up screen help	Screen 99.1
(Comment)	Press to bring up screen for entering inspector comments	Screen99.2 .
(Logout)	Press to save all data entered and leave survey	N/A
(Multi WBS)	Press to create, view or select multiple WBS and locations	Screen 3.1
(CalcSort)	Press to re-calculate the status of or number of multiple locations	N/A
(SetSort)	Resets the sort sequence of systems, etc. by accessing a pop-up window	N/A
(Resort)	Press to resort list in order of priority of WBS items selected	N/A
(HotLine)	Press for important contacts and telephone nurnbers	screen 99.3
(InfoList)	Press to bring up information/directions preloaded for inspector	Screen 99.4
▲	Press Scroll Up button	Used to scroll up through information.
▼	Press Scroll Down button	Used to scroll down through information.

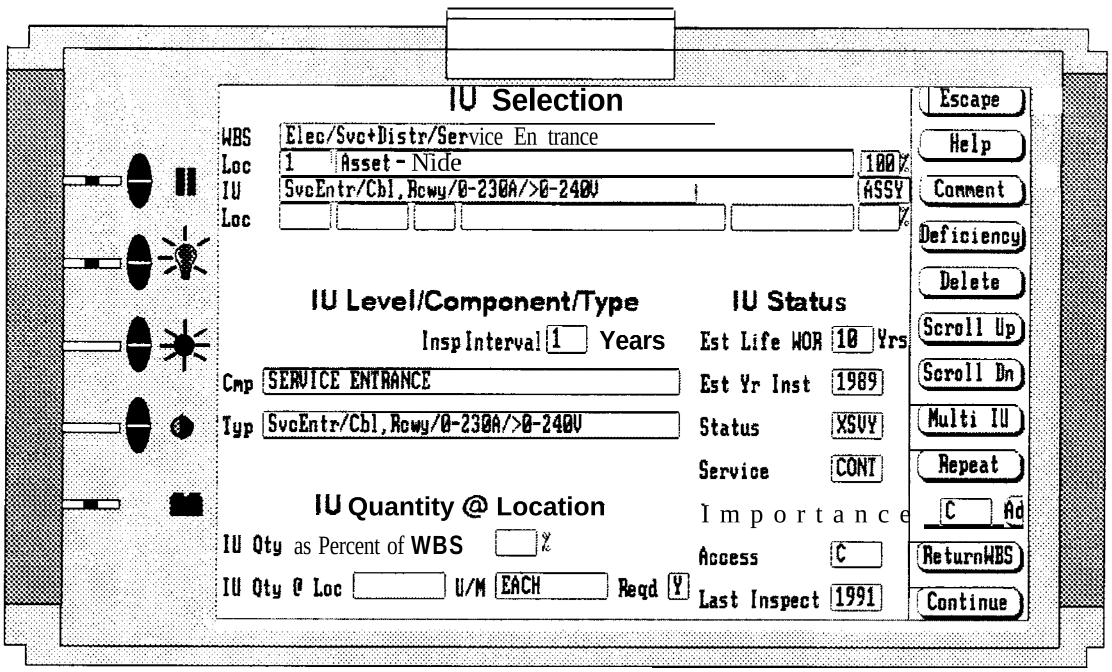
SURVEY STEP CREATE/REVIEW/SELECT MULTIPLE WBS Screen 3.1



SCREEN	ACTION	COMMENT
3.1	1. Define locations of multiple WBS. Could be multiple systems or multiple parts of single system.	Inspector developed
	2. Define percentage of Asset serviced by WBS section	Inspector developed
	3. Press (Continue) after selecting multiple WBS locations from list and continue to Screen 4.0 to select Inspection Unit (IU).	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information or selecting another item
(Escape)	Press to return to Screen 3.0	By pressing (Escape) information is not verified and any changes made are lost
(RtrnWBS)	Press to return to WBS selection screen to make additional selections	N/A
(Delete)	Press to delete a highliited entry on screen	N/A
▲	Press scroll up button	Used to scroll up through information.
▼	Press scroll down button	Used to scroll down through information.

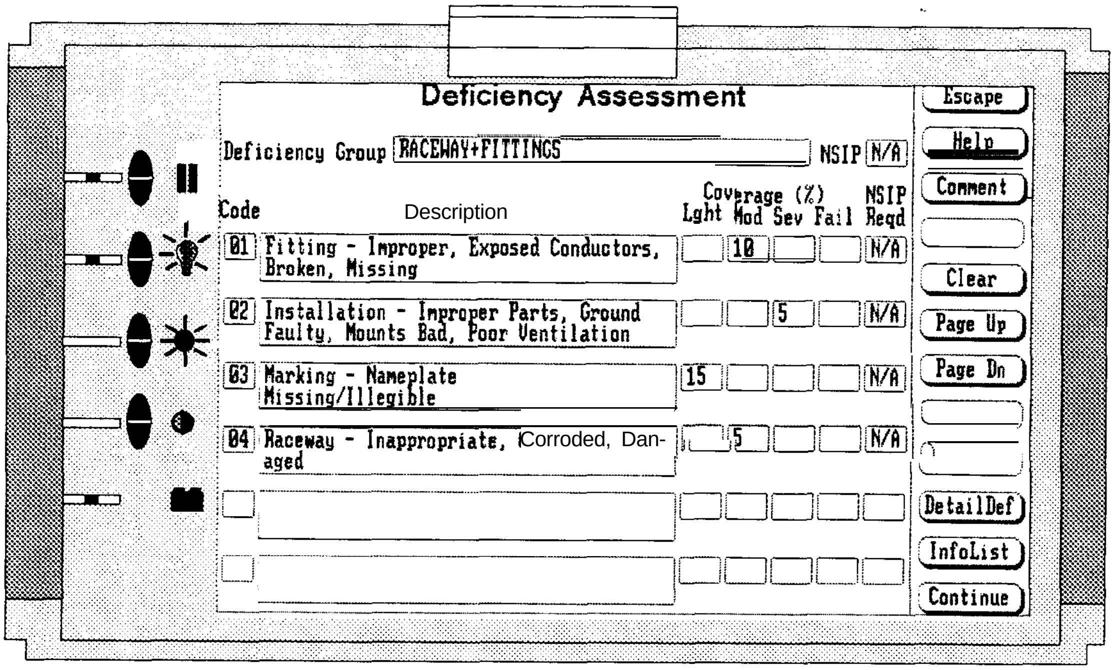
SURVEY STEP IU SELECTION

Screen 4.0



SCREEN	ACTION	COMMENT
4.0	1. Tap "Cmp" title for component picklist Cursor select or enter by pen	Picklist is preformatted
	2. Tap "Typ" title for type of component picklist Cursor select or enter by pen	Picklist is preformatted
	3. Press (Deficiency) to bring up deficiency assessment screen	Screen 4.1 brings up deficiency picklist for WBS IU
	4. Enter estimated life without repair	Inspector generated
	5. Enter estimated year "IU" installed	Inspector generated
	6. Tap "Status" title for picklist Cursor select or enter by pen	Picklist is preformatted
	7. Tap "Service" title for picklist Cursor select or enter by pen	Picklist is preformatted
	8. Tap "Importance" title for picklist	Picklist is preformatted
	9. Tap "Access" title for picklist Cursor select or enter by pen	Picklist is preformatted
	10. Enter year "IU" last inspected	Inspector generated
	11. Enter percentage of WBS served by inspection unit	Inspector generated
	12. Enter quantity of inspection unit at location as required	Inspector generated
	13. Press (Continue) to go to Screen 5.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 3.0	By **pressing** (Escape) **information** is not verified; and any **changes** made are lost
(Help)	Press to bring up screen help	Screen 99.1
(Comment)	Press to bring up screen for entering inspector comments	Screen 99.2
(Delete)	Press to delete an inspection unit record	N/A
(Scroll Up)	Press to scroll up thru inspection units selected	N/A
(Scroll Dn)	Press to scroll down thru inspection units selected	WA
(Multi IU)	Press to create, view. or select **multiple IU's** and locations	Screen 4.2
(Repeat)	Press to repeat or copy inspection **unit** selection data as a new entry	N/A
(AddnlData)	Press to bring up Additional Data screen and enter boiler plate information	Screen 4.3 - Inspector generated
(RtrnWBS)	Press to save data entered and go to Screen 3.0 for **next** selection	By pressing (RtrnWBS) information is verified; corrections made **by** crossing through data and entering new information

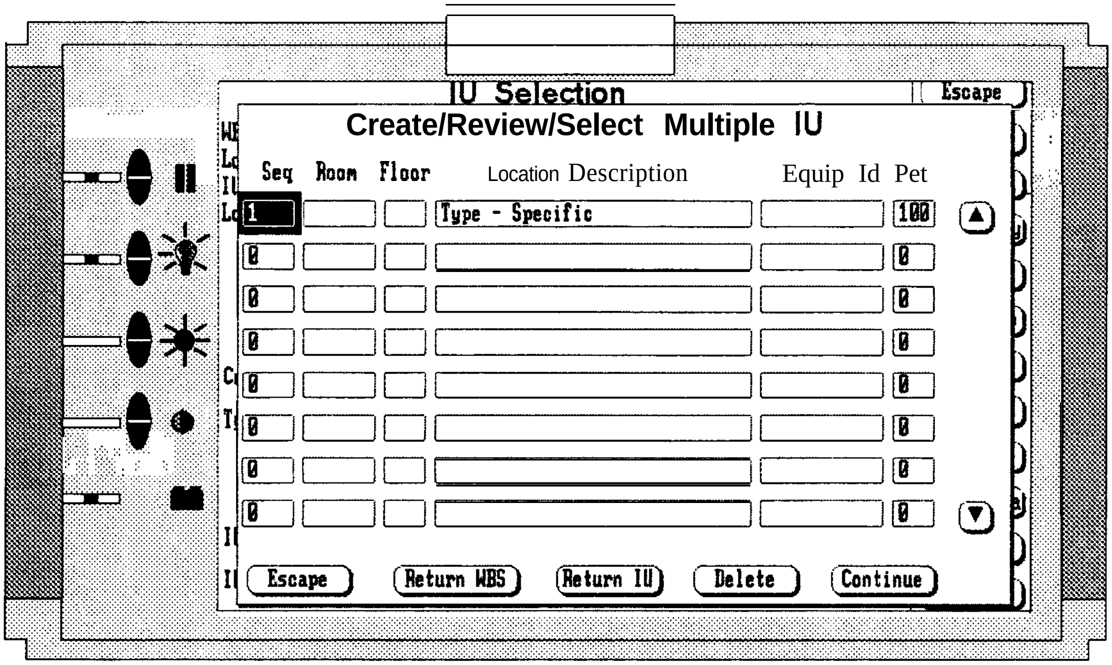
SURVEY STEP DEFICIENCY ASSESSMENT Screen 4.1



SCREEN	ACTION	COMMENT
4.1	1. Select deficiency from list	Picklist preformatted
	2. Select degree of severity of deficiency	Inspector developed
	3. Enter percentage of coverage under selected severity	Inspector developed
	4. Indicate whether non-standard inspection/test procedures are required or recommended	Inspector choice, preset at "No": line through to deselect
	5. Press (Continue) to go to Screen 5.0	By pressing (Continue) information k verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 4.0	By pressing (Escape) information is not verified and any changes made are lost
(Help)	Press to bring up screen help	Screen 99.1
(Comment)	Press to bring up screen for entering inspector comments	Screen 99.2
(Clear)	Press to unselect a deficiency	N/A
(Page Up)	Press to scroll up though data by page	N/A
(Page Dn)	Press to scroll down through data by page	N/A
(Detail Def)	Press to bring up long description of selected deficiency	N/A
(InfoList)	Press to bring up information/directions preloaded for inspector	Screen 99.4

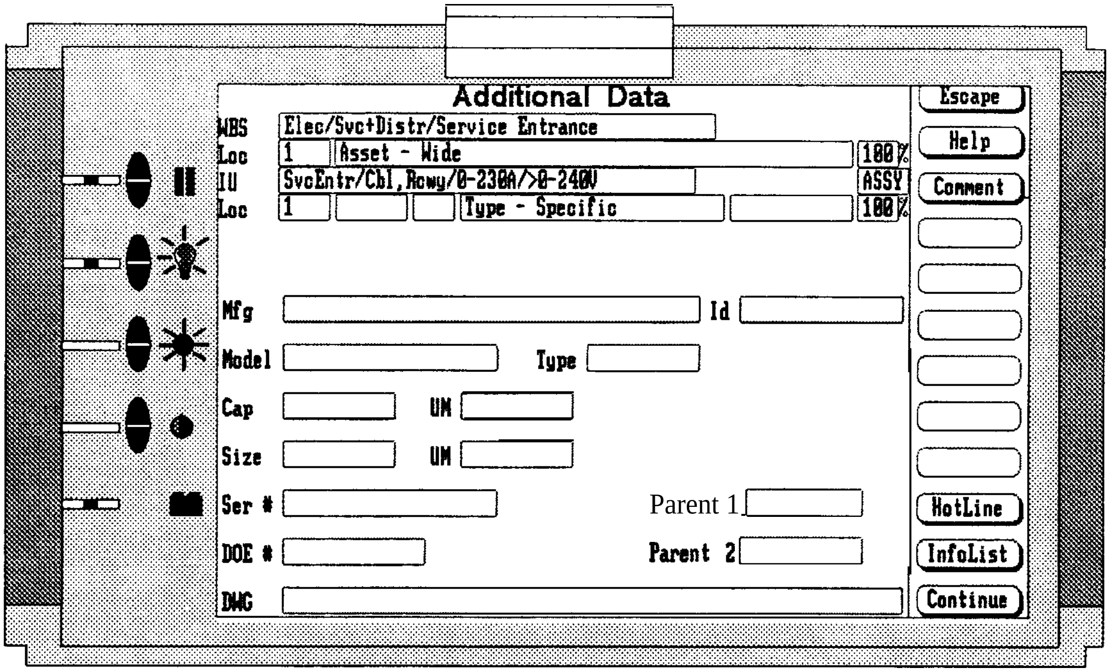
SURVEY STEP CREATE/REVIEW/SELECT MULTIPLE IU

Screen 4.2



SCREEN	ACTION	COMMENT
4.2	1. Define locations of Multiple IU's by room, floor and/or location description - optional equipment identification number can be added	Inspector developed
	[redacted] BS serviced by IU	Inspector developed
	3. Press (Continue) after selecting Multiple IU location from list and continue to Screen 4.1 to select deficiencies	By pressing (Continue) information is verified; corrections made by crossing thru data and entering new information or selecting another item
(Escape)	Press to return to **Screen** 4.0	By **pressing** (Escape) **information** is not verified and any changes made are lost
(RtrnWBS)	**Press** to return to Screen 3.0	WA
(RtrnIU)	Press to return to Screen 4.0	**N/A**
(Delete)	**Press** to delete a highlighted entry on **screen**	**N/A**
▲	Press scroll up button	Used to scroll up through information
▼	Press scroll down button	Used to scroll down through information

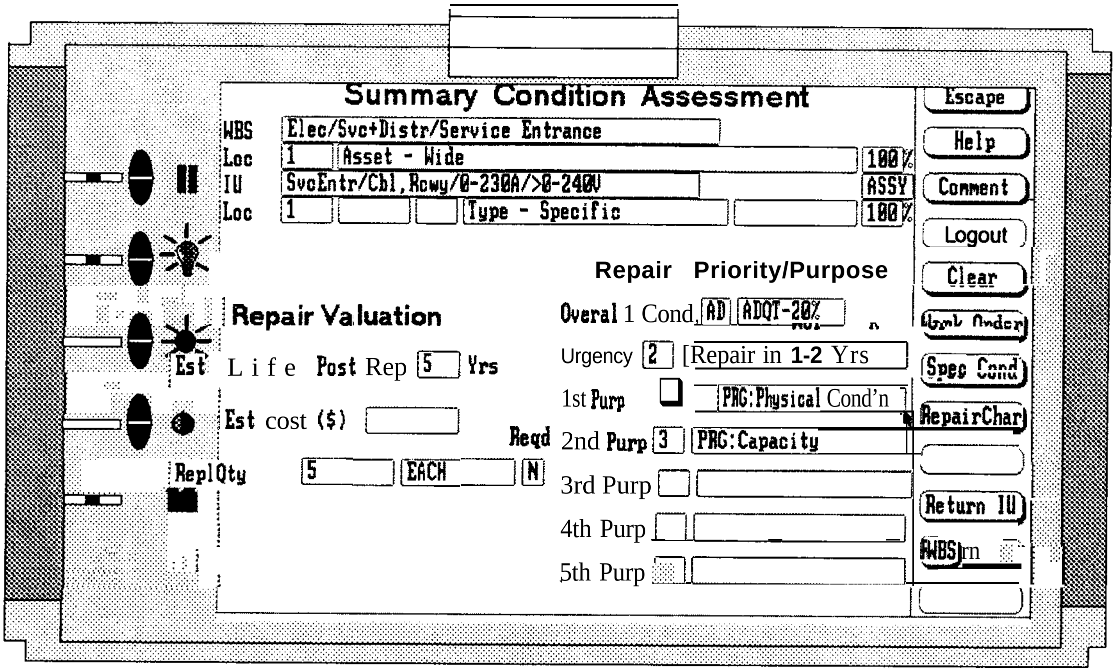
SURVEY STEP ADDITIONAL DATA — Screen 4.3



SCREEN	ACTION	COMMENT
4.3	1. Enter boiler plate data about component being inspected	Inspector generated from data on the component, drawing specifications or determined in the field. This data can be used for inventorying inspection units
	2. Press (Continue) to go to Screen 4.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 4.0	By pressing (Escape) information is not verified; and any changes made are bst
(Help)	Press to bring up screen help	screen 99.1
(Comments)	Press to bring up screen for entering inspector comments	Screen 992
(Hotline)	Press for important contacts and telephone numbers	Screen 99.3
(InfoList)	Press to bring up information/directions preloaded for inspector	screen 99.4

SURVEY STEP SUMMARY CONDITION ASSESSMENT

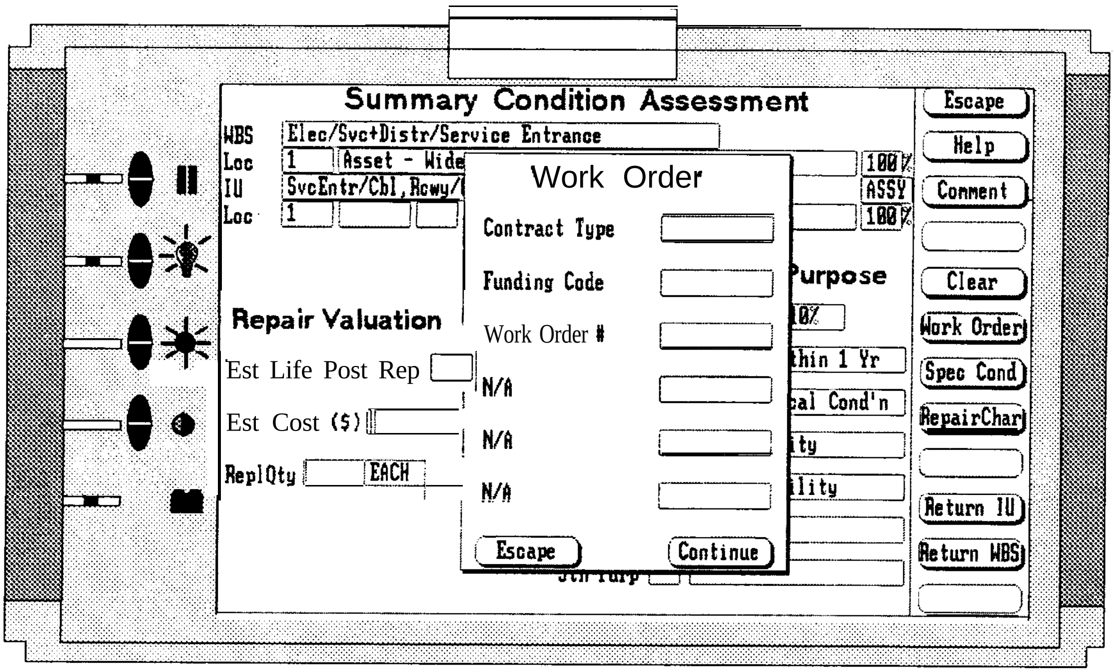
Screen 5.0



SCREEN	ACTION	COMMENT
5.0	1. Tap "Overall Condition" title for picklist Cursor select or select by pen	Picklist preformatted, inspector determined
	2. Tap "Urgency" title for picklist Cursor select or enter by pen	Picklist preformatted, inspector determined
	3. Tap "Purp" title for picklist Cursor select or enter by pen Multiple purposes can be specified	Picklist preformatted inspector determined
	4. Enter estimated life of IU after repairs in years	Inspector determined
	5. Enter an estimated cost for repairs (optional)	Inspector determined
	6. Enter repair quantity as required	Inspector determined
	7. Press to save data entered and go to Screen 4.0 for next selection	By pressing (ReturnIU) information is verified; corrections made by crossing through data and entering new information
	8. Press to save data entered and go to Screen 3.0 for next selection	By pressing (ReturnWBS) information is verified; corrections made by crossing through data and entering new information
(Escape)	Press to return to Screen 4.0	By pressing (Escape) information is not verified and any changes made are lost
(Help)	Press to bring up screen help	Screen 99.1
(Comment)	Press to bring up screen for entering inspector comments	Screen 99.2
(Logout)	Press to save all data entered and leave survey	N/A
(Clear)	Press to clear or delete an entry	N/A
(Work Order)	Press to bring up work order screen pop-up	Screen 5.1
(Spec Cond)	Press to bring up special condition screen pop-up	Screen 5.2
(Repair Char)	Press to bring up special repair characteristics screen pop-up	Screen 5.3

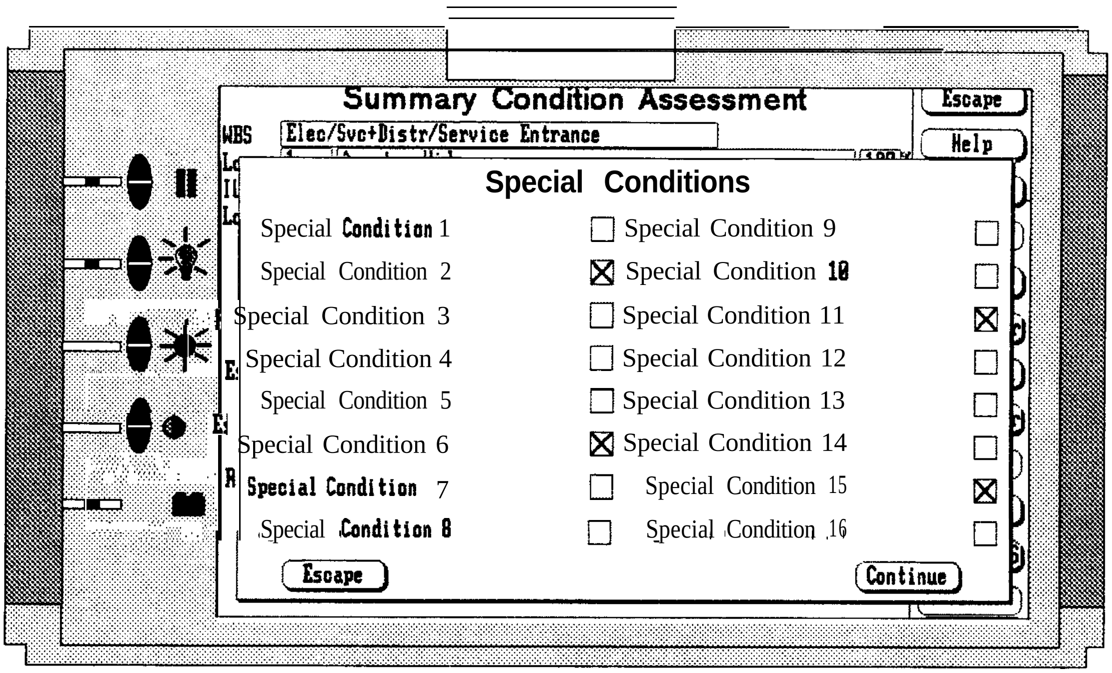
SURVEY STEP WORK ORDER GENERATION

Screen 5.1



SCREEN	ACTION	COMMENT
5.1	1. Enter data to define Work Order number to tag repair to create a job estimate for repairs	Inspector generated as determined by Site Manager prior to survey
	2. Press Continue to go to Screen 5.0	By pressing Continue information is verified; corrections made by crossing through data and entering new information
	3. Press-to return to Screen 5.0	By pressing Escape information is not verified; and any changes made are lost

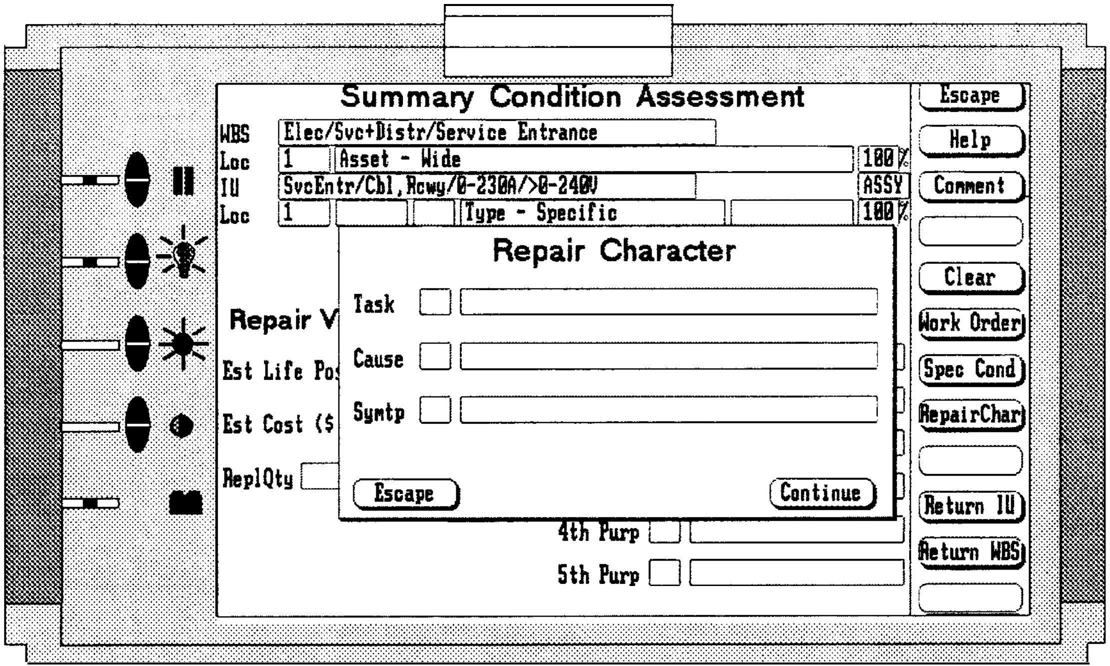
SURVEY STEP SPECIAL CONDITIONS SELECTION Screen 5.2



SCREEN	ACTION	COMMENT
5.2	1. Press box next to special condition to select	Picklist is preloaded by site. Selections determined by Site Manager prior to survey
	2. Press Continue to go to Screen 5.0	By pressing Continue inforrmtion is verified; corrections made ty crossing thnugh data and entering new information
	3. Press-to return to Screen 5.0	By pressing Escape information is not verified; and any changes made are lost

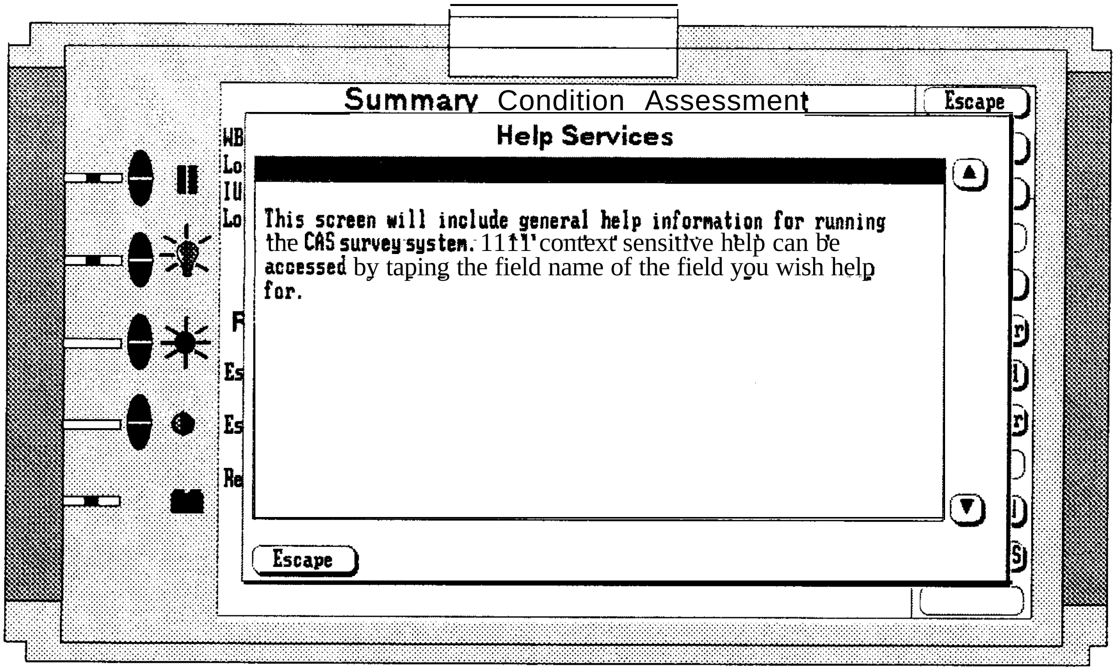
SURVEY STEP REPAIR CHARACTER DOCUMENTATION

Screen 5.3



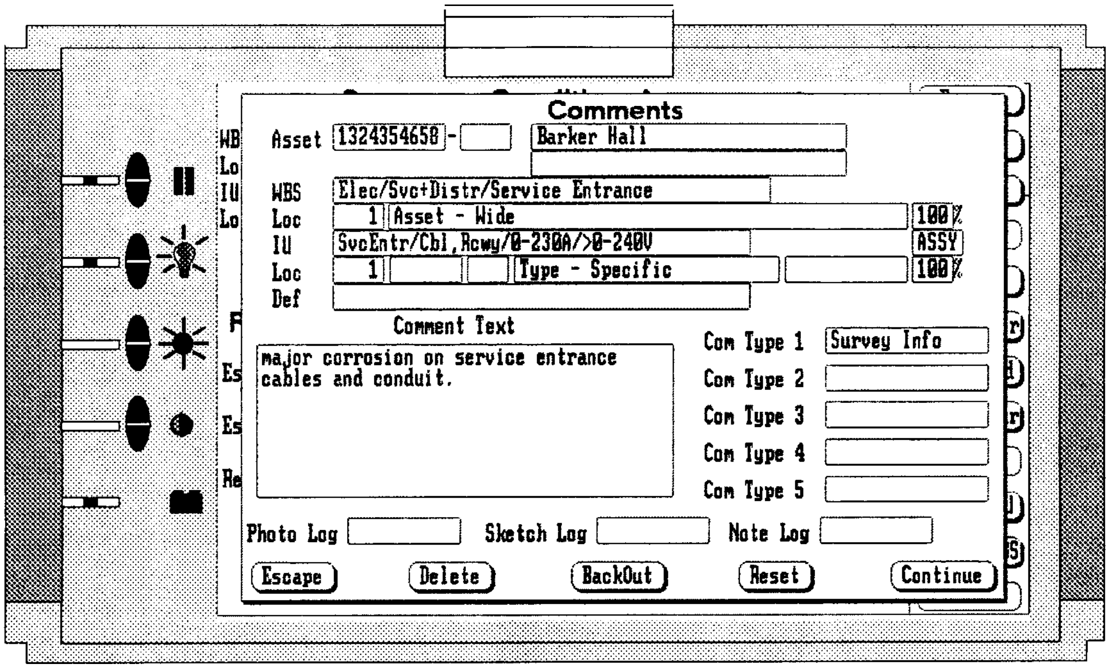
SCREEN	ACTION	COMMENT
5.3	1. Enter repair characteristics for tracking related deficiencies	Inspector generated from input of asset users to document what is deficient, what caused deficiency and any symptoms. Picklist can be preformatted
	2. Press (Continue) to go to Screen 5.0	By pressing (Continue) information is verified; corrections made by crossing through data and entering new information
	3. Press (Escape) to return to Screen 5.0	By pressing (Escape) information is not verified; and any changes made are lost

SURVEY STEP HELP Screen 99.1



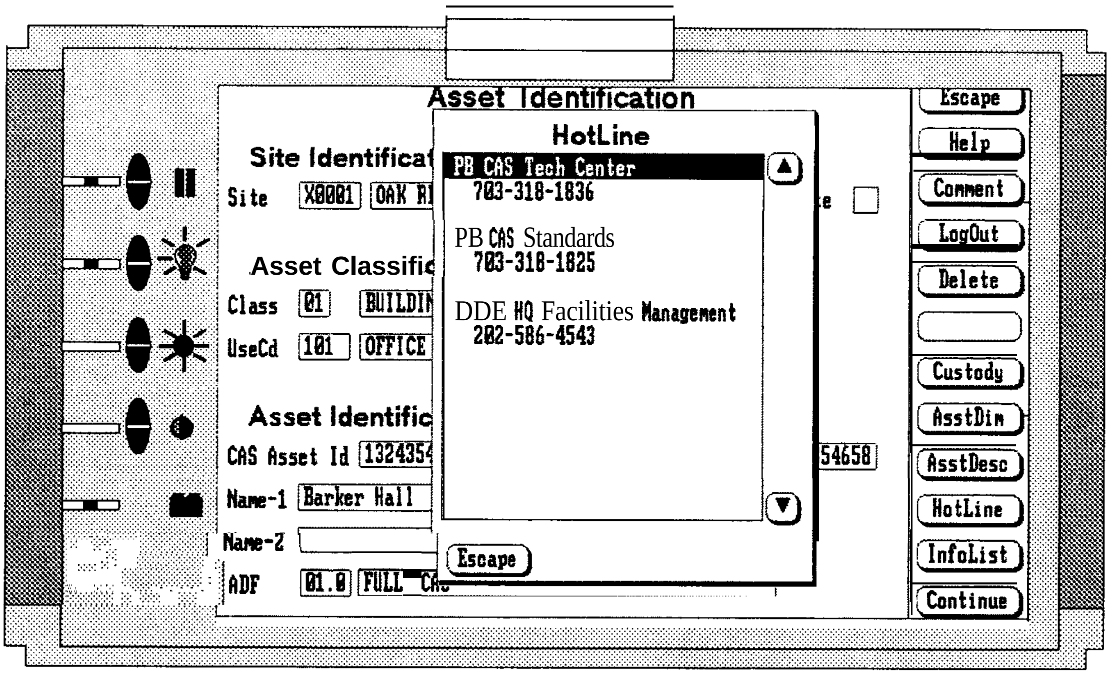
SCREEN	ACTION	COMMENT
99.1	N/A	Screen pop-up help information Dynamic help for locations selected Screen data cannot be changed
Escape	Press to exit Help Screen and return to previous screen	N/A
	Press scroll up button	Used to scroll up through information
	Press scroll down button	Used to scroll down through information

SURVEY STEP COMMENT SCREEN Screen 99.2



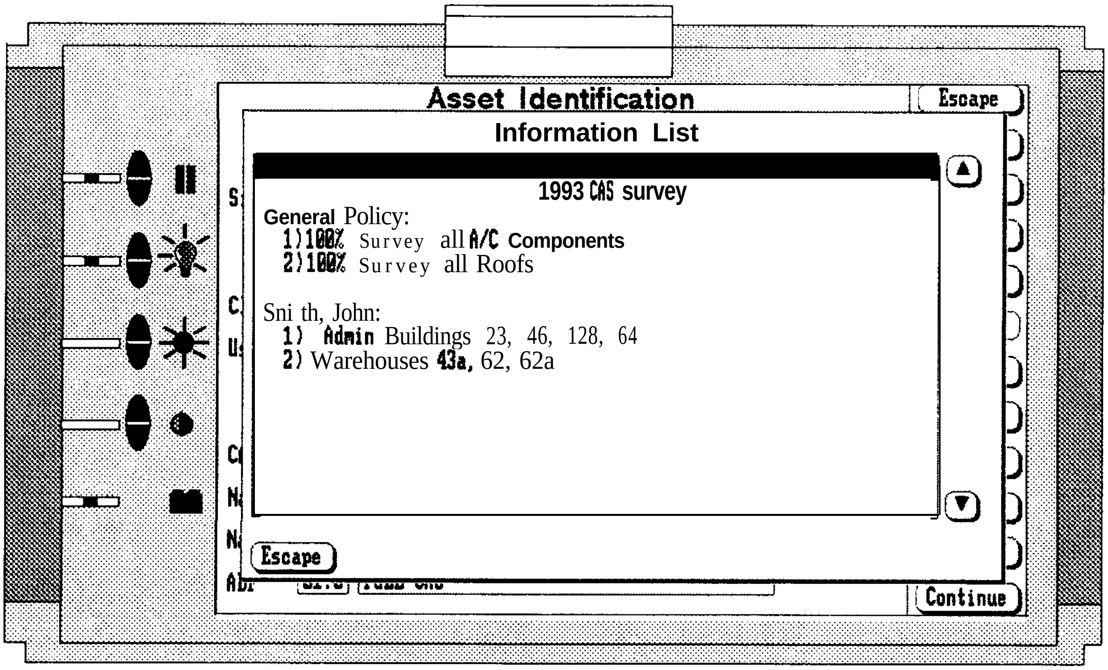
SCREEN	ACTION	COMMENT
99.2	1. Select a Comment Type Selection	Picklist preformatted
	2. Enter Comment inside comment text field (QWERTY keyboard can be called in to use)	Text field expands as required
	3. Enter a Photo, Sketch, or Note Log tag number	Can be standardized or inspector generated
	4. Press (Continue) to return to previous screen	By pressing (Continue) information is verified; corrections made by crossing thru data and entering new information
(Escape)	Press to exit comment screen and **return** to **previous** screen	By **pressing** (Escape) information is not verified and any changes **made** are lost
(Delete)	Press to delete a selected comment	**N/A**
(Backout)	Press to move backwards through the navigation screen at top	This option allows an inspector to move backwards to **enter** or change a comment tagged to a previous screen
(Reset)	Press to move **forward** through the navigation screen at top	This option allows an inspector to move forward after entering a comment on a previous screen to continue the inspection

SURVEY STEP HOTLINE SCREEN Screen 99.3



SCREEN	ACTION	COMMENT
99.3	N/A	Screen pop-up for important contacts and telephone numbers Preformatted and adjusted by Site Manager. Screen data cannot be changed by inspector
(Escape)	Press to exit Hotline screen and return to previous screen	WA
▲	Press scroll up button	Used to scroll up through information
▼	Press scroll down button	Used to scroll down through information

SURVEY STEP INFO SCREEN Screen 99.4



SCREEN	ACTION	COMMENT
99.4	1. CAS inspection parameters & schedules as inputted by site manager	Cannot be changed by inspector
Escape	Press to exit InfoList screen and return to previous screen	N/A
▲	Press scroll up button	Used to scroll up through information
▼	Press scroll dawn button	Used to scroll down through information

DATA COLLECTION METHODS

END OF SUBSECTION

FEDERAL SPECIFICATIONS

FEDERAL SPECIFICATION	TITLE
DOE 10 CFR 435	DOE Energy Conservation
DOE 29 CFR 1910	Occupational Safety & Health Standards
DOE 40 CFR 112	Oil Pollution Prevention
DOE 40 CFR 141	National Primary Drinking Water Regulations
DOE 40 CFR 290	Underground Storage Tanks
DOE 5460.7	Fire Protection
DOE 6430.1A	DOE General Design Criteria
FED-STD 66	(Rev D; Notice 1) Steel, Chemical Composition and Hardening Ability
FS FF-S-325	(Basic; Int Am 3; Notice 1) Shield, Expansion, Nail, Expansion and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS HH-M-622	(Rev D) Mortar, Refractory, Heat Setting, Bonding (Wet and Dry Types)
FS MMM-A-001993	(Basic) Adhesive, Epoxy, Flexible, Filled (for Binding, Sealing and Grouting)
FS QQ-S-763	(Rev E; Am 1; Notice 1) Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting
FS QQ-S-775	(Rev E; Int Am 1) Steel Sheets, Carbon, Zinc-Coated (Galvanized) by the Hot-Dip Process
FS QQ-W-461	(Rev H) Wire, Steel, Carbon (Round, Bare, and Coated)
FS RR-B-191	(Rev B) Bedpan, Corrosion-Resisting Steel
FS RR-F-191/1D	Fencing, Wire and Post, Metal (Chain-Link Fence Fabric)
FS RR-F-191/2D	Fencing, Wire and Post, Metal (Chain-Link Fence Gates)
FS RR-F-l 91/3D	Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FS RR-F-l 91/4D	Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)
FS RR-F-191K/GEN	Fencing, Wire and Post, Metal (Chain-Link Fence Fabric and Accessories)
FS RR-F=22 1 G/G EN	Fencing, Wire, Fence Posts and Accessories (Barbed Wire, Woven Wire, and Netting)
FS SS-C-158	Federal Specification for Cements, Hydraulic, General Specifications (methods for sampling, inspection, and testing)
FS SS-C-181	Federal Specification for Cement, Masonry
FS SS-C-192	Federal Specification for Cements, Portland (10 types)
FS ss-c-206	Federal Specification for Cement, Portland, Pozzolana
FS TT-S-001657	Joint and Seam Sealant
FS WW-P460b	Pipe Fittings, Bronze, Cast
FS WW-P47b	Pipe Fittings, Ferrous, Threaded
FS WW-P541	Plumbing Fixtures
GSA PBS P 5650.18	Maintenance Guidelines
REA Bulletin 160-2	Rural Electrical Association - Mechanical Design Manual for Overhead Distribution Lines
REA Bulletin 163-l	Rural Electrical Association - Steam-Electric Generating Plants, Operation and Maintenance Inspection Manual
REA Bulletin 169-l	Rural Electrical Association - The Application of Shunt Capacitors ot the Rural Electric System
REA Bulletin 43-5	Rural Electrical Association - List of Materials Acceptable for Use on Systems of REA Electrification Borrowers
REA Bulletin 50-1	Rural Electrical Association - Electric Transmission Specifications and Drawings, 115kV Through 230kV

FEDERAL SPECIFICATIONS

REA Bulletin **50-2**	Rural Electrical Association - Electric Transmission Specifications and Drawings, 34.5 kV Through 69kV
REA Bulletin 61-l 2	Rural Electrical Association - Guide for Narrow Profile and Armless Construction (Electric Distribution)
USCE CRD **C400**	Requirements for Water for Use in Mixing or Curing Concrete
USCE **CRD-C109**	Field Test for Absorption by Aggregates
USCE **CRD-C119**	Test for Flat and Elongated Particles in Coarse Aggregates
USCE **CRD-C129**	Test for Particles of Low Specific Gravity in Coarse Aggregate (Sink-Float Test)
USCE CRD-C13	U.S. Army Corps of Engineers Test for Evaluation of Air-Entraining Admixtures for Concrete
USCE **CRD-C213**	Test for the Presence of Sugar in Cement, Mortar, Concrete, and Aggregates
USCE **CRD-C248**	U.S. Army Corps of Engineers Specifications for Slag Cement
USCE **CRD-C300**	Specifications for Pigmented Membrane-Forming Compounds for Curing Concrete

END OF SUBSECTION

NATIONAL STANDARDS

AIR MOVEMENT & CONTROL ASSOCIATION (AMCA)

AMCA 99	Standards Handbook
AMCA 201	Fans and Systems
AMCA 210	Laboratory Methods of Testing Fans for Rating Purposes
AMCA 300	Test Code for Sound Rating
AMCA 301	Method for Calculating Fan Sound Ratings From Laboratory Test Data
AMCA 500	Test Method for Louvers, Dampers and Shutters

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.2	Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 211.3	Standard Practice for Selecting Proportions for No-Slump Concrete
ACI 211.88	Standard Practice of Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 301	Specifications for Structural Concrete for Buildings
ACI 304	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R-89	Hot Weather Concreting
ACI 306R-88	Cold Weather Concreting
ACI 308	Standard Practice for Curing Concrete
ACI 308	Standard Practice for Consolidation of Concrete
ACI 318	Recommendations for Construction of Concrete Pavements and Concrete Bases
ACI 318	Building Code Requirements for Reinforced Concrete
ACI 336.1-89	Standard Specification for the Construction of End Bearing Drilled Piers
ACI 347	Recommended Practice for Concrete Formwork
ACI 508	Guide to Shotcrete

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.4	Cast-Iron Threaded Fittings
ANSI B18.5	Steel Flanges and Flanged Fittings
ANSI 831.5	ASME Code for Pressure Piping - Refrigerant Piping
ANSI C2-1990	National Electrical Safety Code

AMERICAN RAILWAY ENGINEERING ASSOCIATION (AREA)

AREA 101	Standard Plan 101

AMERICAN SOCIETY OF HEATING, REFRIGERATION & AIR CONDITIONING ENGINEERS (ASHRAE)

ASHBAE 3	Guidelines to Reduce CFC Refrigerant Emissions
ASHBAE 15	Safety Code for Mechanical Refrigeration
ASHBAE 20	Methods of Testing for Rating Remote Mechanical Draft Air Cooled Refrigerant Condensers
ASHBAE 24	Methods of Testing For Rating Liquid Coolers
ASHBAE 51	Methods of Testing Fans for Rating
ASHBAE 80A	Energy Conservation in New Building Design
ASHBAE 100	Energy Conservation in Existing Buildings

NATIONAL STANDARDS

AMERICAN SOCIETY OF MECHANICAL ENGINEERS **(ASME)**

ASME	Boiler and Pressure Vessel Code
ASME B16	Fittings Flanges and Valves
ASME B16.1	Cast-Iron Pipe Flanges
ASME 816.11	Forged-Steel Pipe Fittings
ASME 816.22	Copper Tube Fittings
ASME 816.3	Malleable-Iron Pipe Fittings
ASME 816.5	Steel Pipe Flanges
ASME 816.9	Wrought-Steel Pipe Fittings
ASME 831.3	Chemical Plant and Petroleum Refinery Piping
ASME 831.9	Building Services Piping
ASME CSD-1 **,1A**	Controls and Safety Devices for Automatically Fired Boilers
ASME PIC4.1	Steam Generating Units

AMERICAN SOCIETY FOR TESTING **&** MATERIALS (ASTM)

ASTM **A36-89**	Specification for Structural Steel
ASTM A47	Malleable-Iron Pipe Fittings
ASTM A53	Steel Pipe
ASTM **A82-88**	Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM **A90**	Tests for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
ASTM **A106**	Steel Pipe Fittings
ASTM AI26	Cast Iron Valves
ASTM AI 21	Zinc Coated (Galvanized) Steel Barbed Wire
ASTM AI23	Zinc (Hot Galvanized) Coatings on Products, Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip
ASTM AI64	Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM **A185**	Specification for Welded Steel Wire Fabric for Concrete Reinforcement
ASTM A234	Steel Fittings
ASTM **A252-89**	Specification for Welded and Seamless Steel Pipe Piles
ASTM A279	Float and Thermostatic Traps
ASTM A366	Carbon Steel Sheets
ASTM **A370**	Mechanical Testing of Steel Products
ASTM A392	Zinc Coated Steel Chain Link Fence Fabric
ASTM A394	Specification for Zinc-Coated Steel Transmission Tower Bolts
ASTM A41 **6-88**	Specification for Uncoated Seven-Wire Stress-Relieved Steel for Prestressed Concrete
ASTM A421	Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete
ASTM A426	Tests for Weight of Coating on Aluminum-Coated Iron or Steel Articles
ASTM **A444-89**	Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dipped Process for Storm Sewer and Drainage Pipe
ASTM A490	Stainless Steel Sheets
ASTM A491	Aluminum-Coated Steel Chain Link Fabric
ASTM A496	Specification for Deformed Steel Wire for Concrete Reinforcement
ASTM A497	Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement
ASTM AS25	G90 Zinc Coating, Mill Phosphated.
ASTM AS26	Galvanized Steel for Panel Surfaces, Internal Channels, and Trim Items
ASTM A527	Galvanized Steel as Used in Breechings

NATIONAL STANDARDS

AMERICAN SOCIETY FOR TESTING & MATERIALS (ASTM) (Continued)

ASTM A536	Ductile-Iron Pipe Fittings
ASTM A569	Black, Carbon, Hot-Rolled Steel as Used in Breechings
ASTM A570	Hot Rolled Sheet and Strip, Structural Quality
ASTM A572	High Strength Low-Alloy Columbium-Vanadium Steel of Structural Quality
ASTM A505	Aluminum-Coated Steel Barbed Wire
ASTM A024	Metallic-Coated Steel Marcelled Tension Wire
ASTM A61 5-89	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A61 7	Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767-09	Standard Specification for Zinc-Coated (Galvanized) Bars for Concrete Reinforcement
ASTM B6	Specification for Zinc (Slab Zinc)
ASTM B62	Bronze Valves
ASTM B88	Copper Tubing as Drawn Temper, Type L or Annealed Type K
ASTM B209	Aluminum Sheets
ASTM C5	Specification for Quicklime for Structural Purposes
ASTM C6	Specification for Normal Finishing Hydrated Lime
ASTM C29	Test for Unit Weight and Voids in Aggregate
ASTM C31-90	Standard Methods of Making and Curing Concrete Test Specimens in the Field
ASTM C33-90	Specification for Concrete Aggregate
ASTM C39-86	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40	Test for Organic Impurities in Sands for Concrete
ASTM C70	Test for Surface Moisture in Fine Aggregate
ASTM C87	Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C88	Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C91	Specification for Masonry Cement
ASTM C94	Specification for Ready-Mixed Concrete
ASTM C109	Test for Compressive Strength of Hydraulic Cement Mortars
ASTM Cl 14	Methods for Chemical Analysis of Portland Cement
ASTM Cl15	Test for Fineness of Portland Cement by the Turbidimeter
ASTM Cl 17	Test for Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing
ASTM Cl23	Test for Lightweight Pieces in Aggregate
ASTM Cl25	Definitions of Terms Relating to Concrete and Concrete Aggregates
ASTM Cl27	Test for Specific Gravity and Absorption of Coarse Aggregate
ASTM Cl20	Test for Specific Gravity and Absorption of Fine Aggregate
ASTM Cl31	Test for Resistance to Abrasion of Small Size Coarse Aggregate by use of the Los Angeles Machine
ASTM Cl36	Test for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM Cl41	Specification for Hydraulic Hydrated Lime for Structural Purposes
ASTM Cl 43-90	Standard Test Method for Slump of Portland Cement Concrete
ASTM Cl44	Specification for Aggregate for Masonry Mortar
ASTM Cl50	Specification for Portland Cement (8 types)
ASTM Cl51	Test for Autoclave Expansion of Portland Cement
ASTM Cl56	Test for Water Retention by Concrete Curing Materials
ASTM Cl 71	Specification for Sheet Materials for Curing Concrete
ASTM Cl 72-90	Standard Method of Sampling Freshly Mixed Concrete

NATIONAL STANDARDS

AMERICAN SOCIETY FOR TESTING & MATERIALS (ASTM) (Continued)

ASTM C183	Methods of Sampling Hydraulic Cement
ASTM Cl84	Test for Fineness of Hydraulic Cement by the No. 100 and No. 200 Sieves
ASTM Cl86	Test for Heat of Hydration of Hydraulic Cement
ASTM Cl87	Test for Normal Consistency fo Hydraulic Cement
ASTM Cl88	Test for Density of Hydraulic Cement
ASTM Cl 60	Test for Tensile Strength of Hydraulic Cement Mortars
ASTM C191	Test for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C204	Test for Fineness of Portland Cement by Air Permeability Apparatus
ASN C206	Specification for Finishing Hydrated Lime
ASTM C207	Specification for Hydrated Lime for Masonry Purposes
ASTM C219	Definitions of Terms Relating to Hydraulic Cement
ASTM C226	Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement
ASTM C227	Test for Potential Alkali Reactivity of Cement-Aggregate Combinations
ASTM C230	Specification for Flow Table for Use in Tests of Hydraulic Cement
ASTM C233	Method of Testing Air-Entraining Admixtures for Concrete
ASTM C243	Test for Bleeding of Cement Pastes and Mortars
ASTM C260	Specification for Air-Entraining Admixtures for Concrete
ASTM C265	Test for Calcium Sulfate in Hydrated Portland Cement Mortar
ASTM C266	Test for Time of Setting of Hydraulic Cement by Gillmore Needles
ASN C267	Test for Chemical Resistance of Mortars
ASTM C270	Specification for Mortar for Unit Masonry
ASTM C295	Recommended Practice for Petrographic Examination of Aggregates for Concrete
ASTM C309	Specification for Liquid Membrane-Forming Compounts for Curing Concrete
ASTM C311	Sampling and Testing Fly Ash and Raw or Calcined natural Pozolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C330	Specification for Lightweight Aggregates for Structural Concrete
ASTM C331	Specification for Lightweight Aggregates for Concrete Masonry Units
ASTM C332	Specification for Lightweight Aggregates for Insulating Concrete
ASN C423	Testing Sound Absorption Coefficients
ASTM C465	Specification for Processing Additions for Use in Manufacture of Hydraulic Cements
ASN C484-86	Specification for Chemical Admixtures for Concrete
ASTM C535	Test for Resistance to Abrasion of large Size Coarse Aggregate by use of the Los Angeles Machine
ASTM C595	Specification for Blended Hydraulic Cements
ASN C851	Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
ASTM C916.9	Liner Adhesive
ASTM C920	Flanged Joint Mastics
ASTM D25-88	Specification for Round Timber Piles
ASN D75	Methods of Sampling Aggregates
ASN D88	Specification for Calcium Chloride
ASTM D448	Specification for Standard Sizes of Coarse Aggregate for Highway Construction
ASN D859	Tests for Silica in Water and Waste Water
ASTM D877-87	Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

NATIONAL STANDARDS

AMERICAN SOCIETY FOR TESTING & MATERIALS (ASTM) (Continued)

ASTM D924-65	Test method for A-C Loss Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM **D971-82**	Test Method for Interfacial Tension of Oil Against Water by the Ring Method
ASTM D974-87	Test Method for Acid and Base Number by Color-Indicator Titration
ASTM **D1066**	Sampling Steam.
ASTM **D1067**	Tests for Acidity or Alkalinity of Water
ASTM **D1068**	Tests for Iron in Water
ASTM DI126	Tests for Hardness in Water
ASTM **D1143-81**	Method of Testing Piles Under Static Axial Compressive Load
ASTM **D1500-87**	Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524-84	Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
ASTM **D1888**	Tests for Particulate and Dissolved Matter in Water
ASTM **D2216-80**	Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM **D2846**	Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe
ASTM D3370	Practices for Sampling Water
ASTM **D4012**	Glass Fibre Reinforces Underground Storage Tanks
ASTM **E11**	Specification for Wire Cloth Sieves for Testing Purposes
ASTM F552	Standard Definitions of Terms Relating to Chain-Link Fencing
ASTM **F567**	Installation of Chain Link Fence
ASTM F626	Fence Fittings
ASTM **F669**	Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence
ASTM FSOO	Industrial and Commercial Swing Gates
ASTM **F1083**	Pipe, Steel, Hoy-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM **F1183**	Aluminum Alloy Chain Link Fence Fabric
ASTM FI184	Industrial and Commercial Horizontal Slide Gates
ASTM F1234	Protective Coatings on Steel Framework for Industrial Fences

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	Brazing Filler Metals Classification BAg1 (silver)
AWS D1.1	Structural Welding Code - Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS DI.3	Structural Welding Code - Sheet Steel
AWS D5.2	Standard for Welded Steel, Elevated Tanks, Standpipes and Reservoirs for Water Storage
AWS **D9.1**	Sheet Metal Welding Code

AMERICAN **WOOD-PRESERVERS** ASSOCIATION (AWPA)

AWPA **C3-87**	Piles - Preservative Treatment by Pressure Processes
AWPA M4-84	Care of Pressure Treated Wood Products

NATIONAL STANDARDS

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI	Specifications for Placing Reinforcement

INSTITUTE OF ELECTRICAL & ELECTRONIC ENGINEERS (IEEE)

IEEE 112	Test Method B for Motor Efficiency

NATIONAL ASSN OF PLUMBING/HEATING/COOLING CONTRACTORS (NAPHCC)

NSPC	National Standard Plumbing Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	Standard for Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances
NFPA 231	Standard for General Storage
NFPA 24	Standard for Installation of Fire Service Mains and Their Appurtenances
NFPA 26	Recommended Practices for the Supervision of Valves Controlling Water Supplies for Fire Protection
NFPA 30	Flammable and Combustible Liquids Code
NFPA 31	Oil Burning Equipment
NFPA 37	Standard for the Installation and use of Stationary Combustion Engines and Gas Turbines
NFPA JO	Oxygen Systems, Bulk
NFPA 50A	Gaseous Hydrogen Systems
NFPA 50B	Liquefied Hydrogen Systems
NFPA 54	National Fuel Gas Code
NFPA 58	Storage and Handling of Liquid petroleum Gas
NFPA 68	Explosion Venting
NFPA 70	National Electrical Code
NFPA 72	Protective Signaling System
NFPA 72E	Automatic Fire Detectors
NFPA 85A	Prevention of Furnace Explosions in Fuel Oil and Natural Gas Fired Single Burner Boiler Furnaces
NFPA 85B	Prevention of Furnace Explosions in Natural Gas Fired Multiple Burner Boiler Furnaces
NFPA 85D	Prevention of Furnace Explosions in Fuel Oil Fired Multiple Burner Boiler Furnaces
NFPA 85E	Prevention of Furnace Explosions in Pulverized Coal Fired Multiple Burner Boiler Furnaces
NFPA 85F	Installation and Operation of Pulverized Fuel Systems
NFPA 99	Health Care Facilities

PORTLAND CEMENT ASSOCIATION (PCA)

PCA	Specifications for Plain and Reinforced Concrete
PCA	Architectural Concrete Specifications

NATIONAL STANDARDS

UNDERWRITERS LABORATORIES (UL)

UL 58	Steel Underground Tanks for Flammable and Combustible Liquids
UL 80	Standard for Steel Inside Tanks for Oil-Burner Fuel
UL 207	Refrigerant Containing Components and Accessories
UL 343	Standard for Pumps for Oil-Burning Appliances
UL 443	Steel Auxiliary Tanks for Oil-Burner Fuel
UL 485	Central Cooling Air Conditioners
UL 508	Industrial Control Equipment
UL 567	Pipe Connections for Flammable and Combustible Liquids and LP-Gas
UL 778	Motor Operated Water Pumps
UL 834	Heating, Water Supply, and Power Boilers - Electric
UL 959	Refractory Lining Testing for Temperature and Acid Resistance
UL 984	Hermetic Refrigerant Motor Compressors
UL MH 1318	Standard for Glass-Fiber Reinforced Plastic Underground Storage Tanks for Petroleum Products
UL 1478	Relief valves
UL 1479	Fire Test of Through Penetration Fire Stops

NATIONAL STANDARDS

END OF SUBSECTION

INDUSTRY PUBLICATIONS

PUBLICATION	PUBLISHER
1991 ASTM Standards in Building Codes	American Society for Testing and Materials 1916 Race Street Philadelphia, PA 19103
CI Detailing Manual **&** Structural Concrete for Buildings	American Concrete Institute P.O. Box 19150 Detroit, MI 48219-0150
Electrical Protection Handbook	Bussman, Cooper Industries P.O. Box 41460 St. Louis, MO 63178
Electrical Systems for Oil and Gas Production Fatilties	Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709
Fences by Anchor	Anchor Fence Inc. 6500 Eastern Ave Baltimore, Md. 21224
Field Inspection Guide	Chain Link Fence Manufacturer's Institute
"Fibrous Glass Duct Construction Standard," 5th Ed., 1979. SYACNA "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems,' 3rd Ed., **1986.** SMACNA 'HVAC Air Duct Leakage lest Manual," 1st Ed., 1985. SMACNA 'WAC Duct Construction Standards-Metal **&** Flexible,' 1st Ed., 1985. SYACNA 'HVAC **Systems—Testing,** Adjusting and Balancing,' 1st Ed., 1983. SMACNA 'Retrofit of Building Systems and Processes,' 1st Ed. 1982. SMACNA	Sheet Metal & Air Conditioning Contractors' National Association P.O. Box 70 Merrifield, VA 22116
FM Approval Guide **&** FM Loss prevention Data Sheets	Factory Mutual Research Norwood, MA 02062
Index of Federal Specifications, Standards **&** **Commercial** Item Descriptions	General Services Administration Office of Federal Supply and Services 7th & D Streets, S.W. Washington, DC 20202

INDUSTRY PUBLICATIONS

PUBLICATION	PUBLISHER
MASTEBSPEC	American Institute of Architects 1735 New York Ave N.W. Washington, D.C. 20006
National Fire Protection Assn	National Electrical Code NFPA 70, 1990 Edition Recommended Practice for Electrical Equipment Maintenance NFPA 70B, 1990 edition
NRCA Roofing **&** Waterproofing Manual, **The**	National Roofing Contractors Association 6250 River Road Rosemont, IL 60018
On The Fence About Fencing	Chain Link Fence Manufacturer's Institute 1776 Massachusetts Ave N.W. Washington, DC 20036
UL Building Materials **Directory**	Underwriters Laboratories, Inc. 333 Pfingsten Road Northbrook, IL 60062
UL Directory **of General** Information for Electrical Construction, Hazardous Location, and Electric Heating and Air-Conditioning Equipment **ISBN-I-55989-252-8**	Underwriters Laboratories, Inc. 333 Pfingsten Road Northbrook. IL 60062
Vehicle Gate Operators	Anchor Fence Inc. (Stanley Commercial Automation)
Westinghouse Maintenance **Hints**	HB 6001 -R

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END OF SUBSECTION

APPENDIX A

ABBREVIATIONS

A, Amp	Ampere, Area
A/E	Architect-Engineer
AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	American Architectural Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ABMA	American Boiler Manufacturers Association
ABS	Acrylonitrile-Butadiene-Styrene
AC	Alternating Current, Air Conditioning
ACFM	Actual Cubic Feet per Minute
ACGIH	American Conference of Governmental Industrial Hygienists
ACI	American Concrete Institute
ACSM	American Congress on Surveying and Mapping
ADF	Asset Determinant Factor
ADJ	Adjustable
ADM	Action Description Memorandum
ADP	Automated Data Processing
AEC	U.S. Atomic Energy Commission
AFM	U.S. Air Force Manual
AFR	U.S. Air Force Regulation
AFWL	U.S. Air Force Weapons
AGA	American Gas Association
AHU	Air Handling Unit
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALARA	As Low as Reasonably Achievable
Allow	Allowance
Amb	Ambient
AMC	U.S. Army Materiel Command
AMCA	Air Movement Contractors Association
AMC-R	Army Materiel Command Regulation
Amp	Ampere
ANS	American Nuclear Society
ANSI	American National Standards Institute
API	American Petroleum Institute
Approx.	Approximately
AR	U.S. Army Regulation
AREA	American Railway Engineering Association
ARI	American Refrigeration Institute
ARMA	Asphalt Roofing Manufacturers Association
ASBC	American Standard Building Code
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration & Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATM	Atmosphere
AVG	Average
AVLIS	Atomic Vapor Laser Isotope Separation
AWG	American Wire Gauge

APPENDIX A

AWS	American Welding Society
AWWA	American Water Works Association
BAT	Best Available Technology
BATEA	Best Available Technology Economically Achievable
BCPCT	Best Conventional Pollutant Control Technology
BESEP	Base Electronic System Engineering Plan
BHP	Brake Horsepower
BI	Black Iron
BIA	Brick Institute of America
BIL	Basic Impulse Insulation Level
BKRS	Breakers
BLDG	Building
BOCA	Building Official Code Association
BOD	Biochemical Oxygen Demand
	Building Research Advisory Board (now Building Research Board)
BRB	Building Research Board
BRG	Bearing
BTU	British Thermal Unit
°C	Degrees Centigrade (Celsius)
C&GS	U.S. Coast and Geodetic Survey (now National Geodetic Survey)
C M	Clean Air Act
CAMS	Continuous Air Monitoring System
CAS	Condition Assessment Survey
CCTV	Closed Circuit Television
CDR	Conceptual Design Report
CEM	Continuous Emissions Monitoring
CERC	U.S. Army Coastal Engineering Research Center
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CF	Cubic Feet
CFC	Chlorofluorocarbon
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHW	Chilled Water
CI	Cast Iron
CIP	Cast-in-Place, Cast Iron Pipe
CISCA	Ceiling and Interior Systems Contractors Association
CISPI	Cast Iron Soil Pipe Institute
CMP	Corrugated Metal Pipe
CO_2	Carbon Dioxide
COE	U.S. Army Corps of Engineers
COMPR	Compressor
COP	Coefficient of Performance
CP	Concrete Pipe
CPLG	Coupling
CPSC	Consumer Product Safety Commission
CPVC	Chlorinated Polyvinyl Chloride
CRI	Carpet and Rug Institute
CRT	Cathode Ray Tube
C_v	Flow coefficient
c w	Cold Water
CWA	Clean Water Act

APPENDIX A

CYL	Cylinder
DAC	Derived Air Concentration
DARCOM	U.S. Army Development, Acquisition and Readiness Command
DB	Dry Bulb, Decibel
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBF	Design Basis Fire
DBFL	Design Basis Flood
DBG	Distance Between Guides
DBT	Design Basis Tornado
DBW	Design Basis Wind
DC	Direct Current
DCG	Derived Concentration Guide
DCPA	Defense Civil Preparedness Agency
DL	Dead Load
DM	NAVFAC Design Manual
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOP	Dioctylphthalate
DOT	U.S. Department of Transportation
DP	Differential Pressure
DP-1	Assistant Secretary for Defense Programs
DP-34	Director of Safeguards and Security Agreement
DPDT	Double-Pole Double-Throw
DSC	Differential Scanning Calorimetry
DTA	Differential Thermal Analysis
DWT	Double Wrap Traction
DWV	Drain, Waste & Vent
DX	Direct Expansion
DYN	Dyne
EA	Each
ECC	Emergency Control Center
ECP	Entry Control Point
EMCS	Energy Monitoring and Control System
ECS	Emergency Control Station
EDE	Effective Dose Equivalent
EED	Electroexplosive Device
EIA	Electronics Industries Association
EIFS	Exterior Insulation and Finish System
EIMA	Exterior Insulation Manufacturers Association
EIS	Environmental Impact Statement
Elev	Elevator
EM	U.S. Army Engineering Manual
EMS	Energy Management System
EMT	Electrical Metallic Tubing
EO	Executive Order
EOC	Emergency Operating Center
EPA	U.S. Environmental Protection Agency
EPS	Emergency Power System
Equip	Equipment
ERDA	Energy Research and Development Administration (precursor to DOE)
ESF	Engineered Safety Feature

APPENDIX A

Est	Estimated
Ext	Exterior
°F	Degrees Fahrenheit
F M	Federal Aviation Administration
FAI	Fauske and Associates, Inc.
FAR	Federal Acquisition Regulation
FCC	Federal Construction Council
FEMA	Federal Emergency Management Agency
FGA	Flat Glass Marketing Association
FGCC	Federal Geodetic Control Committee
FGD	Flue Gas Desulphurization
FHWA	Federal Highway Administration
FHDA	Fir and Hemlock Door Association
Fig	Figure
FIPS	Federal information Processing Standards
Fixt	Fixture
Flr	Floor
FM	Factory Mutual
Fndtn	Foundation
FPM	Feet Per Minute
FPT	Female Pipe Thread
FR	Federal Register
fr	Frame
FS	Federal Specifications
FSAR	Final Safety Analysis Report
Ft	Foot, feet
Ft/lb	Foot-Pound
FWPCA	Federal Water Pollution Control Act
fy	Yield strength
G	Gauss
g	Gram
GA	Gypsum Association
ga	Gauge
Gal	Gallon
Galv	Galvanized
GDC	General Design Criteria, DOE 6430.1A
GPD	Gallon Per Day
GPH	Gallon Per Hour
GPM	Gallons Per Minute
GSA	General Services Administration
HE	High Explosives
HE-Pu	High Explosives-Plutonium
HF	High Frequency, Hydrogen Fluoride
HI	Hydraulic Institute
HID	High Intensity Discharge
HLW	High-Level Waste
HOA	Hand-Off-Automatic
HP	Horsepower
HR	Hour
Htg	Heating
Htr	Heater
HTW	High Temperature Water

APPENDIX A

HVAC	Heating, Ventilating, and Air-Conditioning
Hvy	Heavy
HW	Hot Water
Hyd	Hydraulic
HX	Heat Exchanger
Hz	Hertz, frequency
IAPMO	international Association of Plumbing and Mechanical Officials
IAS	Intrusion Alarm System
ICBO	International Conference of Building Officials
ICRP	International Commission on Radiological Protection
ID	Inside Diameter
IDA	Intrusion Detection and Assessment
IDS	Intrusion Detection System
IEEE	Institute of Electrical and Electronic Engineers
IES	Illumination Engineering Society
IFM	Irradiated Fissile Material
IFMSF	Irradiated Fissile Material Storage Facility
IHE	Insensitive High Explosives
IMC	Intermediate Metal Conduit
In	Inch
Incl	Installed, Including
Inst	Installation
Insul	Insullation
IP	Iron Pipe
IPS	Iron Pipe Size
IPT	Iron Pipe Threaded
ISDSI	Insulated Steel Door Systems Institute
IU	Inspection Unit
IUEC	International Union of Elevator Contractors
J	Joule
°K	Degrees Kelvin
K	Subgrade modulus, Thousand, heavy wall copper tubing
Kg	Kilogram
kHz	Kilohertz
Klp	1000 pounds
Km	Kilometer
kPa	kilo Pascal
KV	Kilovolt
kVA	kiloVolt Ampere
kW	kilowatt
kWh	kilowatt hour
lb	Pound
lb/hr	Pounds Per Hour
lbf	Pounds Per Foot
LCC	Life-Cycle Cost
LCD	Liquid Crystal Display
LF	Linear Feet
LL	Live load psf - pounds per square foot
LLW	Low-Level Waste
LP	Liquid Petroleum, Low Pressure
LPG	Liquified Petroleum Gas
Lt	Light

APPENDIX A

LV	Low Voltage
MA	Management and Administration (U.S. DOE)
mA	milliAmpre
M M	Material Access Area
Mach	Machine
Maint	Maintenance
MAWP	Maximum Allowable Working Pressure
MBA	Material Balance Area
MBH	Thousand BTUs per Hour
MBMA	Metal Building Manufacturers' Association
MC&A	Material Control and Accountability
MCF	Thousand Cubic feet
Mfg	Manufacturing
Mfr	Manufacturer
MCC	Motor Control Center
mg	Milligram
mg/l	Milligrams per liter
MGPH	Thousand Gallons Per Hour
Mhz	Megahertz
MI	Miles, total level route
MIL-HDBK	U.S. DOD military handbook
MIN	Minute
mIn	Minimum
MIsc	Miscellaneous
ml	Millileter
ML/SFA	Metal Lath/Steel Framing Association
mm	Millimeter
M&O	Management and Operations
MPH	Miles Per. Hour
MPT	Male Pipe Thread
mr/h	milli roentgen/hour
mrad/h	milli roentgen, absorbed dose/hour
mrem	milli roentgen equivalent man
MSSA	Master Safeguards and Security Agreement
Mtng	Mounting
MVA	Million-Volt-Amps
N_2	Nitrogen
N/A	Not Applicable
NAAMM	National Association of Architectural Metal Manufacturers
NACE	National Association of Corrosion Engineers
NAD	North American Datum
NAEC	National Association of Elevator Contractors
NAESA	National Association of Elevator Safety Authorities
NAPHCC	National Association of Plumbing-Heating-Cooling Contractors
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NBC	National Building Code
NBS	National Bureau of Standards
NC	Noise Criteria
NCEL	Naval Civil Engineering Laboratory (references listed under NAVFAC)
NCMA	National Concrete Masonry Association
NDA	Non-Destructive Assay

APPENDIX A

NEC	National Electrical Code
NEII	National Elevator Industry Incorporated
NEMA	National Electrical Manufacturers Association
NEMI	National Elevator Manufacturing Industry, Inc. (now NEII)
NEPA	National Environmental Policy Act
NFGS	Naval Facilities Guide Specification (references listed under NAVFAC)
NFPA	National Fire Protection Association
NGS	National Geodetic Survey (formerly U.S.Coast and Geodetic Survey)
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NIJ	National Institute of Justice
NIST	National institute of Standards and Technology (see NBS)
N O M	National Oceanic and Atmospheric Administration
NO	Normally Open
NO_x	Oxides of Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPDWS	National Primary Drinking Water Standards
NPSH	Net Positive Suction Head
NPT	National Pipe Thread
NRC	Nuclear Regulatory Commission
NRCA	National Roofing Contractors Association
NRTA	Near-Real-Time Accountancy
NRTL	Nationally Recognized Testing Laboratory
NSA	National Security Agency
NSPC	National Standard Plumbing Code
NSPS	New Source Performance Standards
NTIA	National Telecommunications and Information Administration
NTMA	National Terrazzo and Mosaic Association
NUREG	Nuclear Regulatory Commission-produced reference document
NWWDA	National Wood Window and Door Association
OA	Outside Air
OBA	Operating Basis Accident
OBE	Operating Basis Earthquake
o c	On Center
OCS	Office of Computer Services (U.S. DOE)
OD	Outside Dimension
ODH	Oxygen Deficiency Hazards
O & M	Operations and Maintenance
OMB	Office of Management and Budget
OP AMP	Operational Amplifier
Oper	Operator
OPFM	Office of Project and Facilities Management (U.S. DOE)
OS&Y	Outside Screw and Yoke
OSHA	Occupational Safety and Health Administration
OSR	Operational Safety Requirement
o s s	Office of Safeguards and Security (U.S. DOE)
OSTI	Office of Scientific and Technical Information (U.S. DOE)
OWG	Oil, Water, or Gas
OS	Ounce
p	Minimum reinforcing ratio
PA	Protected area
PB	Polybutylene

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PCB	Polychlorinated biphenyls
PCI	Prestressed Concrete Institute
PEL	Permissible Exposure Limit
PF	Protection Factor
Ph	Phase
PI	Point of Intersection, Proportional-plus integral
PIV	Post Indicator Valve
PLF	Pounds per Linear Foot
Pkg	Package
PMFL	Probable Maximum Flood
POL	Petroleum, Oil, and Lubricants
POTW	Publicly-Owned Treatment Works
PPHF	Plutonium Processing and Handling Facility
PPM	Parts Per Million
PRV	Pressure Regulating Valve
PSAR	Preliminary Safety Analysis Report
PSF	Plutonium Storage Facility, Pound-force per square foot
PSI	Pound-force per square inch
PSIA	Pounds per square inch absolute
PSIG	Pound-force per square inch gauge
PTI	Post Tensioning Institute
Pu	Plutonium
PUBN	Publication
PURPA	Public Utility Regulatory Policy Act
PVC	Polyvinyl Chloride
QA	Quality Assurance
Qty	Quantity
R	Resistance
R12, R22	Refigerant (12,22, etc.)
°R	Degrees Rankine
RCP	Reinforced Concrete Pipe
RCRA	Resource Conservation and Recovery Act
RDF	Refuse-Derived Fuel
REM	Roentgen Equivalent Man
Reqd	Required
RFCI	Resilient Floor Covering Institute
RG	Regulatory Guide
RLWF	Radioactive Liquid Waste Facility
RPFM	Real Property and Facilities Management (U.S. DOE)
RPIS	Real Property Inventory System (U.S. DOE)
RPM	Revolutions Per Minute
RSWF	Radioactive Solid Waste Facility
RTD	Resistance Temperature Detector
S&S	Safeguards and Security
SAR	Safety Analysis Report
SARS	Safety Analysis and Review System
SAS	Secondary Alarm Station
SC	Safety Class
SCFM	Standard Cubic Feet per Minute
SCR	Sillicon Control Rectifier
SCS	U.S. Department of Agriculture, Soil Conservation Service
SDI	Steel Deck Institute, Steel Door Institute

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SDWA	Safe Drinking Water Act
SF	Safety Factor
SOFT	Structural Glazed Facing Tile
SISL	Special Isotope Separation Laser
SJI	Steel Joist Institute
SMA	Screen Manufacturers Association
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SNG	Supplementary Natural Gas
SNM	Special Nuclear Materials
SO_2	Sulfur dioxide
SOP	Standard Operating Procedure
SP	Special Publication (of the American Concrete Association)
SPCC	Spill Prevention Control and Countermeasure
SPDT	Single-Pole Double-Throw
SPRI	Single Ply Roofing Institute
SPST	Single-Pole Single-Throw
ssco	Single Speed Center-Opening
SQFT	Square foot
SSE	Safe Shutdown Earthquake
SSFI	Scaffolding, Shoring, and Framing Institute
SSSP	Site Safeguards and Security Plan
SSPC	Steel Structures Painting Council.
ssss	Single Speed Side-Sliding
STC	Sound Transmission Classification
Std	Standard
STP	Standard Temperature and Pressure
Sys	System
SWI	Steel Window Institute
SWP	Safe Working Pressure
SWT	Single Wrap Traction
T	Ton, Temperature
TCA	Tile Council of America, Inc.
TCDD	Tetrachlorodibenzo-p-dioxin
TDS	Total Dissolved Solids
TEC	Total Estimated Cost
TID	Tamper Indicating Device
TIMA	Thermal Insulation Manufacturers Association
TLV	Threshold Limit Value
TM	U.S. Army technical manual
tot	Total
TR	DOD technical report
Transf	Transformer
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage and Disposal
Tstat	Thermostat
TYP	Typical
N	Television
U value	Overall heat transfer coefficient value
UBC	Uniform Building Code
UCRF	Uranium Conversion and Recovery Facility
UEF	Uranium Enrichment Facility

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UEU	Unirradiated Enriched Uranium
UEUSF	Unirradiated Enriched Uranium Storage Facility
UF_4	Uranium tetrafluoride
UF_6	Uranium hexafluoride
UFAS	Uniform Federal Accessibility Standards
UHF	Ultra High Frequency
UL	Underwriters Laboratory
UMC	Uniform Mechanical Code
UO_2	Uranium dioxide
UO_3	Uranium trioxide
UPA	Unit Process Area
UPC	Uniform Plumbing Code
UPHF	Uranium Processing and Handling Facility
UPS	Uninterruptible Power Supply
URF	Uranium Recovery Facility
USC	U.S. Code
USCE	U.S. Army Corps of Engineers
USGS	US. Geological Survey
USPHS	U.S. Public Health Service
USPS	U.S. Postal Service
V	Volt
VA	Volt-Ampere
Vac	Vacuum
VAV	Variable Air Volume
VCT	Vinyl Composition Floor Tile
Vel	Velocity
Vent	Ventilating
VHF	Very High Frequency
Vol	Volume
W	Watt
WB	Wet Bulb
WBT	Wet Bulb Temperature
WC	Water Column
WG	Water Gauge
WB	Wet Bulb
WBS	Work Breakdown Structure
WPCF	Water Pollution Control Federation
WRC	Water Resources Council
Yd	Yard
Yr	Year

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SYMBOLS

°R'	Degrees Rankine
°K	Degrees Kelvin
°F	Degrees Fahrenheit
°C	Degrees Centigrade (Celcius)
$>$	Greater Than
$<$	Less Than
$\geq$	Greater Than or Equal To
$\leq$	Less Than or Equal To
%	Percent
#	Pound, Number
α, A	Alpha
β, B	Beta
ϕ, Φ	Theta
λ, Λ	Lambda
μ, M	Mu
π, Π	Pi
σ, Σ	Sigma
ω, Ω	Omega

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END OF SUBSECTION

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GLOSSARY

Absorption (of Brick): Obtained by immersion in either cold or boiling water for stated periods of time, usually expressed as a percent of the dry brick weight.

Abutment: A substructure composed of stone, concrete, brick, or timber supporting the end of a single span or the extreme end of a multispan superstructure, and in general, retaining or supporting the approach embankment place in contact with it. (1). That part of a structure that takes the thrust of a beam, arch, vault, truss, girder, or foundation wall. (2). In bridges, the end structure that supports the beams, girders, and deck of the bridge, or combinations thereof, and sometimes retains the earthen bank or supports the end of the approach pavement slab. See Retaining Wail; Wing Wall.

Accelerator: Any material added to concrete that speeds the natural setting.

Adit: A short transverse tunnel connecting two parallel tunnels or an entry from the face of the slope to a side-hill tunnel.

Administrative Authority: The authority exercising jurisdiction over the system.

Admixture: Act of mixing or the compound formed by mixing different substances together.

Adzing Machine: The sand, gravel, broken stone, or combinations thereof with which the cementing material is mixed to form a mortar or concrete. The fine material used to produce mortar for stone and brick masonry and for the mortar component of concrete is commonly termed “fine aggregate,” while the coarse material used in concrete only is termed “coarse aggregate.”

Aeration: The bringing about of intimate contact between air and a liquid by one of the following methods: spraying the liquid in the air; bubbling air through the liquid; or by agitating the liquid to promote surface absorption of air.

Aeration, Diffused **Air:** Aeration produced in a liquid by air passed through a diffuser.

Mechanical:
(1). The mixing, by mechanical means, of sewage and activated sludge, in the aeration tank of the activated sludge process, to bring fresh surfaces of liquid into contact with the atmosphere. (2). The introduction of atmospheric oxygen into a liquid by the mechanical action of paddle or spray mechanisms.

Modified:
A modification of the activated sludge process in which a shortened aeration period is employed with a reduced quantity of suspended solids in the mixed liquor.

Aerator: A device that provides aeration.

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Aerator, Baffle: An aerator wherein baffles are provided to cause flow turbulence to accomplish aeration.

Contact:
A biological unit comprised of stone, cement-asbestos, or other surfaces supported in an aeration tank, with diffusion of air up and around the surfaces and flow of settled sewage through the tank.

Diff usion:
An aerator that blows air under a low-pressure through submerged porous plates or perforated pipes so that small air bubbles rise through the sewage continually.

Aerofilter: A commercial term applied to a trickling filter containing a relatively coarse filtering material and operating at a high rate which may be maintained, if necessary, by recirculating the filter effluent or other diluting liquids.

Aggregates: Inert minerals such as sand, gravel, and crushed stone. The aggregates are divided into two sizes, fine and coarse.

Agitator: Device used to cause motion in confined fluid.

Air Binding or Air Bound: A condition in which a bubble or other air pocket is present in a pipeline or equipment item, and by its presence, prevents or reduces the desired flow or movement of the liquid or gas in the pipeline or equipment.

Air Cushion Tank: A closed tank, generally located above the boiler and connected to an hydronic system so that when the system is initially filled with water, air is trapped within the tank. When the water in the system is heated it expands and compresses the air trapped within the air cushion tank, providing space for the extra volume of water without creating excessive pressure. Also called Expansion lank.

Air Lock: A compartment in which air pressure can be equalized to the compressed air inside a shield-driven tunnel as well as the outside air to permit passage of men and material.

Air Shutter: An adjustable shutter on the primary air openings of a burner, used to control the amount of combustion air introduced into the burner body.

Air Vent: Valve installed at the high points in a fluid system to permit air elimination from the system.

Air Washer: Device used to clean air, which may increase or decrease humidity.

Air-Gas Ratio: The ratio of combustion air supply flow rate to the fuel gas supply flow rate.

Alive or Live: See Energized.

Anchor: A piece or connected pieces of metal used for tying together two or more pieces of masonry materials.

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Anchor Bolt:	A metal bolt or stud, headed or threaded, either cast in place, grouted in place, or drilled into finish concrete, used to hold various structural members in the concrete, and to resist shear, tension, and vibration.
Angle Bar:	A rail joint bar.
Antichecking Iron:	A piece of flat iron sharpened on one edge, driven into the end of a tie to prevent checking and splitting. It is bent to special designs or to the shape of C, S, or Z and called C-iron, S-iron, and Z-iron. Drive dowels are used by some roads.
Anticreeper:	A device attached to the base of a rail and bearing against a crosstie, to keep the rail from moving longitudinally under traffic, Also called Rail Anchor.
Appurtenances, Sewer:	Structures, devices, and appliances, other than pipe or conduit, that are integral parts of a sewerage system, such as manholes, surface inlets, etc.
Apron:	A waterway bed protection consisting of timber, concrete, riprap, paving, or other construction placed adjacent to substructure abutments and piers to prevent undermining by scour. Also placed at the ends of pipes and culverts.
Area Wall:	The masonry or concrete surrounding or partly surrounding an area; also serves as a retaining wall.
Areaway:	An open subsurface space adjacent to a building used to admit light or air as a means of access to a basement.
Arrestor, Flame:	A safety device on a gas line that allows gas, but not a flame, to pass through.
Arris:	A sharp edge forming an external corner at the junction of two surfaces.
Atmospheric Burner:	See Burner.
Atomize:	Process of changing a liquid to minute particles or a fine. spray.
Atomlzlng Media:	A supplementary medium, such as steam or air, that assists in breaking fuel oil into a fine spray.
Automatic:	Self-acting, operating by its own mechanism when actuated by some impersonal influence, eg., a change in current strength, not manual, without personal intervention. Remote controls that require personal intervention are not automatic, but manual.
Automatic Block Signaling:	See Block System, Automatic.
Automatic Gas Pilot Device:	Gas pilot incorporating a device, that acts to automatically shut off the gas supply to the appliance burner if the pilot flame is extinguished.
Available Head:	The difference in pressure that can be used to circulate water in the system. Pressure difference that may be used to overcome friction within the system. See Head.

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Backfill:	Material placed adjacent to an abutment, pier, retaining wall, or other structure or part of a structure to fill the unoccupied portion of the foundation excavation. Soil, usually granular, placed behind and within the abutment and wingfalls. (1). The replacement of excavated earth into a trench around and against a basement foundation. (verb) (2). Materials such as sand, crushed stone, or soil, placed to fill an excavation. (noun)
Backfilling:	(1). Earth, soil, or other material used to replace excavated materials around a newly constructed wall. (2). Rough masonry laid behind a facing, or between two faces. (3). Brickwork laid in the space between structural timbers.
Backing Up:	The operation of building up that part of a masonry piece other than its facing.
Back-Up:	That part of a masonry wall behind the exterior facing consisting of one or more widths or thicknesses of brick or other masonry material.
Backwater:	The water of a stream retained at an elevation above its normal level through the controlling effect of a condition existing at a downstream location such as a flood, an ice jam, or other obstruction.
Baff ie:	Plate or vane used to direct or control movement of fluid or air within a confined area. A surface used for deflecting fluids, usually in the form of a plate or wall.
Ballast:	Selected material placed on the roadbed to support it and to hold track in line and surface. Ballast preferably consists of sized hard particles easily handled in tamping, that distribute the load, drain well, and resist plant growth.
Ballast Cleaning:	The process of separating dirt from the ballast by shaking and depositing stone back onto the track.
Ballast Section:	The cross-section of a track around and under the crossties and between and above the toes of the ballast slopes. This section may include subballast.
Ballast Shoulder:	The portion of ballast between the end of the tie and the toe of the ballast slope. It distributes the traffic load over a greater width of roadway and helps hold the track in alignment.
Ballast Tamper:	A power-operated machine for compacting ballast under crossties.
Ballast Tamping:	Compacting ballast under crossties to maintain the line and surface of track.
Ballast, Sub:	See Subbaiiast
Banks, Sludge:	Accumulations of deposits on a waterway bed of solids, sewage, or industrial waste origin.
Base:	The lowest part, or the lowest main division, of a building, column, pier, or wall.

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Base Course: The lowest course of masonry of a wall or pier. A footing course.

Basin:

Catch:
A chamber or well, usually built at the curb line of a street, for the admission of surface water, designed to retain grit and detritus below the point of overflow.

Coagulation:
A basin employed for the coagulation of suspended or colloidal matter, with or without addition of a coagulant, in which the liquor is mixed gently to induce coagulation, flocculation, and agglomeration, in preparation for subsequent sedimentation.

Mixing:
A basin or tank wherein agitation is applied to water, sewage, or sludge to induce dispersion of applied chemicals.

Settling:
(1). A structure designed to hold water or sewage in a quiescent state or at reduced velocity for a sufficient time interval to permit the gravitational deposit of suspended matter with or without the aid of previous flocculation or coagulation. See Tank; Sedimentation; Bed.

Bat: A piece of broken brick.

Batter: Deformation of the surface of the railhead usually close to the end of the rail.

Batter Board: One of a pair of horizontal boards nailed to a post and set at the corners of an excavation, used to indicate the desired level or as a fastening for stretched strings to indicate foundation wall outlines.

Batter Pile: A support pile driven in an inclined position to resist forces that act in other than a vertical direction. When located in a stream, river, or other waterway, it sometimes functions as a cutwater in dividing and deflecting floating ice and debris.

Beam: A structural member transversely supporting a load. See Bridge Beam.

Bearing: Bearings transmit the superstructure load to the substructure. They also provide for longitudinal movement due to expansion and contraction caused by temperature changes and rotational movement due to deflection.

Bearing Capacity: The maximum unit pressure which a soil or other material will withstand without failure or settlement to an amount detrimental to the integrity of the structure function.

Bearing Partition: A partition that supports any vertical load in addition to its own weight.

Bearing Plato: A piece of steel, iron, or other material that receives the load concentration and transmits it to the masonry or concrete.

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Bearing Wall: A wall that supports any vertical load in addition to its own weight.

Bed: The prepared soil, or layer of mortar, on or in which a piece of masonry material is laid.

Contact:
An artificial bed of coarse material, such as broken stone or clinkers, in a watertight basin provided with a controlled inlet and outlet. It is operated on a fill and draw basis in cycles by filling with sewage, standing full, emptying of, and resting while empty, in order to remove and oxidize a portion of the organic impurities by biological action.

Covered Sludge **Drying:**
A sludge drying bed with glass enclosure for protection against rain and snow and for increasing radiant heating to aid evaporation.

Sludge:
An area comprising natural or artificial layers of porous material on which digested sewage sludge is dried by drainage and evaporation, A sludge bed may be open to the atmosphere or covered, usually with a greenhouse-type superstructure. Also called Sludge Drying Bed.

Bed Joint: A horizontal joint between stones usually filled with mortar, lead, or sealant.

Bed Rock (Ledge Rock): A natural mass formation of rock material either outcropping upon the surface, uncovered in a foundation excavation, or underlying an accumulation of unconsolidated earth material.

Belt Course: **See** Strlng Course.

Bench: Part of a tunnel section with the approximately horizontal upper surface temporarily left unexcavated.

Bench Mark: A point of known elevation or point from which several other elevations are established.

Bevel: The angle that one surface or line makes with another when they are not at right angles.

Blank Wall: One having no door, window, or other opening.

Block: (1). A length of track of defined limits, the use of which is governed by block signals or by some other type of signaling. (2). A unit in terra cotta or cement building differing from brick in being larger, and usually hollow.

Block (Hollow): A shape made of clay, terra cotta, or other material fashioned with one or more openings for lightness, whose net sectional area does not exceed 75 percent of its gross sectional area.

Block Signal: A fixed signal at the entrance to a block, to govern trains and engines entering and using the block.

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Block Station:	A place at which block signals are located and from where they may be operated.
Block System, Automatic:	A series of consecutive blocks governed by block signals actuated by a train or engine or by certain conditions affecting the use of the block.
Block System, Manual:	A series of consecutive blocks, governed by block signals.
Blocking:	A method of bonding two adjoining or intersecting walls, not built at the same time, by means of offsets and overhanging blocks consisting of several courses of masonry each.
Blow-Out:	A sudden loss of a large amount of compressed air at the top of a shield.
Blowdown:	Water discharged from the system to control the concentration of salts or other impurities in the circulating water.
Blower:	A fan used to force air under pressure.
Blowoff:	A controlled outlet on a pipe line, tank, or conduit used to discharge sewage or accumulations of material carried by the sewage.
Board, Scum:	A vertical baffle dipping below the sewage surface in a tank, to prevent the passage of floating matter. Also called Scum Baffle.
Boiler:	Closed vessel in which water is heated, steam is generated or superheated, or any combination thereof, under pressure or vacuum by the direct application of heat. The term boiler shall include fired units for heating or vaporizing liquids other than water where these systems are complete within themselves.
Boiler Blowoff:	A boiler outlet that permits sediment emptying or discharge.
Boiler Blowoff Tank:	A vessel designed to receive the discharge from a boiler blow-off outlet and to cool the discharge to a temperature. permitting its safe discharge to the drainage system.
Boiler Economizer:	The last pass of boiler tubes or a heat exchanger located in the flue pipe that extracts some of the heat from the flue gases before they are vented to the atmosphere.
Boiler System:	A system comprised of the boiler, its controls, safety devices, and interconnected piping, vessels, valves, fittings, and pumps.
Boiler, Automatically Fired:	A boiler that cycles automatically in response to a control system.
Boiler, High-Pressure:	A boiler in which steam or vapor is generated at a pressure exceeding 15 psig (103.4 kPa gauge).
Boiler, Hot-Water Heating:	A boiler in which no steam is generated and from which hot water is circulated for heating purposes, then returned to the boiler.

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Boiler, Hot-Water Supply:	A boiler that furnishes hot water to be used externally to itself at a pressure not exceeding 160 psig (1100 kPa gauge) or a temperature not exceeding 250°F (120°C) at or near the boiler outlet.
Bolted Rail **Crossing:**	A railroad crossing assembled from rolled rail with bolted connections as distinguished from solid cast crossing frogs.
Bond:	The tying or bonding of the various pieces and parts of a masonry wall by laying one piece across two or more pieces; the entire system of bonding or breaking joints as used in masonry construction. The mortar between brick is sometimes termed a bond.
Bond (Course):	The header course.
Bond Plug:	A piece of metal resembling a tapered rivet, used to fasten a bond wire to a rail.
Bond Stone:	Stones projecting laterally into the backup wall used to tie the wall together.
Bonding:	The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.
Brace:	Any structural member used to support another; always designed for compression and sometimes for tension under special load conditions.
Brace Rail:	(1). A rail used in conjunction with the truss rod to form a structural support between a terminal and adjacent line post. (2). A device used at switches, movable-point frogs, etc., in combination with switch, tie, or gauge plates, for holding rail in place. Also used on rails at sharp curves to maintain the gauge and prevent overturning rail.
Bracing:	Structural elements, which due to their ability to transmit direct stress, are provided to either prevent buckling of individual members subject to compression, to add rigidity to a structure as a whole, or to resist lateral loads.
Branch:	(1). A special form of vitrified sewer tile and cast-iron pipe used for making connections to a sewer. They are called T, Y, T-Y, double Y, and V branches according to their respective shapes. (2). Any part of a piping system other than a main.
Branch, **Branchline:**	The route miles of track carrying trains from mainline to destination on lesser priority trackage than mainline track.
Breaker, Scum:	A device installed in a sludge digestion tank to break up scum.
Breastboards:	Timber planks to support the face of tunnel excavation in soft ground.
Brick:	A structural unit of burnt clay or shale, formed while plastic into a rectangular prism, usually solid, the net sectional area of which is not less than 75 percent of the gross sectional area.

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Brick and Brick: A method of laying brick whereby the bricks are laid touching each other with only mortar enough to fill the irregularities of the surface.

Brick Veneer: A facing of brick laid against and fastened to sheathing of a frame wall of tile wall construction.

Brickwork: Any structure or structural part made of brick and mortar.

Bridge Beam: A portion of the bridge structure receiving and transmitting vertical, transverse, or oblique stresses produced by externally applied loads, when supported at its end or at intermediate points and ends. The beam resists the development of internal bending or flexural stresses. It could be rolled metal I-shaped or H-shaped. An I-shaped piece or member composed of plates and angles or other structural shapes united by bolting, riveting, or welding. In general, those types of pieces or members are described as built-up beams. These terms are also applied to and define, in general terms only, variations in shape, size, and arrangement of beam type members of reinforced concrete structures.

Bridge Dock: The slab or other surface forming the travel surface of a bridge.

Bridge Seat: The top surface of an abutment or pier upon which the superstructure span is placed and supported. For an abutment it is the surface forming the support for the superstructure and from which the backwall rises. For a pier it is the entire top surface.

Bridge Tie: A sawed tie usually preframed and of the size and length required for track on a bridge. Usually hardwood.

Bridge, Ballast Deck: A bridge with a solid floor provided with drains and covered with ballast, to provide normal and uniform support for track and conforming generally to standard construction used in the same tracks as constructed on roadbed.

Bridge, Dock Span: A bridge in which the track is carried on top of the stringers (girders) or trusses.

Bridge, Girder: A bridge in which the trace is supported on the top of (deck girder) or between two or more steel plate girders (trough girder), normally used on spans of 30 to 120 feet.

Bridge, I-Beam: A stringer type bridge in which the stringers are steel I-beams that directly support the track or ballast section.

Bridge, Stringer: A deck type bridge in which wooden or steel I-beam stringers carry the track across from one bent or pier to another with or without intermediate support.

Bridge, Through Span: A bridge in which the track is carried between girder or trusses. Girder and pony truss bridges (trusses without overhead braces) are called half-through spans; truss bridges with overhead bracing are called through spans.

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Brush:	Woody growth along the right-of-way.
Buckle:	To fail by an inelastic change in alignment (usually as a result of compression). To lose line of track by bulging.
Buckling:	Failure by lateral or torsional instability of a structural member occurring with stresses below the yield or ultimate values.
Bugged Finish:	A smooth finish produced by grinding with power sanders.
Bulkhead:	A water and airtight partition, usually of steel, to temporarily close off the working portion of a compressed air shield tunnel or the ends of a floating tube of a trench type tunnel.
Bulking, Sludge:	A phenomenon that occurs in activated sludge plants whereby the sludge occupies excessive volumes and will not concentrate readily.
Bull Nose:	Convex rounding of a member.
Bull-Header:	A rowlok brick laid with its longest dimension perpendicular to the face of the wall.
Bull-Stretcher:	A rowlok brick laid with its longest dimension parallel to the face of the wall.
Bunker:	Space in which coal or other fuels are stored.
Burner:	A device for the final conveyance of gas, or a mixture of gas and air, to the combustion zone. See specific type *of burner.* (1). Injection Burner. A burner employing the energy of a jet of gas to inject air for combustion into the burner and mix it with gas. (2). Atmospheric Injection Burner. A burner in which the air is injected into the burner by a jet of gas supplied to the burner at atmospheric pressure. (3). Power Burner. See Forced Draft Burner; Induced Draft Burner; premixing Burner; pressure Burner. A burner in which gas, air, or both are supplied at pressure exceeding (for gas) the line pressure, and for air atmospheric pressure. (4). Yellow-Flame Burner. A burner in which only secondary air is depended on for gas combustion.
Burner Assembly:	A burner that is factory-built as a single assembly or as two or more subassemblies that include all essential parts necessary for its normal function when installed as intended.
Burner, Atmospheric:	A gas burner in which air for combustion is supplied by natural draft, the inspirating force being created by gas velocity through the orifices.
Burner, Natural Draft Type:	A burner that depends primarily on the natural draft created in the flue to induce the air required for combustion into the burner.
Burner, Power:	A burner in which all air for combustion is supplied by a power driven fan that overcomes the resistance through the burner.

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Butt Weld: A weld joining two abutting surfaces by depositing weld metal within an intervening space. This weld serves to untie the abutting surfaces of the elements of a member or to join members of their elements abutting upon or against each other. Butt rail welding one rail to another can be accomplished in-plant electrically or by a thermit process in the field.

Buttering: Placing mortar on a brick with a trowel before brick is laid.

Buttress: A piece of masonry, like a pier, built against and bonded into a wall to strengthen the wall against side thrust.

c/B Ratio: The ratio of the weight of water absorbed by cold immersion (usually 24 hours) to the weight absorbed by immersion in boiling water (usually 5 hours). This ratio is also known as the saturation coefficient.

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable) or a combination of conductors insulated from one another (multiple conductor cable).

Spacer Cable:
A type of electric supply line construction consisting of an assembly of one or more covered conductors, separated from each other and supported from a messenger by insulating spacers.

Cable Jacket:
A protective covering over the insulation, core, or sheath of a cable.

Cable Sheath:
A conductive protective covering applied to cables. NOTE: A cable sheath may consist of multiple layers of which one or more is conductive.

Cable **Terminal:**
A device that provides insulated egress for the conductors. Syn: termination.

Caisson: A foundation pier, either circular or rectilinear in plan, usually"' sunk to rock either by means of gravity, compressed air, or by the open-well method.

Caisson Pile: A cast-in-place pile made by driving a tube, excavating it, and filling the cavity with concrete.

Calcite Streaks: Description of a white or milky streak occurring in stone. It is a joint plane usually wider than a glass seam that has been recemented by calcite deposition in the crack. It is structurally sound.

Calibrate: To determine position indicators as required to obtain accurate measurements.

Camber: A slight upward curve of a structural member so that it becomes horizontal, or nearly so, when loaded.

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Cant:	Tilt or inclination, as the inward inclination of a rail, accomplished by using canted tie plates. The undesirable outward tilt of tie plates on sharp curves.
Cap:	The upper member of a column, pilaster, pile, caisson molding, and the like.
Capillary Action:	The process by which water is drawn from a wet area to a dry area through the pores of a material.
Capital:	Column cap.
Car, **Ballast:**	A car specially designed for carrying and distributing ballast.
Car, Hand:	A four-wheeled, hand operated railroad work car for transporting men and tools.
Car, Motor:	A motor-driven railroad work or inspection car.
Car, Trailer or push:	A four-wheeled railroad work car designed to be pushed by hand or pulled by a motor car.
Carbon **Filter:**	Filter using activated carbon as a cleansing agent.
Cascade System:	One having two or more refrigerant circuits, each with a pressure imposing element, condenser, and evaporator, where the evaporator of one circuit cools the condenser of the other (lower-temperature) circuit.
Cast-In-Place Pile:	A concrete pile concreted either with or without a casing in its permanent location.
Catch Basin:	A receptacle, commonly box-shaped and fitted with a grilled inlet and a pipe outlet drain designed to collect rain water and debris from the surface and retain the solid material so that it may be removed at intervals. Catch basins are usually installed at the junction where several drain pipes join, beneath a bridge floor, or within the approach roadway with a grilled inlet adjacent to the roadway curb.
Catcher, Grit:	A chamber usually placed at the upper end of a depressed sewer, or at other points on combined or storm sewers where wear or clogging from grit is possible; the chamber is of such shape and dimensions as will reduce the velocity of flow through it and permit the grit to settle out. Also called Sand Catcher.
Catenary System:	A system of wires suspended between poles and bridges supporting overhead contact wires normally energized with electricity.
Caulking:	(1). The operation or method of rendering a joint tight against water by means of some plastic substances such as oakum, pitch, elastic cement, and the like. (2). The term used in connection with lead joints or bell-and-spigot joints in which the lead is caulked.

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Central Systems: Systems composed of prime movers that convert energy (in the form of heating or cooling) from fuel or electricity. They are located in a single area, to serve distribution systems that deliver the heating or cooling to the conditioned space.

Centralized Traffic Control **(CTC):** The manipulation of automatic and/or cab signals and power operated switches from a central location where signals supersede the superiority of trains.

Centrifuge: A mechanical device utilizing centrifugal force to separate solids from liquids or to separate liquid emulsions.

Cesspool: A pit into which raw household sewage or other untreated liquid waste is discharged and from which the liquid seeps into the surrounding soil or is otherwise removed. Sometimes called Leaching Cesspool.

Chain **Link** Fence: A woven mesh available in various widths, gauges, wire breading strengths, and protective coatings.

Chamber: A general term applied to a space enclosed by walls or to a compartment, often prefixed by a descriptive word, such as "grit," "screen," "discharge," or "flushing," indicating its function.

Chlorination:
A detention basin in which chlorine is diffused through liquid.

Detritus:
A detention chamber larger than a grit chamber, usually with provision for removing the sediment without interrupting the liquid's flow. A settling tank of short detention period designed, primarily, to remove heavy settleable solids.

Diversion:
A chamber that contains a device for drawing off all or part of the flow.

Flowing-Through:
The upper compartment of a two-story sedimentation tank.

Grit:
A small detention chamber or an enlargement of a sewer designed to reduce the velocity of the liquid's flow to permit the separation of mineral from organic solids by differential sedimentation.

Settling:
(1). The second or final element of the so-called biolytic tank that is a combination of a Flocculating and a Settling Tank.
(2). Sometimes used to designate the sedimentation compartment of a two-story tank, as in the case of an Imhoff Tank. See Tank; Sedimentation.

Charge: The amount of refrigerant in a system.

Check: A small lengthwise crack or separation of wood fibers, caused by superficial shrinkage of a timber.

Check **Cracks:** Shrinkage cracks **in concrete still bonded to its base.**

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Check Valve: A device that permits a liquid or gas to flow in one direction only.

Chimney Effect: The tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared with that of the surrounding air or gas. In buildings, the tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air due to the difference in density of outside and inside air.

Chip Cracks: Similar to check cracks, except that the bond has been partially destroyed causing eggshelling. Sometimes referred to as fire cracks, map cracks, crazing, fire checks, or hair cracks.

Chisel, Track: A handled tool to be struck by a sledge, for cutting rail by scoring the base and web until breakage occurs, or for similar cutting. A rail cutter.

Chlorination: Applying chlorine to water, sewage, or industrial wastes, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Combined Residual:
Applying chlorine to water, sewage, or industrial wastes to produce, with natural or added ammonia or certain organic nitrogen compounds, a combined available chlorine residual.

Free Residual:
Applying chlorine to water, sewage, or industrial wastes to produce, directly or through the destruction of ammonia or of certain organic nitrogenous compounds, a free available chlorine residual.

Post:
Applying chlorine to water, sewage, or industrial wastes subsequent to any treatment, including pre-chlorination. The term refers only to a point of application.

Pre:
Applying chlorine to water, sewage, or industrial wastes prior to any subsequent treatment. This term refers only to a point of application.

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

Circuit Breaker: A disconnect capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal conditions such as those of short circuit.

Circuit, Track: A low-voltage flow of electricity in the rails of a track when they are bonded at the joints and form a complete circuit.

Circulating Water Flow: Quantity of hot water flowing into the tower to be cooled.

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Circulator: A motor driven device used to mechanically circulate water in the system. Also called Pump.

Clarification: See Sedimentation.

Clearance: 1). The clear distance between two objects measured surface-to-surface. (2). Clearance refers to the minimum distances provided by the bridge for the passage of vehicular and waterway traffic.

Clip, Switch: The device by which the switch rod is jointed to the switch rail. It is usually united with the switch rail by bolts or rivets. It sometimes has staggered bolt holes in the horizontal leg for making detailed adjustments in positions of the switch rails.

Clip, Transit (Switch): A switch-rod clip drilled with several holes in a line diagonal to the axis of the switch rod, for effecting adjustments in the throw of the switch.

Closer: The last brick laid in a course or the end brick of a part of a course, fitted at the openings. A closer may be a whole brick or less in size.

Closure Rail: The lead rails connecting the heels of a switch with the toe ends of a frog.

Coefficient of Expansion: The change in length per unit length or the change in volume per unit volume per degree change in temperature.

Coefficient of Thermal Expansion: The unit strain produced in a material by a change of one degree in temperature.

Coils, Digester: A system of pipes for hot water or steam installed in a sludge-digestion tank for the purpose of heating the sludge.

Collector:

Grit:
A device placed in a grit chamber to convey deposited grit to one end of the chamber for removal.

Scum:
A mechanical device for skimming and removing scum from the surface of settling tanks.

Sludge:
A mechanical device for scraping the sludge on the bottom of a settling tank to a sump, from which it can be drawn by hydrostatic or mechanical action.

Column: A pillar or pier of slender proportions that carries a load and acts as an upright support.

Combined Feeder/Cutoff: A device that regulates makeup water to a boiler in combination with a low-water fuel cutoff.

Combustion: The rapid oxidation of fuel, producing heat, or heat and light.

Combustion Air: Air supplied in an appliance specifically for the combustion of a fuel gas.

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Combustion Chamber: The portion of an appliance in which combustion normally occurs.

Combustion Products: Constituents resulting from the combustion of a fuel gas with the oxygen in air, including the inerts, but excluding excess air.

Comminution: The process of screening sewage and cutting the screenings into particles sufficiently fine to pass through the screen openings.

Common Use: Simultaneous use by two or more utilities of the same kind.

Communication Lines: See Lines, Communication.

Compound Refrigerating System: System that has several compressors or compressor cylinders in series. The system is used to pump low-pressure vapors to condensing pressures.

Compression: An axle force or stress caused by equal and opposite forces pushing at the ends of a member. In simple bending it is also present above or below the neutral axis.

Compression Tank See Air Cushion Tank

Compressor Seal: Leakproof seal between crankshaft and compressor body.

Compressor, Hermetic Compressor in which the driving motor is sealed in the same dome or housing that contains the compressor.

Compressor, Open-Type: Compressor in which the crankshaft extends through the crankcase and is driven by an outside motor.

Compressor, Refrigerating: The pump of a refrigerating mechanism that draws a vacuum or low-pressure on the cooling side of a refrigerant cycle and squeezes or compresses the gas into the high-pressure or condensing side of the cycle.

Compressor, Screw: A compressor that uses matched screws or other rotating devices to provide pumping action.

Compromise Bars: Special joint bars to connect rails of different sections in such a way that the gauge sides and the top of the head and running surfaces are held in line. Also called Offset Bars.

Computer: An electric calculator capable of receiving programmed data and interpreting, manipulating, and storing the data. The system is composed of (1) a card reader/punch which functions as an input (output device), (2) a central processing unit (CPU) which is where the actual computing is done, (3) a printer which is an output device, and (4) a disc drive, and (5) a plotter which can provide graphic display of program output. Computers vary in size and speed of computation. Data storage varies between disc, tape, and drum types.

Concrete: A mixture of two components, cement paste and aggregates.

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Concrete, plain: Concrete either without reinforcement, or reinforced only for shrinkage or temperature changes.

Condenser: The heat exchanger in a refrigeration system that removes heat from the hot high-pressure refrigerant gas and transforms it into a liquid.

Conditioning Sludge: Fluid sludge treatment to facilitate dewatering, usually by the addition of chemicals.

Conductor: A material in the form of a wire, cable, or bus bar, suitable for carrying an electric current.

Bundled Conductor:
An assembly of two or more conductors used as a single conductor maintained in a predetermined configuration. The individual conductors of the assembly are called subconductors.

Covered Conductor.
A conductor covered with a dielectric having a rated insulating strength less than the Voltage of the circuit in which the conductor is used.

Fiber Optic Conductor:
See **Fiber** Optic **Cable** Communication; **Fiber** Optic Cable **Supply.**

Grounded Conductor:
A conductor that is intentionally grounded, either solidly or through a noninterrupting current-limiting device.

Grounding Conductor:
A conductor used to connect the equipment or wiring system with a grounding electrode(s).

Insulated Conductor:
A conductor covered with a dielectric (other than air) having a rated insulating strength equal to or greater than the Voltage of the circuit in which it is used.

Lateral Conductor:
A wire or cable extending in a general horizontal direction at an angle to the general direction of the line conductors, and entirely supported on one structure.

Line Conductor: (Overhead supply or communication lines)
A wire or cable intended to carry electric currents, extending along the route of the line, supported by poles, towers, or other structures, but not including vertical or lateral conductors.

Open Conductor:
A type of electric supply or communication line construction in which the conductors are either bare, covered, or insulated, and without grounded shielding; individually supported at the structure either directly or with insulators. Syn: open wire.

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Conductor Shielding: An envelope enclosing a cable conductor and providing an equipotential surface in contact with the cable insulation.

Conduit: (1). A structure containing one or more ducts. NOTE: Conduit may be further designated as iron pipe conduit, tile conduit, etc. If it contains one duct only it is called single-duct conduit; if it contains more than one duct it is called multiple-duct conduit, usually with the number of ducts as a prefix, for example, two-duct multiple conduit. (2). Piping, usually metal or concrete that protects other piping or wiring from damage. Used to bury underground utilities.

Conduit System: Any combination of duct, conduit, conduits, manholes, handholds, and vaults joined to form an integrated whole

Congestion: To fill to excess; overcrowd.

Connected Load: The total load in BTU/hr attached to the boiler. It is the sum of the outputs of all terminal units and all heat to be supplied by the boiler for process applications.

Connectors: A device that holds two or more structural members intact.

Construction Joint: The interface/meeting surface between two successive concrete pours.

Contact (Trolley) Wire: The overhead wire, sometimes referred to as trolley wire, which the pantograph of an electric locomotive rides against (contacts) to collect its electrical current (source of power).

Contaminant: A substance (dirt, moisture, chemicals, etc.) foreign to the primary system media (water, gas, etc.)

Contamination: A general term signifying the introduction into water of microorganisms, chemicals, wastes, or sewage, that renders the water unfit for its intended use.

Control: Automatic or manual device used to stop, start, and/or regulate flow of gas, liquid, and/or electricity.

Control Valve: A valve that permits regulation of gas or fluid flow in a piece of equipment, or feeder.

Control, Low-Pressure: Cycling device connected to low-pressure side of system.

Control, Motor: A temperature or pressure operated device used to control the running of the motor.

Control, Operating: An automatic control, other than a safety control, to start or regulate input according to demand, and to stop or regulate input on satisfaction of demand.

Control, Pressure Motor: A high or low-pressure control connected into the electrical circuit used to start and stop the motor when there is need for refrigeration or for safety purposes.

Control, Primary Safety: A control directly responsive to flame properties, sensing the presence of flame, and (in event of ignition) failure or loss of flame, causing shutdown.

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Control, Refrigerant:	Device used to regulate flow of liquid refrigerant into an evaporator, such as a capillary tube, expansion valves, and/or high and low side float valves.
Control, Temperature:	A thermostatic device that automatically stops and starts a motor (or other equipment), operation of which is based on temperature changes.
Converter:	A heat exchange unit designed to transfer heat from one distributing system to another. These may be either steam-to-water or water-to-water units. They are usually of shell and tube design.
Cooling Plant:	The machinery that produces chilled water or cool refrigerant gas (chiller or compressor), the condenser, cooling tower and condenser water pumps for water cooled plants, air cooled condensers for air cooled systems, and chilled water pumps and expansion tanks for chilled water systems.
Coping:	The material or member used to form a capping or finish on top of a wall, pier, or the like, to protect the masonry below by throwing off the water to one or more sides.
Corbel:	That part of the masonry built outward from the face of masonry by projecting successive masonry courses.
Corbel Out:	To build out one or more courses of brick or stone from the face of a wall, to form a support for timbers.
Corroslon:	The gradual deterioration or destruction of a substance or material by chemical action, frequently induced by electro-chemical processes, the action proceeding inward from the surface.
Corrosivity:	The tendency of a metal to wear away another material by chemical attack.
Counterflow:	In heat exchange between two fluids, the opposite direction of flow, coldest portion of one meeting coldest portion of the other.
Counterflow lower:	A type of tower in which the air and water streams are in countercurrent flow.
Counterfort:	A buttress or portion projecting outward from a wall and upward from the foundation to provide additional resistance to thrusts.
Course:	One of the continuous horizontal layers (or rows) of masonry units which, bonded together, form a masonry structure.
Cradle:	(1). One of a series of masonry piers to support the bell ends of cast-iron pipes laid above the ground's surface; the pipe lengths are self-supporting between cradles. (2). In trenches in soft ground or at great depths, a continuous concrete footing extending to the horizontal diameter of the pipe, and sometimes an inch or two higher; used generally with vitrified-clay sewer pipes.

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Cramp:	An anchor for masonry, made of a short, flat bar of metal, with both ends turned down at right angles, and used for tying the masonry together by bedding the bent ends in holes provided in the masonry units.
Crane, Track	A power-operated crane used principally for setting rails in track renewal, but having many similar uses in maintenance work. Also called Maintenance Crane.
Crank, Adjustable (Switch Stand):	A switch-operating device by which the position of the mechanism at the base of the spindle can be altered to adjust the switch.
Crank, Breakable (Switch Stand):	A short crank casting of soft metal, designed to break when the switch is run through and therefore prevent damage to switch-point rails.
Crawl Space:	A shallow space below the living quarters of a basementless structure, normally enclosed by the foundation wall.
Creep:	The time-dependent deformation of steel or concrete due to sustained load.
Creosote:	An oily aromatic compound distilled from tars, used in the preservation of wood exposed to the elements.
Crib:	(1). The ballast or the open space between two adjacent crossties. (2). A crisscross structure of logs, timber, concrete, or other members, used to retain a fill or as a bridge support.
Critical Vibration:	Vibration that is noticeable and harmful to structure.
cross Level:	The distance one rail is above or below another. This should not be confused with Superelevation on curves.
Crossflow Tower:	A type of tower in which the air and water streams are in crosscurrent flow.
Crossing Protection:	An arrangement of signs or electric signaling devices designed to prevent accidents at grade crossings. May include short arm gates.
Crossing, Grade **(Xing):**	A crossing or intersection of a railroad and a highway at the" same level or grade.
Crossover:	Two turnouts with the track connecting their frogs, arranged to form a passage between two nearby and generally parallel tracks.
Crosstie:	See Tie.
Crowfoot:	(Stylolite.) A dark gray to black zig-zag marking occurring in stone. Usually structurally sound.
Crown:	The top or high point of a generally horizontal surface.
Cryogenic Fluid:	Substance that exists as a liquid or gas at ultra-low temperatures (-50°F or lower).
Cryogenics:	Refrigeration that deals with producing temperatures of 50°F below zero and lower.

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Current-Carrying Part: A conducting part intended to be connected in an electric circuit to a source of Voltage. Noncurrent carrying parts are those not intended to be so connected.

Curvature, Degree of: A measure of the sharpness of a simple curve in which a 1° curve is taken as the central angle subtended by a chord or arc of 100 feet and for which the radius is taken as 5,730 feet. Sharper curves are in direct proportion; i.e., a 10° curve is taken as one having a radius of 573 feet. Railroads use the chord definition, highways the arc of definition.

Curve, Compound: A curve composed of two or more simple curves which join on common tangent points or common easement curve and which lead in the same general direction; i.e., to left or right, but each with different radii.

Cut **Stone:** Finished, dimensioned stone, ready to set in place.

Cut-In: Temperature or pressure valve that closes control circuit.

Cut-out: Temperature or pressure valve that opens control circuit.

Cutting: Handwork required to finish a stone that cannot be done by machine.

Cycle: Series of events that have the tendency to repeat the same events in the same order.

Damp Course: A course or layer of impervious material in a wall or floor to prevent the entrance of moisture from the ground or from a lower course.

Damper: A valve or plate installed in ductwork to regulate the amount of flow through the duct.

Dampproofing: One or more coatings of a compound that is impervious to water. Usually applied to the back of stone or face of a wall.

Dashpot: A damping device used to delay movement. A piston moves in a cylinder and a trapped liquid or gas is allowed to leave the trapped space at a controlled rate through a hole in the piston or by another route. An air dashpot is frequently used in waterflow detection devices to delay the signal and eliminate false signals due to water pressure surges.

Dead Load: A constant load due to the mass of the members, the supported structure, and permanent attachments or accessories.

Deenergize: Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth or removal of electrical power from an electrically operated device such as a relay or contactor. NOTE: The term is used only with reference to current-carrying parts that are sometimes energized (alive) Syn: dead.

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Deenergized, Apparently Dead:	Electric apparatus, such as overhead wires, third rail, transformers, switches, motors, etc., is deenergized when disconnected from the normal power source, but such apparatus is dangerous to life until it is known to be properly grounded.
Deformed Bars:	Reinforcing bars with closely spaced shoulders, lugs, or projections formed integrally with the bar during rolling to firmly engage the surrounding mortar. Wire mesh with welded intersections not farther apart than 12 inches (30 cm.) in the direction of the principal reinforcement and with cross wires not smaller than No. 10, may be rated as a deformed bar.
Dehydrate:	To remove water in all forms from matter. Liquid, hygroscopic, crystallized, or hydrated water are included.
Density:	The weight of a substance per unit volume. As applied to gases, the weight in pounds of a cubic foot of gas at standard pressure and temperature.
Deodorizer:	Device that absorbs various odors, usually by principle of absorption. Activated charcoal is commonly used.
Derail:	A track safety device to guide rolling stock off the rails at a selected spot as a means of protection against collisions or other accidents.
Derailment:	Anytime the wheels of a car or engine are off the head of the rail.
Desiccant:	Substance used to collect and hold moisture in refrigerating system. A drying agent. A common desiccant is activated alumina silica gel.
Designated Person:	A qualified person designated to perform specific duties under the conditions existing. Syn: designated employee.
Detector, Leak:	Device used to detect and locate gas leaks.
Detritus:	(1). The heavier mineral debris moved by natural water courses, usually in bed-load form. (2). The sand, grit, and other coarse material removed by differential sedimentation in a relatively short period of detention.
Dewatering, Screenings:	The removal of a large part of the water content of sewage or waste screenings by draining or by chemical means.
Diagnosis:	Analysis of physical or electrical symptoms to determine condition.
Diamond Sawed:	Finish produced by sawing with diamond toothed saws (either circular or gang).
Differential:	As applied to refrigeration and heating: difference between cut-in and cut-out temperature or control pressure.

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Diffuser:	A porous plate or tube through which air is forced and divided into minute bubbles for diffusion in liquids. Commonly made of Carborundum, alundum, or silica sand.
Digestion:	The anaerobic decomposition of organic matter, resulting in partial gasification, liquefaction, and mineralization.
Dilution:	(1). A method of disposing of sewage, industrial waste, or sewage treatment plant effluent by discharging it into a stream or other body of water. (2). The ratio of flow volume of a stream to the total volume of sewage or sewage treatment plant effluent discharged into it.
Dimensioned Stone:	Stone precut and shaped to specified sizes.
Disconnecting or Isolating Switch:	A switching device used for changing the connections in a circuit or for isolating a circuit or equipment from a source of power. NOTE: It is required to carry normal load current continuously and also specified abnormal or short-circuit current for short intervals. It is required to open or close circuits either when negligible current is broken or made, or when no significant change in the Voltage across the terminals of each of the switch poles occurs. Syn: disconnector, isolator.
Disinfection:	The killing of the larger portion (but not necessarily all) of the harmful and infectious microorganisms in or on a medium by means of chemicals, heat, ultraviolet light, etc.
Distribution System:	A system of conduits, orifices, weirs, or nozzles for receiving the circulating water entering the tower and distributing it over the area where it is in contact with air.
Distributor:	A device used to apply liquid to the surface of a filter or contact bed, of two general types, fixed or movable. The fixed type may consist of perforated pipes or notched troughs, sloping boards, or sprinkler nozzles. The movable type may consist of rotating disks or rotating, reciprocating, or traveling perforated pipes or troughs applying a spray, or a thin sheet of liquid. **Fixed:** A distributor consisting of perforated pipes or notched troughs, sloping boards, or sprinkler nozzles, all of which remain stationary when the distributor is operating. Movable: A distributor consisting of rotating or reciprocating perforated pipes or troughs, from which the liquid is discharged in the form of a spray, or in thin sheets. **Rotary:** A movable distributor made up of horizontal arms that extend to the edge of the circular trickling filter bed and revolve about a central post, distributing liquid over the bed through orifices in the arms.

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Dolly, Rail, or **Timber:** A device consisting of one or more wide rollers mounted in a frame, used as a platform and as a truck for moving rail, long heavy timbers, and other items.

Dome, Gas: In sludge digestion tanks, usually a steel cover floating on the gas overlying the sludge.

Domestic Sewage: The water borne waste derived from ordinary living processes.

Dope: Term used for additives used either to accelerate or retard the set of any type of mortar.

Down **Spouts:** Pipes used to carry off water when it is not desirable to allow water to free fall from scuppers.

Downdraft: Excessive high air pressure existing at the outlet of chimney or stack that tends to make gases flow downward in the stack.

Downs-am: In the direction in which the water is flowing.

Draft: A current of air, usually referring to the difference in pressure which causes air or gases to flow through a chimney flue, heating unit, or space.

Draft Gauge: Instrument used to measure air movement.

Draft Indicator: An instrument used to indicate or measure chimney draft or combustion gas movement. Draft is measured in units of inches of water column.

Drain Cock A valve installed in the lowest point of a boiler or at low points of a heating system to provide for complete drainage of water from the system.

Drainage System: Includes all the piping, within public or private premises, that conveys sewage, rain water, or other liquid wastes to the point of disposal. It does not include the mains of a public sewer system or private or public sewage-treatment.

Drift: One or more small tunnels excavated within and ahead of the full cross-section.

Drill, **Track:** A machine designed to operate horizontally to drill holes through webs of rails, especially for track bolts. It may be a one man ratchet drill or a geared drill machine with a frame, rail clamps, feed screw, high speed steel bit and chuck, and alternating crank handles turned by two men or operated by electric, gasoline, or air power.

Drip: Any projecting piece of material, member, or part of a member so shaped and placed as to throw off water and prevent its running down the face of a wall or other surface of which it is a part.

Drip Log: The container placed at a low point in a piping system to collect and remove condensate.

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Dry Packing: Filling a void with stiff mortar, placed in small increments, or gravel packed into the space between rock excavation, and poured-in-place tunnel lining to permit drainage of seepage water.

Dry Seam: Unhealed fracture that is a plane of weakness.

Dry-Out: Soft, chalky mortar caused by water evaporating before setting.

Dryer, Flash: A device for vaporizing water from partly dewatered and finely divided sludge through contact with a current of hot gas or superheated vapor. Included is a squirrel cage mill for separating the sludge cake into fine particles.

Duct: A single enclosed raceway for conductors or cable.

Dust: An air suspension (aerosol) of particles of any solid material, usually with particle size less than 100 microns.

Dusting: The development of dust on the surface of concrete. Dusting can be the result of trowelling too soon, too much water in the mix, improper mix design, or other reasons.

DWV: An acronym for "drain-waste-vent" referring to the combined sanitary drainage and venting systems.

Effective Area of Brick **Masonry:** The section area that lies between the centroid of the tensile reinforcement and the compression face of the structural member.

Effective Area of **Reinforcement:** The area obtained by multiplying the right cross-sectional area of the metal reinforcement by the cosine of the angle between its direction and to determine the reinforcements effectiveness.

Effective Depth: The distance from the center of gravity of tensile reinforcement to the compression surface of a structural member.

Effectively Grounded: Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of Voltages that may result in undue hazard to connected equipment or people.

Efflorescence: Mortars or cements that contain excess soluble salts will contribute to masonry efflorescence. Efflorescence can only occur when water penetrates the masonry or concrete, dissolves the salts, and upon evaporation deposits them on the face of the wall. The surest efflorescence preventative is to keep water out of masonry or concrete.

Effluent: (1). A liquid that flows out of a containing space. (2). Sewage, water, or other liquid, partially or completely treated or in its natural state, as the case may be, flowing out of a reservoir, basin, or treatment plant, or part thereof.

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Eggshelling: Refers to the condition of chip-cracked concrete, mortar, or plaster. The form taken is concave to the surface and the bond is partially destroyed.

Egress: The act of departing from a point of access.

Ejector, Pneumatic: A device for raising sewage, sludge, or other liquid by alternately admitting compressed air to the pot above the liquid.

Electric Supply Equipment: Equipment that produces, modifies, regulates, controls, or safeguards a supply of electrical energy. Syn: supply equipment.

Electric Supply Lines: See **Lines.**

Electric Supply Station: Any building, room, or separate space within which electric supply equipment is located and the interior of which is accessible, as a rule, only to qualified people. This includes generating stations and substations, including their associated generator, storage battery, transformer, and switchgear rooms or enclosures, but does not include facilities such as pad-mounted equipment and installations in manholes and vaults.

Electric Water Valve: Solenoid type (electrically operated) valve used to turn water flow on and off.

Electrified Territory: That portion of the railroad consisting of main tracks, secondary tracks, sidings, yards, and industrial tracks equipped for electric train operation by catenary system or by third rail and necessary substations, transmission and signal power lines located above or adjacent to the tracks.

Electronic Leak Detector: Electronic instrument that measures electronic flow across gas gap. Electronic flow changes indicates presence of gas molecules.

Electronic Sound Tracer: Instrument used to detect leaks by locating source of high frequency sound caused by the leak.

Electrostatic Filter: Filter type that gives particles of dust electric charge. This causes particles to be attracted to plate so they can be removed from air stream or atmosphere.

Elevation (of Outer Rail on Curve): See Superelevation.

Elutriation: Sludge conditioning process in which certain constituents are removed by successive decantations with fresh water of plant effluent, thereby reducing the demand for conditioning chemicals.

Enclosed: Surrounded by case, cage, or fence designed to protect the contained equipment and minimize the possibility, under normal conditions, of dangerous approach or accidental contact by people or objects.

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Enclosure Wall:	An exterior non-bearing wall in skeleton construction, anchored to columns, piers, or floors, but not necessarily built between columns or piers nor wholly supported at each story.
End Play:	Slight movement of shaft along center line.
Endpost:	The piece of an insulating joint that separates the rail ends.
Energize:	Apply electrical power to an electrically operated device such as a relay or contactor.
Energized:	Electrically connected to a source of potential difference, or electrically charged to have a potential significantly different from that of earth in the vicinity. NOTE: Also Alive or Live.
Energized, **Live** (Dangerous to **Life):**	Electric apparatus, such as overhead wires, third rail, transformers, switches, motors, etc., is energized when connected to the normal power source. All systems are considered to be energized until a qualified individual knows the circuit has been deenergized.
Engine Bum:	Destruction of rail head metal caused by spinning locomotive wheels.
Engine Bum Fracture:	A rail break caused by an engine burn.
Entablature:	Consists of an architrave, frieze, and cornice.
Entasis:	The curve resulting from the gradual diminishing of the diameter of the upper two-thirds of a column.
Enthalpy:	Total amount of heat in one pound of a substance calculated from accepted temperature base. Temperature of 32°F is accepted base for water vapor calculation. For refrigerator calculations, accepted base is 40°F.
Entropy:	Mathematical factor used in engineering calculations. Energy in a system.
Entry Control Point:	Controlled access entry point to a site or secured area.
Epoxy Resin:	A flexible usually thermal setting resin made by polymerization of an epoxide and used as an adhesive.
Equipment:	A general term including fittings, devices, appliances, fixtures, apparatus, and similar terms used as part of or in connection with an electric supply or communication system.
Erosion:	The gradual deterioration of soil due to weather, liquid, wind, and/or human intervention.
Evasé Stack:	An air exhaust stack increasing in cross-section in the direction of airflow to regain air pressure.
Excess Air:	Air that passes through an appliance and appliance flues in excess of that required for complete combustion of the gas; Usually expressed as a percentage.
Exfiltration:	Air or fluid flow outward through a wall, leak, membrane, etc.

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Expansion Anchor: A metal expandable unit inserted into a drilled hole that grips stone by expansion.

Expansion Joint: (1). A bituminous fiber strip used to separate blocks or units of concrete to prevent cracking due to expansion as a result of temperature changes. Also used in concrete slabs. (2). Joints placed in the bridge wearing surface and in the deck itself to allow for longitudinal movement by structural members due to changes in temperature. They prevent cracking in the wearing surface and deck. (3). A joint whose primary purpose is to absorb the longitudinal expansion and contraction in a pipe due to temperature changes.

Expansion Loop: A large radius loop in a pipe line that absorbs the longitudinal expansion and contraction in the line due to temperature changes.

Expansion Shim (Rail): Spacer inserted between ends of abutting rails while track is being laid to provide allowance for expansion of steel when temperature changes.

Expansion Tank: A device to control pressure in an hydraulic system by storing excess volume resulting from increased operating temperatures.

Explosion-Proof Apparatus: Apparatus enclosed in a case capable of withstanding an explosion of a specified gas or vapor that occurs within it; capable of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within; and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

Exposed: Not isolated or guarded.

Exterior Wall: Any outside wall or vertical enclosure of a building other than a party wall.

External Corrosion: Corrosion of that portion of a metal structure (pipe) that is exposed to external elements such as air, water, or soil.

Face: (1). The front or exposed surface of a wall. (2). The vertical surface at the head of a tunnel excavation.

Faced Wall: A wall in which the facing and backing are so bonded with masonry as to exert common action under load.

Facilities: Buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein; outside plant, including site development features such as landscaping, roads, walks, and parking areas; outside lighting and communication systems; central utility plants; utilities supply and distribution systems; and other physical plant features. As used in these criteria, the term “nuclear facilities” is synonymous with this same term as contained in DOE 5480.5.

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Facing: Any material forming a part of the wall used on the exterior as a finishing surface.

Fan: A radial or axial flow device used for moving or producing artificial currents of air.

Centrifugal:
A fan rotor or wheel within a scroll type of housing including driving mechanism supports for either belt drive or direct connection.

Propeller:
A propeller or disc-type wheel within a mounting ring or plate and including driving mechanism supports for either belt drive or direct connection.

Tube Axial:
A propeller or disc-type wheel within a cylinder including driving mechanism supports for either belt drive or direct connection.

Vane Axial:
A disc-type wheel within a cylinder, a set of air guide vanes located either before or after the wheel, including driving mechanism supports for either belt driie or direct connection.

Fascia: A flat member or band at the building surface, the edge beam, or a bridge.

Fastener, Tie-flak: A special tie-plate long enough to support the bases of a guard rail and the adjacent running rail, with a rail brace riveted to it for supporting the guard rail.

Fastenings, Auxiliary Track: Spring washers, tie plates, rail braces, rail anchors, and other accessories.

Fastenings, Track: A term commonly applied to splice bars, bolts, and spikes.

Fat: Material accumulated on the trowel during the finishing operation and used to fill in small imperfections. Also a term to describe working characteristics of any type mortar.

Federal Railroad Administration (FRA): A government agency under the U.S. Department of Transportation.

Feeder, Chemical, Dry: A mechanical device for applying dry chemicals to sewage at a rate controlled manually or automatically, by the rate flow.

Ferrous: This relates to objects made of iron or steel.

Fiber Optic Cable-Communication: A fiber optic cable meeting the requirements for a communication line, located in the communication space of overhead or underground facilities.

Fiber Optic Cable-Supply: A fiber optic cable located in the supply space of overhead or underground facilities.

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Fill (Filling):	Material, usually earth, used for the purpose of raising or changing the surface contour of an area, or for constructing an embankment.
Filter:	Device for removing small particles from a fluid or air/gas. A porous material (fiberglass or foam plastic) installed in the air or fluid circulation system to remove dust particles and pollen. Some are disposable, whereas some may be cleaned and reused.
Fire Division Wall:	Any wall that subdivides a building to resist the spread of fire, but is not necessarily continuous through all stories to and above the roof.
Are **Resistance:**	The property of a material or assembly to withstand fire, characterized by the ability to confine a fire, and/or to continue to perform a given structural function.
Fire stop:	Any piece or mass of fire resistant material used for filling in open spaces or close openings in order to prevent the passage of fire.
Fire lube **Boiler:**	A steel boiler in which the hot gases from combustion are circulated through tubes surrounded by boiler water that fills the space between the boiler shell and the tubes.
Flre Wall:	Any wall that subdivides a building to resist the spread of fire by starting at the foundation and extending continuously through all stories to and above the roof.
Fireproofing:	Any material or combination of materials used to enclose structure members to make them fire resistant.
Firing Device:	The burner, either oil, gas, or coal.
Firing Rate:	The rate at which air, fuel, or an air-fuel mixture is supplied to a burner, expressed in volume or heat units supplied per unit of time.
Fishing Space:	Space between head and base of a rail occupied by a splice bar (angle bar, joint bar).
Flame **Arrestor:**	See Flashback **Arrestor.**
Flame Failure Response Time:	The time interval between the loss of flame and de-energizing the safety shutoff valve.
Flame Retention **Device:**	A device added to a burner that aids in holding the flame base close to the burner ports.
Flame **Rollout:**	A condition where flame rolls out of a combustion chamber when the burner is turned on.
Flame lest for **Leaks:**	When an air-refrigerant mixture is fed to flame, this flame will change color in presence of heated copper. The tool used is principally a torch.
Flame Velocity:	The speed at which a flame moves through a fuel-air mixture.

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Flammability Limits: The maximum percentages of a fuel in an air-fuel mixture that will burn.

Flange: (1). A projecting edge, rib, or rim on any object such as the base of a rail on the top and bottom horizontal parts of a beam or girder. (2). On a car wheel, the inside rim that projects below the tread.

Flange Frog: See Frog, Self-Guarded.

Flanger: A form of plow for clearing ice and snow from the inside of rails to provide a clear passage for wheel flanges. Sometimes placed under a special car called a flanger car, but usually carried under a snowplow. Also frequently attached to locomotives, either on or just behind the pony trucks.

Flangeway: Space between running rail and guard rail or timber in road crossing to provide clearance for passage of wheel flanges.

Flare Opening: Horizontal distance between the gauge line of running rail and the side of the head of a guard rail or frog wing rail at the widest part of its flared end.

Flash Gas: This is the instantaneous evaporation of some liquid refrigerant in evaporators that cools the remaining liquid refrigerant to the desired evaporation temperature.

Flash Point: The temperature at which an oil will give off sufficient vapor to support a flash flame but not continuous combustion.

Flashback: An undesirable flame characteristic in which burner flames strike back into a burner to burn there or to create a pop after the gas supply has been turned off.

Flashback Arrestor: A gauze, grid, or any other portion of a burner assembly used to avert flashback.

Flashing: The material used and the process of making watertight the roof intersections and other exposed places on the outside of the house.

Float **Valve:** Type of valve operated by a sphere or pan that floats on a liquid surface and controls the liquid level.

Floc: Small gelatinous masses, formed in a liquid by the addition of coagulants thereto, through biochemical processes, or by agglomeration.

Flocculator: An apparatus for the formation of floc in water or sewage.

Flotation: A method of raising suspended matter to the surface of a liquid in a tank as scum; (eg., by aeration, by the evolution of gas, chemicals, electrolysis, heat, or bacterial decomposition), and the subsequent removal of the scum by skimming.

Flow Control Valve: A specially designed check valve usually installed in the supply pipe. to prevent gravity circulation of hot water within the heating system when the pump is not in operation.

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Flow Meter:	Instrument used to measure velocity or volume of fluid movement.
Flow of Metal (Rail):	Rolling out of steel on the crown of a rail toward sides of the head. More common on the low side of a curve located where less than established speed is used frequently.
Flue:	An enclosed chimney passage to carry exhaust smoke and fumes of the heating plant to the outer air.
Flue Gases, Flue **Products:**	Products of combustion and excess air in flues.
Flue Lou:	The heat lost in flue products exiting from the flue outlet.
Fluid Coupling:	Device that transmits drive energy to energy absorber through a fluid.
Flume:	An open conduit, constructed of wood, masonry, or metal, and constructed on a grade; sometimes elevated. **Parshall:** A device developed by Parshall, for measuring the flow of liquid in an open conduit, consisting essentially of a contracting length, throat, and an expanding length. At the throat is a sill over which the flow passes at Belanger's critical depth. The upper and lower heads are each measured at a definite distance from the sill. Unless the sill is submerged more than about 67%, the low head need not be measured. See **Flume, Venturi.** **Venturi:** An open flume with a contracted throat that causes a drop in the hydraulic grade line, used for measuring flow. See **Flume, Parshall.**
Foam **Leak Detector:**	A system of soap bubbles or special foaming liquids brushed over joints and connections to locate leaks.
Foaming **Sludge:**	An increase in the sludge gas in Imhoff and separate digestion tanks causing large quantities of froth, scum, and sludge to rise and overflow from openings at or near the top of the tanks.
Footing:	A masonry section, usually concrete, in a rectangular form wider than the bottom of the foundation wall or pier it supports.
Footing **Form:**	A wooden or steel structure, placed around the footing that will hold the concrete to the desired shape and size.
Forced Draft:	Air movement from the fan discharge through the heat exchanger, cooling tower, or boiler.
Forced Draft Burner:	A burner in which combustion air is supplied by a fan or blower.
Forced Draft Tower:	Type of mechanical draft tower in which the air moving device is located at the air inlet.

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Forms (Form Work, Lagging, Shut&ring):	The wooden or metal construction providing means for receiving, molding, and sustaining in position the plastic mass of concrete placed therein to the certain dimensions, outlines, and details of surfaces planned for its integral parts.
Formwork:	The total system of support for freshly placed concrete including the mold or sheathing that contacts the concrete, all supporting members, hardware, and necessary bracing.
Foundation:	(1). The material(s) through which the load of a structure is transmitted to the earth. (2). The supporting portion of a structure below the first floor construction, or below grade, including the footings.
Foundation Wall:	That portion of a load-bearing wall below the level of the adjacent grade, or below the first tier of floor beams or joists, that transmits the superimposed load to the footing.
Fracture, Detail:	A progressive transverse fracture originating in the head of a rail.
Freon:	Trade name for a family of synthetic chemical refrigerants manufactured by DuPont De Nemours Inc.
Friction Head:	In a hydronic system the friction head is the loss in pressure resulting from the flow of water in the piping system.
Frog:	A device used where two running rails intersect, providing flangeways to permit wheels and wheel flanges on either rail to cross the other.
Frog Angle:	Angle formed by intersecting gauge lines of the rails, or by tangents to the gauge lines at their point of intersection when the frog is curved.
Frog Number:	One-half the cotangent of one-half the frog angle, or the number of units of center-line length in which the spread is one unit, The rate of spread of the gauge lines at the frog. The number of units of length for a spread of one unit.
Frog Rigid Bolted:	A frog built entirely of rolled rails, with fillers between rails, and rigidly held together with bolts.
Frog, Point of:	The actual point of frog, also called the 1/8 inch point of frog, is the point at which the spread between gauge lines is 1/2 inch, which is the standard width of all manufactured frog points except solid manganese steel frogs. In the latter, the metal point is 5/8 inch wide, but the 1/8 inch is marked on the casting. All measurements are made from the 1/8 inch point of frog. The theoretical point of frog, the point of intersection of the gauge lines, is at a distance ahead of the 1/8 inch point which in inches is equal to one-half the frog number. This dimension is needed in turnout layouts.

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Frog, Self-Guarded (Flange Frog):	A frog with a guard member for guiding the flange of a wheel past the point of frog by engaging the tread rim of the wheel in a horizontal plane above the top of the running surface of the frog. This makes a guard rail unnecessary.
Frog, Spring:	A frog constructed so that one wing rail will spring open when activated by force of the wheel flange passing through it.
Frog, Throat of:	Point at which the converging wings of a frog are closest together.
Frostline:	The depth of frost penetration in soil. This depth varies in different parts of the country. Footings should be placed below this depth to prevent movement.
Frozen Joint:	A joint so tight that the rails cannot move as temperature varies.
Fuel:	Any substance used for combustion.
Fuel Gas:	Any substance in a gaseous form when used for combustion.
Fuel-Oil Burner:	Pressure Atomizing or Gun Type: A burner designed to atomize the oil for combustion under an oil supply pressure of 100 psig. Vaporizing or Pot Type: These burners use the heat of combustion to vaporize the oil in a pool beneath the vaporizing ring. This vapor rising through the ring ignites and maintains combustion in the burner. **Rotary** Type: A burner employing a throw ring that mixes the oil and air.
Fusee:	A pyrotechnic signaling device carried by train crews and track workers. When ignited it burns with a red light for a short period of time. A fusee may be dropped from the rear of a train to warn following trains of danger and it is used in many other ways, including emergency use by track workers. to indicate to an approaching train a dangerous condition of, track or structure. It is used either in daylight or darkness.
Galvanic Action:	Corrosion action between two metals of different electronic activity. The action is increased in the presence of moisture.
Gang Saw:	A machine with multiple blades used to saw rough quarry blocks into slabs.
Gas:	One of the following fuel gases: natural gas, liquefied petroleum (LP) gas, LP air mixture, manufactured gas, or mixed gas.
Gas Distribution Piping:	A pipe within the building that conveys gas from the point of delivery to the points of usage.
Gas Pressure Regulator:	A device for controlling and maintaining a predetermined gas pressure.

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Gas Service Piping: The pipe from the gas main or other source of supply including the meter, regulating valve, or service valve to the gas distribution system of the building served.

Gas Valve: Device for controlling gas flow.

Gas-Noncondensible: A gas that will not become liquid under given pressure-temperature conditions.

Gasket: A resilient or flexible material used between mating surfaces, refrigerating unit parts, or refrigerator doors to provide a leak proof seal.

Gate **of Track:** Distance between gauge lines of rails laid in track.

Gate Valve: A valve designed so that the opening for flow (when the valve is fully open) is essentially the same as the pipe and the direction of flow through the valve is in a straight line.

Gauge Line: A line five-eighths inch below the running surface of a rail on the side of the head nearest the track center; the line from which measurements of gauge are made.

Gauge Manifold: A device constructed to hold compound and high-pressure gauges and valves to control flow of fluids through it.

Gauge Rod: A device for holding track to correct gauge, generally consisting of 1 1/4 inch rod with a forged jaw on one end and a malleable jaw on the other end, adjustable through a locknut. Sometimes consists of a rod made in two parts with a solid jaw on each, united by a turnbuckle. Also called a lie Rod.

Gauge Tool: A tool by which the gauge of track is determined. It is made of wood and steel, or all steel and sometimes has a guard rail gauge attached. It may be combined with a track level.

Gauge, Compound: Instrument for measuring pressures both below and above atmospheric pressure.

Gauge, High-pressure: Instrument for measuring pressures in the range of 0 psig to 500 psig.

Gauge, Low-Pressure: Instrument for measuring pressures in the range of 0 psig and 50 psig.

Gauge, Narrow: A gauge narrower than standard gauge. A gauge of 24 inches or less is commonly employed for industrial railways. Meter gauge is often used in foreign countries.

Gauge, Vacuum: Instrument used to measure pressures below atmospheric pressure.

Gauging (of Track): Bringing two opposite rails into their correct relative positions as regards to their distance apart.

Girder: A large beam, usually horizontal, that serves as a main structural member.

Glass Seam: Vein fillings of coarsely crystalline calcite, that do not necessarily decrease the strength of stone.

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Grade:	(1). Rate of rise or fall of the grade line, expressed as a percentage of length; feet of rise of fall per 100 feet of length. Also gradient. A steady rise or fall of one foot per 100 feet is a 1% grade. (2). The elevation of the invert of the bottom of a pipe line, canal, culvert, sewer, etc.
Grade Crossing:	see Crossing, Grade.
Grade Line (Grade):	(1). The line of a profile representing top-of-rail elevations of track. (2). A series of staked elevations transferring this line to the ground of roadbed.
Grade Rail:	The rail first surfaced to track elevation; the line rail on tangents, the inner or low rail on curves.
Grade Separation:	A term applied to the use of a bridge structure and its approaches to divide or separate the crossing movement of vehicular, pedestrian or other traffic, by confining portions thereof to different elevations.
Granular Base:	Evenly graded mixture of fine and course aggregates to provide, when compacted, a smooth and even surface below footings.
Grate Area:	Grate surface area measured in square feet. (Used in estimating the fuel burning rate.)
Grinder, Screenings:	A device for grinding, shredding, or macerating material removed from sewage by screens.
Grit:	The heavy mineral matter in water or sewage such as sand, gravel, cinders, etc.
Grommet:	Rings of compressible material inserted under heads and nuts of bolts connecting sections of tunnel liners to seal the bolt hole.
Gross Output:	A rating applied to boilers. The total quantity of heat the boiler will deliver and at the same time meet all limitations of applicable testing and rating codes.
Grounded:	Connected to or in contact with earth or connected to some extended conductive body that serves instead of the earth.
Grounded Effectively.	See Effectively Grounded.
Grounded System:	A system of conductors in which at least one conductor or point is intentionally grounded, either solidly or through a non-interrupting current-limiting device.
Grout:	A mixture of cementitious material (cement, lime), sand, and sufficient water to make a consistency that will flow without separation of ingredients.

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Guard Rail:	(1). A rail laid parallel to and inside a running rail to prevent wheels from being derailed or to hold wheels in proper alignment and keep wheels on the other rail from striking the points of switches or frogs in turnouts or crossings. (2). An additional pair of rails laid parallel to and between the running rails of bridges, bridge approaches, and at other critical locations, to keep derailed wheels on the ties and near the running rails.
Guard Rail Clamp:	A device consisting of a yoke and fastening devices engaging the running rail and guard rail. Not all guard rails have clamps.
Guarded:	Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by people or objects. NOTE: Wires that are insulated, but not otherwise protected, are not considered guarded.
Handhole:	An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter, for the purpose of installing, operating, or maintaining equipment and/or cable.
Head:	Head refers to a pressure difference. See Pressure Head; Available Head.
Head (Total):	In flowing fluid, the sum of the static and velocity pressures at the point of measurement.
Head Block (Switch):	A pair of ties (or, in old types of turnouts, a single tie) used to support the switch-point operating mechanism and the switch stand.
Head Pressure:	Pressure that exists in condensing side of a refrigerating system.
Head Rod:	The switch rod nearest the point of a switch, usually placed between the two headblock ties.
Head, Static:	Pressure of fluid expressed in terms of column height of the fluid, such as water or mercury.
Head, Velocity:	In flowing fluid, height of fluid equivalent to its velocity pressure.
Head-Pressure Control:	Pressure operated control that opens an electrical circuit if the high-side pressure becomes excessive.
Header:	(1). A brick laid lengthwise across a wall serving as a bond. A masonry unit laid flat with its largest dimension perpendicular to the face of the wall; generally used to tie two wythes of masonry together. (2). A piping arrangement for interconnecting two or more supply or return tappings of a boiler. Also a section of pipe, usually short in length, to which a number of branch circuits are attached.

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Heat Exchanger:	Device used to transfer heat from a warm or hot surface to a cold or cooler surface. Evaporators and condensers are heat exchangers.
Heat Transfer:	Movement of heat from one body or substance to another. Heat may be transferred by radiation, conduction, convection, or a combination of these three methods.
Heat Transmission:	Any time-rate of heat flow; usually refers to conduction, convection, and radiation combined.
Heat Transmission Coefficient:	Any one of a number of coefficients used in calculating heat transmission through different materials and structures by conduction, convection, and radiation.
Heat, Latent:	Heat characterized by a change of state of the substance concerned, for a given pressure and always at a constant temperature for a pure substance, i.e., heat of vaporization or fusion.
Heat, Sensible:	Heat that changes the temperature of a substance without changing its form.
Heat, Specific:	The heat absorbed (or given up) by a unit mass of a substance when its temperature is increased (or decreased) by 1 degree.
Heater, Switch:	A device for melting snow at switches by means of steam, an electric current, gas jets, or oil.
Heating Value:	Amount of heat that may be obtained by burning a fuel; usually expressed in Btu per pound or Btu per gallon.
Heel Block (Switch):	A block which spans joints and fills the space between adjacent rails at the heel of a switch, joined with outside splice bars by continuous bolts to form a unit joint. Also serves as a foot guard.
Heel Length:	Distance between the heel end and half-inch point of a frog, measured along gauge lines.
Heel of Frog:	The end of a frog farthest from the switch.
Heel of Switch:	The end of a switch rail farthest from the point of switch.
Heel Spread (Frog):	Distance between gauge lines at the heel end of a frog.
Heel Spread (Switch):	The distance between the gauge lines at the heel of the switch rails.
Helical or Rotary Screw Type Compressor:	Refrigeration compression achieved by trapping the refrigerant gas in the space formed by the flutes of meshing screws, reducing the gas volume and compressing the gas.
Hermetic Motor:	Compressor drive motor sealed within same casing that contains the compressor.
Hermetic System:	Refrigeration system that has a compressor driven by a motor contained in a compressor dome or housing.

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Hermetically Sealed Unit:	A sealed, hermetic-type condensing unit is a mechanical condensing unit in which the compressor and its motor are enclosed in the same housing with no external shaft or shaft seal; the compressor motor operating in the refrigerant atmosphere. The compressor and compressor motor housing may be of either the fully-welded, brazed, or service-sealed type. In the fully-welded or brazed type, the housing is permanently sealed and is not provided with means of access for servicing internal parts in the field. In the service-sealed type, the housing is provided with some means of access for servicing internal parts in the field.
High-Temperature Water System **(HTW):**	A hot water system operating at temperatures over 350°F with usual pressures of about 300 psi.
High Are:	The rate of a burner at or near design maximum fuel input.
High Side:	Parts of a refrigerating system that are under condensing or high side pressure.
High Side Float:	Refrigerant control mechanism that controls the liquid refrigerant level in the high-pressure side of mechanism.
High-Pressure Cut-Out:	An electrical control switch operated by the high side pressure that automatically opens an electrical circuit if head-pressure is too high or condensing pressure is reached.
High-Pressure Steam System:	One that operates above 15 psig (100 kPa above atmospheric).
High-Strength Adhesive:	A bonding agent of high ultimate strength used to join individual pieces of stone into preassembled units.
Highway-Crossing Protection:	An arrangement of one or more highway-crossing signals, with or without gates, to protect highway traffic.
Hog Ring:	A C-shaped wire clip that attaches the tension wire to the chain link fabric at approximately 24" intervals.
Hollow Wall:	A wall built of solid masonry units laid in and so constructed to provide air space within the wall.
Horsepower:	A unit of power equal to 33,000 foot pounds of work per minute. One electrical horsepower equals 746 watts.
Hot Water Heating Systems:	Hydronic system in which heated water is circulated through terminal units.
House Track:	Tracks serving freight houses.
I-Beam:	A structural member of rolled steel whose cross-section resembles the capital letter I.
Idler:	A pulley used on some belt drives to provide proper belt tension and eliminate belt vibration.
Ignition:	The act of starting combustion.

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ignition System, Direct:	An automatic ignition system that uses an electrically energized device to ignite fuel at a main burner.
ignition Temperature:	The minimum temperature at which combustion can be started.
ignition Transformer:	A transformer designed to provide a high Voltage current. Used in many heating systems to ignite fuel.
impact:	An allowance equal to the calculated percentage of the live load which is added to the live load of the structure to provide for the dynamic and vibratory effects of traffic loading.
impedance Bond:	An electrical apparatus at code change points in electric traction areas to separate signal and traction current.
impeller:	The rotating part in pump that increases the water supply pressure by centrifugal force.
inches of **Mercury** Column:	A unit used in measuring pressures. One inch of mercury column equals a pressure of 0.491 lb/in^2.
inches **of** Water Column:	A unit used in measuring pressures. One inch of water column equals a pressure of 0.578 oz/in^2. One inch mercury column equals about 13.6 in. water column.
incise:	To cut inwardly or engrave, as in an inscription.
incombustible (Building Material):	Any building material that does not contain matter subject to rapid oxidation within the temperature limits of a standard fire test of not less than 2.5 hours duration. NOTE: Materials that continue burning after this time period are combustible.
incomplete Combustion:	Combustion in which the fuel is only partially burned.
induced Draft:	A process in which air is drawn through a heat exchanger, boiler, or cooling tower before entering the fan.
induced Draft Burner:	A burner that depends on draft induced by a fan or blower at the flue outlet to draw in combustion air and vent flue gases.
induced Draft Tower:	Type of mechanical draft tower in which the air moving device is located at the air exhaust.
infiltration:	Air leakage into a building from the out-of-doors as a result of wind and indoor-outdoor temperature difference.
ingress:	The act of entering a structure or area through an access point.
input **Rate:**	The quantity of heat or fuel supplied to an appliance expressed in volume or heat units per unit time, such as cubic feet per hour or Btu per hour.
input Rating:	The gas-burning capacity of an appliance in Btu per hour as specified by the manufacturer. Appliance input ratings are based on sea level operation up to 2,000 feet elevation. For operation at elevations above 2,000 feet input ratings should be reduced at the rate of 4 percent for each 1,000 feet above sea level.

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Inscription:	Lettering cut in stone.
Inspection:	Visual and mechanical checking of facility/system condition, performed on a regularly scheduled basis, to determine the extent of the maintenance and repair work required to ensure proper system operation.
Insulated:	Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current. NOTE: When any object is said to be insulated it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is uninsulated.
Insulated Switch:	A switch in which the fixtures, principally the gauge plates and the switch rods connecting one rail to the other, are provided with insulation so that electric currents will not be shunted. Also the turnout rail contains an insulating joint.
Insulating **Rail Joint:**	Sometimes called Insulated Joint. A rail joint designed to stop the flow of electric current from rail to rail, as at the end of a track circuit, by means of nonconductors so placed as to separate rail ends and other metal parts.
Insulation:	Thermal insulation is a material used for covering pipes, ducts, vessels, etc. to effect a reduction of heat loss or gain.
Insulation **(as applied to cable):**	That which is relied upon to insulate the conductor from other conductors, conducting parts, or from ground.
Insulation **Shielding:**	An envelope that encloses the cable insulation and provides an equipotential surface in contact with the cable insulation.
Insulator:	Insulating material in a form designed to support a conductor physically and electrically separate it from another conductor or object.
Interceptor:	A device designed and installed to separate and retain deleterious, hazardous, or undesirable matter from normal wastes while permitting normal sewage or liquid wastes to discharge into the drainage system by gravity.
Interchange Track:	A track used for the transfer of cars from one railroad to another.
Interior Wall:	Any wall entirely surrounded by the exterior walls of a building.
Interlocking:	An arrangement of signals, switch lock, and signal appliances to interconnected that their movements succeed each other in a predetermined order. It may be operated manually or automatically.
Invert:	The floor, bottom, or lowest portion of the internal cross-section of a closed conduit. Used particularly with reference to aqueducts, sewers, tunnels, and drains. Originally it referred to the inverted arch which was used to form the bottom of a masonry-line sewer.

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Ion Exchange: A chemical reaction used in water or waste-water treatment processes in which mobile hydrated ions of a solid are exchanged (with ion of like charge in solution).

Ionize: To convert totally or partially into **ions (charged particles).** This principle is used in some smoke detectors.

Isolated: Not readily accessible to people unless special means for access are used.

Isolated by Elevation: Elevated sufficiently so that people may safely walk underneath.

Isolator: See Disconnecting Switch; Isolating Switch.

Jack, **Track:** A compound ratchet-lever jack which trips its load by a single operation, as distinguished from an automatic lowering jack which lets the load drop by successive stages. There are two kinds: single-acting, in which the load is raised on the down stroke of the level; and double-acting, in which the load is raised on both up and down strokes. Track jacks now usually have 1 5-ton capacity.

Jacket: A protective covering over the insulation, core, or sheath of a cable.

Jet Burner: A burner in which streams of gas or air-gas mixtures collide in air at some point above the burner and burn there.

Joint: The space between the adjacent surfaces of two members or components joined and held together by welds, bolts, nails, glue, cement, mortar, or other means.

Joint Bar: A steel angle bar or other shape used to fasten together the ends of rails in a track. They are used in pairs, and are designed to fit the space between centers of holes, vertical locations of holes, and their diameter.

Joint Tie: A cross tie used under a rail joint.

Joint Use: Simultaneous use by two or more kinds of utilities.

Joint, Compromise: A special rail joint, sometimes also called a step joint, for uniting rails of different sections; made so it brings gauge sides and joined rail heads into line so that continuous smooth surfaces are presented to treads and flanges of passing wheels.

Joint, Expansion, Bellows: An item of equipment used to compensate for the expansion and contraction of a run of pipe. The device is built with a flexible bellows that stretches or is compressed as necessary to accept the movement of the piping.

Joint, Expansion, Slip: A joint in which the provision for expansion and contraction consists of a cylinder that moves in and out of the main body of the device.

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Joint-Bar Drilling: Provision of suitable holes at the ends of rail, switch, frog, or other track member to receive joint-bar bolts. In specifying joint-bar drilling, give the distance from rail end to center of the first hole, successive distance between centers of holes, vertical locations of holes, and their diameter.

Joints, Supported and Suspended: A supported rail joint has a tie directly under the rail joint. A suspended joint is one in which ends of the rail joint are carried by two consecutive ties.

Jumbo: A frame with platforms to support men and drills for rock excavation, rolling on steel rails or rubber wheels.

Keeper, Switch-Stand: See Latch, Switch-Stand.

Kelvin Scale: Thermometer scale on which the unit of measurement equaling the centigrade degree of absolute zero is -273.16°C.

Key: A section of concrete formed to lock into another pour to stop water penetration or provide easier joining of pieces.

Lacing Course: A course of brick, or several adjacent courses considered collectively, inserted at frequent intervals, as a bond course in a stone wall.

Lagging: Timber planks, steel plates, or other materials inserted above tunnel-supporting ribs to hold soil or rock.

Laser: A concentrated, monochromatic light beam. Often used to control the direction of tunnel excavation, particularly of tunnel-boring machines.

Latch, Switch-Stand: A device for catching and holding the lever of a switch stand in position; also called a switch keeper. Two latches are used at each switch stand.

Latent Heat: Heat energy absorbed in the process of changing the form of a substance (melting, vaporization, fusion), without change in temperature or pressure.

Leachate: A solution containing dissolved and finely suspended solid matter and microbial waste products produced by ground water or infiltrating surface water movement through solid waste.

Leaching: (1). The removal of soluble constituents from soils or other material by water. (2). The disposal of a liquid through a nonwatertight artificial structure, conduit, or porous material by downward and/or lateral drainage, into surrounding permeable soil.

Lead Track: An extended track connecting either end of a yard with the main track.

Lead, Actual: The length between the actual point of switch and the half-inch point of frog, measured on the line of the straight track.

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Lead, **Curved:**	The degree of curvature in a turnout between the heel of the switch and the toe of the frog, measured on the centerline of the turnout track.
Leader:	An exterior drainage pipe for conveying storm water from roof or gutter drains.
Leak **Detector:**	Device or instrument such as a halide torch, an electronic sniffer; or soap solution used to detect leaks.
Lean Mixture:	An air-gas mixture that contains more air than the amount needed for complete combustion of the gas.
Lens, Switch Lamp:	A lens set in a switch lamp. A side-angle lens, which spreads a light of low intensity over a wide area, is most commonly used with yard switches.
Level:	The condition of track in which the elevation of the rails is transversely equal. Also a tool used to determine that condition in surfacing track.
Limit Control:	Control used to open or close electrical circuits as temperature or pressure limits are reached.
Line:	The condition of track in regard to uniformity in direction over short distances on tangents, or uniformity in variation in direction over short distances on curves.
Line Port Cap:	A cap that attaches the top rail to a line post.
Line Port **Ties** or Clips:	These fasteners are installed approximately every 15 inches and are used to attach the fabric to the line posts.
Line Posts Barbed Wire **Arms:**	Extensions that provide for strands or barbed wire on a vertical, inward, or outward angle of degree.
Une **Posts:**	Intermediate posts spaced a maximum of 10 feet apart and considered to be the backbone of the fence line.
Une **Rail:**	The rail on which alignment is based; the east rail of tangent track running north and south, the north rail of tangent track running east and west, the outer rail on curves, or the outside rails in multiple track territory.
Uner **Plate:**	A steel plate segment, generally preformed to support a tunnel excavation.

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Lines:	Communication Lines: The conductors and their supporting or containing structures that are used for public or private signal or communication service, and which operate at potentials not exceeding 400 Volts to ground or 750 Volts between any two points of the circuit and the transmitted power of which does not exceed 150 watts. When operating at less than a nominal Voltage of 90 Volts no limit is placed on the transmitted power of the system. Under specified conditions communication cables may include communication circuits exceeding the preceding limitation where such circuits are also used to supply power solely to communication equipment. NOTE: Telephone, telegraph, railroad signal, data, clock, fire and police alarms, cable television, and other systems conforming with the above are included. Lines used for signaling purposes, but not included under the above definition, are considered supply lines of the same Voltage and are to be so installed. **Electric** Supply **Lines:** Those conductors used to transmit electrical energy and their necessary supporting or containing structures. Signal lines of more than 400 Volts are always supply lines and those of less than 400 Volts may be considered as supply lines if so run and operated throughout. Syn: supply lines.
Lining:	Any sheet, plate, or layer of material used temporarily or permanently to allow for the finishing of an interior surface.
Lining Track	Shifting the track laterally to conform to established alignment. Maintenance lining is ordinarily done during repairs; general lining is done to make the track conform throughout to predetermined alignment.
Lintel:	A horizontal structural member that supports the load over an opening such as a door or window.
Lipped Joint:	The junction of two rails when the gauge sides are not in alignment.
Liquefied Petroleum Gases:	The terms Liquefied Petroleum Gases, LPG, and LP Gas mean and include any fuel gas composed predominantly of any of the following hydrocarbons or mixtures: propane, propylene, normal butane or isobutane, and butylenes.
Liquid Absorbent:	A chemical in liquid form that has the property to “take on” or absorb moisture.
Liquid **Receiver:**	Cylinder connected to condenser outlet for storage of liquid refrigerant in a system.
Liquor:	**Mixed:** A mixture of activated sludge and sewage in the aeration tank undergoing activated sludge treatment.

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Liquor (Continued):	Supematant: (1). The liquor overlying deposited solids. (2). The liquid in a sludge-digestion tank that lies between the sludge at the bottom and the floating scum at the top.
Live Load:	A dynamic load such a traffic load that is supplied to a structure suddenly or that is accompanied by vibration, oscillation or other physical condition affecting its intensity.
LNG:	Liquefied natural gas. Natural gas that has been cooled until it becomes a liquid.
Lock Washer:	A spring washer.
Lockout:	See Safety Shutdown.
Low Fire start:	The lightoff ignition of a burner with the fuel controls in a low-fire position. In a system with guaranteed low-fire start, interlocks are used to prevent startup if the burner is not in the low-fire position.
Low Side:	That portion of a refrigerating system which is under the lowest evaporating pressure.
Low Side Float Valve:	Refrigerant control valve operated by the level of liquid refrigerant on the low-pressure side of the system.
Low Temperature Water System **(LTW):**	A hot water heating system operating at design water temperatures of 250°F or less and a maximum working pressure of 160 psi.
Low Voltage Protection:	The effect of a device operative on the reduction or failure of Voltage to cause and maintain the interruption of power supply to the equipment protected.
Low Water Fuel Cutoff:	A device that shuts off the fuel when the boiler water falls to an unsafe level.
Low-Pressure Steam System:	One that operates at 15 psig (100 kPa above atmospheric) and under.
LP Gas-Air Mixtures:	Liquefied petroleum gases distributed at relatively low-pressures and normal atmospheric temperatures fhat have'" been diluted with air to produce desired heating value and utilization characteristics.
Main:	Duct or pipe containing the system's major or entire fluid flow.
Main Track **(M.T.):**	A track extending through yards and between stations upon which trains are operated by timetable or trainorder or both, or the use of which is governed by block signals.
Mainline:	Route miles of track systems carrying main tracks.
Maintenance:	Day-to-day, periodic, or scheduled work required to preserve or restore a facility or equipment to a condition so that it can be effectively utilized for its designed purpose.

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Make-Up: Water added to the system to replace water lost by evaporation, drift, blowdown, and leakage.

Make Up Water Line: The water connection to the boiler or system for filling or adding water when necessary.

Manhole: An opening by which a man may enter or leave a sewer, conduit, or other closed structure for inspection, cleaning, and other maintenance operations, closed by a removable cover.

Drop:
A manhole installed in a sewer where the elevation difference of the incoming sewer exceeds by two feet or more the outgoing sewer elevation; a vertical waterway outside the manhole is provided to divert the sewage from the upper to the lower level so that it does not fall freely into the manhole, except at peak rate of flow.

Flushing:
A manhole provided with a grate so that sewage or water may be accumulated and then discharged rapidly for flushing a sewer.

Junction:
A manhole at the junction of two or more sewers.

Line:
A manhole on a sewer at a point where no other sewers connect. It is often located at a point where the sewer changes direction, either in line or grade.

Manhole **Cover:** A removable lid that closes the opening to a manhole or similar subsurface enclosure.

Manhole Grating: A grid that provides ventilation and a protective cover for a manhole opening.

Manometer: Instrument for measuring the pressure of gases and vapors. Gas pressure is balanced against column of liquid such as mercury, in U-shaped tube.

Manual: Capable of being operated by personal intervention.

Manufactured Gas: A fuel gas that is artificially produced by some process, as opposed to natural gas, which is found in the earth. Sometimes called town gas.

Marker, Snow **Flanger:** Post or sign indicating the proximity of an obstruction which makes it necessary to raise snow flanges or close snowplow wings.

Masonry: Stone, brick, concrete, hollow-tile, concrete-block, gypsum-block, or other similar building units/materials, or a combination of the same, bonded together with mortar to form a wall, pier, buttress, or similar mass.

Mastic: A pasty material used as a cement (as for setting tile) or a protective coating (as for thermal insulation or waterproofing).

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Mate: A structure somewhat similar to a frog point, placed opposite a tongue switch to guide wheels and carry them throughout the extent of the switch. It is frequently used in industrial tracks laid in paved streets.

Mechanical Draft: The movement of air through a heat exchanger, boiler, or cooling tower by means of a fan or other mechanical device.

Mechanical Draft Tower: Type of cooling tower through which the air movement is effected by mechanical devices. See Forced Draft Tower; Induced Draft lower.

Medium, Heating: A substance used to convey heat from the heat source to the point of use; usually air, water, or steam.

Medium-Temperature Water System: A hot water system operating at temperatures of 350°F or less, with pressures not exceeding 150 psi.

Methane: A hydrocarbon gas with the formula CH,, the principal component of natural gases.

Middle Ordinate: The distance measured from gauge line or rail on a curve to the middle of a string drawn taut and held to contact with a gauge line of rail at its ends. The middle ordinate forms a convenient means of measuring detailed curvature and is used in the adjustment of curves and the investigation of accidents. It is also a factor in bending rails to a desired curvature.

Mineral Fiber: Fibers formed from mineral slag, the most common being glass wool, used in loose or batt form for thermal and/or fireproofing.

Miter: The junction of two units at an angle. The junction line usually bisects on a 45 degree angle.

Mixed Face: The portion of a tunnel where both rock and soft ground occur in the same cross-section.

Mixed Gas: A gas in which the heating value of manufactured gas is raised by co-mingling with natural or LPG (except where natural gas or LPG is used only for “enriching” or “reforming”).

Modulating: A type of device or control that tends to adjust by increments (minute changes) rather than by either full-on or full-off operation.

Monolith: A body of plain or reinforced concrete cast or erected as a single integral mass or structure.

Mortar: A mixture of cementitious materials and aggregate, with or without the addition of plasticizers or other admixtures, reduced to a plastic state by the addition of water and suitable for use to bind masonry units together.

Motor Control: Device to start and/or stop a motor at certain temperature or pressure conditions.

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Motor Starter: High capacity electric switches usually operated by electromagnets.

Movable Bridge: A bridge of any type having one or more spans capable of being raised, turned, lifted, or slid from its normal vehicular and/or pedestrian service location to provide for the passage of navigation. The movements of the superstructure may be produced either manually or by engine power.

Mucking: Removal of material excavated or blasted from areas of excavation or tunneling.

Nail, Dating: A galvanized or copper nail with a large head in which the last two numerals of the year are stamped; used when a tie is laid or treated to indicate its service life.

Natuml **Bed:** The horizontal stratification of stone as it was formed in the deposit.

Natuml Convection: Movement of a fluid caused by temperature differences (density changes).

Natuml **Draft:** Refers to the movement of air through a heat exchanger, cooling tower, or boiler by the force of the air density differential (produced by the addition of heat).

Natuml **Draft** Tower: Type of cooling tower through which the air movement is effected by the difference in densities of intake and exhaust air.

Natuml Gas: Any gas found in the earth, as opposed to gases that are manufactured.

Neat: Generally, basecoat plaster, mortar, or grout to which sand is added at the job.

Neoprene: A synthetic rubber resistant to hydrocarbon oil and gas.

Non-Bearing Wall: Any wall that carries no load other than its own weight.

Number, Turnout: The number corresponding to the number of frog used in a turnout.

Nutlock: A spring washer.

Odomnt: A substance added to an otherwise odorless, colorless, and tasteless gas to give warning of gas leakage and to aid in leak detection.

Oil Burner Relay: A special, multi-purpose control used with oil burners. The device controls the operation of the oil burner and also acts as a safety to prevent operation in the event of malfunction.

Oil, Refrigeration: Specially prepared oil used in refrigerator mechanisms. It circulates to some extent with refrigerant. The oil must be dry (entirely free of moisture), otherwise moisture will condense out and freeze in the refrigerant control and may cause refrigerant mechanism to fail. An oil classified as a refrigerant oil must be free of moisture and other contaminants.

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Outfall:	The point or location where sewage or drainage discharges from a sewer, drain, or conduit.
Overload Protector:	A device either temperature, pressure, or current operated, that will stop operation of unit if dangerous conditions arise.
Oxidation:	The combining of oxygen with another element to form a new substance, such as in burning and rust formation.
Packaged Boiler:	A boiler having all components; including burner, boiler, controls, and auxiliary equipment, assembled as a unit.
Panel Wall:	A non-bearing wall in skeleton construction, built between columns or piers, wholly supported at each story.
Pantograph:	A device located on top of electric engines which collects power from the overhead contact wire by means of sliding contact shoe.
Parent Track:	A track from which a turnout is constructed. A maintrack is the parent track in regard to a passing track or spur, a ladder track is the parent track in regard to the yard tracks.
Parging:	To coat or plaster with mortar or grout.
Party Wall:	A wall used, or adapted for use, for joint service by adjoining buildings.
Passing Track:	A track auxiliary to the main track used for meeting or passing trains.
Paste:	Composed of Portland cement, water, and air.
Pavement:	A layer of concrete or asphalt in areas such as roads, sidewalks, or parking lots.
Pedestal:	An upright compression member whose height does not exceed three times its average least lateral dimension, such as a short pier used as a base for a column.
Percolation:	(1). The flow or trickling of a liquid downward through a contact or filtering medium. The liquid may or may not fill the pores of the medium. (2). The movement or flow of water through the interstices or pores of a soil or other porous medium. Also termed Filtration.
Perm:	A measure of water vapor movement through a material (grains per square foot per hour per inch of mercury difference in vapor pressure).
pH or **pH** Value:	A term based on the hydrogen ion concentration in water, that denotes whether the water is acid, alkaline, or neutral. A pH value of 8 or more indicates a condition of alkalinity; of 6 or less, acidity. A pH of 7 means the water is neutral.
Phase Break:	A location where overhead wires are arranged to provide an insulated section between different sources of electric power.

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Pier:	(1). A column of masonry, usually rectangular in horizontal cross-section, used to support other structural members. (2). Masonry or concrete supports, set independently of the main foundation. (3). Piers transmit the load of the superstructure to the foundation material and provide intermediate support between abutments.
Pilaster:	A pier, built as an integral part of a wall, projecting slightly from either vertical surface.
Pile:	A member usually driven or jetted into the ground deriving its support from the underlying strata and by the friction of the ground on its surface. The usual functions of a pile are: (a) to carry a superimposed load; (b) to compact the surrounding ground; (c) to form a wall to exclude water and soft material, or to resist the lateral pressure of adjacent ground.
Pilot:	A small flame used to ignite the gas at the main burner.
Pilot Fiame-Establishing Period:	The interval of time that fuel is permitted to be delivered to a pilot burner before the primary safety control is required to prove the pilot flame.
Pilot Switch:	A control used in conjunction with gas burners. Its function is to prevent operation of the burner in the event of pilot failure.
Pilot Tunnel:	A small tunnel excavated over the entire length or over part of a tunnel, to explore ground conditions and assist in final excavation.
Pilot, Continuous (or Constant Burning Pilot):	A pilot that burns without turndown throughout the entire time the burner assembly is in service, whether the main burner is firing or not.
Pilot, **Intermittent:**	A pilot that is automatically lighted each time there is a call for heat. It burns during the entire period the main burner is firing.
Pilot, Interrupted:	A pilot that is automatically lighted each time there is a call, for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.
Piiotj proved:	A pilot flame supervised by a primary safety control.
Pioneer Bore:	Same as pilot tunnel.
Plate:	Sill plate, a horizontal member anchored to a masonry wall. Sole plate, bottom horizontal member of a frame wall. Top plate, top horizontal member of a frame wall supporting ceiling joists, rafters, or other members.
Plate Girder:	This type of structural member is used for intermediate span lengths not requiring a truss yet requiring a member larger than a rolled beam.
Platform, High:	A passenger station platform at approximate car-floor height.

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Platform, Low:	A passenger station platform at approximate top-of-rail height.
plumb:	Exactly perpendicular; vertical.
Pneumatic:	Pertaining to air or other gases.
Point of Switch, Theoretical:	The point where the gauge line of the switch rail, if produced would intersect the gauge line of the stock rail. Also called Vertex.
point Rails:	Switch rails,
pointing:	Pushing mortar into a joint after masonry is laid.
Poling Boards:	Timber or steel planks driven into the soft ground at the tunnel face over supporting steel or timber sets to hold back soil during excavation.
pollution:	The addition of sewage, industrial wastes, or other harmful or objectionable material to water. Sources of pollution may be privies, septic tanks, subsurface irrigation fields, seepage pits, sink drains, barnyard wastes, etc.
pond, Sewage **Oxidation:**	A pond, natural or artificial, into which partly treated sewage is discharged and natural purification processes take place under the influence of sunlight and air.
Poppet:	A piston like device that acts as a valve to stop gas or fluid flow.
post Purge period:	A period of time after the fuel valves close, during which the burner motor or fan continues to run to supply air to the combustion chamber.
post, Bumping:	A device at the end of a stub track to prevent rolling stock from going off the ends of the rails.
power Disconnect:	A switch for connecting and disconnecting electrical power.
Pre-Purge period:	A period of time on each startup during which air is introduced into the combustion chamber (and associated flue passages) in volume and manner to completely replace the air or fuel-air mixture contained therein prior to initiating ignition.
Preaeration:	A preparatory treatment of sewage comprising aeration to remove gases, add oxygen, or promote flotation of grease, and aid coagulation.
preassembled **Units:**	Two or more stones combined into a single unit by the use of epoxy resins, steel framing, or concrete backing.
precast **Concrete:**	A concrete member that is cast and cured in other than its final position.
Prechlorination:	Chlorination of sewage prior to treatment.
Precipitation, Chemical:	Precipitation induced by addition of chemicals.
premixing Burner:	A burner in which all, or nearly all, combustion air is mixed with the gas as primary air.

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pressure Burner: A burner in which an air and gas mixture under pressure is supplied, usually at 0.5 to 14 inch water column.

Pressure Drop: The pressure difference at two ends of a circuit (or part of a circuit), the two sides of a filter, or the pressure difference between the high-side and low-side in a refrigeration mechanism.

pressure Grouting: A method of pumping concrete into unstable soil to restore support.

Pressure Head: The force available to cause water or vapor circulation in an hydronic system. See Head; Available Head.

Pressure Reducing Valve: A diaphragm-operated valve installed in the make-up water line of a hot water heating system to introduce water into the system and to prevent the system from possible exposure to city water pressures higher than the working pressure of the boiler.

Pressure Regulator: A device for controlling and maintaining a uniform outlet pressure.

Pressure **Relief** Valve: A device for protecting a hot water boiler (or other pressurized device) from excessive pressure by opening at a pre-determined pressure and discharging water or steam at a rate sufficient to prevent further build-up of pressure.

Primary Air: The combustion air introduced into a burner that mixes with the gas before it reaches the port. Usually expressed as a percentage of air required for complete combustion of the gas.

Primary Air inlet: The opening or openings through which primary air is admitted into a burner.

primary Control: Device that directly controls the operation of heating system.

Process, Activated Siudgo: A biological sewage treatment process in which a mixture of sewage and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated sewage (mixed liquor) by sedimentation and wasted or returned to the process as needed. The treated sewage overflows the weir of the settling tank in which separation from the sludge takes place.

Profile: A longitudinal section through a track that shows elevation and depression. Also, a drawing showing grade line of a railroad, usually obtained from levels taken on top of the rail.

Propane: A hydrocarbon gas heavier than methane but lighter than butane. It is used as a fuel gas alone, mixed with air, or as a major constituent of liquefied petroleum gases.

Proven **Prepurge:** A provision of the control system for preventing burner operation until prescribed air flow is proven to be established during prepurge.

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Pulling iron:	An anchor secured in the wall, ceiling, or floor of a manhole or vault to attach rigging used to pull cable.
Pulling Tension:	The longitudinal force exerted on a cable during installation.
Pulsation:	(Firebox) A panting of the flames in a boiler or furnace, indicating cyclic and rapid changes in the pressure in the combustion space.
Putrefaction:	Biological decomposition of organic matter with the production of ill-smelling products associated with anaerobic conditions.
Pyrometer:	Instrument for measuring high temperatures,
Qualified:	A description for an individual having adequate knowledge of the installation, construction, or operation of apparatus and the hazards involved.
Quarry:	The location of a natural stone deposit that is mined, with stone removed from the ground.
Quoins:	Stones at the corners of a wall emphasized by size, projection, rustication, or by a different finish.
Raceway:	Any channel designed and used solely for holding conductors.
Rack, Bar:	A screen composed of parallel bars, either vertical or inclined, placed in a waterway to catch floating debris from which the screenings may be raked.
Radiation:	The transmission of energy by means of electromagnetic waves.
Raggle:	A groove or channel made in a mortar joint or in the solid masonry material, to receive roofing, metal flashing, or other material that is to be sealed in the masonry.
Rail:	A rolled steel shape designed to be laid end-to-end in two parallel lines of ties, to form a track for railroad rolling stock, traveling crones, and the like.
Rail Anchor.	A device attached to a rail to keep it from moving longitudinally as a result of temperature change of under traffic. Also called Anticreeper.
Rail Bender:	A tool or shop machine for ending rails to fit curves in tracks, turnouts, or turntable circles; to introduce bend in stock rails; and for a variety of allied operations. Two common types are the Samson the Jim Crow, the latter sometimes modified by addition of a roller for continuous bending of rails.
Rail Bond:	A device used to transfer an electric circuit at a rail joint.
Rail Brace:	A metal casting made to fit against the side of a rail or guard rail and to be spiked to the tie on the outside of a track or the inside of a guard rail to prevent the rail from inclining backward with the thrust of wheels. Made in plain and adjustable types.

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Rail Brand: An identification mark, including manufacturer's name or initials, month and year the rail was rolled, weight per lineal year, initials of section, number of the heat, portion of the ingot, and process of manufacturer.

Rail Creeping: Intermittent longitudinal sliding movement of rails in track under traffic or because of temperature changes. The effect of rail creeping is resisted by anticreepers or rail anchors.

Rail Fastenings: See Fastenings, Track.

Rail Joint Bar: See Joint Bar.

Rail Joint **Base** plate: A special tie plate used under some types of rail joints.

Rail Joint Expander: A rail puller/expander operated by hand or by machine which increases or decreases the gap between adjoining rail ends.

Rail Joint, Insulated: A rail joint which arrests the flow of electric current from rail to rail, as at the end of a track circuit, by means of nonconductors separating rail ends and other metal parts.

Rail Joint, Pumping: A rail joint usually poorly supported so that mud is created by passage of wheels and pumped up through ballast.

Rail Layer: A small crane, manually or power operated, to set new rail in place with the use of few men.

Rail Saw, Portable: A tool or machine for sawing steel rails, commonly a hacksaw or a circular steel saw, set in a vertical frame.

Rail Section: The pattern or dimensional details of rail, such a width of base, height of rail, thickness of web, width and thickness of head, angle of head, and angle of base. Each particular pattern is identified by a brand name or symbol such as ASCE, AREA, ARA, PRR and others in addition to its weight per yard.

Rail lie Wire: Wire used to attach the chain link fabric to the top rail at approximately 24 inch intervals.

Rail, High: The outer or elevated rail of a curved track.

Rail, Lead: See Closure **Rail.**

Rail, Low: The inner rail of a curve which is maintained at grade while the opposite or outer rail is elevated.

Rail, Relayer: Rail with some wear suitable for reuse in track. Relayer rail is divided into maintrack relayer rails, and yards and side-track relayer rails. It may be cropped then welded or used as shorter length rail.

Rail Rest: A support for one or more emergency-repair rails consisting of two or more shelved upright posts of slabs of timber, iron or concrete.

Rail, Ribbon: Continuous welded rail free of joints or with very few joints in long stretches.

Random Separation: Installed with no deliberate separation.

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Rankine Scale: Name given the absolute (Fahrenheit) scale. Zero on this scale is -460°F.

Readily Accessible: Direct access without requiring the use of tools from removing or moving any panel, door, or similar obstruction.

Readily Climbable: Having sufficient handholds and footholds to permit an average person to climb easily without using a ladder or other special equipment.

Reamer: A steel toll designed to true or enlarge holes in wood or steel, to facilitate passage of bolts or rivets.

Recess: A sinkage.

Recording Thermometer: Temperature measuring instrument with a pen marking a moving chart. Temperatures can be digitally recorded.

Reflector: A lens device attached to switch stand, showing different colors to indicate position of switch. The colors arise from light reflected from the locomotive headlight.

Refrigerant: Substance used in refrigerating mechanisms to absorb heat in evaporator coils by change of state from a liquid to a gas, and to release its heat in a condenser as the substance returns from the gaseous state back to a liquid state.

Refrigerant Charge: The quantity of refrigerant in a refrigerant system.

Refrigerant Control: Device that meters refrigerant and maintains pressure difference between high-pressure and low-pressure side of mechanical refrigerating system while unit is running.

Register: Combination grille and damper assembly covering an air opening or the end of an air duct.

Reglet: A recess to receive and secure metal flashing.

Regulated: Processed for constant and precise output.

Regulator: See Pressure Regulator.

Reinforced Brick Masonry (R-B-M): Brick masonry in which metal is embedded in such a manner that the two materials act together in resisting forces.

Reinforcement: Structural steel shapes, steel bars, rods, wire mesh, or expanded metal embedded or encased in brick, other masonry, or concrete to increase its strength.

Reinforcing: Steel rods or metal fabric placed in concrete slabs, beams, or columns to increase their strength.

Relay: An electrical device which contains motors or magnets which, when excited, cause circuits to open and/or close. This, in turn, allows switches to be thrown or signals to display desired indications.

Relay: An electrically operated switch. Usually the control circuit of the switch uses low Voltage while the switch makes and breaks a line Voltage circuit; however, both the control and load circuits are of the same Voltage in some instances.

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Relayer Rail:	See Rail, Relayer.
Relief or Relieve:	Projection of ornamentation.
Relief Valve:	Safety device designed to open before dangerous pressure is reached.
Remote power Element Control:	Device with sensing element located apart from operating mechanism.
Remote System:	Refrigerating system that has condensing unit located outside and separate from refrigerator cabinet.
Remotely Operable (as ● pplisd to equipment):	Capable of being operated from a position external to the structure in which it is installed or from a protected position within the structure.
Repair:	Restoration of a facility or equipment to a condition that allows it to be used for its intended purpose.
Reprise:	Inside corner of a stone member with a profile other than a flat plane.
Retaining Wall:	A wall for sustaining the pressure of earth or filling deposited behind it, designed to resist lateral pressure, used at railroad fills or cuts. See Wing Wall; Abutment.
Retarder:	Any material added to concrete, mortar, or grout that slows up its natural set.
Return Mains:	Pipes or conduits that return the heating or cooling medium from the heat transfer unit to the heat or refrigeration source.
Return or Return Head:	Stone facing with the finish appearing on both the face and the edge of the same stone, as on the corner of a building.
Return piping:	The portion of the piping system that carries water from the terminal units back to the boiler.
Reveal:	The exposed portion of a stone between its outer face and a window or door set in an opening.
Rich Mixture:	A mixture of gas and air containing too much fuel or too little air for complete combustion of the gas.
Right **of Way:**	Land or water rights used for the railroad roadbed and its structures.
Ringelmann Scale:	Measuring device for determining smoke density.
Riprap:	Brickbats, stones, blocks or concrete or other protective covering material of like nature deposited upon river and stream beds and banks, lake tidal or other shores to prevent erosion and scour by water flow, wave or other movement.
Roadbed:	The finished surface of roadway upon which track and ballast rest.
Roadbed Shoulder:	The portion of subgrade lying between the ballast-covered portion and the ditch in cuts, and the top of slope on embankments.

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Roadway: (1). The part of a railway prepared to receive track. During construction the roadway is often referred to as the grade. (2). The portion of highway, including shoulders, for vehicular use. NOTE: A divided highway has two or more roadways. See Shoulder; Traveled Way.

Rock Bolts: Steel bolts inserted and anchored in bore holes around the periphery of a tunnel excavation to hold rock in place.

Rod, Operating: A rod attached to a switch, derail, or other device, for moving it from one position to another.

Rolled Beam: The rolled beam is used for short spans. The beam comes from the rolling mill as an integral unit composed of two flanges and a web.

Rotary Snowplow: A car with a bladed wheel on the front end set at right angles to track and driven by an engine on the car. It cuts the snow and discharges it to one side of track.

Rotor: Rotating part of a mechanism.

Rowlok: A brick laid on its edge. Frequently spelled *rolok*.

Rubble Masonry: Uncut stone, used for rough work, foundations, backing, and the like.

Run-Out: This term generally applies to the horizontal portion of branch circuits or the measurement of play in a bearing/shaft.

Running Rail: The rail or surface on which the wheel bears, as distinguished from a wing rail or guard rail.

Runoff (Curve): The profile through which the superelevation of a curve is brought to the level of the tangent, or through which different elevations on a compound curve are connected.

Runoff (Surface): The grade through which the raised portion of track is connected with the old grade. It generally includes the two rails and is made at a long easy slope for comfort and safety.

Rural **Districts:** All places not urban. This may include thinly settled areas within city limits.

Rustication: A recessed surface cut around or across the face of a stone to produce shadow accent.

Safety (also known as limit): A control responding to changes in liquid level, pressure, or temperature.

Safety Control: Device that will stop the unit if unsafe pressures and/or temperatures are reached.

Safety Motor Control: Electrical device used to open circuit if the temperature, pressure, and/or the current flow exceed safe conditions.

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Safety Shutdown (also known as lockout): Shutting off all fuel and ignition energy to the burner by means of a safety control or controls so that restart cannot be accomplished without manual reset.

Safety Valve: A device for protecting a steam boiler from excessive pressure by opening at a predetermined pressure setting and allowing steam to escape at a rate equal to or greater than the steam generating capacity of the boiler.

Sag: The distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated, the sag referred to is the sag at the midpoint of the span.

Initial Unloaded Sag:
The sag of a conductor prior to the application of any external load.

Final Sag:
The sag of a conductor, under specified conditions of loading and temperature applied, after it has been subjected for an appreciable period to the loading prescribed for the location, or equivalent loading, and the loading removed. Final sag includes the effect of inelastic deformation (creep).

Final Unloaded Sag:
The sag of a conductor after it has been subjected for an appreciable period to the loading prescribed for the loading district in which it is situated, or equivalent loading, and the loading removed. Final unloaded sag shall include the effect of inelastic deformation (creep).

Total Sag:
The distance measured vertically from the conductor to the straight line joining its two points of support under conditions of ice loading equivalent to the total resultant loading for the location.

Maxlmum Total Sag:
The total sag at the midpoint of the straight line joining the two points of support of the conductor.

Apparent **Sag of** a Span:
The maximum distance between the wire in a given span and the straight line between the two points of support of the wire measured perpendicularly from the straight line.

Sag of a Conductor at any Point In a Span:
The distance measured vertically from the particular point in the conductor to a straight line between its two points of support.

Apparent Sag at any Point In the Span:
The distance, at the particular point in the span, between the wire and the straight line between the two points of support of the wire measured perpendicularly from the straight line.

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Sand Float Finish:	Lime mixed with sand resulting in a textured finish.
Sanitary Drainage System:	A drainage system that carries sewage and excludes storm, surface, and ground water.
Sanitary Sewer:	A building sewer that conveys sewage only.
Saturation:	Condition existing when substance contains maximum ot another substance for that temperature and pressure.
Scaffold or Staging:	A temporary structure or platform enabling workmen to reach high places.
Scale, **Track:**	A scale with a weighbridge supporting a section or running track, used to find weight of rolling stock.
Scaling:	(1). The flaking or peeling away of the near-surface portion of hardened concrete or mortar. (2). Removing loose pieces of rock from the tunnel surface after blasting.
Scour:	Erosion of a concrete surface exposing the aggregate.
scrap Rail:	Rails of standard section not fit for use as relayer rail.
Screening:	The removal of relatively coarse floating and suspended solids by straining through racks or screens.
Screw Spike:	A cylindrical threaded steel spike with a special head, designed to be turned with a special wrench into holes bored in ties, to secure rails or to act as a tie plate holder in tie plates with holes intended for this use.
Scum:	A mass of sewage matter that floats on the surface of sewage.
Scuppers:	These are located along the curb line and provide for drainage from the deck.
Seal, **Shaft:**	A device used to prevent leakage between shaft and housing.
Sealant:	A resilient compound used as the final weatherface in stone joints. (This term is sometimes misused to indicate clear water-repellent treatments that are sometimes sprayed or otherwise applied to masonry.)
Sealed Unit:	A motor-compressor assembly in which the motor and compressor operate inside a sealed dome or housing. See Hermetic System.
Secondary Air:	Combustion air externally supplied to a burner flame at the point of combustion.
Section Tool House:	A small building used for storing the section motor car or hand car, maintenance-of-way tools, and other equipment of a section gang.
Sediment:	(1). Any material carried in suspension by water that will ultimately settle to the bottom after the water loses velocity. (2). Fine water-borne matter deposited or accumulated in beds.

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Sedimentation: The process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material. Also called Settling. See precipitation, Chemical.

Selvage: The manufactured finish to the top and bottom ends of the fabric. Heights 6 feet and higher are knuckled on one side and twisted on the other.

Sensible Heat: Heat that causes a change in substance's temperature.

Sensor: A material or device that goes through a physical change or an electronic characteristic change as the conditions change.

Separation: The distance between two objects, measured surface-to-surface, usually filled with a solid or liquid material.

Separator, Adjustable: A metal block of two or more parts, acting as a filler between running rail and guard rail and providing a means of maintaining the proper width of flangeway.

Septic Tank A water tight receptor that receives the discharge of a building sanitary drainage system or part thereof, and is designed and constructed so as to separate solids from liquids, digest organic matter through a period of detention, and allows liquids to discharge into the soil outside of the tank through a system of open joint or perforated piping or a seepage pit.

Sequence Controls: Group of devices that act in series or in time order.

Service Drop: The overhead conductors between the supply and the building or structure being served.

Service Pipe: A pie connecting water or gas mains into a building from the street.

Set-In: The amount that the lower edge of a brick on the outside face of a wall is held back from the line of the top edge of the brick directly below it. Also called Set-off.

Sets: Steel ribs or timber framing to support the tunnel excavation temporarily.

Settlement: Sinking of solid particles in concrete, asphalt, or soil.

Sewage: Any liquid waste containing animal and vegetable matter in suspension or solution, that may include liquids containing chemicals in solution.

Sewage **Ejector (Pneumatic):** A device for lifting sewage by air pressure.

Sewage Pump: A permanently installed mechanical device other than an ejector for removing sewage or liquid waste from a sump.

Shaft: A vertical excavation to gain access to tunnels or mines from the surface.

Shake (Timber): A lengthwise separation of wood, following annular rings.

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Sheave: A wheel having a groove or grooves in its face surface for the passage of cable. This term may be applied collectively to include both sheave and its housing block.

Shell & Tube Flooded Evaporator: Device that flows water through tubes built into a cylindrical evaporator or vice-versa.

Shell Type Condenser: Cylinder or receiver that contains condensing water coils or tubes.

Shield: A steel cylinder with open or closed face equal to the tunnel diameter for tunnel excavation in soft ground.

Shim, Track: A bearing piece, usually wood or metal of various thickness, at least equal to the width and length of the tie plate, for temporary use between the tie plate and ties to raise (surface) the rail to a desired relative elevation. Usually, used to spot surface a track when the roadbed is frozen and the ties cannot be surfaced tamped; or for temporary use to bring the tops of adjoining rails of different height to a desired plane or elevation.

Shot Sawed: Description of a finish obtained by using steel shot in the gang-sawing process to produce random markings for a rough surface texture.

Shotcrete: Concrete mixture sprayed onto the rock surface.

Shoulder: The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use and for lateral support of base and surface course.

Shoulder, Ballast: See Ballast Shoulder.

Shrinkage: The volume change in concrete caused by drying normally occurring during the hardening process.

Shrouding: Metallic bands placed over the ends of steam nozzles to provide support, stability and minimize radial leakage.

Side Planing: Cuts made on sides of the head of the switch rail to form a taper from the full width of head to the point.

Side Track (S.T.): A track used to temporarily store cars.

Side-Wall Pressure: The crushing force exerted on a cable during installation.

Sight Glass: A glass tube sealed within a fluid system, providing a means to examine, visually, the fluid in the system.

Signal, Highway, Electric: A highway crossing signal which is actuated automatically by the approach of a train and which then displays one or any combination of several features such as red lights (flashing or nonflashing) horizontally swinging disk, crossing gates, or warning bell, all designed to warn motorists or the approach of a train.

Sill Course: See String Course.

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Sills: The horizontal timbers of a house that either rest upon the masonry foundation or, in the absence of such, form the foundations.

Siphon, Dosing: A siphon for automatically discharging the liquid purposefully accumulated in a tank into some sewage treatment device such as an Intermittent or Trickling Filter.

Skeleton Construction: A type of building construction in which all loads are transmitted to the foundations by a rigidly connected framework of suitable material.

Skew: Inclination in any direction.

Skimmings: Grease and scum skimmed from sewage settling tanks.

Slab-on-Grade: A concrete slab placed on grade, sometimes having insulation board or an impervious membrane beneath it, on a granular base.

Slick Line: Pipe or hose inserted between the rock surface and forms to place concrete lining.

Slip Joint: A connection that permits vertical or horizontal movement of the cladding with respect to the structural frame.

Sloughing: The phenomenon associated with trickling filters and contact aerators whereby slime and solids accumulated in the media are discharged with the effluent.

Sludge: The accumulated settled solids deposited from sewage or industrial wastes, raw or treated, in tanks or basins, and containing more or less water to form a semiliquid mass.

Activated:
Sludge floc produced in raw or settled sewage by the growth of zooglear bacteria and other organisms in the presence of dissolved oxygen and accumulated in sufficient concentration by returning floc previously formed.

Digested:
Sludge digested under anaerobic conditions until the volatile content has been reduced, usually around 50%.

Fresh:
Sludge recently deposited and removed from sedimentation tanks before decomposition has advanced far.

Primary:
Sludge obtained from a Primary Settling Tank.

Returned:
Settled activated sludge returned to mix with incoming raw, or primary settled, sewage.

Septic:
Sludge from a septic tank or partially digested sludge from an Imhoff tank or sludge digestion tank.

Sludge Bulking: See Bulking, Sludge.

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Sludge Conditioning: Treatment of liquid sludge preliminary to dewatering, to facilitate dewatering and drainability, usually by the addition of chemicals.

Sludge Dewatering: The process of removing a part of the water in sludge by any method, such as draining, evaporation, pressing, centrifuging, exhausting, passing between rollers, or acid flotation, with or without heat. It involves reducing from liquid to a spadable condition rather than merely changing the density of the liquid (concentration) on the one hand or drying (as in a kiln) on the other.

Smoke: An air suspension (aerosol) of particles usually, but not necessarily, solid; often originating in a solid nucleus, formed from combustion or sublimation. Also defined as carbon or soot particles less than 0.1 micron in size that result from the incomplete combustion of carbonaceous materials such as coal, oil, tar, and tobacco.

Smooth Finish: A finish of minimum textural quality, presenting the least interruption of surface. Smooth finish may be applied to any surface, flat or molded and is produced by a variety of machines.

SNG: Supplementary Natural Gas. Gases that are manufactured to duplicate natural gas.

Soldier: A brick laid on its end so that its longest dimension is parallel to the vertical axis of the face of the wall.

Solenoid Valve: Electromagnet with a moving core that serves as a valve, or operates a valve.

Solid Wall: A wall built of solid masonry units, laid contiguously, with the spaces between the units completely filled with mortar. Also walls built of solid concrete.

Soot: A black substance, mostly consisting of small particles of carbon, that can result from incomplete combustion and appear as smoke.

Spall: A fragment, usually in the shape of a flake, detached from a larger mass by a blow, weathering, pressure, or expansion within the larger mass.

Span: The distance between structural supports such as walls, columns, piers, piles, beams, girders, and trusses.

Span kngth: The horizontal distance between two adjacent supporting points of a conductor.

Span Win: An auxiliary suspension wire that serves to support one or more trolley contact conductors or a light fixture and the conductors that connect it to a supply system.

Spiling: Same as poling boards.

Splay: A beveled or slanted surface.

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Springing Line: A line marking the level from which the curve of an arch or vault rises from the upright or impost.

square: A unit of measure, 100 square feet (30.5 sq. meters), usually applied to roofing material. Sidewall coverings are sometimes packed to cover 100 square feet and are sold on that basis. A tool used by masons to obtain accuracy.

Square Foot (Steam): A term used to express the output of boilers and radiation. When applied to boilers, it is 240 Btu/hr; when applied to terminal units, it represents the amount of radiation that will emit 240 Btu/hr when supplied with steam at 215ºF and air at 65ºF.

Standard Atmosphere: Condition when air is at 14.7 psia pressure at 68ºF temperature.

Standard Conditions: Used as a basis for air-conditioning calculations. Temperature of 68ºF, pressure of 29.92 in. of Hg, and relative humidity of 30 percent.

Static Pressure: The normal force per unit area at a small hole in the pipe wall through which the fluid (water) flows.

Steam: Water in vapor state.

Stoker: Machine used to supply a furnace with coal.

Storm Drainage System: A drainage system that carries rain water, surface water, condensate, cooling water, or similar liquid wastes.

Strainer: Device such as a screen or filter used to retain solid particles while liquid passes through.

Stress: The resistance of a body to distortion when in a solid or plastic state and when acting in an unconfined. Stress is produced by the strain (distortion) and holds in equilibrium the external forces causing the distortion. It is measured in pounds or tons. Within the elastic limit the strain in a member of a structure is proportional to the stress in that member.

Stretcher: A masonry unit laid flat with its longest dimension parallel to the face of the wall.

String Course: A narrow, vertically faced, and slightly projecting course in an elevation, such as window-sills that are made continuous. Also, horizontal moldings running under windows separating the walls from the plain part of the parapets and dividing towers into stories and stages, and the like.

Stringing Mortar: The name applied to the method by which a brick-layer picks up sufficient mortar for a number of bricks and spreads it before laying the brick.

Stringlining: A method for determining the corrections to be made in the alignment of a curve, by measuring ordinates to the outer rail and without the use of surveying instruments,

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Structural Deck: The structural deck or slab that provides the load carrying capacity of the deck system.

Structure Conflict: A line so situated with respect to a second line that the overturning of the first line will result in contact between its supporting structures or conductors and the conductors of the second line, assuming that no conductors are broken in either line.

Stucco: Most commonly refers to an outside plaster made with Portland cement as its base.

Subballast: Any material of superior character, which can be spread on the finished subgrade of the roadbed, to provide better drainage, prevent upheaval by frost and better distribute the load over the roadbed.

Subgrade: Gravel, crushed rock or the like, usually inferior to the ballast used in the track, spread on the surface of the cut or fill prior to distributing ties and ballast. That portion of ballast over 18" inches below bottom of ties is usually classified as subballast, commonly known as subgrade material.

Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

Substation: A location where power is received at high voltage and changed to required voltages and characteristics for distribution to the catenary system, third rail, and other electric apparatus. It may contain transformers, rotating machinery, circuit breakers, sectionalizing switches, rectifiers, etc.

Sulfur Dioxide: Gas once commonly used as a refrigerant. Refrigerant number is R-764; chemical formula is SO,. Cylinder color code, black; boiling point at atmospheric pressure 14°F.

Sump: A tank or pit that receives liquid wastes only, located below the elevation of the gravity system and is emptied by pumping.

Sump Drainage: A liquid or air tight tank that receives sewage and/or liquid waste located below the elevation of the gravity system and' is emptied by pumping.

Sump Pump: A permanently installed mechanical device other than an ejector for removing liquid waste from a sump.

Superelevation: The height the outer rail is raised above the inner or grade rail, on curves, to resist the centrifugal force of moving trains. This should not be confused with cross level, on tangent (straight) track.

Superheat: Temperature of vapor above boiling temperature of its liquid at that pressure.

Superheater (Heating): Devices that add heat to saturated fluids.

Supply Equipment: See **Electric** Supply Equipment.

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Supply Main: The pipe used to distribute water from the boiler to the supply branches of the terminal units.

Supply Station: See Electric Supply Station.

support: An angle, plate, or other stone that carries a gravity load.

Supporting Structure: The main supporting unit (usually a pole or tower).

supports: Devices for supporting and securing pipe, fixtures, and equipment.

Surface (of Track): The condition of a track as to vertical evenness or smoothness over short distances.

Surface, Running (Tread): The top surface of the railhead on which the wheel tread rides or runs.

Surfacing, Out-of-Face: Raising the entire track to a new grade.

Surround: An enframement.

Susceptiveness: The characteristics of a communications circuit including its connected apparatus that determine the extent to which it is adversely affected by inductive fields.

Sweat-Out: Soft, damp mortar caused by poor drying conditions.

Switch: (1). A pair of movable track rails, with their fastenings and operating rods, providing a connection over which to move rolling stock from one track to another. Also called Split Switch. (2). A device for opening, closing, or changing the connection of a circuit. A switch is understood to be manually operable unless otherwise stated.

Switch Fixtures: The connecting and bearing parts for the rails of a split switch.

Switch Guard: A structure, usually of manganese steel, secured outside the running rail at the point of switch, with suitable flares to engage with the tread rim of wheels and guide them past the switch point without blow or undue wear.

Switch Heater: A device for melting snow with heat generated by an electric current, or by gas or oil; used for movable parts of switches, etc.

Switch Lock: A fastener, usually a spring padlock, used to secure the switch of derail stand in place and thus maintain correct position of these members.

Switch Plate: A special metal tie plate for use on switch ties, each plate being long enough to extend not only under the stock rail and its supporting braces, but also under the switch rail in open position. Switch plates are furnished in sets to correspond with switch length. There are two plates to each tie; however, at point of switch, the two may be replaced by a gauge plate which carries both switch rails.

Switch Rail (Point Rail): The tapered rail of a split switch.

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Switch Rod, Adjustable: A switch rod with an attachment for altering its length to keep the switch rails in their proper positions. Adjustment is usually effected through staggering holes in the clips which connect switch road and switch rail.

Switch Stand, Center Throw: A switch stand with a spindle higher than 1 foot but less than 2 feet. This type is commonly used in yards, less frequently on main track because targets are not as readily visible to engineman as are high switch stands.

Switch Target: A visual day signal fixed on the spindle of a switch stand, or the circular flaring collar fitted around the switch-lamp lens, and painted a distinctive color to indicate the position of the switch.

Switch, Actual Point of: See Point of Switch.

Switch, Air Flow: A device used to prove the flow of air.

Switch, High-Pressure: A pressure-actuated device to monitor liquid, steam, or gas pressure and arranged to shut down the burner at a preset high-pressure.

Switch, Low-Pressure: A pressure-actuated device to monitor liquid, steam, or gas pressure and arranged to shut down the burner at a preset low-pressure.

Switch, Pressure: A pressure-responsive device that makes or breaks an electrical circuit and may be automatically or manually reset.

Switch, **Staggered-Point:** A switch in which one point is placed in advance of the other, as in a turnout from inside a curve.

Switch, Stand: A device by which a switch is thrown, locked, and its position indicated. It consists essentially of a base, spindle, level, and connecting rod, together with target, and can be equipped with a lamp or banner. Unless described as "low" or "center throw," its target spindle extends 2 feet or more above top-of-rail elevation.

Switch, Theoretical Point **of:** See Point of Switch.

Switch, Throw of: The distance, measured along the center line of the rod nearest the point connecting the two switch rails, through which switch points are moved sideways to bring either point against the stock rail; standardized at 4 3/4 inches.

Switch-Point Lug: The lug attached to a switch point, to which the front rod is connected.

Switchboard: A type of switchgear assembly that consists of one or more panels with electric devices mounted thereon, and associated framework.

System Fuel Train: A series of valves, regulators, and controls between the burner and the source of fuel, that regulates and controls the flow of fuel to the burner.

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Systems Testing Adjusting & Balancing: (1). The balance of air and water distribution. (2). Adjustment of total system to provide design quantities. (3). Electrical measurement. (4). Performance verification of all equipment and automatic controls. (5). Sound and vibration measurement.

Tail Beam: A relatively short beam or joist supported in a wall on one end and by a header at the other.

Tamper, Air: An air-driven tool for compacting ballast under ties. Commonly used in sets of 4, 8, or 12 tools in connection with a portable air compressor.

Tamper, Electric: An electrically driven tool used for compacting ballast under ties. Commonly used in sets of 4, 8, or 12 tools in connection with a portable generator set. (Electric tampers are of three general classes: vibrator, magnetic impulse, and mechanical impulse.)

Tamper, Mechanical: A power-driven machine for compacting ballast under ties.

Tank

Aeration:
A tank in which sludge, sewage, or other liquid is aerated.

Concentration:
A settling tank of relatively short detention period in which sludge is concentrated by settling prior to vacuum filtration or to disposal.

Detritus:
A detention chamber larger than a grit chamber, usually with provision for removing the sediment without interrupting the flow of sewage. A settling tank of short detention period designed primarily to remove heavy settleable solids.

Dosing:
A tank into which raw or partly treated sewage is introduced and held until the desired quantity has been accumulated, after which it is discharged at such a rate as may be necessary for the subsequent treatment.

Final Settling:
A tank through which the effluent from a trickling filter, or aeration or contact aeration tank flows for the purpose of removing the settleable solids. Also called Final Settling Basin.

Imhoff:
A deep two-storied sewage tank originally patented by Karl Imhoff consisting of an upper or continuous flow sedimentation chamber and a lower or sludge-digestion chamber. The floor of the upper chamber slopes steeply to trapped slots, through which solids may slide into the lower chamber. A lower chamber receives no fresh sewage directly, but is provided with gas vents and a means for drawing digested sludge from near the bottom.

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lank (Continued):

Mixing:
A tank or channel so designed as to provide a thorough mixing of chemicals introduced into liquids.

Primary Settling:
The first settling tank through which sewage is passed in a treatment works.

Sedimentation:
A tank or basin in which water, sewage, or other liquid containing settleable solids is retained for a sufficient time; and in which the velocity of flow is sufficiently low, to remove by gravity a part of the suspended matter. Usually, in sewage treatment, the detention period is short enough to avoid anaerobic decomposition. Also termed Settling or Subsidence Tank.

Septic:
A single-story settling tank in which the settled sludge is in immediate contact with the sewage flowing through the tank, while the organic solids are decomposed by anaerobic bacterial action.

Skimming:
A tank so designed that floating matter will rise and remain on the surface of the sewage until removed, while the liquid discharges continuously under curtain walls or scum boards.

Sludge-Digestion:
A tank in which the solids resulting from sewage sedimentation are stored for the purpose of permitting anaerobic decomposition to the point of rendering the product nonputrescible and inoffensive.

lapping: Setting a brick down on its bed of mortar with a light blow of the trowel blade or end of handle.

Team Track: A track on which freight is transferred directly between railroad cars and highway vehicles.

Temper: To moisten and mix clay, plaster, mortar, and similar materials to the proper consistency for working.

Template: A pattern used in the fabrication operation.

Tension: An axial force or stress caused by equal and opposite forces pulling at the ends of the members. In simple bending it is also present above or below the neutral axis.

Tension Dar: A sturdy strip threaded through the last vertical link of the fabric. It attaches the fabric to the terminal posts.

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Tension, Unloaded:	Final: The longitudinal tension in a conductor after it has been subjected for an appreciable period to the loading prescribed for the location, or equivalent loading, and the loading removed. Final unloaded tension includes the effect of inelastic deformation (creep). Termination. See Cable Terminal.
	Initial: The longitudinal tension in a conductor prior to the application of any external load.
Terminal Post garbed Wire:	Corner, end, and gate posts extend 1 foot above the fabric to allow the barbed wire to be connected directly to the terminal posts. This allows the barbed wire to be stretched taut and maintains the highest possible degree of security.
Terminal posts:	A generic name for an end, corner, pull, or gate post depending on its function.
Test:	To determine quantitative performance of equipment.
Texture:	Any finish other than a smooth finish.
Therm:	A unit of heat having a value of 100,000 Btu.
Thermal Conductivity:	A term indicating the ability of a material to transmit heat. Thermal conductivity is the reciprocal of thermal resistance.
Thermocouple:	Device that generates electricity using the principle that if two dissimilar metals are welded together and the junction is heated, a Voltage will develop across open ends.
Thermocouple Thermometer:	Electrical instrument using thermocouple as source of electrical flow, connected to milliammeter calibrated in temperature degrees.
Thermometer:	Device for measuring temperatures.
Thermostat:	Device responsive to ambient temperature conditions. A control (switch) operated by the temperature of the air.
Thermostatic Control:	Device that operates system or part of system based on temperature changes.
Thimble:	The cylindrical pieces of an insulating joint which surround portions of the bolts.
Third Rail:	An electric conductor located alongside the running rail from which power is collected by means of a sliding contact shoe attached to the truck of electric equipment.
Throat:	The undercut of a projected molding to form a drip.
Throat of Frog:	The point at which the converging wings of a frog are closest together just ahead of frog point.
Throw of Switch:	See Switch, Throw of.
Throw Rod:	The rod attached to the head rod of a switch, connecting the switch to a switch stand or other operating device.

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Tie: (1). A transverse support to which rails are fastened to keep them in line, gauge and grade. Usually wooden or concrete. (2). Any unit of material used to resist the spreading of a wall, or the separation of the two solid parts of a hollow wall.

Tie Plate: A metal plate at least 6 inches wide and long enough to provide a safe bearing area on the tie, with a shoulder to restrain outward movement of the rail.

Tie Plate, Canted: A tie plate tapered in thickness usually on a slope of 1 in 20, for the purpose of inclining the rail toward the center of track for easier maintenance of gauge, more uniform wear of head, and central loading of rail.

Tie Plate, Twin: A tie plate in two parts which mate to form a combined width equal to that of the stand tie plate, for use back of the heel of switch to the point where standard tie plates may be applied without their ends infringing.

Tie Plug: A wooden pin driven in to fill an unused spike hole in a tie, to exclude moisture, prevent decay, and provide solid wood for redriving the spike. Usually supplied in the form of sticks containing several plugs; frequently of treated wood.

lie Rod: See Gauge Rod.

lie Spacing: The distances between tie centers in track or turnout.

lie Tamper: See Ballast Tamper.

lie longs: A tool designed to engage a tie with a lever grip; with handles by which ties can be carried or drawn into or out of the track renewals.

Illth: Soil condition/suitability for plant growth.

lime Delay: A deliberate delay of a predetermined time in the action of a safety device or control.

Toe End of Frog: The end of a frog nearest the switch.

Toe Spread: The distance between gauge lines at the toe end of the frog.

Tolerance: Acceptable dimensional allowance, under or over specified, ideal net sizes.

Tooling: Compressing and shaping the face of a mortar joint, usually with a special tool, other than a trowel.

Toothing: The temporary end of a wall built so that the end stretcher of every alternate course projects.

Total Air: The total amount of air supplied to a burner. It is the sum of primary, secondary, and excess air.

Track: The rail, ties, rail fastenings, hardware and roadbed between points four feet outside of each rail.

Track Brace: An auxiliary fastening designed to function as a rail brace and a gauge rod.

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Track Fastenings, Auxiliary:	The term commonly applied to spring washers, tie plates, rail braces, anticreepers and gauge rods.
Track Fastenings:	The term commonly applied to rail joints, bolts and spikes.
Track **Level:**	A board with a spirit level attached, to level the rails of a rack usually equipped with a series of steps to set superelevation on the outset rail of curves.
Track **Liner:**	A device designed to minimize manual labor in lining track. It consists generally of a base resting securely on the roadbed to act as a fulcrum for some form of lever arm.
Track Shim:	A hardwood or fiber plate, generally as wide as the bearing of a standard tie plate but of varying thickness; used to restore the running surface of track heaved by frost or otherwise distorted.
Track, Body:	Each of the parallel tracks of a yard, on which cars are switched or stored.
Track, House:	A track alongside of or entering a freight house; used for cards receiving or delivering freight at the house.
Track, **Ladder:**	A track connecting successively the body tracks of a yard.
Track, **Repair** or Rip:	One of the body tracks in a car repair yard or shed, on which repairs are made to rolling stock.
Track, Spur:	A track connected with the parent track at one end only.
Track, Storage:	One of the body tracks in a storage yard, or a track used for storage purposes.
Track-Laying Machine:	A machine designed to minimize the manual labor of placing rails, fastenings, ties and other materials.
Trailing **Point:**	A switch in which points face away from the normal direction of traffic. A trailing point move would pass over the frog and then the switch points.
Train:	A locomotive with or without cars and displaying markers.
Transformer:	Apparatus that serves to increase or decrease voltage.
Transformer Vault:	An isolated enclosure either above or below ground with fire-resistant walls, ceiling, and floor in which transformers and related equipment are installed and not continuously attended during operation. See Vault.
Transition Spiral:	An easement curve.
Transpose Rail:	Changing rail from one side to the other on curves because of headware from tangent to full curvature or just reversed.
Traveled Way:	The portion of the roadway for the movement of vehicles, exclusive of shoulders and full-time parking lanes.

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Trestle: A bridge structure consisting of beam, girder or truss spans supported upon bents. The bents may be of the piled or of the frame type. When of framed timbers, metal or reinforced concrete they may involve two or more tiers in their construction. Trestle structures are designated as "'wooden," "frame," or "framed," "metal," "concrete," "wooden pile," "concrete pile," etc., depending upon or corresponding to the material and characteristics of their principal members.

Trim: Stone used as sills, copings, enframements, etc., with the facing of another material.

Truss: A jointed structure having an open built web construction so arranged that the frame is divided into a series of triangular figures with its component straight members primarily stressed axially only. The triangle is the truss element and each type of truss used in bridge construction is an assemblage of triangles. The connecting pins are assumed to be frictionless.

Truss Rod: A rod used in brace assemblies to draw and hold the line post firmly to the brace rail. The truss rod uses an adjustable turnbuckle to maintain proper tension.

lubes, Diffuser: Air tubes used in aeration tanks of the activated sludge process.

Tuck Pointing: A method of refinishing old mortar joints, the loose mortar is dugout and the tuck is filled with fine mortar left projecting slightly or tooled.

Tunnel Locations:

Bored vs. Cut-and-Cover Tunnels:
Tunnels bored by whatever means require a minimum of overburden depending upon soil conditions. Shallow tunnels are most economical by cut-and-cover construction unless other conditions (such as interference with city street traffic) preclude this method.

Mountain Tunnels:
Tunnels through mountains are used to carry transportation facilities or water.

Tunnels at Shallow Depth and Under City Streets:
These are primarily used for rapid transit or other transportation in urban areas.

Underwater Tunnels:
Built by various methods under rivers, harbors, or other waterways to serve any one of the service purposes, these tunnels are used when clearance requirements or land use prevent construction of bridges.

Tunnel Media:

Mixed Face Tunnels:
These tunnels have part of their cross-sections in rock and part in soft ground, with rock interface often weathered and frequently difficult to construct.

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Tunnel Media (Continued):

Rock Tunnels:
Rock tunnels are excavated in a firm, cohesive medium that may vary from relatively soft marl and sandstone to the very hard igneous rocks such as granite. Bedding and fissuring of rock layers and the presence of water control construction methods and difficulties.

Soft Ground Tunnels:
This category includes all tunnels built in soft, plastic, or non-cohesive soils where water may or may not be a problem.

Tunnel Service Ciassitications:

Aqueduct & Sewers:
Used to convey fresh water or sanitary wastes and storm water, the sizes and construction of these tunnels vary according to local conditions.

Highway Tunnels:
These accommodate all types of vehicles permitted on public highways, except that their use by bicycles and horse-drawn vehicles may be limited or prohibited.

Railroad Tunnels:
These tunnels serve standard railroad trains and may need special clearances for electric traction from catenaries.

Rapid Transit Tunnels:
These tunnels serve urban and metropolitan rapid transit trains, to meet standards of particular systems.

Shafts:
These are vertical or inclined excavations that serve as access to mines or tunnel construction, or for tunnel ventilation. They are built to suit requirements.

Special Tunnels:
Tunnels are also used to carry water pipes, electric cables, or other utilities.

Underground Caverns:
These are tunnels built to house underground hydroelectric, power plants, hardened defense facilities, and special waste storage. The tunnels vary widely according to service" requirements and local conditions.

Turbidity: (1). A condition of a liquid due to fine visible material in suspension, that may not be sufficient size to be seen as individual particles by the naked eye but prevents the passage of light through the liquid. (2). A measure of fine suspended matter (usually colloidal) in liquids.

Turnout **(T.O.):** An arrangement of a switch and a frog with closure rails, by which rolling stock can be diverted from one track to another.

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Ultimate CO_2: The percentage of carbon dioxide in dry combustion products when a fuel (gas) is completely burned with exactly the amount of air needed for complete combustion. This is the theoretical maximum CO, that can be obtained for a given gas in burning the gas in air.

Undercut: Cut or molded to present an overhanging part, as a drip mold.

Updraft: Excessively low air pressure, existing at the outlet of a chimney or stack, that tends to increase the velocity and volume of gases passing up the stack.

Urban **Districts:** Thickly settled areas (whether in cities or suburbs) or where congested traffic often occurs. A highway, even though in thinly settled areas, on which the traffic is often very heavy, is considered as urban.

Utility: An organization responsible for the installation, operation, or maintenance of electric supply or communication systems.

Utility Gases: Natural gas, manufactured gas, liquefied petroleum gas-air mixtures, or mixtures of any of these gases.

Utility Interactive System: An electric power production system that is operating in parallel with and capable of delivering energy to a utility electric supply system.

Utilization Equipment: Equipment, devices, and connected wiring that utilize electric energy for mechanical, chemical, heating, lighting, testing, or similar purposes and are not a part of supply equipment, supply lines, or communication lines.

Valve: **Foot:**
(1). A valve placed in the bottom of the suction pipe of a pump, that opens to allow water to enter the suction pipe, but closes to prevent water from passing out of it at the bottom end. (2). Reverse action in valve attached to drainage pipe of a vacuum chamber allowing water to drain out but closing the valve to hold the vacuum.

Valve Solonold: Valve actuated by magnetic action by means of an electrically energized coil.

Vapor **Barrier:** Material used to retard the movement of water vapor into walls, and prevent condensation in them. Usually considered as having a perm value of less than 1 .O. Applied separately over the warm side of exposed walls or as a part of batt or blanket insulation.

Vault: An enclosure above or below ground that personnel may enter and is used for the purpose of installing, operating, or maintaining equipment or cable that need not be of a submersible design.

Velocity Pressure: Pressure exerted by a flowing gas by virtue of its movement in the direction of its motion. It is the difference between total pressure and static pressure.

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Veneer:	A facing of masonry material attached but not bonded to the backing.
Voltage:	The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal Voltage of a system or circuit is the value assigned to a system or circuit of a given Voltage class for the purpose of convenient designation. The operating Voltage of the system may vary above or below this value.
	Voltage of Circuit not Effectively Grounded: The highest nominal Voltage available between any two conductors of the circuit. NOTE: If one circuit is directly connected to and supplied from another circuit of higher Voltage (as in the case of an autotransformer), both are considered of higher Voltage, unless the circuit of the lower Voltage is effectively grounded, in which case its Voltage is not determined by the higher Voltage circuit. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.
	Voltage of a Constant Current Circuit: The highest normal full-load Voltage of the current.
	Voltage of an Effectively Grounded Circuit: The highest nominal Voltage available between any conductor of the circuit and ground unless otherwise indicated.
	Voltage to around of a Grounded Circuit: The highest nominal Voltage available between any circuit conductor and that point or circuit conductor that is grounded.
	Voltage to Ground of en Ungrounded Circuit: The highest nominal Voltage available between any two conductors of the circuit concerned.
	Voltage to Ground of • Grounded Circuit Conductor: The nominal Voltage between such conductor and that point or circuit conductor that is grounded.
	Voltage to Ground of an Ungrounded Circuit Conductor: The highest nominal Voltage between such conductor and any other circuit conductor concerned.
Wail Plate Anchor:	A machine bolt anchor, with a head at one end and threaded at the other, and fitted with a plate or punched washer to securely engage the brickwork or concrete and hold the wall plate or other member in place.
Wall Plate:	Footing placed on the rock shelf to temporarily support the arch ribs of tunnel sets.
Wall Tie:	Strip of metal used for tying a facing veneer to the body of a wall.

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Walls, Bearing:	A wall supporting a vertical load in addition to its own weight.
Walls, **Cavity:**	A wall in which the inner and outer wyths are separated by an air space, but tied together with metal ties.
Walls, Composite:	A wall in which the facing and backing materials are bonded together.
Water Column:	Abbreviated as W.C. A unit used for expressing pressure. A 1 inch water column equals a pressure of 0.578 oz/in.
Water Cooled Condenser:	Condensing unit that is cooled through use of water.
Water Hammer:	Pressure rise in a pipeline caused by a sudden change in the rate of flow or stoppage of flow in the line.
Water Repellent:	Any of several types of clear liquids used to render masonry wails less absorptive. These treatments are said to maintain a material's ability to breathe away moisture, as distinct from "sealers" that form impervious, non-breathing coatings.
Water Retentivity:	The property of mortar that prevents the rapid loss of mix water by absorption.
Water Table:	A slight projection of the lower masonry or brickwork on the outside of a wall and slightly above the ground as a protection against water.
Water Tube Boiler:	A steel, hot-water boiler in which water is circulated through the tubes and hot gases from fuel combustion are circulated around the tubes inside the shell.
Waterproofing:	See **Dampproofing.**
Wearing **Course:**	The wearing course provides the riding surface for traffic and is placed on top of the structural slab. When the wearing course is poured with the slab it is referred to as a monolithic deck. Wearing surfaces are either asphalt concrete or Portland cement concrete.
Weep Hole:	A drainage opening usually inserted at the base of a stone unit to release moisture accumulating between the stone and backup.
Weir:	A flow control device commonly found in water and waste treatment systems. Free: A weir that is not submerged, the tail water is below the crest, or where the flow is not in any way affected by the tail water. Parabolic: A weir with a notch parabolic in shape with the axis of the parabola vertical. proportional: A weir used to maintain a constant velocity in a channel regardless of depth of sewage, and shaped so the channel depth is proportional to the flow.

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Weir (Continued):

Rectangular:
A weir whose notch is rectangular in shape.

Submerged:
A weir that, when in use, has the water level on the downstream side at an elevation equal to, or higher than, the weir crest; the rate of discharge is affected by the tailwater.

Suppressed:
A weir with one or both sides flush with the channel of approach. This presents contraction of the nappe adjacent to the flush side. The suppression may occur on one end, or both ends.

Triangular:
A weir whose notch is triangular in shape, usually used to measure very small flows.

Welded Wire Mesh: A series of longitudinal and transverse wires arranged substantially at right angles to each other and welded together at all points of intersection.

Wide Flange **Beam (Carnegie Beam):** A steel rolled member having an H-shape with its flanges wider and its web thinner than an I-beam.

Wind (wined): A warp in a semi-finished stone slab to be removed by further fabrication.

Windage: Wind induced loss of circulating water.

Wing Wail: An extension wall of an abutment wall which retains adjacent earth and/or deflects or guides a stream into pipes, culverts, and the waterway of a bridge.

Wire Gauges: The American Wire Gauge (AWG), formerly known as Brown & Sharpe (B&S), is the standard gauge for copper, aluminum, and other conductors with the sole exception of steel conductors for which the Steel Wire Gauge (Stl WG) is used. NOTE: The Birmingham Wire Gauge is obsolete.

With(e) or Wyth(e): A continuous vertical 4-inch (lo-cm.) or greater section or, thickness of masonry eg., the thickness of masonry separating flues in a chimney.

Wooden **Brick:** Piece of seasoned wood, made the size of a brick, and laid where it is necessary to provide a nailing space in masonry walls.

Workability: An essential property of any mortar for masonry construction since it is only through this property that the mortar can be brought into intimate and complete contact with the masonry units, thereby incorporating the properties of the mortar into the masonry. Or, that property of freshly mixed concrete that determines the ease and homogeneity with which it can be mixed, placed, compacted, and finished.

Yard Track **(Y.T.):** A track within a year used to receive cars for classification for rerouting.

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END OF SUBSECTION

APPENDIX C

TECHNICAL **BULLETINS/UPDATES/ADVISORIES**

INDEX OF BULLETINS/ADVISORIES FOLLOWED BY

BULLETINS/ADVISORIES AS DEVELOPED

SEE FOLLOWING EXAMPLE

APPENDIX C

TECHNICAL ADVISORY T0501 -1

DATE: 1 0/91
SYSTEM: Roofing (CSI 07000)
ASSEMBLY: Built-Up (CSI 07510)
SUBJECT: Rooftop Lighting and Insect Damage

"In March, 1988 a professional roofing magazine article described a bizarre but apparently avoidable, phenomenon. In about a dozen documented cases ranging from Washington State to Florida, beetles have bored through roof membranes, causing leaks. It was determined that the beetles are attracted to lights (especially mercury vapor) mounted on, over, or near roof surfaces, including nearby billboard lighting. Falling to the roof, they burrow into the roof substrate, seeking protection from the sun during the day. The types of roof membrane affected were asphaltic BUR, modified bitumen, and single-ply roofing. Evidently, no instance has yet been found among coal tar BUR. It is advisable to exercise care in the selection of roof membranes where billboards mav exist adiacent to a olanned roof installation, or when rooftop liahtina is reauired. The roof specifier should discuss the types of luminaire to be used with project electrical engineers before mercury vapor fixtures are specified."

Source: **Roofing Design Criteria Options.** RD. **Herbert II**

EXAMPLE: TECHNICAL ADVISORY BULLETIN

END OF SUBSECTION

APPENDIX D

REVISIONS SUMMARY

AT A GLANCE SUMMARY OF ALL

REVISIONS UP TO LATEST REVISION DATE

APPENDIX D

END OF SUBSECTION