Department of Energy

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

Deficiency Standards & Inspections Methods Manual

Prepared by:
Parsons Brinckerhoff Facilities Services, Inc.

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The United States Department of Energy
Off ice of Organization, Resources and Facilities Management
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Washington, DC 20585

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BOOK ONE

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CAS PROGRAM OVERVIEW

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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?

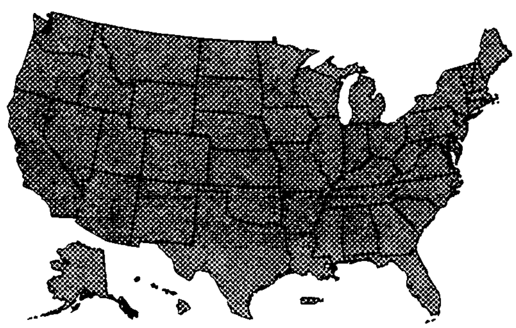
  Strategies for beginning to use CAS and the key roles facility managers and CAS inspectors play within the CAS process are detailed.

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.

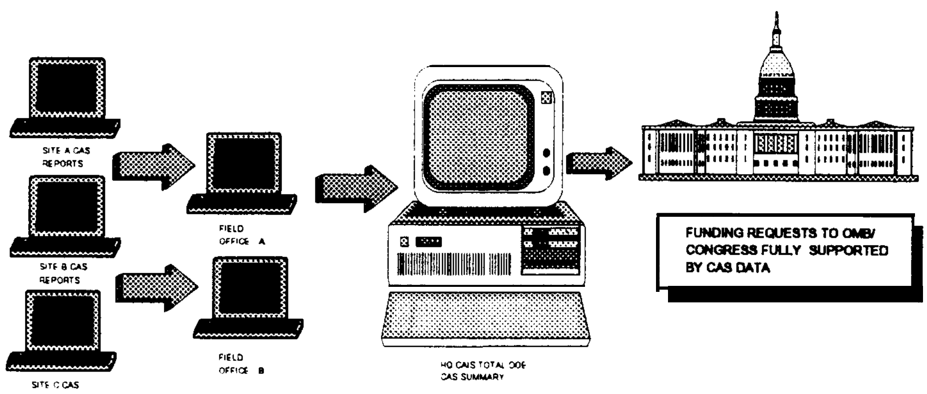
The current state of condition assessment across all DOE assets is mixed. While DOE regulations dictate facility assessments be made, no one methodology is mandated to conduct them. As a result, DOE surveys have varied from site to site, with some locations providing exhaustive in-depth analysis while 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.

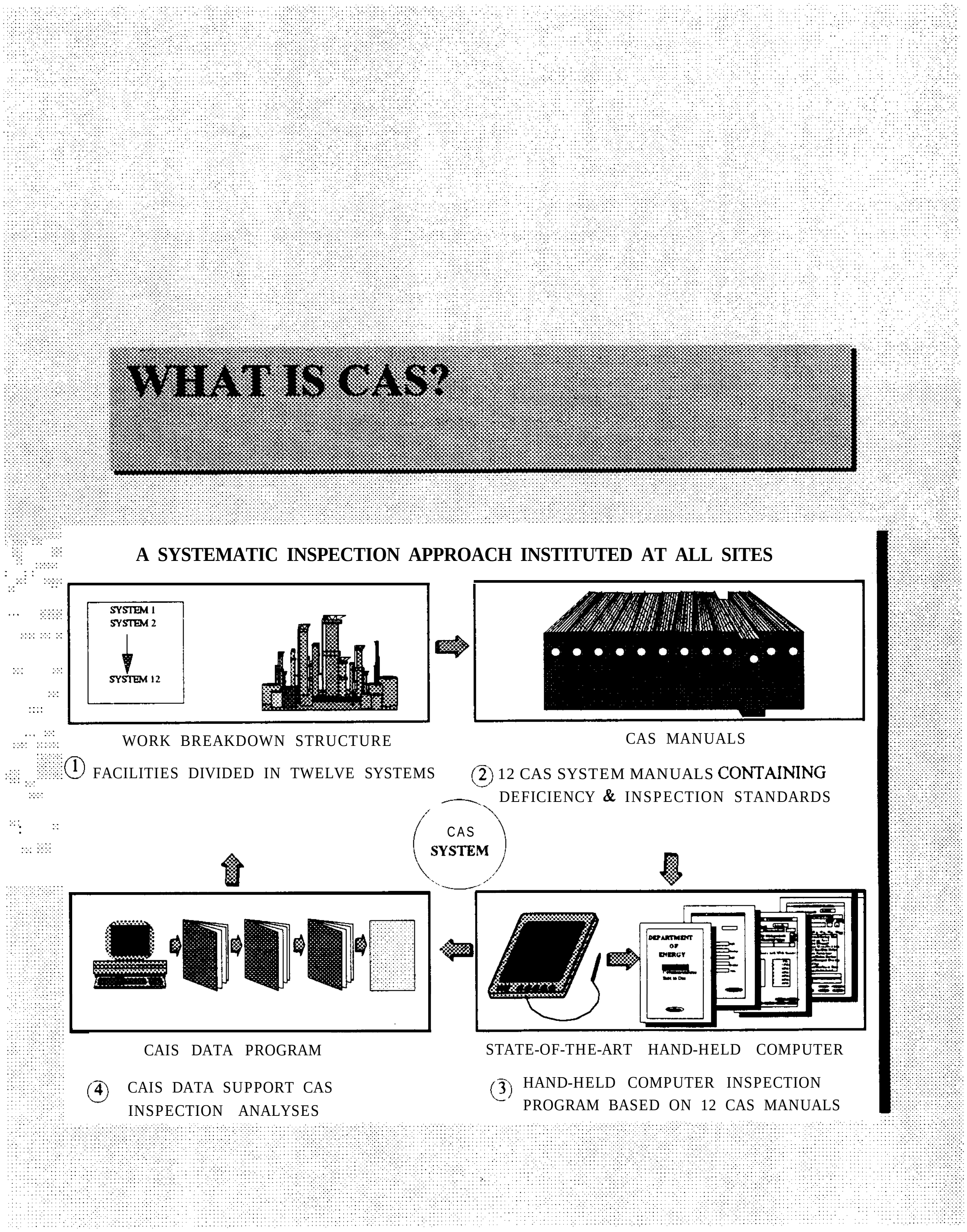
Identify Repair/Replacement Funding:

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 Funding 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



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.)	CONTROL 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	0.1 1 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	THERMA L &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)

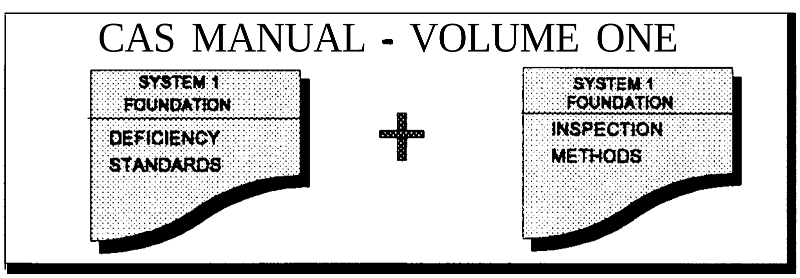
*NOTE: This section supersedes Means 0.10 cateaorv and includes FIS 700 Series Asset Codes.

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 Technlcal **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.

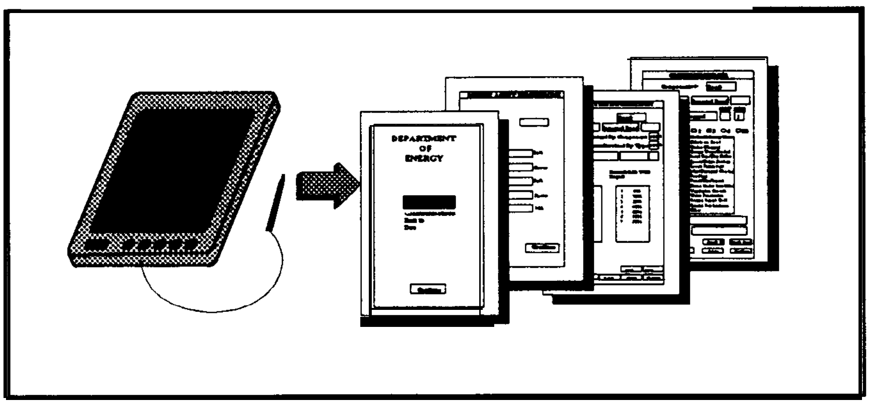
Appendix D Revisions Summary - All revisions listed in chronological sequence. The last revision listed will be the most current modification.

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.

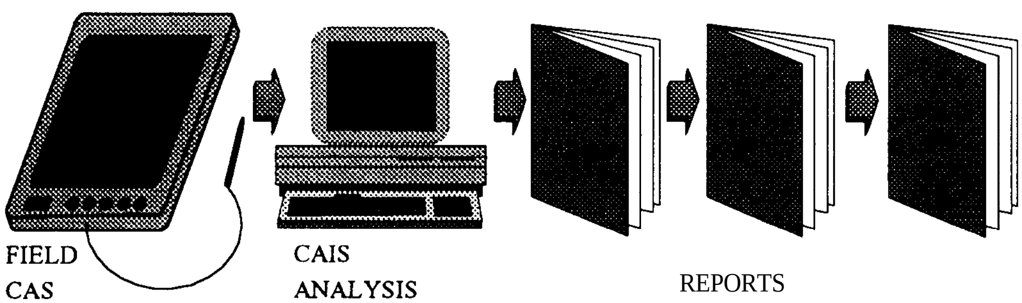
In short, the CAS process will be conducted in a carefully structured, "standardized" manner to ensure that the quality of raw inspection data is consistent throughout all DOE installations.

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

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:

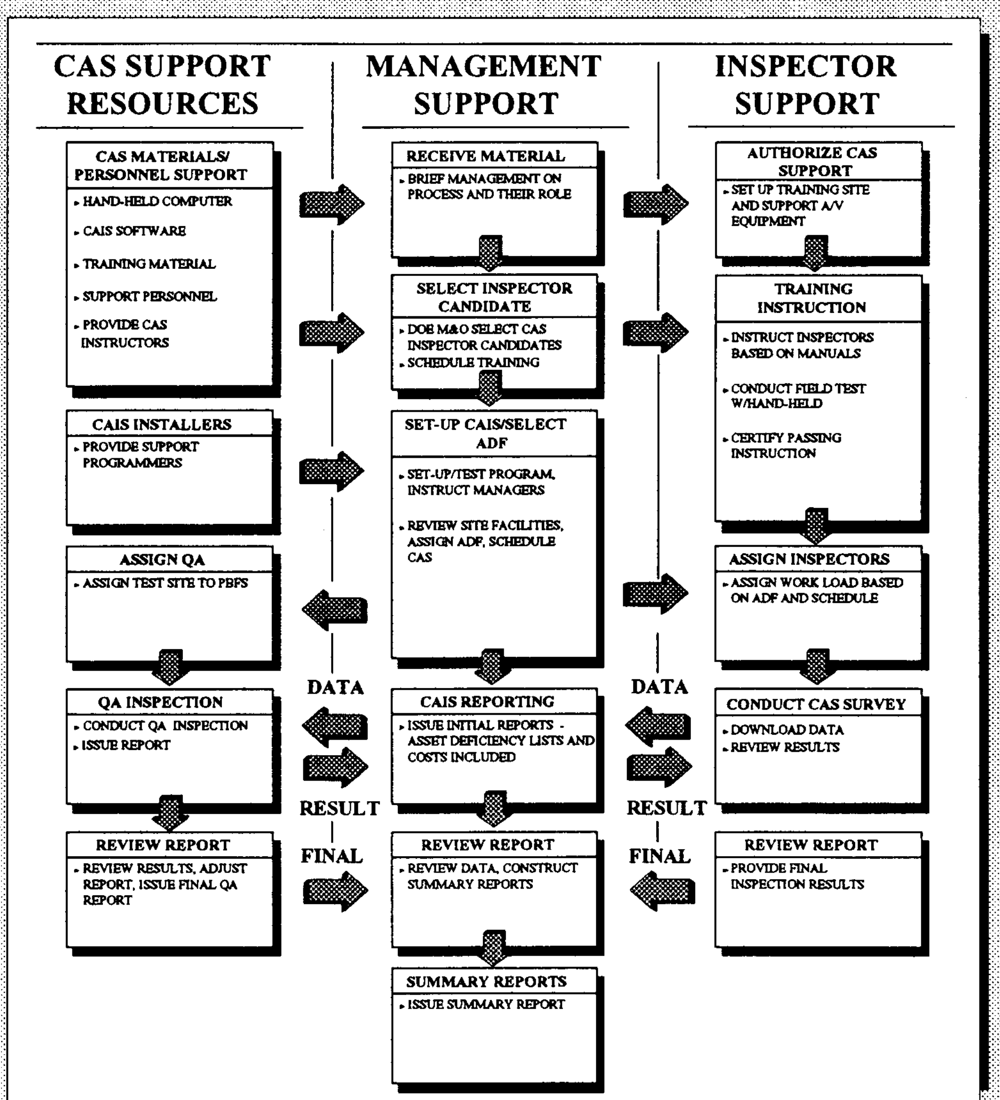
Costs to accomplish repairs and replacements are generated by the manipulation of field data in the CAIS program, which employs several methods including determining cost as a percentage of total replacement and/or direct entry of costs. (See Section 1, Subsection 1 .1 for discussion of cost development.)

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

HOW IS CAS IMPLEMENTED?



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:

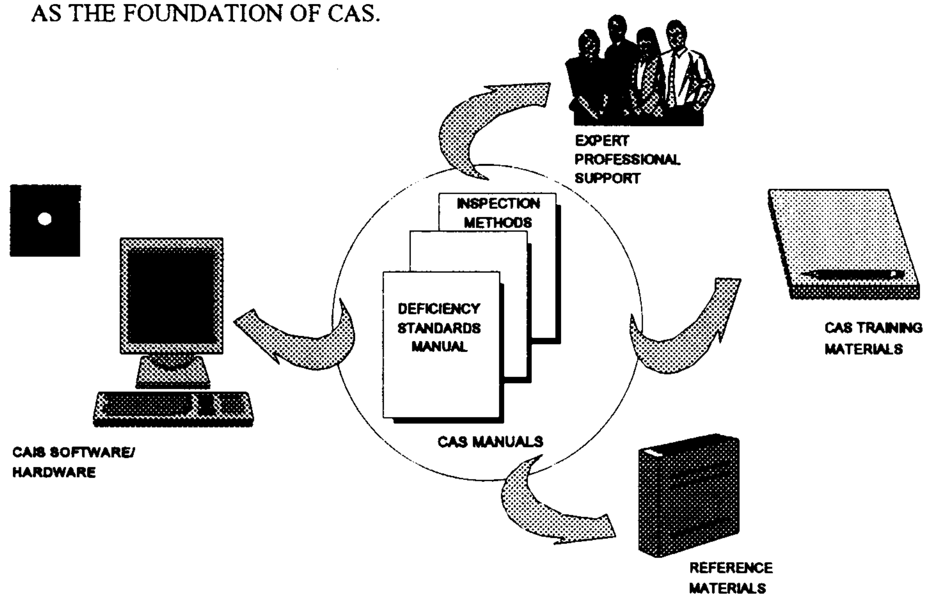
Without highly skilled, knowledgeable inspectors, the CAS Program will not succeed. The integrity of these inspectors and their expertise will ensure that the base data supporting the entire CAS process will be an accurate reflection of the condition of the DOE inventory of facilities and assets.

INTRODUCTION

HOW IS CAS IMPLEMENTED?

CAS SUPPORT RESOURCES

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



INTRODUCTION

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:

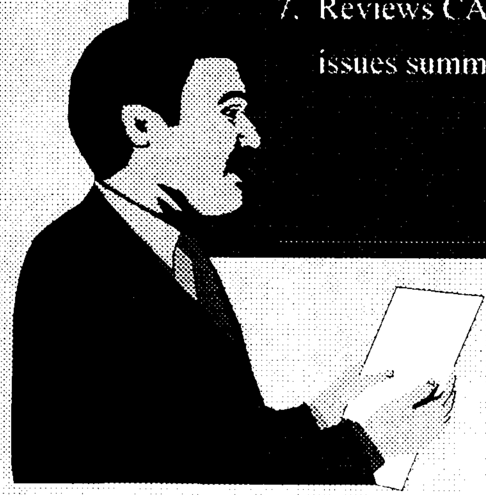
The Contractor will provide support resources in order to field questions from various site locations. Expert engineers, architects, and computer programmers will answer with written and/or verbal responses all inquiries originating from the field.

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:

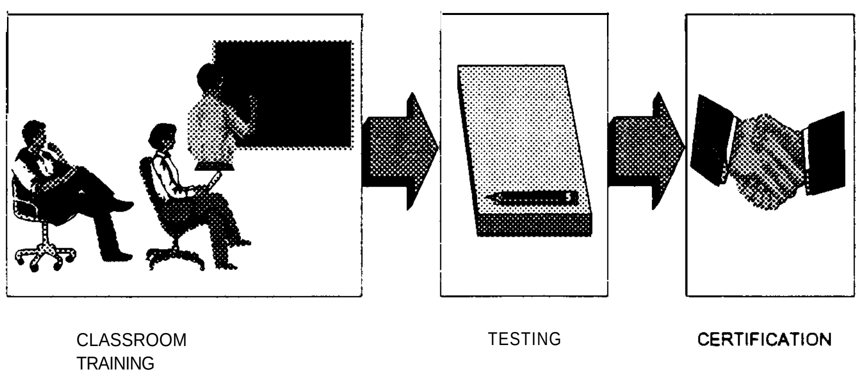
The process of up-loading CAS field data to the PC-based CAIS program will be demonstrated to the M&O CAS managers. Analysis processes will be examined using predetermined, formatted reports. Final management project "sorts" and prioritization schemes, and construction of summary reports for higher authorities,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

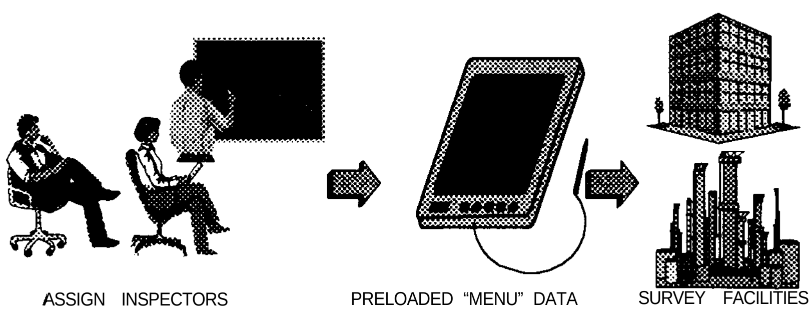
At the completion of the CAS training, each candidate is required to take and pass a written examination based on the material covered in the class. It is the goal of the training team to pass 100% of the candidates. Those having difficulty will receive additional instructor attention during the class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

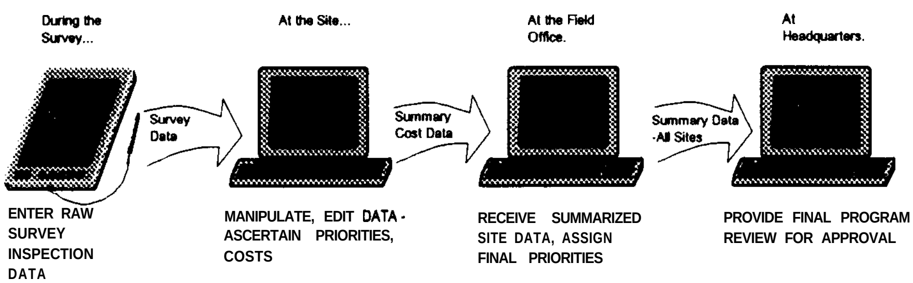
CAS Report Generated by **CAIS:**

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.

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



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 ail 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.

INTRODUCTION

END OF SUBSECTION

ASSET DETERMINANT **FACTOR/CAS** REPAIR **CODES/CAS** 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 vears	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)[1]	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)'	0.07, 0.08
8	Asset ELECTRICAL only	ELECTRICAL inspection (base CAS - assembly level or optional component level)[1]	0.09
9	Asset SITE inspection only	SITE inspection (base CAS - assembly or optional component level) [1]	0.12
10	As develooed bv each site	As constructed bv site2	As Reauired

GENERAL NOTES:

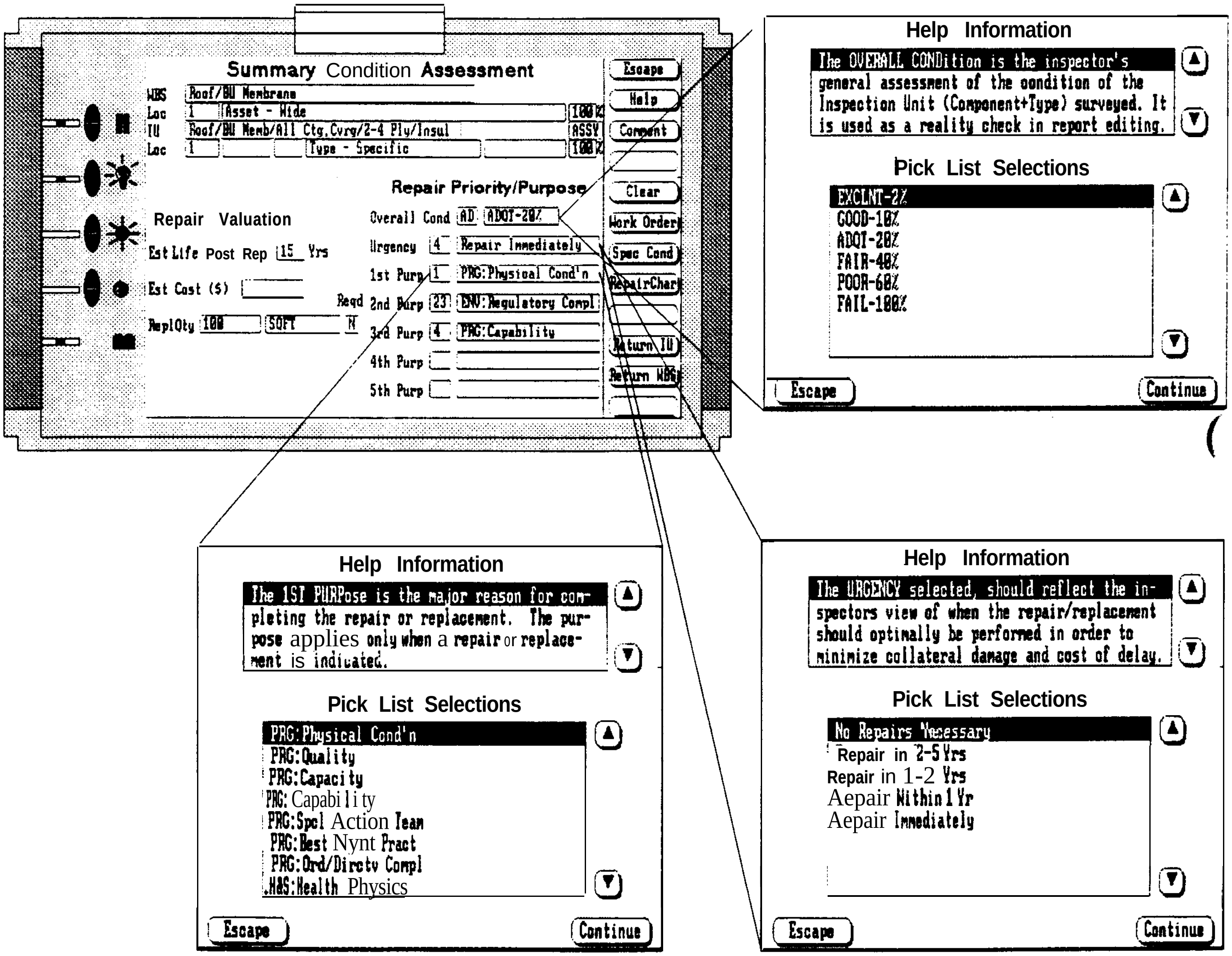
1. Survey may combine levels (eg., ADF #1, Systems 0.01-0.06, 0.11, and 0.12 Assembly level survey; 0.07, 0.08, and 0.09 Component level survey.)
2. Other surveys may be structured on an as-required by sites.
3. ADF values are auidelines onlv and svstems mav be added to base ADF values as reauired.

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 systems 0.05 Roofing, 0.07 Conveying, 0.08 Mechanical, and 0.09 Electrical is recommended.
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	Fall: Non-operational or significantly substandard performance. Replacement required because repair cost is >60% of replacement cost.

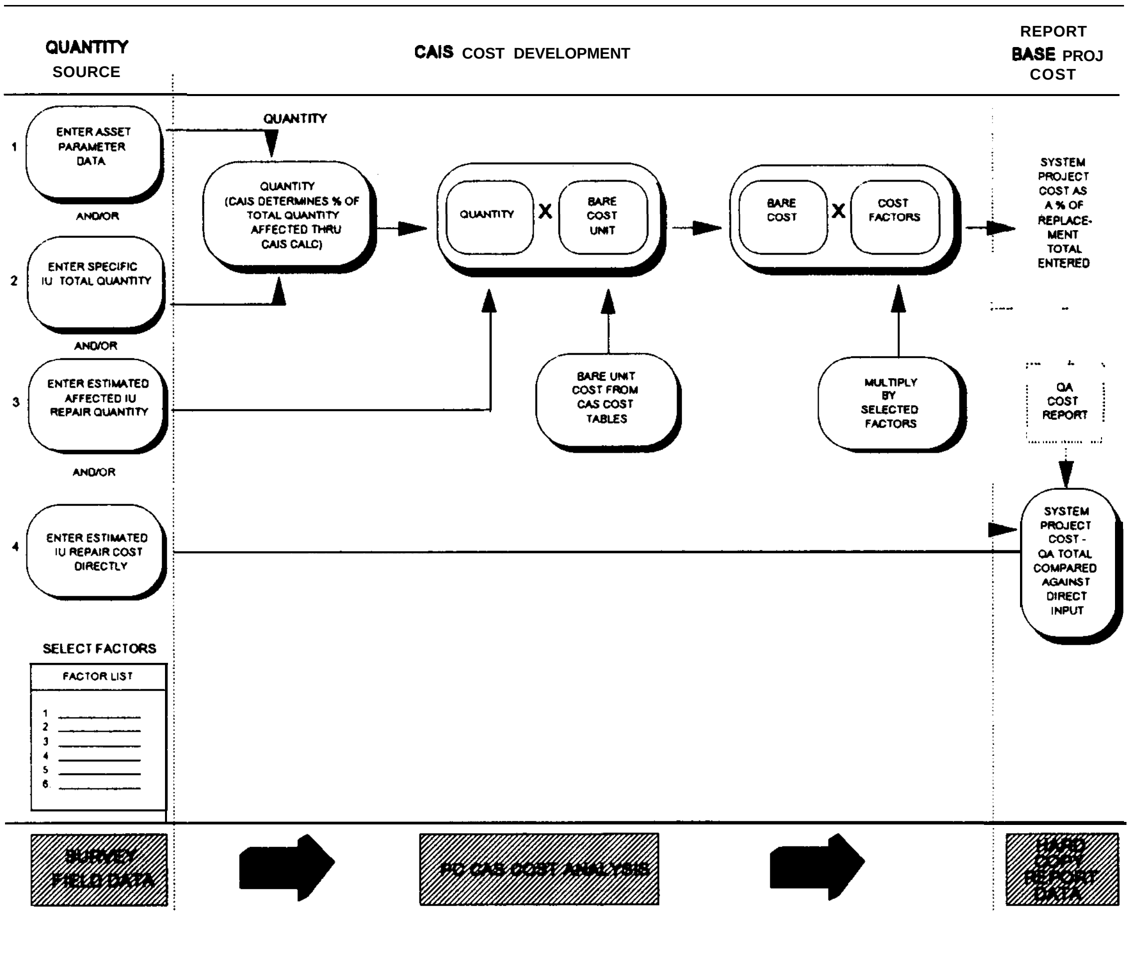
PURPOSE CODE*	**DEFINITION**
P2	PRG: Capacity
H2	H&S: Industrial Safety
E2	ENV: Solid Waste Management
S4	S&S: Security
•	Partial list based on CAMP Order DOE 4330.4A dated 1O-l 7-90.

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 year.
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

Tool and material requirements to perform inspections will vary from one system to another and will depend on the scope of the inspection.

STANDARD INSPECTION

Standard Inspection Methods are primarily non-invasive visual observations. Few tools or materials are required. However, rather than repeat each individually, the Guides refer to a class "Standard Inspection Tools - Mechanical." The Standard Inspector should carry these items at all times. Additional tools or materials may be required. They will be identified individually on the Guide Sheets.

STANDARD INSPECTION TOOLS (Mechanical)

- Flashlight
- Mirror
- Rags
- Small flat screwdriver
- Small phillips screwdriver

STANDARD TOOL GROUP (Additional)

- Acoustical Analyzer
- Gas Detector
- InfraScope
- Moisture Detector
- Sample Bottles for Chemical Analysis
- Shock Pulse Monitor
- Stroboscope
- Ultrasonic Analyzer
- Ultrasonic Flowmeters
- Ultrasonic Noise Meter
- Vibration Analyzer

NON-STANDARD INSPECTIONS

Non-Standard Inspection Methods are invasive visual observations with many tests. Many tools and materials are required. However, rather than repeat each individually, the Guides refer to a class "Non-Standard Inspection Tools - Mechanical." Additional tools or materials may be required.

NON-STANDARD TOOL GROUP (All Trades)

- 12' measuring tape
- 3/8" drive socket set and ratchet
- Assorted center punches, drift punches, steel chisel
- Ball peen hammer
- Crescent wrenches 4" and 8"
- Emery cloth
- Extension cords and inspection lights
- File
- Grease guns and oilers
- Hack saw and spare blades
- Open and box end wrenches 1/4" and 3/8"
- Pipe wrenches to 14"
- Pliers - vise grip (2), slip joint, needlenose, diagonal, cutting pliers, side cutters
- Pocket knife
- Small level and square
- Small set of Allen wrenches
- Standard and phillips head screwdrivers - various sizes
- Various cleaning tools - brushes, scrapers, etc.
- Wire brush

GUIDE SHEET TOOL & MATERIAL LISTING

NON-STANDARD INSPECTIONS (Continued)

Additional **Non-Standard Inspection** Tools - **Mechanical** (Refrigeration)

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

Additional Non-Standard **Inspection** Tools - Mechanical (Plumbing)

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

Other Tools **&** Materials for Non-Standard **Inspections**

- Acoustical analyzer
- Borescope
- Displacement gauges
- Dye penetrants
- Eddy current techniques
- Gas detector
- Infrared Scope
- Moisture detector
- Sample bottles for chemical analysis
- Shock pulse monitor
- Smoke capsules
- Stroboscope
- Tracer gases for leak detection
- Ultrasonic analyzer
- Ultrasonic flowmeters
- Vibration analyzer
- Video camera

END OF SUBSECTION

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 (e.g., consultants, outside labs).

TESTING METHODS

GENERAL

During the course of the Condition Assessment Survey, 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. Testing will not be required on all assets. Where indicated, results of testing will be recorded in Data Collection Methods.

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.

Standard Methods are generally quick, visual, hands-off walk-throughs not requiring a component to be taken out of service. Few tests are required in the associated Guide Sheets. Where tests are indicated, they are non-invasive. Examples include leak detection, vibration analysis, and stroboscopic observations.

Non-Standard Methods are generally those that require a component to be taken out of service to allow internal inspections or variations in operation not allowed while in service. Examples include eddy current analysis of tubing and smoke testing.

Some of the 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.

STANDARD TEST METHODS

- Acoustic Emission
- Acoustic Resonance
- Chemical Analysis
- Correlation Water Leak Testing
- Gas Detection-Gas Leak Detection with Tracers
- Ground Radar Moisture Tracer
- Moisture Tracer
- Shock Pulse Monitoring
- Stroboscopes
- Thermography
- Ultrasonic Flowmeters
- Ultrasonic Testing
- Velocity/Volume Flow Meters (Mechanical)
- Vibration Analysis

STANDARD TEST DESCRIPTION

Acoustic Emission

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.

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 (e.g., consultants, outside labs).

TESTING METHODS

STANDARD TEST DESCRIPTION (Continued)

Acoustic Resonance

Applying 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. This method is 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. This method is excellent for analyzing piping systems, bearings, and gears.

Correlation Water Leak Testing

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

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, samples are drawn, either with an aspirator or an electric pump, into a reaction chamber where the sample 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, furnaces, etc.

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 locating piping and identifying flaws such as delaminations in concrete.

Moisture Tracer

Moisture trapped in materials affects the conductance of those materials relative to passage of electronic signals. Moisture can be detected by passing low frequency radio signals between a transmitter and a receiver traversing the questionable material. This technique allows moisture identification in roofing without cutting into the membrane.

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. Monitor output analysis allows the operator to determine bearing condition and remaining useful life.

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.

TESTING METHODS

STANDARD TEST DESCRIPTION (Continued)

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, 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 in turn produces sound. Transducers can be clamped to piping to monitor the intensity and direction of this sound. Microprocessors can be used to convert this information into velocity, and given the piping dimensions, determine volumetric flow-rate. While 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. A generated pulse echo can be monitored to identify location of interfaces. Measuring the velocity and attenuation of the pulse can determine material characteristics. This method is commonly used to identify flaws in metal structures.

Velocity/Volume Flow Meters (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. While primarily used in balancing of 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. An equipment signature can be developed by measuring and recording these parameters at key equipment points. 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. These techniques can be used as precursors to equipment failures and predictors of remaining useful life.

NON-STANDARD TEST METHODS

- Borescopic Inspections
- Displacement Gauges
- Dye Penetrants
- Eddy Current Techniques
- Gas Leak Detection with Tracers
- Smoke Testing
- Television Inspection

TESTING METHODS

NON-STANDARD TEST DESCRIPTION

Borescopic Inspections

Using a combination of lenses 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. This is an excellent tool for small tank and pipe inspections, engine interiors, pumps, etc.

Displacement Gauges

A generic term used to cover a group of devices used to 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 to identify warpage, shaft distortion, bearing wear, 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. This method is 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 heat exchanger tubing.

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 may then be used to identify leak location.

Smoke Testing

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

Television Inspections

The user can scan and record inaccessible surfaces using remotely operated cameras and lighting systems. This is an excellent tool for large tanks and underground pipe inspections.

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 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 inspections only and utilizes the standard guide sheets as a reference.

TABLE ONE

Assembly/Component	Annual Inspection	Biennial	Triennial	5 Years	10 Years
General Components:					
Air Compressors	S			NS	
Automated Dessicant Air Dryer		S		NS	
Compressed Gas Storage Tanks			S		
Engines	S			NS	
Equipment Controls			S	NS	
Interceptors, Traps, & Drains			S		
Motors			S		NS
Pipe & Accessories			S	NS	
Pumps	S				NS
Refrigerated Air Dryer		S		NS	
Sewage Ejectors	S			NS	
Storage Tanks		S		NS	
Tanks & Sumps		S		NS	
Water Conditioners			S		NS
Water Heaters	S			NS	
Fire Protection System:					
Alarm Check Valves	S		NS		
Detectors, Alarms, Operating Devices			S	NS	
Hose Cabinets			S	NS	
Pipe, Fittings, Valves, Supports			S	NS	

S - STANDARD GUIDE SHEET- NS - NON STANDARD GUIDE SHEET

INSPECTION FREQUENCY

TABLE ONE

Assembly/Component	Annual Inspection	Biennial	Triennial	5 Years	10 Years
Heating System:					
Boilers, Fuel-Fired	S,NS				
Boilers, Electric	S,NS				
Burners	S,NS				
Condensate Return Tanks		S		NS	
Deaerators		S		NS	
Furnaces	S				
Terminal Heating Units		S		NS	
Cooling System:					
Absorption Chillers	S			NS	
Centrifugal Chillers	S			NS	
Condensers	S			NS	
Condensing Units	S			NS	
Cooling Towers	S,NS				
Liquid Coolers	S			NS	
Packaged Chillers	S			NS	
Reciprocation Compressors	S			NS	
Terminal Cooling Units		S		NS	
Ventilation:					
Air Handlers	S			NS	
Ductwork & Accessories			S		NS
Fans			S		NS
Packaged HVAC Units	S			NS	

S - STANDARD GUIDE SHEET — NS - NON STANDARD GUIDE SHEET

END OF SUBSECTION

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**
0.08 MECHANICAL		
0.08.01 Plumbing		
PIPE & PIPE FITTINGS		
Black steel pipe, schedule 40, 1/2-8"	30	20
Copper, type K, including fittings and supports. 1/2-2"	35	30
Copper, type L, including fittings and supports, 3/8-3"	35	30
VALVES		
Bronze gate valves, 3/8-1"	15	50
Iron body. bronze mounted gate valves, 6"	15	50
Brass tee and lever handle type, 1/2-3/4"	15	100
Hose gate drain valves, bronze 2"	15	100
SHOCK ABSORBERS		
Shock absorbers, 3/4 x 4" long	25	100
WATER METERS		
Disk-type water meters, 3/4-2" diameter	25	100
INSULATION		
Piping insulation, 1/2-2 1/2"	15	75
CIRCULATING PUMPS (IN-LINE)		
Iron body circulation pump, 1/12 hp	15	50
Iron body circulating pump, 1/8 hp	15	50
Iron body circulating pump, 1/2 hp	15	50
DOMESTIC HOT WATER GENERATORS		
Gas-fired hot water generator, commercial, cement lined, 70% efficient, 500 - gal/h recovery rate	20	100
Gas-fired hot water generator, commercial, cement lined, 75% efficient, 100 - gal/h recovery rate	20	100
Electric-heated hot water generator, residential, glass lined, 100% efficient, 8-120 gal/h recovery rate	20	100
PIPE & PIPE FITTINGS		
Cast iron soil pipe, extra heavy (bell), 2-6"	40	100
Cast iron soil pipe, no hub, 1 1/2-2"	40	100
FLOOR DRAINS		
Cast iron flat round-top floor drains, 3-5" outlet	40	100
Cast iron flat square-top floor drains, 3-5"outlet	40	100
Rough brass top funnel-type floor drains, 3-4" outlet	40	100
Cast iron top floor drain with bucket, 3-6" outlet	40	100
AREA DRAINS		
Cast iron area drains, grate, 3" throat	40	100
TRENCH DRAINS		
Trench drain, light duty, 2-4" outlet - 2' 0" overall	25	100
WATER CLOSETS		
Floor-mounted water closets, washdown, and siphon jet types	35	100
Wall-mounted water closets, washdown, and siphon jet types	35	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.08 MECHANICAL		
0.08.01 Plumbing (Continued)		
URINALS		
Pedestal-type urinals, washdown, and siphon jet types	35	100
Wall-hung urinals, washdown, blowout, and siphon jet types	35	100
Floor-mounted urinals, washdown, and women's type	35	100
LAVATORIES		
Vitreous china, wall-hung lavatory, 20 x 18"	35	100
Iron enamel, wall-hung lavatory, 20 x 18"	40	100
Enameled steel, wall-hung lavatory, 20 x 18"	35	100
BATHTUBS		
Cast iron enamel bathtub, 5' 0" recessed	40	100
Enameled steel bathtub, 5' 0" recessed	35	100
SHOWERS		
Terrazzo shower receptor, 32 x 48"	50	100
Enameled steel shower receptor 32 x 48"	35	100
Plastic shower receptor, 32 x 48"	20	100
Aluminum and glass shower, commercial grade	25	100
WASH SINKS		
Iron enamel, highback, single sink, 24 x 48"	35	100
Enameled steel, highback, single sink, 24 x 48"	35	100
Stainless steel, highback, single sink	40	100
Plastic, highback, single sink	15	100
DRINKING FOUNTAINS		
Stainless steel electric drinking fountain	20	100
PIPE & FITTINGS (up to 3")		
Gas and oil	20	40
VALVES & COCKS (up to 3")		
Gas and oil	20	50
PIPING SPECIALTIES & ACCESSORIES (up to 3")		
Gas and oil	20	50
METERS (up to 3")		
Gas	30	25
Oil	20	50
TAN KS		
Oil storage	20	100
PUMPS (up to 3")		
Oil	15	50
EQUIPMENT		
Gas compressor	15	20
Oil preheater (steam)	15	25
Preheater (electric)	10	50
INSULATION	15	75

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life. Years	**Percent Replaced**
0.08.02 Fire Protection Automatic sprinkler system, wet type, concealed piping	**Life**	**100**
Simplex-type fire pumps, 20 hp, 500 gpm, 1750 rpm	20	100
Fire hose cabinets, primed steel, 1 25" hose, recessed	Life	100
Siamese connection, brass, 2 1/2 x 2 1/2 x 4"	Life	100
Roof manifold, brass (vertical), 2 1/2 x 2 1/2 x 4"	Life	100
Dry chemical enameled steel extinguisher	Life	100
0.08.03 HVAC BOILERS (steam) Packaged marine type (No. 2 oil) • 40 hp	25	100
• 50 hp	25	100
• 150 hp	25	100
• 700 hp	25	100
Packaged marine type (No. 6 oil) • 80 hp	25	100
• 250 hp	25	100
• 700 hp	25	100
Steel-fire box, base, jacket (light oil) • 25 hp	20	100
• 160 hp	20	100
• 540 hp	20	100
Steel-fire box, base, etc., packaged • 50 hp	20	100
• 170 hp	20	100
• 460 hp	20	100
Cast iron sectional w/jacket, trim, & burner (No. 6 oil) • 60 hp	20	100
• 120 hp	20	100
• 170 hp	20	100
Cast iron sectional with jacket, trim, and burner (steam and gas) • 40 hp	25	100
• 100 hp	25	100
• 170 hp	25	100
Hot water (gas)	20	100
Hot water (electric)	15	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	**Replacement Life,** Years	Percent **Replaced**
0.08 MECHANICAL SYSTEMS		
0.08.03 HVAC (Continued)		
FURNACES		
Upflow, gas-fired		
. 80,000 BTU	20	100
. 105,000 BTU	20	100
Upflow, oil-fired		
. 85,000 BTU	20	100
. 100,000 BTU	20	100
. 125,000 BTU	20	100
Upflow, electric heat		
. 77,400 BTU, 22 kW, 240V	15	100
. 120,000 BTU	20	100
. 140,000 BTU	20	100
Horizontal flow, gas-fired		
. 105,000 BTU	20	100
. 125,000 BTU	20	100
PUMPS		
Horizontal split case type		
. 3x2 1/2", 1 1/2 hp	20	100
. 5 x 4", 20 hp	20	100
• 10x 8", 125 hp	20	100
End suction type		
. 1 1/2 x 1 1/4", 3/4 hp	15	100
. 3 x 2 1/2", 1 1/2 hp	15	100
. 5 x 4", 7 1/2 hp	15	100
AIR CONTROL		
Boiler fittings	20	100
Air separators		
• 56 gal/min (2" screwed)	20	100
• 300 gal/min (4" flanged)	20	100
• 2,950 gal/min (12" flanged)	20	100
Compression tank and fittings		
• 15 gal (13" diameter x 34 1/2")	20	100
• 180 gal (30" diameter x 70")	20	100
• 280 gal (36" diameter x 74")	20	100
AUXILIARY EQUIPMENT (up to 500 ph)		
Feed water treatment	15	100
Deaerators	20	100
Breeching	20	100
Flues	20	100
Draft control	15	100
HEAT EXCHANGERS		
DX	20	100
Water or steam	20	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	**Replacement Life, Years**	**Percent** Replaced
0.08 MECHANICAL SYSTEMS		
0.08.03 HVAC (Continued)		
HEAT RECOVERY		
All types	15	100
EQUIPMENT INSULATION		
All types	15	100
WATER CHILLING		
Reciprocating compressor, electric		
• 81 ton caoacitv	20	100
Centrifugal compressor, electric		
• 120 ton capacity	20	100
Absorption machine, steam		
• 230 ton capacity	20	100
HEAT PUMPS		
Single package, air-to-air		
. 24.000 BTU	10	100
• 48,000 BTU	15	100
. 60,000 BTU	15	100
Split system, air-to-air		
• 36,600 BTU outdoor	15	100
• 36,000 BTU indoor	15	100
COOLING TOWERS		
Packaged centrifugal blow-through		
• 200 ton capacity	15	100
Packaged axial flow		
• 200 ton capacity	15	100
Packaged draw-through		
• 150 ton capacity	15	100
Ejector type		
• 250 ton capacity	20	100
CONDENSERS		
Water-cooled condenser		
• 30 ton capacity	20	100
Air-cooled condenser		
• 100 ton capacity	20	100
Evaporative condenser		
• 10 ton capacity	20	100
PIPE & FITTINGS	20	40
DIVERTING VALVES	15	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.08 MECHANICAL SYSTEMS		
0.08.03 HVAC (Continued)		
FREEZE PROTECTION	15	100
PUMPS		
Horizontal split case type		
. 3x2 1/2", 1 1/2 hp	20	100
. 5 x 4", 20 hp	20	100
• 10 x 8", 125 hp	20	100
End suction		
• 1 1/2 x 1 1/4", 3/4 hp	15	100
. 3 x 2 1/2", 1 1/2 hp	15	100
. 5 x 4", 7 1/2 hp	15	100
DIRECT EXPANSION SYSTEM		
Refrigerant circulation system	30	100
Pipe and fittings	30	100
Accessories	25	100
INSULATION (piping and equipment)	15	75
PIPE & FITTINGS	20	40
VALVES		
Gate	15	50
Butterfly	15	50
Plua	15	50
OS&Y (outside screw and yoke)	15	50
PIPING SPECIALTIES &ACCESSORIES	10	50
PUMPS		
Horizontal split case type		
• 2-3" size up to 1 1/2 hp	20	100
• 4-5" size up to 20 hp	20	100
• 8-10" size up to 125 hp	20	100
End suction		
• 1 1/4 1 1/2" size up to 3/4 hp	15	100
• 2-3" size up to 1 1/2 hp	15	100
• 4-5" size up to 7 1/2 hp	15	100
Distribution systems		
• Steam	20	50
. Glycol	20	50
• Other liquid	20	50

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.08 MECHANICAL SYSTEMS **0.08.03** HVAC (Continued) AIR-HANDLING EQUIPMENT Single zone with mixing box HW coil, CW coil, flat filter 1750-2750 cfm	20	100
Single zone with mixing box HW coil, CW coil, manual roll filter 1750-2750 cfm	20	100
Single zone with mixing box, HW coil, CW coil, auto roll filter 1750-2750 cfm	20	100
Single zone with mixing box HW coil, DX coil, flat filter 1750-2750 cfm	20	100
Roof top unit 1750-2750 cfm	15	100
Single zone with mixing box, HW coil, DX coil, roll filter 1750-2750 cfm	20	100
Single zone with mixing box, HW coil, DX coil, auto roll filter 1750-2750 cfm	20	100
Four zone with mixing box, dampers, HW coil, CW coil, flat filter 1750-2750 cfm	20	100
Four zone with mixing box, dampers, HW coil. CW coil, roll filter 1750-2750 cfm	20	100
Four zone with mixing box dampers, HW coil, CW coil, auto roll filter 1750-2750 cfm	20	100
Air tempering (packaged) . 24,000 BTU	15	100
Air temperature (split system) outdoor section . 24,000 BTU	15	100
. 60,000 BTU	15	100
Air tempering (split system) . 24000 BTU	20	100
. 60,000 BTU	20	100
AIR TEMPERING (incremental) Through wall type, fixed . 11,700 BTU cool	10	100
• 13,300 BTU Heat (HW)		
Through wall type . 11,700 BTU Cool	10	100
• 15,300 BTU Heat (elect)		
Through wall type, remove chassis . 14,600 BTU	10	100

STANDARD SYSTEM DESIGN LIFE TABLES

ITEM DESCRIPTION	Replacement Life, Years	Percent Replaced
0.08 MECHANICAL SYSTEMS		
0.08.03 HVAC (Continued)		
DUCTWORK		
Round		
• Low pressure	Life	100
• Medium pressure	Life	100
• High pressure	Life	100
Rectangular		
• Low pressure	Life	100
• Medium pressure	Life	100
• High pressure	Life	100
Plenums	Life	100
REGISTERS &GRILLES		
12 x 8"	25	100
DIFFUSERS		
8" Neck	25	100
DAMPERS		
8" Round	25	100
TROFFERS (Light texture type)	20	100
AIR TREATMENT EQUIPMENT	20	100
HEAT RECOVERY EQUIPMENT	15	100
ANTIVIBRATION EQUIPMENT	15	100
INSULATION		
Cooling (vapor barrier)	15	75
Heating	15	75
EXHAUST FANS		
Direct drive, 1/4 hp	20	100
Belt drive, 1/2 hp and over	20	100
VENTILATORS	15	100
MAKEUP AIR UNITS	20	100
Inside/Outside	15	100
BASEBOARD HEATING UNITS (hot water)		
Radiant, cast iron panel		
• 7 1/4" high	30	100
Nonferrous element		
• 4" deep x 36" long	25	100
CONVECTOR HEATING UNITS		
Baseboard panel with 9 l/l 8" high enclosure		
• 1" Tube	20	100
Free standino or semirecessed		
• 24" high x-36" long	25	100
INDUCTION UNIT W/CABINET		
90-510 cfm	20	100
FAN COIL UNITS W/CABINETS		
155-215 cfm	20	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	**Replacement Life,** Years	**Percent Replaced**
0.08 MECHANICAL SYSTEMS		
0.08.03 HVAC (Continued)		
RADIATORS		
Cast iron, free standing		
• Six tube, 32" high	40	100
• Five tube, 22" high	40	100
• Three tube, 25" high	40	100
FINNED TUBE ELEMENTS		
Copper fin-tube		
• 48 fins/ft, 1 1/4" pipe	35	100
Steel Fin-Tube		
• 40 fins/ft	35	100
DUCT-MOUNTED COIL SECTIONS		
Duct-mounted coil sections, steam	20	100
Duct-mounted coil sections, hot water	20	100
Duct-mounted coil sections, electric	15	100
RADIANT HEATING UNITS		
Radiant heating units, electric	40	100
Radiant heating units, hot water	25	100
UNIT HEATERS		
Unit heaters, gas	15	100
Unit heaters, electric	15	100
Unit heaters, hot water	20	100
Unit heaters, steam	20	100
Space heater, steam/hot water	20	100
Air curtains, steam/hot vater	20	100
Unit air conditioners with heating	15	100
Package humidifiers	10	100
Package dehumidifiers	15	100
ROOM THERMOSTATS		
Low voltage heating	25	100
Low voltage cooling	25	100
Line voltage heating	25	100
Low voltage heating and cooling	25	100
Line voltage heating, heavy	25	100

STANDARD SYSTEM DESIGN LIFE TABLES

TABLE TWO

ITEM DESCRIPTION	**Replacement Life, Years**	Percent **Replaced**
0.08 MECHANICAL SYSTEMS **0.08.03 HVAC** (Continued) POSITIONAL DAMPER-Motor-Actuated Modulating type with external return spring-transformer, inspection and 115 VAC	20	100
Modulating type with Internal return spring-transformer, 115 VAC	20	100
1" Modulating motorized valves	15	100
I $^{1}/_{4}$" Modulating motorized valves	15	100
I $^{1}/_{2}$" Modulating motorized valves	15	100
2" Modulating motorized valves	15	100
UNIVERSAL RELAYS SPST, use w/low voltage controls, heat only	25	100
SPDT, use w/low voltage controls, heat or cool only	25	100
DPDT, use w/low voltage controls, heat and cool	25	100
AQUASTATS External bellows type, close on pressure drop, 2-50lb range	25	100
Remote bulb tvpe. mercurv tube thermostat	25	100
Make circuit on drop-line voltage	25	100
Make circuit on rise-line voltage	25	100
OTHER CONTROLS All parts, components, devices, tubing, wiring, and accessories necessary to control air and liquid distribution systems, components, and equipment	25	100
All parts, components, devices, tubing, wiring, and accessories necessary to monitor, record, or otherwise indicate status of any of the components of the distribution systems or equipment	25	100
All parts, components, devices, accessories, and equipment necessary to detect and repair leaks and to make adjustments, alignments, inspections, and sampling, and trial and final HVAC startup	N/A	N/A
All parts, components, devices, piping or duct systems, accessories, and equipment for special cooling or heating systems, storage cells, dust and fume collectors, deodorizing system, carbon monoxide equipment, special sound attenuating equipment, air curtains, paint spray booth, and ventilation system	Per item	100
All parts, components, devices, piping or duct systems, accessories, and equipment	Per item	100
0.08.05 Special Mechanical Systems Simplex air compressor, 1 hp with 30 gal receivery	25	100
Vacuum pumps, controls, and accessories, 1 hp with 30 gal receiverv	25	100
Carbon dioxide cvlinders. simolex and duplex	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

0.08 SYSTEM - MECHANICAL

0.08.01	PLUMBING
0.08.01.01	Domestic Water Systems
0.08.01.02	Drain, Waste, & Vent Systems
0.08.01.03	Compressed Air Systems
0.08.01.04	Vacuum Systems
0.08.01.05	Gas Systems
0.08.02	FIRE PROTECTION
0.08.02.01	Wet Pipe Sprinkler Systems
0.08.02.02	Dry Pipe Sprinkler Systems
0.08.02.03	Standpipe Systems
0.08.02.04	Halon Fire Suppression
0.08.02.05	CO, Fire Suppression
0.08.03	HEATING & VENTILATING
0.08.03.01	Fuel Oil System
0.08.03.02	Boilers
0.08.03.03	Hot Air Furnaces
0.08.03.04	Heating Hot Water Distribution System
0.08.03.05	Steam Distribution & Condensate Return System
0.08.03.06	Chemical Water Treatment
0.08.03.07	Terminal Heating Units
0.08.03.08	Air Handlers & Fans
0.08.03.09	Ductwork & Accessories
0.08.04	COOLING
0.08.04.01	Centrifugal Chillers
0.08.04.02	Absorption Chillers
0.08.04.03	Packaged Reciprocating Chillers
0.08.04.04	Packaged HVAC Units
0.08.04.05	Packaged Condensing Unit
0.08.04.06	Refrigeration Compressors
0.08.04.07	Condenser
0.08.04.08	Cooling Towers
0.08.04.09	Chilled Water Distribution System
0.08.04.10	Condenser Water System
0.08.04.11	Chemical Water Treatment
0.08.04.12	Terminal Cooling Units
0.08.05	SPECIAL SYSTEMS
0.08.05.01	Drinking Water Cooling Systems

SYSTEM WORK BREAKDOWN **STRUCTURE**

WBS LEVEL TABLE

0.05	*LEVEL 1*	0.0
ROOFING	*SYSTEM*	**MECHANICAL**
0.05.01	LEVEL 2	**0.08.01**
BUILT-UP	***ASSEMBLY***	**PLUMBING**
0.05.01.01	*LEVEL 3*	**0.08.01.01**
MEMBRANE	***COMPONENT***	*Don.* **WATER**
0.05.01.01.01	*LEVEL 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

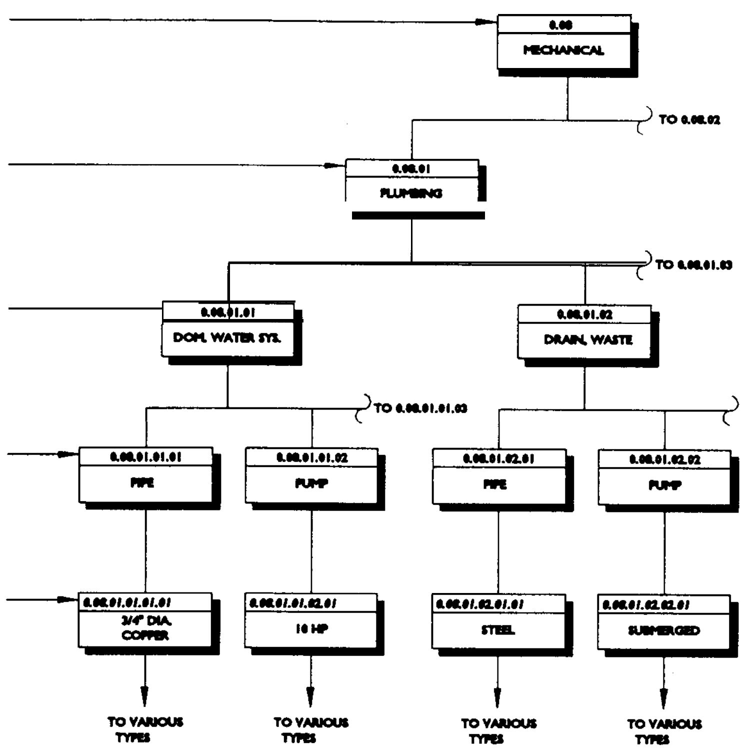


FIG. 1

SYSTEM WORK BREAKDOWN STRUCTURE

WBS LEVEL TABLE

0.05	LEVEL I	**0.08**
ROOFING	***SYSTEM***	**MECHANICAL**
0.05.01	***LEVEL 2***	**0.08.01**
BUILT-UP	*ASSEMBLY*	**PLUMBING**
0.05.01.01	***LEVEL 3***	**0.08.01.01**
MEMBRANE	*COMPONENT*	*Don. WATER*
0.05.01.01.01	***LEVEL 4***	**0.08.01.01.01**
3-PLY ASPHALT	***SUBCOMPONENT/ TYPE***	**PIPE**
0.05.01.01.01.01	*LEVELS*	**0.08.01.01.01.01**
NOT **USED**	***TYPE***	**3/4" DIA. COPPER**

WBS COST DEVELOPMENT HIERARCHY

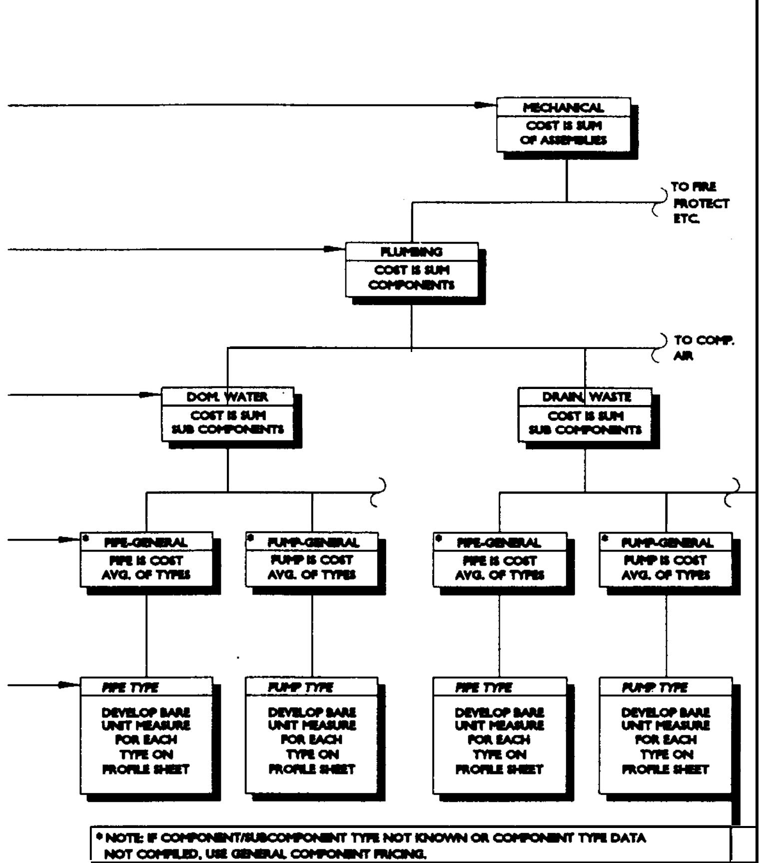


FIG. 2

END OF SUBSECTION

0.08.01 .Ol DOMESTIC WATER SYSTEMS (CSI 15411)

DESCRIPTION

The typical Domestic Water System provides potable water conditioning, heating, and distribution, taking its source from outside the building and terminating in domestic plumbing fixtures. The system consists of water conditioners (filters and softeners), water heaters, transfer and circulating pumps, and strainers, and the connecting piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Water Conditioners (CSI 15457)

Water Conditioners filter solids and other contamination in incoming water and control water hardness. In most large installations, more than one conditioner will be provided to allow for regeneration of the conditioner's capability.

Conditioners typically have:

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

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

Water Heaters (CSI 15460)

Water heaters elevate incoming water temperature to typically 120°F for bathing or 180°F for dishwashing.

In small facilities, the water heater is typically a glass-lined tank heated either by electric resistance heating elements or by a gas burner.

Larger facilities rarely employ electric heating except in small, point-of-use heaters (maintenance shops, garages, etc.). Large facilities typically employ a large storage tank with an incorporated heating coil. The coil is fed by a high-temperature water system or low-pressure steam.

Rarely, the water heater will be a large gas/oil-fired unit dedicated to domestic water use. As with all fossil-fueled units, particular attention must be paid to venting.

Tanks (CSI 15175)

Tanks are used primarily for storage and for load and surge control in a domestic water system. In remote locations, where the local water supply may be unreliable, facilities employ large holding tanks to maintain a reasonable reserve. This is also true in large buildings where continuity of supply would be dependent on booster pumps. In these buildings, the storage facilities (typically in building penthouses) provide a relative constant pressure and flow even when power is lost to the boosters.

Storage Tanks may be also employed to act as demand control devices in domestic hot water systems.

0.08.01 .01 DOMESTIC WATER SYSTEMS (CSI 15411)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Tanks (CSI 15175) (Continued)

Storage tanks are typically large, closed steel containers although some facilities do employ open, rectangular, lined concrete structures.

Storage tanks typically have:

- Corrosion protection system (sacrificial elements)
- Level control devices (float, electrode)
- Level indication (sight glasses)
- Relief valves on pressurized units.
- Tank Manholes for periodic servicing and inspections

Hot Water storage tanks are normally insulated.

Smaller tanks are sometimes placed in domestic water systems to compensate for the expansion and contraction of the water due to temperature changes and/or to provide NPSH for system pumps. These units are typically ceiling mounted, steel tanks, with automated makeup water (usually a Pressure reducing valve) and manual vents and drains. A sight glass is also provided.

pumps (CSI 15453)

Pumps provide for the hot water circulation throughout the distribution system to minimize the wait time involved when hot water is required at a far point in the system (also eliminates associated waste). Pumps are also used to boost system pressure in tall buildings or where the building is far from the water source.

Domestic water pumps are typically single-stage centrifugal pumps. Circulators are usually small (fractional horsepower) in-line units, and booster pumps are usually larger, pedestal-mounted units.

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

Motors (CSI 15170)

Circulator pumps are typically driven via spring-coupled, open AC motors. Booster pumps are typically driven via rigid or flex-coupled AC motors.

Piping & Rfflngs (CSI 15411)

Piping and fittings provide the distribution network for the domestic water system. In small facilities, this is usually a two-pipe system. In larger facilities, a third line is employed to recirculate domestic hot water.

DOE currently requires that copper be used for distribution: Type K below grade and Type L above grade. CPVC and PB plastic pipe and tubing are permitted where the pipe is not subject to impact damage or otherwise prohibited by DOE. However, older facilities may have brass, copper, or galvanized steel pipe. Where very large sizes are needed black iron (steel) or cast iron may be used.

All fittings should be compatible with the type of piping materials used in the system to minimize corrosion induced by galvanic action. Fittings for Type K are flared brass, solder-type bronze or wrought copper. Fittings for Type L are solder-type bronze or wrought copper.

Dielectric unions should be provided with appropriate end connections for the pipe materials installed (screwed, soldered, or flanged), which 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.

0.08.01 .Ol DOMESTIC WATER SYSTEMS (CSI 15411)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15411) (Continued)

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

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

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

Pipe penetrations of fire barriers should be sealed with fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valve8 (CSI 15100)

Valves are primarily used to switch conditioner tanks, isolate water heaters and other components for maintenance, and isolate terminal fixtures. In addition, shut-off duty valves are typically provided at each branch connection to supply mains.

Drain valves are installed at low points 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 the pump to prevent idle pump windmilling and system flow reversal in the hot water circulation lines.

Regulating valves are used to control water or steam flow through the storage tank heating coils and to control fuel to fossil heaters.

Relief valves are required on all water heaters and pressurized tanks.

A backflow preventer is used to prevent potable water contamination at any cross-connect between the potable water system and other systems (drainage, chill water, etc.). The codes have changed in recent years on permissible methods for backflow prevention. Caution should be used in selecting replacements.

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

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge point of each booster pump or pump group. They are rarely used with circulators.

Temperature gauges are usually provided on large water heaters, storage tanks, branch lines, and circulator pumps.

Hangers, Supports, & Anchors (CSI 15140)

Pipe hangers and supports are provided to support piping and to allow for expansion and contraction. They should be securely attached to building construction 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 elevated temperatures for dishwashing (180°F). However, it is not uncommon to see bare 120°F lines.

0.08.01 .01 DOMESTIC WATER SYSTEMS (CSI 15411)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Equipment Controls & panel8 (CSI 15950)

Few controls are used in the typical domestic water system. (In general, metering is provided at the source). The system is usually turned on and left running except for routine maintenance services.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Small in-line circulators may use a simple light switch for control. In some cases, system pressure is used to cycle the system booster pump.

Water temperature controls are provided either through thermal bulb sensing and by modulating an hydraulically controlled regulating valve, or by activating solenoid-operated valves or contacts.

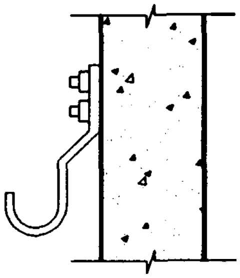
Fixtures (CSI 15440)

Fixtures covered in this specialty include sinks, water closets, showers, tubs, and water fountains. Service water heating shall provide 11 CPF flow within 10 seconds.

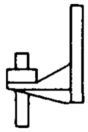
OTHER RELATED COMPONENTS

See the following subsections for related components:

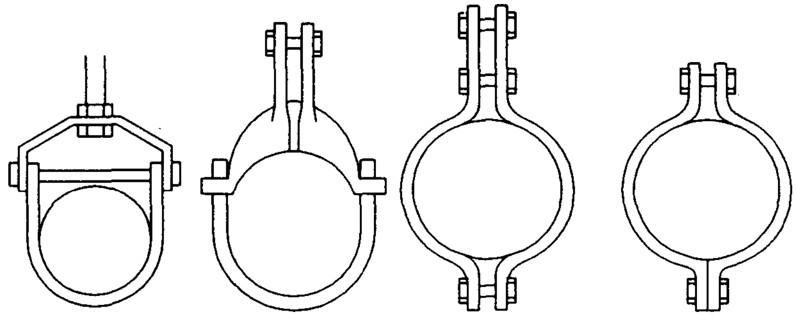
NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.



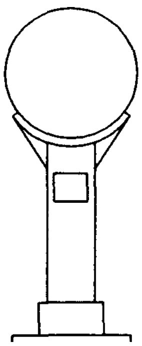
WALL BRACKET



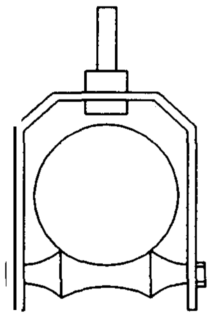
SIDE BEAM BRACKET



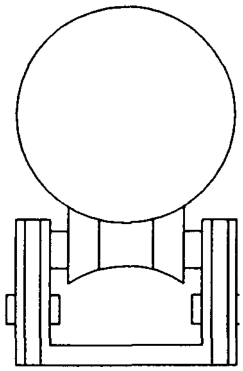
PIPE CLAMPS



PIPE SADDLE



ROLLER HANGER



BASE WITH ROLLER

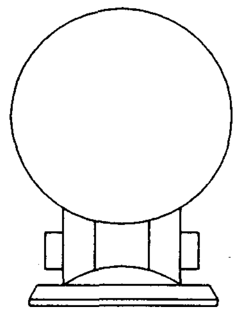
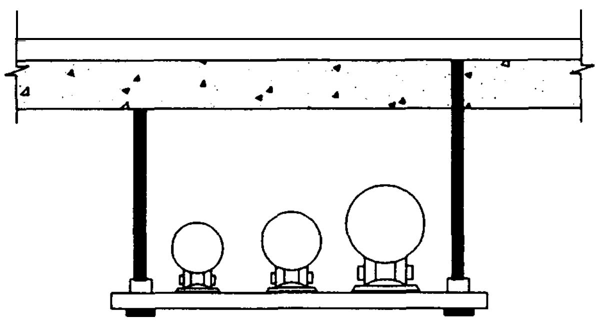
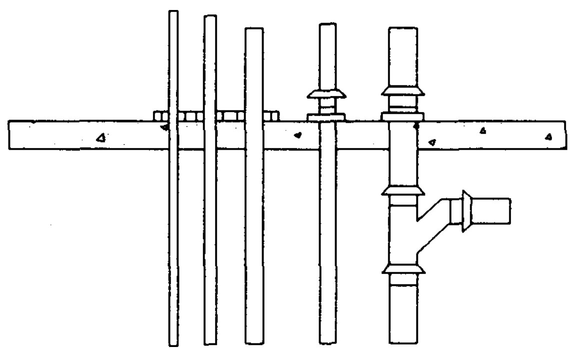


PLATE WITH ROLLER

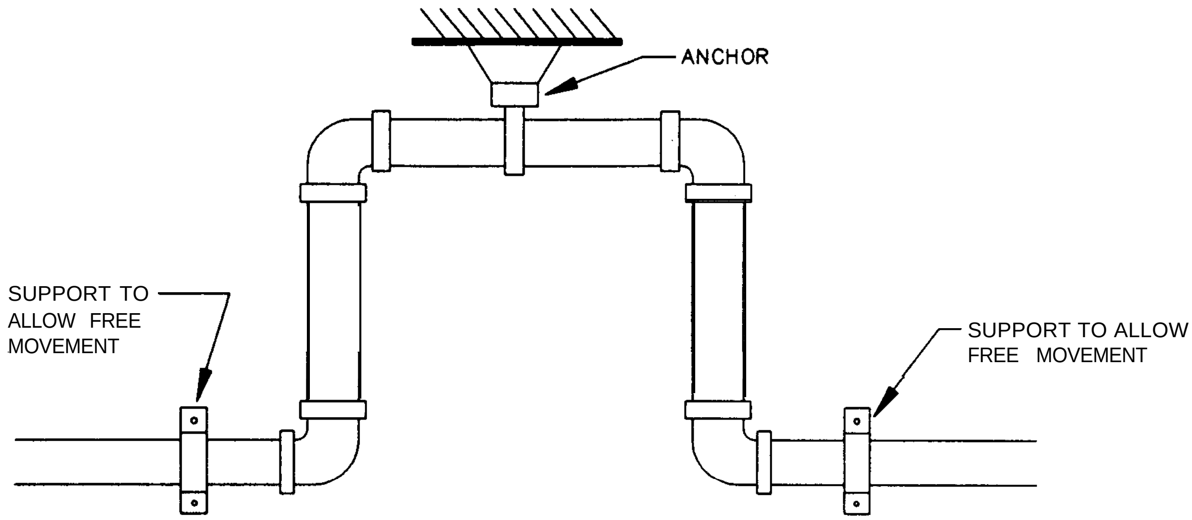


TRAPEZE HANGER

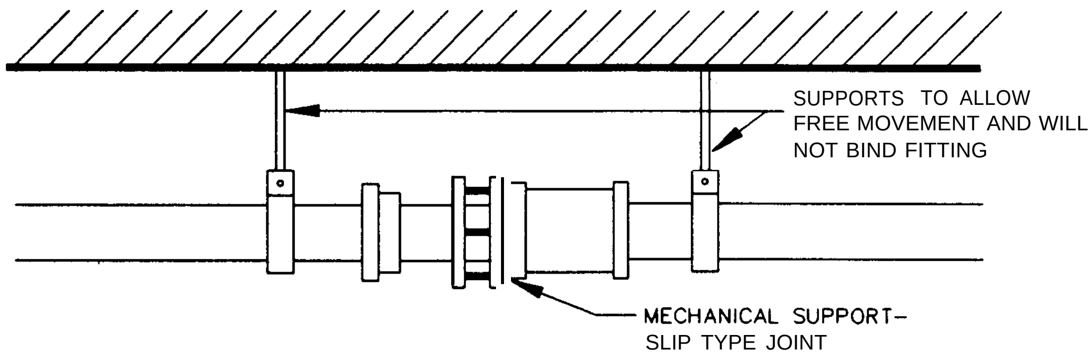


VERTICAL PIPE SUPPORTS

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PIPE HANGERS AND SUPPORTS		
PLUMBING-DOMESTIC WATER (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080101-1



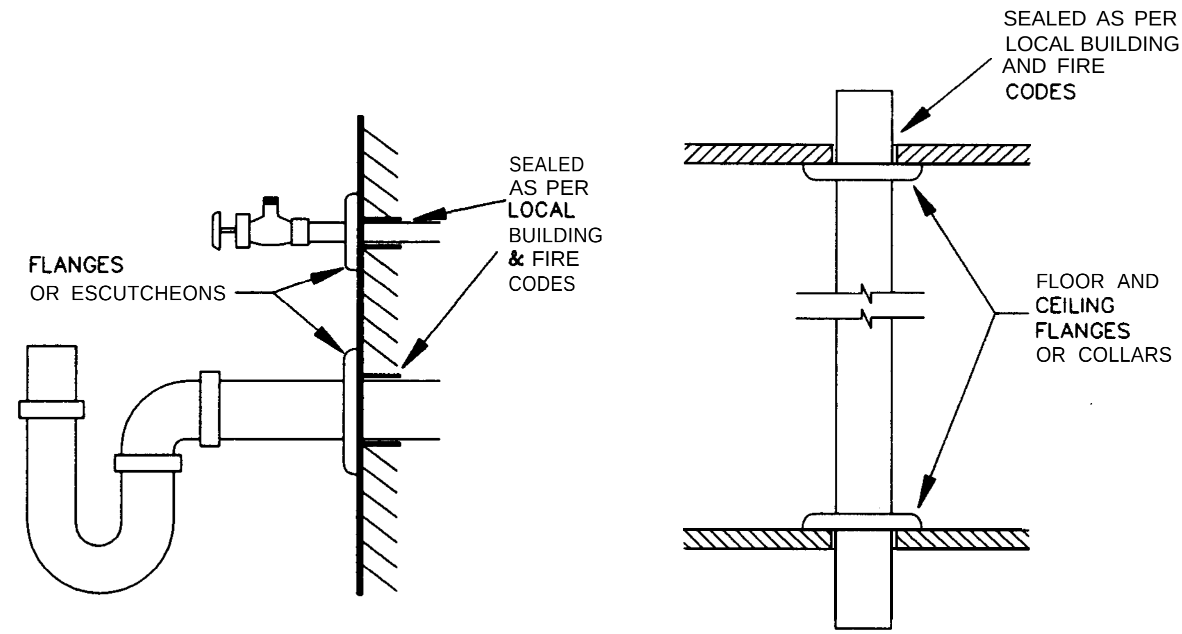
a. EXPANSION LOOP FOR WATER LINE



b. EXPANSION JOINT

(SUPPORTS AS SHOWN ALLOW FOR EXPANSION AND CONTRACTION)

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	EXPANSION ALLOWANCE FOR PIPING	
PLUMBING-DOMESTIC WATER (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080101-2



TYPICAL FINISHED TREATMENT OF OPENINGS

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	WALL AND FLOOR PENETRATIONS		
PLUMBING-DOMESTIC WATER (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080101-3

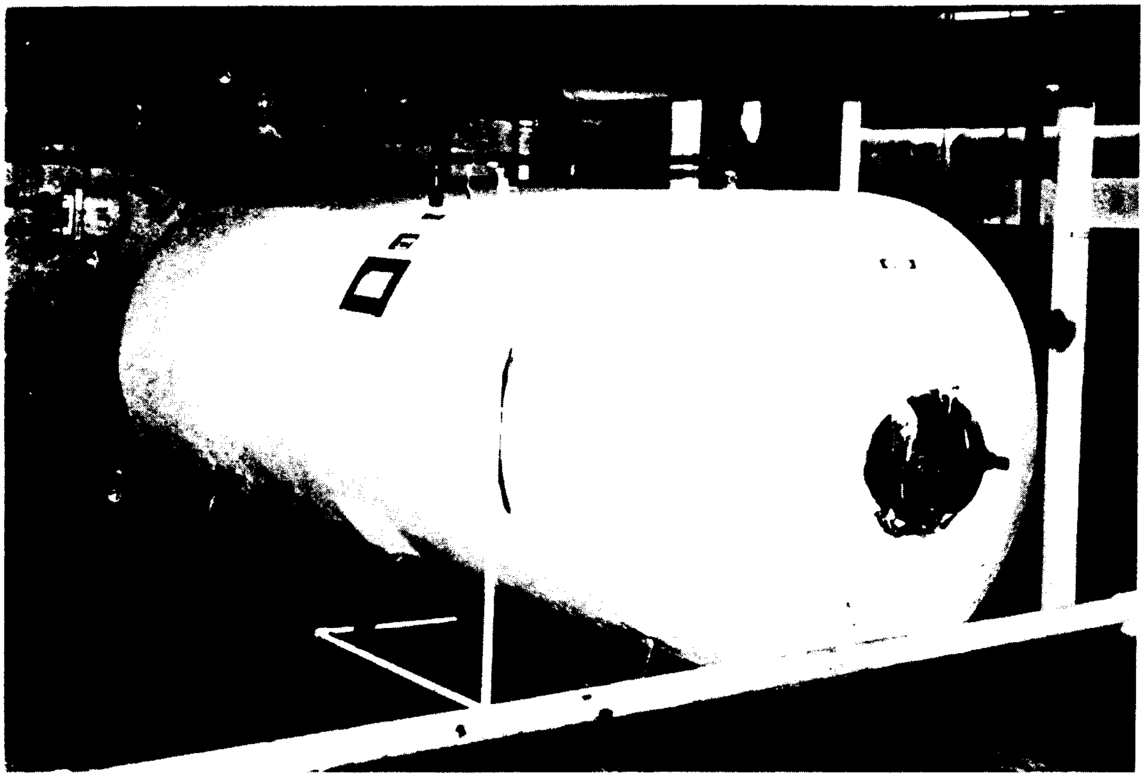


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	STORAGE TANK HEATER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-4

APPROVAL PENDING

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DOMESTIC WATER DISTRIBUTION		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-5

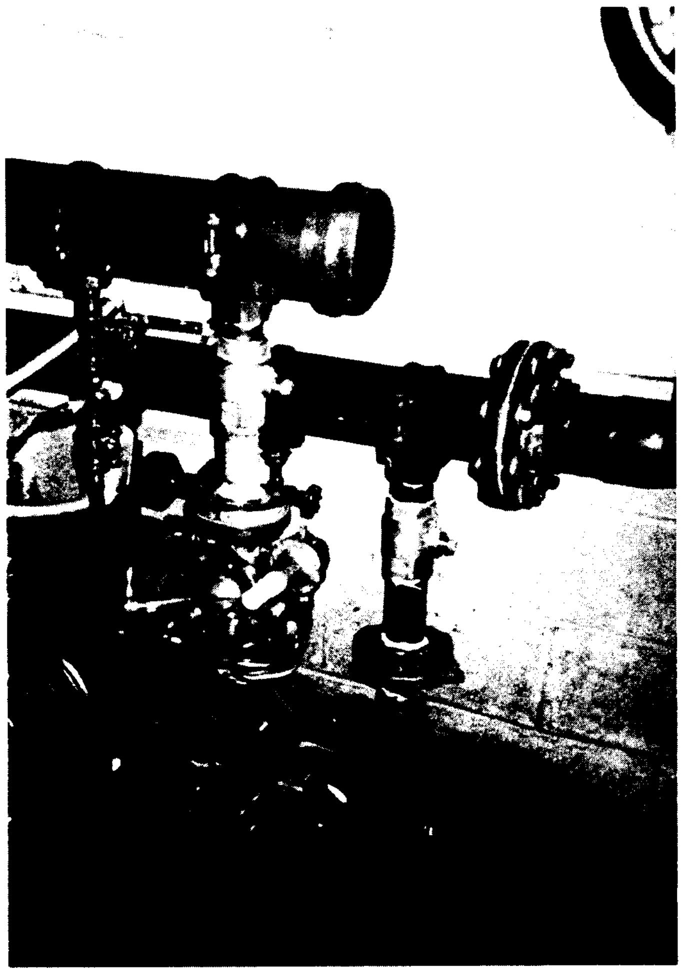
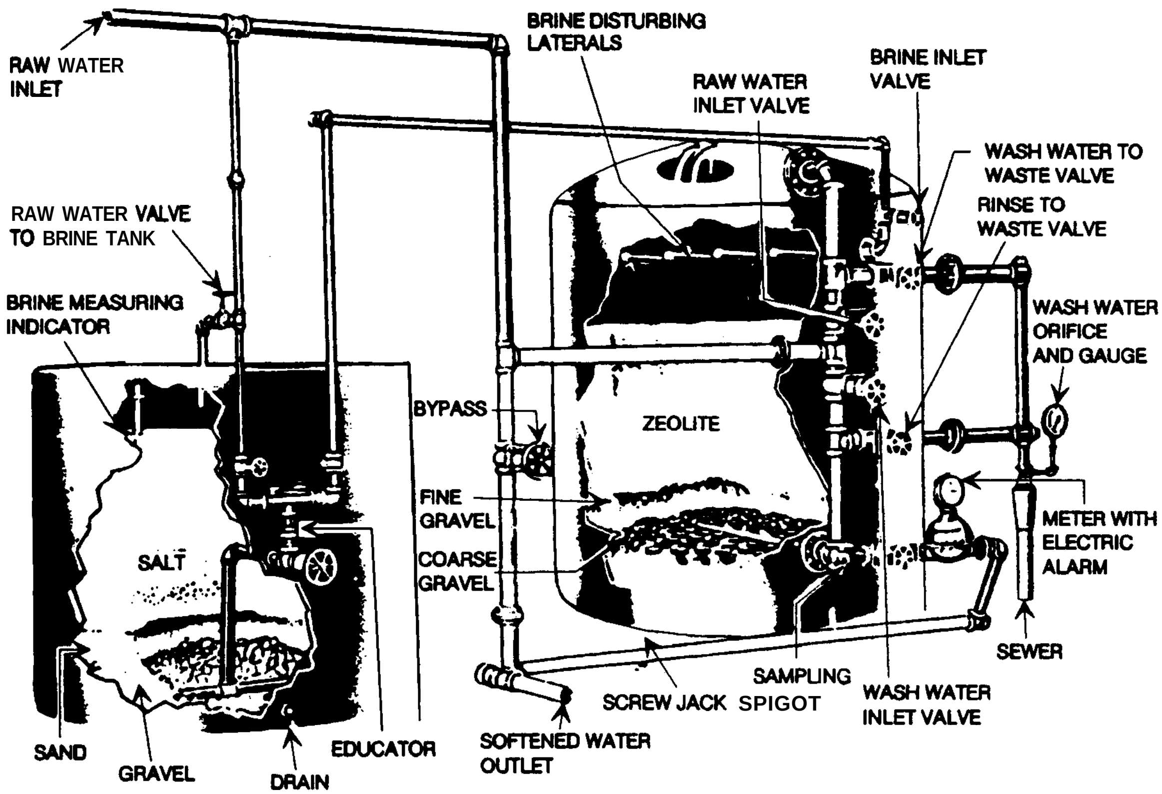


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL BOOSTER PUMP		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-6



SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SODIUM ZEOLITE SOFTENER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-7

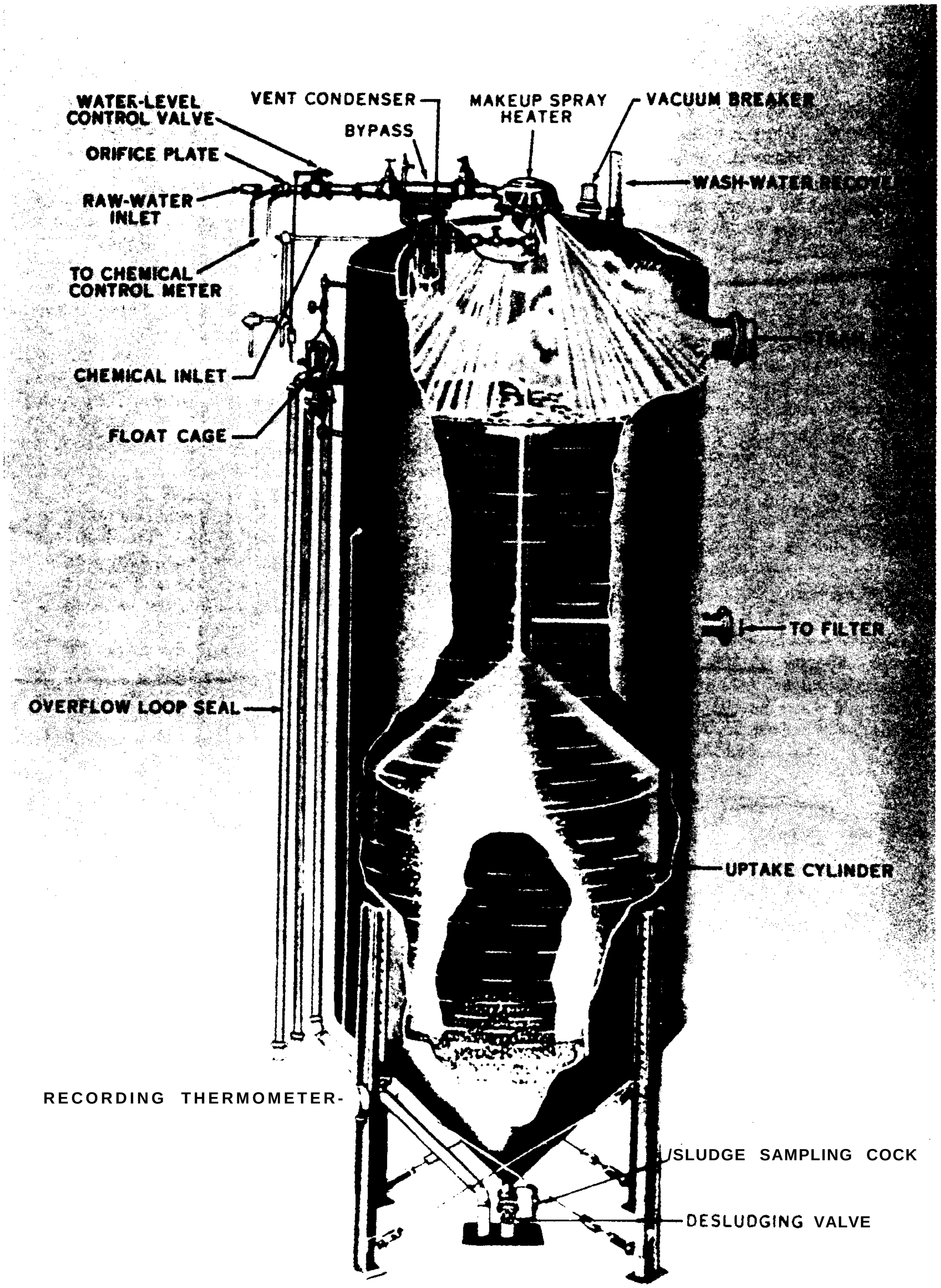
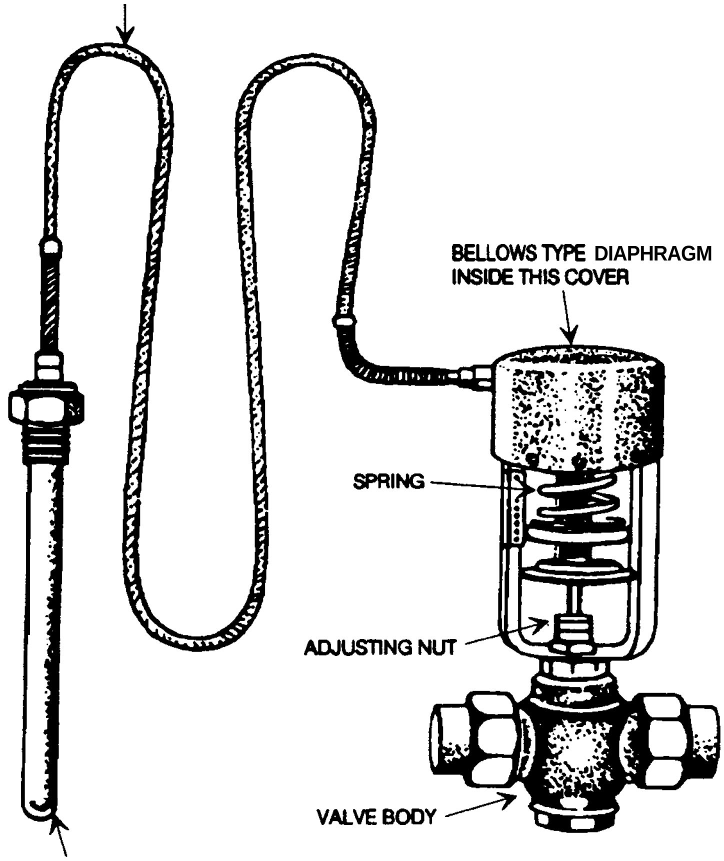


PHOTO ILLUSTRATION

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	LIME SODA SOFTENER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing NO. A080101-8



SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TEMPERATURE REGULATING VALVE		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-9

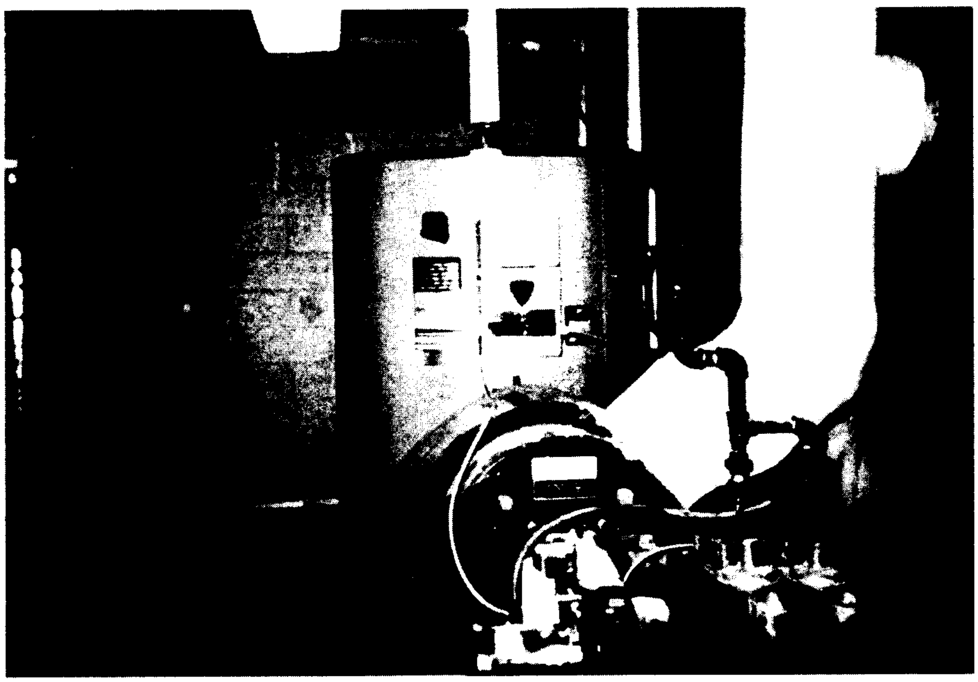


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	NATURAL GAS FIRED HOT WATER HEATER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-10

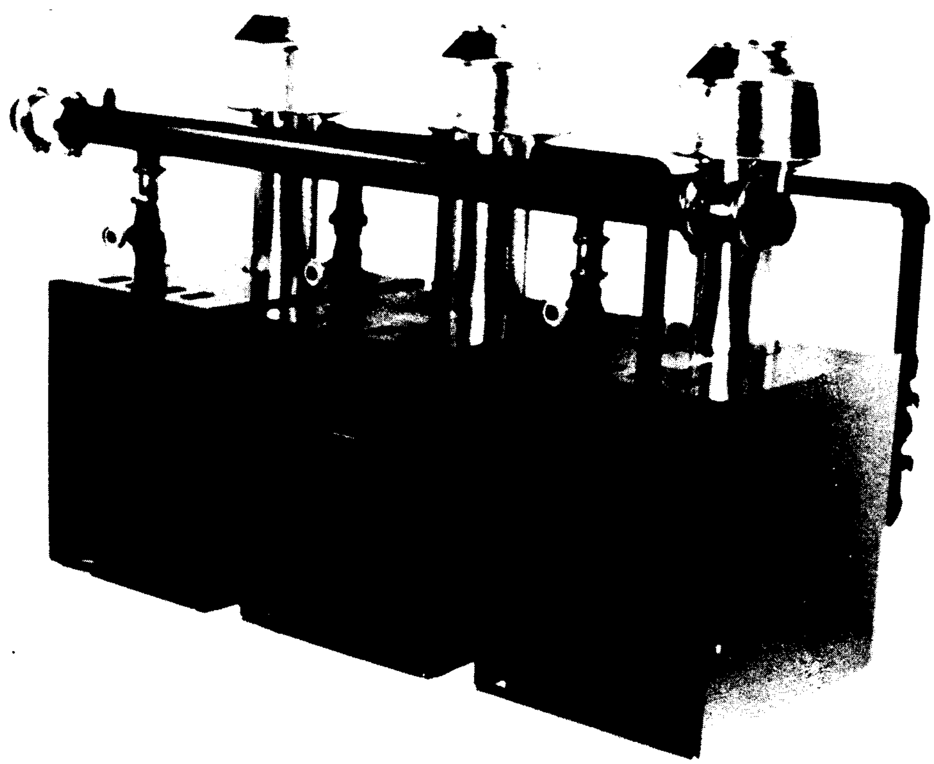


PHOTO ILLUSTRATION

SOURCE: ARMSTRONG INTERNATIONAL

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	GAS FIRED HOT WATER HEATERS IN PARALLEL CONFIGURATION		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-11

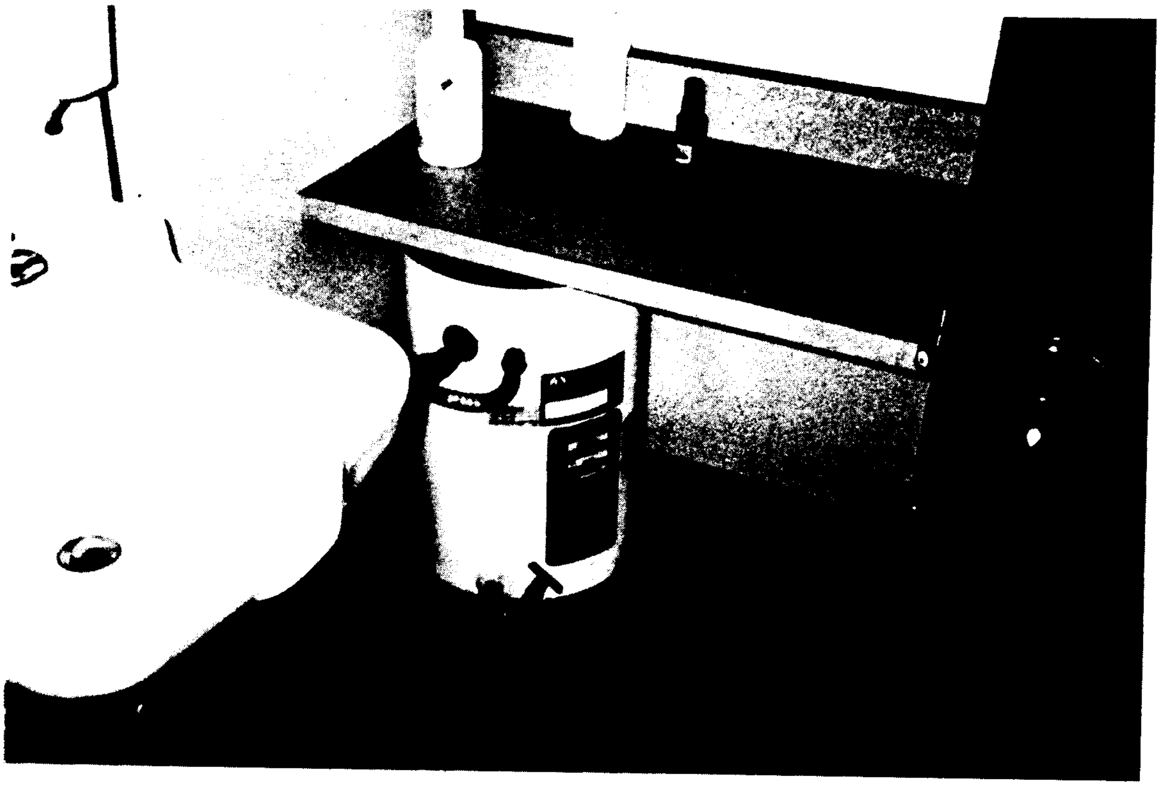


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	ELECTRIC HOT WATER HEATER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. A080101-12

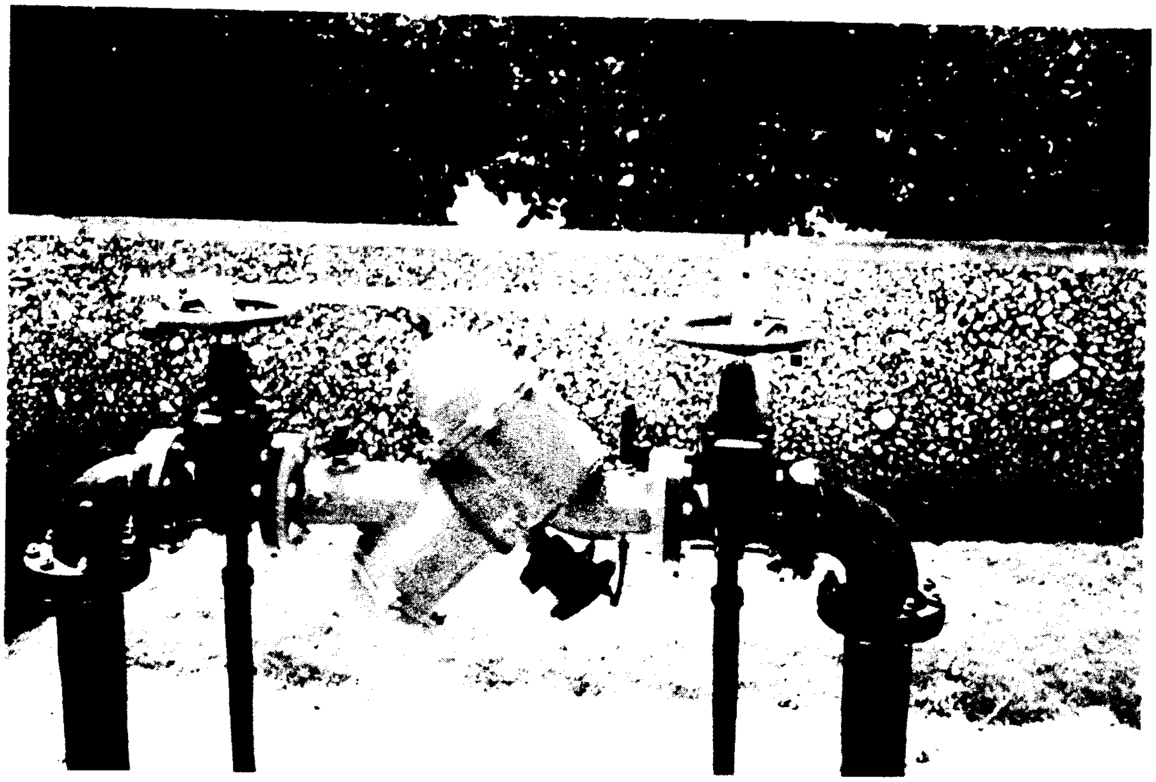


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BACKFLOW PREVENTOR		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Orawhg No. A080101-13

DEFICIENCY FACTORS
0.08.01 .Ol DOMESTIC WATER SYSTEMS (CSI 15411)

PROBABLE FAILURE POINTS

- Piping leakage due to corrosion, especially in hot water circuits where chemical reaction rate is greater and there is limited ability to treat the domestic water.
- Inability of system to deliver rated capacity to terminal points due to internal scaling of the distribution network.
- Inadequate pressure at terminal points due to piping failures and/or clogged strainers, filters, or aerators.
- Inadequate hot water temperature at terminal points due to heat losses in distribution lines; poor insulation.
- Inadequate temperature at terminal points due to insufficient heating capacity. Cold water at the hot water taps caused by circulator and/or check valve failure.
- Water conditioner cannot be regenerated due to caking, exhausted resin, or cycling system control failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Water Conditioners

Caked Bed:	Caused by normal use but accelerated by improper cycling of conditioner phase controls.
Exhausted Resin:	Caused by normal use but accelerated by improper cycling of conditioner phase controls.
Defective Spray Nozzles:	Blockage is usually due to scaling in feed lines.
Tank, Pipe, or Fitting Leakage:	Age, physical damage, severe internal or external corrosion; failure of gaskets at manhole or other fittings.
Defective Brine Tank Control:	Level control wear.
Excessive Corrosion:	Local conditions.

Water Heaters

Inoperative:	Control failure, blocked tubing, and open heating elements.
Inadequate Capacity:	Cannot maintain temperature due to blockage in tubing, scaling in tubes, and open electric elements.
Overheating:	Failure of control elements.
Shell Distortion:	Blisters or bulges in the metal caused by overheating, fatigue, physical damage, loss of external support.
Tank, Pipe, or Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage due to thermal fatigue.
Defective Burner:	Corrosion, blockage by scale, loose fasteners.
Defective Heating Elements:	Electrically open, scaling.
Ducts, Vents Leakage:	Corrosion, loose fasteners.
Excessive Corrosion:	Local conditions.

DEFICIENCY FACTORS
0.08.01.01 DOMESTIC WATER SYSTEMS (CSI 15411)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Tanks

Metal Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support.
Spalling, Cracking of Concrete:	Age, settling of structure, environmental conditions.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance, local environment.
External Leakage:	Due to severe internal or external corrosion; concrete cracking: metal splitting; gasket failure at manholes or other fittings.
Loose or Missing Fasteners:	Due to corrosion, damage.
Wet, Damaged, Missing Insulation:	Due to leakage, abuse, improper installation.

pump8

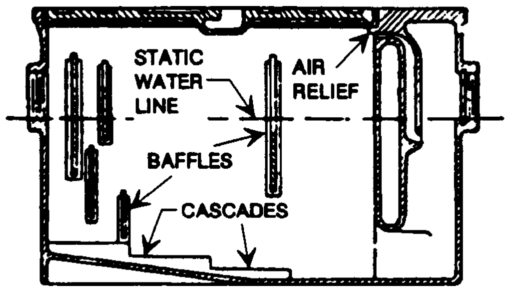
Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller, or locked motor.
Excessive Noise or Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective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

Motors

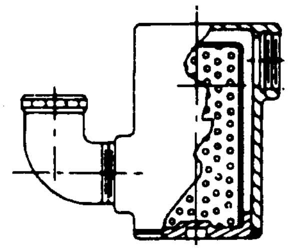
Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling: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

Piping **& Fittings**

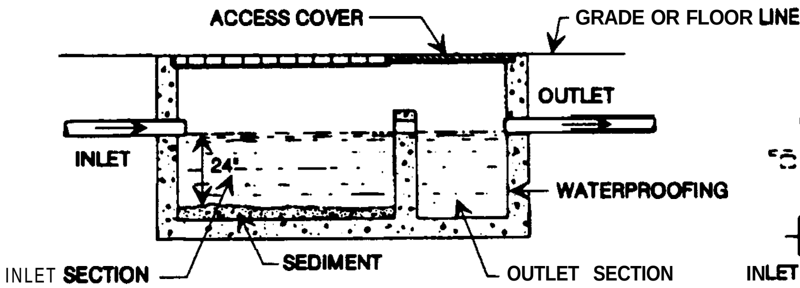
Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Caused by corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.



GREASE INTERCEPTOR

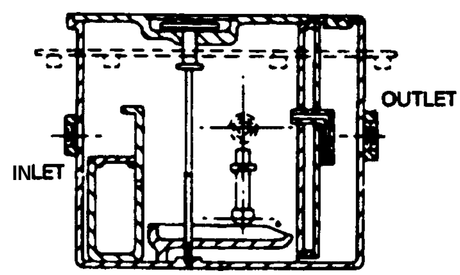


SOLIDS INTERCEPTOR



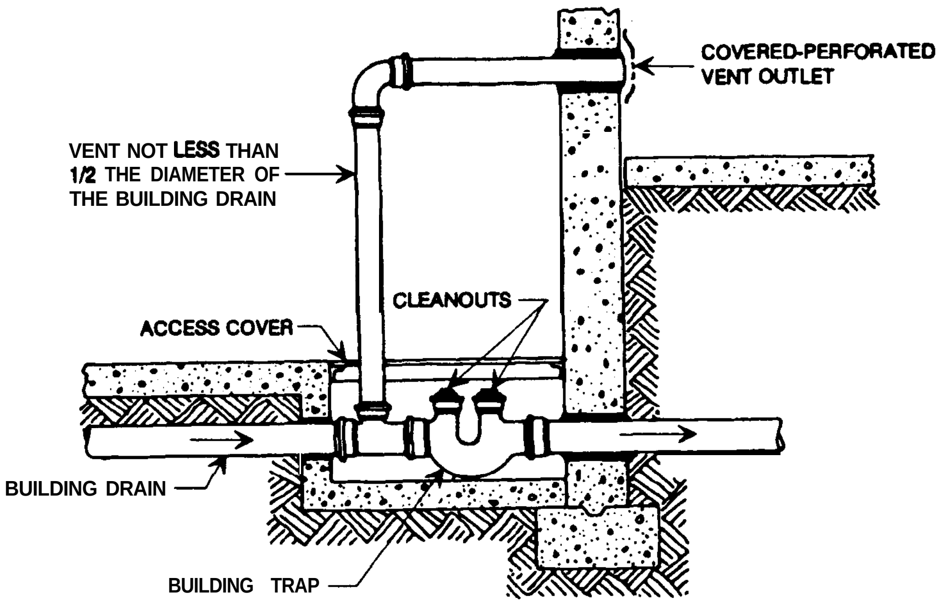
SECTION VIEW

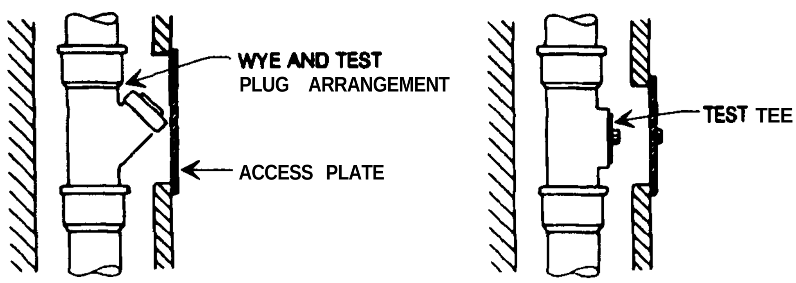
SAND INTERCEPTOR FOR OIL-GAS



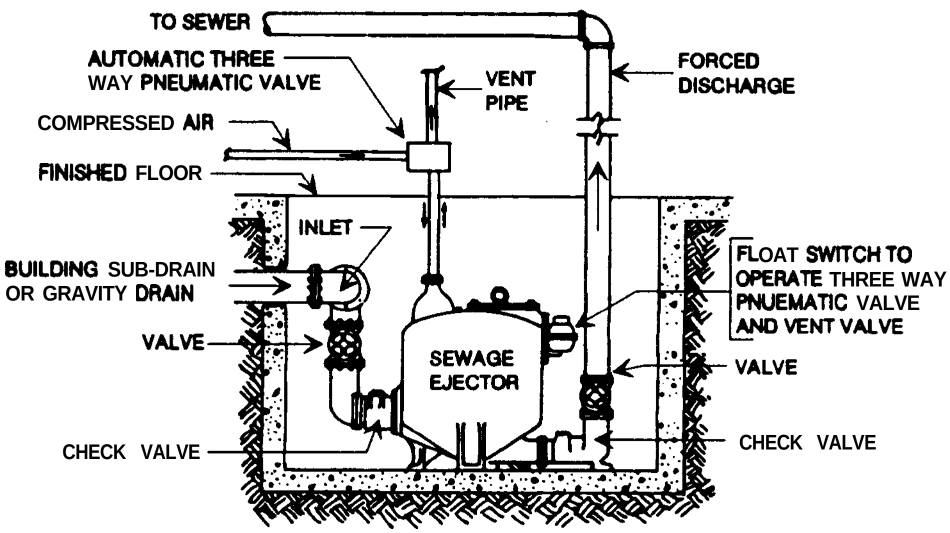
OIL INTERCEPTOR

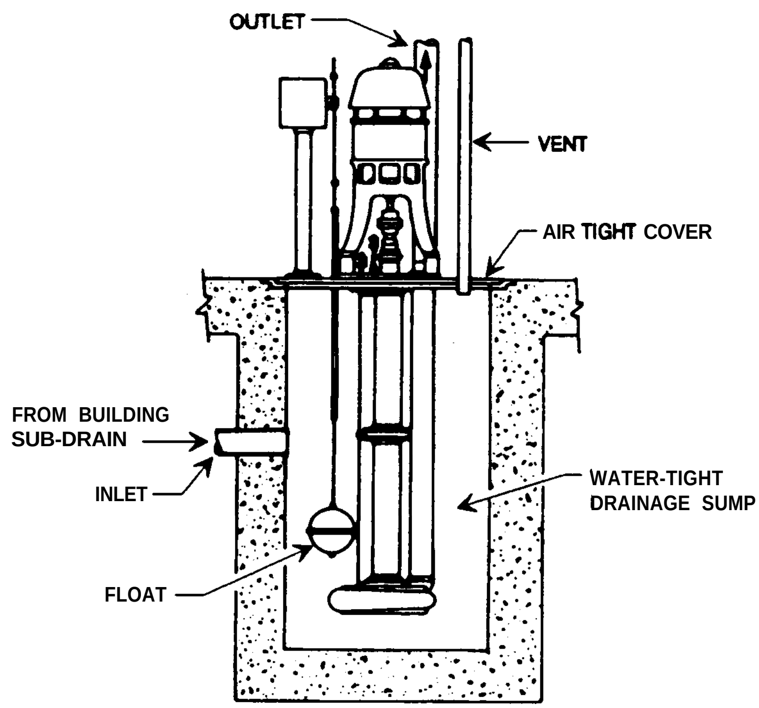
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	INTERCEPTORS		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date	Drawing No.
		5/93	AO80102-1





SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TRAPS AND CLEANOUTS		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080102-2





SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SEWAGE EJECTOR AND SEWAGE PUMP		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing no. A080102-3

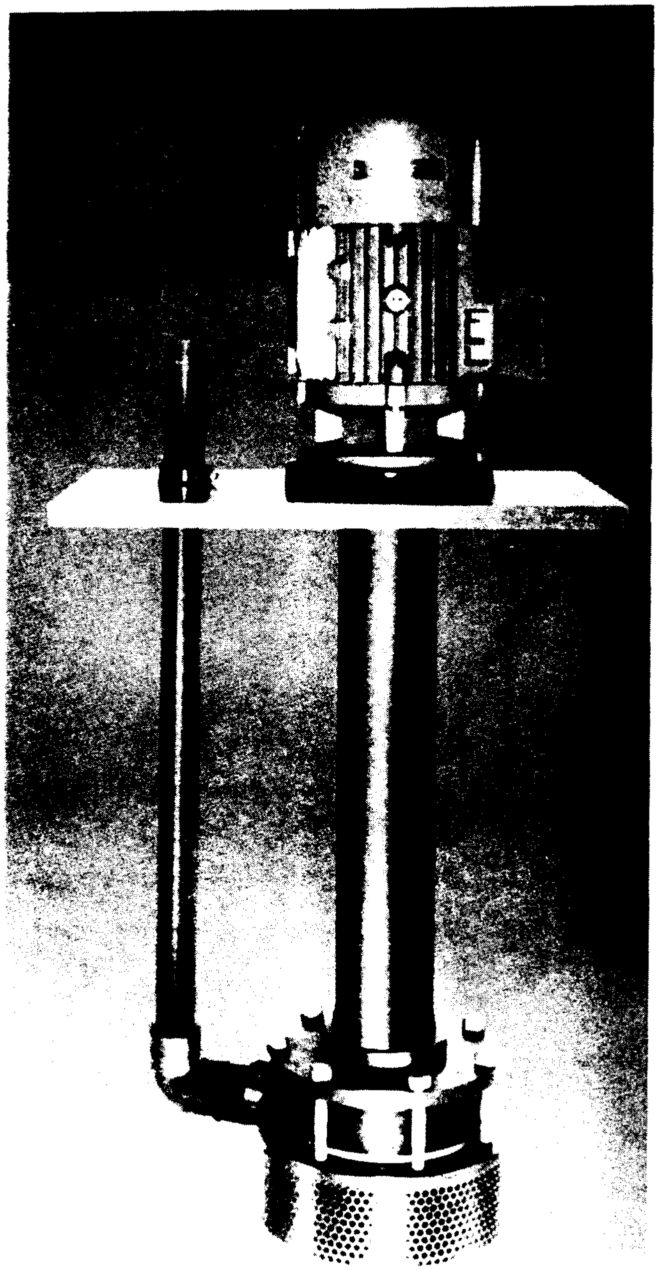


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL SUMP PUMP		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080102-4

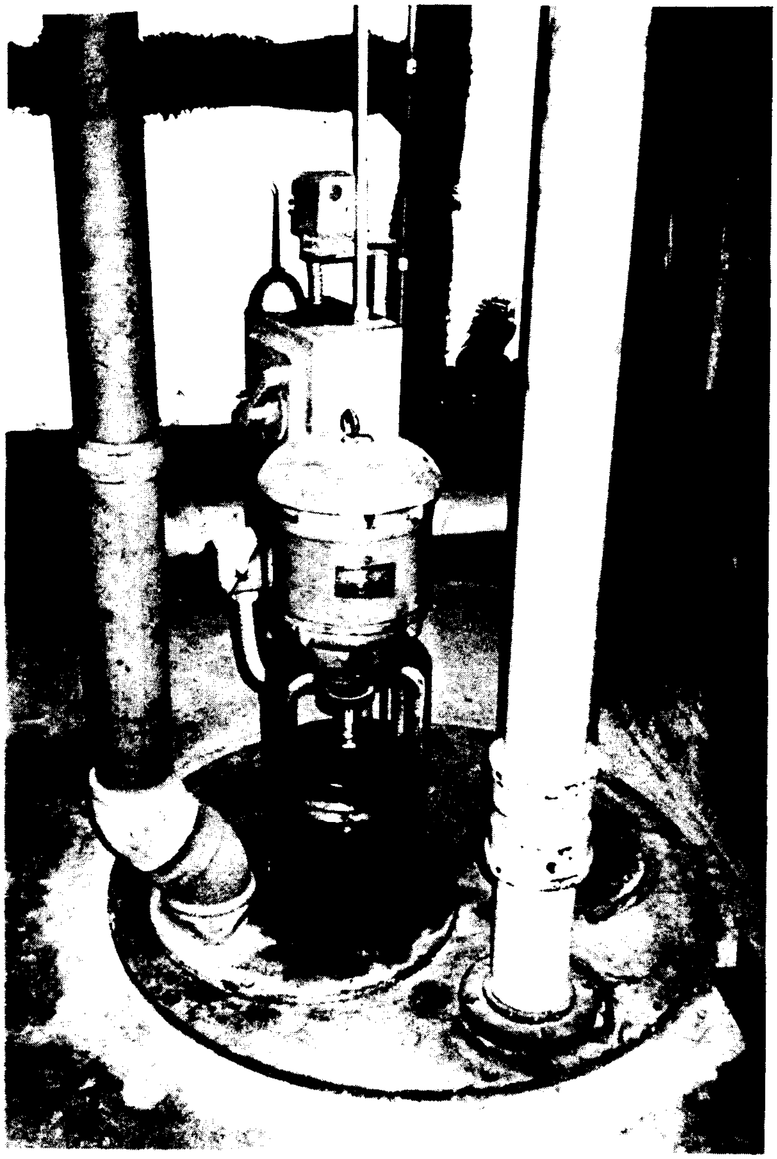


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SUMP PUMP		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080102-5

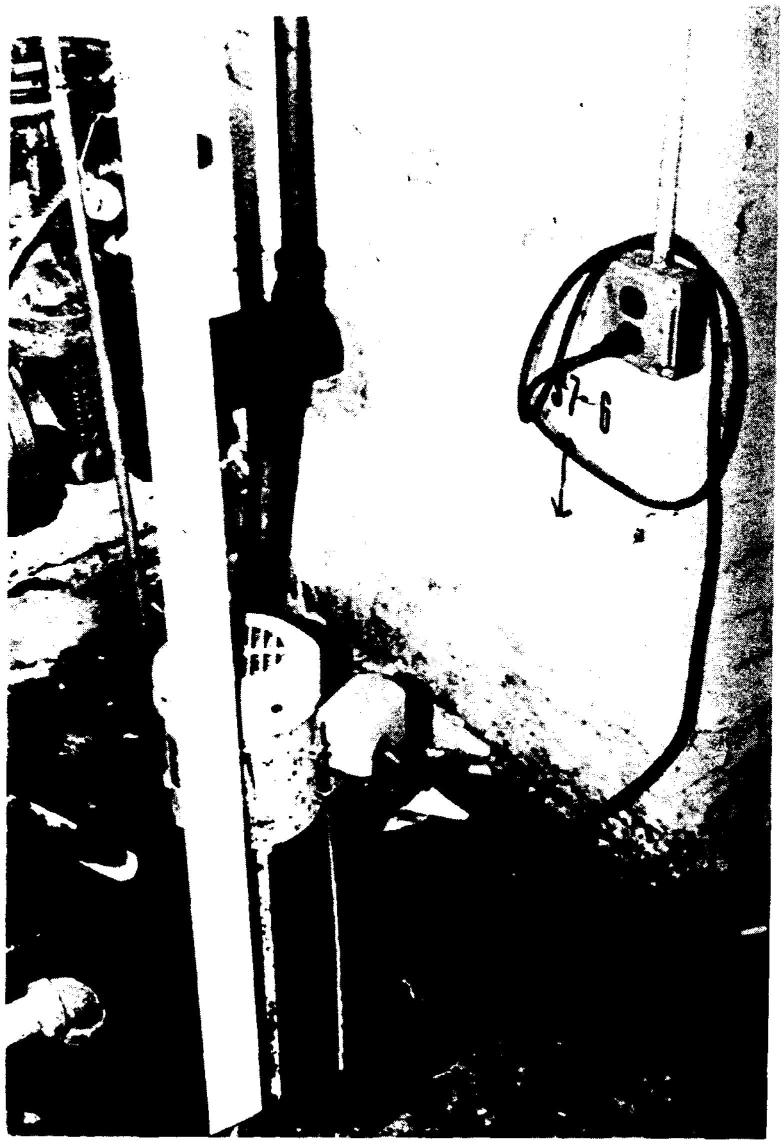


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FLOAT ACTUATED SUMP PUMP		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080102-6

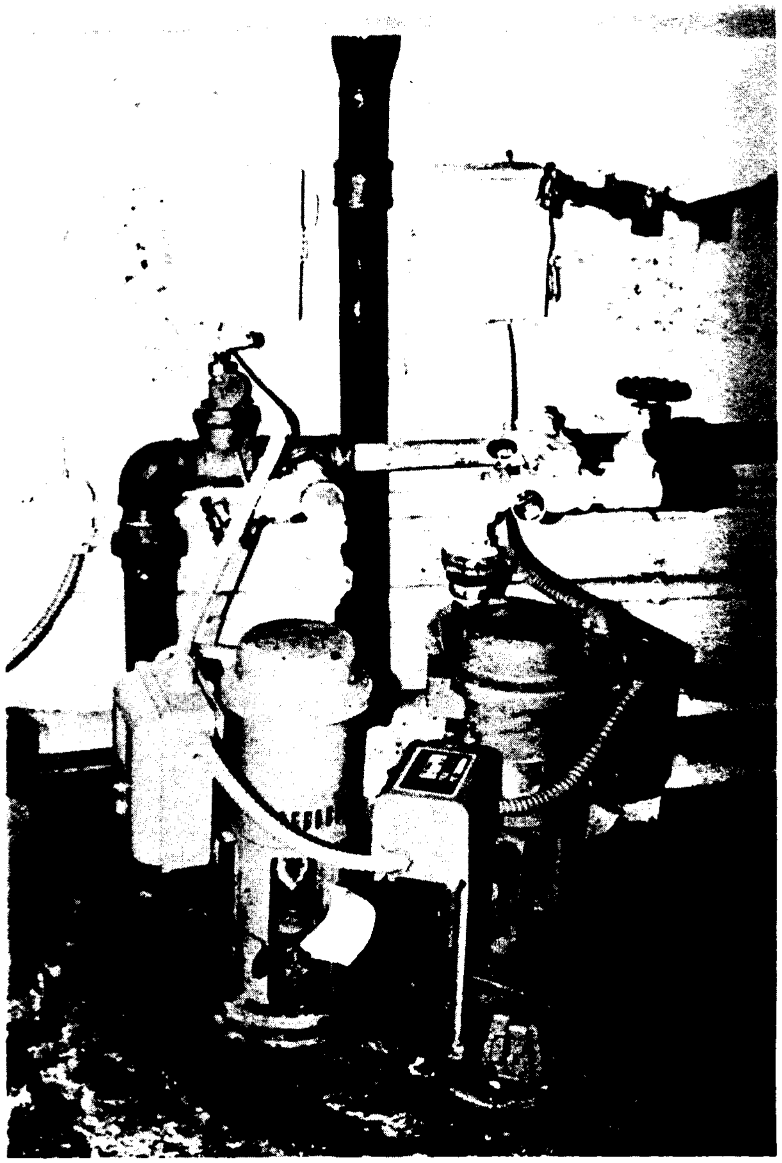


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DUPLEX SUMP PUMPS		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. A080102-7

DEFICIENCY FACTORS
0.08.01 .01 DOMESTIC WATER SYSTEMS (CSI 15411)

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Rfflngs (Continued)

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, 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.

Instrumentation

Missing: Taken out for service or repair and not replaced.

Inoperative: Failed internal mechanism, corrosion, loss of sensing medium.

Inaccurate: Wear, corrosion, imbalance in internal components, miscalibration.

Illegible: 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

Wet: System leakage or external causes.

Missing: Never installed, or taken off and not replaced.

Damaged: Physical abuse.

Equipment Controls & Panels

Motor Starter Inoperative: Overloaded, open coils, wear in linkage.

Relays Pitted or Burned: Normal aging, overloading.

Bypassed Controls: Poor maintenance.

Damaged Wiring: Corrosion, overheating, age.

Housing Corrosion: Age, poor maintenance.

DEFICIENCY FACTORS
0.08.01 .01 DOMESTIC WATER SYSTEMS (CSI 15411)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Terminal Fixtures

inadequate Pressure (<15-25 psig):	Dirty filters, aerators, damaged piping, excessive scaling in distribution system, booster pump failure.
Inadequate Volume (l-6 GPM):	Volume requirements depend on type of fixture. Deficiency caused by dirty filters, aerators, damaged piping, excessive scaling in distribution system, booster pump failure.
Inadequate Temperature (<110°F within 10 seconds):	Heater, check valve failure, problem with circulator.
Excessive Pressure (>80 psig):	Pressure regulating valve failure.
Excessive Volume (2-8 GPM):	Flow restrictor failure.
Excessive Temperature (> 130°F at washing taps):	Excessive heater capacity, heater controls, mixing valves.

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED HOT WATER CONTROL VALVE		
PLUMBING-DOMESTIC WATER SYSTEM (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. 0080101-1

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	LEAKING DOMESTIC HOT WATER HEATER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-2

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYTEMS	DETERIORATED INSULATION		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-3

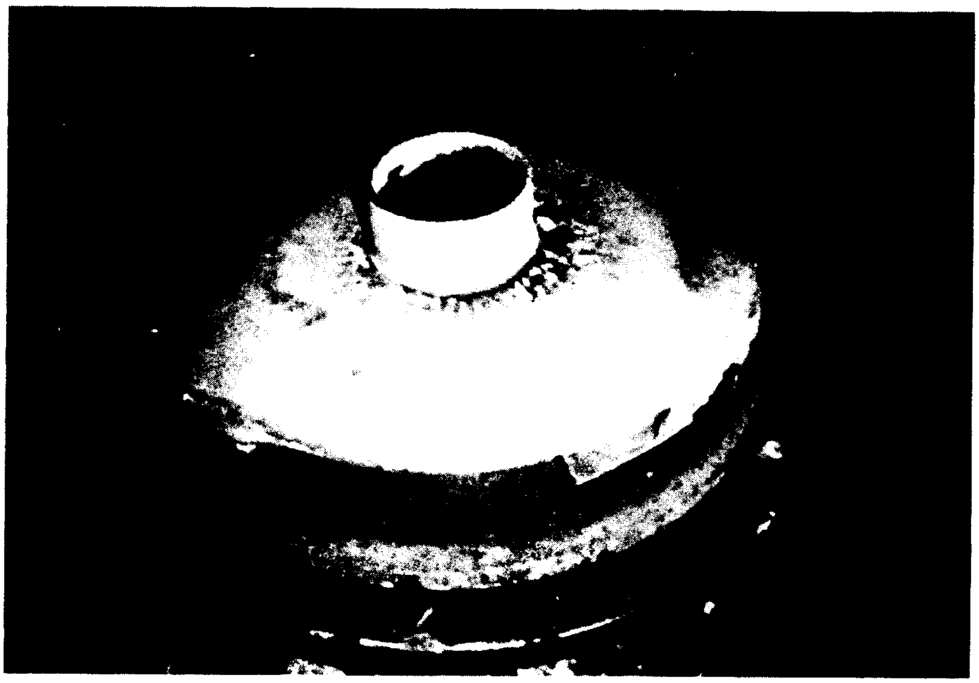


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	DAMAGED IMPELLER		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-4

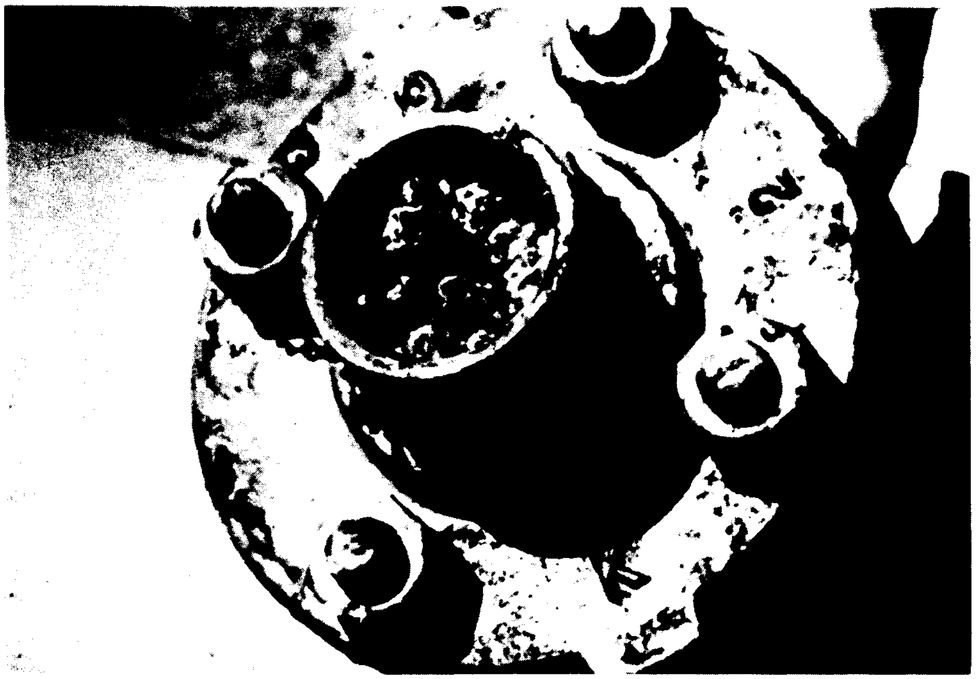


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED PIPE FLANGE		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-5

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED PRESSURE REGULATOR WITH RUPTURED DIAPHRAM		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-6

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	DETERIORATED INSULATION ON HOT WATER TANK		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-7

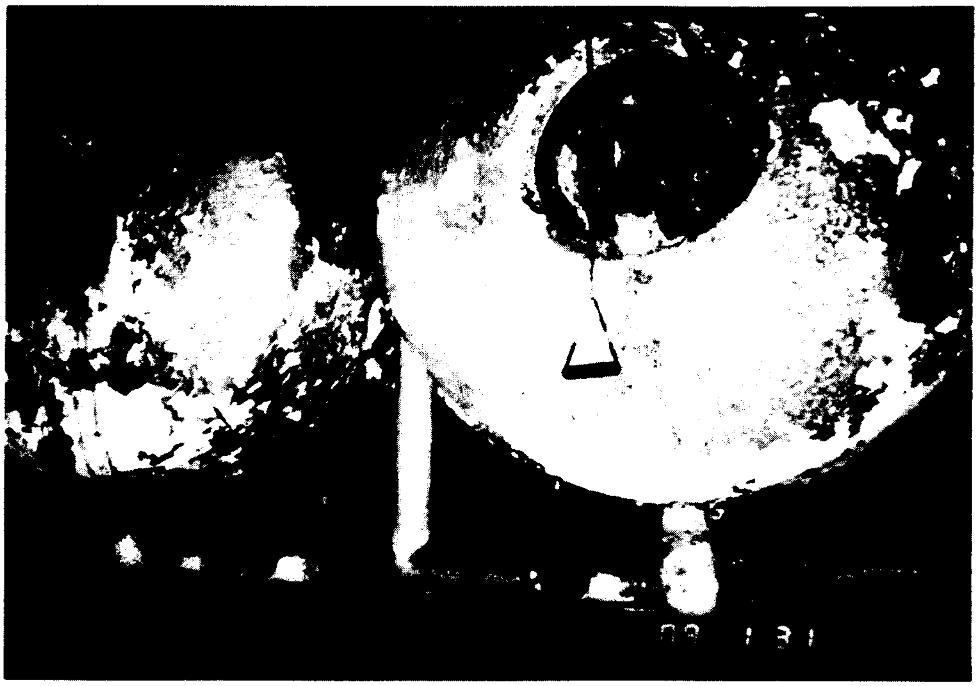


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	HOT WATER TANKS, MANHOLE COVER CORROSION, PROTECTIVE COAT PEELING		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-8

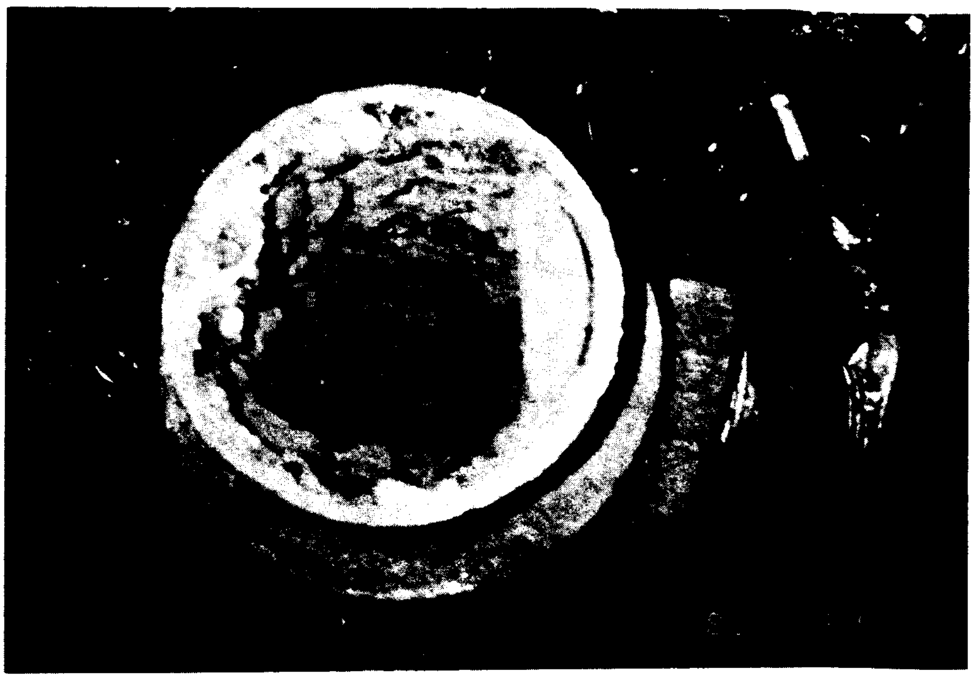


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED WATER PIPE		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. D080101-9

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	WATER LEAK ON STORAGE TANK		
PLUMBING-DOMESTIC WATER (CSI 15411)	Revision No.	Issue Date 5/93	Drawing No. 0080101-10

DEFICIENCY FACTORS
0.08.01 .Ol DOMESTIC WATER SYSTEMS (CSI 15411)

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DEFICIENCY FACTORS
0.08.01.01 DOMESTIC WATER SYSTEMS (CSI 15411)

END OF SUBSECTION

0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

DESCRIPTION

Drain, Waste, and Vent Systems provide for the disposal of waste products associated with a facility's domestic water system and storm water. Sources include all domestic plumbing fixtures, floor drains, and other area drains. The discharge is into the local sewerage system or a storm water drainage system. The waste system consists of floor drains and traps, collection sumps, sewerage ejectors, sewerage pumps, and the collection piping, fittings, valves, and supports. The storm drainage consists of area drains, collection sumps, sump pumps, and the collection piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Drains & Traps (CSI 15412)

The primary purpose of drains and traps is to collect fluids and provide an air seal between the sewerage system and the building environment, preventing sewer gas backflow into the building environment.

Most fixtures will have traps (referred to as direct discharge). In some cases, the trap is buried in the floor and fixture discharges into an open floor drain (referred to as indirect discharge).

Traps should be large enough to provide adequate drainage. Seals should be maintained in traps to keep them effective.

Because storm water systems have no unpalatable in-line gases, traps are generally not used in this portion of Drain, Waste, and Vent (DWV).

Drains are generally placed at low points in the floor or other areas to minimize ponding.

Traps are provided in many sizes and shapes. When they serve a purpose other than vapor sealing, (eg., grease, oil, hair removal) they are referred to as interceptors.

Drain line blockage and backup generally results in localized waste ponding (increased level in the fixtures). Where such ponding is close to potable water, provisions must be made to prevent cross-contamination. This is generally provided by an "air gap"; i.e., a minimum physical space between the water supply discharge and the maximum waste level.

Sumps & Tanks (CSI 15175)

In small facilities, waste is generally discharged directly into the local collection system (exterior to the building). In larger facilities with below ground levels, waste is commonly collected in sumps, generally located in the lowest facility level.

Sewerage and Storm Water Sumps are similarly constructed in ground tanks. The primary difference between them is the venting system requirements imposed on the sewerage tanks. In some facilities a common sump is used for both systems, in which case the more stringent venting requirements must be met.

Sewerage Ejectors (CSI 15412)

Sewerage Ejectors are hydraulically operated devices used to move raw sewerage from the collection sump into the external collection piping. The most common use air over water as the prime mover, creating a water ram to push the waste to the desired outlet level. As with the sewerage sumps, they are generally found in the lowest facility level,

Pumps (CSI 15160)

Pumps provide waste fluid evacuation from the collection sumps. They are typically installed in pairs at the top of the sump. Staging is generally provided to permit alternating pump and backup use in the event of pump failure and/or heavy demand.

0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

pumps (CSI 15160) (Continued)

Sump Pumps are typically single-stage, centrifugal pumps, flex coupled to their motors, though many are sealed, submersible units.

Pump couplings should be flexible, capable of absorbing torsional vibration and shaft misalignment. All couplings should be covered with a metal coupling guard.

Pumps should be arranged to provide access for periodic maintenance and repair, including removal of motors, impellers, couplings, and accessories.

Pumps and piping should be supported separately so that the weight of the piping system does not rest on the pump.

Motors (CSI 15170)

Pumps are typically driven via a closed motor with coupling.

piping & Fittings (CSI 15060)

Piping and fittings provide the collection system for waste fluid and storm drainage.

DOE design requirements dictate Type L copper tubing or galvanized steel for 1 1/2" or smaller drain, waste, and vent piping above grade. Greater than 1 1/2" should be cast iron soil pipe (ABS or PVC may be allowed in the 1 1/2"-6" range in some projects). Underground pipe must be cast iron soil pipe with hubs unless accessible (then hubless is allowed).

It should be noted that ABS, PVC and other plastic pipe may be more suitable where corrosive waste water conditions exist (including high cathodic corrosion potential soils).

All fittings should be compatible with the type of piping materials used in the system: therefore above ground, Type L waste lines should be solder-type bronze or wrought copper.

Cast-Iron Soil Pipe joints should be made with lead and oakum caulked joints, compression joints, or hubless joints.

Trap Primer valves and floor/funnel drains with trap primer valve discharge connections are required by DOE where there is the possibility of seal loss in floor/funnel drain traps.

Escutcheons are required at wall, ceiling, and floor penetrations in occupied areas. Seals are required where piping passes through fire walls,

Valves (CSI 15100)

In general, few valves exist in the drain, waste, and vent system to minimize restrictions to flow during normal operation. Exceptions include isolation valves required for servicing the sumps and pumps.

Sumps generally have an inlet isolation valve that permits tank service. In addition, large check valves (foot valves) are usually installed in the sump on the pump suction lines (these are needed to maintain pump prime.

Isolation and check valves are provided at the pump discharge to prevent flow reversal into the sump.

Drain valves are 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.

0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Supports & Anchors (CSI 15140)

Supports and anchors are used to prevent excessive stress on pipe, fittings, and equipment. They keep pipe from sagging, weakening related joints and fittings, and take piping weight off the pumps and tanks to which they are attached.

Hangers and supports should be securely attached to building construction at sufficiently close intervals to support piping and its contents.

Most piping supports can be spaced at 10 foot intervals. Exceptions:

- Cast iron soil pipe, 5 foot
- Copper tube <=11/4 inch, 6 foot
- Steel pipe > = 1 inch, 12 foot

Supports should be installed to allow for expansion and contraction in system.

Equipment Control8 & panels **(CSI 15950)**

Few controls are used in the typical DWV water system. (Metering is generally provided at the water source and sewerage use prorated accordingly). The DWV system is usually turned on and left running except for routine maintenance services.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Multiple pumps employ an alternator to switch use. Motor starters are typically activated by a level float in the sump.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

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DEFICIENCY FACTORS
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

PROBABLE FAILURE POINTS

- Reduced removal capacity (pressure/flow) due to pump/ejector failure, pipe scaling, or blockage.
- System leakage due to corrosion, physical damage, normal seal wear.

SYSTEM ASSEMBLIES/DEFICIENCIES

Drains & Traps

Leakage:	Corrosion, physical damage.
Loss of Seal:	Leakage, physical damage, shift in position.
Blockage:	Collapse of drain line, poor maintenance.
Inadequate Air Gap:	Poor installation, shift in position of components.

Sumps & Tanks

Shell Distortion:	Blisters or bulges in the metal caused by fatigue, physical damage, loss of external support.
Tank or Fitting Leakage:	Age, corrosion, physical damage.
Excessive Corrosion:	Normal aging of system, corrosive waste materials.
Loose or Missing Access Covers:	Poor maintenance.
Vent Leakage:	Corrosion, loose fasteners.

sewerage Ejectors

Shell Distortion:	Blisters or bulges in the metal caused by overpressurization, fatigue, physical damage.
Leakage:	Age, corrosion, physical damage.
Inoperative:	Blockage, control system failure.
Excessive Corrosion:	Normal aging of system, corrosive waste materials.
Loose or Missing Access Covers:	Poor maintenance.

pumps

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

DEFICIENCY FACTORS
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Motors

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
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.

Instrumentation

Missing:	Taken out for service or repair and 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
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

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.

Equipment Controls & Panels

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

DEFICIENCY FACTORS
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

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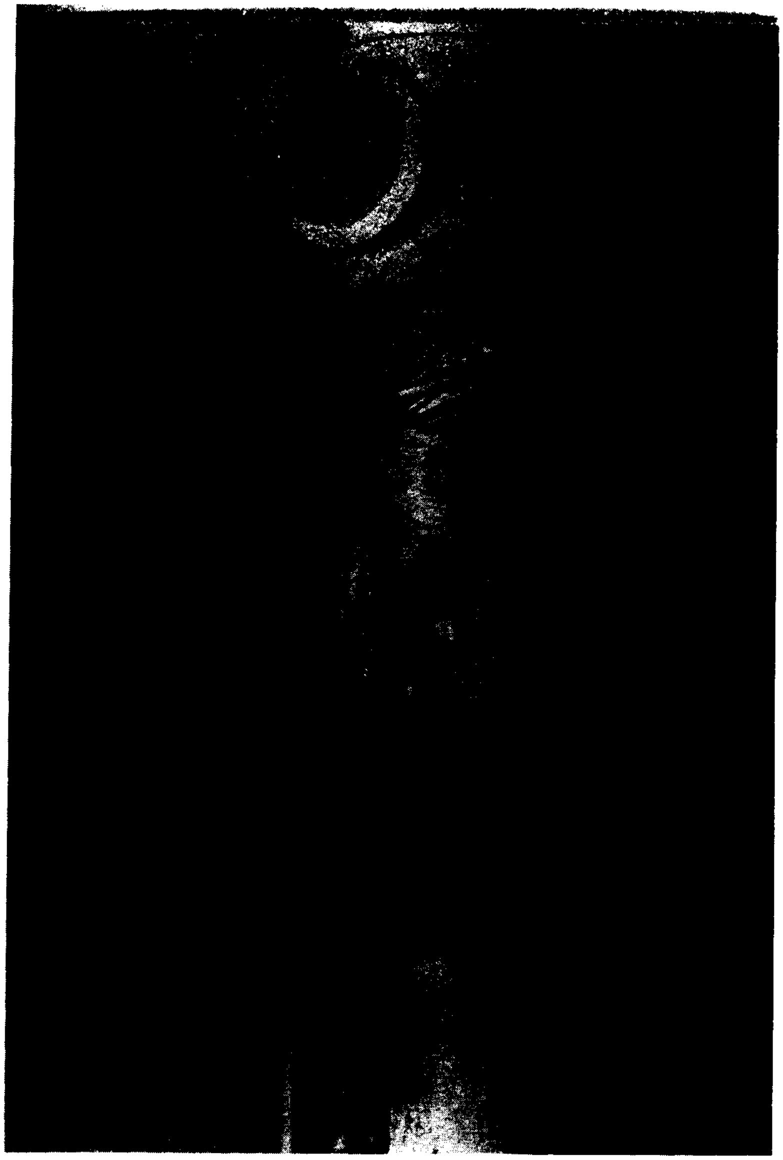
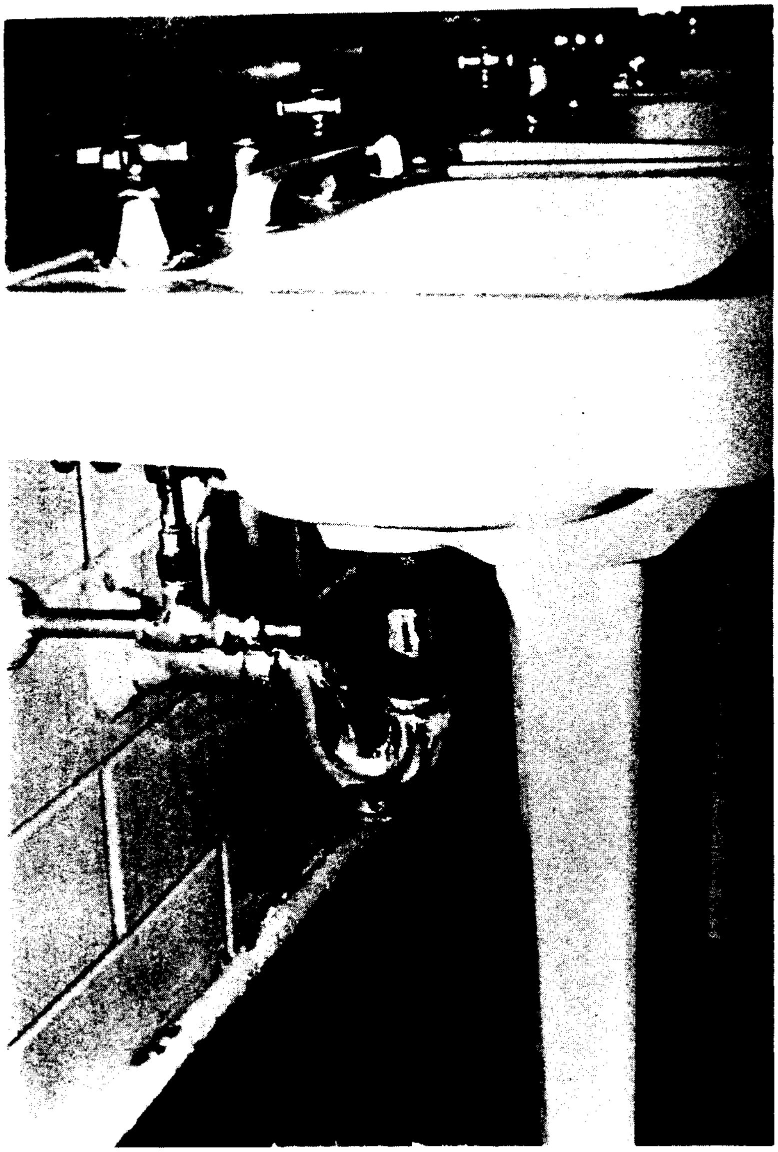


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	LEAKING AND CORRODED DRAIN PIPE		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. D080102-1



NOTE: ATTEMPT TO STOP LEAK WITH TAPE

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	SINK TRAP LEAKING		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. D080102-2

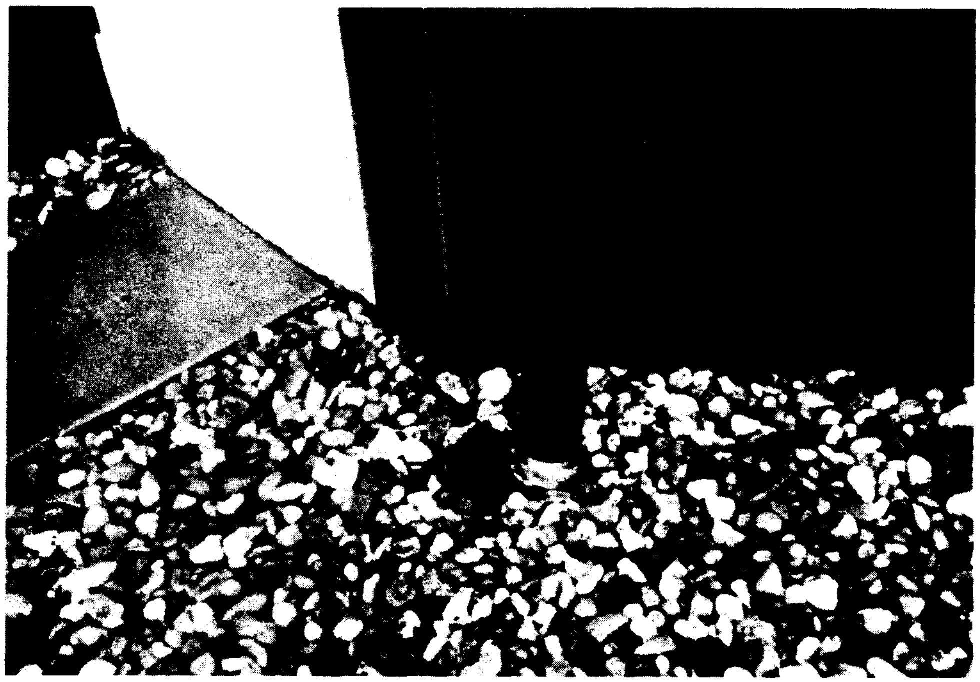


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	BROKEN VENT PIPE AT ROOF LEVEL		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. D080102-3

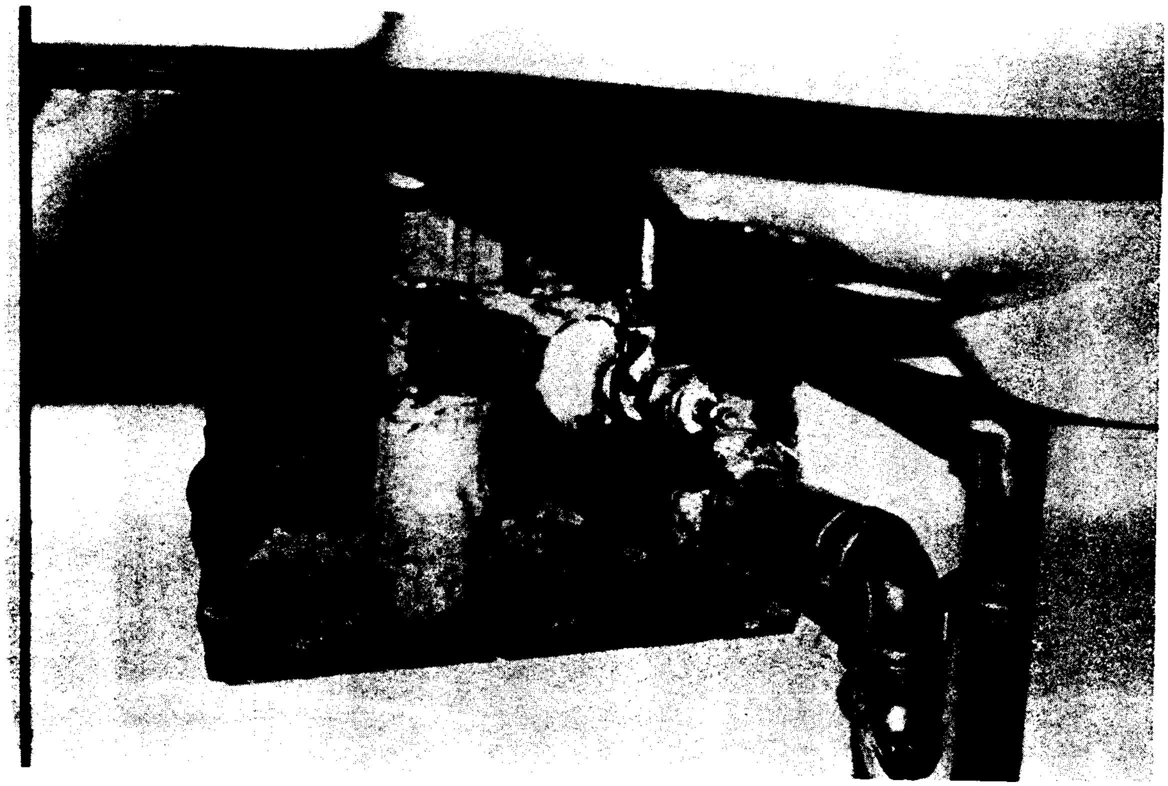


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	WALL DETERIORATION CAUSED BY LEAKING WATER SUPPLY		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. D080102-4

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	LEAKING WASTE ELBOW		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing No. D080102-5

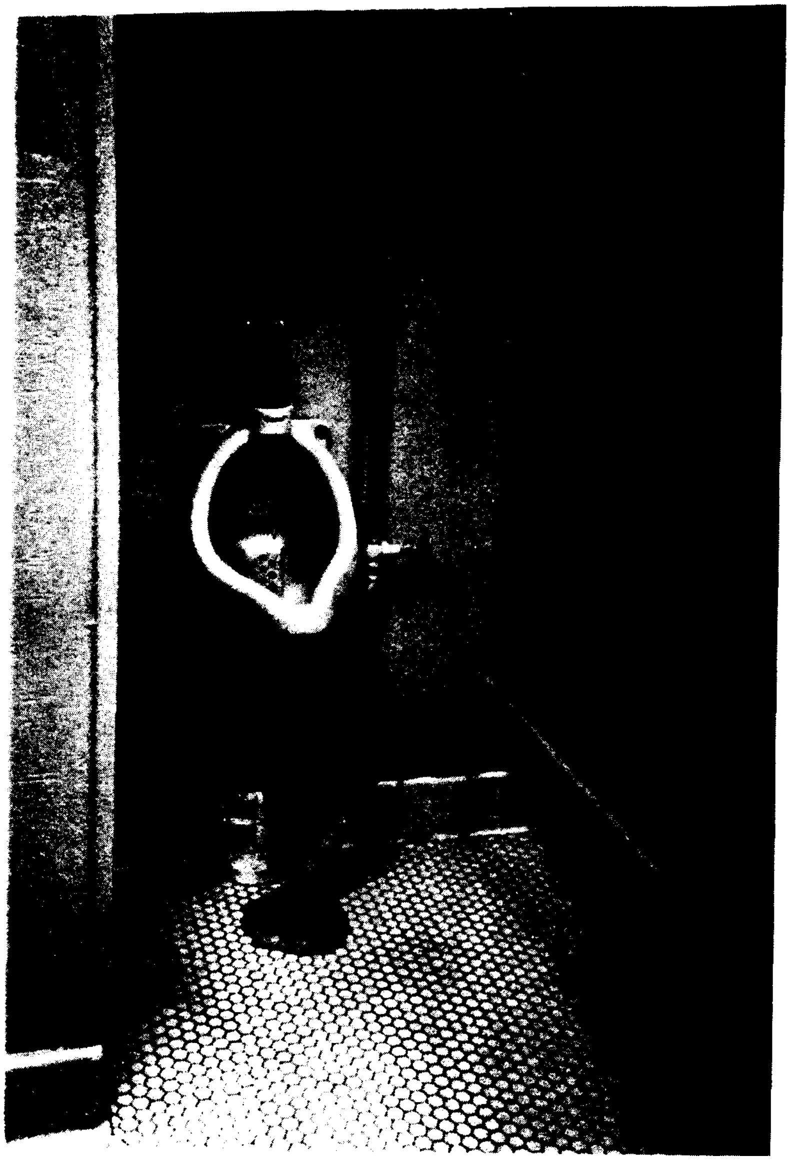


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED, LEAKING DRAIN AND TRAP ON URINAL		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	issue Date 5/93	Drawing No. D080102-6

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED, ACTIVE LEAKING SHOWER DRAIN PIPE		
PLUMBING-DRAIN, WASTE AND VENT (CSI 15400)	Revision No.	Issue Date 5/93	Drawing MO. D080102-7

DEFICIENCY FACTORS
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

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DEFICIENCY FACTORS
0.08.01.02 DRAIN, WASTE, & VENT SYSTEMS (CSI 15420)

END OF SUBSECTION

0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

DESCRIPTION

The typical Compressed Air System provides air pressurization, drying, and distribution, taking its source from air outside the building and terminating in pneumatic controls and general utility outlets. The system consists of air compressors, coolers, storage tanks, dryers, and the connecting piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Air Compressors (CSI 15481)

Typical air compressor installations are duplex reciprocating units. They are usually motor-driven via a belt and pulley assembly. They frequently employ unload mechanisms to minimize load on startup and/or to permit continual running. Lubrication is provided with a crankcase oil sump and an integral oil pump. Air is normally filtered at the compressor intake.

Variations include multi-stage units and centrifugal, vane, screw, and lobe compressors. Older units may have a steam engine drive. Vane and lobe units are typically motor driven via a coupling.

Lubrication may be “Oil Flooded”, “Oil-Free” or “Oil-Less”. The “Oil-Free” description does not permit oil to enter the compression chamber. The “Oil-Less” description has sealed, oil-free bearings. In flooded systems, separators are required downstream (air) to separate and return oil to the lubrication system. Large flooded systems usually include an oil filter.

DOE requires that new control air compressors be duplex non-lubricated type with oil-lubricated crankcase and distance piece.

Belt guards should totally enclose all pulleys and belts.

Air coolers are used to remove the heat of compression between compression stages and at the compressor outlet. Between stage units are called inter-coolers, and outlet units are called aftercoolers. Cooler presence is dependent on compressor design. Smaller units do not have coolers.

The typical aftercooler is air-cooled. Air movement may be natural or forced with fan blading. A common approach uses the compressor pulley for air movement. Larger units employ water cooling.

Motors (CSI 15170)

Motors for compressors are typically open AC motors.

Tanks (CSI 15450)

Storage tanks provide reserve capacity in the air system, allowing for demand fluctuations. Tanks are typically small units, frequently mounted under the compressors. Larger system have larger, independent tanks.

Filters & Dryers (CSI 15481)

Filters and dryers are installed in the distribution line to remove oil, moisture, and particulate matter from the air. This reduces corrosion in the distribution piping and fouled control mechanisms.

The most common dryer is a small refrigerated unit employing a hermetic compressor, a shell and tube evaporator, and a fan-cooled condenser. Separation (drying) takes place in the evaporator. Variations use water-cooled condensers.

0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Filters & Dryers (CSI **15481)** (Continued)

An alternative approach uses a desiccant or drying agent such as silica gel. In small units, the desiccant is periodically replaced. In larger units, dryers are installed in parallel with controls to alternate the dryer in use. The desiccant of the "off-line" dryer is regenerated using a heating mechanism.

DOE requires that control air be filtered and dried using refrigerated air dryers for a dew point of 15° F and regenerative silica type for a dew point below 15° F.

Other filter types include media, coalescing units, and oil separators.

Piping & Fittings (CSI 15410)

Piping and fittings provide the distribution network for the compressed air system. Typical systems are installed in copper pipe, which reduces internal contamination due to corrosion and prolongs the life of the system. Variations use steel pipe.

Installations vary with application. Low-pressure systems operate at pressures of 125 psig or less, and temperatures of 200° F or less. Medium-pressure systems operate at pressures between 125 psig and 200 psig, or temperatures of more than 200° F. Systems are considered high pressure if they exceed these parameters.

DOE design requirements currently dictate the use of copper piping for high pressure air in all inaccessible locations (plastic pipe may be used if installed in conduit).

Branch air piping is usually connected to mains from the top of main to minimize carryover. Drain legs and drain traps are provided at the end of each main, each branch, and each low point in piping system.

Air and drain piping is usually installed with 1/8-inch-per-foot slope downward in the direction of air flow.

Piping should be connected to equipment using flex joints to minimize vibration transmission.

Air piping should be connected to equipment with unions, and with shutoff valves and strainers when indicated.

Air-line lubricators and filters should be installed in lines serving control equipment and devices.

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

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valves (CSI 15100)

Valves are primarily used to permit switching storage tanks and/or dryers, isolating compressors and other components for maintenance and isolation of terminal fixtures. In addition, shut-off duty valves are typically provided at each branch connection to supply mains.

Check valves are used on the discharge side of compressors and tanks to prevent system flow reversal.

Pressure regulating valves are used to drop storage pressure to control system pressure. Control systems typically operate in the 15-25 psig range.

Temperature regulating valves are used to control the flow of water through the inter/aftercoolers.

Relief valves are typically installed on the compressor itself, especially on units with intercoolers. They are required on all pressurized tanks.

0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Valves (CSI 15100) (Continued)

Solenoid valves are frequently used to cycle desiccant type dryers, although many units are still manually operated.

Automatic drain valves are typically installed on long pipe runs, intercoolers, aftercoolers, separators, storage tanks, and dryers. Condensation is usually discharged to nearest floor drain. Special drainage may be required where oil or other contamination is a problem.

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 pressure regulator, between stages of the compressor, between coolers, and on the storage tanks.

Snubbers are generally used to dampen pressure fluctuations and extend gauge life.

Temperature gauges are sometimes provided on compressor piping between stages and at the compressor discharge.

Some installations include air flow meters to verify and monitor flow.

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.

Vibration isolation mounts should be provided on all compressors.

Equipment Controls & Panels (CSI 15950)

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

Compressors frequently have oil pressure and temperature limits interlocked with the starter that can trip compressor operation.

Compressor cycling (or loading/unloading) is usually controlled by a storage tank pressure limit interlocked with the starter.

Water temperature controls are provided either through thermal bulb sensing and modulation of a hydraulically controlled regulating valve or activation of solenoid operated valves or contacts.

0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

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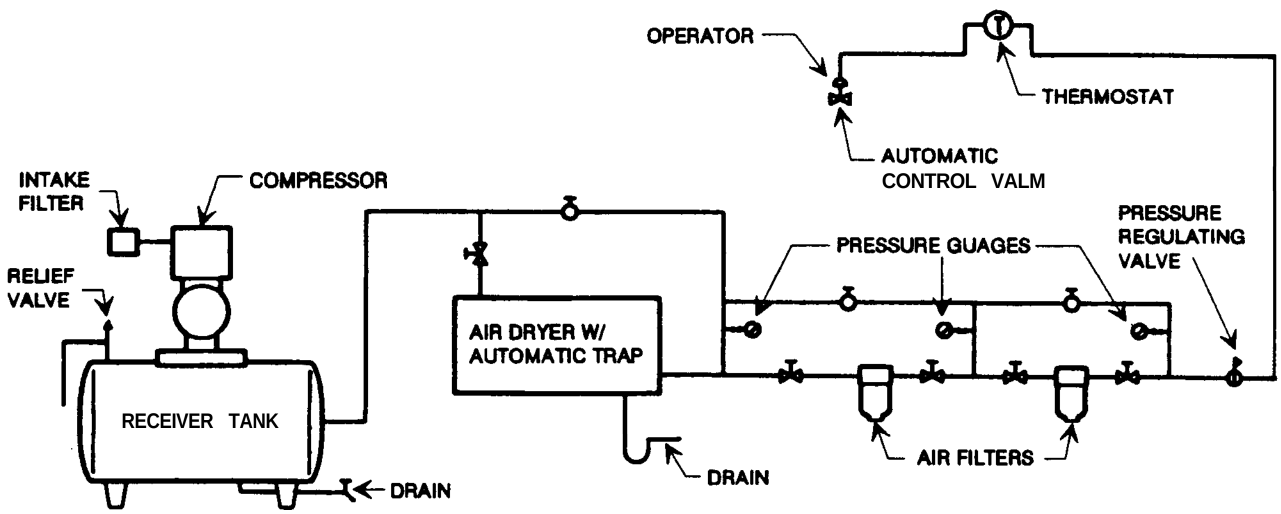
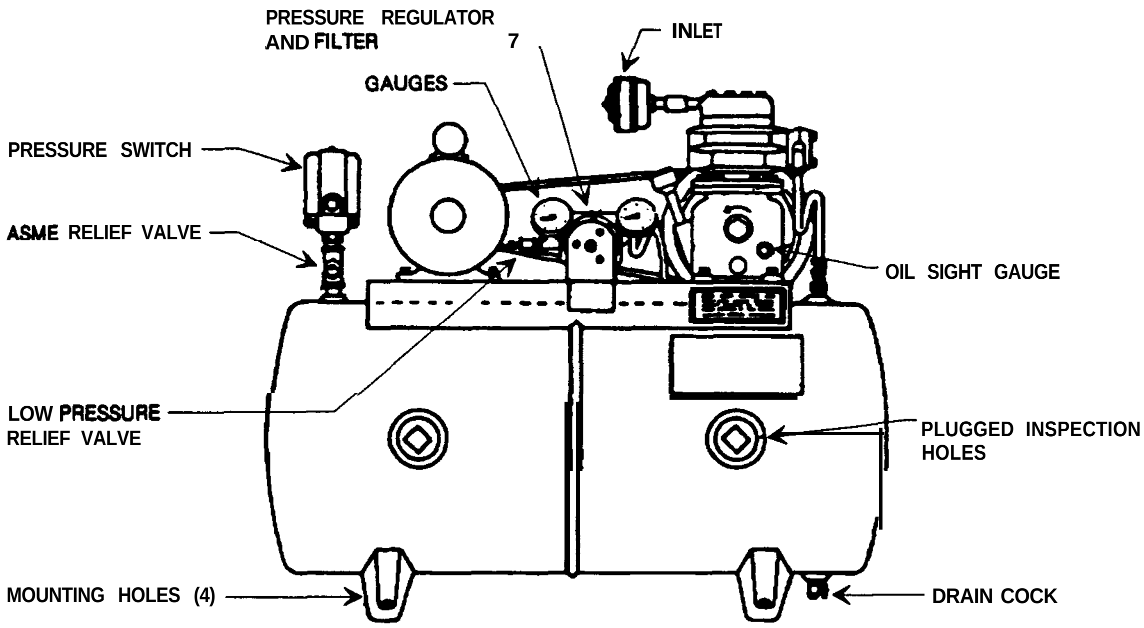


SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE, "R.S. Means Co., Inc., Kingston, Massachusetts"

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL COMPRESSED AIR SYSTEM		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-1



SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL CONTROL AIR STATION		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-2

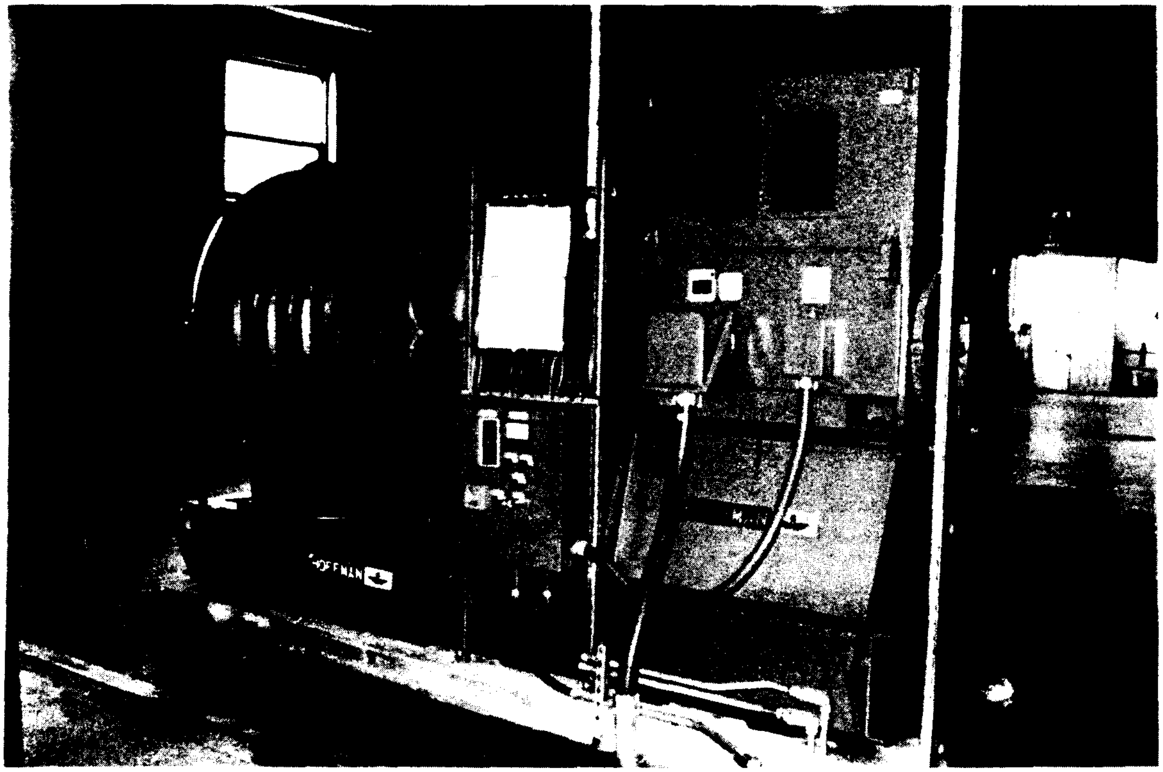


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL COMPRESSOR SKID MOUNTED		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-3

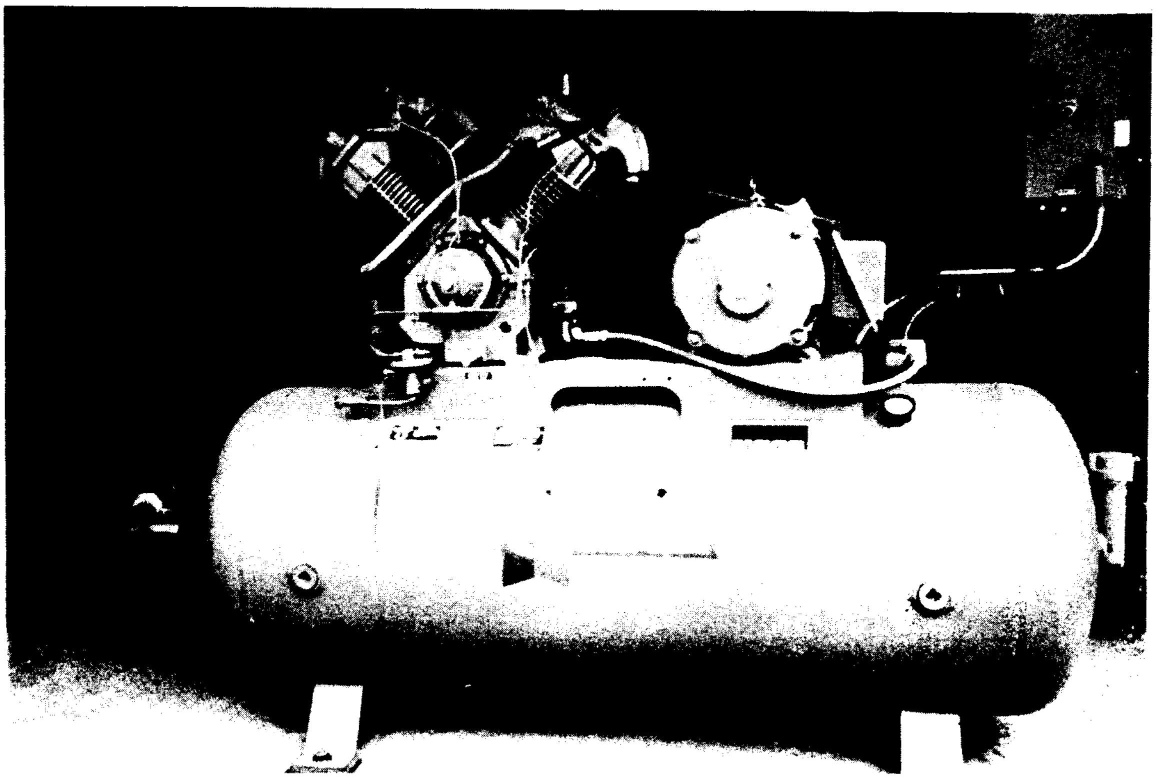


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	RECIPROCATING COMPRESSOR WITH RECEIVER TANK		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-4

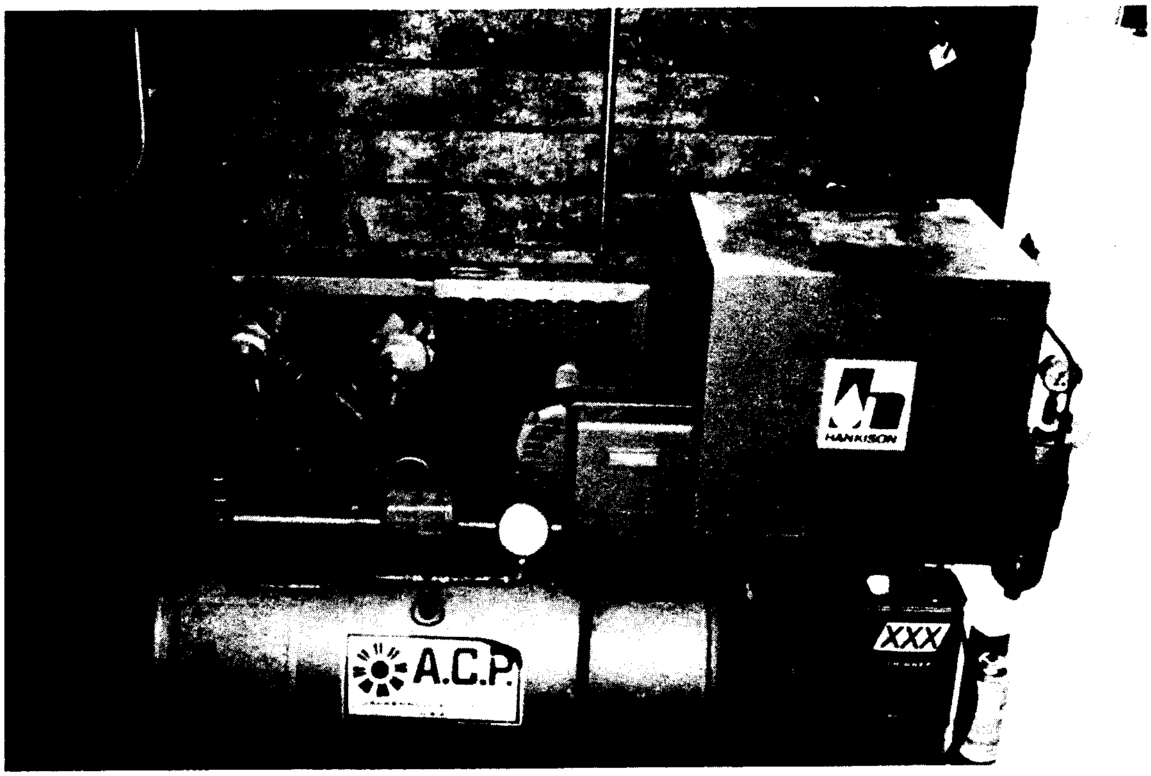


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	RECIPROCATING COMPRESSOR WITH RECEIVER TANK AND AIR DRYER		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-5

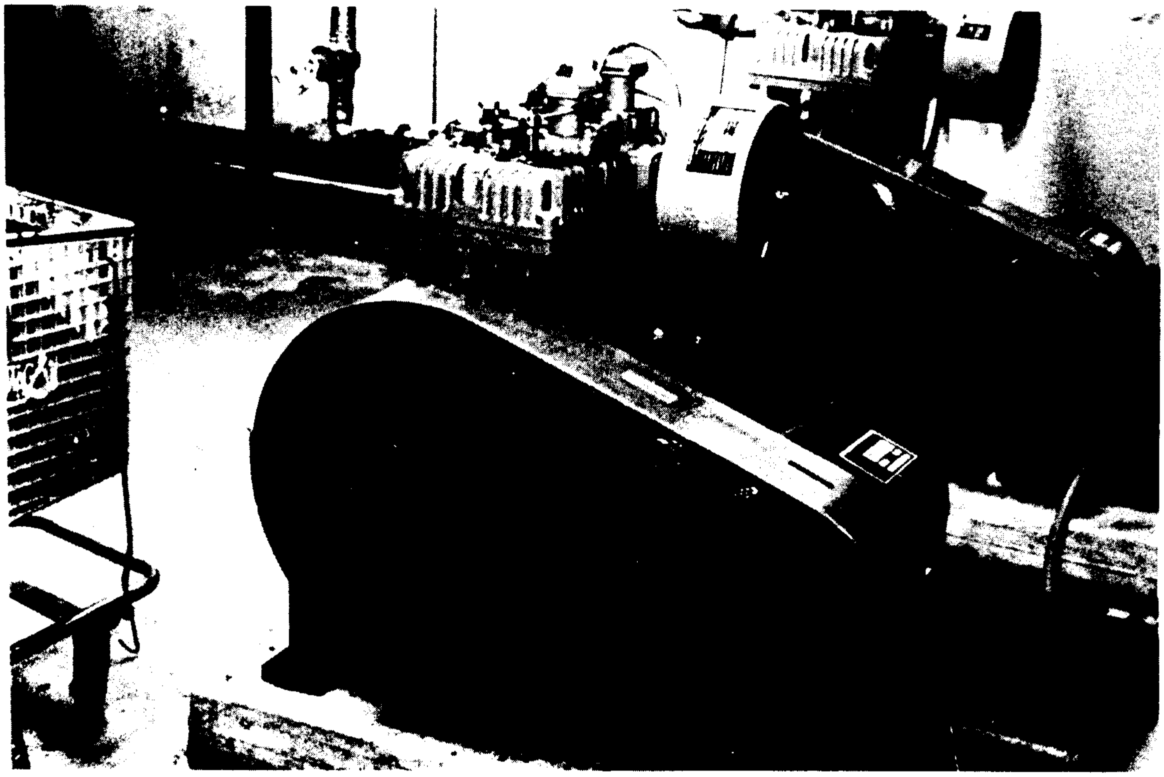


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	RECIPROCATING COMPRESSOR IN PARALLEL ON COMMON HEADER		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-6

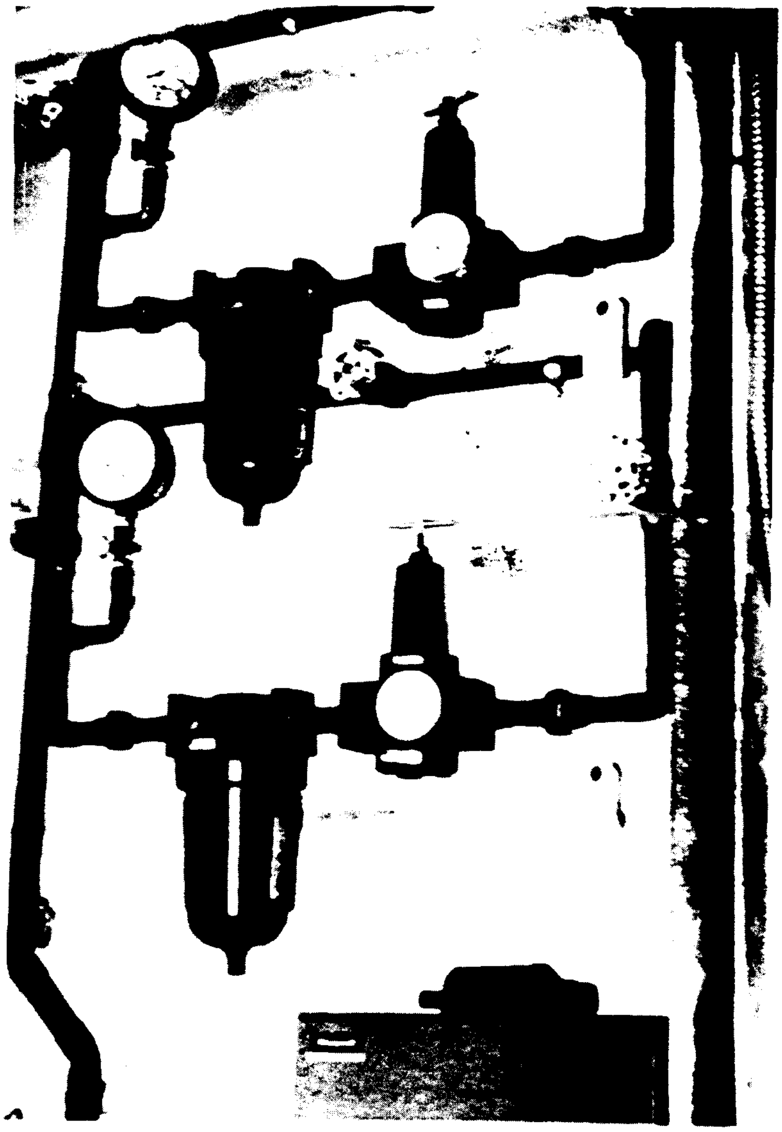


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL CONTROL AIR STATION		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080103-7

DEFICIENCY FACTORS
0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

PROBABLE FAILURE POINTS

- Loss of System Pressure - due to wear of compressor parts, leakage in pipe and fittings.
- Moisture Content Too High - due to failure of dryers.
- System leakage due to corrosion, physical damage, normal wear of seals.

SYSTEM ASSEMBLIES/DEFICIENCIES

Air Compressors

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked rotor.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.
Air Filter Inadequate:	Missing, damaged.
Cooler Leakage:	Corrosion, physical damage.
Cooler Blockage of Flow:	Corrosion, damaged coil fins.

Motors

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

Tanks

Shell Distortion:	Blisters or bulges in the metal caused by fatigue, over-pressurization, physical damage, loss of external support.
Tank, Pipe, or Fitting Leakage:	Age, corrosion, physical damage.
Excessive Corrosion:	Normal aging, contamination.

DEFICIENCY FACTORS
0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Filters & Dryers

Compressor Missing:	Taken out for service, repair, not returned.
Compressor Inoperative:	Winding failure, defective internal controls.
Condenser Damage:	Fin damage, fan failure.
Exhausted Desiccant:	Caused by normal use, but also accelerated by improper cycling of conditioner phase controls.
Excessive Corrosion:	Normal aging, contamination.
Leakage:	Age, physical damage, severe internal or external corrosion, failure of gaskets at fittings.

Piping & Rfflngs

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, 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.

Instrumentation

Missing:	Taken out for service or repair and 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
0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

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.

Equipment Controls & Panels

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

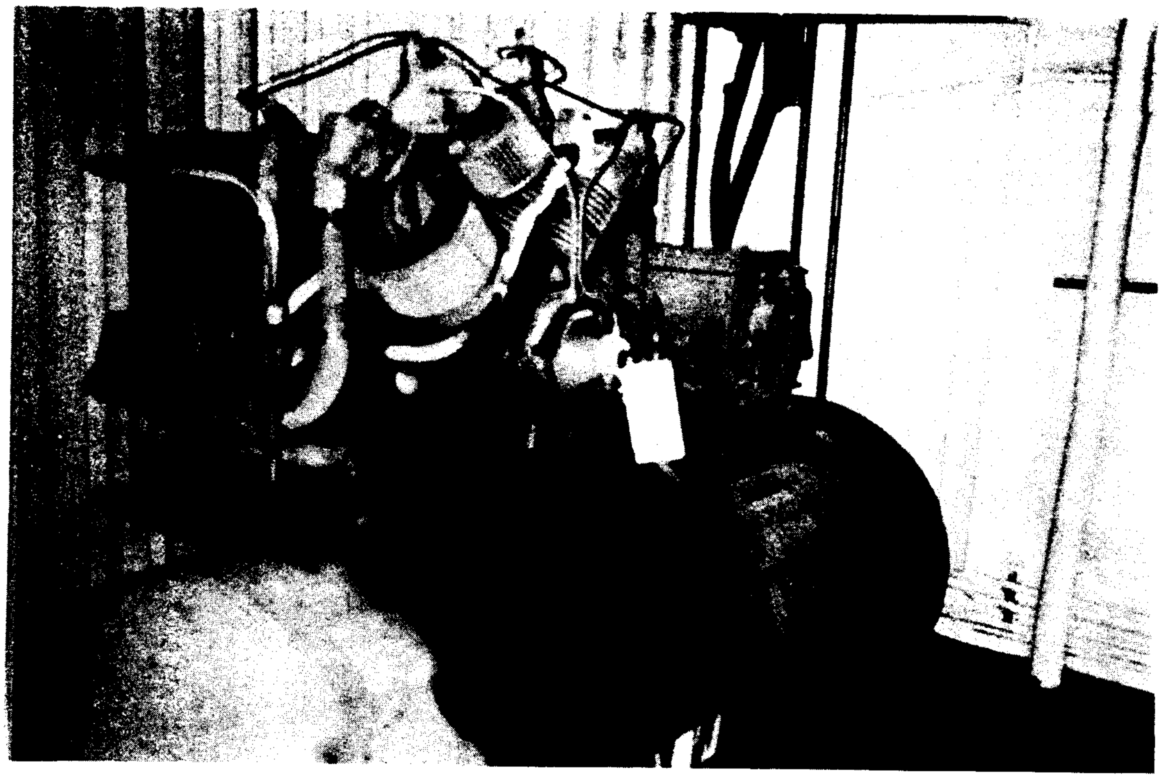


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	AIR COMPRESSOR-NUMEROUS OIL LEAKS, DIRTY, AIR LEAKS		
PLUMBING-COMPRESSED AIR SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. D080103-1

DEFICIENCY FACTORS
0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

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DEFICIENCY FACTORS
0.08.01.03 COMPRESSED AIR SYSTEMS (CSI 15481)

END OF SUBSECTION

0.08.01.04 VACUUM SYSTEMS (CSI 15482)

DESCRIPTION

Vacuum systems are typically found in health care and production facilities. In health care units they provide a means of removing body fluids and waste products generated during medical procedures. In production units they serve a wide range of functions, including waste removal, product manipulation, and environment control. A system typically consists of one or more holding tanks, vacuum pumps (air compressors), and the connecting piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Holding Tanks (CSI 15175, 15455)

Holding tanks are used to provide a reserve capacity, allowing for large fluctuations in system load. While some tanks are small units frequently mounted under the vacuum pumps, most installations employ larger, independent tanks. Because the tank is used primarily to “contain” the vacuum, there are few, if any, fittings attached.

Vacuum Pumps (Air Compressor) (CSI **15482)**

Small vacuum installations employ duplex reciprocating compressors, identical to those in compressed air systems. They are usually motor-driven via a belt and pulley assembly. They frequently employ unloader mechanisms to minimize load on startup and/or to permit continual running. Lubrication is provided with a crankcase oil sump and an integral oil pump. Air is normally exhausted through a local muffler vented outdoors.

Larger, older vacuum installations employ duplex vane or lobe compressors, usually motor-driven via flexible coupling. They maintain a positive displacement by using a water seal process at the shaft seals and in the compression chamber. Internal lubrication is provided by the sealing water. Air is normally exhausted through a local muffler vented outdoors.

Guards should totally enclose all pulleys, belts, and couplings.

Motors **(CSI** 15170)

Motors for vacuum pumps are typically open AC motors.

Valves (CSI 15100)

Valves are used to permit isolation of holding tanks, pumps, and vacuum mains for maintenance. Unlike the compressed air system, regulating valves are generally not found in the main distribution network. The network is maintained at a common vacuum and controls, if needed, are included on equipment attached at the system terminal points.

Relief valves (vacuum breakers) are employed at critical locations to prevent component damage due to excessive vacuum. At least one will be mounted on each holding tank.

Solenoid valves are frequently used to cycle sealing water flow to the vacuum pumps.

Instrumentation (CSI 15130)

Vacuum gauges are typically provided at the holding tank and/or on the suction of each pump.

Temperature gauges are not usually provided.

Sealing water flow indicators are generally provided in the pump supply line.

piping **&** Flfflngs (CSI **15060)**

Vacuum piping is commonly installed as copper or steel pipe.

Fittings are made of compatible materials.

0.08.01.04 VACUUM SYSTEMS (CSI 15482)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

piping **& Fittings** (CSI **15060)** (Continued)

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.

Strainers/filters are typically provided at the terminal fixture to prevent pulling waste or products into the vacuum main.

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

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Special attention should be paid to the sleeving and venting of piping which passes through inaccessible or sealed spaces, or plenums.

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.

Equipment Controls & Panels (CSI 15950)

Vacuum pump control is performed via a typical motor assembly (motor, starter, and disconnect)

Vacuum pumps frequently have oil pressure limits interlocked with the starter that can trip pump operation.

Pump cycling (or loading/unloading) is usually controlled by a holding tank pressure limit interlocked with the starter.

Sealing water controls are usually provided through a pump starter interlock.

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

DEFICIENCY FACTORS
0.08.01.04 VACUUM SYSTEMS (CSI 15482)

PROBABLE FAILURE POINTS

- Loss of System Vacuum - due to wear of pump parts, leaks in pipe and fittings.
- System leakage due to corrosion, physical damage, normal seal wear.
- Tank leakage due to age, excessive corrosion, physical damage.

SYSTEM ASSEMBLIES/DEFICIENCIES

Tanks

External Leakage:	Severe internal or external corrosion; failure of gaskets at flange or other fittings.
Loose or Missing Fasteners:	Corrosion, damage.
Corrosion:	Weathering, contamination.
Shell Distortion:	Excessive pressure differential, metal fatigue, manufacturing defects.

Vacuum Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked rotor.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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.
Excessive Load:	Bearing wear, misalignment
Excessive Corrosion:	Poor maintenance.
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.

DEFICIENCY FACTORS
0.08.01.04 VACUUM SYSTEMS (CSI 15482)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

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.

Instrumentation

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Supports & Anchors

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

Equipment Controls & Panels

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

DEFICIENCY FACTORS
0.08.01.04 VACUUM SYSTEMS (CSI 15482)

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DEFICIENCY FACTORS
0.08.01.04 VACUUM SYSTEMS **(CSI 15482)**

END OF SUBSECTION

0.08.01.05 GAS SYSTEMS (CSI 15488,15590)

DESCRIPTION

The typical Gas Supply system provides gas preparation and transfer for use in heat and electrical generation equipment (ovens, boilers, furnaces, emergency generators). The system consists of storage tanks, strainers, and the connecting piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Compressed Gas Tanks (CSI 15175)

Storage tanks are used in remote areas where a local gas distribution system is not available. In most installations, more than one above ground tank will be provided, usually outdoors to prevent accidental gas accumulation.

Valves (CSI 15100)

Valves are used to permit switching service tanks, isolating gas system components for maintenance, and isolating 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 tanks or service entrance piping to the terminal equipment. The service distribution pressure is usually less than 5 psig. Exceptions to this pressure limit may be found in industrial processing plants, research buildings, and power plants.

Special safety valves are employed in “gas trains” to shut off gas supply to burners in emergencies. They are essentially solenoid-operated valves, but usually require manual reset after a failure.

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

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the tank manifold and/or on the suction and discharge of each regulating valve.

Temperature gauges are not usually provided.

Metering is generally provided at the service entrance to permit billing. Meters should be readily accessible for examination, reading, replacement, or necessary maintenance.

Piping & Fittings (CSI 15050)

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, 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.

Fittings are made of compatible materials,

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

Strainers are typically provided at the inlet to main tank or service entrance regulating valves, to protect the sensitive control devices downstream.

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

0.08.01.05 GAS SYSTEMS (CSI 15488,15590)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Flfflngs (CSI 15060) (Continued)

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.

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

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

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.

Equipment Controls & Panels (CSI 1 5950)

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.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	GAS METER WITH PRESSURE REGULATOR AND ISOLATION VALVE		
PLUMBING-GAS SYSTEMS (CSI 15488, 15590)	Revision No.	Issue Date 5/93	Drawing No. A080105-1

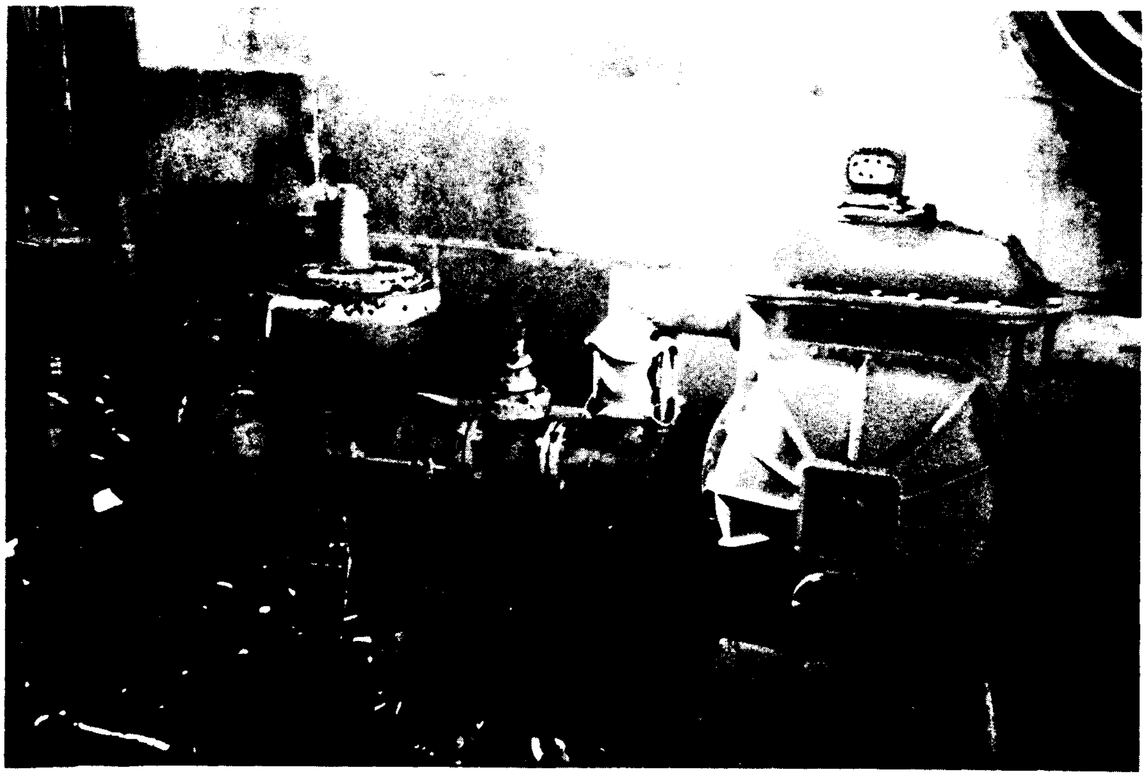

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	LARGE SERVICE W/ METER, PRESSURE REGULATOR, CHECK VALVE AND ISOLATION VALVES		
PLUMBING-GAS SYSTEMS (CSI 15488, 15590)	Revision No.	Issue Date 5/93	Drawing No. A080105-2

DEFICIENCY FACTORS
0.08.01.05 GAS SYSTEMS (CSI 15488,15590)

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, defective strainers, regulator failure.
- Pipe leakage due to internal corrosion.

SYSTEM ASSEMBLIES/DEFICIENCIES

Tanks

External Leakage:	Severe internal or external corrosion, failure of gaskets at flange or other fittings.
Loose or Missing Fasteners:	Corrosion, damage.
Corrosion:	Weathering, contamination.

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:	Worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.

Instrumentation

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

DEFICIENCY FACTORS
0.08.01.05 GAS SYSTEMS (CSI 15488,15590)

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.

Equipment Controls & Panels

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

END OF SUBSECTION

0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

DESCRIPTION

A typical Wet Pipe Sprinkler System distributes water to extinguish or prevent the spread of fire. The system has sprinklers attached to a piping network with water under pressure at all times. When fire occurs, individual sprinklers are activated by heat and water flows immediately. The system consists of piping and hangers, sprinklers,, valves, pumps, gauges, and sprinkler alarm devices.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fire Pumps (CSI 15320)

Fire pumps are often used to supplement the water supply pressure when the sprinkler system exceeds the capability of the normal water supply system. This is true in high rise buildings, remote locations where the local water pressure is low, and in large systems where there is excessive head loss in the lines.

Two types of fire pumps are used to supply the wet sprinkler system: horizontal shaft centrifugal and vertical shaft turbine. The centrifugal type is used where the suction source is available under pressure to the fire pump unit. The turbine type is used when the suction source is below the pumping unit.

These pumps must deliver 150 percent of the rated flow at 65 percent of the rated pressure; may be single-stage or multiple-stage; are usually provided with a circulation relief valve to prevent overheating and damage; and are provided with a pressure (case) relief valve to prevent excessive pressure build-up.

Jockey pumps (CSI 15320)

Jockey pumps are provided to compensate for pressure fluctuations in the system caused by leakage or pipe expansion and contraction. Because the jockey pump is smaller, it can provide compensation without surging (hunting and seeking the setpoint) and is more economical than starting a large motor or an engine and is less destructive to the fire pump.

Motors (CSI 15170)

Most fire and jockey pumps are driven by a horizontally coupled AC motor, although it is not unusual to find other drives. Many multi-stage turbine fire pumps are driven by a vertically coupled AC motor.

Engines (CSI 15320)

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

Alarm Check Valves (CSI 15100)

A device known as an alarm check valve is installed at the source. It is generally located at or near the base of the sprinkler riser and designed to give an alarm if a water flow occurs equal to the discharge of one or more automatic sprinklers.

The alarm valve is usually a check valve that lifts from its seat when water flows into a sprinkler system. The valve rises and water flows into the chamber, activatings electrical contacts to transmit an alarm. This is tied into the central fire alarm system, and in some cases, directly to the local fire department. A unique feature of the alarm check valve is the retarding devices, included to prevent false alarms. They consist of retard chambers, check valve bypasses, or small electric pumps to decrease normal pressure fluctuations,

0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Detectors, Alarms, & Control Devices (CSI 15330)

The basic detection and control device in a sprinkler system is the sprinkler head itself. It reacts to environmental conditions (excessive heat) and opens to release the suppressant (water).

Other detectors are employed to signal system changes. The most common is the flow switch, typically vanes or paddles inserted in the waterway that activate electric switches signaling flow at some location in the system.

An additional alarm device, known as a water gong, is usually connected to the system, sometimes directly to the alarm check valve. It is a simple paddle or vane that extends into the waterway. Any water movement operates the gong.

Finally, any system valve whose closure would reduce the system's capability without knowledge of the owner should be provided with a supervisory (tamper) switch (eg., main or branch supplies, riser valves, etc.). The switch should be tied into the alarm system to alert the fire department if the valve is closed without approval.

Piping & Fittings (CSI 15060)

Piping provides water from an outside water source to the sprinklers. It is typically cast iron, malleable iron, or steel. Although copper pipe is permitted, it is rarely used because of cost.

All fittings and joints should be compatible with the type of piping materials used to prevent corrosion. Fittings should be of a heavy schedule where the water pressure exceeds 175 psi.

Reducers and bushings should be the one-piece type, and couplings and unions should not be used on pipe larger than 2 inches.

Piping subject to corrosive atmospheres should be protected with an approved corrosion resistive coating.

Sprinklers are essentially nozzles placed at intervals along the piping network to distribute a uniform pattern of water on the area being protected. They are typically installed one head per hundred-thirty square feet, but may be different for specialized systems.

Sprinklers are listed for specific applications based on an orifice size, deflector design, frame finish, and temperature rating.

Sprinkler orifices range from 1/4 to 3/4 inches in size. Deflectors allow different patterns of water distribution. Sprinkler frame finish may be plated for aesthetic or protection purposes.

Sprinklers are normally held closed by heat-sensitive elements that press on a cap over the sprinkler orifice and are anchored by the sprinkler frame. The heat sensitive elements are designed to release at different temperatures, depending on the application. There are basically four types of release mechanisms: fusible link, flangible bulb, flangible, and bimetallic pellet. All these release to allow water flow when subjected to heat.

Sprinklers subject to mechanical injury should be protected with approved guards.

Valves (CSI 15100)

Valves are primarily used to turn off the water supply for system maintenance, to conduct flow tests, and to initiate fire alarms.

A check valve is located in each sprinkler riser to prevent water back flow.

Drain valves are installed at risers and low places in the system to allow drainage. Special drains, referred to as "Inspector Test Connections," are placed in critical locations to permit verification of flow capability through the system.

0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Valves (CSI 15100) (Continued)

Valves should be in the appropriate open or closed position and sealed as required.

All valves must be in accessible locations and tagged.

Supports & Anchors (CSI 15140)

Pipe hangers and anchors are provided to support piping and allow for expansion and contraction. They should be secured to building construction at approved intervals. They should be ferrous material and should not be used to support other components.

Instrumentation (CSI 15135)

Pressure gauges on Wet Pipe Sprinkler Systems typically provide pressure readings at the inlet and outlet of the alarm check valves.

Code requires that pressure gauges have a maximum limit of not less than twice the normal working pressure. (Ideally normal system pressure will be at gauge mid-point.)

Each gauge connection should be equipped with a shut-off valve and drain.

Equipment Controls (CSI 15950)

In addition to the control circuits used in the alarms (tamper and switches), a Wet Pipe Sprinkler System may also employ pump controls. These typically consist of motor starters with associated relays and switches. Both the fire pump and the jockey pump are usually controlled and activated by low pressure controllers mounted at the fire pump discharge.

0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

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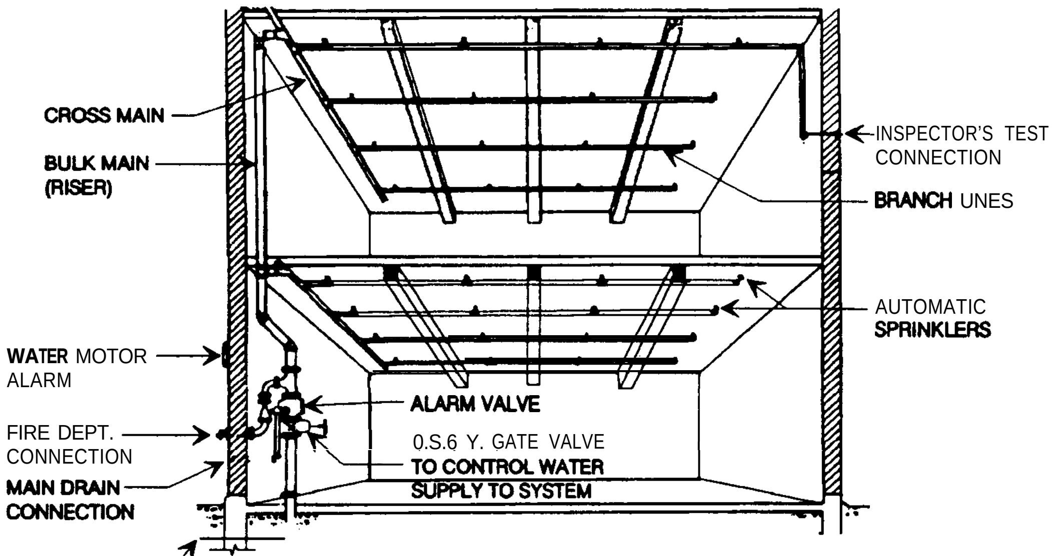


TYPICAL AUTOMATIC WET PIPE SPRINKLER SYSTEM INDICATES PIPE FILLED WITH WATER WHEN SYSTEM IS SET FOR SERVICE.

WET-PIPE SYSTEM

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL AUTOMATIC WET PIPE SPRINKLER SYSTEM		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-1

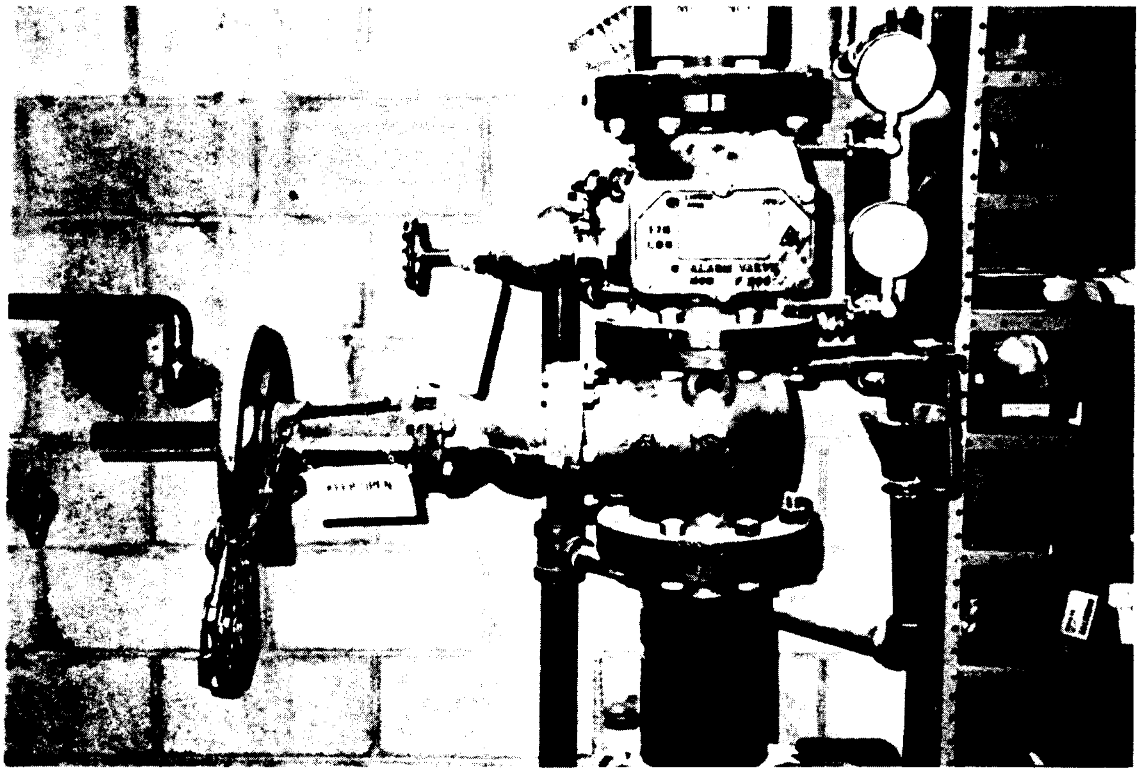
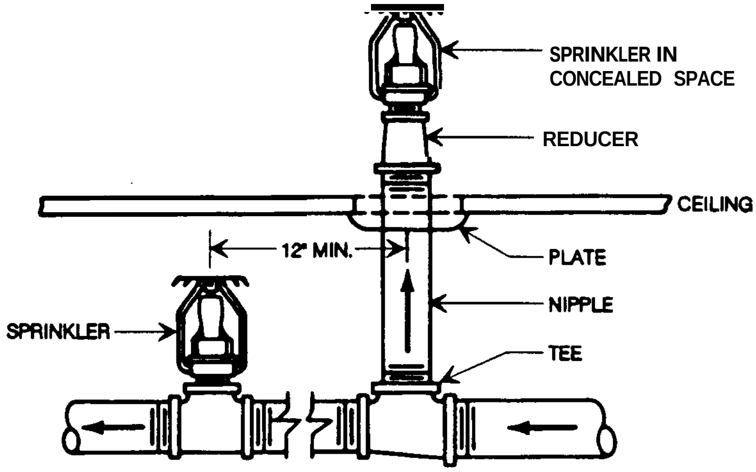


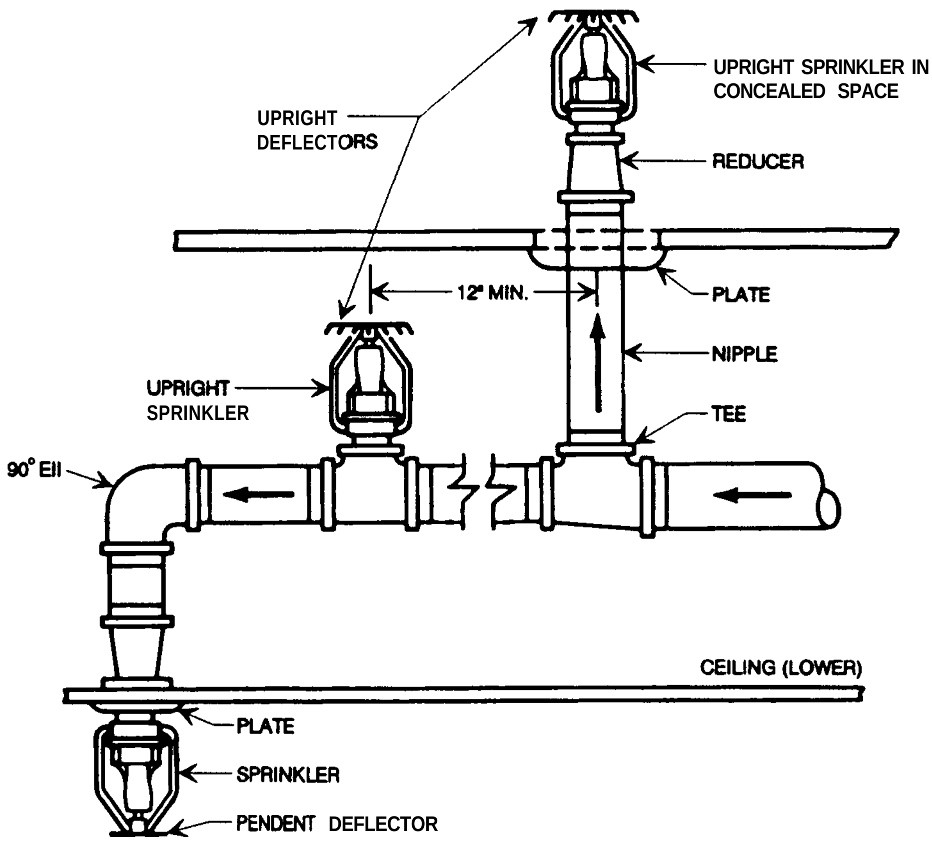
PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ALARM VALVE AND TRIMMINGS		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS **(CSI 15330)**	Revision No.	Issue Date	Drawing No.
		5/93	A080201-2



FOR SI UNITS: 1 IN. = 25.4 MM

SPRINKLER ON RISER NIPPLE FROM BRANCH LINE IN LOWER FIRE AREA

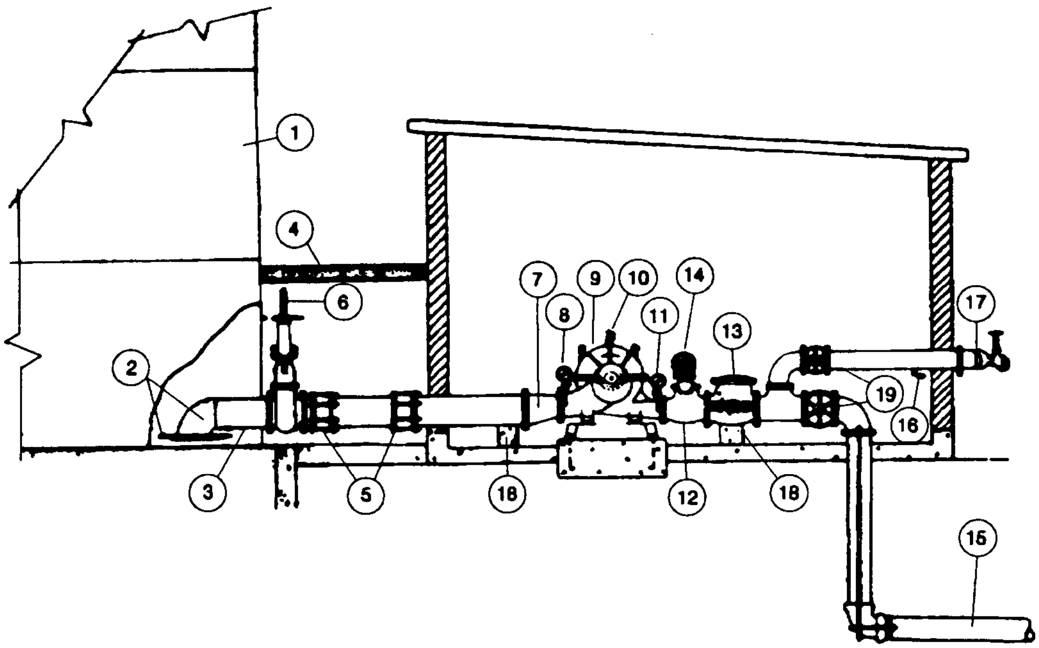


FOR SI UNITS: 1 IN. = 25.4 MM

ARRANGEMENT OF BRANCH LINES SUPPLYING ABOVE AND BELOW CEILINGS.

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL SPRINKLER INSTALLATION		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-3

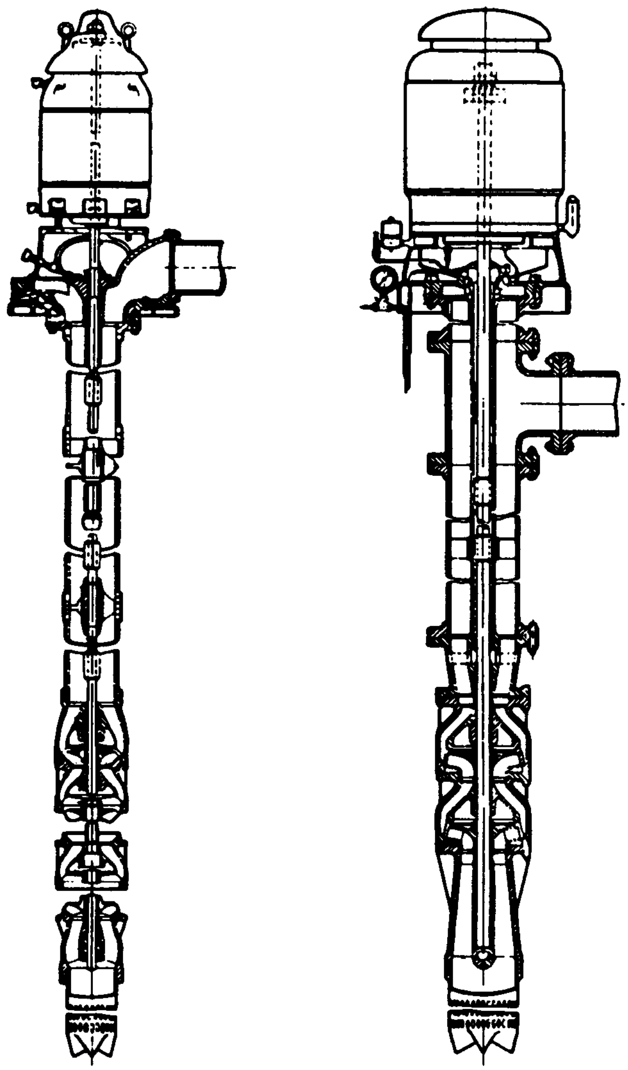


1. ABOVEGROUND SUCTION TANK.
2. ENTRANCE ELBOW AND 4 FT. X 4 FT. (1.2M X 1.2M) SQUARE VORTEX PLATE. DISTANCE ABOVE BOTTOM OF TANK- ONE-HALF DIAMETER OF SUCTION PIPE WITH A MINIMUM OF 6 IN. (152 MM).
3. SUCTION PIPE.
4. FROSTPROOF CASING.
5. FLEXIBLE COUPLINGS FOR STRAIN RELIEF.
6. O.S. & Y. GATE VALVE.
7. ECCENTRIC REDUCER.
8. SUCTION GAGE.
9. HORIZONTAL SPLIT-CASE FIRE PUMP.
10. AUTOMATIC AIR RELEASE.
11. DISCHARGE GAGE.
12. REDUCING DISHARGE TEE.
13. DISCHARGE CHECK VALVE.
14. RELIEF VALVE (IF REQUIRED).
15. DISCHARGE PIPE.
16. DRAIN VALVE OR BALL DRIP.
17. HOSE VALVE MANIFOLD WITH HOSE VALVES.
18. PIPE BUPPORTB.
19. INDICATING GATE OR INDICATING BUTTERFLY VALVE.

HORIZONTAL SPLIT-CASE FIRE PUMP INSTALLATION WITH WATER SUPPLY UNDER A POSITIVE HEAD.

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

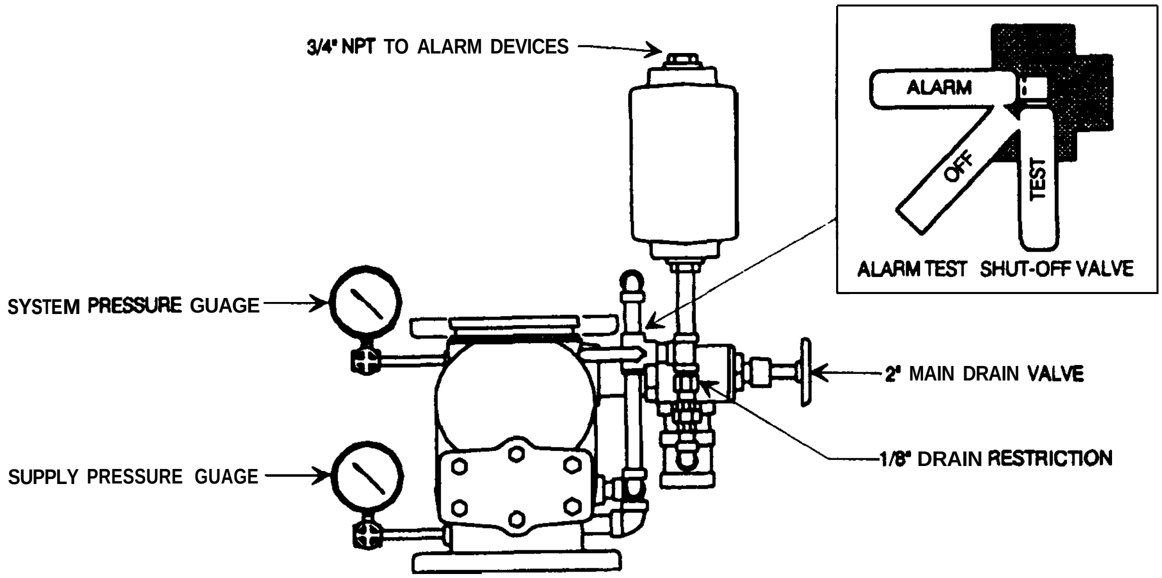
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HORIZONTAL SPLIT CASE FIRE PUMP INSTALLATION		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-4



ILLUSTRATIONS OF WATER-LUBRICATED AND OIL-LUBRICATED SHAFT PUMPS.

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	VERTICAL SHAFT FIRE PUMP		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-5

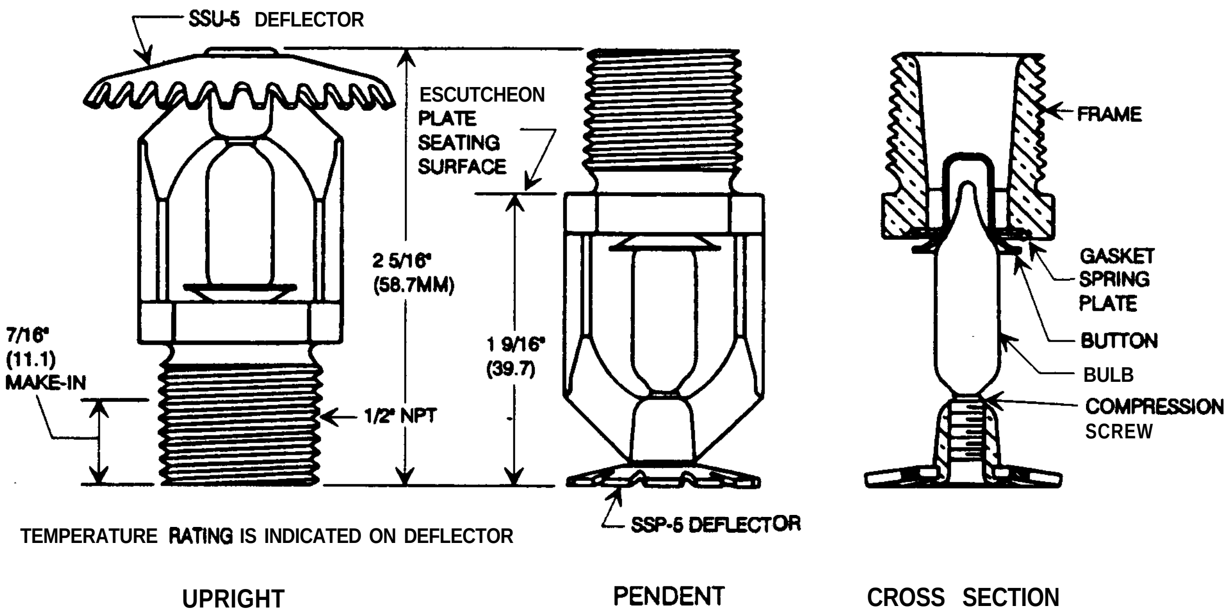


(COURTESY OF THE VIKING CORPORATION)

WET PIPE SPRINKLER SYSTEM ALARM VALVE

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	ALARM VALVE		
FIRE PROTECTION-W ET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-6



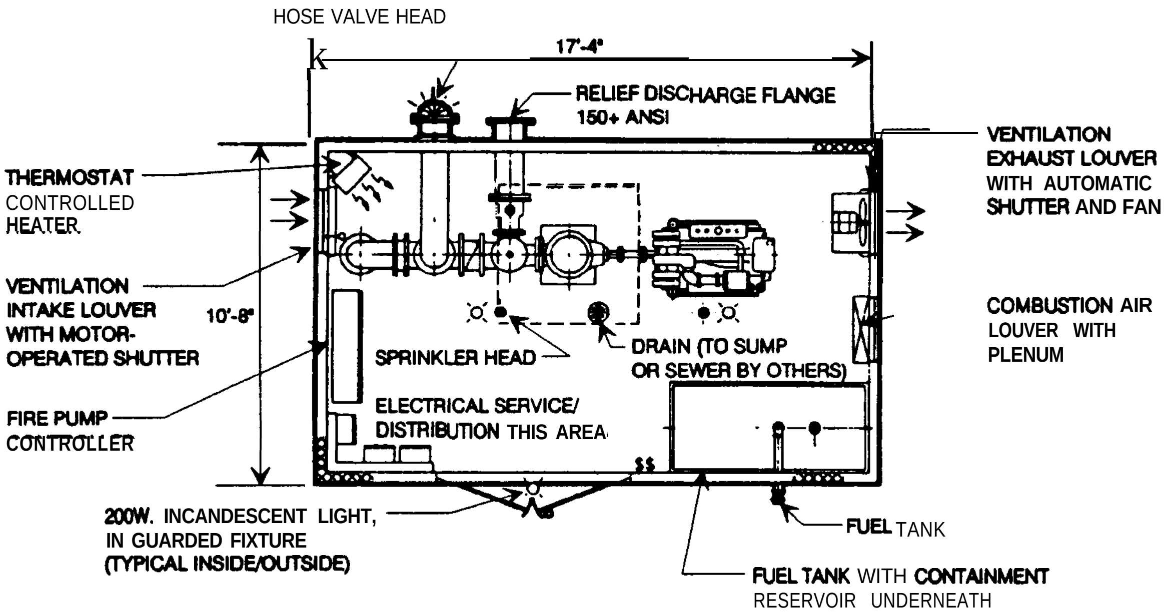
FRANGIBLE BULB SPRINKLER HEAD

(COURTESY OF GRINNELL FIRE PROTECTION SYSTEMS COMPANY CO.)

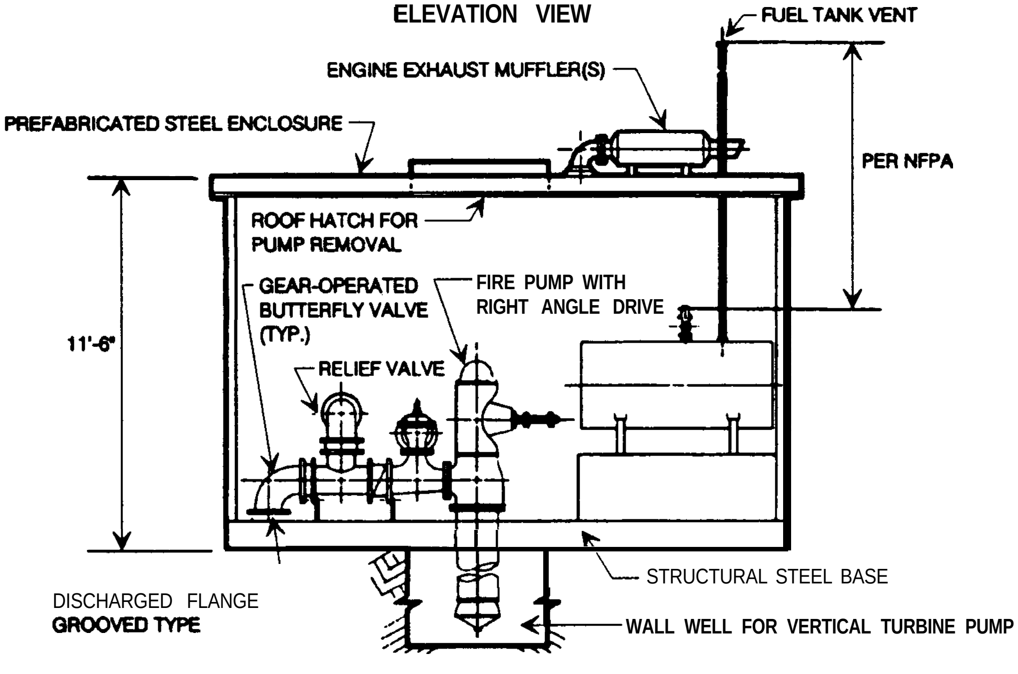
SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FRANGIBLE BULB SPRINKLERS		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-7

VERTICAL DIESEL DRIVE FIRE PUMP MODULE
PLAN VIEW



VERTICAL DIESEL DRIVE FIRE PUMP MODULE
ELEVATION VIEW



VERTICAL DIESEL DRIVE FIRE PUMP

(COURTESY OF SYSTECON)

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DIESEL FIRE PUMP INSTALLATION		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-8

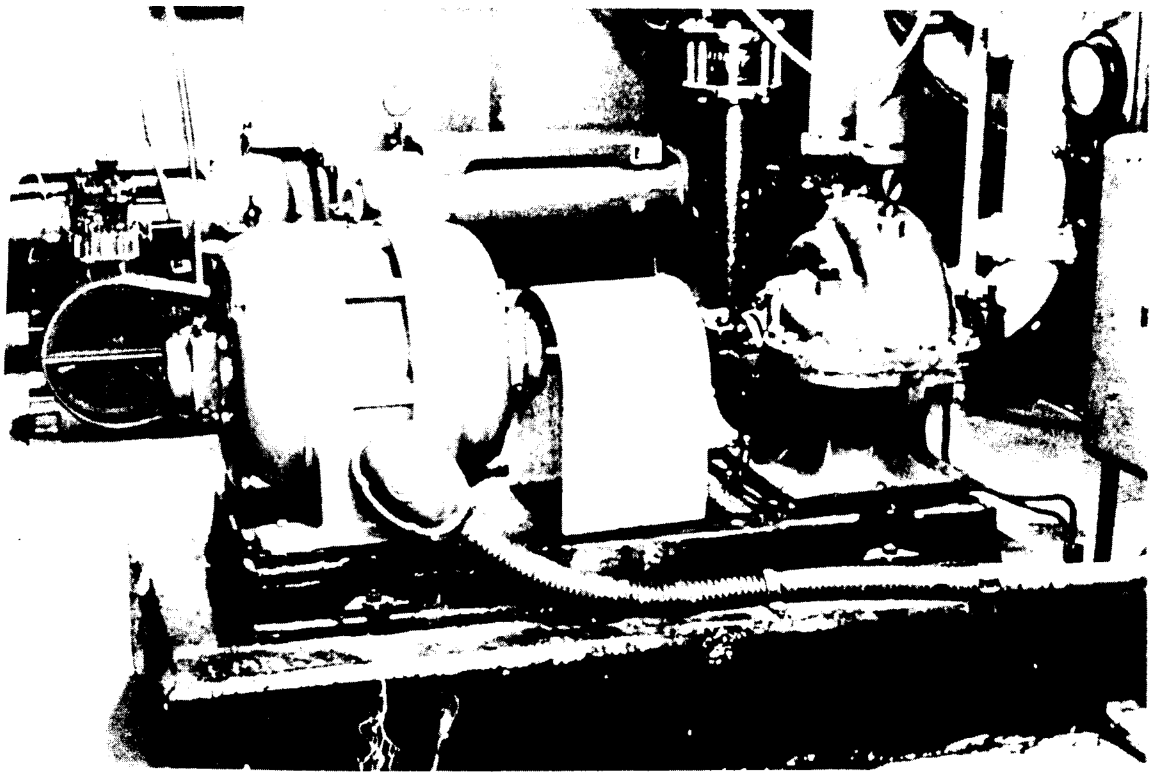


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	ELECTRIC MOTOR DRIVEN HORIZONTAL SPLIT CASE FIRE PUMP		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-9

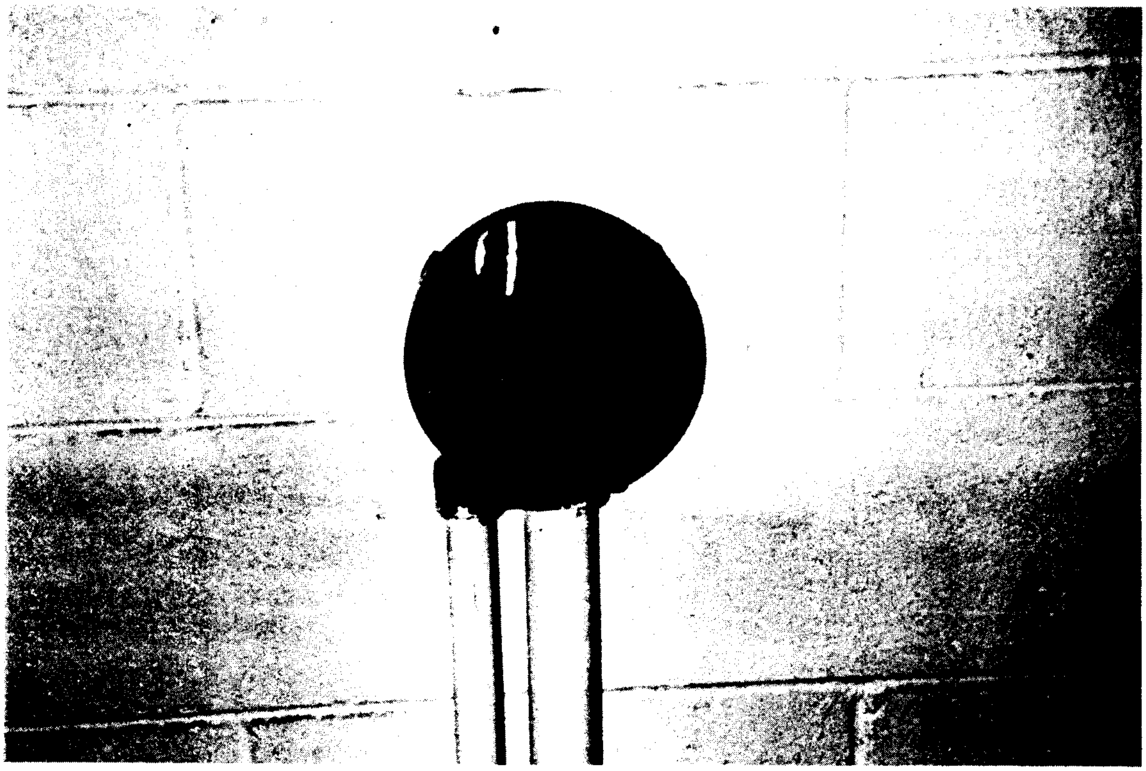


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	WATER POWERED FIRE ALARM (WATER GONG)		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-10

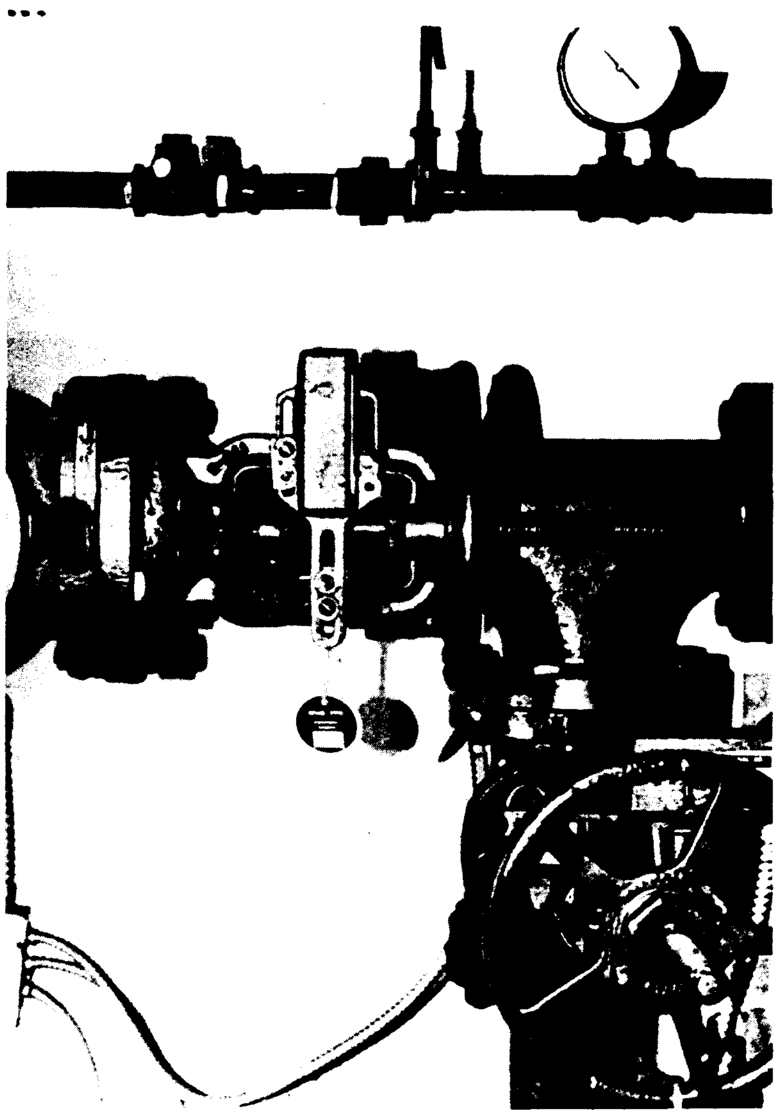


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FIRE CONTROL VALVES (OS&Y) WITH TAMPER SWITCHES		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-11

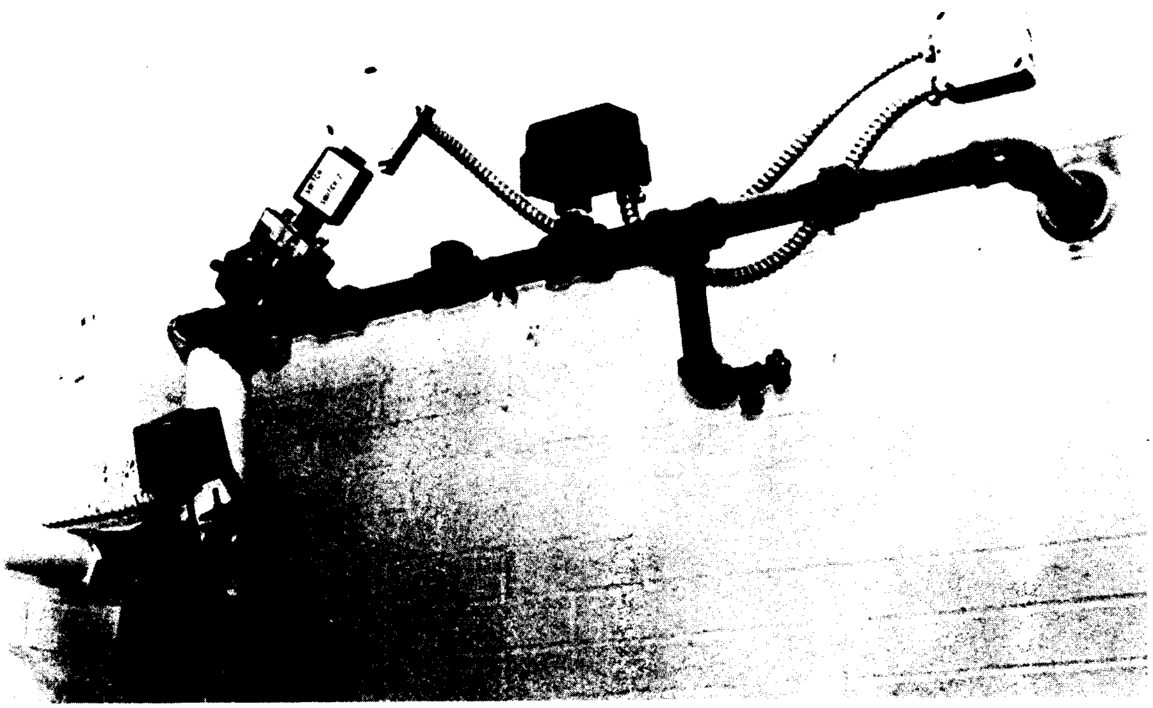


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TAMPER SWITCHED ISOLATION VALVES W/ FLOW SWITCH AND BRANCH DRAIN VALVE		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. A080201-12

DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

PROBABLE FAILURE POINTS

- System leaks due to corrosion.
- Inability of the system to deliver rated capacity (pressure and flow) to sprinkler heads due to internal corrosion or failure of check valves to open.
- Valve leakage due to improper seal.
- Alarm valve not operating due to corrosion, blockage, or electrical component failure.
- Fire pump will not run due to poor maintenance, corrosion.

SYSTEM ASSEMBLIES/DEFICIENCIES

Fire pumps

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

Jockey Pumps

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

Motors

Missing:	Taken out for service or repair, not returned.
Inoperative:	Winding or bearing failures.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.

DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors (Continued)

Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charging.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Compression Loss:	Defective rings or valves, cracked block.
Defective Bearings:	Poor lubrication, normal wear.
Radiator or Fan Damaged:	Bent fins, punctures, loose joints.
Engine Damaged:	Abuse, stress.
Fuel or Water Pump Worn:	Normal wear and tear.
Defective Coupling:	Broken spring, worn insert, misalignment.
Defective Battery Charger:	Poor maintenance.
Battery Dead:	Lack of maintenance.
Leakage (Fuel, Water):	Corrosion, abuse.

Alarm Check Valves

Valves Will Not Cycle Properly:	Corrosion or valve obstruction.
Insufficient Water Flow:	Valve obstructed by scale, corrosion.
Leakage:	Corrosion, drains or checks fail to close.
Severe Corrosion:	Normal aging, improper materials.
Alarm Not Transmitting:	Lack of water flow, electrical malfunction.

Detectors, Alarms, & Control Devices

Detector Missing:	Taken out for service and not returned.
Detector Inoperative:	Physical damage, wear, abuse, corrosion.
Detector Damaged:	Abuse.
Alarm Missing:	Taken out for service and not returned.
Alarm Inoperative:	Not transmitting, lack of water flow, electrical malfunction

DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

SYSTEM ASSEMBLIES/DEFICIENCIES

Detectors, Alarms, & Control Devices (Continued)

Alarm Damaged:	Abuse.
Operating Device Missing:	Taken out for service and not returned.
Operating Device Inoperative:	Not transmitting, lack of water flow, electrical malfunction.
Operating Device Damaged:	Abuse.
Severe Corrosion:	Normal aging, improper materials.
Leakage:	Due to corrosion, failure of drains or checks to close.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.
Sprinkler/Nozzle Missing:	Taken out for repair, not replaced.
Sprinkler/Nozzle Physical Damage:	Lack of sprinkler guards, painting, other foreign materials.
Sprinkler/Nozzle Corrosion:	Non-coated sprinkler.
Sprinkler/Nozzle Leakage:	Partial failure of sealing element due to overheating, freezing, abuse.

Valves

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

Supports & Anchors

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

Instrumentation

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

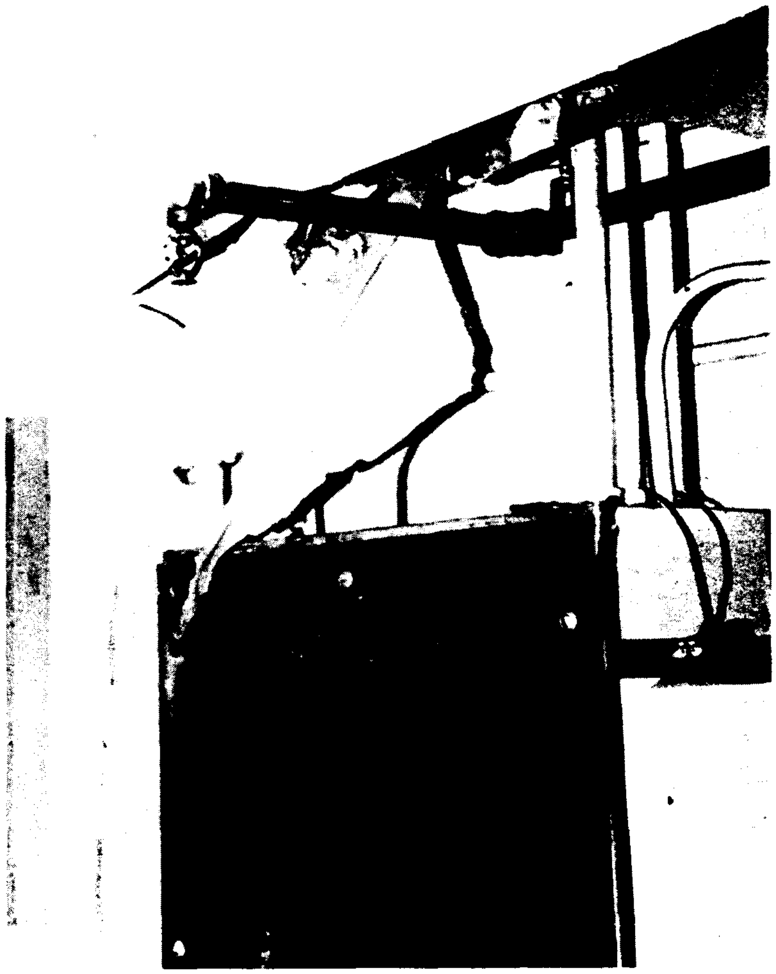


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	SPRINKLER INSTALLED DIRECTLY OVER ELECTRICAL PANEL		
FIRE PROTECTION-WET PIPE SPRINKLER SYSTEMS (CSI 15330)	Revision No.	Issue Date 5/93	Drawing No. D080201-1

DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

SYSTEM ASSEMBLIES/DEFICIENCIES

Instrumentation (Continued)

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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

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DEFICIENCY FACTORS
0.08.02.01 WET PIPE SPRINKLER SYSTEMS (CSI 15330)

END OF SUBSECTION

0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

DESCRIPTION

A typical Dry Pipe Sprinkler System employs automatic sprinklers installed in a piping system containing air or nitrogen under pressure. The pressure is released when sprinklers open, allowing water to open a dry-pipe valve. The water then flows into the system and out the sprinklers. The system consists of piping/anchors, sprinklers, valves, pumps, compressors, exhausters, gauges, and sprinkler alarm devices.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fire Pumps (CSI 15320)

Fire pumps are often used to supplement the water supply pressure when the sprinkler system exceeds the capability of the normal water supply system. This is true in high rise buildings, remote locations where the local water pressure is low, and in large systems where there is excessive head loss in the lines.

Two types of fire pumps are used to supply the Dry Pipe Sprinkler System: horizontal shaft centrifugal and vertical shaft turbine. The centrifugal type is used where the suction source is available under pressure to the fire pump unit. The turbine type is used when the suction source is below the pumping unit.

These pumps must deliver 150 percent of the rated flow at 65 percent of the rated pressure; may be single-stage or multiple-stage; are usually provided with a circulation relief valve to prevent overheating and damage; and are provided with a pressure (case) relief valve to prevent excessive pressure build-up.

Compressors (CSI 15480)

Dry pipe pressure is usually maintained using compressed air (in special cases nitrogen may be used). An independent compressor is typically provided to accomplish this.

Although the system consumes very little air during normal status, fairly large compressors are required to permit rapid repressurization after a system activation.

The dry pipe pressure is maintained at 20 psi (1.4 bars) in excess of that required to hold the check valve shut (calibrated trip pressure).

Motors (CSI 15170)

Most fire and jockey pumps are driven by a horizontally coupled AC motor, although it is not unusual to find other drives. Many multi-stage turbine fire pumps are driven by a vertically coupled AC motor.

Compressors on small systems typically use integral, direct-drive motors. Large capacity systems require a larger compressor that is typically driven by an AC induction motor with v-belts.

Engines (CSI 15320)

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

Alarm Check Valves (CSI 15100)

A device known as an alarm check valve may be installed at the fire suppression water supply source. It is generally located at or near the base of the sprinkler riser and designed to give an alarm if a water flow occurs equal to the discharge of one or more automatic sprinkler. They are used in combined wet/dry systems.

0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Alarm Chock **Valves** (CSI 15100) (Continued)

The alarm valve is usually a check valve that lifts from its seat when water flows into a sprinkler system. The valve rises and water flows into the chamber activating the electrical contacts to transmit an alarm. This is tied into the central fire alarm system, andin some cases, directly to the local fire department. A unique feature of the alarm check is the retarding devices, included to prevent false alarms. They consist of retard chambers, check valve bypasses, or small electric pumps to decrease normal pressure fluctuations.

Dry Pipe Valves (CSI 15100)

Dry pipe valves are an essential addition to alarm check valves. They are installed between the water supply and the system dry header. They keep the water out of the dry pipe until its needed.

There are several types, although differential is the most common. In this unit, the differential areas exposed to water pressure and air pressure allow the air to keep the valve shut. A drop in air pressure reduces the difference in force, allowing the check/flapper to open.

In other types, mechanical latches or similar devices are used to hold the check closed. A mechanical trip is required to open the valve when pressure drops.

Detectors, Alarms, & Control Devices (CSI 15330)

The basic detection and control device in a sprinkler system is the sprinkler head itself. It reacts to environmental conditions (excessive heat) and opens to release the suppressant (water).

Other detectors are employed to signal system changes. The most common is the flow switch, typically vanes or paddles inserted in the waterway that activate electric switches and signal flow at some location in the system.

An additional alarm device, known as a water gong, is usually connected to the system, sometimes directly to a alarm check valve. It is a simple paddle or vane that extends into the waterway. Any water movement operates the gong.

Finally, any system valve whose closure would reduce the system's capability without knowledge of the owner, should be provided with a supervisory (tamper) switch (eg., main or branch supplies, riser valves, etc.). The switch should be tied into the alarm system to alert the fire department if the valve is closed without approval.

Piping & Rfflngs (CSI **15060)**

Piping provides water from an outside water source to the sprinklers. It is typically cast iron, malleable iron, or steel. Although copper pipe is permitted, it is rarely used because of cost.

All fittings and joints should be compatible with the type of piping materials used to prevent corrosion. Fittings should be of a heavy schedule where the water pressure exceeds 175 psi.

Reducers and bushings should be the one-piece type, and couplings and unions should not be used on pipe larger than 2 inches.

Piping subject to corrosive atmospheres should be protected with an approved corrosion resistive coating.

Sprinklers are nozzles placed at intervals along the piping network to distribute a uniform pattern of water on the area being protected. They are typically installed one head per hundred-thirty square feet, but may be different for specialized systems.

Sprinklers are listed for specific applications based on an orifice size, deflector design, frame finish, and temperature rating.

0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

piping & Fittings (CSI 15060) (Continued)

Sprinkler orifices range from 1/4 to 1/2 inches in size. Deflectors allow different patterns of water distribution. Sprinkler frame finish may be plated for aesthetic or protection purposes.

Sprinklers are normally held closed by heat sensitive elements that press on a cap over the sprinkler orifice and are anchored by the sprinkler frame. The heat sensitive elements are designed to release at different temperatures, depending on the application. There are four types of release mechanisms: fusible link, flangible bulb, flangible, and bimetallic pellets. All these release to allow water flow when subjected to heat.

Sprinklers subject to mechanical injury should be protected with approved guards.

Valves (CSI 15100)

Valves are primarily used to turn off the water supply for system maintenance, to conduct flow tests, and to initiate fire alarms.

A check valve is located in each sprinkler riser to prevent back flow of water.

Drain test valves, referred to as the "inspector's test connection," are installed at risers and low places in the system to allow drainage and system testing.

Valves should be in the appropriate open or closed position and sealed as required.

All valves must be in accessible locations and tagged.

Supports & Anchors (CSI 15140)

Pipe hangers and anchors are provided to support piping and allow expansion and contraction. They should be secured to building construction at approved intervals.

Pipe hangers and anchors should be ferrous material and should not be used to support other components.

Instrumentation (CSI 15135)

Pressure gauges on Dry Pipe Sprinkler Systems typically provide pressure readings at the inlet and outlet of the alarm check valves and on both sides of the dry pipe valves.

Code requires that pressure gauges have a maximum limit of not less than twice the normal working pressure. (Ideally normal system pressure will be at gauge mid-point.)

Each gauge connection should be equipped with a shut-off valve and drain.

Equipment Controls & Panels (CSI 15950)

In addition to the control circuits used in the alarms (tamper and switches), a Dry Pipe Sprinkler System may also employ pump and compressor controls. These typically consist of motor starters with associated relays and switches. The fire pump, jockey pump, and the system air compressor are each usually controlled and activated by low-pressure controllers mounted at the unit discharge.

0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

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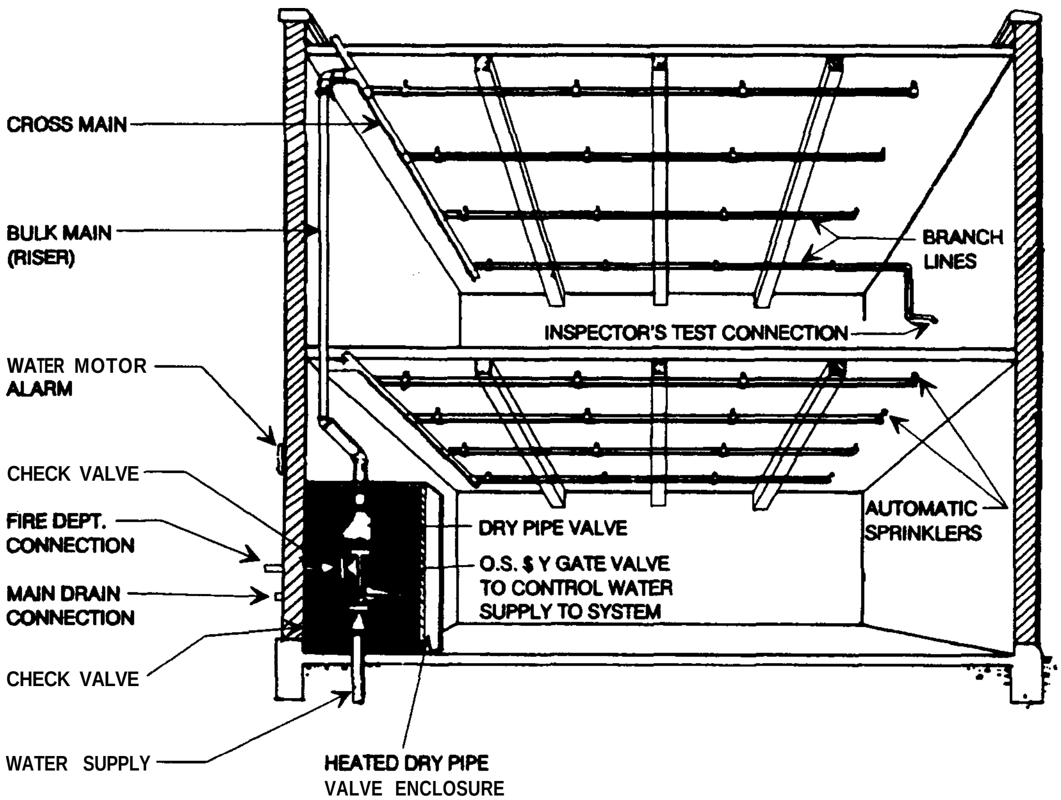
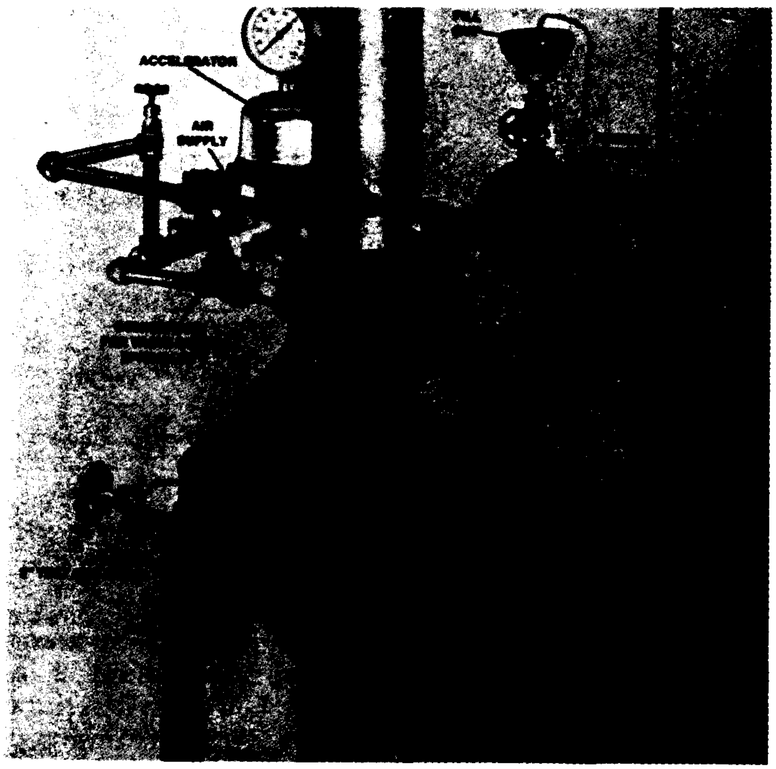


TYPICAL AUTOMATIC DRY PIPE SPRINKLER SYSTEM
▭ INDICATES PIPE FILLED WITH WATER WHEN SYSTEM IS SET FOR SERVICE

DRY-PIPE SYSTEM

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DRY PIPE SYSTEM		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-1

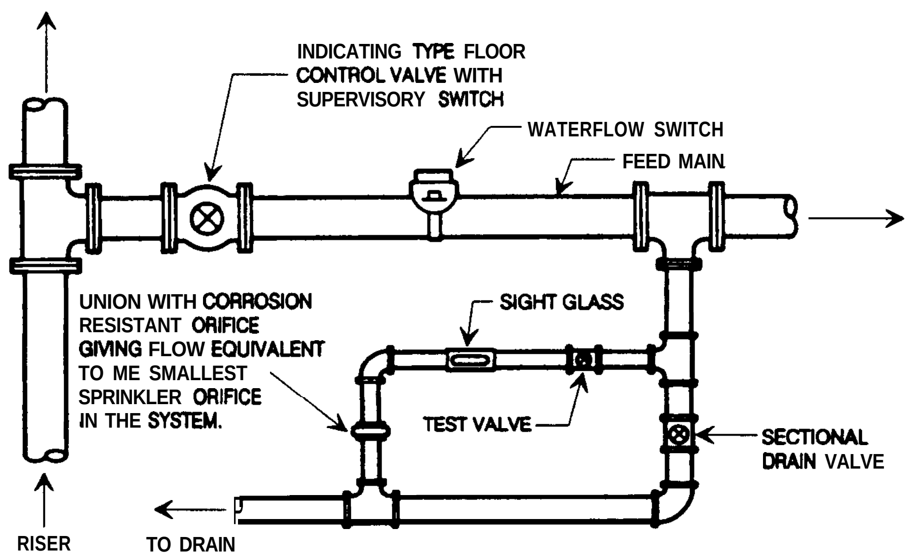


TYPICAL DRY-PIPE VALVE WITH TRIMMINGS

PHOTO ILLUSTRATION

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME I

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DRY PIPE VALVE WITH TRIMMINGS		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-2



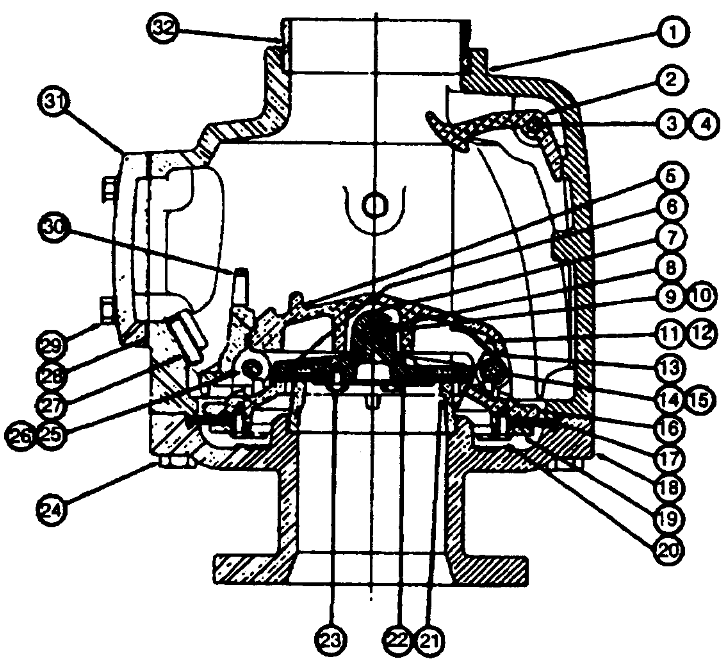
CONTROL VALVE

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BRANCH CONTROL ASSEMBLY		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 153353	Revision No.	Issue Date 5/93	Drawing No. A080202-3

MODEL D
6" (150mm)
MFG. 1975-

MODEL E
3' (80mm), 4' (100mm)
MFG. 1979
6" (150mm)
MFG. 1980



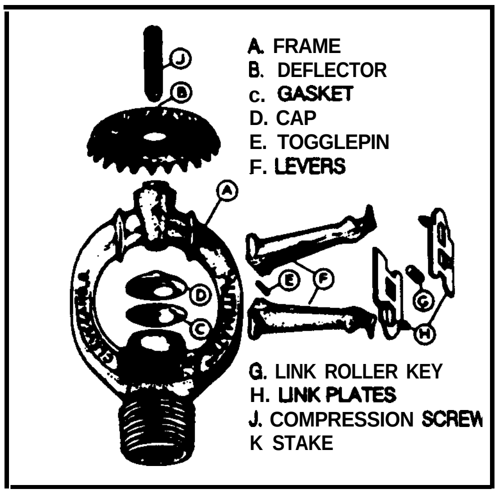
DRY PIPE SPRINKLER SYSTEM VALVE

(COURTESY OF THE VIKING CORPORATION)

2 Latch
3 Latch Pin
4 3/8" NPT Pipe Plug
5 Clapper Arm
6 Clapper Rubber
7 Clapper
8 Clapper Bushing
9 Hinge Pin
10 Cotter Pin
11 Right-Hand Spring
12 Left-Hand Spring
13 Side Stop Pin
14 Cotter Pin
15 Clapper Shaft
16 Air Plate
17 Air Plate Rubber
18 Base
19 Clamp Ring
20 3/-16 x 3/4 H.H.C. Saw
21 seat
22 Clamp Plate
23 5/16-18 x 1/2" H.H.C. Screw
#10-24 x 1/2" HH.C. Screw
1/2"-13 x 1-1/4" H.H.C. Screw
24 m-11 x 2" H.H.C. screw
3/4-10 x 2-1/4" H.H.C. Screw
25 cotter Pin
26 Clapper Shaft
27 1/2-13 x 1-3/4" Socket Set Screw
28 Hand Hole Cover Gasket
29 5/8-11 x 1-1/2" H.H.C. Screw
5/8-11 x 2" H.H.C. screw
30 Hook
31 Hand Hole Cover
32 Adapter

SOURCE: MEANS, " R E PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER C O W . PE, R.S. Means C O . . Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SYSTEM VALVE		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-4

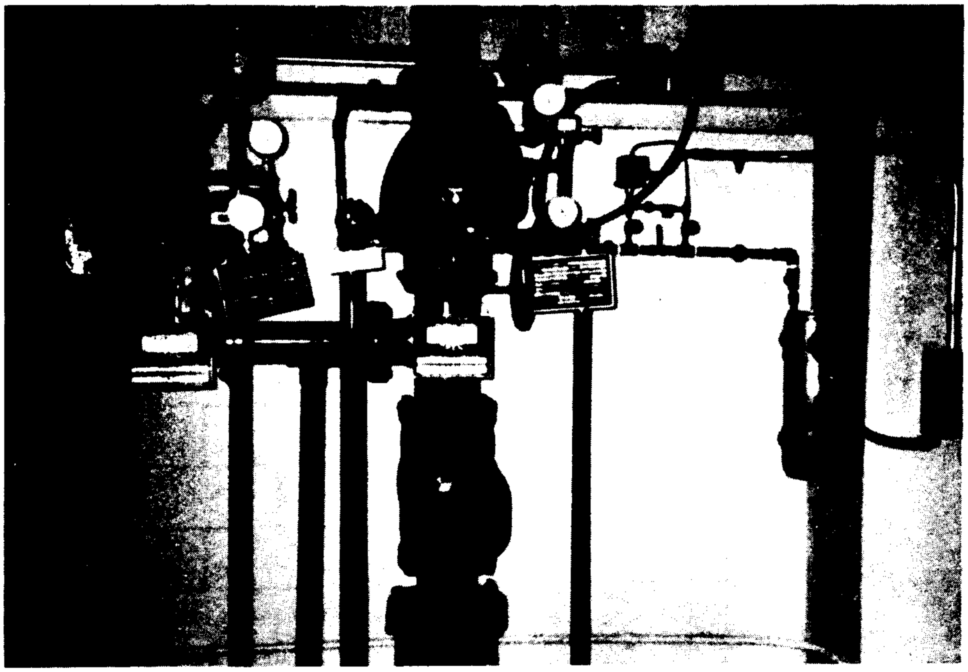


SPRINKLER HEAD COMPONENTS

(COURTESY OF 'AUTOMATIC' SPRINKLER CORPORATION)

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SPRINKLER HEAD COMPONENTS		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-5



NOTE: FILL CUP AND PRIMARY CHAMBER TOP RIGHT. AIR COMPRESSOR IS USED TO MAINTAIN PRESSURE IN DRY PIPE.

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DRY SYSTEM VALVE		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-6

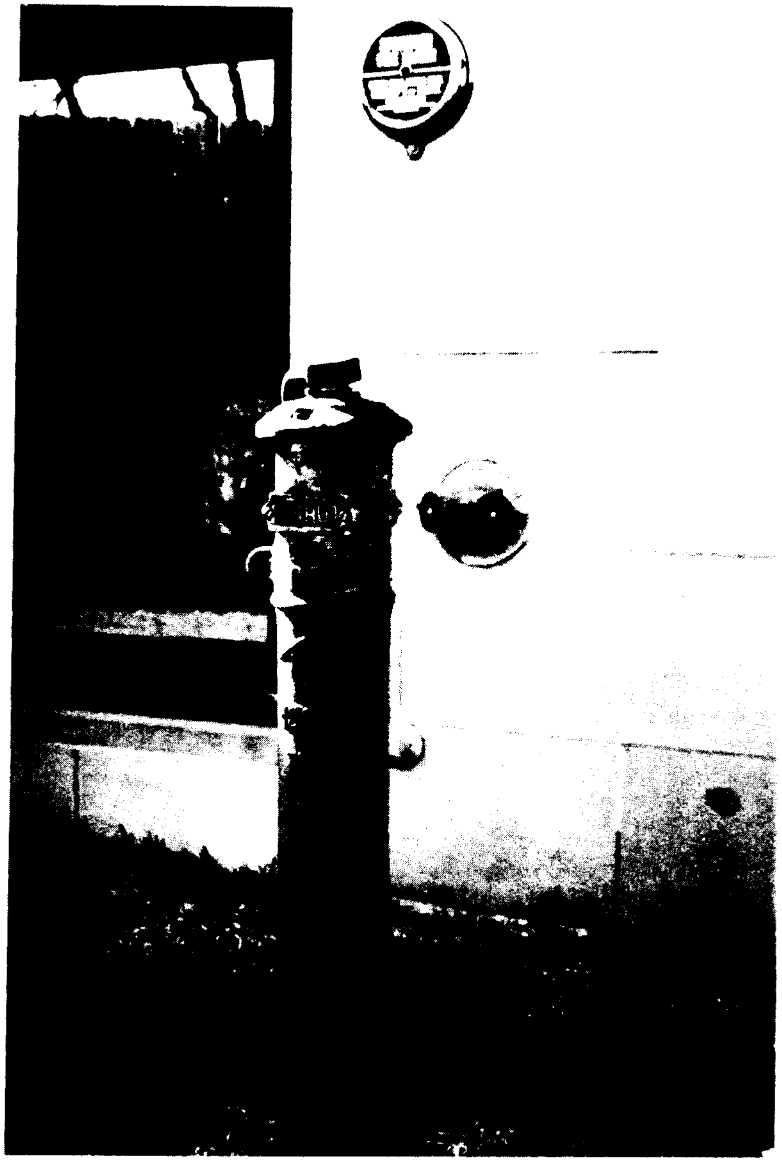


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	POST INDICATOR VALVE, FIRE DEPT. CONNECTION(SIAMESE) AND ALARM BELL		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-7

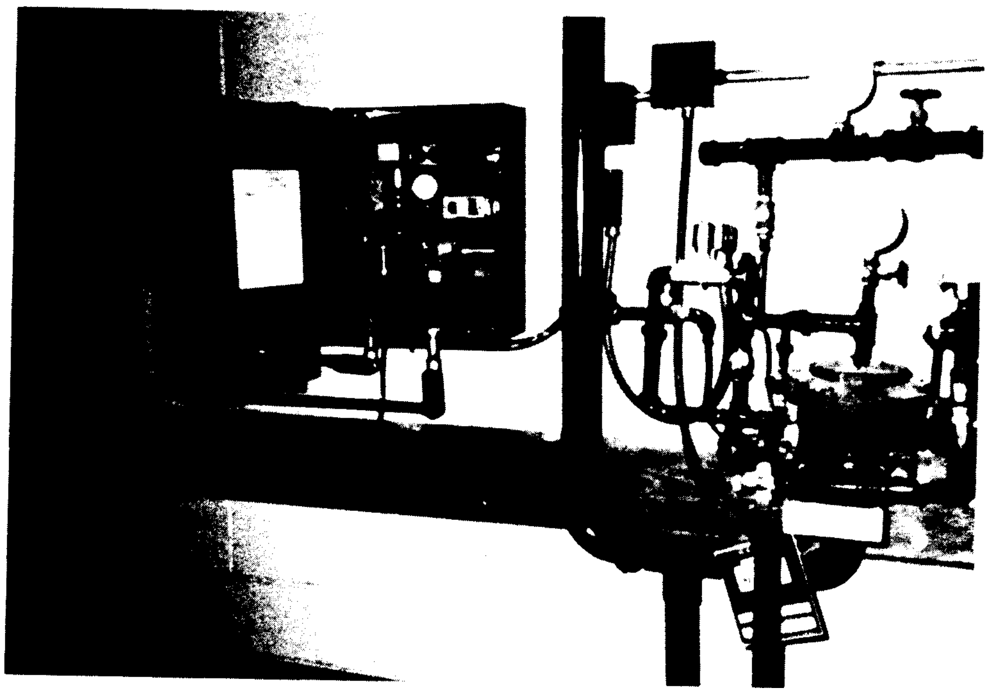


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	COMBINATION PREACTION WITH PRESSURIZED AIR		
FIRE PROTECTION-DRY PIPE SPRINKLER SYSTEMS (CSI 15335)	Revision No.	Issue Date 5/93	Drawing No. A080202-8

DEFICIENCY FACTORS
0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

PROBABLE FAILURE **POINTS**

- System leaks due to corrosion.
- Inability of the system to deliver rated capacity (pressure and flow) to sprinkler heads due to internal corrosion or failure of check valves to open.
- Valve leakage due to improper seal.
- Alarm valve not operating due to corrosion, blockage, or electrical component failure.
- Dry pipe valve not operating due to corrosion, blockage.
- Inadvertent system operation due to air loss, compressor failures, leaks.
- Fire pump will not run due to poor maintenance, corrosion.

SYSTEM ASSEMBLIES/DEFICIENCIES

Fire Pumps

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

Compressors

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Caused by bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.
Air Filter Inadequate:	Missing, damaged.

Motors

Missing:	Taken out for service or repair, not returned,
Inoperative:	Winding or bearing failures.

DEFICIENCY FACTORS
0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors '(Continued)

Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate charging of battery.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Compression Loss:	Defective rings or valves, cracked block.
Radiator or Fan Damaged:	Bent fins, punctures, loose joints.
Defective Bearings:	Poor lubrication, normal wear.
Engine Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.
Defective Battery Charger:	Poor maintenance.
Battery Dead:	Lack of maintenance.
Leakage (Fuel, Water):	Corrosion, Abuse

Alan-n Chock **Valves**

Valves Will Not Cycle Properly:	Corrosion or valve obstruction.
Insufficient Water Flow:	Valve obstructed by scale, corrosion.
Leakage:	Corrosion, failure of drains, or checks to close.
Severe Corrosion:	Normal aging, improper materials.
Alarm Not Transmitting:	Lack of water flow, electrical malfunction.

Dry Pipe Valves

Valves Will not Cycle Properly:	Corrosion or valve obstruction.
Insufficient Water Flow:	Valve obstructed by scale, corrosion.
Leakage:	Corrosion, failure of drains, or checks to close.
Severe Corrosion:	Normal aging, improper materials.

DEFICIENCY FACTORS
0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

SYSTEM ASSEMBLIES/DEFICIENCIES

Dry Pipe Valves (Continued)

Alarm Not Transmitting:	Lack of water flow, electrical malfunction.

Detectors, Alarms, & Control Devices

Detector Missing:	Taken out for service and not returned.
Detector Inoperative:	Physical damage, wear, abuse.
Detector Damaged:	Abuse.
Alarm Missing:	Taken out for service and not returned.
Alarm Inoperative:	Not transmitting, lack of water flow, electrical malfunction.
Alarm Damaged:	Abuse.
Operating Device Missing:	Taken out for service and not returned.
Operating Device Inoperative:	Not transmitting, lack of water flow. electrical malfunction.
Operating Device Damaged:	Abuse.
Severe Corrosion:	Normal aging, improper materials.
Leakage:	Corrosion, failure of drains, or checks to close..

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.
Sprinkler/Nozzle Missing:	Taken out for repair, not replaced.
Sprinkler/Nozzle Physical Damage:	Lack of sprinkler guards, painting, other foreign materials.
Sprinkler/Nozzle Corrosion:	Non-coated sprinkler.
Sprinkler/Nozzle Leakage:	Partial failure of sealing element due to overheating, freezing, abuse.

Valves

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

DEFICIENCY FACTORS
0.08.02.02 DRY PIPE SPRINKLER SYSTEMS (CSI 15335)

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.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

END OF SUBSECTION

0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

DESCRIPTION

A typical Standpipe System provides a means for manually applying water to fires in buildings. Through an arrangement of valves and piping, hose connections are located in such a manner that water can be discharged in streams or spray patterns through attached hoses and nozzles. System components include hose valve outlets, piping, hangers and anchors, hoses, nozzles, cabinets, fire pumps, and alarms. Systems may be wet or dry. (NFPA Code IU.)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fire Pumps (CSI 15320)

Fire pumps are often used to supplement the water supply and provide additional pressure when the standpipe system exceeds the capability of the normal water supply system.

Two types of fire pumps are used to supply the standpipe system: horizontal shaft centrifugal and vertical shaft turbine. The centrifugal type is used where the suction source is available under pressure to the fire pump unit. The turbine type is used when the suction source is below the pumping unit.

These pumps must deliver 150 percent of the rated flow at 65 percent of the rated pressure; may be single-stage or multiple-stage; are usually provided with a circulation relief valve to prevent overheating and damage; and are provided with a pressure (case) relief valve to prevent excessive pressure build-up.

Motors (CSI 15170)

Most fire and jockey pumps are driven by a horizontally coupled AC motor, although it is not unusual to find other drives. Many multi-stage turbine fire pumps are driven by a vertically coupled AC motor.

Engines (CSI 15320)

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

Detectors, Alarms, & Control Devices (CSI 15375)

There are no automatic operating devices in a standpipe system. However, there are several detectors and alarms.

Indicators on critical valves are typically employed to flag valve position and to transmit a signal to a central control station if a valve is moved from its normal position.

Water flow alarms are also installed. These are usually simple paddles or vanes that extend into the waterway. Any water movement activates an alarm, which may in turn activate an electric switch or mechanically trip a signaling system transmitter.

Piping & Fittings (CSI 15060)

Piping provides water from an outside water source to the standpipe. Cast iron, malleable iron, steel, and copper pipe comprise the rest of the distribution system.

All fittings and joints should be compatible with the type of piping materials used to prevent corrosion.

Reducers and bushings should be the one-piece type, and couplings and unions should not be used on pipe larger than 2 inches.

0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Flfflngs (CSI **15060)** (Continued)

Piping subject to corrosive atmospheres should be protected with an approved corrosion-resistive coating.

Valves (CSI 15100)

Valves are primarily used to turn off and control the water supply.

Drain valves are installed on standpipes to allow system drainage.

Valves should be in the appropriate open or closed position and sealed as required.

Tamper switches may be installed on standpipe valves.

All valves must be in accessible locations and tagged

Supports **&** Hangers (CSI 15140)

Pipe hangers and anchors are provided to support piping and allow for expansion and contraction. They should be secured to the building construction at approved intervals.

Pipe hangers and anchors should be made of ferrous material and should not be used to support other components.

Instrumentation (CSI 15135)

Pressure gauges on standpipe systems provide water pressure readings at the pump and throughout the piping system. They should have a maximum limit of not less than twice the normal working pressure. Each gauge connection should be equipped with a shut-off value and drain.

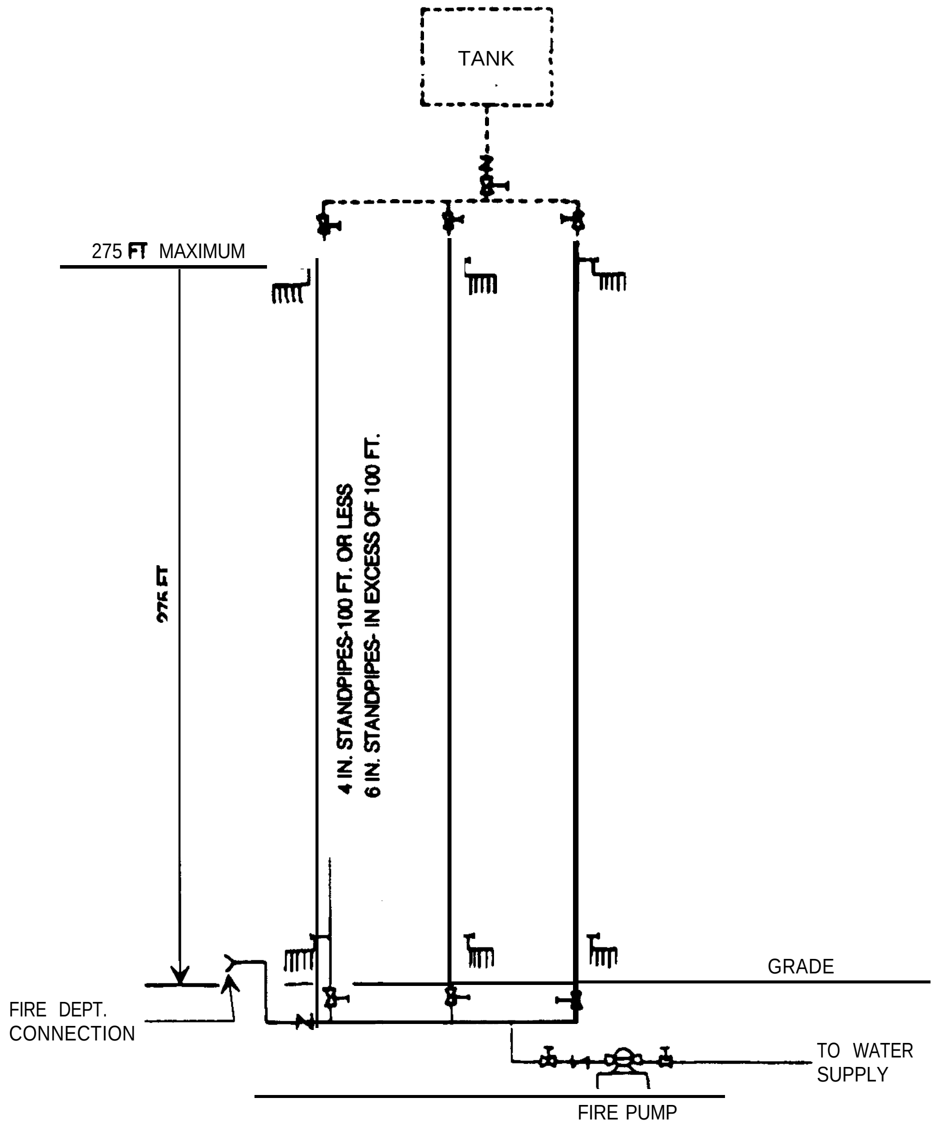
Hose **Cabinets** (CSI 15375)

Hoses direct the water from the standpipe to the area of the fire and are frequently provided by the fire department. However, some facilities have critically located cabinets to meet the needs of the fire-fighting team.

The cabinet hose will usually have a standpipe branch cutoff valve, a fire hose already attached to the standpipe outlet, and a nozzle pre-attached to the hose. The hose is usually mounted on a rack that rotates and allows for a rapid payout. The cabinet is usually painted red and has a glass door to permit easy verification of hose presence.

Equlpmont Controls (CSI 15950)

In addition to the control circuits used in the alarms (tamper and switches), a standpipe system may also employ pumps controls. These typically consist of motor starters with associated relays and switches. Both the fire pump and the jockey pump are usually controlled and activated by low-pressure controllers mounted at the discharge of the fire pump.

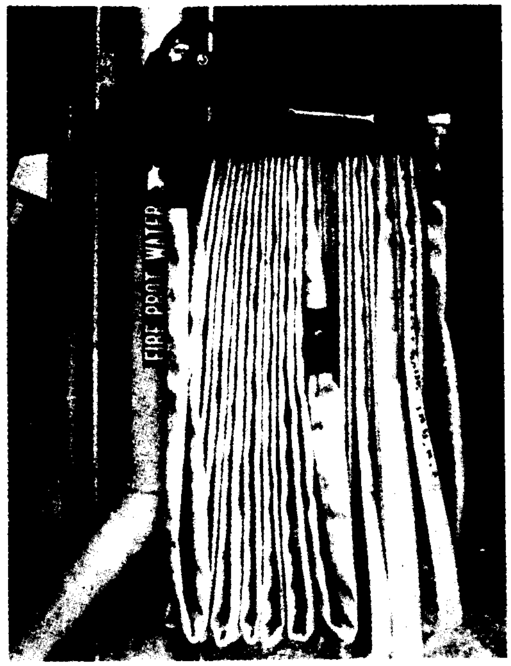


FOR SI UNITS: 1 in.= 25.4 mm: 1 ft.= 0.3048 m

TYPICAL SINGLE ZONE SYSTEM

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL SINGLE ZONE STANDPIPE		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. A080203-1



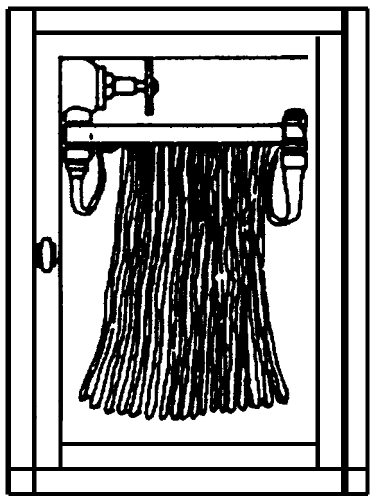
CONVENTIONAL PIN RACK

SEMI-AUTOMATIC HOSE RACK ASSEMBLY

PHOTO ILLUSTRATION

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME I

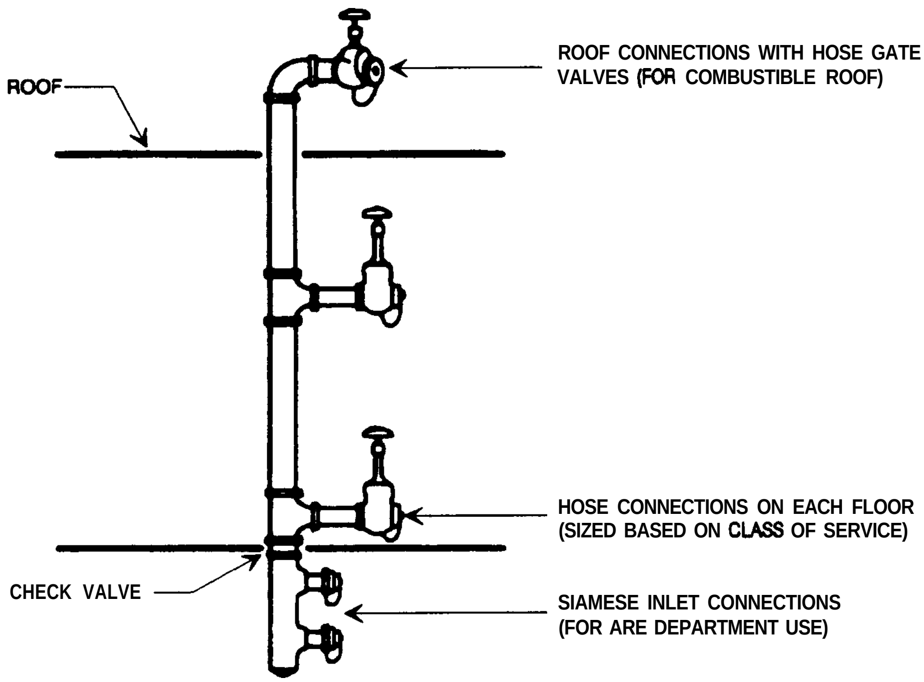
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOSE ASSEMBLIES		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. A080203-2



HOSE STATION

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOSE CABINET		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. A080203-3



DRY STANDPIPE RISER

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	STANDPIPE RISER		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. A080203-4

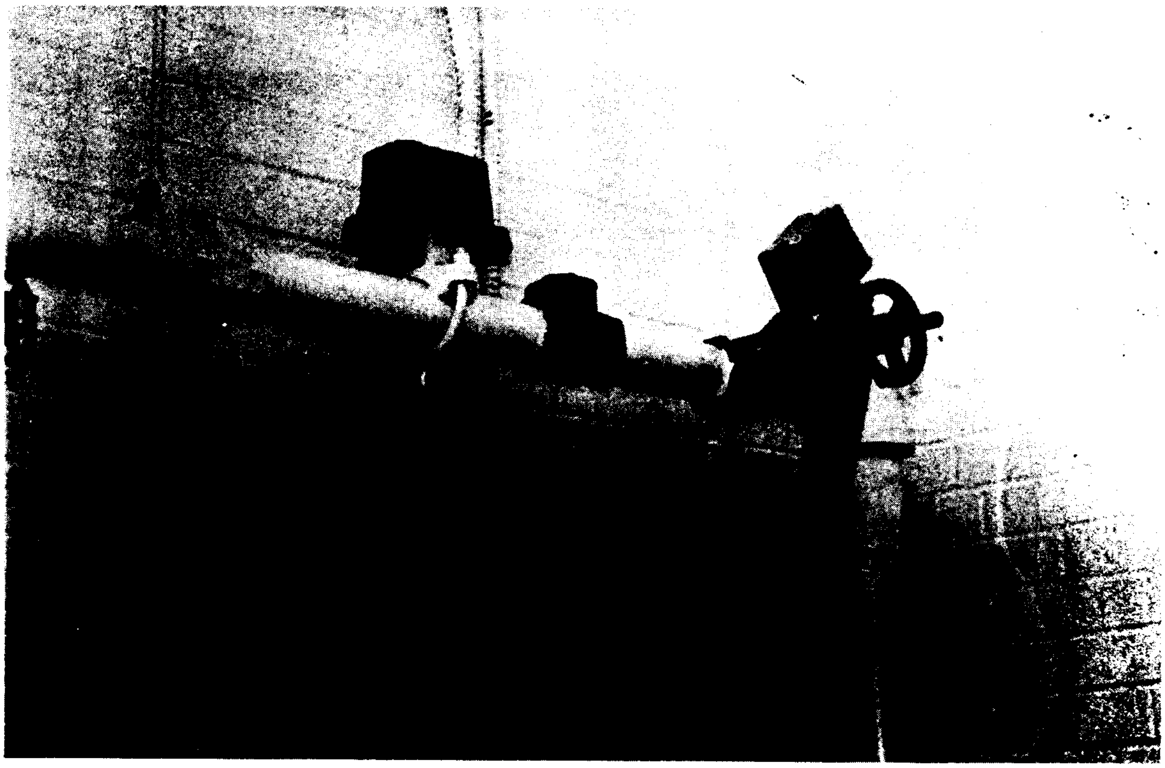


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TAMPERED OS&Y VALVE WITH CHECK VALVE AND FLOW SWITCH		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawhg No. A080203-5

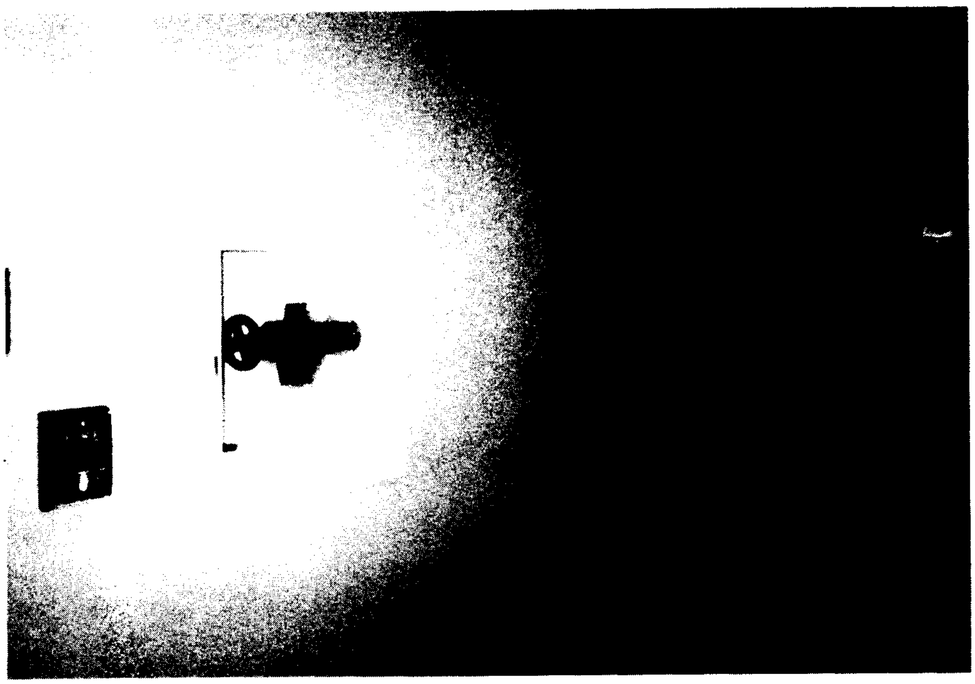


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FIRE HOSE STATION (NO HOSE) WITH MANUAL PULL BOX		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. A080203-6

DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

PROBABLE FAILURE POINTS

- System leaks due to corrosion.
- inability of the system to deliver rated capacity to internal corrosion or failure of valves to open.
- Inadequate pressure on the system due to piping failures.
- Valve leakage due to improper seal or corrosion.
- Inaccurate reading on pressure gauges due to corrosion, leakage, or miscalibration.
- Fire pump seal leakage due to corrosion.
- Alarm not operating due to corrosion, blockage, or electrical component failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Fire pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked impeller.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment, failed internal relief.
Inadequate Capacity:	Low pressure, low flow caused by wear in rings or impellers, failed internal relief.
Leakage in Packing or Mechanical Seal:	Normal wear.
Severe Corrosion:	Normal aging, leakage, poor maintenance.
Defective Bearing:	Age , normal wear, improper lubrication.

Motors

Missing:	Taken out for service or repair, not returned.
Inoperative:	Winding or bearing failures.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.
Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Defective Bearings:	Poor lubrication, normal wear.
Damaged:	Abuse, stress.
Defective Coupling:	Broken spring, worn insert, misalignment.

Engines

Missing:	Taken out for service or repair, not returned.
Inoperative:	Poor maintenance, lack of use, inadequate battery charging.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment.

DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

SYSTEM ASSEMBLIES/DEFICIENCIES

Engines (Contmued)

Excessive Load:	Bearing wear, misalignment.
Corrosion:	Aging, poor maintenance.
Compression Loss:	Defective rings or valves, cracked block.
Defective Bearings:	Poor lubrication, normal wear.
Radiator or Fan Damaged:	Bent fins, punctures, loose joints.
Engine Damaged:	Abuse, stress.
Fuel or Water Pump Worn:	Normal wear and tear.
Defective Coupling:	Broken spring, worn insert, misalignment.
Defective Battery Charger:	Poor maintenance.
Battery Dead:	Lack of maintenance.

Detectors, Alarms, & Control Devices

Detector Missing:	Taken out for service and not returned.
Detector Inoperative:	Physical damage, wear, abuse.
Detector Damaged:	Abuse.
Alarm Missing:	Taken out for service and not returned.
Alarm Inoperative:	Not transmitting, lack of water flow, electrical malfunction.
Alarm Damaged:	Abuse.
Operating Device Missing:	Taken out for service and not returned.
Operating Device Inoperative:	Not transmitting, lack of water flow, electrical malfunction.
Operating Device Damaged:	Abuse.
Severe Corrosion:	Normal aging, improper materials.
Leakage:	Corrosion, failure of drains or checks to close.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Valves

Valve Inoperative:	Corrosion, physical damage to operating mechanism.
Valve Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.

DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valve8 (Continued)

Valve Corrosion:	Normal aging, use of incompatible materials.
Valve Physical Damage:	Bent stem, broken linkage, cracked housing.
Valve Inadequate Seating:	Worn parts, blocked by scale.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.

Supports & Hangers

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

Instrumentation

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

Hose Cabinets

Missing:	Taken out for service, not replaced.
Physical Damage:	Abuse.
Corrosion:	Aging, poor maintenance, leakage.
Leakage:	Corrosion, damaged parts, abuse.
Improper Configuration:	Wrong hose nozzle.

Equipment Controls & Panels

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

DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS **(CSI 15375)**

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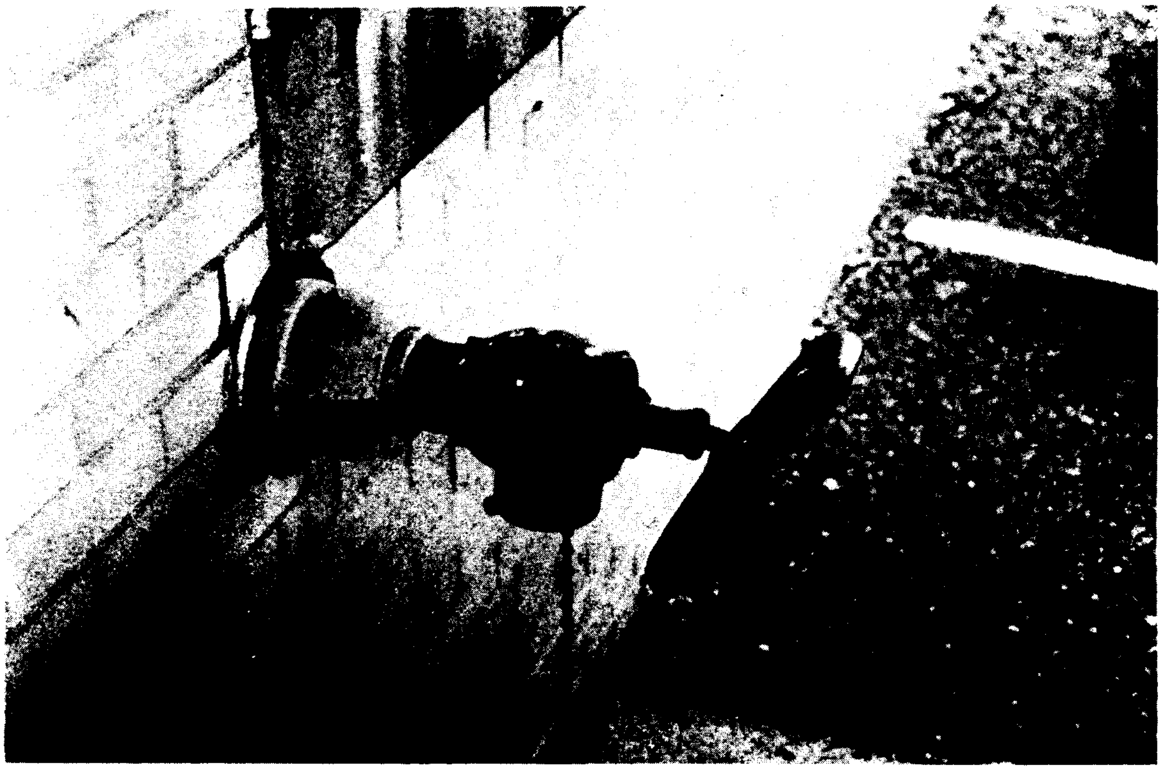

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	STANDPIPE VALVE WITH BENT VALVE STEM	
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. D080203-1

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	HOSE STATION WITH HOSE FALLEN FROM RACK		
FIRE PROTECTION-STANDPIPE SYSTEMS (CSI 15375)	Revision No.	Issue Date 5/93	Drawing No. D080203-2

DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

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DEFICIENCY FACTORS
0.08.02.03 STANDPIPE SYSTEMS (CSI 15375)

END OF SUBSECTION

0.08.02.04 HALON FIRE SUPPRESSION (CSI 15385)

DESCRIPTION

A typical Halon Fire Suppression System provides a means for applying a gaseous agent to fires in buildings. The system is used in enclosed spaces where the agent inhibits the chemical interaction of fuel and oxygen, thus extinguishing the fire. The system consists of detection and actuation devices, supply containers, piping and nozzles, and auxiliary equipment.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Compressed Gas Tanks (CSI 15395)

Supply containers store the halon and should have a capacity sufficient for the largest single hazard protected.

Automatic Detection, Alarms, & Operating Devices (CSI 15955)

Automatic detection devices detect heat, flame, smoke, combustible vapors, or an abnormal condition in the system, trip the system and/or sound a local alarm, and send a signal to the fire department.

Operating devices cause the system to trip and expel the agent on the fire. They may be automatic and/or manual. Automatic release is usually by alarm detection. Manual release is usually by activating an electrical switch or opening a control valve.

These devices also shut off the equipment necessary for successful system operation and performance.

Manual releases should be protected by a switch cover to prevent inadvertent activation.

Control equipment supervises the actuating device. This equipment can be either electronic or pneumatic.

Alarms or indicators or a combination of both are used to indicate the system operation, hazards to personnel, or any supervised device failure.

Audible and visible alarms should be used to warn personnel of discharge.

Piping & Rfflngs (CSI 15090)

Piping provides halon from containers to the nozzles. Specifications vary with the type and pressurization requirements.

All fittings and joints should be compatible with the type of piping materials used to prevent corrosion.

Welding and brazing alloys should have a melting point of 1000°F.

Piping subject to corrosive atmospheres should be protected with an approved corrosion-resistive coating.

Nozzles located throughout the areas protected provide a halon flow to extinguish the fire. They consist of an orifice and any associated horn, shield, or baffle. They should be marked to identify the manufacturer, size, and type, and should have blow-out discs or caps where clogging by foreign material is likely.

Valves (CSI 15100)

Valves are primarily used to turn halon systems off and on. They should be in the appropriate open or closed position and sealed as required. All valves must be in accessible locations and tagged.

0.08.02.04 **HALON** FIRE SUPPRESSION **(CSI 15365)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Supports **& Hangers** (CSI 15140)

Pipe hangers and anchors are provided to support piping and allow for expansion and contraction. They should be secured to building construction at approved intervals.

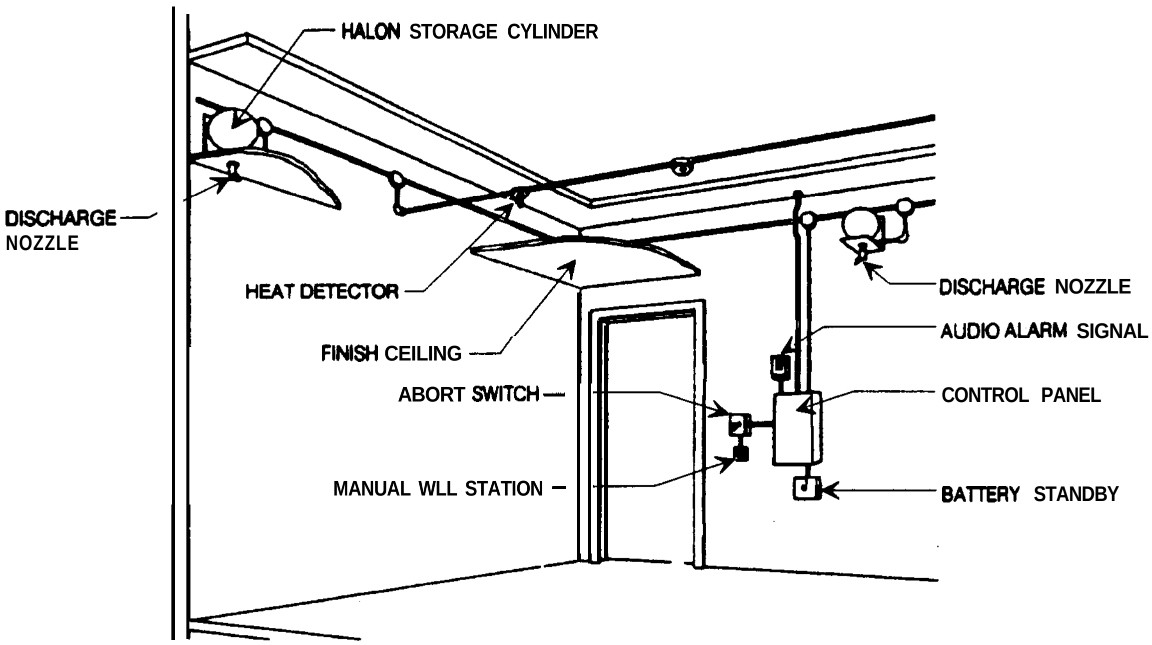
Pipe hangers and anchors should be made of ferrous material and should not be used to support other components.

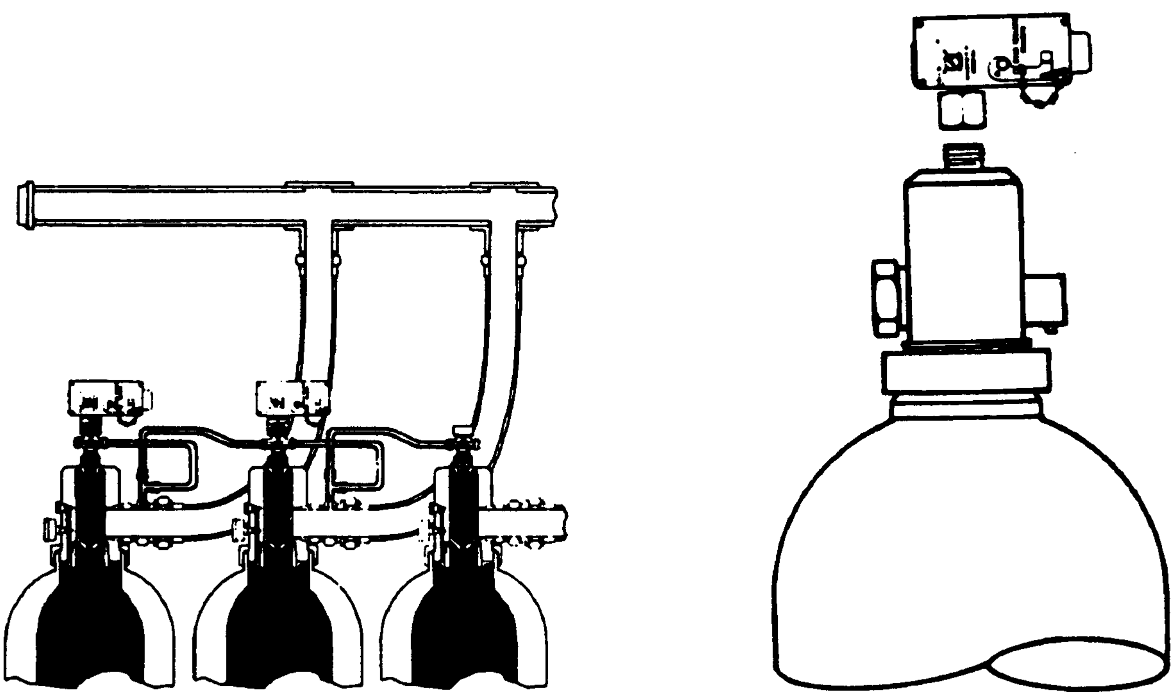
Instrumentation (CSI 15135)

Pressure gauges provide halon pressure readings on the system, essentially indicating the charge.

Code requires that pressure gauges have a maximum limit of not less than twice the normal working pressure. (Ideally, normal system pressure will be at gauge mid-point.)

Each gauge connection should be equipped with a shut-off valve and drain.





(COURTESY OF KIDDE) HALON 1303 SYSTEM

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SYSTEM COMPONENTS		
FIRE PROTECTION-HALON FIRE SUPPRESSION (CSI 15365)	Revision No.	Issue Date 5/93	Drawing No. A080204-1

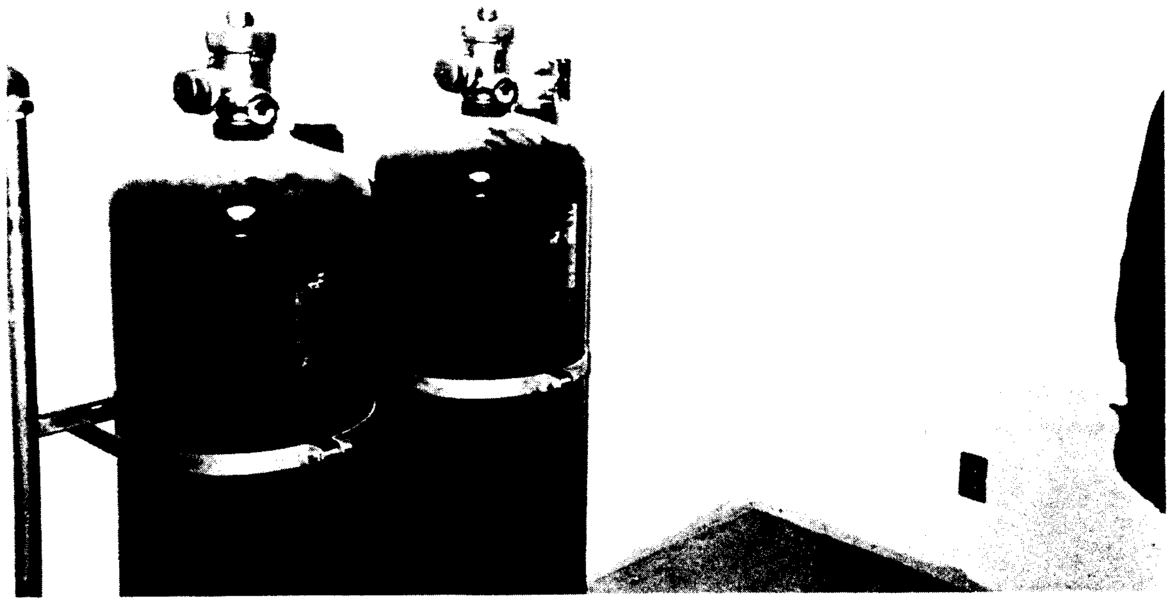


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HALON CYLINDERS WITH CHARGE INDICATORS		
FIRE PROTECTION-HALON FIRE SUPPRESSION (CSI 15365)	**Revision No.**	**Issue** Date 5/93	**Drawing** No. A080204-2

DEFICIENCY FACTORS
0.08.02.04 HALON FIRE SUPPRESSION (CSI 15365)

PROBABLE FAILURE POINTS

- System leaks due to faulty piping or valves.
- Inability of the system to deliver rated capacity due to obstructed nozzles or failure of valves to open.
- Inadequate pressure on the system due to piping failures
- Alarm not operating due to corrosion, blockage, or electrical component failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Compressed Gas Tanks

Missing:	Removed and not replaced.
Physical Damage:	Bent, broken.
Obstructed:	Foreign material in orifice.
Valve Will Not Open:	Corroded, damaged.

Automatic Detection, Alarms, & Operating Devices

Detector Missing:	Taken out for service or repair, not returned.
Detector Inoperative:	Corroded or electrical fault.
Detector Physical Damage:	Bent, broken.
Operating Device Missing:	Taken out for service or repair, not returned.
Operating Device Inoperative:	Damaged or obstructed.
Operating Device Physical Damage:	Bent, broken.
Alarm Inoperative:	Damaged or electrical fault.
Alarm Fails to Sound Alarm:	Damage or obstructed alarm device.
Alarm Missing:	Removed for repair and not replaced.
Visible Alarm Inoperative:	Electrical fault.
Abort Switch Not Working:	Damaged, or electrical fault.
Relays Pitted or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.

Piping & Flfflngs

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Use of incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.
Sprinkler/Nozzle Missing:	Taken out for repair, not replaced.

DEFICIENCY FACTORS
0.08.02.04 HALON FIRE SUPPRESSION (CSI 15385)

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings (Continued)

Sprinkler/Nozzle Physical Damage:	Lack of sprinkler guards, painting, other foreign materials.
Sprinkler/Nozzle Corrosion:	Non-coated sprinkler.

Valves

Valve Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Normal aging, use of incompatible materials.
Physical Damage:	Bent stem, broken linkage, cracked housing.

Supports & Hangers

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

Instrumentation

Missing:	Taken out of service, not replaced.
Inoperative:	Failed interval mechanism, corrosion, loss of sensing medium.
Illegible:	Defaced by chemicals, corrosion, damage.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.

END OF SUBSECTION

0.08.02.05 CO, FIRE SUPPRESSION (CSI 15380)

DESCRIPTION

A typical CO, Fire Suppression System provides a means to apply gaseous agent CO, to fires in buildings. The system is used in enclosed spaces where the agent inhibits the chemical interaction of fuel and oxygen, thus extinguishing the fire. The system consists of detection and actuation devices, supply containers, piping and nozzles, and auxiliary equipment.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Compressed Gas Tanks (CSI 15360)

Supply containers store the CO, and should have a capacity sufficient for the largest single hazard protected.

Automatic Detection, Alarms, & Operating Devices (CSI 15955)

Automatic detection devices detect heat, flame, smoke, combustible vapors, or an abnormal condition in the system, trip the system and/or sound a local alarm, and send a signal to the fire department.

Operating devices cause the system to trip and expel the agent on the fire. They may be automatic and/or manual. Automatic release is usually by alarm detection. Manual release is usually by activating an electrical switch or opening a control valve.

These devices also shut off the equipment necessary for successful system operation and performance.

Manual releases should be protected by a switch cover to prevent inadvertent activation.

Control equipment supervises the actuating device. This equipment can be either electronic or pneumatic.

Alarms or indicators or a combination of both are used to indicate the system operation, hazards to personnel, or any supervised device failure.

Audible and visible alarms should be used to warn personnel of discharge.

An abort switch is recommended to avert premature system activation.

Piping & Fittings (CSI 15050)

Piping provides CO, from containers to the nozzles. Specifications vary with the type and pressurization requirements of the system.

All fittings and joints should be compatible with the type of piping materials used to prevent corrosion.

Welding and brazing alloys should have a melting point of 1000°F.

Piping subject to corrosive atmospheres should be protected with an approved corrosion-resistive coating.

Nozzles located throughout the areas protected provide a flow of CO, to extinguish the fire. They consist of an orifice, and any associated horn, shield, or baffle. They should be marked to identify the manufacturer, size, and type of nozzle. Nozzles should have blow-out discs or caps where clogging by foreign material is likely.

Valves (CSI 15100)

Valves are primarily used to turn CO, systems off and on. They should be in the appropriate open or closed position and sealed as required. All valves must be in accessible locations and tagged.

0.08.02.05 CO_2 FIRE SUPPRESSION (CSI 15360)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Supports & Hangers (CSI 15140)

Pipe hangers and anchors are provided to support piping and allow expansion and contraction. They should be secured to building construction at approved intervals.

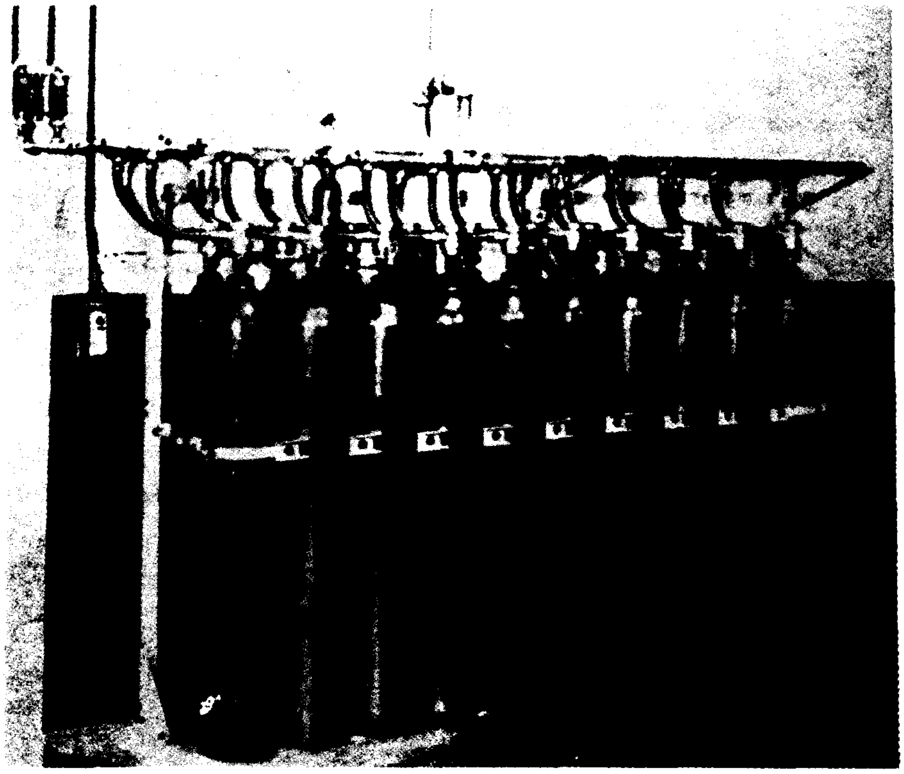
Pipe hangers and anchors should be ferrous material and should not be used to support other components.

Instrumentation (CSI 15135)

Pressure gauges on the CO_2 tanks provide pressure readings on the system, indicating the charge.

Code requires that pressure gauges have a maximum limit of not less than twice the normal working pressure. (Ideally normal system pressure will be at gauge mid-point.)

Each gauge connection should be equipped with a shut-off valve and drain.

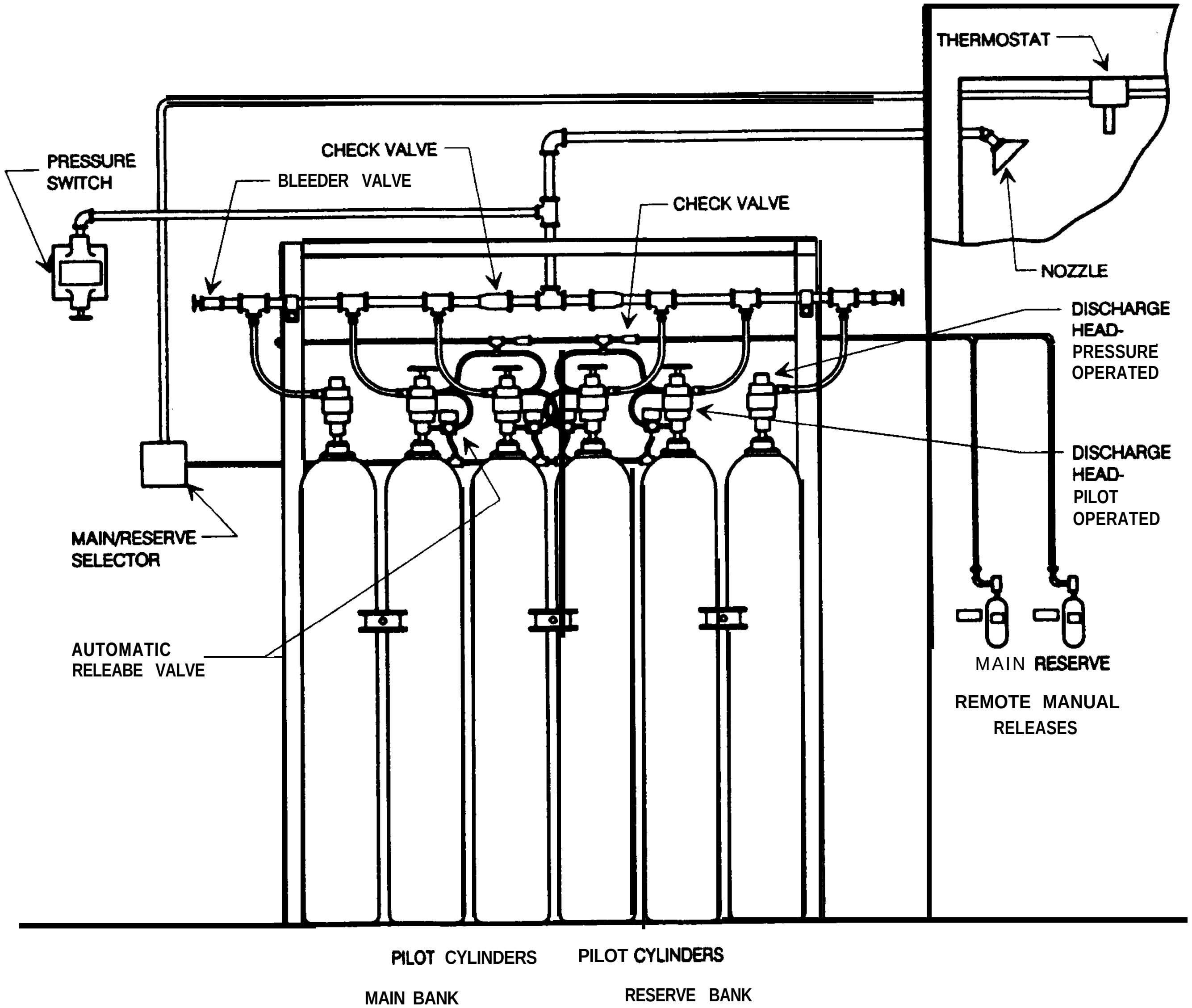


TYPICAL HIGH PRESSURE STORAGE FACILITY

PHOTO ILLUSTRATION

SOURCE: NATIONAL FIRE PROTECTION ASSOCIATION, NFC VOLUME 1

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HIGH PRESSURE CO_2 STORAGE CYLINDERS		
FIRE **PROTECTION-CO_2** FIRE SUPPRESSION **(CSI 15360)**	Revision No.	Issue Date 5/93	Drawing No. A080205-1

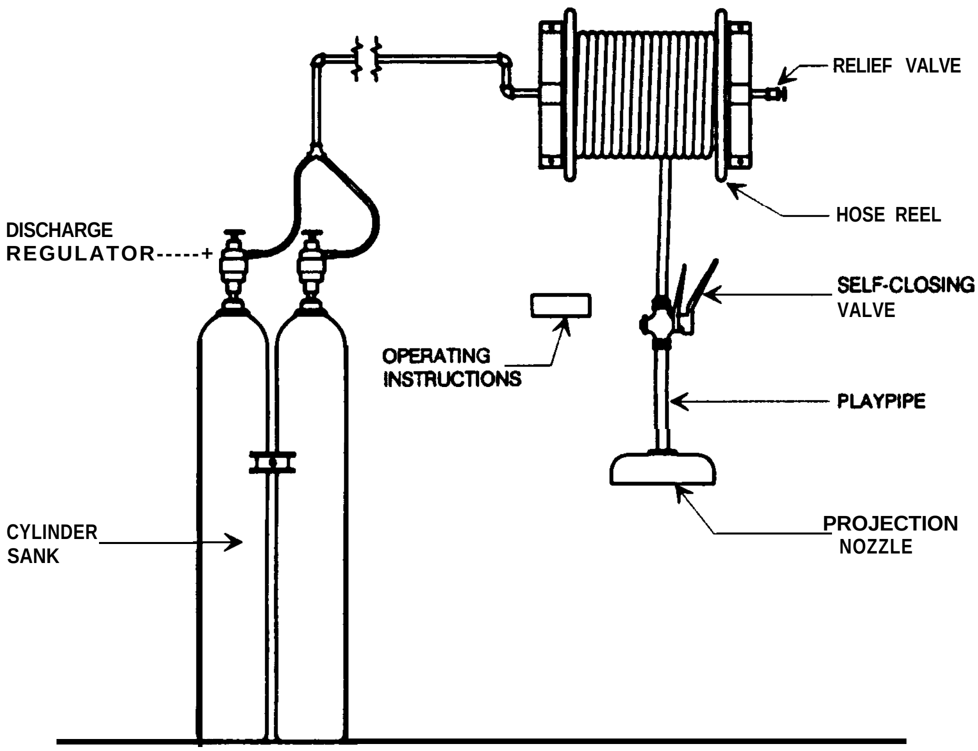


HIGH PRESSURE CARBON DIOXIDE CYLINDER BANK

(COURTESY OF CARDOX CORPORATION)

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CYLINDER BANK		
FIRE PROTECTION-CO_2 FIRE SUPPRESSION (CSI 15360)	Revision No.	Issue Date 5/93	Drawing No. A080205-2



HIGH PRESSURE CO, SYSTEM HOSE REEL INSTALLATION

SOURCE: MEANS, FIRE PROTECTION, DESIGN CRITERIA, OPTIONS, SELECTION, J. WALTER COON, PE, R.S. Means Co., Inc., Kingston, Massachusetts

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOSE REEL INSTALLATION		
FIRE PROTECTION-CO_2 FIRE SUPRESSION (CSI 15360)	Revision No.	Issue Date 5/93	Drawing No. A0802053

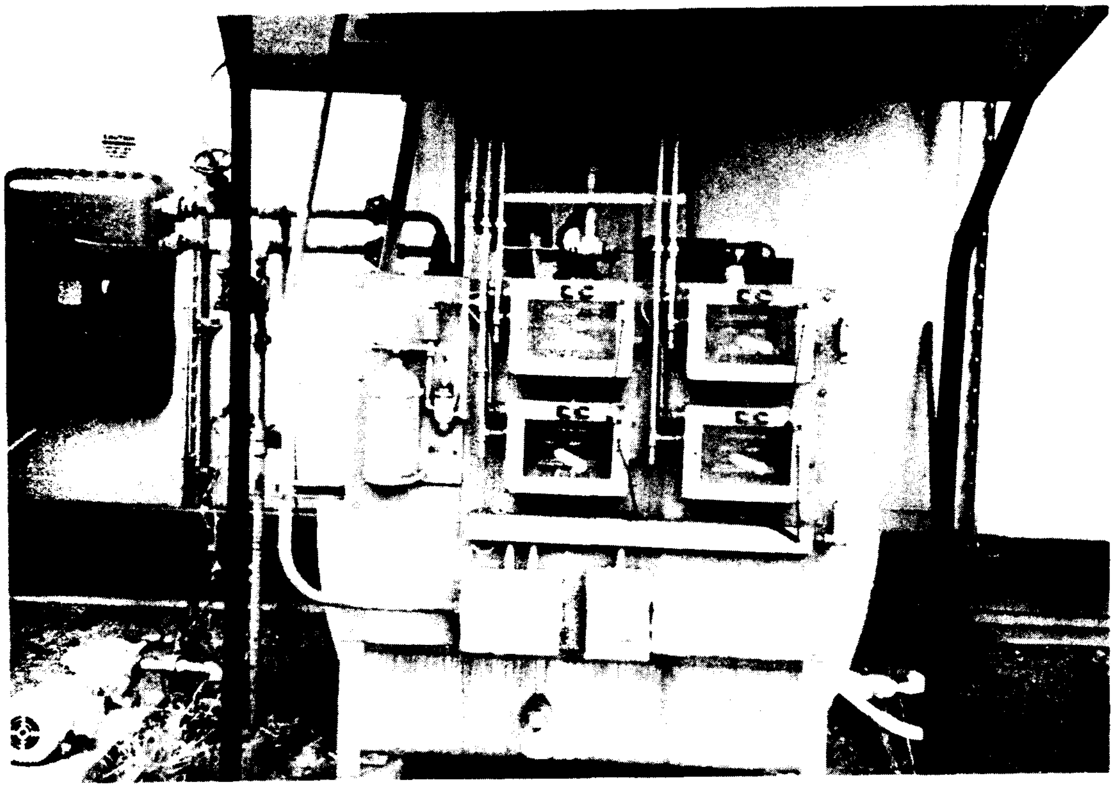


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	REFRIGERATED CO_2 STORAGE TANK WITH ZONE CONTROL VALVES		
FIRE PROTECTION-CO_2 FIRE SUPPRESSION (CSI 15360)	Revision No.	Issue Date 5/93	Drawing No. A0602054

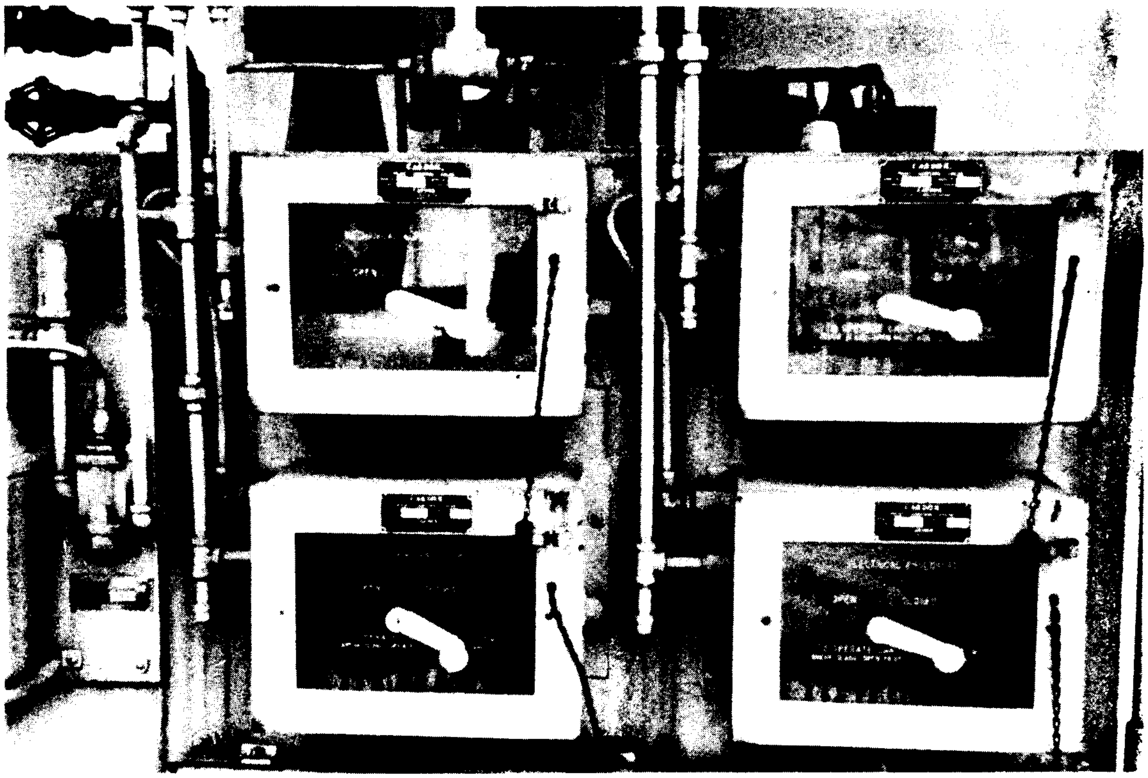


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CLOSEUP OF ZONE CONTROL VALVES FOR REFRIGERATED TANK		
FIRE PROTECTION-CO_2 FIRE SUPPRESSION (CSI 15360)	Revision No.	Issue Date 5/93	Drawing No. A080205-5

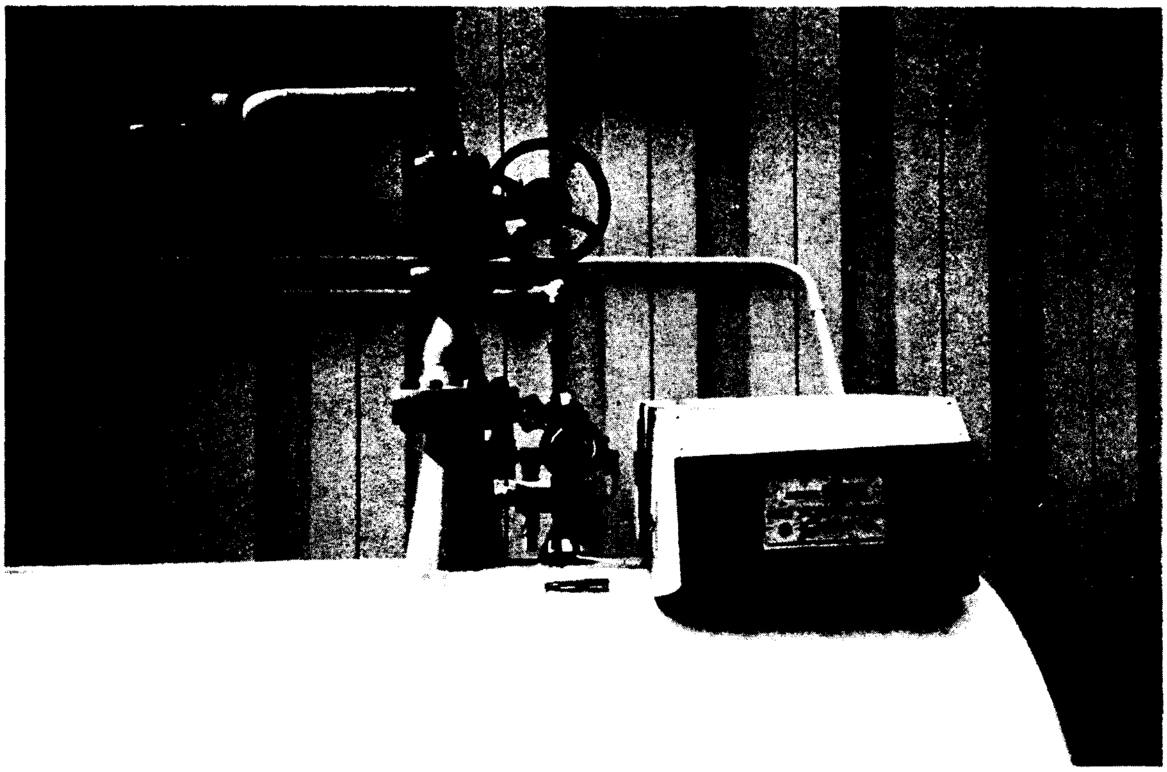


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	REFRIGERATED TANK ISOLATION VALVE, PRESSURE GAUGE AND REFRIGERATION UNIT		
FIRE PROTECTION-CO_2 FIRE SUPPRESSION (CSI 15360)	Revision No.	Issue Date 5/93	Drawing No. A0802056

DEFICIENCY FACTORS
0.08.02.05 CO, FIRE SUPPRESSION (CSI 15380)

PROBABLE FAILURE POINTS

- System leaks due to faulty piping or valves.
- Inability of the system to deliver rated capacity due to obstructed nozzles or failure of valves to open.
- Inadequate pressure on the system due to piping failures.
- Alarm not operating due to corrosion, blockage, or electrical component failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Compressed Gas Tanks

Missing:	Removed and not replaced.
Physical Damage:	Bent, broken.
Obstructed:	Foreign material in orifice.
Valve Will Not open:	Corroded, damaged.

Automatic Detection, Alarms, & Operating **Devices**

Detector Missing:	Taken out for service or repair, not returned.
Detector Inoperative:	Corroded or electrical fault.
Detector Physical Damage:	Bent, broken.
Operating Device Missing:	Taken out for service or repair, not returned.
Operating Device Inoperative:	Damaged or obstructed.
Operating Device Physical Damage:	Bent, broken.
Alarm Inoperative:	Damaged or electrical fault.
Alarm Fails to Sound Alarm:	Damaged or obstructed alarm device.
Alarm Missing:	Removed for repair and not replaced.
Visible Alarm Inoperative:	Electrical fault.
Abort Switch Not Working:	Damaged, or electrical fault.
Relays Pitted or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.

Piping & Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.
Sprinkler/Nozzle Missing:	Taken out for repair, not replaced.

DEFICIENCY FACTORS
0.08.02.05 CO, FIRE SUPPRESSION (CSI 15380)

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings (Continued)

Sprinkler/Nozzle Physical Damage:	Lack of sprinkler guards, painting, other foreign materials.
Sprinkler/Nozzle Corrosion:	Non-coated sprinkler.
Sprinkler/Nozzle Leakage:	Partial failure of sealing element due to overheating, freezing, abuse.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Normal aging, use of incompatible materials.
Physical Damage:	Bent stem, broken linkage, cracked housing.

Supports & Anchors

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

Instrumentation

Missing:	Taken out of service, not replaced.
Inoperative:	Failed interval mechanism, corrosion, loss of sensing medium.
Illegible:	Defaced by chemicals, corrosion, damage.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.

END OF SUBSECTION

0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

DESCRIPTION

The typical Fuel Oil Supply System provides storage, preparation, and transfer of fuel for use in heat 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, the heating of fuel oil is required to permit rapid firing in the utility equipment.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Storage Tanks (CSI 15175)

Tanks provide for routine fuel storage. In most installations, more than one underground tank will be provided. Heavy oil storage tanks will usually include heating capability.

Storage tanks typically have:

- Corrosion Protection System (sacrificial elements)
- Heating Coils
- Hot Wells
- Ladders inside tank, anchored to top and bottom
- Pipe connections on top for fill, supply, return, vent, gauging, and heating coils
- Remote Oil Gauges
- Tank manhole for periodic servicing and inspections

In some installations, typically for emergency generator stations, a smaller, intermediate fuel oil tank (called a day tank) is provided. It is usually installed indoors and at some elevation to allow for supply by gravity in the event pumping power is lost.

Current requirements dictate secondary containment on storage tanks. This is effected by providing double shells (liners) and/or containment barriers such as diking.

Pumps (CSI 15160)

Pumps provide liquid fuel transfer from the storage tanks to the consuming equipment. They also facilitate maintaining storage tank temperature by recirculating hot fuel oil.

Smaller fuel pumps are used to supply make-up to day tanks.

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 by a closed motor with coupling.

Piping & Fittings (CSI 15050)

Duplex strainers are typically provided at the suction and discharge point of the fuel oil transfer pumps. These are used to protect the pumps 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.

Fuel oil pipe 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.

0.08.03.01 FUEL OIL SYSTEM (CSI 155001

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15060) (Continued)

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.

Drawn copper tubing, Type L with wrought copper fittings and brazed joints for 2 inch and smaller is typically used, above ground, within buildings. 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 per ten 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 for 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 materials installed (screwed, soldered, or flanged) to isolate dissimilar metals, prevent galvanic action, and stop corrosion.

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

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valves (CSI 15100)

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

Regulating valves are used to control water or steam flow through the storage tank heating coils and in-line heaters.

Special safety valves are employed in “gas trains” to shut off gas supply to burners in emergencies. They are solenoid-operated valves, but usually require manual reset after a failure.

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 and protected from physical damage. Valves should be tagged.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge point 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 underground storage tanks. This is typically a remote hydraulic unit manually pressurized by the attendant.

Level indication for the day tanks is usually a simple sight glass. Remote level indication is not often used.

0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

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 building construction at close intervals.

Insulation (CSI 15520)

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 permit the omission of the insulation.

In-Line Heaters (CSI 15590)

Most fuel oils require preheating to effect proper combustion. Although typical burners incorporate small electrical preheaters, the fuel oil system typically has its own heating devices.

Steam or hot water coils are frequently provided in the storage tank hotwells. These are usually simple copper coils immersed in the oil directly.

In-line heaters are also provided near the fuel oil pumps. The typical installation employs a shell and tube heat exchanger using steam for the heating medium. As a substitute or to provide heating during system startup, small electric heaters are also employed.

Some pipelines, especially heavy oils, use heat tracing to minimize fuel congealing at low temperatures.

Equipment Controls & Panels (CSI 15950)

Few controls are used in the typical fuel oil system. (Generally metering is provided at the burner or emergency generator which are covered under separate standards). The system is usually turned on and left to run though 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 a hydraulically controlled regulating valve or through thermostatic control of electric heating elements.

Float type level controls are typically used in day tanks to control makeup.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

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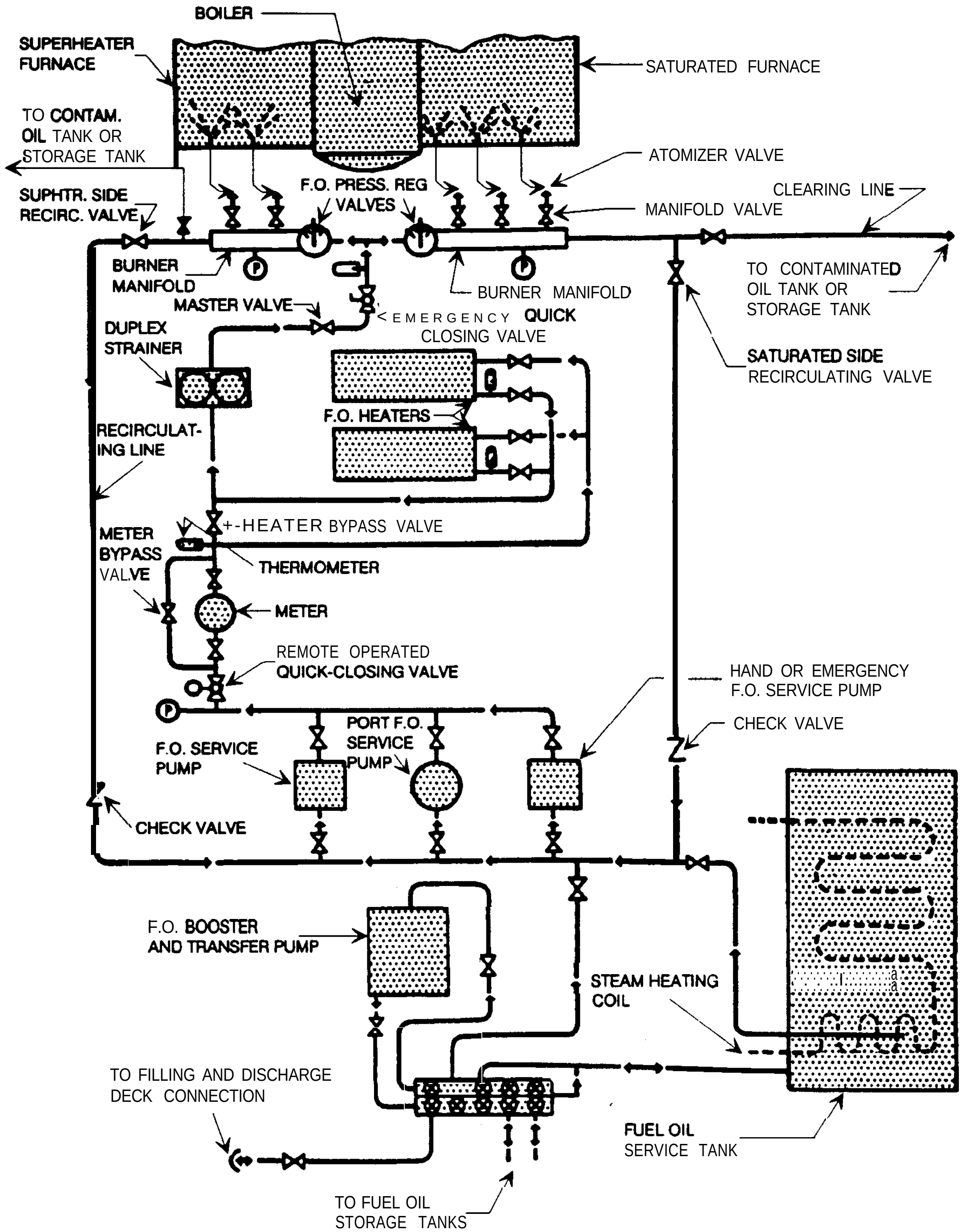
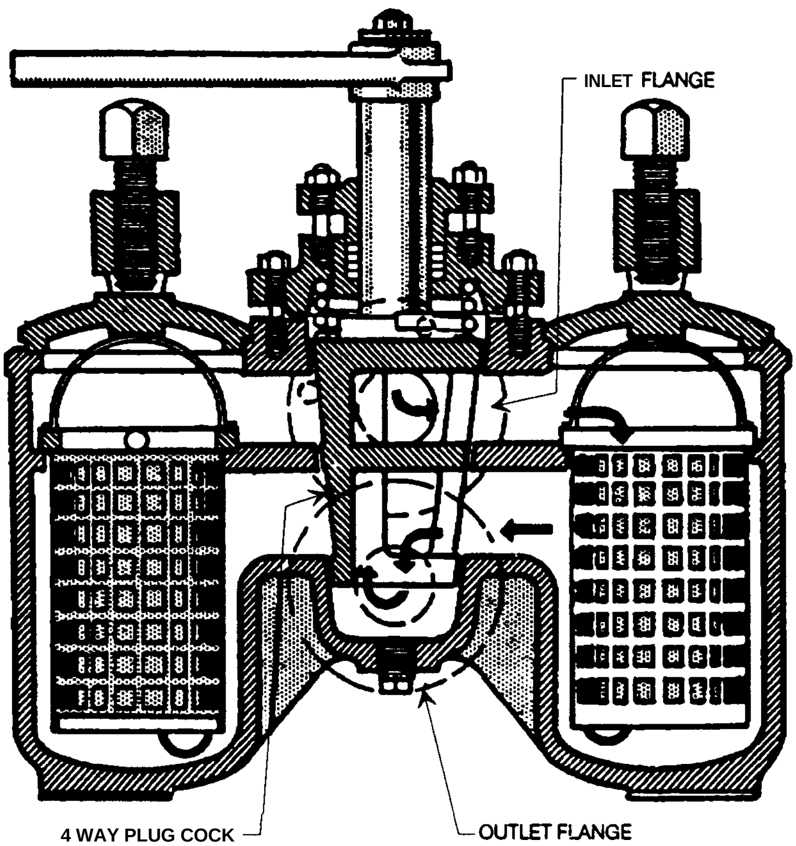


FUEL OIL SYSTEM

SOURCE FIREMAN, BUREAU OF NAVAL TRAINING COURSE, NAVPERS 10520-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL FUEL OIL SYSTEM		
HEATING AND VENTILATING FUEL OIL SYSTEM (CSI 15590)	Revision No.	Issue Date 5/93	Drawing No. A080301-1

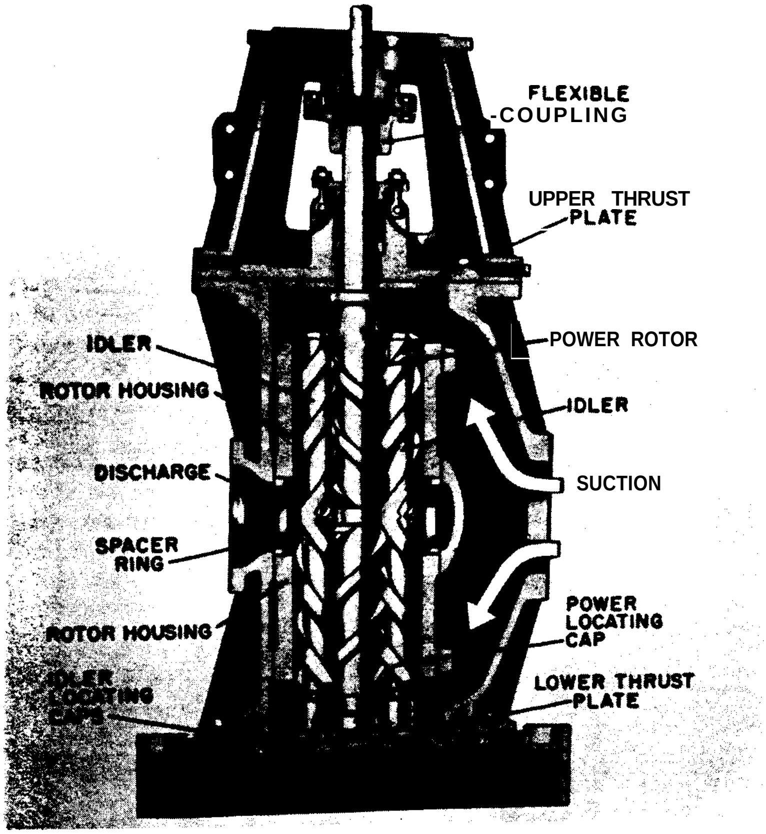


DUPLEX OIL STRAINER

(COURTESY OF UNITED STATES NAVAL INSTITUTE, NAVAL AUXILIARY MACHINERY)

SOURCE: FIREMAN. BUREAU OF NAVAL TRAINING COURSE. NAVPERS 10520-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FUEL OIL STRAINER		
HEATING AND VENTILATING FUEL OIL SYSTEM (CSI 15590)	Revision No.	Issue Date 5/93	Drawing No. A080301-2



MAIN LUBE OIL SERVICE PUMP

SOURCE: MACHINIST'S MATE 3&2, BUREAU OF NAVAL TRAINING COURSE, NAVPERS 10524-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CROSS SECTION TYPICAL FUEL OIL PUMP		
HEATING AND VENTILATING FUEL OIL SYSTEM (CSI 15590)	Revision No.	Issue Date 5/93	Drawing No. A080301-3

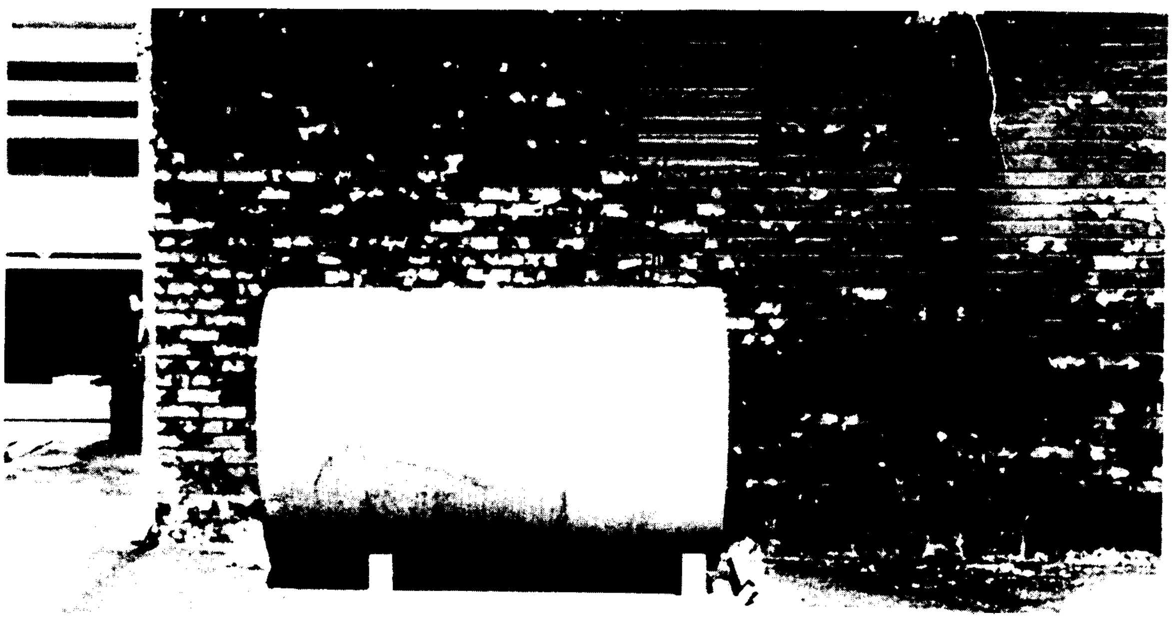


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ABOVE GROUND FUEL OIL STORAGE TANK		
HEATING AND VENTILATING FUEL OIL SYSTEM (CSI 15590)	Revision No.	Issue Date 5/93	Drawing No. A080301-4

DEFICIENCY FACTORS
0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

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, defective strainers, pumping failure.
- Pipe leakage due to internal corrosion.
- Loss of temperature control due to failed temperature sensors.

SYSTEM ASSEMBLIES/DEFICIENCIES

Tanks

External Leakage:	Severe internal or external corrosion, failure of gaskets at manhole or other fittings.
Leaking Heat Coil:	Thermal fatigue, corrosion.
Loose or Missing Fasteners:	Corrosion, damage.
Internal Corrosion:	Poor maintenance, inadequate venting, contamination, heating coil leakage.
Shell Distortion:	Blisters or bulges in the metal caused by overheating, fatigue, physical damage, loss of external support.
Secondary Containment Leakage:	Corrosion, damage.

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked gears.
Excessive Noise or Vibration:	Bearing wear, lack of lubrication, imbalance in internal components, misalignment, contamination.
Excessive Load:	Bearing wear, misalignment, failed internal relief.
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.
Severe Corrosion:	Caused by 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.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

DEFICIENCY FACTORS
0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, 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.

Instrumentation

Missing:	Taken out for service or repair and not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	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:	System leakage or external causes.
Damaged:	Physical abuse.

DEFICIENCY FACTORS
0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

In Line **Heaters**

Inoperative:	Control failure, blocked tubing, open heating elements.
Inadequate Capacity:	Can not maintain temperature due to blocked/scaled tubing, open electric elements.
Overheating:	Failure of control elements.
Leakage in Coils:	Corrosion, stress.
Severe Corrosion:	Aging, poor maintenance, leakage.

Equipment Controls & Panels

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

DEFICIENCY FACTORS
0.08.03.01 FUEL OIL SYSTEM (CSI 15500)

END OF SUBSECTION

0.08.03.02 BOILERS (CSI 15555)

DESCRIPTION

Many large heating and ventilating systems use boilers to produce the fluid heating media (steam or high-temperature water). The boiler converts a raw energy source (fuel or electric power) into heat and transfers this heat to the water passing through the boiler. The boiler employs controls to manage the rate of heat transfer.

The typical boiler consists of a casing; combustion chamber (furnace, fire box, flue) and/or heat exchange surfaces (shell and tubes, electric coils); breeching and stacks to remove gases from fossil fueled units; burners or electric heating coils; combustion air fans; boiler trim (control devices); major accessories like economizers, superheaters, blowdown separators; control panels; pipe, and fittings.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Casings (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 walls of the casing are usually lined with refractory to provide insulation and to protect the casing itself 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 and depends on general design.

Most large commercial boilers are watertube boilers. The combustion chamber is 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 watertube units. However, the most common unit is the Scotch Marine design. It 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 for 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 using 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.

Shells & Tubing (CSI 15555)

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

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

NOTE: This standard does not include forced air systems used for heating.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Shells & Tubing (CSI 15555) (Continued)

In firetube boilers, there is generally only one shell or steam drum and the tubes are installed horizontally within the drum. The combustion chamber is also mounted concentrically. The exterior surface of the combustion chamber is a primary heat exchange surface. Gases leaving the combustion chamber pass through the inside of these tubes to provide additional heating. Baffles and endplates direct the gases in a pattern that promotes natural (convection) circulation on the waterside.

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

Electric boilers have a simple shell with no tubing. There is no combustion chamber per se nor any need for special baffling.

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 it 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 corrosion.

Fittings on stacks and chimneys include:

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

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

There are four primary ways of producing heat for the boiler: gas burners, oil burners, coal firing, and electric resistance heating. The first three produce combustion gases that heat the water indirectly, and the last provides direct water heating. Other methods such as woodburning and special fluidized beds are available but beyond the scope of this standard.

Gas burners are typically simple rings supplied by a "gas train." The only moving part is an interlocked damper that regulates the amount of mixing air.

These burners are typically high radiant, multi-port type burners integral with the front head of the boiler and approved for operation with natural, manufactured, or mixed gas.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

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

Gas burners should have a gas pilot, premix type with automatic electric ignition, complete with electronic detector to monitor pilot so the 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 a primary gas shut-off valve, motor operated with spring return, designed to start and stop the gas burner 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. A simple gun that provides pressurized oil through a burner tip that induces atomization is typical. Air is provided through a damper for primary mixing and combustion. Variations are the use of steam or compressed air through the gun to improve atomization. These burners generally employ a mechanical linkage that varies the amount of mixing air in conjunction with the amount of fuel oil supplied. Ignition is usually provided by a gas pilot, though a light oil (air atomized) pilot, or even hand firing may be used in some cases.

Very old installations may have rotary cup burners. These devices feed oil through a high-speed cylinder that accelerates and rotates the oil, inducing atomization. The cylinder is motor-driven. They are not as effective as other methods and are no longer permitted by code.

Oil burners should have an automatic electric ignition, complete with an electronic detector to monitor pilot so the primary fuel valve cannot be opened 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
- 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.

Some boilers will have a combination of gas/oil burners that combine low-pressure air atomizing types for oil and high radiant multi-port types for gas, for operation with commercial #2 fuel oil and natural, manufactured, or mixed gas.

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. The combustion rate is controlled by the raking/banking of the coals on the bed and by varying the availability of combustion air via dampers.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

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

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

The last of the boiler heat sources is electric resistance heating. These are generally simple heating elements, sheathed for protection from corrosion, immersed directly in the boiler main shell.

Combustion Air Fans (CSI 15860)

Combustion air is provided to boilers via two methods: forced draft and induced draft. 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. In many cases, no special devices are required because an adequate draft is produced by the chimney.

Fan drives are usually motors. but large plants may use 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 to 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 (small boilers may use a direct drive motor). Very large units may have a steam turbine to drive the induced and/or forced draft fans.

Boiler Trim (CSI 15570)

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

High-Temperature water boiler trim should include:

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

Low water cut-off for water boilers should be mounted on the side of boiler and wired into the 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.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Boiler Trim (CSI 15570) (Continued)

Pressure and temperature gauges for water boilers should be mounted on the 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 the temperature-sensing elements adjacent to the hot water outlet.

Steam boiler trim should include:

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

Low water cut-offs should be an integral part of the boiler feed-water control. They are wired into the burner control circuit to prevent burner operation if boiler water level falls below a safe operating level.

There is typically an auxiliary low water cut-off providing a second low water cut-off, wired in series to primary unit.

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

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

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

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. They 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 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 a siphon, cock, and test connection. Range should suit operating pressure.

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

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. They are usually chain operated.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Major Accessories (CSI 15570)

On very large boiler installations, several major accessories are typically found.

An economizer is typically 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 overall boiler efficiency. It employs feedwater controls to regulate flow. While it is desirable to extract as much heat as possible from the exhaust, care must be taken to prevent condensation in the stack.

A second accessory is the superheater, another heat exchanger mounted in the boiler casing, that transfers heat from the combustion gases to the saturated steam leaving the steam drum. The device is used where dry superheated steam is required by the system. However, if the boiler is used for heating only, a superheater is usually not installed.

When employed, both of these devices will usually be equipped with relief valves, isolation valves, and frequently with soot blowers.

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 small tanks with a regulated water supply to cool and dilute the discharge. The drain should be connected to the sewer and vented to 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.

Boiler water treatment facilities are usually provided. They vary depending mostly on the size of the boiler they feed. One-shot feeders are typically provided for boilers less than 30 BHP, bypass feeders are 30-150 BHP and treatment pump feeders are >150 BHP. Treatment pump feeders generally include a positive-displacement type pump, with a manual adjustment of the pumping capacity from zero.

Equipmont Controls & Panels (CSI 15970)

Boiler controls must comply with “improved risk” criteria established in DOE 5480.7.

Control panels for fuel-fired boilers provide an electronic programming relay, blower motor starter, 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/ 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.

Panels for electric boilers should include a step controller with a recycling relay to return the controller to the OFF position after power failure. Some smaller units may use heavy-duty multi-stage thermostats in lieu of a step controller. A control circuit switch, pilot light for each step, and supply voltage indicator should be included.

0.08.03.02 BOILERS (CSI 15555)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Piping & Fittings (CSI **15060)**

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

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

Oil and gas piping should provide shut-off 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 to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

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

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

OTHER RELATED COMPONENTS

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.03.02 BOILERS (CSI 15555)

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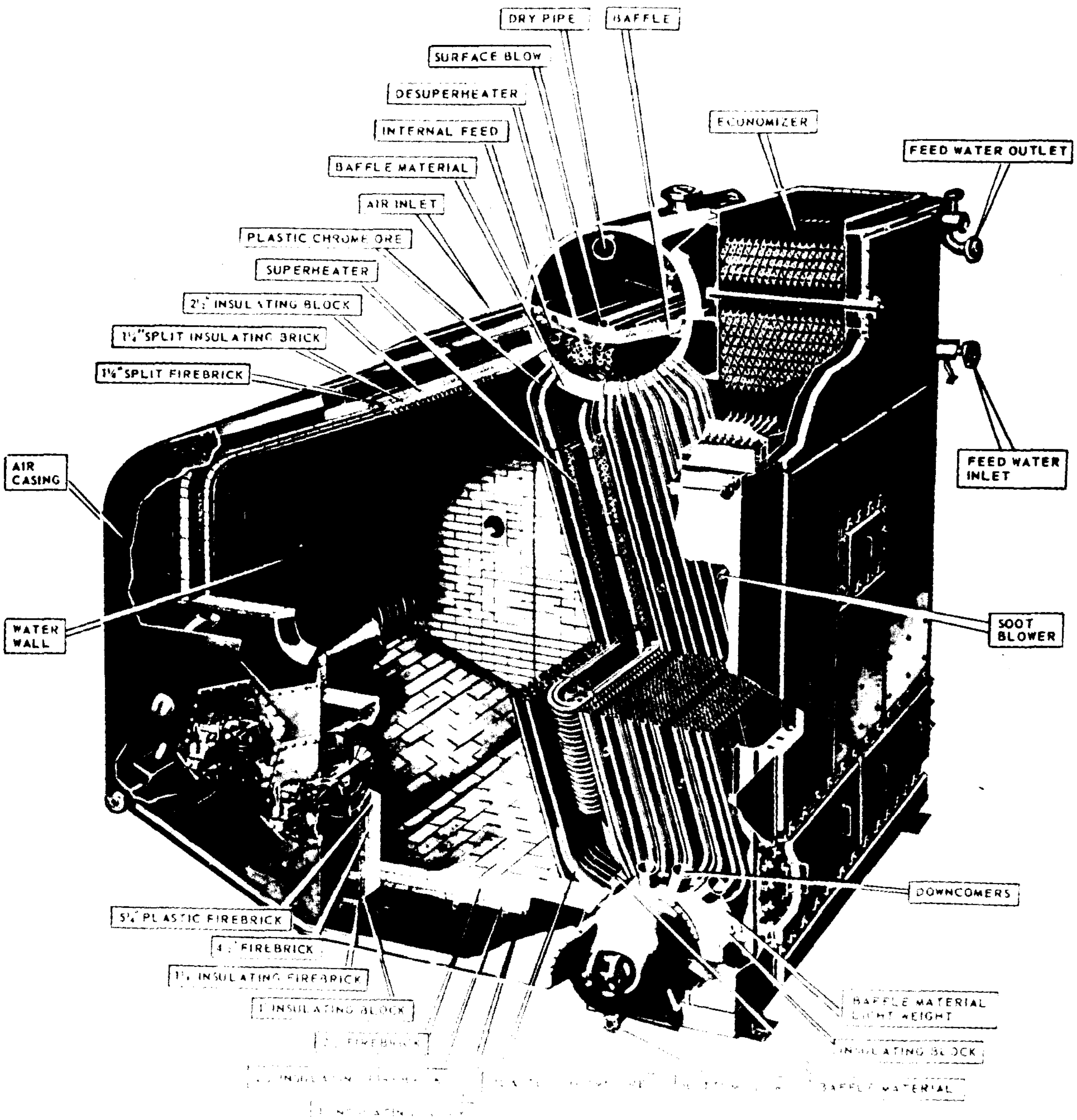
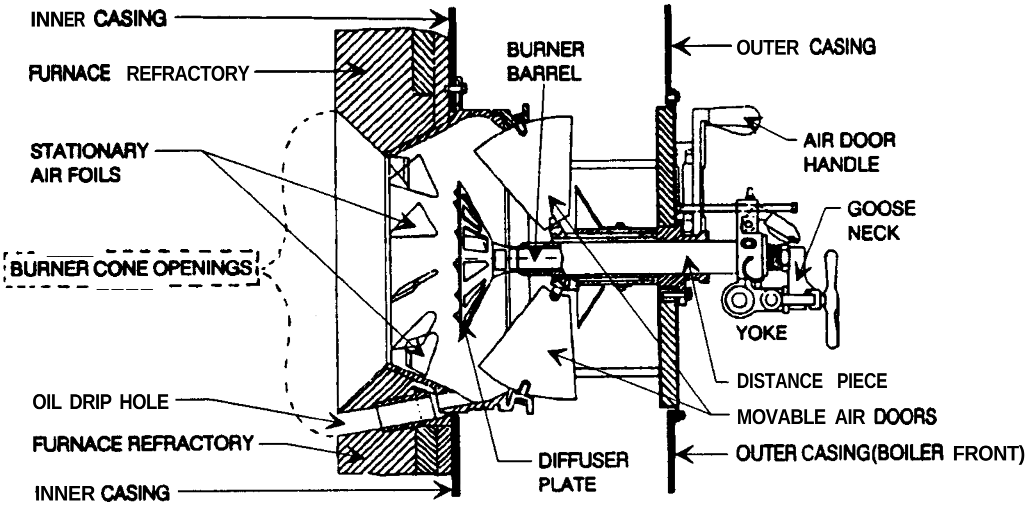
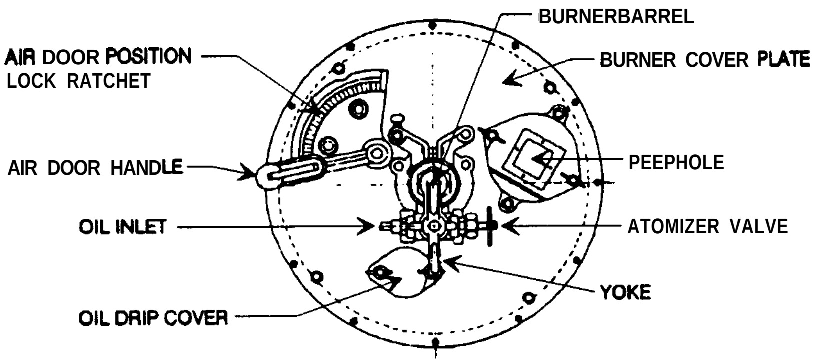


SOURCE BOILERMAN 3 AND 2. BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE. NAVPERS 10535-D

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HEATING BOILER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	issue Date 5/93	Drawing No. A080302-1

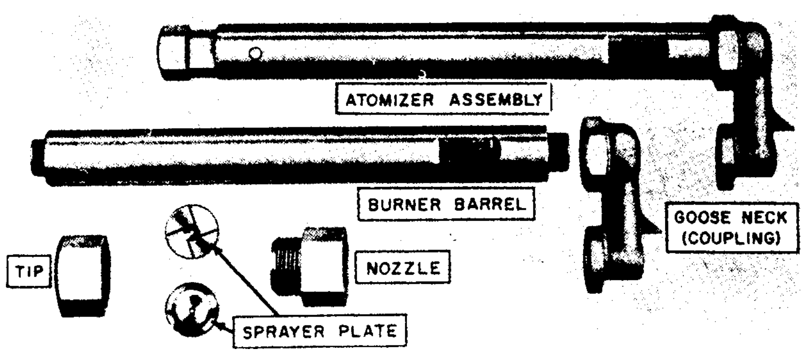


BURNER (SIDE VIEW)



BURNER (FRONT VIEW)

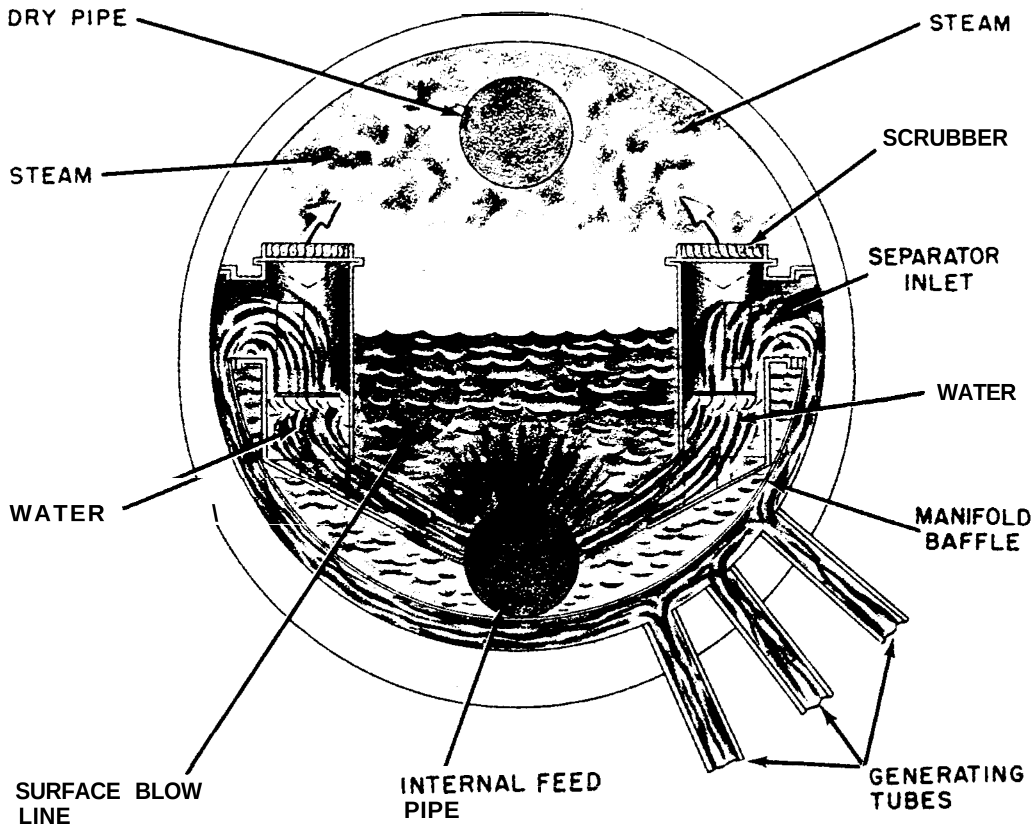
BURNER ASSEMBLY



ATOMIZER-BEFORE AND AFTER ASSEMBLY

SOURCE: FIREMAN, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10520-B

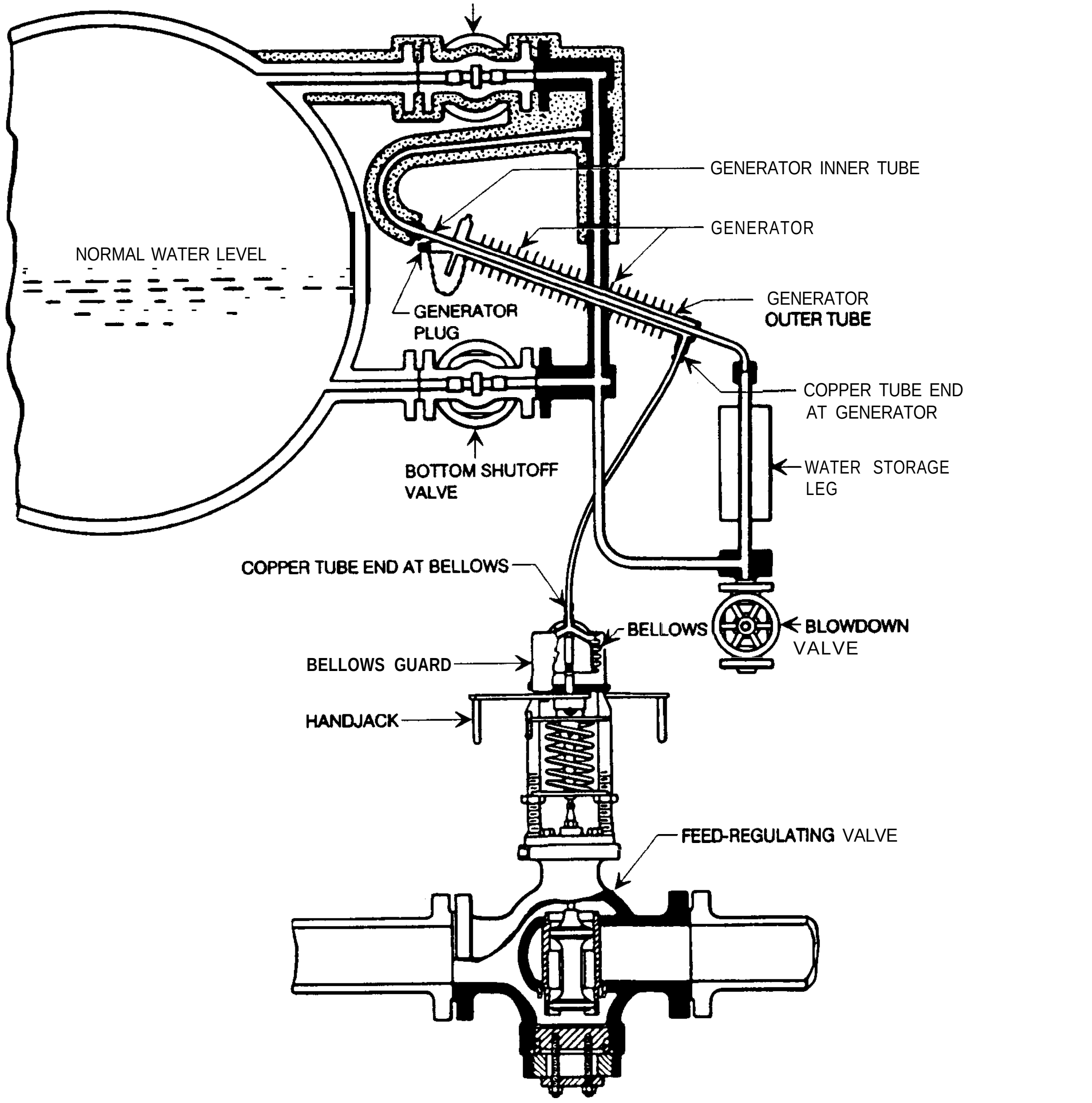
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	OIL BURNER ASSEMBLY		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-2



FLOW OF STEAM AND WATER IN THE STEAM DRUM OF A DOUBLE-FURNACE BOILER

SOURCE: BOILERMAN 3 AND 2, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10535-D

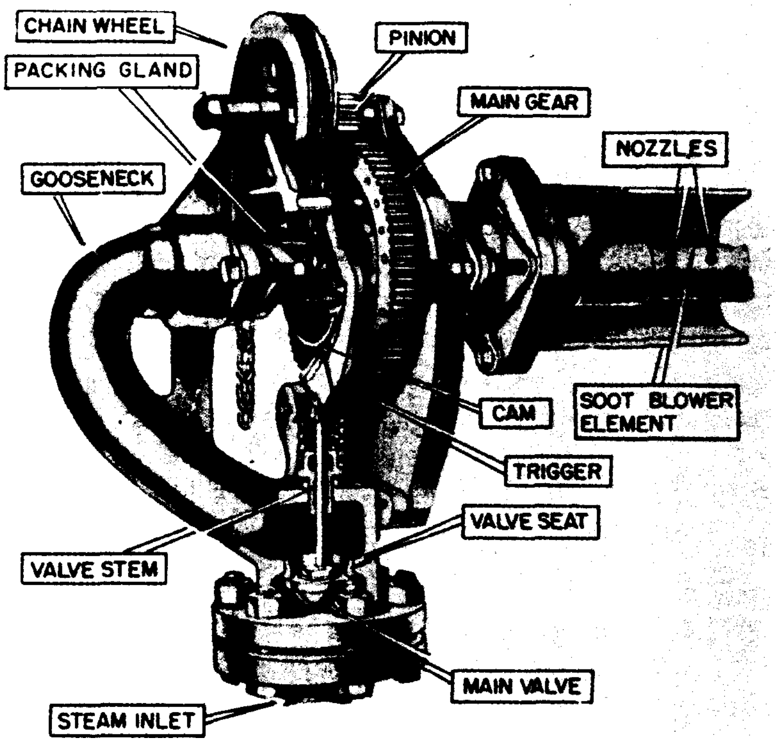
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BOILER STEAM DRUM		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-3



SINGLE-ELEMENT FEED WATER REGULATOR

SOURCE: BOILERMAN 3 AND 2, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10535-D

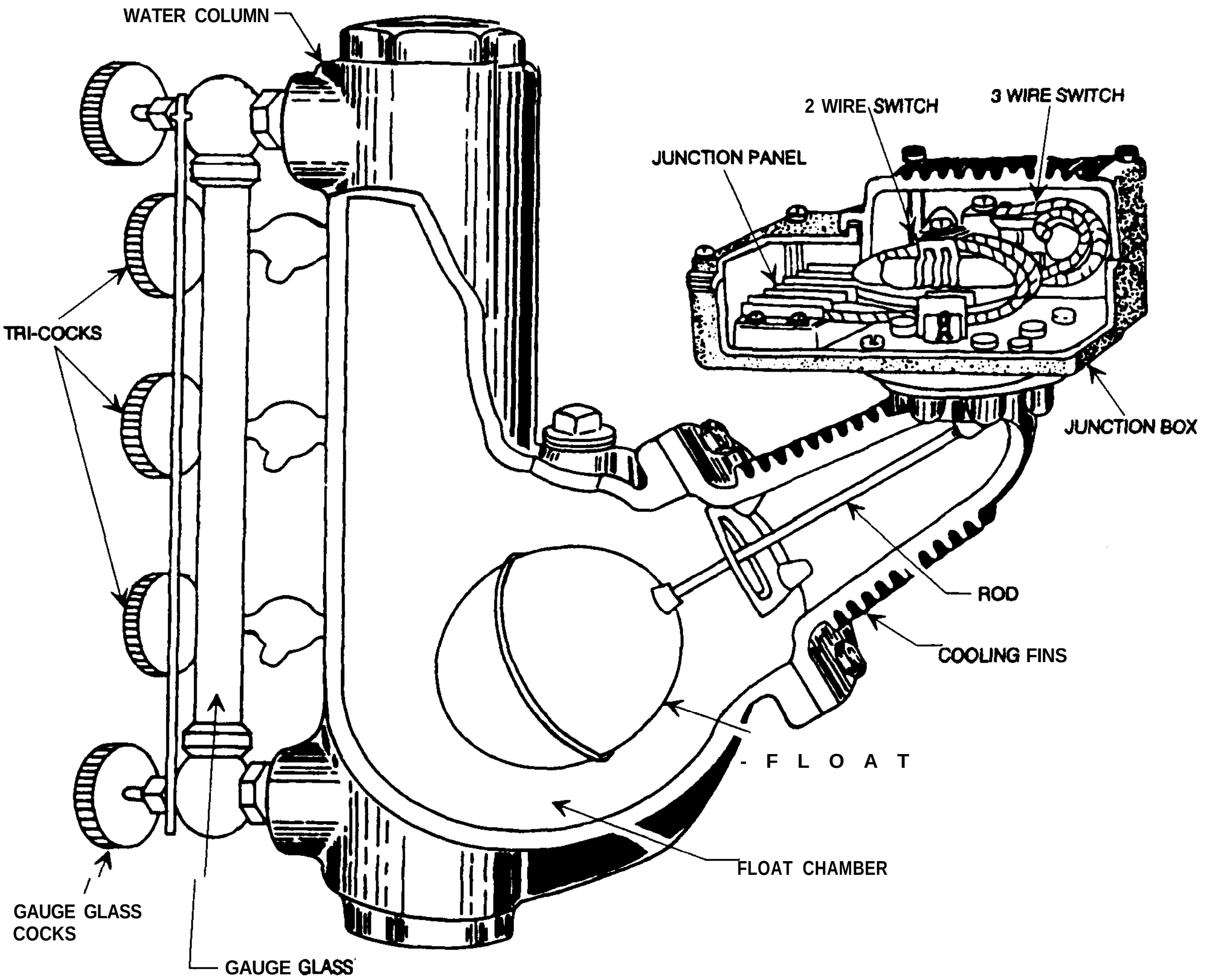
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	GENERATOR TUBE, WATER LEVEL CONTROLLER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-4



SOOT BLOWER HEAD

SOURCE: FIREMAN, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10520-B

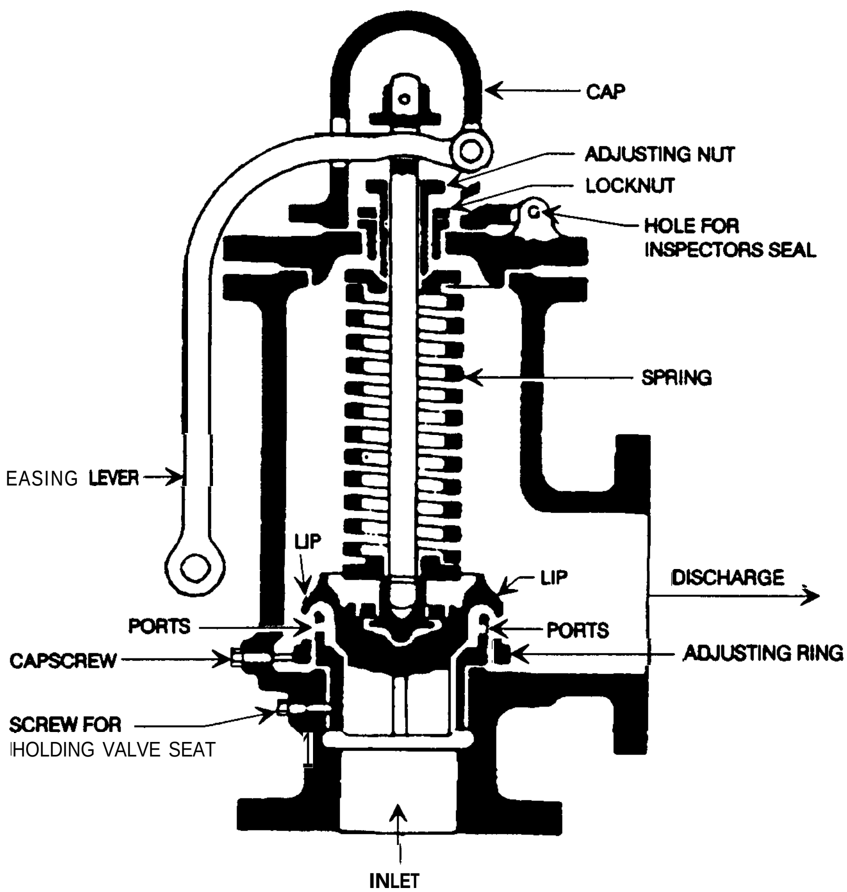
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SOOT BLOWER ASSEMBLY		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-5



FEED-WATER AUTOMATIC LEVEL CONTROL

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

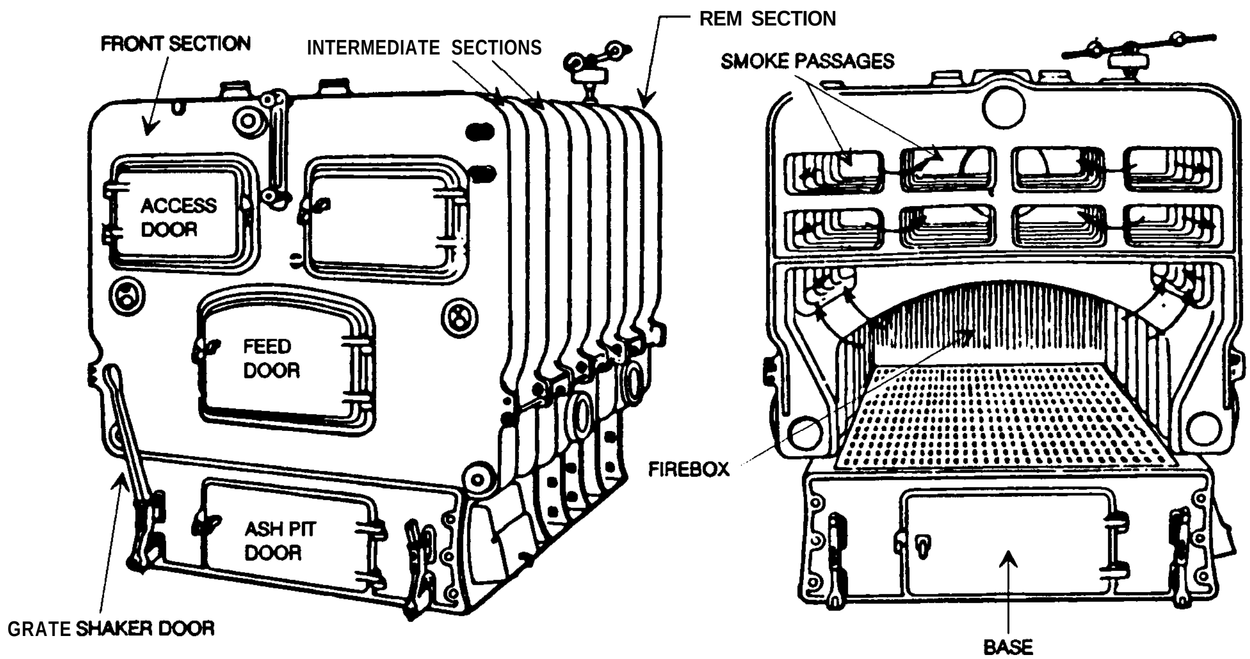
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FLOAT TYPE LEVEL CONTROL		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-6



A TYPICAL PRESSURE RELIEF VALVE

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL PRESSURE RELIEF VALVE		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-7



A SQUARE SECTIONAL CAST IRON BOILER

SOURCE: NAVFAC TECHNICAL TRAINING CENTER. NTTC COURCE 230. INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SECTIONAL BOILER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-8

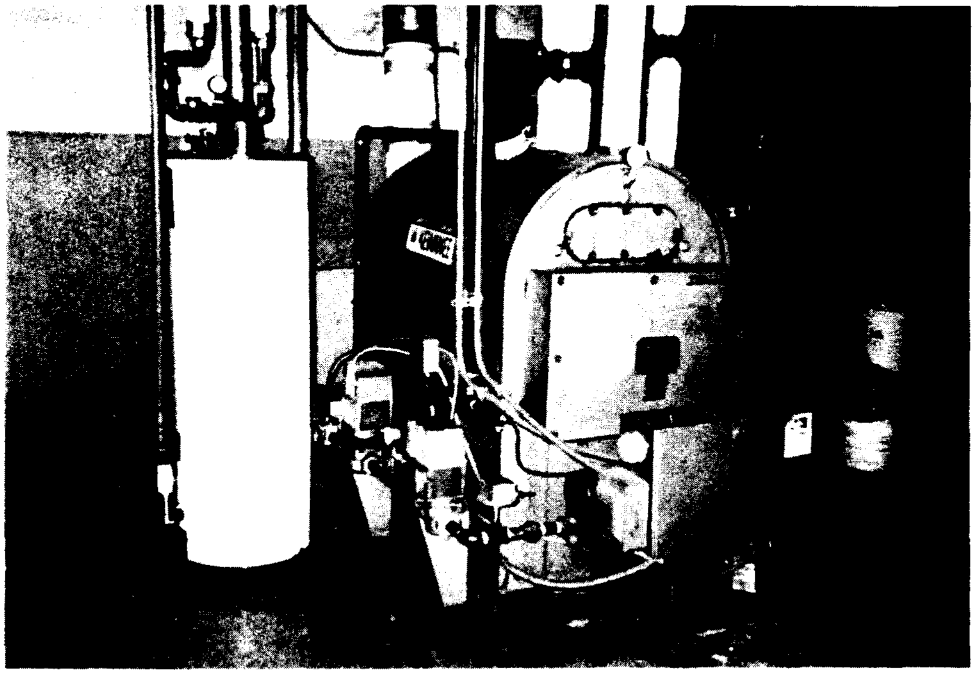


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SMALL PACKAGED NATURAL GAS FIRED BOILER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-9

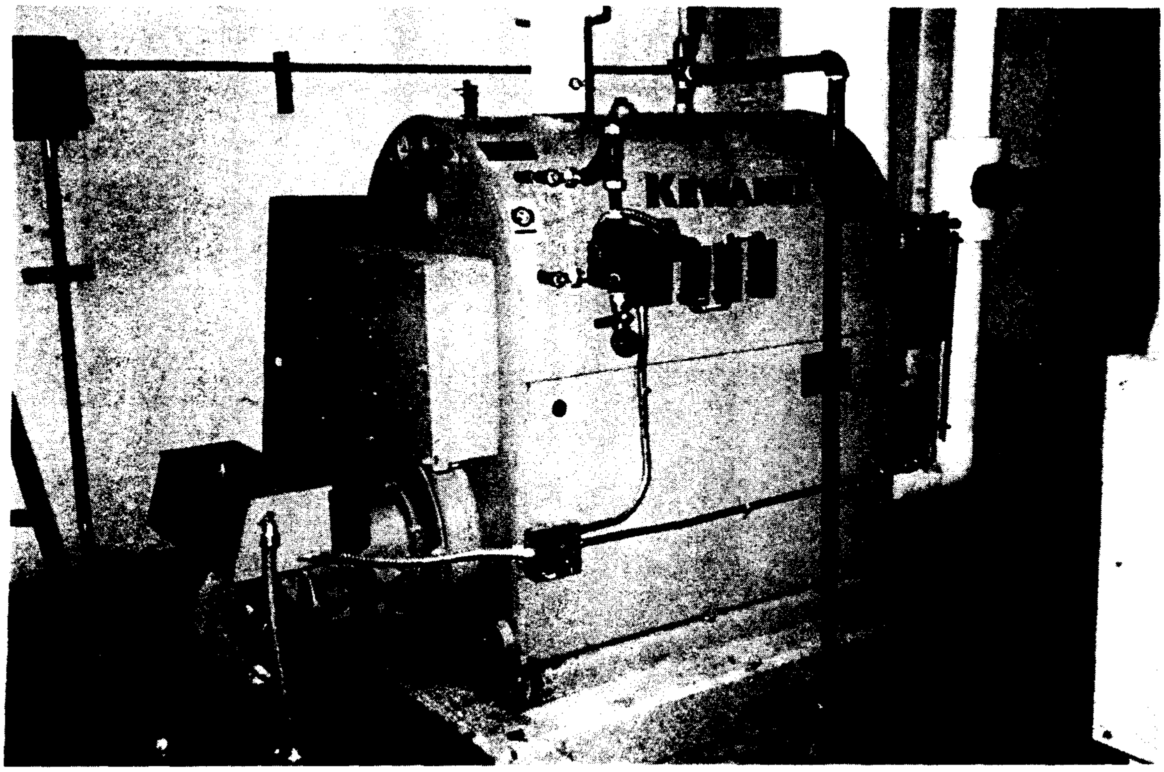


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SMALL PACKAGED DIESEL FIRED BOILER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-10

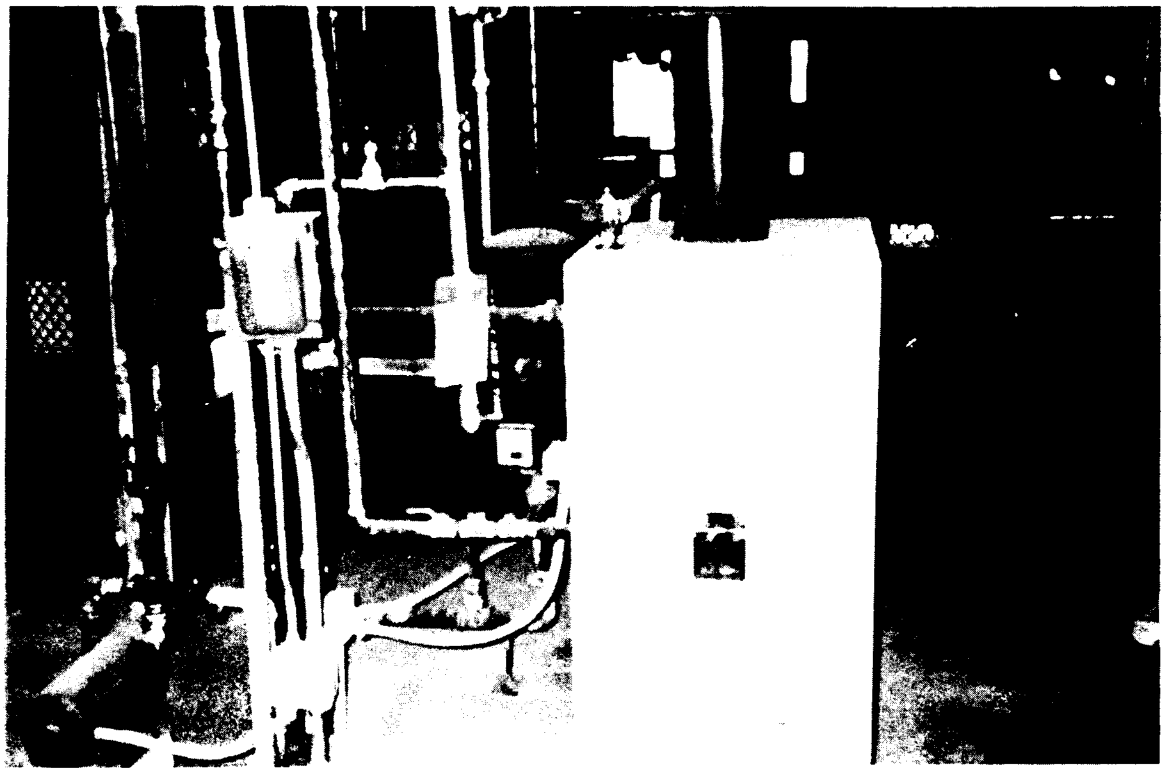


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SMALL PACKAGED BOILER WITH HOT WATER CIRCULATING PUMP		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-11

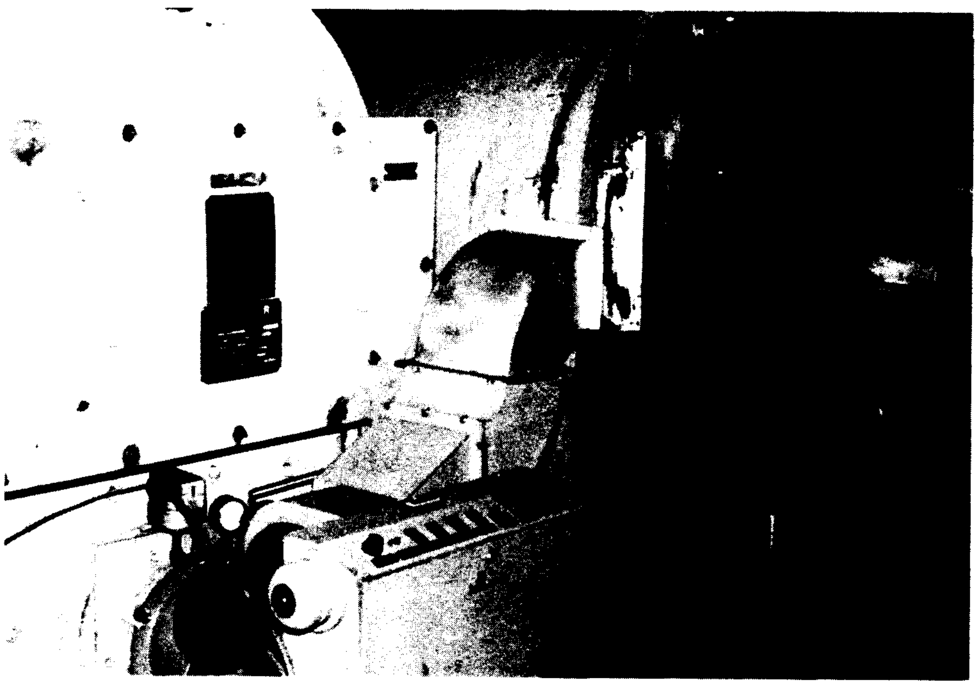


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	MULTIPLE BOILERS IN PARALLEL CONFIGURATION		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-12

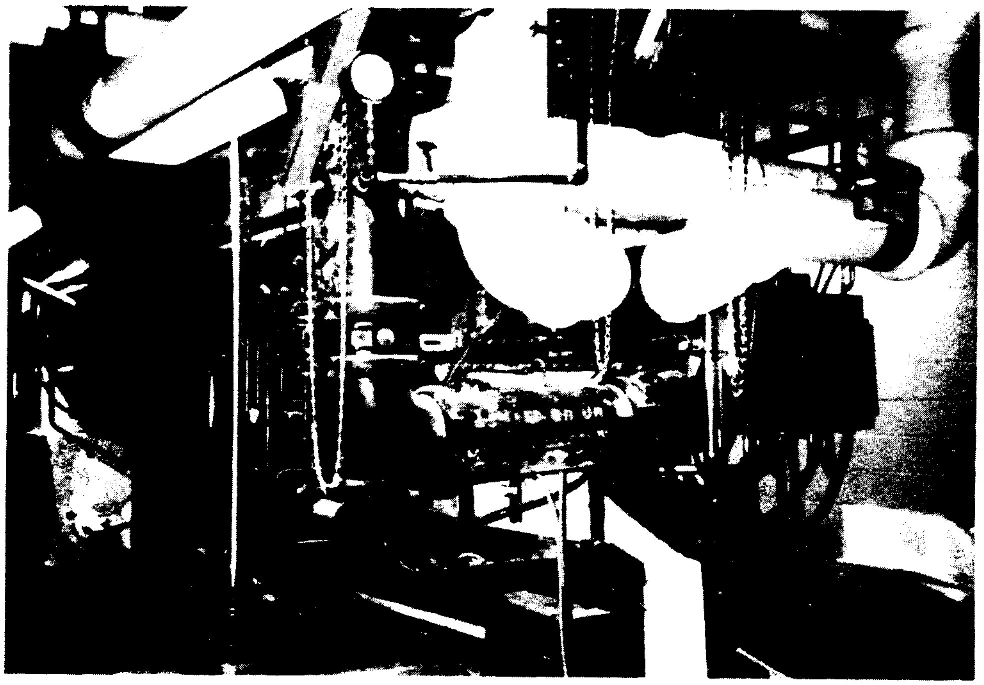


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PARAFLOW UNIT, COMBINATION CHILLER/BOILER		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. A080302-13

DEFICIENCY FACTORS
0.08.03.02 BOILERS (CSI 15555)

PROBABLE FAILURE POINTS

- Boiler tube leaks 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.

SYSTEM ASSEMBLIES/DEFICIENCIES

Casings

Insulation Wet, Damaged, or Missing:	Leaks, physical abuse, poor maintenance.
Leakage:	Failed fasteners or weld, internal refractory breakdown.
Blisters, Buckling:	Overheated metal, probable refractory lining failure.
Excessive Corrosion:	Leakage, poor maintenance.

Combustion Chambers

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

Shells & Tubing

Shell Blistered or 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.
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 burning of fuel.
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
0.08.03.02 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Fuel Burning/Heating Equipment

Gas Ring Distortion:	Overheating, physical abuse, loose fasteners.
Oil Burner Distortion:	Overheating, loose fasteners, physical abuse.
Mixing Dampers Inoperative:	Physical damage.
Burner Excessive Corrosion:	Leaks.
Burner Excessive Noise, Vibration:	Loose fasteners, worn bearings.
Compressor Excessive Noise, or Vibration:	Loose fasteners, wear.
Coal Grate Damage:	Overheating, metal fatigue, corrosion.
Coal Grate Inoperative:	Failed drive/bearings.
Electric Heating Element Corrosion:	Poor water treatment.
Electric Heating Element Inoperative:	Corrosion, physical damage.

Combustion Air Fans

Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment,
Excessive Corrosion:	Poor maintenance, improper fuel mixing.
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.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Boiler Trim

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

DEFICIENCY FACTORS
0.08.03.02 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES

Boiler Trim (Continued)

Gauges Illegible:	Defaced by chemicals, corrosion, physical damage.
Low Water Cut-off 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, poor maintenance.
Soot Blower Inoperative:	Corrosion, wear, physical damage, missing parts.
Soot Blower Excessive Corrosion:	Environment, poor maintenance.
Soot Blower Leakage:	Corrosion, wear.

Major Accessories

Economizer Coil Damage:	Physical abuse, wear.
Economizer Coil Leakage:	Corrosion, contamination, overheating.
Economizer Regulating Valve Inoperative:	Corrosion.
Economizer Casing Leakage:	Corrosion, physical damage, loose fasteners.
Superheater Tube Leakage:	Corrosion, thermal stress.
Superheater Excessive Corrosion:	Poor maintenance.
Blowdown Separator Leakage:	Corrosion, thermal stress.
Blowdown Separator Regulating Valve Inoperative:	Corrosion.
Blowdown Separator Excessive Corrosion:	Poor maintenance.

Equipment Controls & Panels

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

Piping & Fittings

Excessive Corrosion:	Aging, poor maintenance, leakage.
Leakage:	Improper installation, corrosion.

DEFICIENCY FACTORS
0.08.03.02 BOILERS (CSI 15555)

SYSTEM ASSEMBLIES/DEFICIENCIES

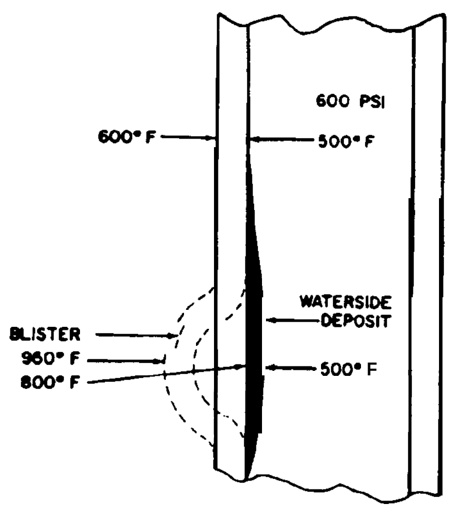
Piping **& Fittings** (Continued)

Physical Damage:	Abuse, stress.
Strainers inoperative:	Corroded.

Baked sludge on boiler tube

Carbonized oil on boiler

Scale on boiler tube

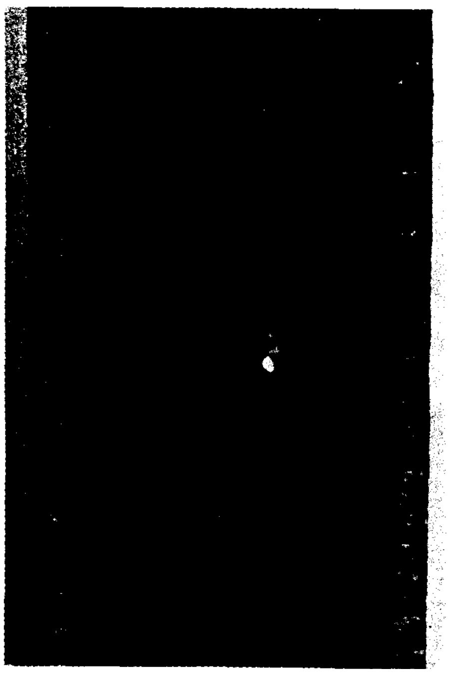


Effect of waterside deposit on boiler tube.

PHOTO ILLUSTRATION

SOURCE: BOILERMAN 3 AND 2. BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE. NAVPERS 10535-D

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	WATERSIDE DEPOSITS		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. 0080302-I



Oxygen pit in boiler tube

Scab formed over oxygen pit

PHOTO ILLUSTRATION

SOURCE: BOILERMAN 3 AND 2, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10535-D

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	TUBE PITTING		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. D080302-2

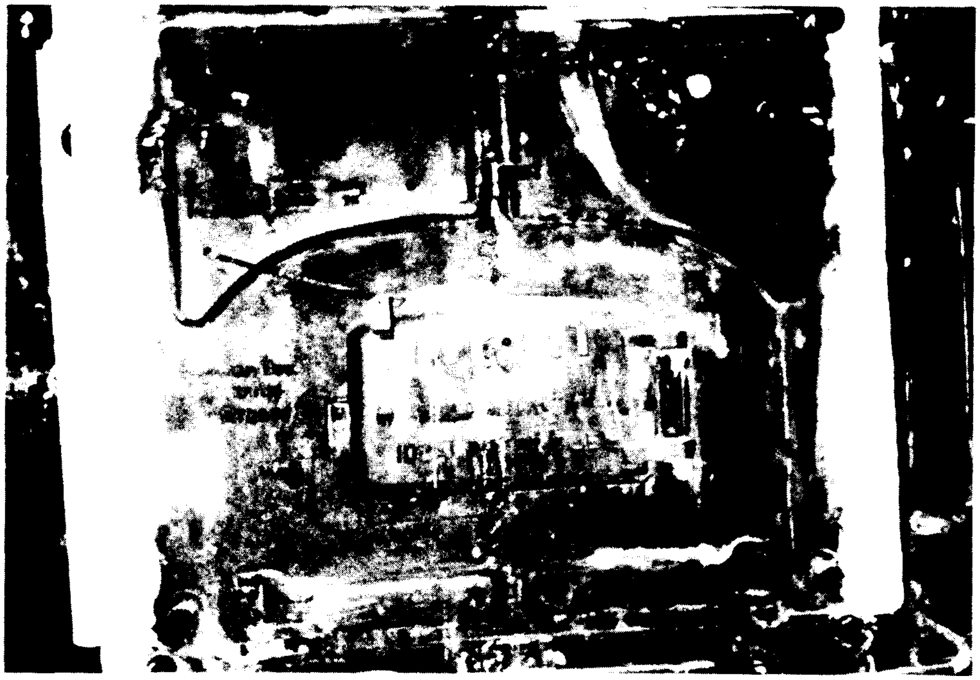


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORROSION AND LEAKAGE BOILER CASINGS		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. D080302-3

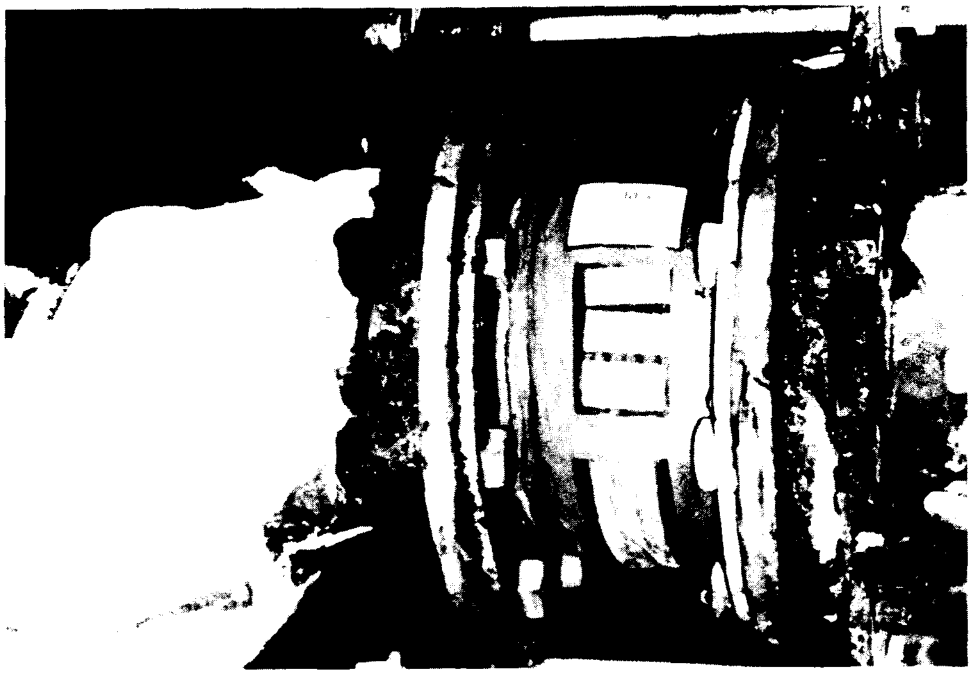


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORROSION ON CASING AND DAMPER ASSEMBLY		
HEATING AND VENTILATING BOILERS (CSI 15555)	Revision No.	Issue Date 5/93	Drawing No. D080302-4

DEFICIENCY FACTORS
0.08.03.02 BOILERS (CSI 15555)

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DEFICIENCY FACTORS
0.08.03.02 BOILERS (CSI 15555)

END OF SUBSECTION

0.08.03.03 HOT AIR FURNACES (CSI 15610)

DESCRIPTION

Some small heating and ventilating systems may employ a small furnace to produce the hot air for general heating purposes. The furnace converts a raw energy source (fuel or electric power) into heat and transfers this heat to the air passing through the furnace. The furnace employs controls to manage the rate of heat transfer.

The typical furnace consists of a casing; combustion chamber (furnace, fire box, flue) and/or heat exchange surfaces (shell and tubes, electric coils), breeching and stacks to remove gases from fossil fueled units, burners or electric heating coils, combustion air fans, control devices, major accessories like humidifiers, control panels, pipe and fittings.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Casings (CSI 15555)

The furnace 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 to prevent air leakage. Larger units 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. However, the spacing between the combustion chamber and the outer casing precludes the need for insulation on most small residential units.

Combustion Chambers (CSI 15620)

The combustion chamber is the area of the furnace where fuel is burned. Construction varies, depending significantly on general design.

Most small commercial furnaces employ a small hearth area made with brickwork. Residential furnaces are usually not lined at all; containment is provided by the metal casing.

Combustion chambers typically have access plates to allow inspection and servicing. On residential units, access is generally provided by removing the burner itself.

Heat Exchangers (CSI 15620)

Most furnaces employ a simple, vertical, single-pass shell and tube heat exchanger to conduct combustion gas heat to building heating air. To promote conduction, removable baffles are frequently inserted in the gas stream to create turbulence. The heat exchanger and baffles are usually heavy gauge, welded sheet metal.

Breeching, Chimneys, & Vent Stacks (CSI 15575)

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

A breeching connects the furnace to a vent stack or chimney. It is typically made of sheet metal and has few, if any, fittings. In some installations, barometric dampers are installed to regulate draft and 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 furnace. 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 furnace. This effect increases with chimney height.

0.08.03.03 HOT AIR FURNACES (CSI 15810)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Breeching, Chlmneys, **&** Vent Stacks (CSI 15575) (Continued)

Chimneys are generally masonry structures lined with refractory; vent stacks are fabricated of sheet metal.

Fittings on stacks/chimneys include:

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

Fuel Burning/Heating Equipment (CSI **15595, 15617)**

There are three primary ways of producing heat for the furnace: gas burners, oil burners, and electric resistance heating. The first two produce combustion gases that heat the air indirectly; the last provides direct heating. Other methods such as coal firing, woodburning, and special fluidized beds are available but beyond the scope of this standard.

Gas burners are typically horizontal, perforated tubes arranged in a bank and supplied by a "gas train." The only moving part is generally a manual damper, regulated to control the amount of mixing air.

Gas burners should have a gas pilot, premix type with automatic electric ignition, complete with an electronic detector to monitor pilot so primary fuel valve cannot open until pilot flame has been established.

Gas burners typically provide:

- Air flow safety switch
- Controls and linkage for firing sequence
- Flame safeguard control
- Gas cocks
- Gas electric ignition assembly
- Gas pressure regulator
- Safety gas valves

Oil-fired burners used to be the mainstay of installations. However, most new burners have been installed as gas or converted to gas from oil. Typical oil burners are simple guns that provide pressurized oil through a burner tip that induces atomization. Air is provided through a damper for primary mixing and combustion. Small combination pump and fan assemblies are frequently part of the gun.

Oil burners should have an automatic electric ignition, complete with an electronic detector to monitor pilot so primary fuel valve cannot open until 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
- Ignition assembly
- Oil filter
- Oil solenoid valves

Because most heating furnaces are small, fuel oil supply storage is typically in a small above ground tank.

Electric resistance heating generally consists of simple heating elements, sheathed for protection from corrosion, immersed directly in the circulating air stream.

0.08.03.03 HOT AIR FURNACES (CSI 15810)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Heat Circulating Air Fans (CSI 15860)

Circulation of heating air is typically provided to furnaces using a forced draft fan; i.e., the fan discharges to the furnace heat exchanger. The fan is generally a small centrifugal unit, typically a squirrel cage. Fans are motor-driven either by direct drive or by using a belt.

Motors (CSI 15170)

Motors are usually used to drive the burner and fans. In most cases these are belt-driven (small furnaces may use a direct-drive motor). Very large units may have a steam turbine, but these are rare for furnaces.

Air Cleaners (CSI 15885)

All furnaces require some method for cleaning/filtering the recirculated air. Replaceable filters are the most common method, and cleanable units are a close second. Some very large units may employ a filter roll drive assembly for advancing the filter.

Additional accessories include charcoal filters and ultraviolet lighting to remove/destroy contaminants other than dust particles.

Humidifiers (CSI 15810)

Perhaps the most common hot air furnace accessory is a humidifier. It is used to maintain the system supply air in a humidity range of 30 to 60% relative humidity. Many types are found in the field.

The simplest is probably sponge-mounted on a rotary drum immersed in both the air stream and a water pan. The hot airstream absorbs moisture from the sponge. Water level is maintained in the water pan using a small, float-operated valve.

An alternative approach uses a water pan with a heating source (electric element or hot gas) to facilitate water evaporation.

Equipment Controls & Panels (CSI 15970)

Temperature controls are used both to regulate space temperature of the areas served (by turning furnace on and off) and to provide safety limits for furnace operation.

Several interlocks are generally provided between the furnace duct stat, the heat source, and the fan control. Usually the duct temperature must achieve a certain level before the fan will kick in. If the furnace duct temperature gets too high, the heat source is shut off. The fan continues to run to lower duct temperature to safe limits.

Another common interlock employs an air flow sensor to prevent operation if fan operation is lost.

Large units may require a motor starter for the circulating fan and/or burner.

Furnaces should have a local switch or disconnect adjacent to the unit.

Piping & Fittings (CSI 15060)

Piping and fittings for furnaces include fuel supplies and humidifier water supply.

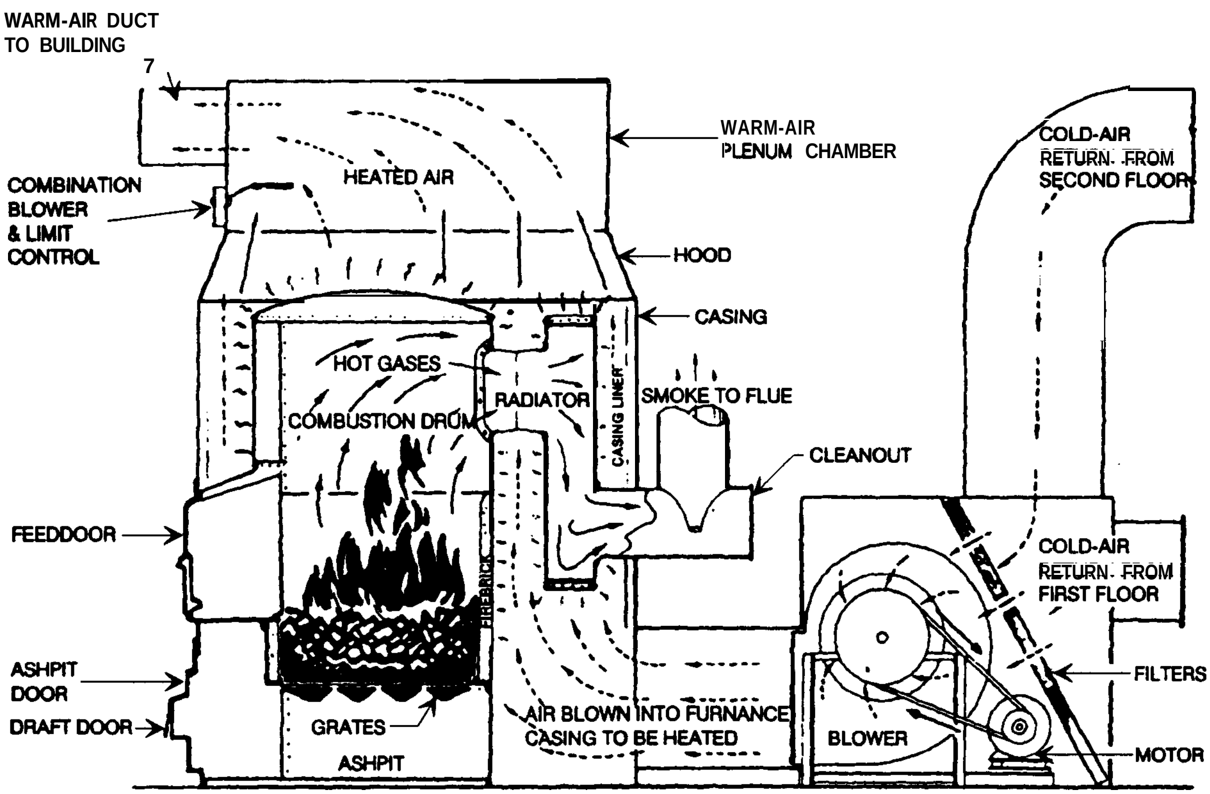
Oil and gas piping should provide shutoff valves and unions with sufficient clearance for burner removal and service.

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

0.08.03.03 HOT AIR FURNACES (CSI 15810)

OTHER RELATED COMPONENTS

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.



A COAL-FIRED FORCED WARM-AIR FURNACE

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	COAL-FIRED FORCED WARM-AIR FURNACE		
HEATING AND VENTILATING HOT AIR FURNACES (CSI 15610)	Revision No.	Issue Date 5/93	Drawing No. A080303-1

DEFICIENCY FACTORS
0.08.03.03 HOT AIR FURNACES (CSI 15810)

PROBABLE FAILURE POINTS

- Leakage in furnace heat exchanger due to corrosion, overheating, embrittlement.
- Inability of system to deliver rated capacity due to internal scaling of heating surfaces, burner/heating element failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Casings

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

Combustion Chambers

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

Heat Exchangers

Baffles Distorted:	Overheating.
Shell Elistered or Buckled:	Overheating, over-pressurization.
Loose, Broken Fasteners:	Corrosion, stress, vibration.
Excessive Corrosion:	Environment, poor maintenance.
Leakage:	Corrosion, heat fatigue.
Tubes Blocked:	Excessive scale buildup.

Breeching, Chimneys, **&** Vent Stacks

Excessive Corrosion:	Poor gas temperature control, incomplete fuel burning.
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.

Fuel Burning/Heating Equipment

Gas Burner Distortion:	Overheating, physical abuse, loose fasteners.
Oil Burner Distortion:	Overheating, physical abuse, loose fasteners.
Mixing Dampers Inoperative:	Wear, corrosion, abuse.
Burner Excessive Corrosion:	Poor maintenance.

DEFICIENCY FACTORS
0.08.03.03 HOT AIR FURNACES (CSI 15810)

SYSTEM ASSEMBLIES/DEFICIENCIES

Fuel Burning/Heating Equipment (Continued)

Burner Excessive Noise, Vibration:	Loose fasteners, worn bearings.
Electric Heating Element Corrosion:	Contamination.
Electric Heating Element Inoperative:	Corrosion, physical damage.

Circulating Air Fans

Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance.
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.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Air Cleaners

Corroded Filter Frame:	Environment, poor maintenance.

Humidifiers

Pan Leakage:	Corrosion, loose/missing fasteners, badly seated float valve.
Rotor Inoperative:	Defective motor.
Level Controller Damage:	Physical abuse, corrosion.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

Piping & Fittings

Excessive Corrosion:	Aging, poor maintenance, leakage.
Leakage:	Corrosion, physical damage.
Physical Damage:	Abuse, poor maintenance.
Strainer inoperative:	Corrosion, abuse.

DEFICIENCY FACTORS
0.08.03.03 HOT AIR FURNACES (CSI 15610)

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DEFICIENCY FACTORS
0.08.03.03 HOT AIR FURNACES (CSI 15810)

END OF SUBSECTION

0.08.03.04 HEATING HOT WATER DISTRIBUTION SYSTEM (CSI **15510)**

DESCRIPTION

The typical Heating Hot Water System provides water heating and distribution, taking its source from the building's domestic water system. The system consists of water heaters, circulating pumps, expansion tanks, and the connecting piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Water Heaters (CSI 15460)

Water heaters raise 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. DOE Design Criteria stipulate a maximum supply temperature of 200ºF.

In small facilities, the water heater is typically a tank heated either by electric resistance heating elements or a gas/oil burner. Older, residential type heaters may combine the domestic water and heating water functions in a common fuel-fired heater, using an internal heat exchanger to segregate the two systems. These older units were typically oil-fired units with small, refractory-lined combustion chambers.

Larger facilities rarely use electric water heaters for space heating. Typically, large facilities employ a large storage tank with a heating coil incorporated. The coil is fed by either a high-temperature water system or low-pressure (15 psig) steam.

Pumps (CSI 15453)

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

Heating water pumps are typically single-stage centrifugal pumps. Residential circulators are usually small (fractional horsepower) in-line units; booster pumps are usually larger pedestal-mounted units.

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

Motors (CSI 15170)

Motors are used to drive the circulating pumps. In-line circulator pumps are typically driven via spring-coupled motors pedestal-mounted pumps are typically driven via rigid or flex-coupled motors.

Expansion Tanks (CSI 15175)

Variations in system water temperature can cause a significant change in water volume; compensation 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 maintained either through a level control or a pressure-regulating valve on the makeup water supply line.

Piping 8 Fittings (CSI 15510)

Piping and fittings provide the distribution network for the heating water system.

DOE requires that heating distribution 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.

0.08.03.04 HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15510) (Continued)

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.

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.

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

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valves (CSI 15100)

Valves are primarily used to permit switching pumps, isolating water heaters and other components for maintenance, and isolating terminal fixtures. In addition, shut-off duty valves are typically provided at each branch connection to supply mains.

Drain valves are installed at low points in mains, risers, 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 the 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 water or steam flow through the storage tank heating coils and to control fuels to fossil heaters. Balancing valves are used to proportion flow to risers, branches, and devices.

Relief valves are required on all water heaters and pressurized tanks.

A backflow preventer is used to prevent potable water contamination at any cross-connect between the potable water system and other systems (heating, drainage, chilled water, etc.). The codes have changed in recent years on permissible methods for backflow prevention. In general, double check valves are no longer acceptable.

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

Instrumentation (CSI 15135)

Pressure gauges are typically provided at the suction and discharge of each booster pump or pump group. They are rarely used with circulators.

Temperature gauges are usually provided on large water heaters and storage tanks and at branch lines and circulator pumps.

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)

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 200°F.

0.08.03.04 HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Equipment Controls & Panels (CSI 15950)

Few controls are required in the typical heating hot water system. The system is usually turned on and left running except for routine maintenance services.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Small in-line circulators may use a simple light switch for control. In some cases, system pressure is used to cycle the system booster pump.

Water temperature controls are provided either through thermal bulb sensing and modulation of a hydraulically controlled regulating valve or activation of solenoid operated valves or contacts.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.03.04 HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 155101

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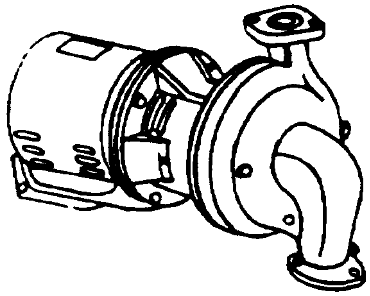
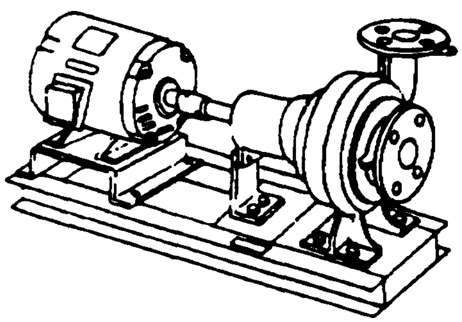


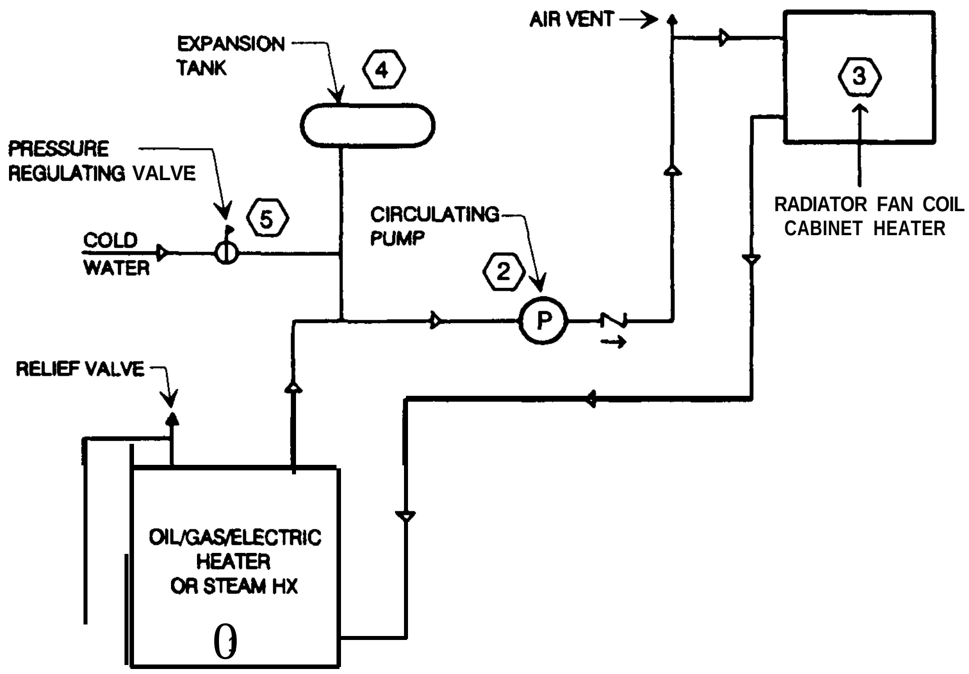
IN-LINE CENTRIFUGAL PUMP



BASE MOUNTED CENTRIFUGAL PUMP

SOURCE: FIREMAN. BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE. NAVPERS 10520-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HYDRONIC HEATING CIRCULATING PUMPS		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue oats 5/93	Drawing No. A080304-1



SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE, "R.S. Means Co., Inc., Kingston, Massachusetts"

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HYDRONIC HEATING SYSTEM		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15620)	**Revision** No.	**Issue Date** 5/93	**Drawing No.** A080304-2

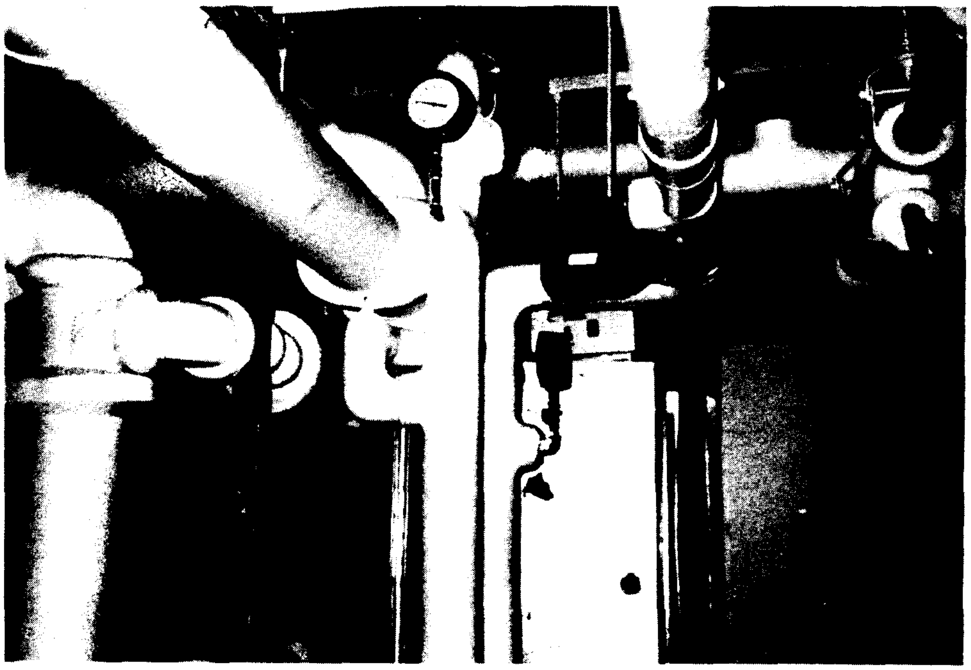


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOT WATER CIRCULATING (FREEZE PROTECTION) PUMP FOR AIR HANDLER		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080304-3

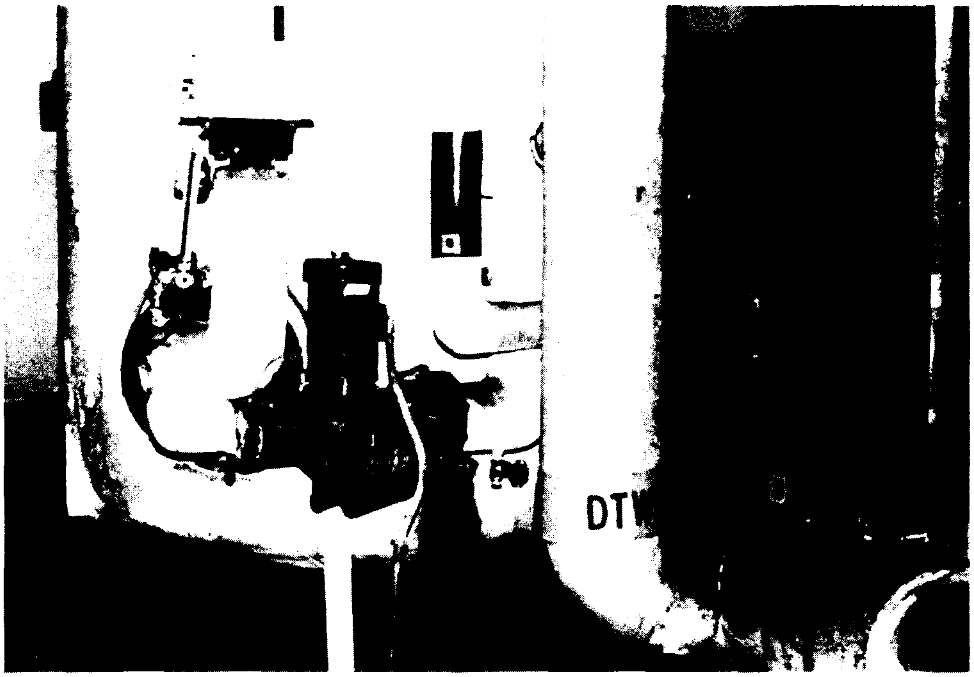


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOT WATER TANK WITH IN LINE VERTICALLY MOUNTED CIRCULATING PUMP		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	**Drawing** No. A080304-4

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HOT WATER REGULATING VALVE		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080304-5

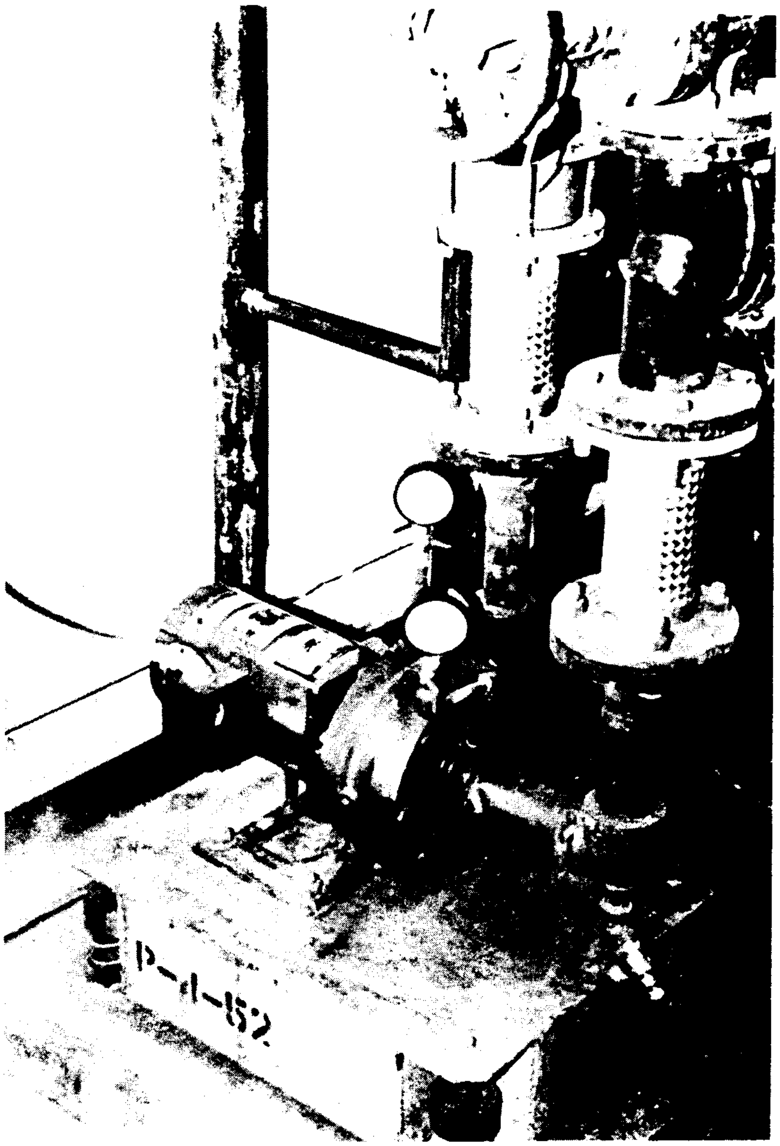


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BOOSTER PUMP		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080304-6

DEFICIENCY FACTORS
0.08.03.04 HEATING HOT WATER DISTRIBUTION (CSI 15510)

PROBABLE FAILURE POINTS

- Piping leaks due to corrosion. Especially true in hot water circuit where chemical reaction rate is greater.
- Inability of system to deliver rated capacity to terminal points due to internal scaling of the distribution network.
- Inadequate pressure at terminal points due to piping failures.
- Inadequate temperature of hot water at terminal points due to heat losses in distribution lines, poor insulation.
- inadequate temperature at terminal points due to insufficient heating capacity or caused by failure of circulator and/or check valves.

SYSTEM ASSEMBLIES/DEFICIENCIES

Water Heaters

Inoperative:	Control failure, blocked tubing, open heating elements.
Inadequate Capacity:	Can not maintain temperature due to blocked/scaled tubing, open electric elements.
Overheating:	Control element failure.
Shell Distortion:	Blisters or bulges in the metal caused by overheating, fatigue, physical damage, loss of external support.
Tank, Pipe, or Fitting Leakage:	Age, corrosion, physical damage.
Leaking HX Coil:	Corrosion, physical damage, due to thermal fatigue.
Defective Burner:	Corrosion, blockage by scale, loose fasteners.
Defective Heating Elements:	Electrically open, scaling.
Duct, Vent Leakage:	Corrosion, loose fasteners.

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment, cavitation.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.

Motors

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.

DEFICIENCY FACTORS
0.08.03.04 HEATING HOT WATER DISTRIBUTION (CSI 15510)

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors (Continued)

Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Expansion Tanks

Severe Corrosion:	Poor maintenance, inadequate water treatment.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Inadequate Pressure:	Makeup valve failure.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, water contamination, lack of maintenance.
Physical Damage:	Bent, broke, 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:	Water 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.

Instrumentation

Missing:	Taken out for service or repair and 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
0.08.03.04 HEATING HOT WATER DISTRIBUTION (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:	System leakage or external causes.
Damaged:	Physical abuse.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

DEFICIENCY FACTORS
0.08.03.04 HEATING HOT WATER DISTRIBUTION (CSI 15510)

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PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	IMPELLER DAMAGE		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-1

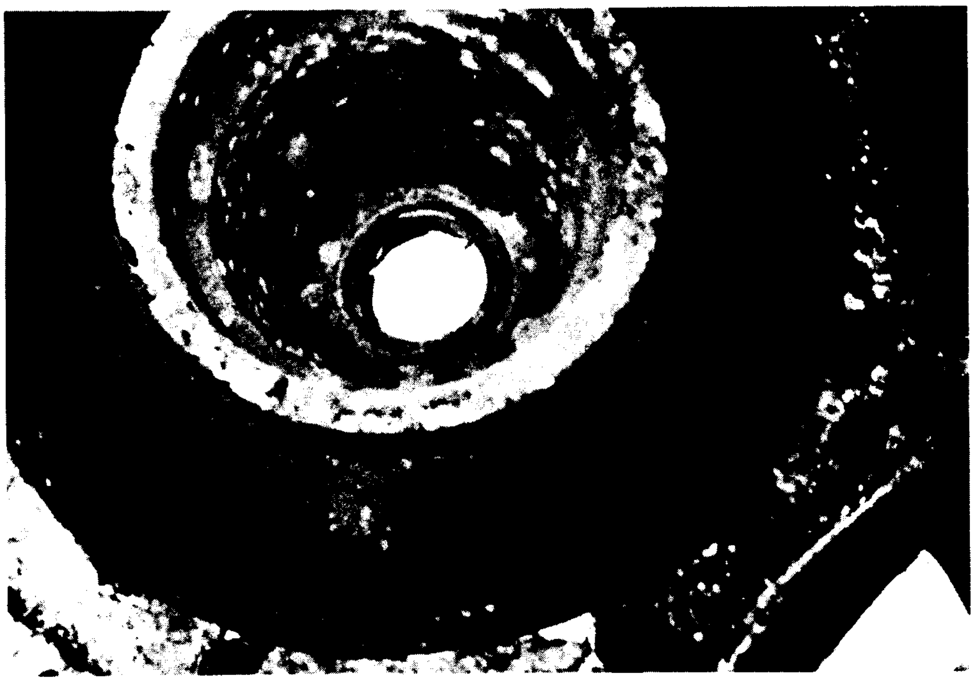

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	PUMP CASING CORROSION		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-2

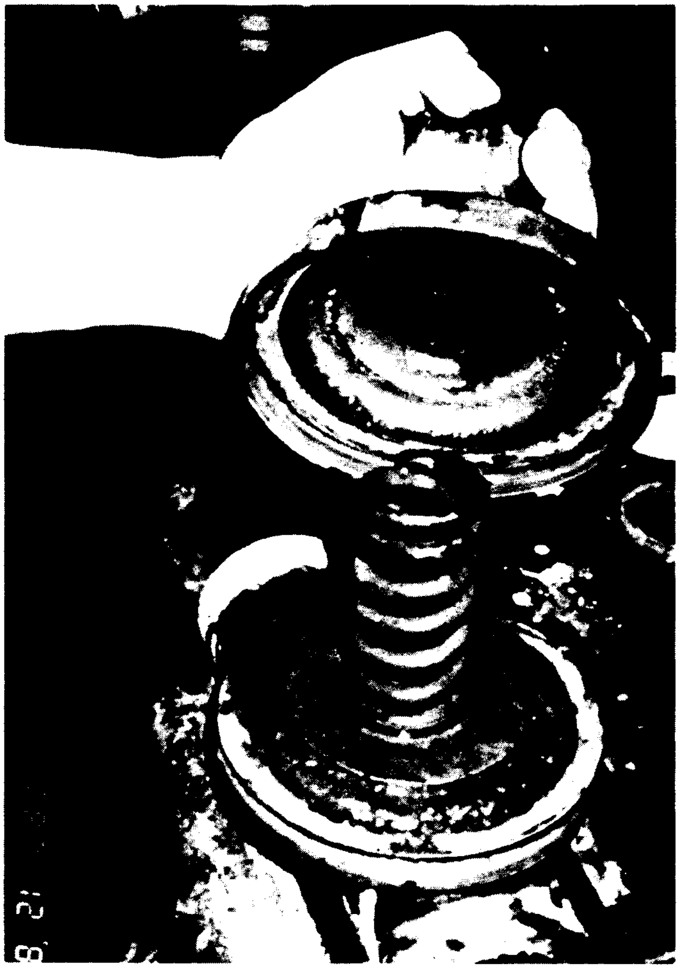

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORROSION IN REGULATING VALVE		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-3

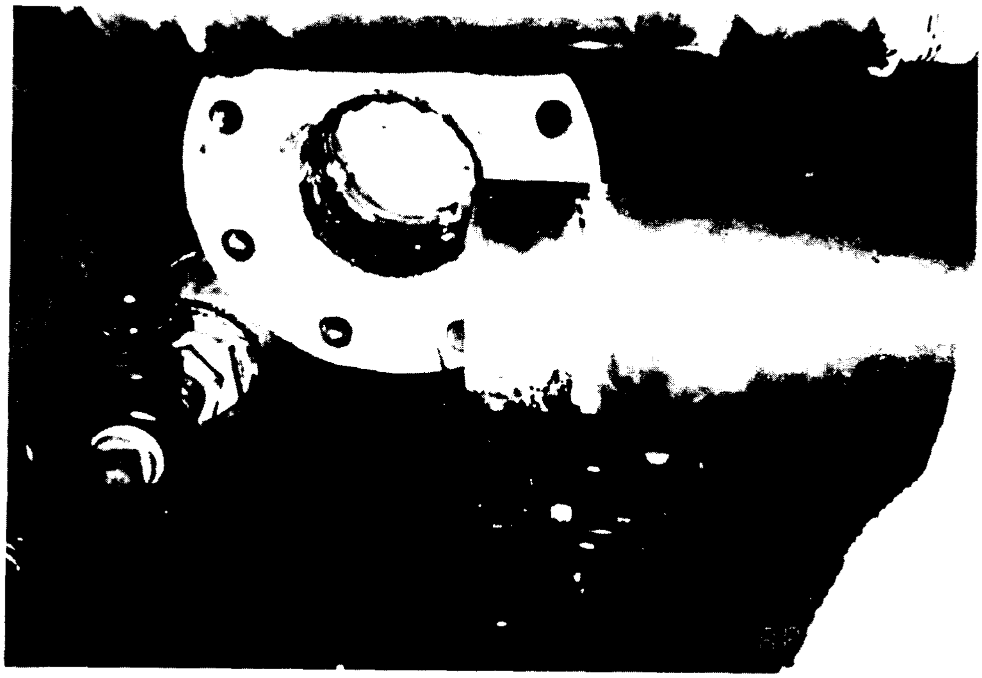

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	INTERNAL PIPE CORROSION		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-4

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	MISSING INSULATION, CORRODED HOT WATER VALVE		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-5

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	DETERIORATED INSULATION, CORRODED UNIONS		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-6

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED HOT WATER SUPPLY PIPE TO HOT WATER COIL FOR AIR HANDLER		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	issue Date 5/93	Drawing No. D080304-7

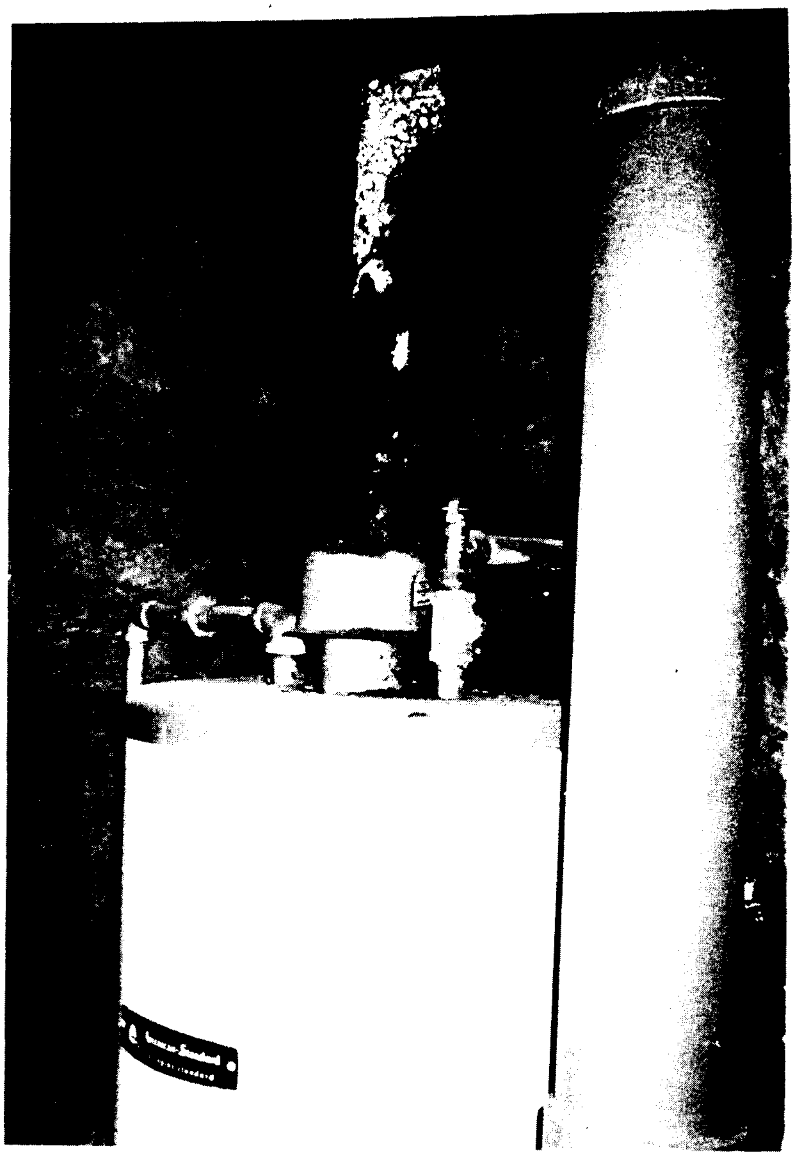

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORRODED HEATER FLUE PIPE		
HEATING AND VENTILATION HEATING HOT WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080304-8

DEFICIENCY FACTORS
0.08.03.04 HEATING HOT WATER DISTRIBUTION **(CSI 15510)**

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DEFICIENCY FACTORS
0.08.03.04 HEATING HOT WATER DISTRIBUTION (CSI 15510)

END OF SUBSECTION

0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

DESCRIPTION

The typical Steam Distribution and Condensate Return System provides steam distribution to facility heat exchange devices, collects condensate return, and prepares condensate for recycling via the boiler feed system. The system consists of steam and condensate piping, steam traps, return tanks and pumps, deaerators, and the connecting fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15520)

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

Current DOE design criteria requires that steam distribution piping be minimum Schedule 40 with appropriate fittings. Condensate piping and feed water piping should be Schedule 80.

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

Due to large changes in temperature, steam systems incorporate many expansion joints and loops.

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.

Strainers are typically provided at the suction of the water pumps to protect the pumps themselves. They are also installed at the pressure reducing station upstream of the regulator.

Flexible connectors are usually 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.

Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Flanges or escutcheons should fit over pipe penetrations through walls in public areas.

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, 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 has been achieved in the trap. Impulse traps rely on pressure differentials to cycle a small plate covering outlet ports. Both types are susceptible to wear and corrosion, prone to leaks, and considered maintenance intensive. Newer traps have fewer or no moving parts. They rely on port sizing or thermostatic elements, are relatively maintenance free, and susceptible primarily to blockage by scale or thermostatic element failure.

0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Condensate Return Tanks (CSI 15175)

Condensate return tanks provide a collection point for condensate lines that drain 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. Some large systems employ steam or compressed air to “pump” condensate through the main.

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 (CSI 15580)

Deaerators prepare water for feed service to the boilers. They are designed to preheat the water, provide de-oxygenation, and to 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-condensables rise through a vent condenser and escape to the atmosphere. Mixing and separation are controlled by cones and baffles or trays 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 motor-driven via a flexible coupling. However, many duplex steam pumps and small steam turbine drives are still located in larger plants although rare in single-building heating systems.

Valves (CSI 15100)

Valves are primarily used to permit switching pumps and isolating tanks and other components for maintenance. In addition, shut-off duty valves are typically provided at each branch connection to supply mains.

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 pumps to prevent windmilling of idle pumps.

0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 155201

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Valves '(CSI 15100) (Continued)

Pressure regulating valves (PRV) are used to reduce main steam pressure to the level required by distribution system devices. They are also used to control water and steam flow through the deaerator.

Relief valves are installed on most reducing stations to protect downstream components.

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.

Equipment Control8 & Panels (CSI 15950)

Most steam and condensate system control is provided by mechanical regulating valves (PRVs and traps).

Electric condensate pump control is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the condensate tank.

Electric transfer pump control is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the deaerator.

Electric feed pump control is performed via a typical motor assembly (motor, starter, and disconnect) interlocked with a float assembly in the boiler water column.

Level sensors are used to activate steam/compressed air solenoid valves when these are used for "pumping."

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 return tank and deaerator to system operation, each is usually equipped with level alarms.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual pipina svstem sections of CSI Division 15.

0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

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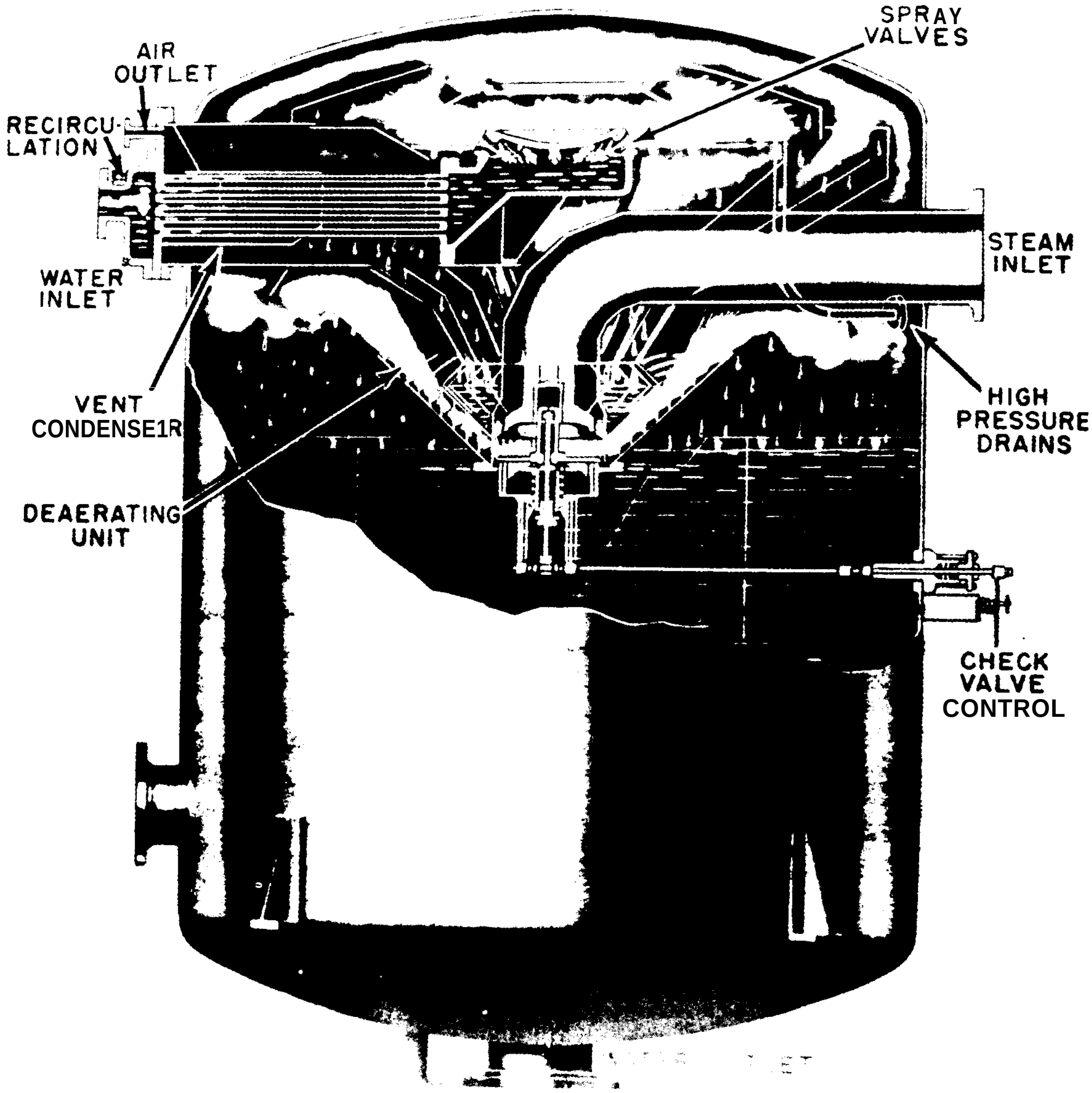
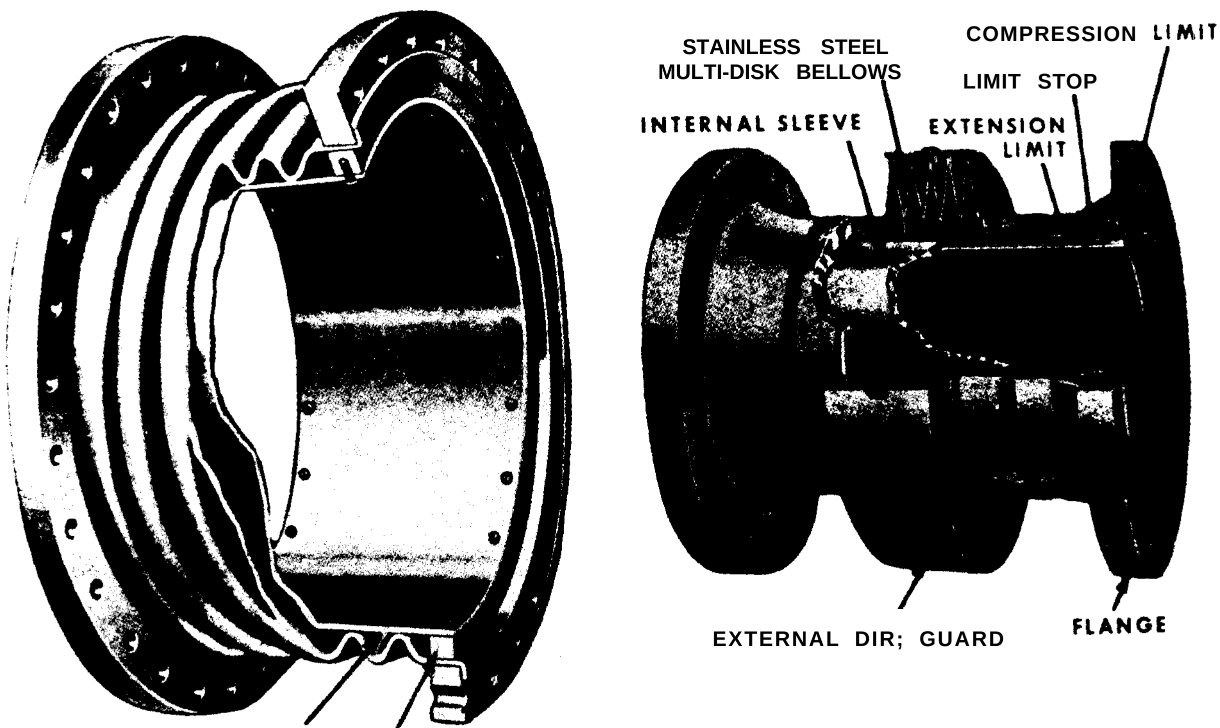


SOURCE: FIREMAN, BUREAU OF NAVAL PERSONNEL NAVY TRAINING COURSE, NAVPERS 10520-B

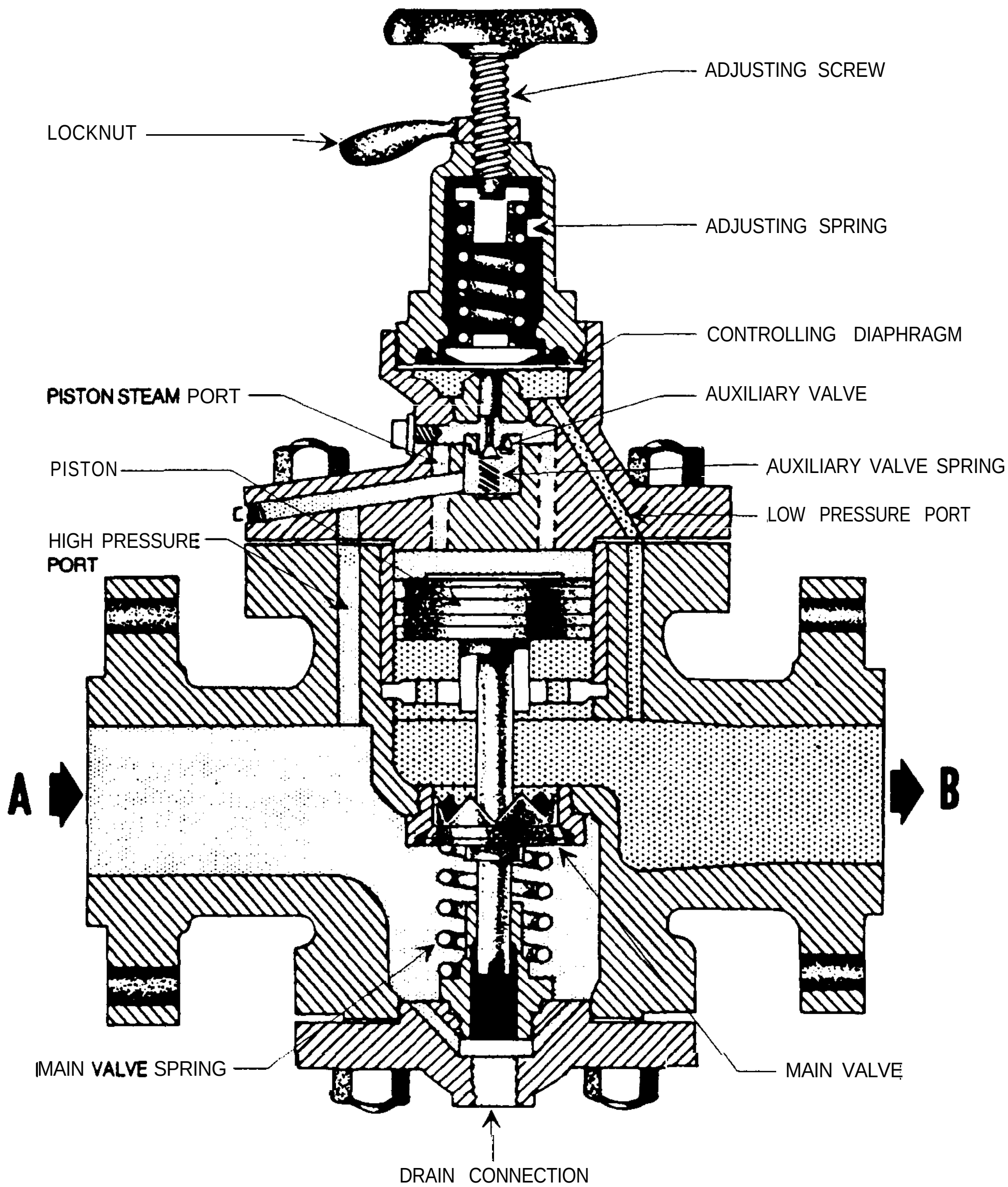
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DEAERATOR		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A0803051



CORRUGATED TYPE AND BELLOWS TYPE EXPANSION JOINTS

SOURCE: MACHINIST'S MATE 3&2, BUREAU OF NAVAL TRAINING COURSE, NAVPERS 10524-B

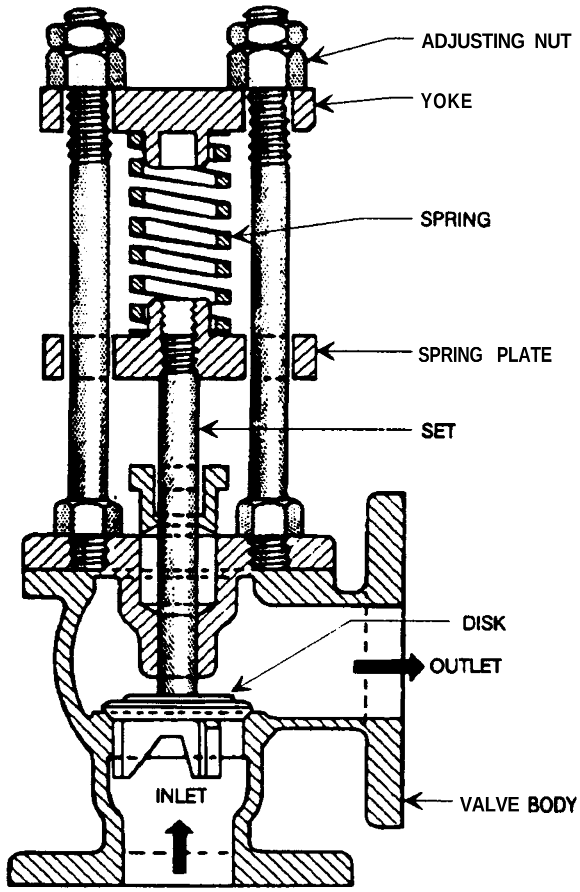
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	EXPANSION JOINT		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-2



SPRING-LOADED REDUCING VALVE, SHOWING FLUID FLOW

SOURCE: MACHINIST'S MATE 3&2. BUREAU OF NAVAL TRAINING COURSE. NAVPERS 10524-B

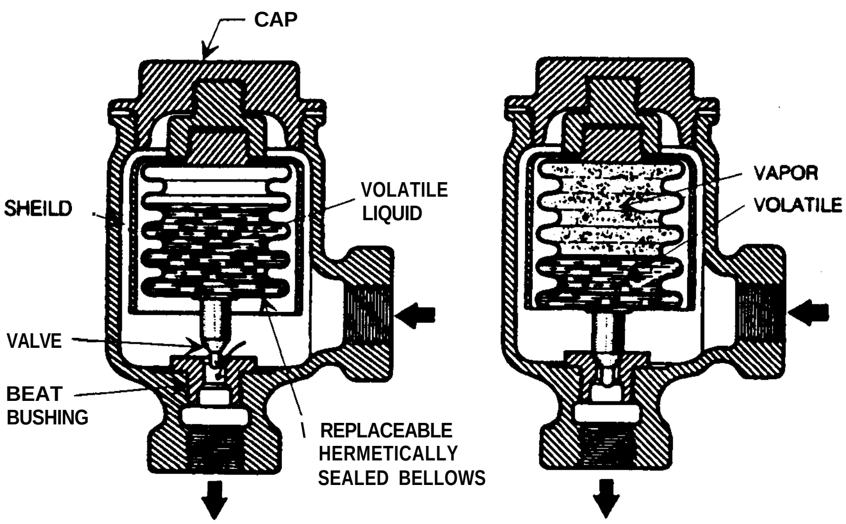
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL REDUCING VALVE		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-3



RELIEF VALVE

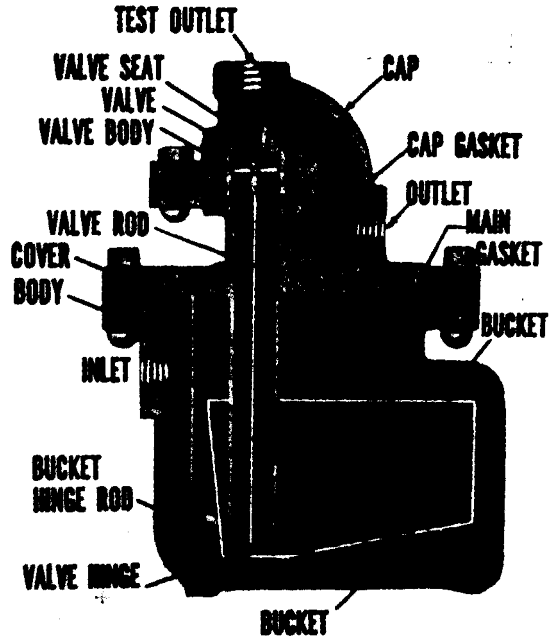
SOURCE: MACHINIST'S MATE 3&2, BUREAU OF NAVAL TRAINING COURSE, NAVPERS 10524-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SIMPLE RELIEF VALVE		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-4

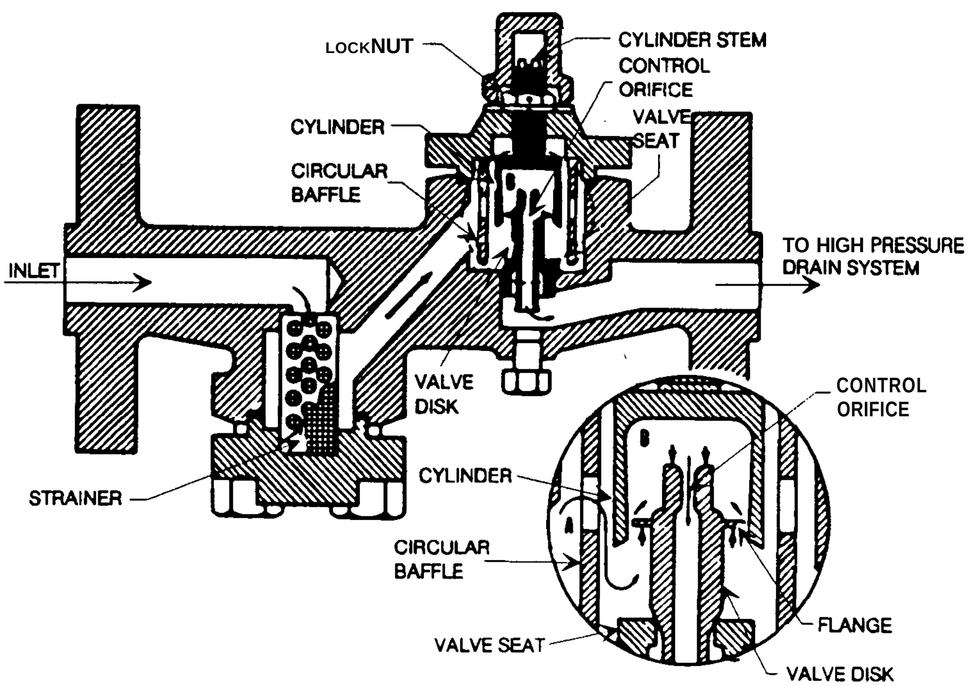


(A) TRAP COLD; VALVE OPEN **(B) TRAP HOT: VALVE CLOSED**

THERMOSTATIC STEAM TRAP



BUCKET TYPE STEAM TRAP



IMPULSE STEAM TRAP

SOURCE: MACHINIST'S MATE 3&2. BUREAU OF NAVAL TRAINING COURSE. NAVPERS 10524-B

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	STEAM TRAPS		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM **(CSI 15480)**	**Revision No.**	Issue Date 5/93	**Drawing No.** A080305-5

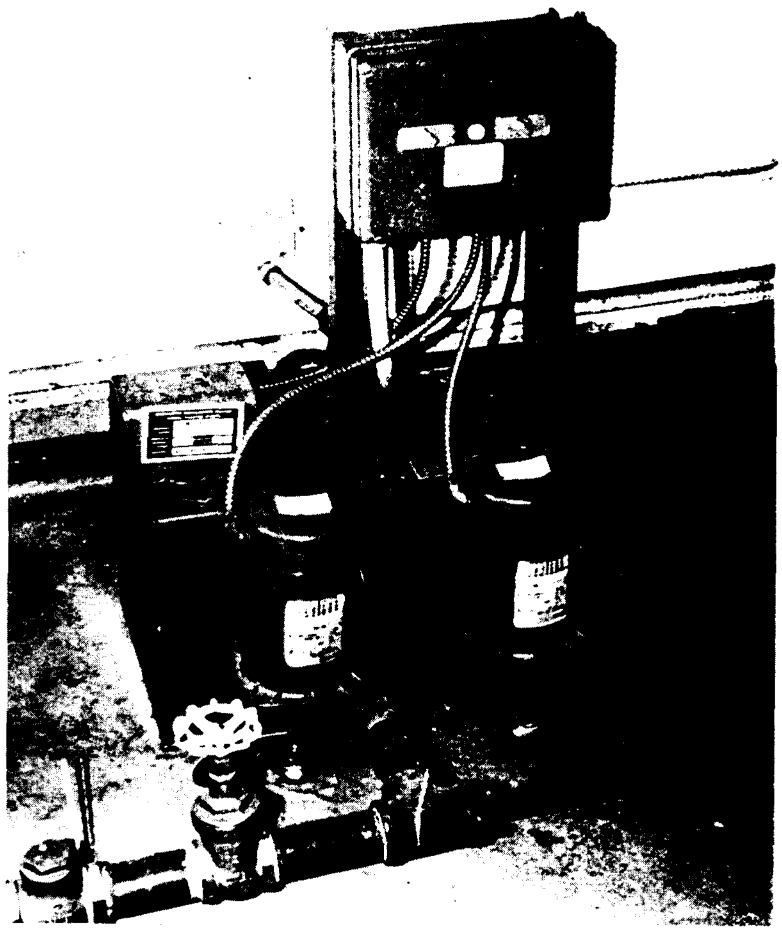
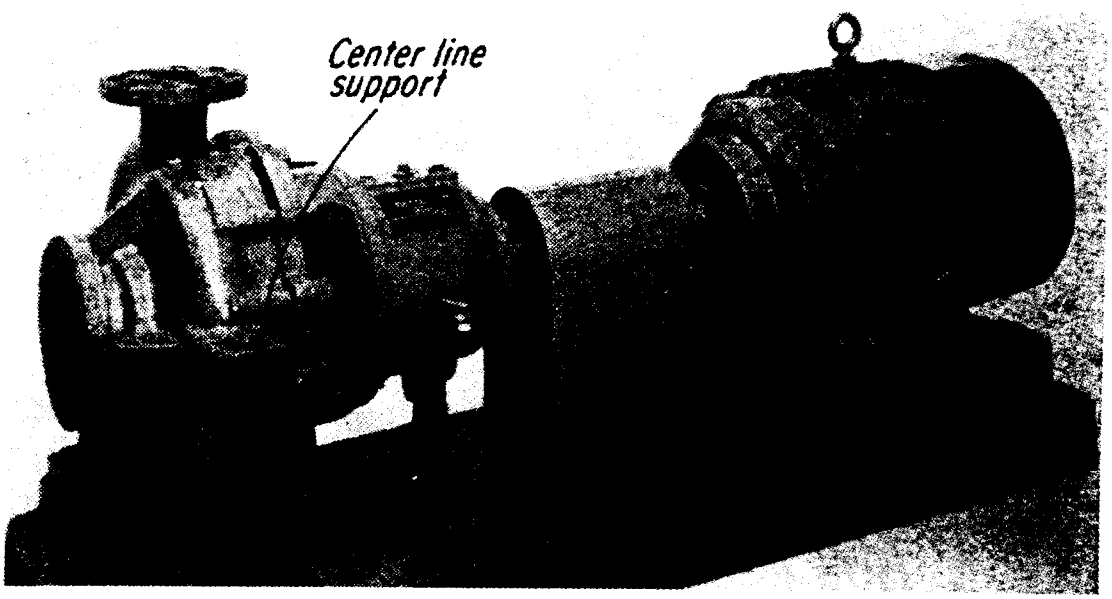


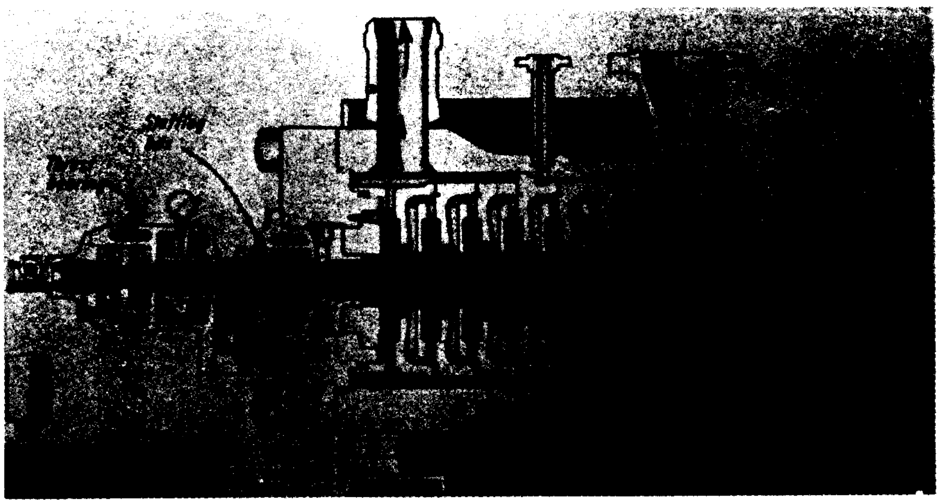
PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CONDENSATE RETURN UNIT		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-6



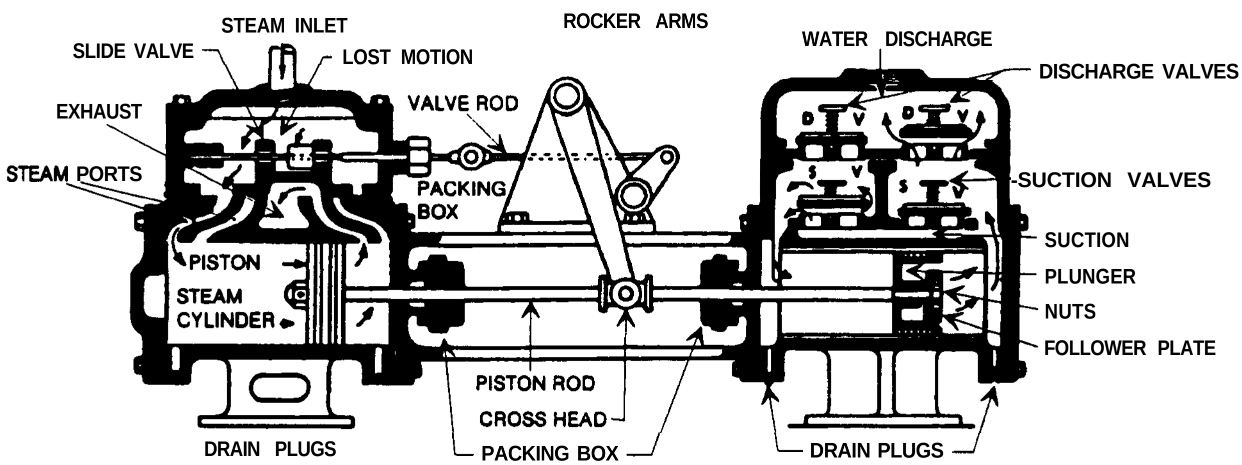
SOURCE POWER, AIR AND LIQUID HANDLING SYSTEMS

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HIGH TEMPERATURE PUMP		
HEATING AND VENTILATION-STEAK DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	**Revision No.**	**Issue Date** 5/93	**Drawing No.** A080305-7



SOURCE: POWER, AIR AND LIQUID HANDLING SYSTEMS

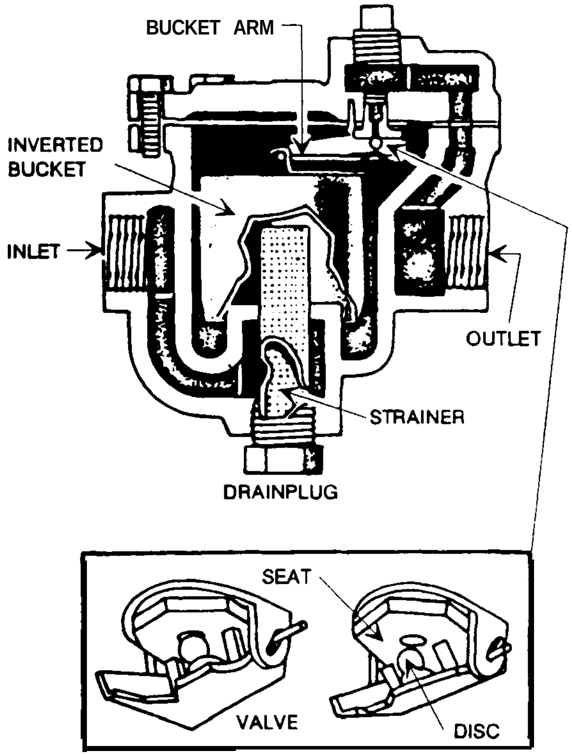
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	MULTISTAGE CENTRIFUGAL FEED PUMP		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date	Drawing No.
		5/93	A080305-8



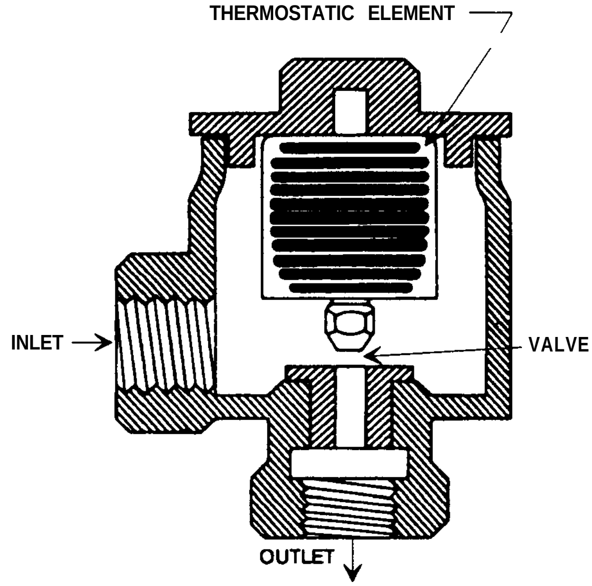
CUTAWAY VIEW OF A DUPLEX STEAM RECIPROCATING PUMP

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

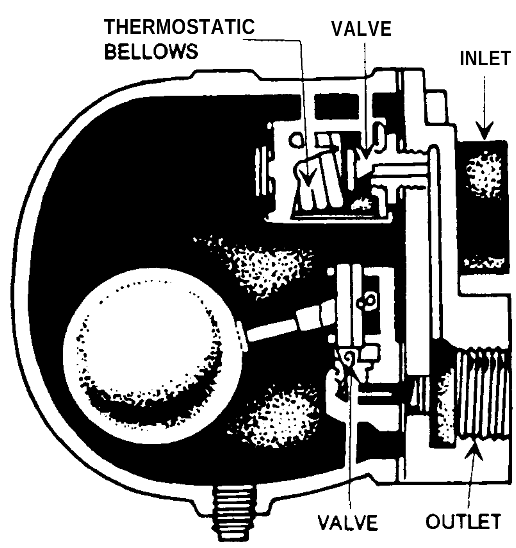
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DUPLEX STEAM PUMP		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawhg No. A0803059



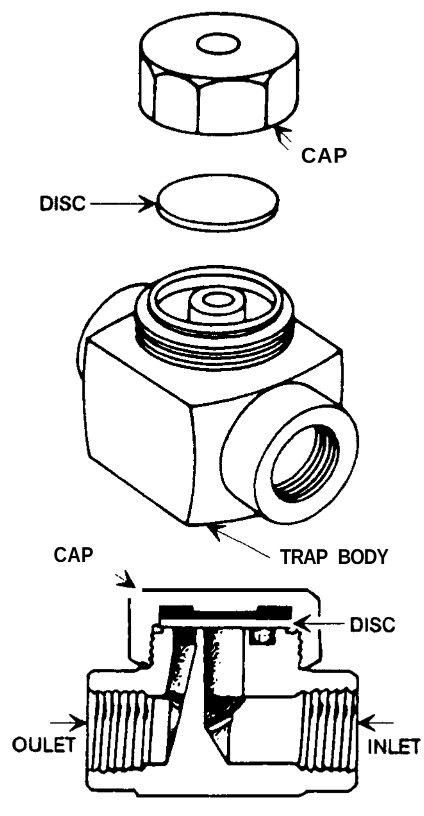
AN INVERTED BUCKET TRAP



A TYPICAL THERMOSTATIC TRAP



AN EXAMPLE OF A FLOAT THERMOSTATIC TRAP



A TYPICAL THERMODYNAMIC TRAP

SOURCE: NAVFAC TECHNICAL TRAINING CENTER, NTTC COURCE 230, INTERMEDIATE HEATING AND MAINTENANCE

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL STEAM TRAPS		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-10

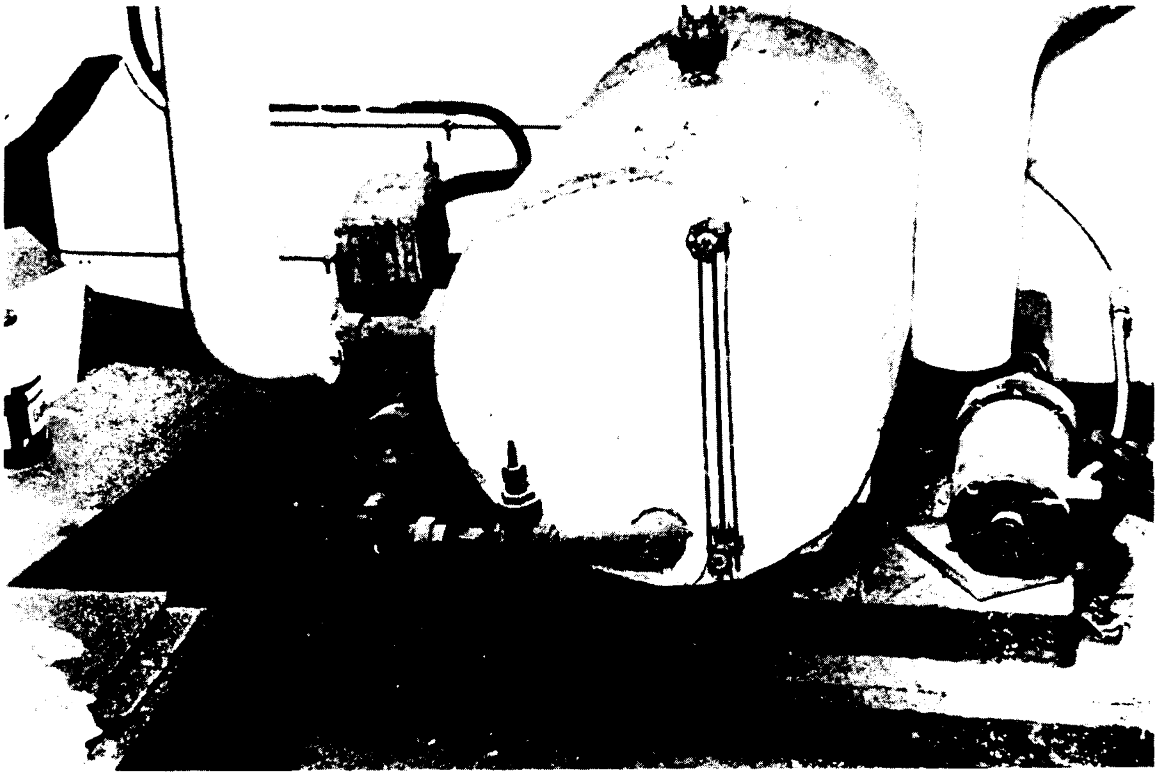


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CONDENSATE RETURN TANK WITH FLOAT ACTUATED PUMPS		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-11

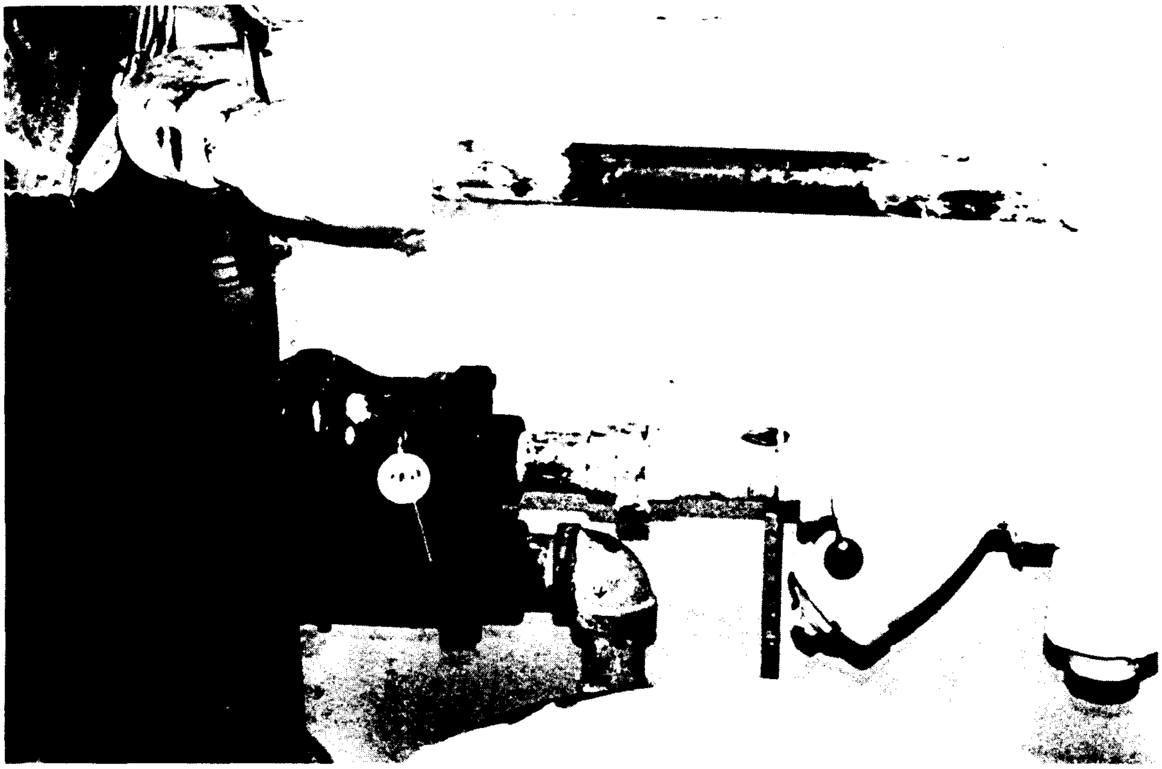


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TRAP WITH IN LINE STRAINER		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-12

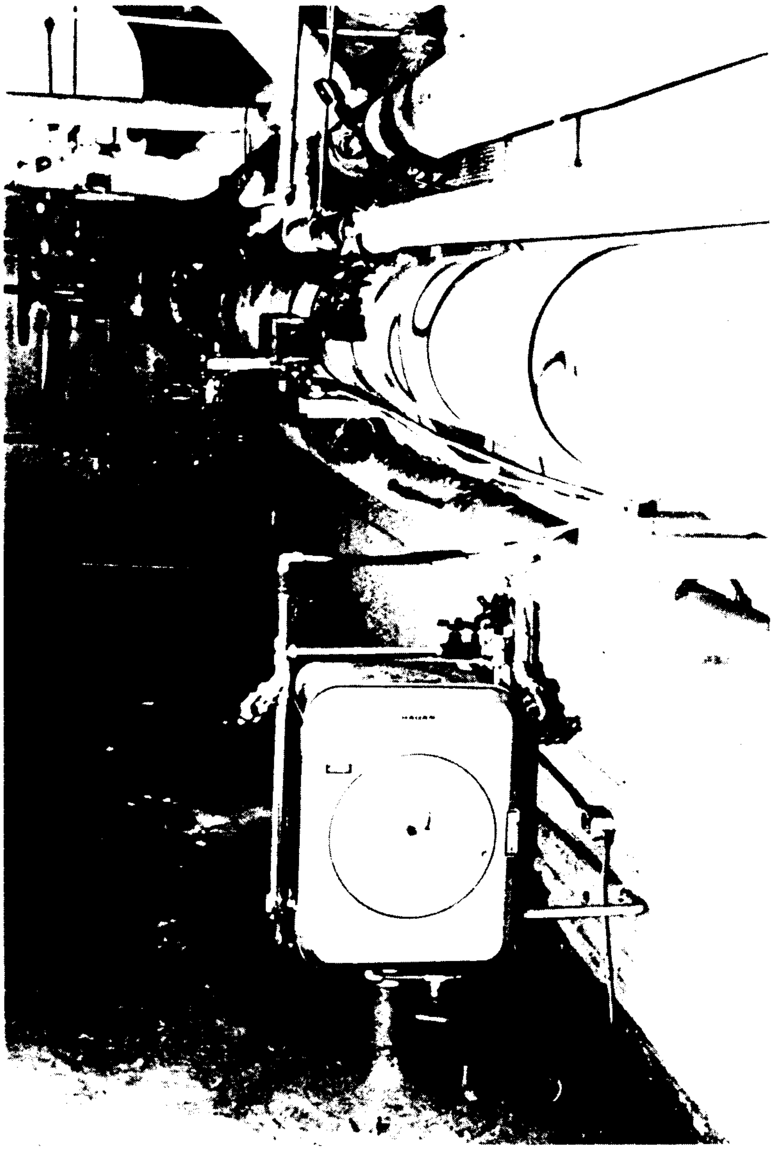


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	STEAM FLOW CHART RECORDER		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A080305-13

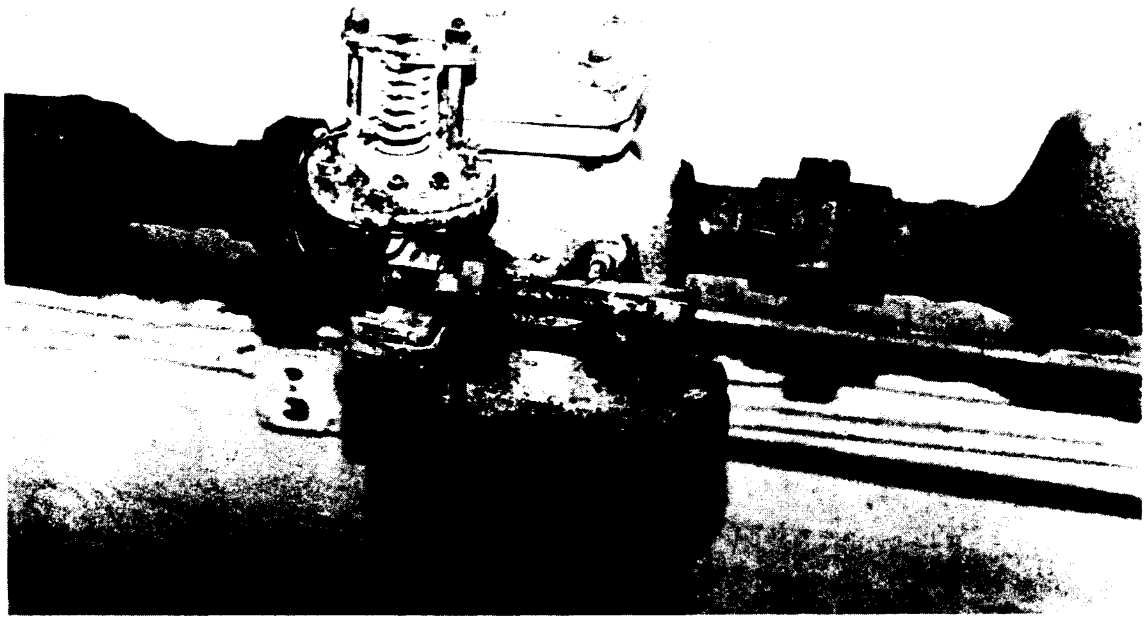


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	REGULATING CHECK VALVE		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A08030514

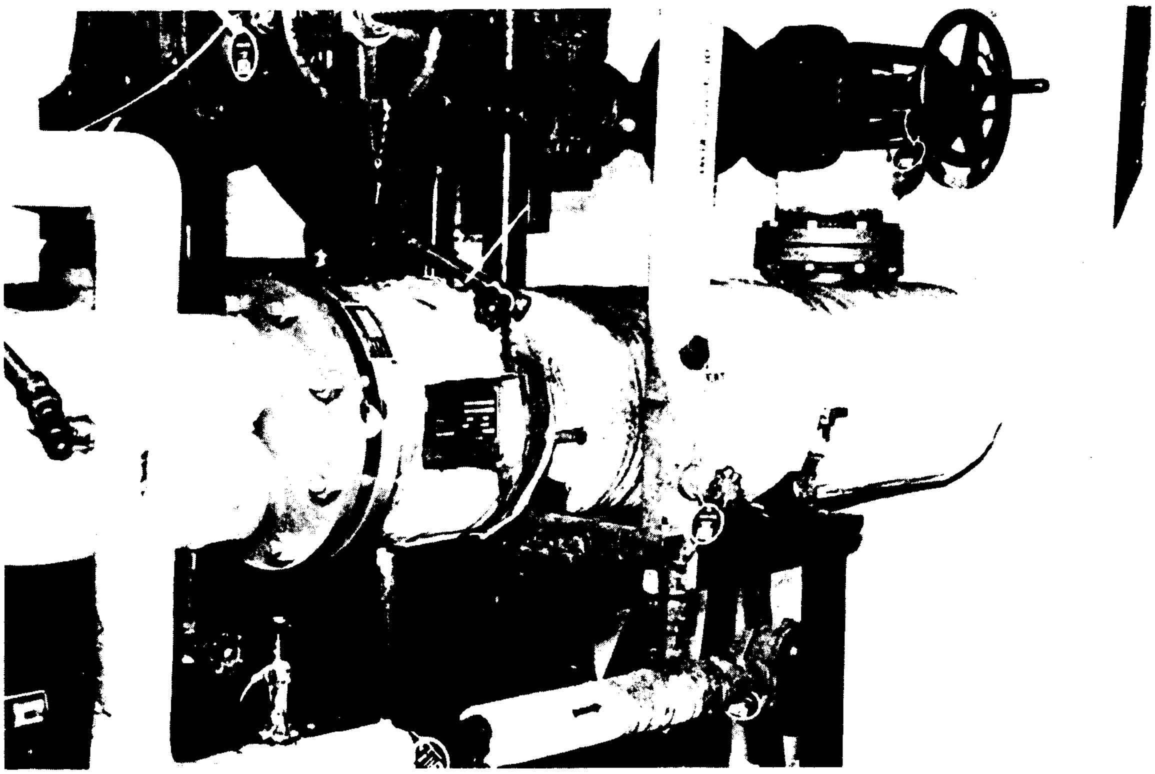


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CONVERTER		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. A08030515

DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

PROBABLE FAILURE POINTS

- **Piping leaks due to corrosion, especially** in condensate circuit.
- Traps failing open and pressurizing condensate return.
- Traps failing closed and backing up condensate.
- Inadequate pressure at terminal points due to regulator failures.
- Excessive makeup requirements due to system leakage.

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings	
Physical Damage:	Bent, broken, crimped, crushed.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Environment, contamination.
Strainers Inoperative:	Inaccessible due to corrosion, physical damage.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.
Steam Traps	
Internal Leakage/Blockage:	Failure of internal elements, wear, scale on seats.
External Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Environment, poor maintenance.
Condensate Return Tanks	
Inoperative:	Level control failure, defective pump.
Tank, Pipe, or Fitting Leakage:	Age, corrosion, physical damage.
Severe Corrosion:	Aging, lack of maintenance.
Access Plate Seal Leakage:	Defective gasket, deteriorate of base metal.
Deaerators	
Inoperative:	Level control failure, defective pump.
Shell, Pipe, or Fitting Leakage:	Age, corrosion, physical damage.
Severe Corrosion:	Aging, lack of maintenance.
Access Plate Seal Leakage:	Defective gasket.
Spray Nozzle Defects:	Physical damage, corrosion, erosion.
Baffle, Cone Defects:	Physical damage, corrosion, erosion, missing fasteners.
Vent Condenser Defects:	Leakage, corrosion.

DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Won't Turn:	Failed bearings, locked impeller, bound linkage, failed solenoids.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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.
Excessive Corrosion:	Poor maintenance.
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, improper use.
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.

Instrumentation

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

DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM (CSI 15520)

SYSTEM ASSEMBLIES/DEFICIENCIES

Instrumentation (Continued)

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:	System leakage or external causes.
Damaged:	Physical abuse.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM
(CSI 15520)

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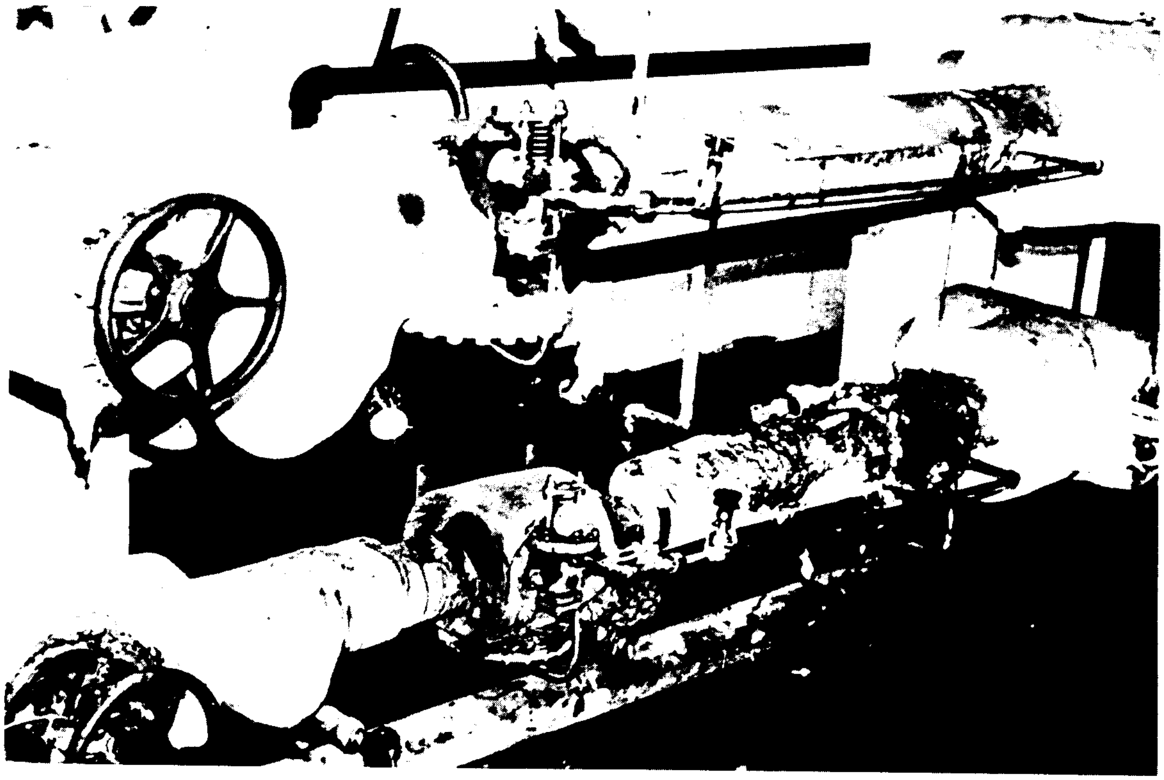

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	INSULATION DAMAGE AND STEAM LEAKAGE		
HEATING AND VENTILATION-STEAN DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15520)	Revision No.	Issue Date 5/93	Drawing No. D080305-1

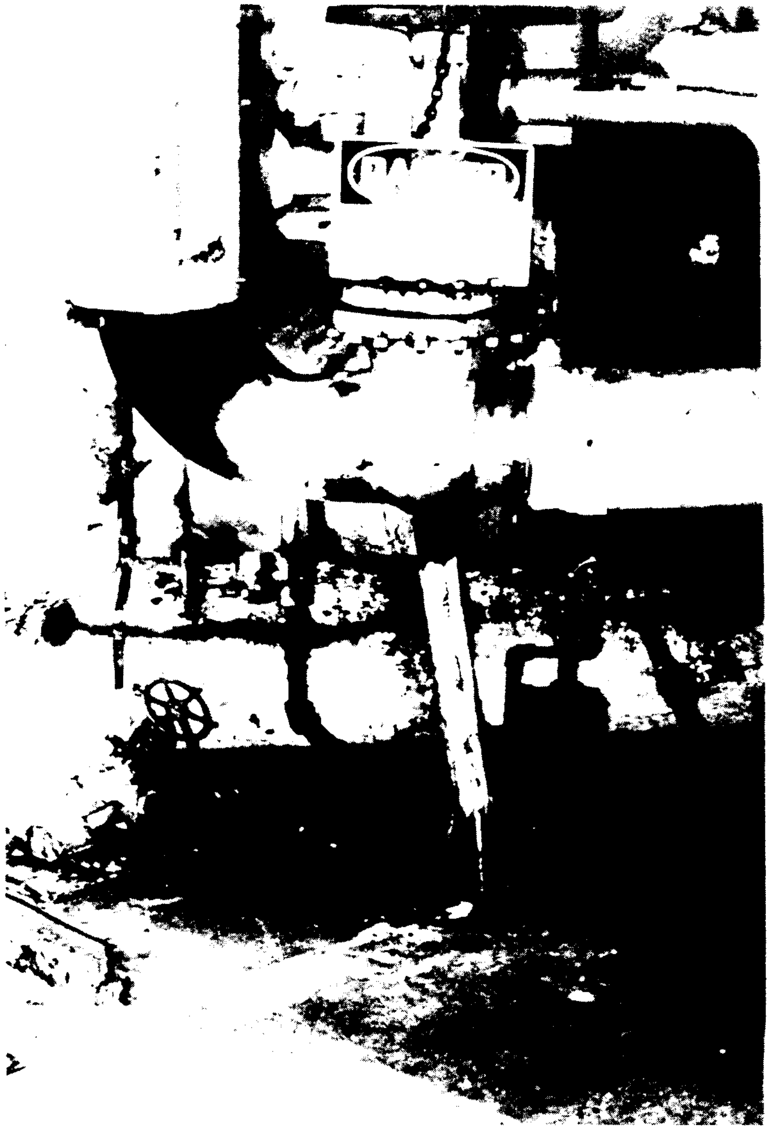

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	MISSING INSULATION AND CORROSION		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15520)	Revision No.	Issue Date 5/93	Drawing No. DO803052

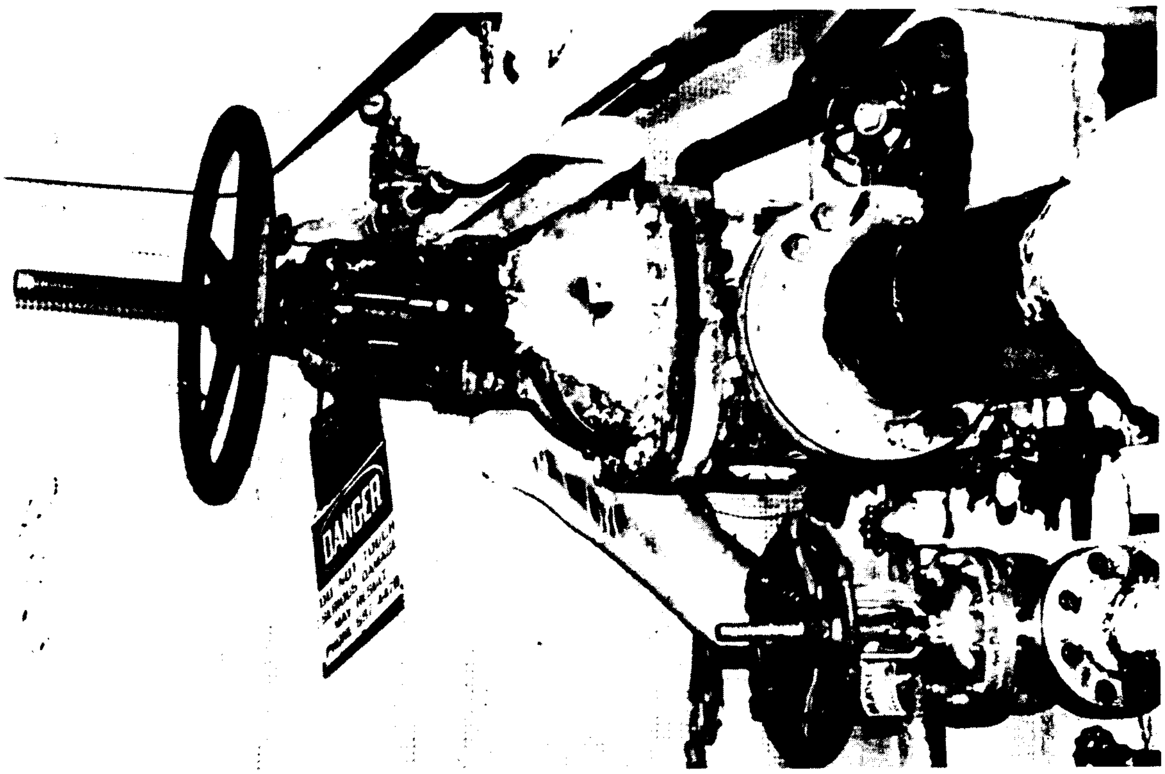

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	ISOLATION VALVE WITH CORROSION AND PACKING GLAND LEAKAGE		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM (CSI 15480)	Revision No.	Issue Date 5/93	Drawing No. D080305-3

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	ISOLATION VALVE WITH CORROSION, **MISSING** INSULATION, BROKEN HANDLE, BENT STEM		
HEATING AND VENTILATION-STEAM DISTRIBUTION AND CONDENSATE RETURN SYSTEM **(CSI 15480)**	Revision No.	Issue Date 5/93	Drawing No. D080305-4

DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM
(CSI 155201

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DEFICIENCY FACTORS
0.08.03.05 STEAM DISTRIBUTION & CONDENSATE RETURN SYSTEM
(CSI 15520)

END OF SUBSECTION

0.08.03.06 CHEMICAL WATER TREATMENT (CSI 15545)

DESCRIPTION

The typical Chemical Water Treatment provides mixing, metering, and distribution of required treatment materials to facility heating systems such as boiler water and heating hot water. Their purpose is to inhibit the development of scale, corrosion, and biological growth. The typical system consists of mixing tank, agitator, metering pump, and the connecting piping, fittings, valves, and instrumentation.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Mixing Tanks (CSI 15450)

The typical mixing tank for boiler water treatment is a simple plastic drum with an agitator mounted on the side. Chemicals and mixing water are added manually by the operator. Separate tanks are provided for each boiler and, in some cases, separate drums are used for each chemical to allow independent metering. The agitators have typically slow-speed motors with blading mounted on shaft extensions.

Although the same approach can be used for other water treatment systems, the common approach is to feed chemicals directly into in-line reservoirs known as “shot feeders.” Part of the normal circulating water is fed through the reservoir to introduce the chemicals to the system. Shot feeders capacity are typically 5 gallon cast iron or steel, and provide a funnel with a shut-off valve and air release valve on the top, a drain valve on the bottom, and recirculating shut-off valves on the side.

Metering Pumps (CSI 15160)

Pumps meter the chemical mixture into the treated system. They are generally positive displacement types, usually employing a piston pump (though diaphragm pumps are also common). Metering is accomplished by varying pump speed and/or stroke. Due to the corrosive effects of some chemicals, exposed sections (suction and discharge valves, piston, rings, etc.) are frequently made of stainless steel to extend pump life.

Motors (CSI 15170)

Motors are usually used to drive the chemical addition pump. Although some are belt-driven, most are direct drive or gearhead motors.

Piping & Fittings (CSI 15060)

Piping and fittings provide the distribution network for the chemical treatment system. Generally the systems are small, with treatment tanks located close to the treated system.

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.

Valves (CSI 15100)

Valves are primarily used to isolate mixing tanks, reservoirs, and other components for maintenance.

Check valves are used on the discharge side of pumps if not already incorporated in pump design.

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

0.08.03.06 CHEMICAL WATER TREATMENT (CSI 15545)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Instrumentation (CSI **15135, 15150)**

Few gauges are used in the chemical treatment systems. Pressure gauges are sometimes provided at the discharge of metering pumps or pump groups.

However, several meters are frequently found. Flow meters are common to validate feed quantities. Also, conductivity and pH meters are commonly used to determine the need for adjustments in the treatment process.

Equipment Controls & Panels (CSI 15980)

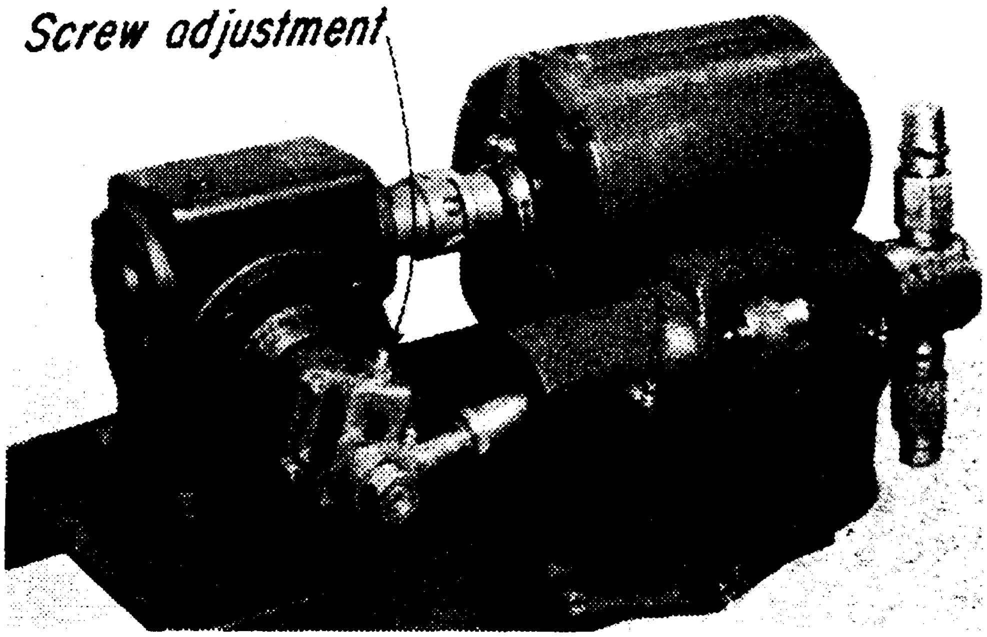
Few controls are used in the typical chemical treatment system. The agitator on the mixing tank is usually small enough to allow control by a light switch.

In some newer systems, sensors (pH, conductivity, TDS) are employed in the treated systems and are interlocked with the feeders to automatically adjust chemical addition. These devices may also be used to control the blowdown of boilers and bleed-off rates for cooling towers.

OTHER RELATED COMPONENTS

See the following subsections for related components:

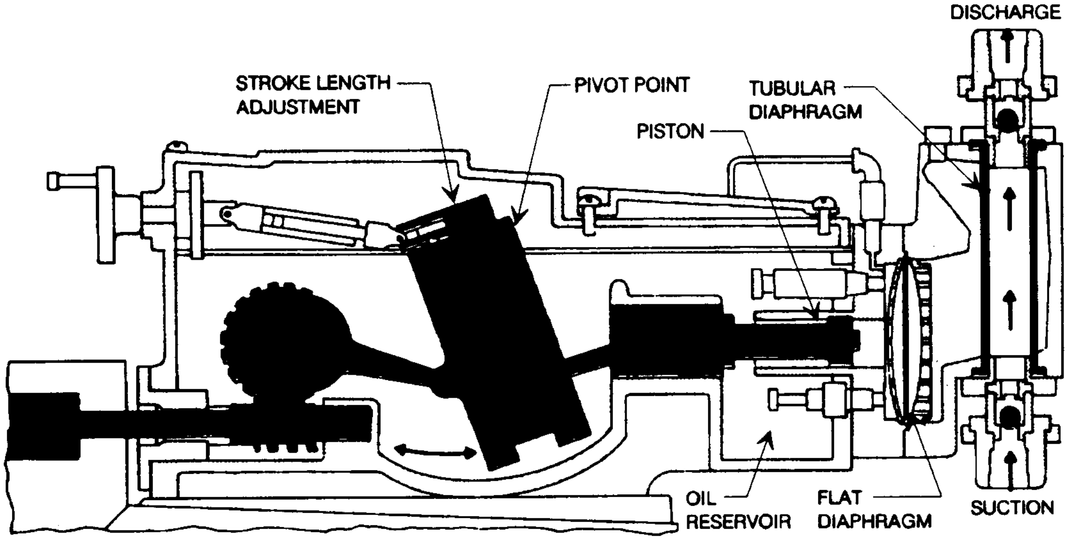
NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.



CLEAR LIQUIDS, SOME SLURRIES. AND HIGHLY VISCOUS LIQUIDS ARE METERED
BY VARIETY OF INTERCHANGEABLE HEADS, PLUNGERS

SOURCE: POWER, AIR AND LIQUID HANDLING SYSTEMS

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PISTON TYPE METERING PUMP		
HEATING AND VENTILATION CHEMICAL WATER TREATMENT (CSI15545)	Revision No.	Issue Date 5/93	Drawing No. A080306-1



INWARD SQUEEZE OF A TUBULAR DIAPHRAGM IN THIS TWO-DIAPHRAGM METERING PUMP DISCHARGES THE METERED FLUID INTO OUTLET LINE. A FLAT DIAPHRAGM, MOVING IN RESPANCE TO PISTON, ACTUATES TUBULAR DIAPHRAGM VIA THE INTERMEDIATE FLUID. EXTERNAL HANDWHEEL VARIES STROKE WHILE PUMP IS RUNNING. AS IN ALL DIAPHRAGM PUMPS, AIR CUTS ACCURACY, MUST BE BLED FROM PRESSURIZED HYDRAULIC OIL.

SOURCE: POWER, AIR AND LIQUID HANDLING SYSTEMS

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CROSS SECTION METERING PUMP		
HEATING AND VENTILATION CHEMICAL WATER TREATMENT (CSI 15545)	Revision No.	Issue Date	Drawing No.
		5/93	A080306-2

DEFICIENCY FACTORS
0.08.03.06 HEATING SYSTEMS WATER TREATMENT **(CSI 15545)**

PROBABLE FAILURE POINTS

- Piping leaks due to corrosion, especially in water circuit where chemical reaction content is great.
- Inability of system to deliver rated capacity to terminal points due to failure of the feeder mechanism.

SYSTEM ASSEMBLIES/DEFICIENCIES

Mixing Tanks

Tank, Pipe, or Fitting Leakage:	Age, physical damage, severe internal or external corrosion; gasket failure at manhole or other fittings.
Excessive Corrosion:	Environment, normal use.
Agitator Inoperative:	Normal wear.

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Run:	Failed bearings, locked piston.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Inadequate Capacity:	Low pressure, low flow caused by wear, defective diaphragm.

Motors

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

DEFICIENCY FACTORS
0.08.03.06 HEATING SYSTEMS WATER TREATMENT (CSI 15545)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Product 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.

Instrumentation

Missing:	Taken out for service or repair and 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.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

END OF SUBSECTION

0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

DESCRIPTION

Terminal Heating Units provide for heat transfer from the heating media (steam, hot water, hot air, electricity or fuel) to the air in the heated spaces. They are called terminal units because they are physically placed at the end (terminus) of the distribution system at the point where heat is actually required. Terminal Units include radiators, baseboard heaters, reheat coils, induction units, cabinet heaters, convectors, and space heaters. The Terminal Heat Transfer Unit System consists of the units themselves, associated controls, steam traps, insulation, filters, and the connecting fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Terminal Heating Units (CSI 15830)

Radiators:

Older steam heating systems terminate at simple radiators, usually cast iron devices with either a one- or two-pipe distribution system. In the one-pipe system, condensate return is by gravity through the same pipe as the steam supply. The radiators are physically located by windows to facilitate natural convection air flow. Because of their reliance on this method of heat transfer, the units were usually designed for full exposure (i.e., not enclosed in cabinets). However, due to their poor aesthetic appeal, most remaining units have been enclosed, greatly reducing their thermal efficiency.

Baseboard Heaters & Electric:

Older hot water systems were terminated in baseboard heaters, usually copper piping with aluminum fins to promote heat transfer. Although the frame usually hides the heater itself, openings are provided to facilitate natural convection upward across the heating surface. Another approach employed electric heating elements in baseboard heaters. Their appearance is similar to hot water units.

Reheat Coils, Induction Units:

Forced air heating systems frequently provide small finned coils within the distribution system to allow local temperature control. These units may be designed for either steam or hot water. When the forced air flow is directly across or through the coil and the coil is physically located in the ductwork, it is referred to as a reheat coil. When the forced air flow is not directly across or through the coil, but rather it bypasses the coil inducing a secondary air flow and heat exchange, the unit is called an induction unit. These are usually placed under windows and at the terminus of the duct.

Cabinet Heaters, Unit Heaters, Unit Ventilators, Fan Coil Units:

To promote better heat transfer efficiencies, most terminal devices now employ an individual unit fan to force air across the heat transfer surface. When used solely for heating, they are referred to as cabinet heaters, unit heaters, unit ventilators, convectors, etc. When used in conjunction with or interchangeable with cooling coils, they are called fan coil units. The heat source in these units may be steam, hot water, or electric heating elements.

Space Heaters:

Most of the above units are floor or wall mounted. However, in larger areas such as equipment spaces, warehouses, garages, etc., the units may be ceiling hung. Although almost identical to previously mentioned units, those hung from ceilings are usually referred to as space heaters. In addition to the heat sources already named, many small space heaters use gas or even oil as a heat source. These are usually small units with burners similar to those found in residential heaters.

0.08.03.07 TERMINAL HEATING UNITS (CSI 158301

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Motors (CSI 15170)

Motors are usually used to drive the burner and fans. In most cases these are direct-drive units with the fans mounted directly on the motor shaft. Some older space heaters or cabinet heaters employ belt drives.

Equipment Controls & Panels (CSI 15950)

Radiators and fluid baseboard heating units generally have no controls other than valve throttling. Electric baseboard heating generally employs a small, local thermostat to cycle elements.

Most other Terminal Heat Transfer Units use regulating valves (electric or pneumatic) to vary the heating media fluid flow through the unit. Exposed units (cabinet heaters, fan coils, etc.) usually have a self-contained thermal bulb in the air stream to operate the regulating valves. Hidden units, such as reheat coils, will typically use a local space thermostat to control the valve.

Units with a self-contained fan usually employ a manual fan control switch (ON-OFF or speed selection). Some newer systems use bank controllers for cycling banks or groups of terminal units to be switched on and off for energy conservation.

piping & Fittings (CSI 15090)

Most piping and fitting requirements are covered within their respective distribution systems (steam and condensate, heating hot water, gas, drain, waste and vent, etc.). However, because the terminal units are high maintenance items compared to the distribution piping, they are more likely locations for failure. Therefore, the inspector should be particularly alert for problems in this area.

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 installed (screwed, soldered, or flanged) effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valves (CSI 15100)

Manual valves are primarily used to isolate units and other components for maintenance.

Regulating valves are also used to control the flow of water and steam through the terminal units. These valves may be two- or three-way bypass units modulated by local thermal bulbs or remote thermostats. They may be mechanical, electrical and/or pneumatic.

Manual and/or automatic vent valves are common on terminal units. They are used to purge the units after shutdown for maintenance or seasonal outages.

insulation (CSI 15250)

A minimal amount of insulation is used for thermal efficiency in terminal units, primarily on steam piping. However, almost every unit will employ insulation batting for noise reduction.

Ductwork (CSI 15890)

Like piping, most ductwork items are covered under their respective distribution system. However, because the terminal units are high maintenance items (compared to the duct), duct joint failures are more likely at the terminal units themselves. Therefore, the inspector should be particularly alert for problems in this area.

0.08.03.07 TERMINAL HEATING UNITS (CSI 158301

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Ductwork (CSI 15890) (Continued)

All induction units and some fan coil units receive air from the buildings' central air handling system. At each terminal unit there are one or more reductions in duct and/or joint size. These items are frequently disconnected for maintenance. At the point of entry, baffles are frequently installed for noise reduction. These "hidden" devices are common sources of reduced terminal unit performance.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

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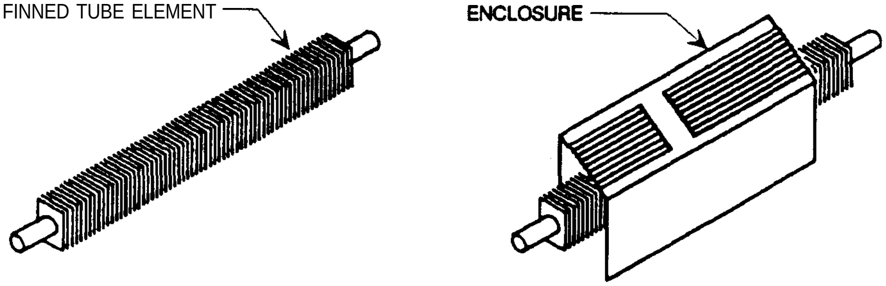
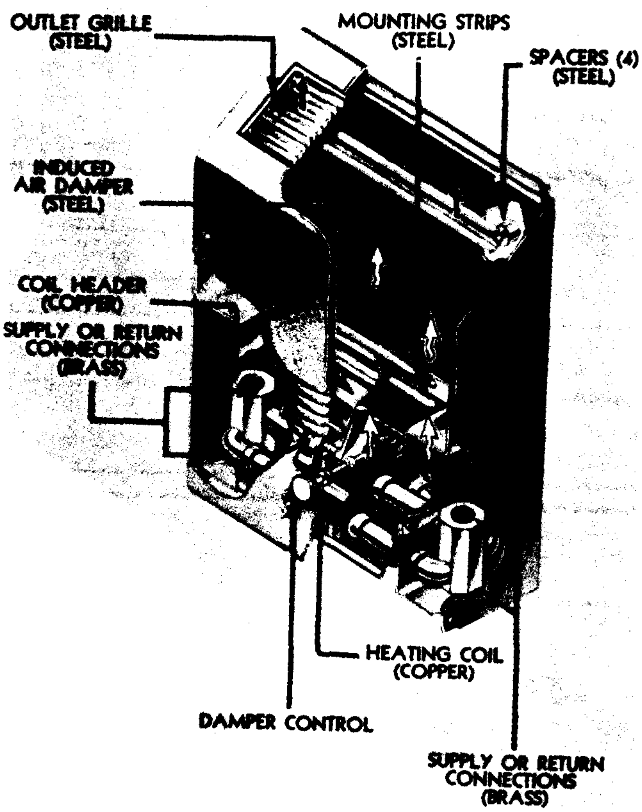
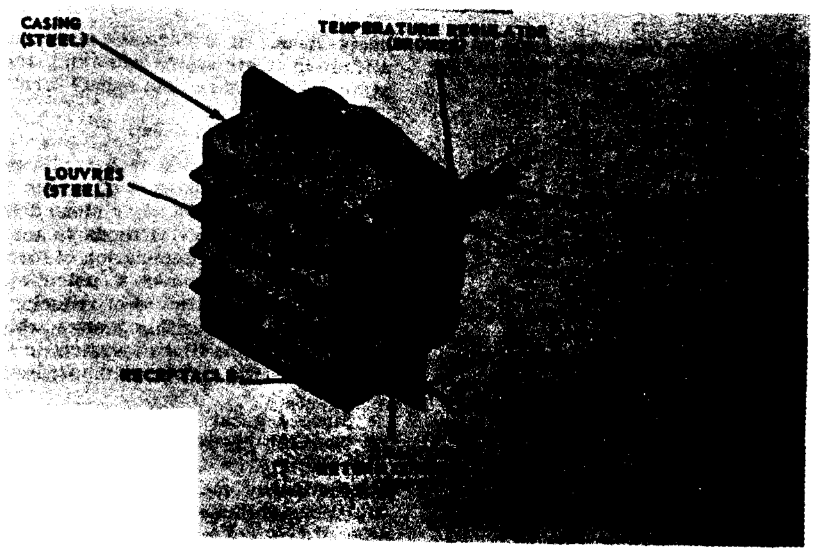


PERIMETER RADIATION





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SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE, "R.S. Means Co., Inc., Kingston, Massachusetts"

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TERMINAL UNITS		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080307-1

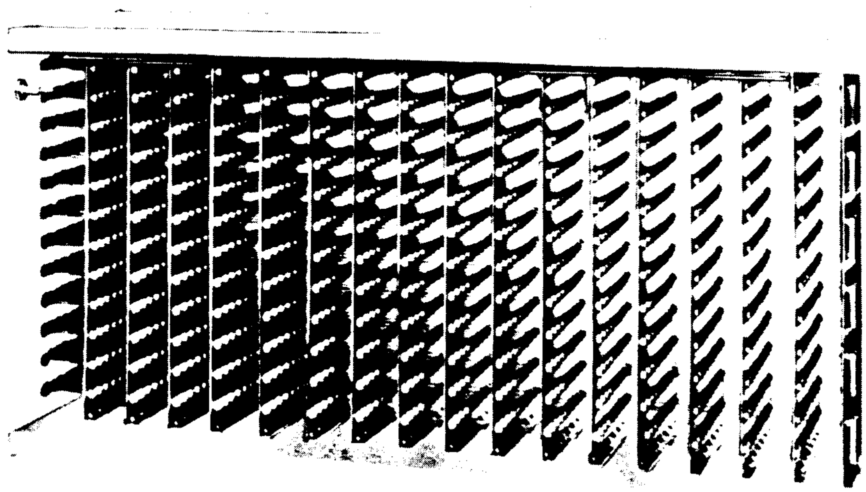

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ELECTRICAL RESISTANCE HEATER		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080307-2

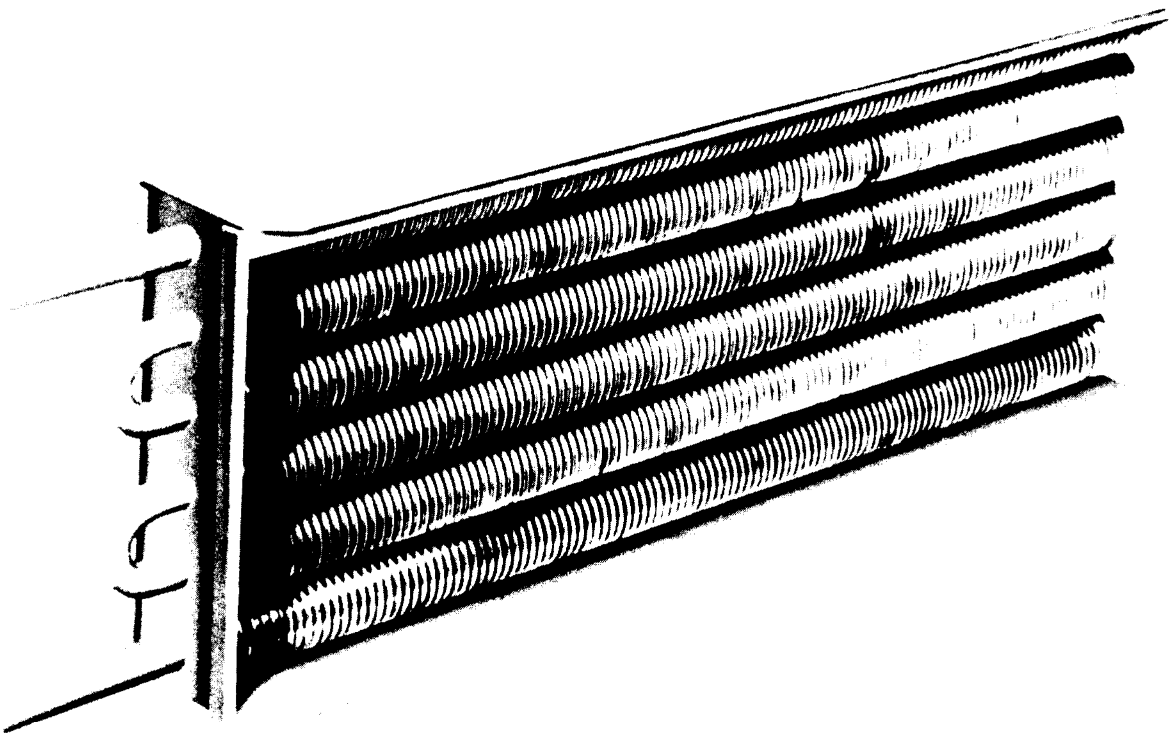

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HOT WATER HEATING COIL		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080307-3

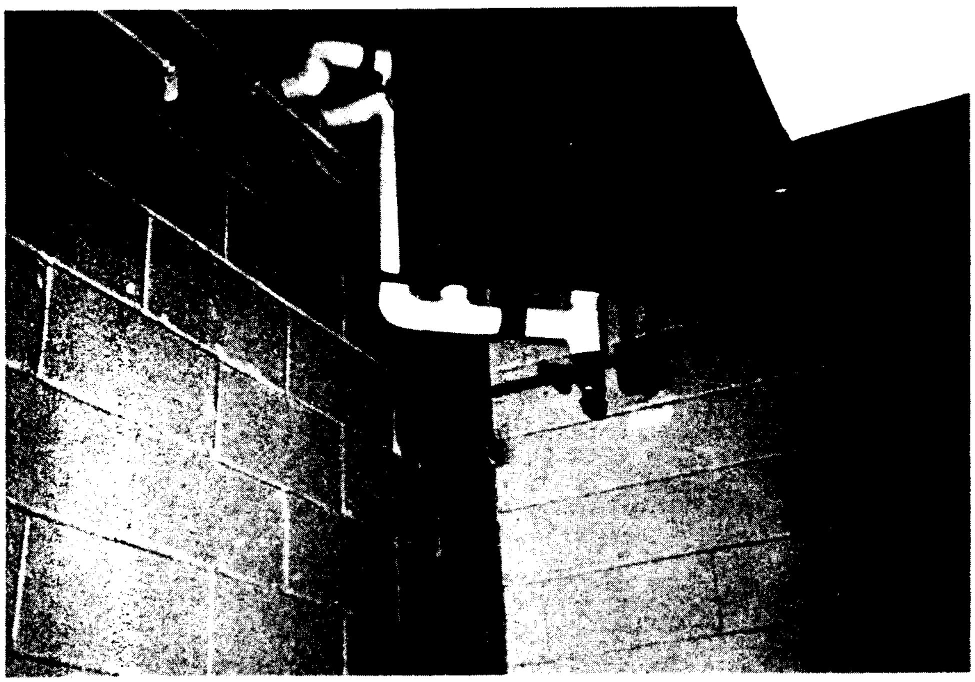

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SPACE HEATER, HOT WATER COIL WITH FAN		
HEATING AND VENTILATION TERMINAL HEATING UNITS **(CSI 15830)**	Revision No.	Issue Date 5/93	Drawing No. A080307-4

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SPACE HEATER, ELECTRIC		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 3/93	Drawing No. A080307-5

DEFICIENCY FACTORS
0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

PROBABLE FAILURE POINTS

- Reduction in heat transfer capability due to piping and/or HX coil blockage.
- Piping leaks or heat exchanger due to corrosion, especially in condensate circuit.
- Loss of air flow due to fan failure.
- Poor temperature control due to physical damage, poor maintenance.

SYSTEM ASSEMBLIES/DEFICIENCIES

Terminal Units

Inoperative:	Control failure, defective fan, frozen valves, defective wiring.
HX Coil Leakage:	Age, corrosion, physical damage.
Severe Corrosion:	Aging, lack of maintenance.
Missing Fan:	Taken out for maintenance and not returned.
Severe Physical Damage to Cabinet:	Abuse.

Motors

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

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

Piping 8 Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Age, poor maintenance, leakage.
Physical Damage:	Abuse, stress, poor maintenance.

Valves

Leakage:	Improper packing, corrosion.
Inoperative:	Corrosion, damaged operating mechanism.
Excessive Corrosion:	Age, poor maintenance, leakage.

DEFICIENCY FACTORS
0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Physical Damage:	Abuse, stress, poor maintenance.
Poor Regulation:	Worn off seat/disc, defective sensing mechanism, blocked lines.

Insulation

Missing:	Poor maintenance.
Wet:	Improper drainage, leaks in coils.
Damaged:	Poor maintenance, corroded fasteners.

Ductwork

Excessive Noise:	Improper air flow, loose or missing fasteners.
Physical Damage:	Bent, broke, crimped, crushed.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Condensation, inadequate insulation.
Dampers Inoperative:	Corrosion, physical damage.
Damaged Expansion Joints:	Poor maintenance, abuse, overpressurization.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	FAN COIL UNIT, CORRODED BASE, BROKEN FRONT COVER		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. D080307-1

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	FAN COIL UNIT, CLOGGED FILTER, CORRODED PAN, CLOGGED COILS		
HEATING AND VENTILATION TERMINAL HEATING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. D080307-2

DEFICIENCY FACTORS
0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

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DEFICIENCY FACTORS
0.08.03.07 TERMINAL HEATING UNITS (CSI 15830)

END OF SUBSECTION

0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

DESCRIPTION

Air Handlers and Fans ventilate spaces and simultaneously use the air to transfer heat from the heating source (steam, hot water, hot air, electricity, or fuel) to the heated spaces. This component group is different from Terminal Units in that the components serve large single areas or multiple spaces and generally employ ductwork to connect these areas. This equipment group includes large Heating and Ventilating Units, Air Handler Units, Supply Fans, Return Fans, and Exhaust Fans. Air Handlers and Fans consist of the units themselves, associated controls, air cleaners, ductwork, and the related piping, fittings, valves, insulation, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Air Handlers & Fans (CSI 15850)

Heatina & Ventilating Units:

Older, large heating systems frequently employ one or more centrally located fan housings with "heating only" coils to condition associated spaces. These units are typically pedestal-mounted (some are ceiling-hung), connected to outside air with a pneumatically operated damper, using a single centrifugal fan to transport the air to the conditioned space. Supply is normally 100% outside air (no recirculation). Heat is provided via a single finned tube, steam/air or hot water/air heat exchanger. Air filtration is usually provided with sheet media or prefabricated, throw-away filters.

Another common arrangement employs a gas fired heater. These are usually roof-mounted units.

Heating and Ventilating Unit air distribution is accomplished using sheet metal ductwork with manually adjustable zone dampers. Some variations include pneumatically/electrically operated zone dampers, multiple heating coils, and coil face bypass dampers for temperature control.

Air Handler Units:

Generically applied, "air handler" can be used with any fan coil device. However, it is usually reserved for large volume units that have both heating and cooling capability.

More modern heating systems frequently employ one or more centrally located fan housings with multi-function capabilities. These units are typically pedestal-mounted (rarely ceiling-hung). They are usually connected to both outside air and recirculated air, use a main centrifugal fan to transport the air to the conditioned space, and sometimes employ a return air fan in the same assembly. Air supply is usually constant volume, with the source mixture (outside and return) controlled by pneumatic dampers. Heat is provided via a multiple finned tube, steam/air or high-temperature water/air heat exchangers. There is commonly a pre-heat coil for elevating the temperature of outside air intake and a main heat coil to control mixed air temperature. Air filtration is usually provided with sheet media or prefabricated, throw-away filters.

In addition to heating, air handlers usually have additional function capabilities. Cooling is usually provided, either employing an independent cooling coil (finned tube air/fluid heat exchanger with chilled water, glycol or commercial refrigerant), or using one of the heating coils. Cooling also provides dehumidification.

Humidification may be provided with water or steam injection. These include integral spray pans with level controls, spray pumps and distribution nozzles; steam injection nozzles; or add-on units with electrically heated water pans. Any time humidification control is provided via injection, eliminators are included in the air handler housing to remove excess entrainment.

Air distribution is usually multi-zone with pneumatic/electric zone dampers. Significant variations include variable volume supplies using variable vortex dampers on the fans or variable speed motors; automatic filter roll advancement; gas-fired heaters.

0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Air Handlers & Fans (CSI 15850) (Continued)

Supply Fans:

Some facilities require large volumes of untempered fresh air. Examples include boiler houses, generator buildings, and incinerators. This need is fulfilled with large "fresh air" intake fans.

Many units are wall-mounted, guarded propeller fans, employing little or no ductwork, taking source from outside air with gravity dampers. No heat exchange coils or filters are used.

Larger units will be pedestal-mounted with an enclosure and ductwork, and will employ controlled dampers for outside air intake and will have filters. Variations include in-line axial fans.

Exhaust Fans:

All forced ventilation buildings need to exhaust the excess air provided by the Heating and Ventilating, AHU, and supply units. This facilitates circulation and frequently exhausts improper environmental gases (eg., restrooms, garage areas, laboratories).

Most units are roof-installed, pedestal-mounted centrifugal fans with no accessories.

Larger units will be pedestal-mounted with an enclosure and ductwork, but do not employ dampers or filters.

In warehouses, garages, boiler rooms, etc., units are frequently wall mounted, guarded propeller fans with little or no ductwork.

Return Air Fans:

Modern Air Handler Units usually allow for recirculated air intake to reduce the energy consumption requirements for conditioning. Although the return can usually be accomplished via ductwork and dampers alone, additional "return" fans are sometimes employed. When not included within the AHU structure, these units should be treated separately by the inspector.

Almost all of these units will be suspended in duct units employing a constant speed, centrifugal fan. A common arrangement is the over and under profile where the return air unit is mounted directly above the associated air handler. These units do not use heat exchange coils or filters. However, they may include pneumatically operated dampers to direct the air to exhaust ("relief") or recirculate positions. Variations include in-line axial fans.

Motors (CSI 15170)

Most Air Handlers and Fans are belt-driven using an open AC induction motor. A significant variation is the variable frequency motor used in some variable volume systems. Motors are also used to drive automatic roll filters.

Equlpment Controls & Panels (CSI 15950)

Air Handler and Fan controls vary significantly depending on the unit functions provided.

Most units employ a typical motor starter and disconnect for the standard AC motor. Variable frequency drives require special controllers.. These are provided with their own standard in the special equipment section of these manuals.

0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Equipment Controls & Panels (CSI 15950) (Continued)

Temperature control in heat exchangers is usually implemented using a thermal sensing bulb, a capillary tube. or bimetallic element. Although these sometimes directly activate the heat source regulating control (i.e., electric heating element switch or DX refrigerant valve), in most heating controls the sensor interfaces with a pneumatic control system. This allows for variations in proportioning and inversion of signals, effecting better temperature control. The pneumatic control signal is then fed to a two- or three-way regulating valve.

Humidity control is accomplished in a similar manner but employs a different sensor, usually horse hair or other element to physically change with changes in humidity.

Temperature sensors are frequently installed to limit unit operation. Freezestats provide coil protection when outside air intake is apt to cause icing in or on the air handler heat exchangers. They interact with the motor control circuit to shut down the unit at a preset temperature.

A similar approach is sometimes used to sense a high-temperature ("firestats") as an indication of fire potential. Modern units install smoke detectors, either as a substitute or in addition to firestats to indicate fire in the system.

Freezestats are typically installed in the outside air intake just downstream of the preheated coil. Firestats and smoke detectors are usually installed in the return air duct. Humidistats are located downstream of the heat exchangers and the humidifier or in the conditioned space.

When humidification is accomplished via a water spray system or an electric bath heater, a float valve is normally installed to control water level. This allows for the makeup of water loss to the air.

Differential pressure controls are sometimes installed in air handlers. They are typically used with automatic roll filters to determine when filters are dirty, and to then advance the roll to a clean section.

Air Cleaners (CSI 15885)

Most Heating and Ventilating units, AHUs, and supply fans incorporate air cleaning devices. The most common are prefabricated, throw-away filters, but many other devices are found in the field.

Variations in the prefabricated, throw-away filter include bag filters, box filters, and HEPA (high efficiency particulate air) filters. Other variations include media inserted into guides or frames, cleanable metal filters, automatic filter rolls. The latter use a supply roll and an uptake roller to permit "changing" the filtration surface without removing the filter. Although these can be manually operated, roll filters typically include drive mechanisms (motor, reducer, chains, and sprockets) to automatically advance the filter.

In special applications, electrostatic filters are installed. These devices use high potential wires to ionize the air and allow for particulate matter redirection and capture.

Ductwork & Fittings (CSI 15890)

Most ductwork and fitting requirements are covered by the ductwork standard. However, because air handlers and fans are high maintenance items compared to distribution ductwork, they are more likely locations for duct failures. The inspector should be particularly alert for problems in this area.

Ducts and fittings are not only used to distribute the air leaving the air handlers, fans, etc. They are frequently used to supply outside air to the units and, sometimes, to connect major sections of the units in large assemblies.

Large flexible duct joints are frequently used to allow for assembly expansion and contraction and to permit easy component removal for repair or replacement.

0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Piping & Fittings (CSI 15411)

Like ductwork, most piping and fitting requirements are covered within their respective distribution systems (steam and condensate; heating hot water; gas; drain, waste, and vent; etc.). However, because the air handlers and heating and ventilating units are high maintenance items compared to distribution piping, they are more likely locations for failure. The inspector should be particularly alert for problems in this area.

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.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Instrumentation (CSI 15130)

Pressure gauges are typically provided at the suction and discharge of each fan.

Temperature gauges are usually provided at each stage of an air handler: i.e. before and after each HX, and on the piping supplying the HX coils.

Manometers are frequently installed to monitor the pressure drop across filter banks.

Valves (CSI 15100)

Manual valves are primarily used to isolate and drain units and other components for maintenance.

Regulating valves are also used to control the flow of water, glycol, and steam through the units. These valves may be two- or three-way (bypass) units modulated by local thermal bulbs, pneumatic controls, or remote thermostats. They may be mechanical, electrical, and/or pneumatic.

Manual and/or automatic vent valves are common on terminal units. They are used to purge the units after shutdown for maintenance or seasonal outages.

Steam traps are found on all heat exchangers that use steam.

Insulation (CSI 15250)

Insulation is used for thermal efficiency and noise isolation in air handlers, heating and ventilating units, and related ductwork. It may be found either outside or inside the units. Asbestos-containing materials were frequently used on older units, but most modern units use fiberglass materials.

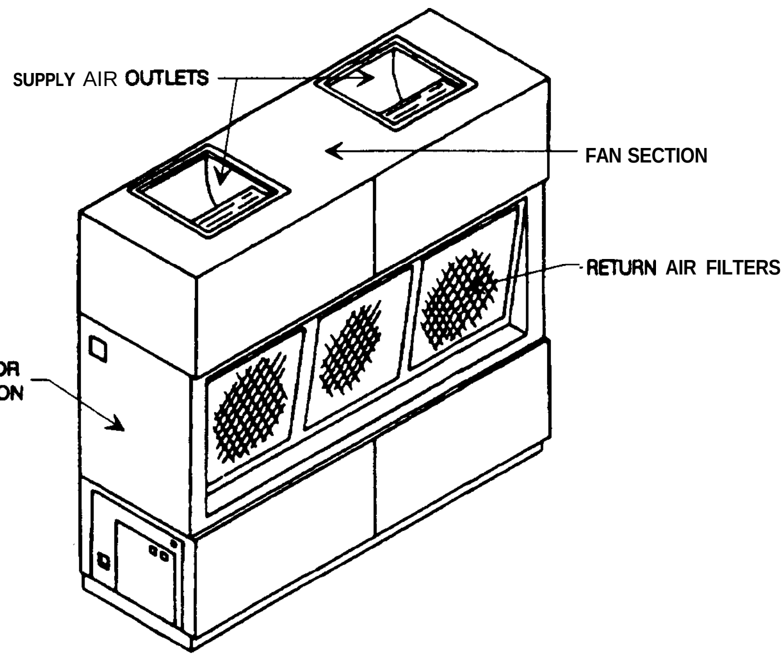
Generally insulation provides some vapor barrier to protect its insulating characteristics and minimize corrosion.

In some recent installations, the duct material and the insulation are one and the same.

OTHER RELATED COMPONENTS

See the following subsections for related components:

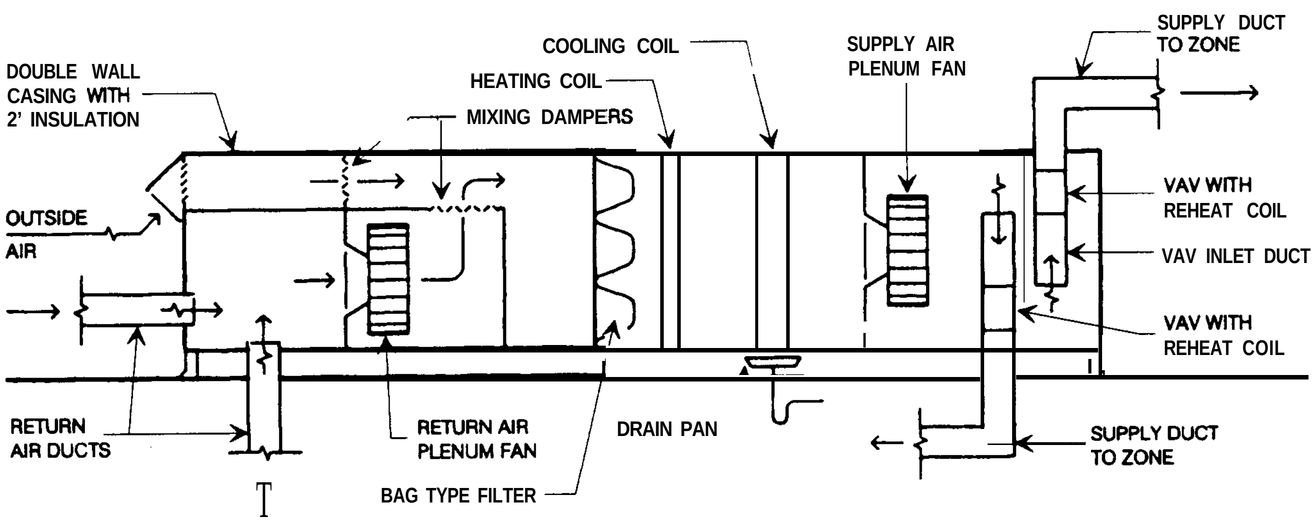
NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.



PACKAGED VERTICAL FAN COIL AIR HANDLING UNIT

SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE, "R.S. Means Co., Inc., Kingston, Massachusetts"

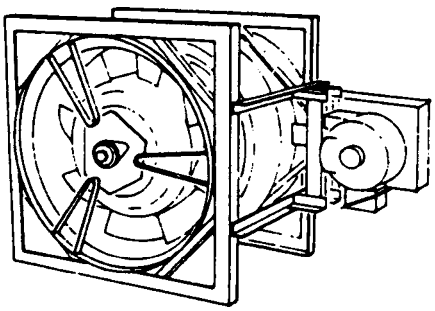
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	VERTICAL A.H.U.		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-1



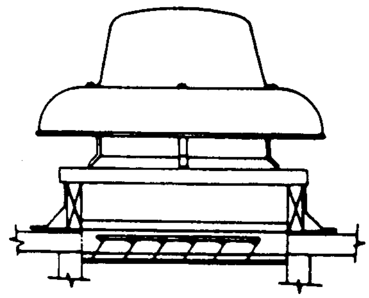
CUSTOMIZED AIR HANDLING UNIT

SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE. "R.S. Means Co., Inc., Kingston, Massachusetts"

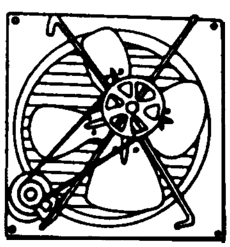
SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	AIR HANDLER CROSS SECTION		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-2



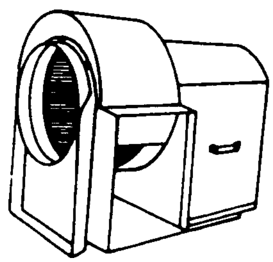
AXIAL FLOW, BELT DRIVE, CENTRIFUGAL FAN



CENTRIFUGAL ROOF EXHAUST FAN



BELT DRIVE PROPELLER FAN WITH SHUTTER



BELT DRIVE, UTILITY SET

BASIC FAN TYPES

SOURCE: MEANS HVAC SYSTEMS EVALUATION, HAROLD R. COLEN, PE, "R.S. Means Co., Inc., Kingston, Massachusetts"

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL FANS		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-3

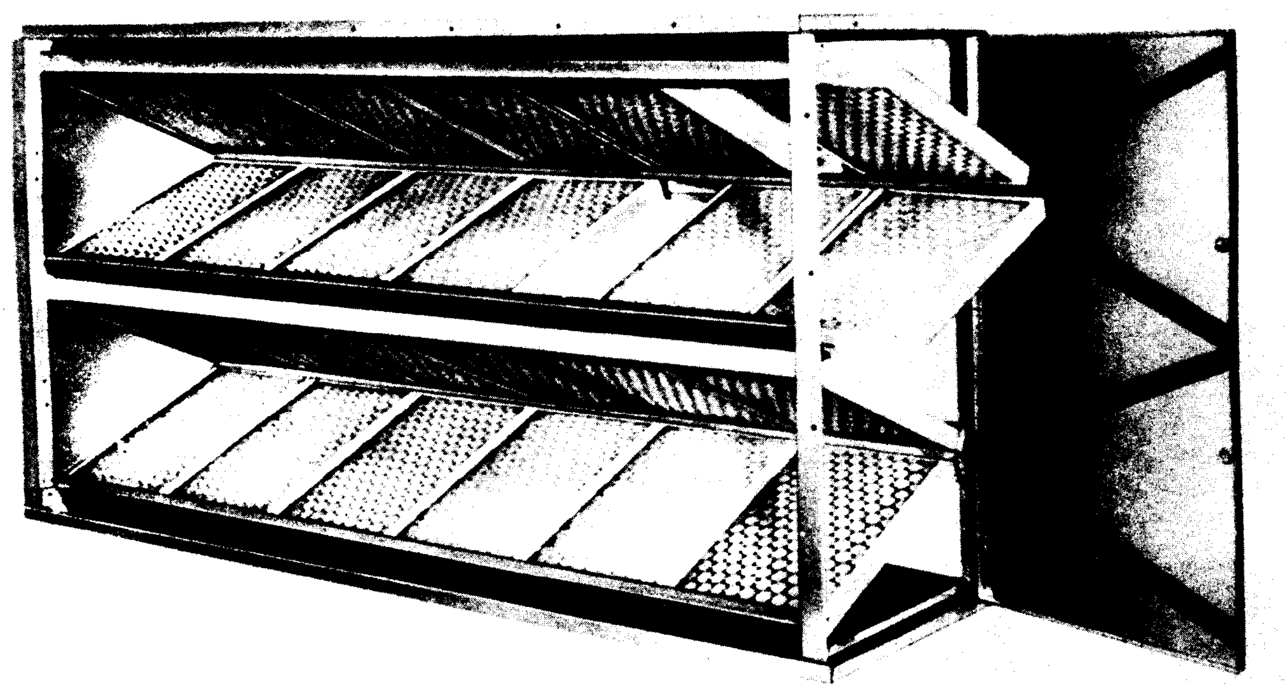


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL AIR FILTER RACK		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-4

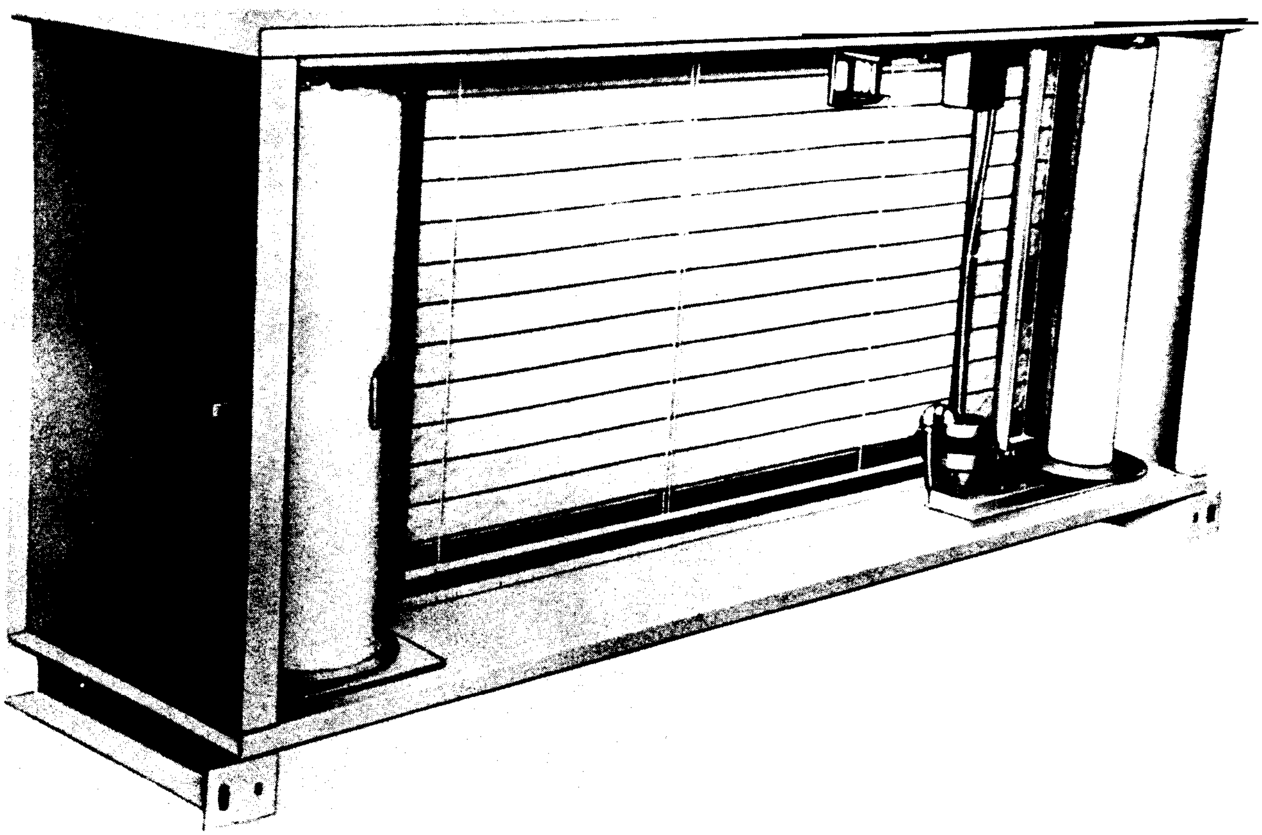


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ROLLED FILTER		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-5

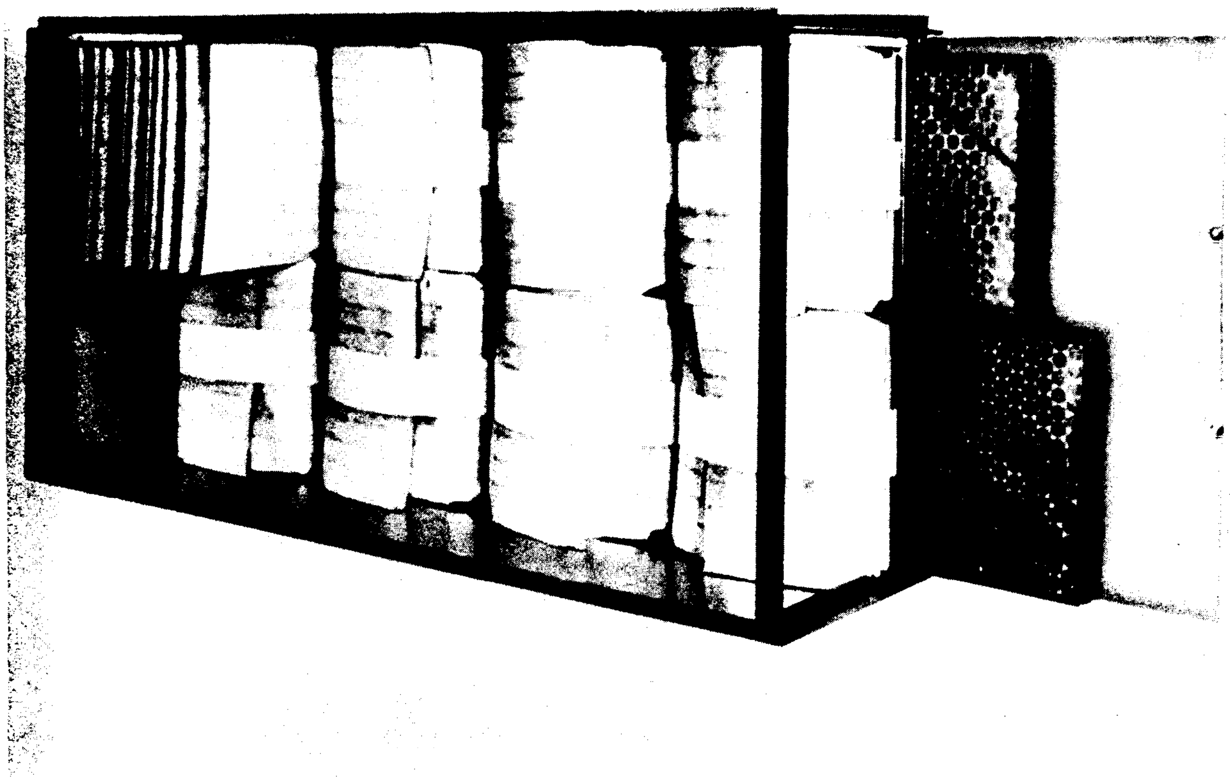


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL BAGGED FILTER/WITH RACK		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	issue Date 5/93	Drawing No. A080308-6

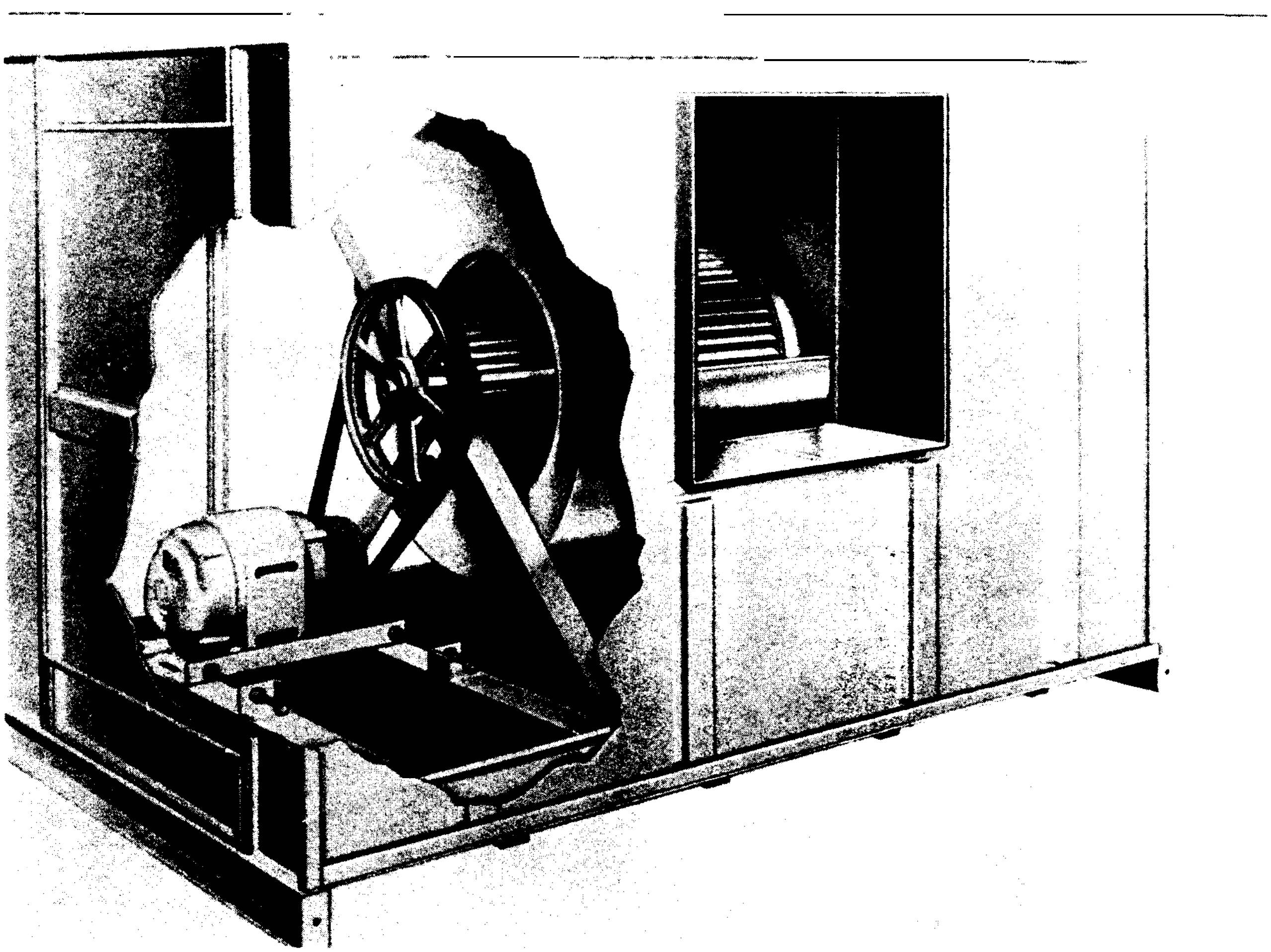


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL BELT DRIVEN CENTRIFUGAL FAN		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	issue Date 5/93	Drawing No. A080308-7

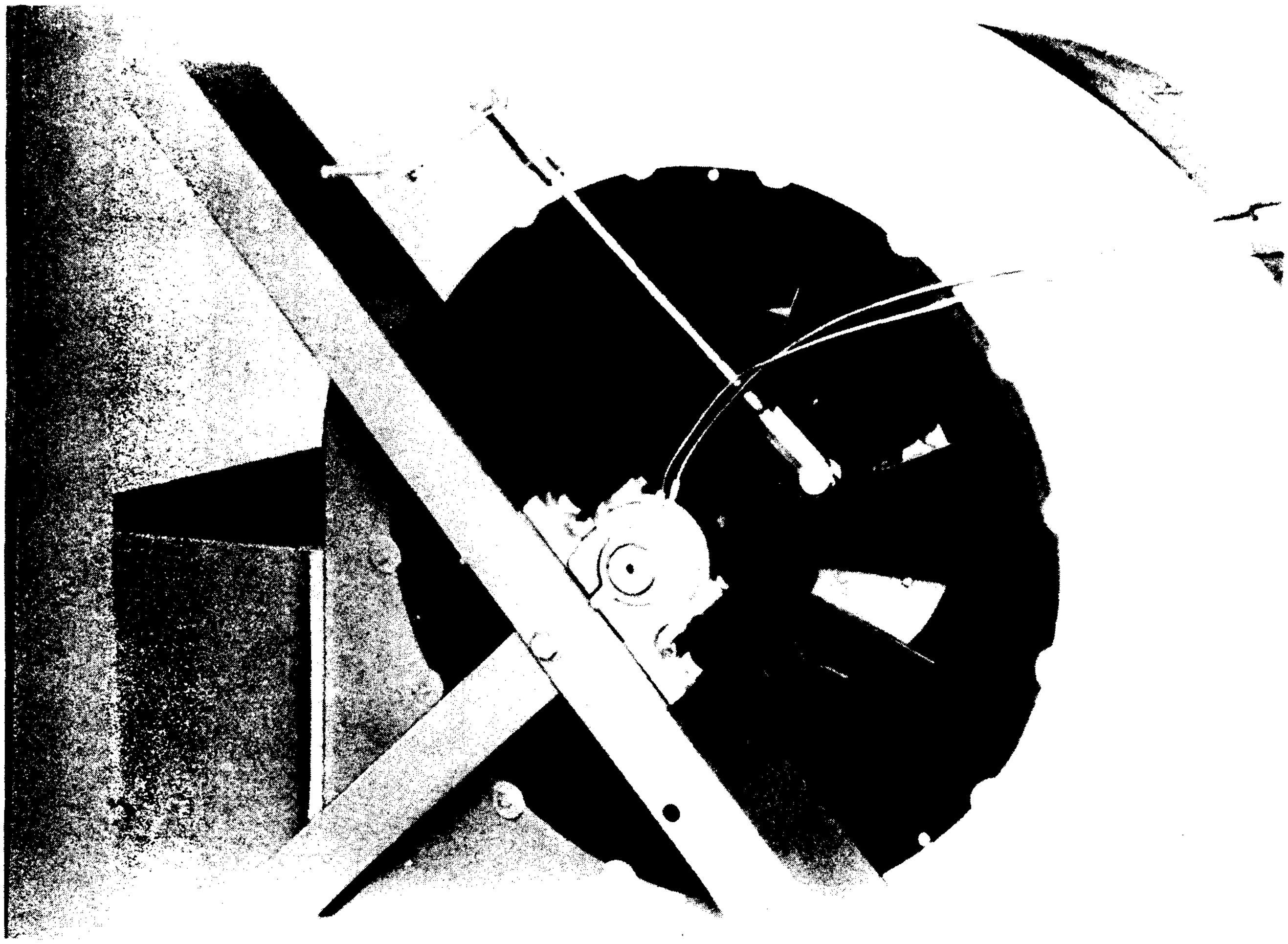
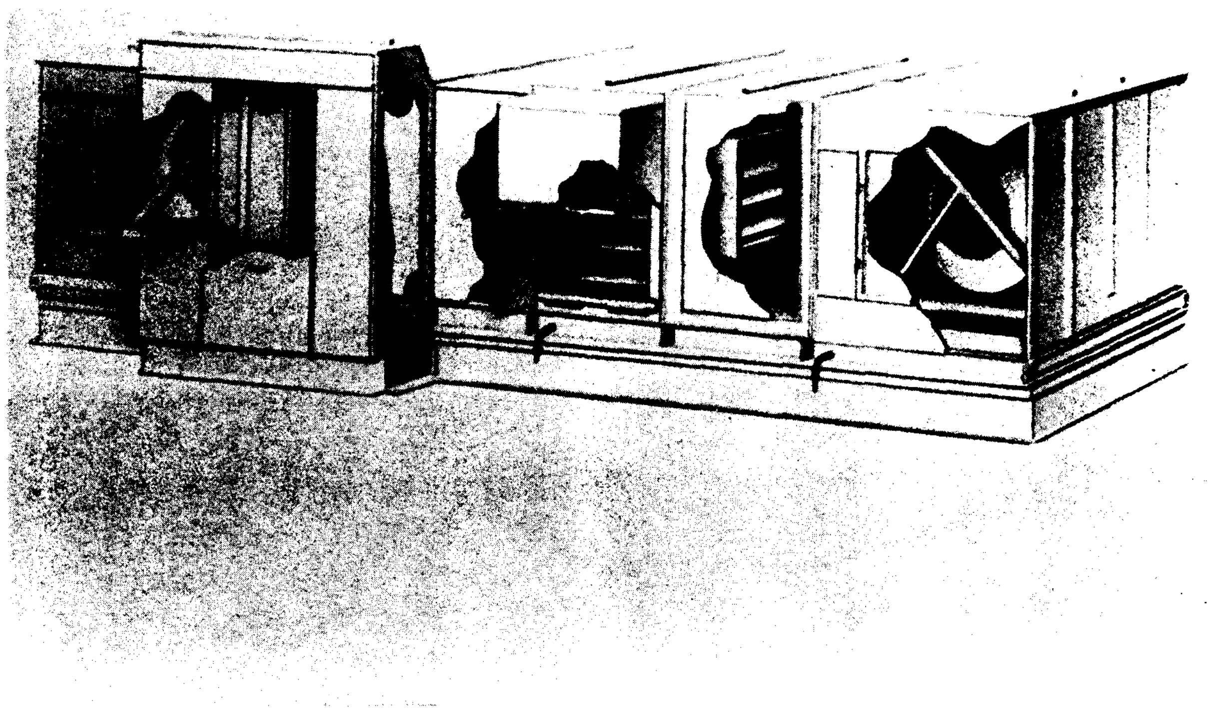


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	VARIABLE VORTEX TO CENTRIFUGAL FAN		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-8

4 3 2



1. CENTRIFUGAL SUPPLY FAN
2. VARIABLE DAMPER
3. FILTER ASSEMBLY
4. HEAT EXCHANGER COILS

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL AIR HANDLER UNIT		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-9

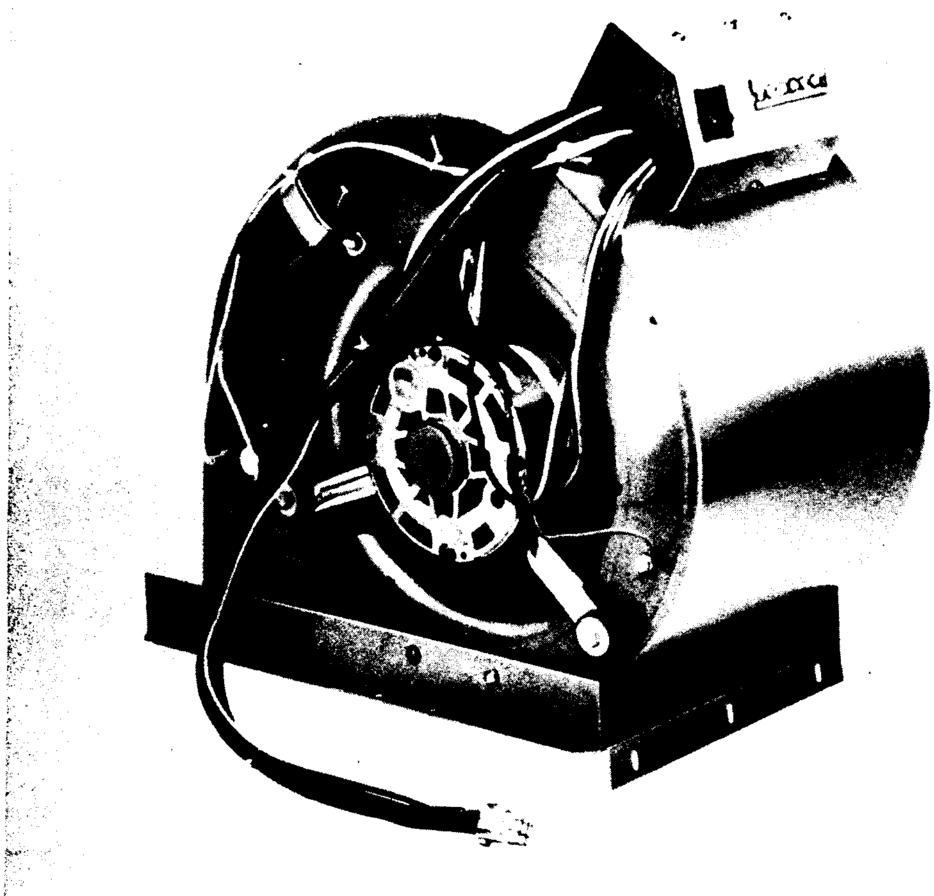


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DIRECT DRIVE CENTRIFUGAL FAN TYPICAL IN PACKAGED UNIT		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-10

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BELT DRIVEN CENTRIFUGAL FAN MOUNTED W/ VIBRATION ISOLATORS		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-11

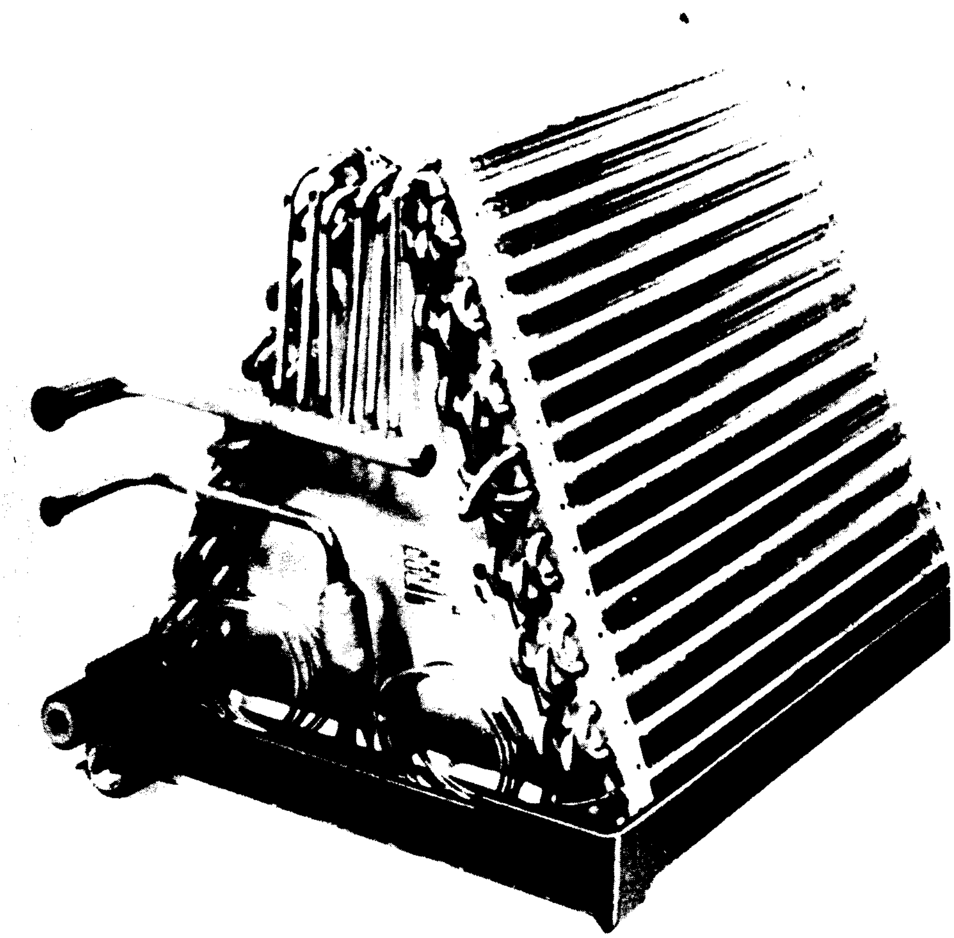
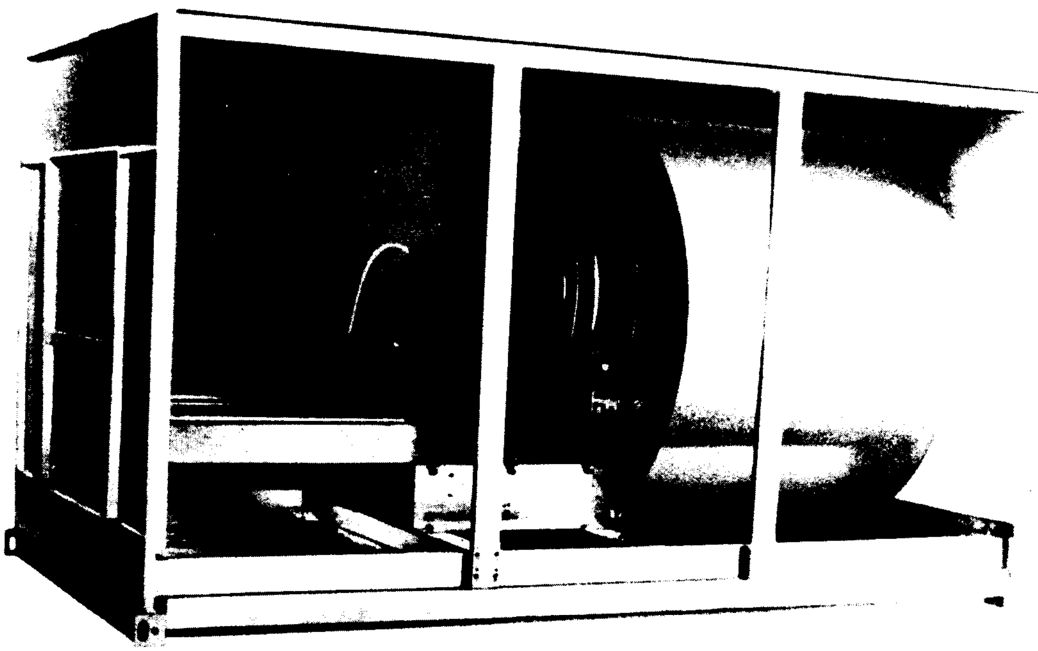


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL "A" COIL FROM A PACKAGED UNIT		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-12



NOTE: TUBING RUNNING TO REAR MOTOR BEARING ALLOWING LUBRICATION FROM A REMOTELY MOUNTED GREASE FITTING

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTIFUGAL FAN		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-13

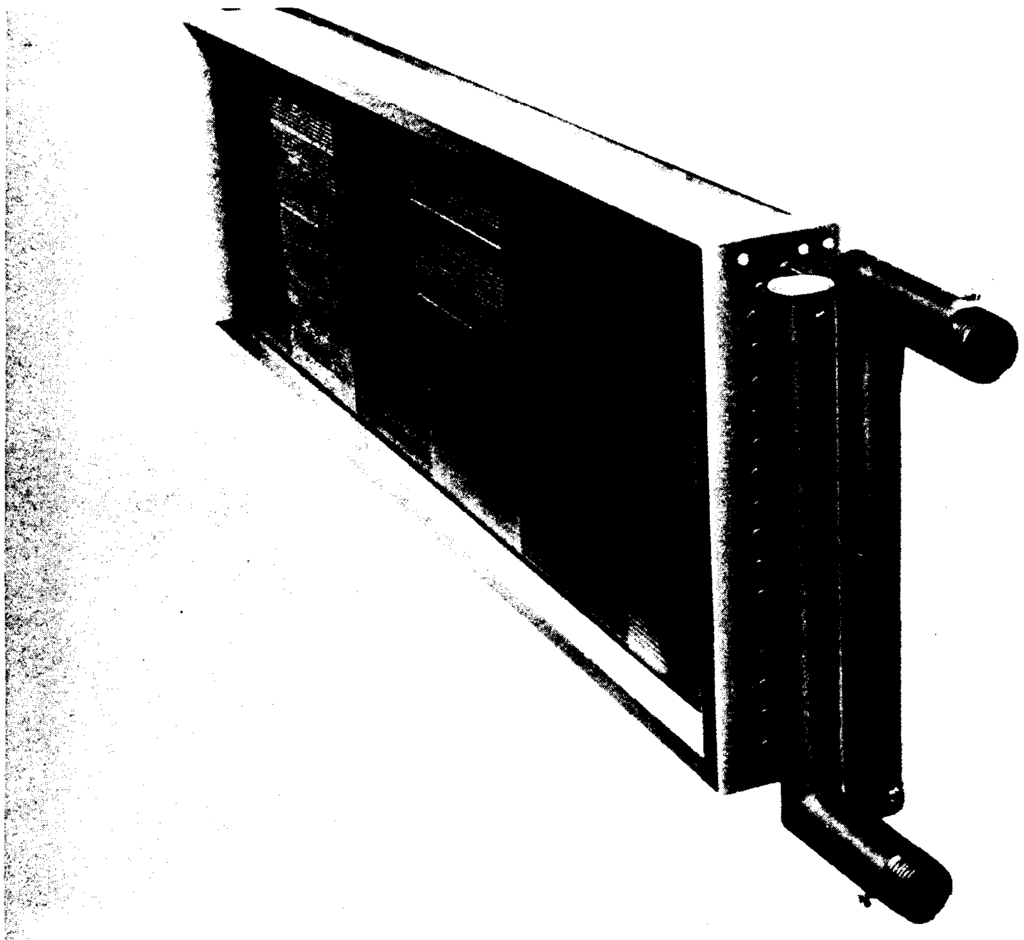


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGY/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HEAT EXCHANGER COIL HOT OR COLD WATER		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-14

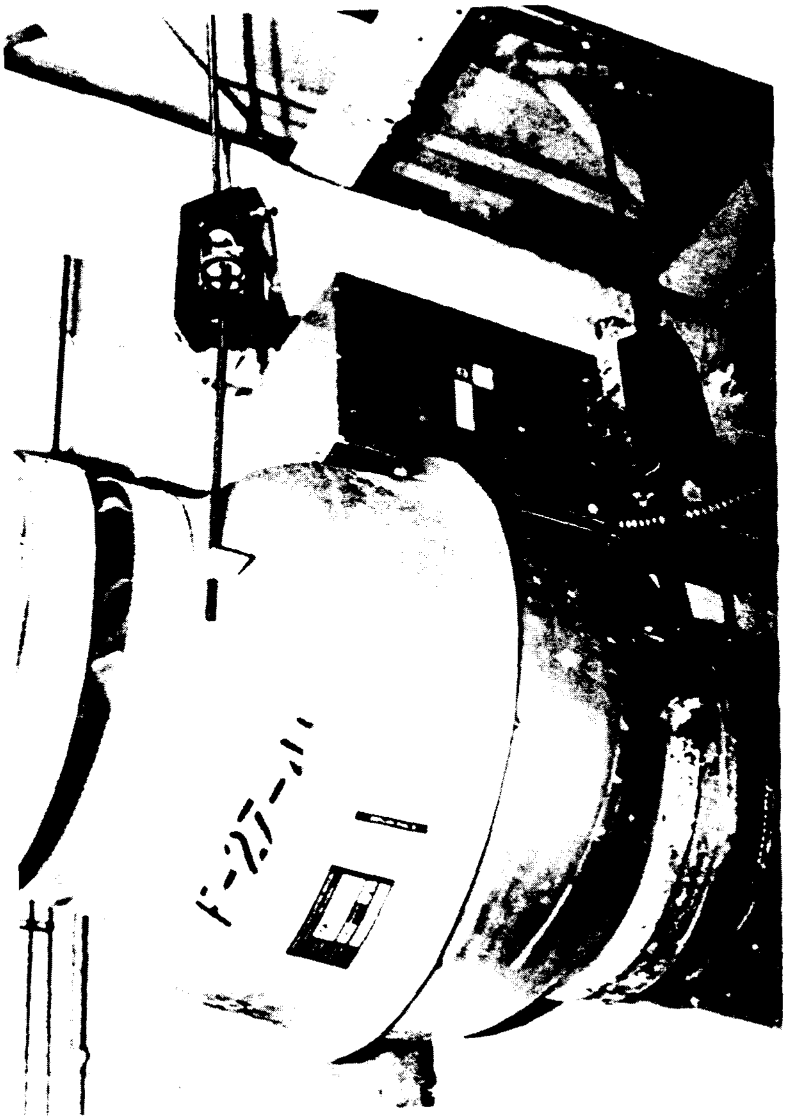


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	AXIAL FLOW CENTIFUGAL FAN
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.: — / Issue Date: 5/93 / Drawing No.: A080308-15

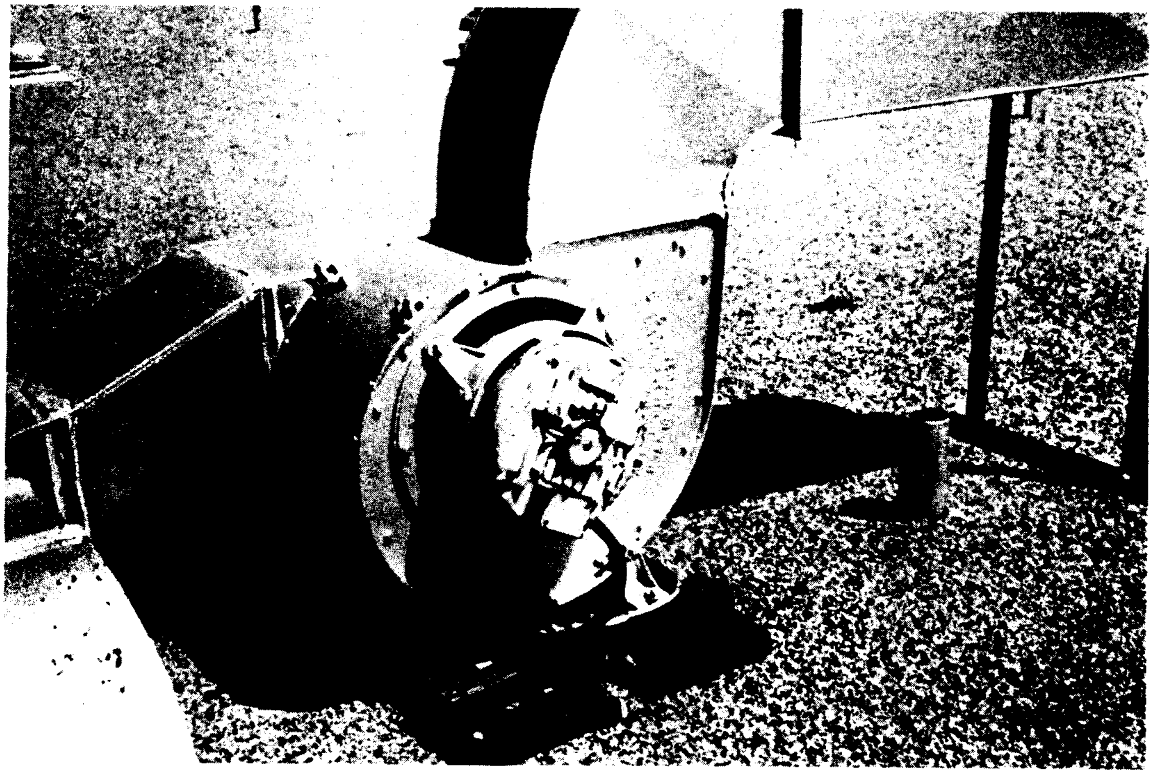


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	ROOF EXHAUST FAN		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. A080308-16

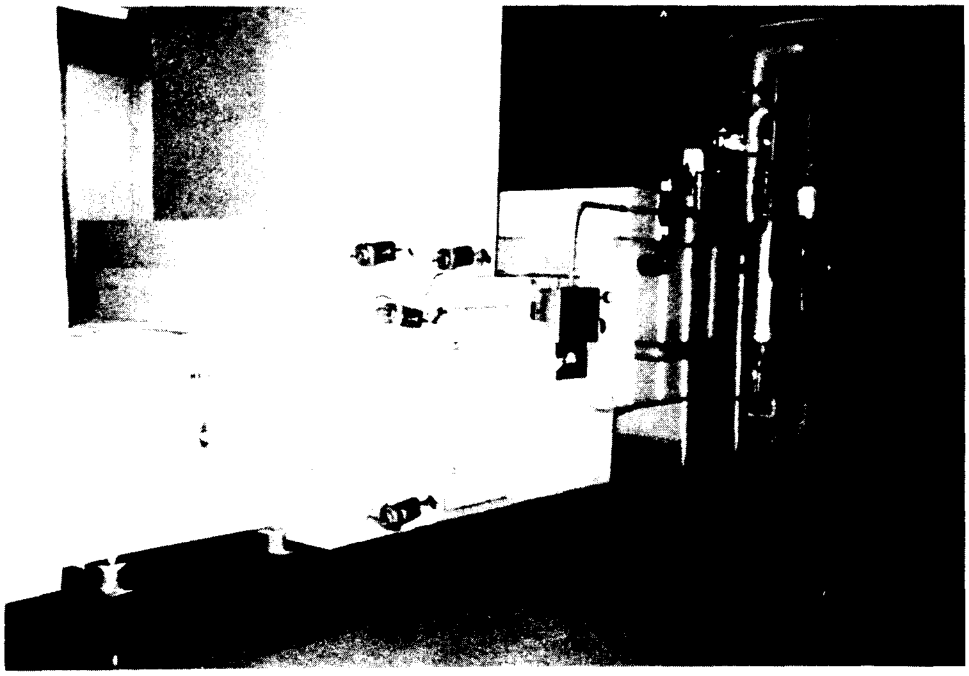


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	MULTIZONE AIR HANDLER		
HEATING AND VENTILATION AIR HANDLERS AND FANS **(CSI 15850)**	Revision No.	Issue Date 5/93	Drawing No. A080308-17

DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

PROBABLE FAILURE POINTS

- Reduction in heat transfer capability due to piping and/or HX coil corrosion.
- Piping leaks or heat exchanger due to corrosion especially in condensate circuit.
- Loss of air flow due to fan failure, damaged or blocked coils.
- Poor temperature control due to physical damage, poor maintenance.

SYSTEM ASSEMBLIES/DEFICIENCIES

Air Handlers & Heating & Ventilating Units

Inoperative:	Control failure, defective fan, frozen valves, defective wiring.
Excessive Noise:	Loose fasteners, improper speed, damper malfunctions.
Excessive Vibration:	Fan imbalance, poor alignment.
Fan Missing:	Taken out for maintenance and not returned.
Fan Imbalanced:	Blading damage, excessive corrosion.
Fan Corrosion:	Normal aging, poor maintenance.
Fan Damage:	Cracks, distortion due to physical abuse, fatigue.
HX Coil Leakage:	Age, corrosion, physical damage.
HX Coil Corrosion:	Age, improper drainage, poor filtration, inadequate maintenance.
HX Coil Damage:	Abuse, poor maintenance, poor installation.
Humidifier Nozzles Inoperative:	Corrosion, scaling, abuse.
Humidifier Pan Corrosion:	Normal aging, improper maintenance.
Severe Corrosion:	Aging, lack of maintenance.
Severe Physical Damage to Cabinet:	Abuse.

Ventilation Fans

Inoperative:	Control failure, defective fan, defective wiring.
Excessive Noise:	Loose fasteners, improper speed, damper malfunctions.
Excessive Vibration:	Fan imbalance, poor alignment.
Fan Missing:	Taken out for maintenance and not returned.
Fan Imbalanced:	Blading damage, excessive corrosion.
Fan Corrosion:	Normal aging, poor maintenance, local environment.
Fan Damage:	Cracks, distortion due to physical abuse, fatigue.
Severe Corrosion:	Aging, lack of maintenance, local environment.
Severe Physical Damage to Cabinet:	Abuse.

DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

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 environment.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

Air Cleaners

Frame Damage:	Corrosion, physical damage, inadequate support, improper joining.
Roll Mechanism Inoperative:	Corrosion, physical damage, missing parts.

Ductwork & Fittings

Excessive Noise:	Improper air flow, loose or missing fasteners.
Physical Damage:	Bent, broke, crimped, crushed.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Condensation, inadequate insulation.
Dampers Inoperative:	Corrosion, physical damage.
Damaged Expansion Joints:	Poor maintenance, abuse, over-pressurization.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.

Piping & Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Normal aging, poor maintenance.
Physical Damage:	Abuse, stress, improper maintenance.
Strainers Inoperative:	Corrosion, abuse.

DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS **(CSI 15850)**

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Instrumentation

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

Valves

Leakage:	Improper packing, corrosion.
Severe Corrosion:	Aging, poor maintenance, leakage.
Physical Damage:	Abuse, stress.
Inoperative:	Corrosion, damaged operating mechanism.
Poor Regulation:	Worn seat/disc, defective sensing mechanism, blocked lines.
Inadequate Seating:	Worn seat/disc, check valve frozen by corrosion.

Insulation

Missing:	Poor maintenance, corroded fasteners.
Wet:	Leaking coils, piping, poor drainage.
Damaged:	Corroded fasteners, abuse, aging.

DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

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PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	FAN HOUSING CORROSION		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. D080308-1

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	LEAKAGE AND RUSTING AIR HANDLER CASING		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. D080308-2

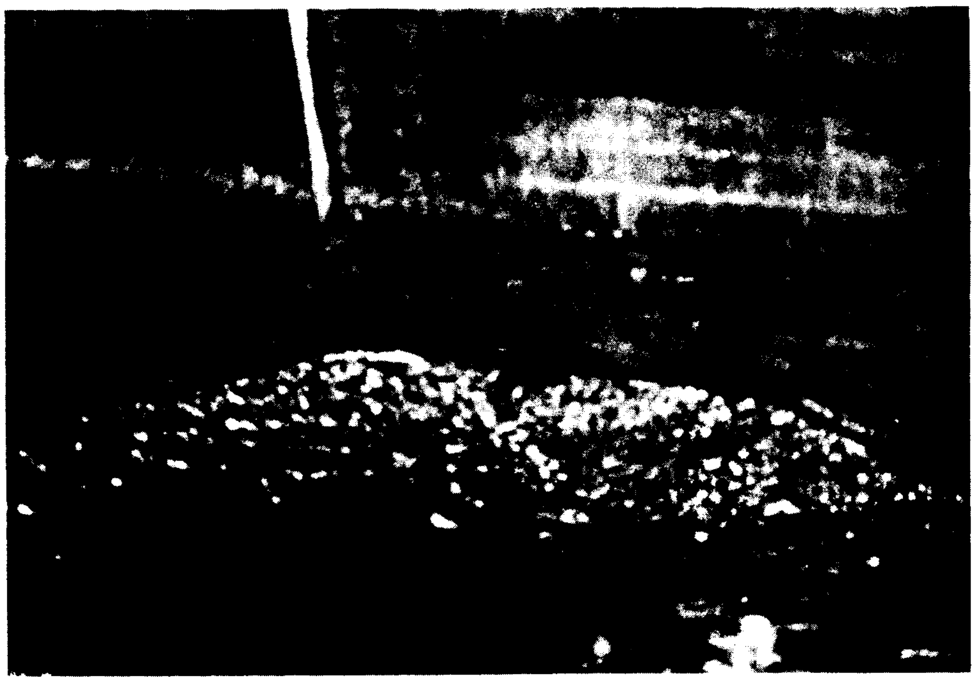

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	COIL FRAME CORROSION IN AIR HANDLER	
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue Date 5/93	Drawing No. D080308-3

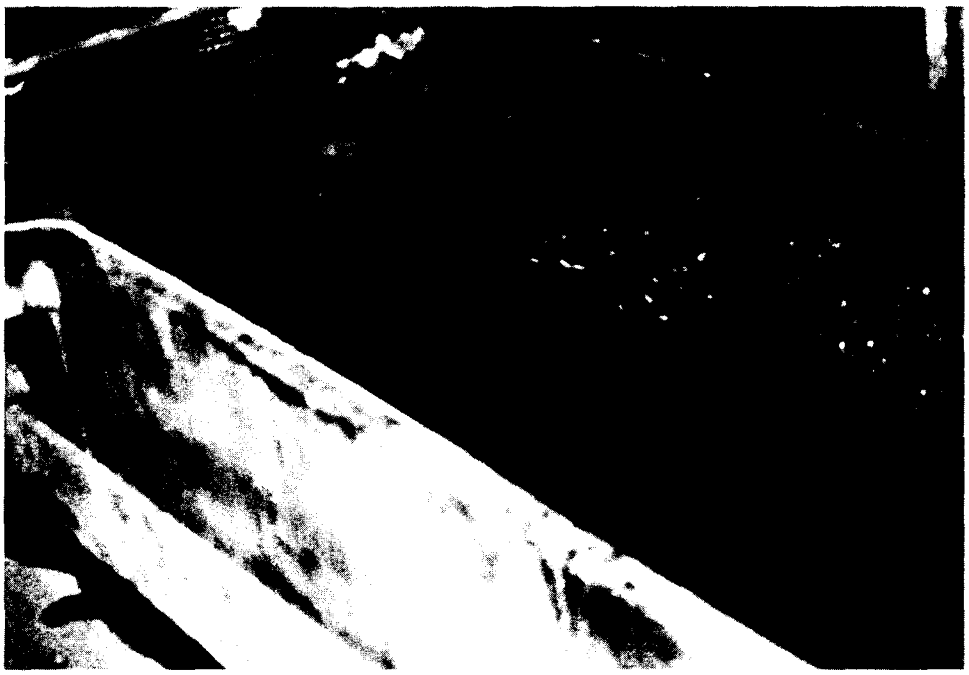

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	DETERIORATION OF SPRAY SUMP IN AIR HANDLER		
HEATING AND VENTILATION AIR HANDLERS AND FANS (CSI 15850)	Revision No.	Issue oats 5/93	Drawing No. D080308-4

DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

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DEFICIENCY FACTORS
0.08.03.08 AIR HANDLERS & FANS (CSI 15850)

END OF SUBSECTION

0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

DESCRIPTION

The typical Ventilation Ductwork System provides air distribution, regulation, and return throughout the building. The system consists of air distribution ducts, turning vanes, balancing dampers, mixing dampers, variable air volume units, air outlets and inlets, and the connecting joints and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Ductwork **& Fittings** (CSI 15890)

Ductwork and fittings provide the distribution and collection network for the ventilation system.

Ductwork is typically sheet metal fabricated into rectangular boxes, suspended under floors (slabs), which connects the building's air handlers and fans to the final distribution spaces. The duct is usually hidden by a suspended ceiling in public areas.

The primary distribution control is accomplished by duct sizing. Because CFM of delivered air is proportional to the size of the duct (as well as air pressure), the duct generally decreases in size from the supply point to the terminal distribution devices.

Further control of the design distribution is accomplished by including turning vanes and manual dampers. Turning vanes provide a smoother transition in air direction, reducing turbulence and associated air pressure drops (head losses), increasing potential air flow in the duct. Dampers act as valves to regulate the quantity of air in a given branch. They introduce air pressure drops with associated turbulence, decreasing potential air flow. Damper adjustments allow the staff to change (balance) the amount of air distributed to each area.

High air velocities in ductwork introduce noise and vibration. Therefore, ducts are usually sized to restrict velocity below 800 FPM. Where this is not reasonable or possible, insulation is used to provide noise reduction.

Some alternative duct designs include construction with insulation board or flexible plastic.

Several major installation types or mixes are available: single duct or dual duct; constant volume, variable temperature; variable volume, constant temperature; and hybrid combinations.

The single duct (i.e., one air flow path to each space) is the most common installation resulting in an almost constant amount of air delivered. Temperature control is provided by varying the air temperature supply at the source and tempering with reheat coils.

The dual duct (deck) approach provides two air sources (a "hot" deck and a "cold" deck) to each area. Temperature is controlled by varying the mix of the two sources with dampers. This approach still provides an almost constant volume of air because the dampers are tied together or "ganged" to effect inverse action (as one opens the other closes).

The variable volume, constant temperature approach usually uses a single duct, but allows for varied air flow through the duct. Temperature is controlled by varying the amount of hot air allowed into the space. To work effectively, this system must be supplied with a variable volume air handler. Also, the duct requires more insulation for noise due to constant flow changes.

All duct fittings should be compatible with the type of duct materials used in the system. Flexible connectors are usually used on the inlet and outlet side of each VAV box, duct heater, etc. to minimize the effects of vibration and to facilitate maintenance.

Duct sleeve seals should be provided at foundation and basement wall penetrations

Duct penetrations of fire barriers should be sealed using fire barrier penetration sealers.

Fire dampers should be installed at fire wall penetrations.

0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Air Cleaners (CSI 15885)

Most heating and ventilating units, AHUs, and supply fans incorporate air cleaning devices. While the most common are prefabricated throw-away filters, there are many other devices found in the field.

Variations in the prefabricated throw-away filter include bag filters, box filters, and HEPA (high efficiency particulate air) filters.

Variations to the prefab throw-away filter include media inserted into guides or frames, cleanable metal filters, automatic filter rolls. The latter use a supply roll and an uptake roller to permit “changing” the filtration surface without removing the filter. Although these can be manually operated, roll filters typically include drive mechanisms (motor, reducer, chains, and sprockets) to automatically advance the filter.

In special applications, electrostatic filters are installed. These devices use high-potential wires to ionize the air. allowing for redirection and capture of the particulate matter present.

Insulation (CSI 15290)

HVAC duct is typically insulated to provide energy efficiency. This is normally applied to the exterior of the duct. In some installations, the insulation is applied internally or the insulation material takes the place of the duct itself.

Variable Air Volume Boxes (CSI 15930)

Variable air volume (VAV) boxes are ductwork devices that control of the amount of air delivered to a space. They are commonly installed as zone or multi-room controls. Although effectively a volume controller, their purpose is primarily temperature control. They are usually installed in the supply duct in a suspended ceiling.

The VAV box is a simple, pneumatically or electrically controlled damper. In response to a demand for more heat, the local thermostat sends a signal to the damper causing it to open, delivering more hot air.

Variations include the addition of a small heat exchanger (i.e. a heating coil or electric elements) a small fan for local recirculation, and/or dampers to control the mix of supply versus recirculated air. Other designs may use electric/electronic controls instead of pneumatics.

Air Outlets & Inlets (CSI 15940)

Air outlets and inlets generically refer to a multitude of manual air flow devices that regulate the characteristics of the air movement. These include diffusers, louvers, registers, and grills.

A grill serves to break up or delaminate the incoming air, reducing draft effects and noise. Louvers have movable vanes that redirect air flow. Registers have dampers to close off or throttle the air flow. Diffusers have concentric rings to mix space air with the incoming air.

Supports & Anchors (CSI 15140)

Duct hangers and supports are provided to support the duct and allow for the expansion and contraction. They should be securely attached to the building construction at sufficiently close intervals.

0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

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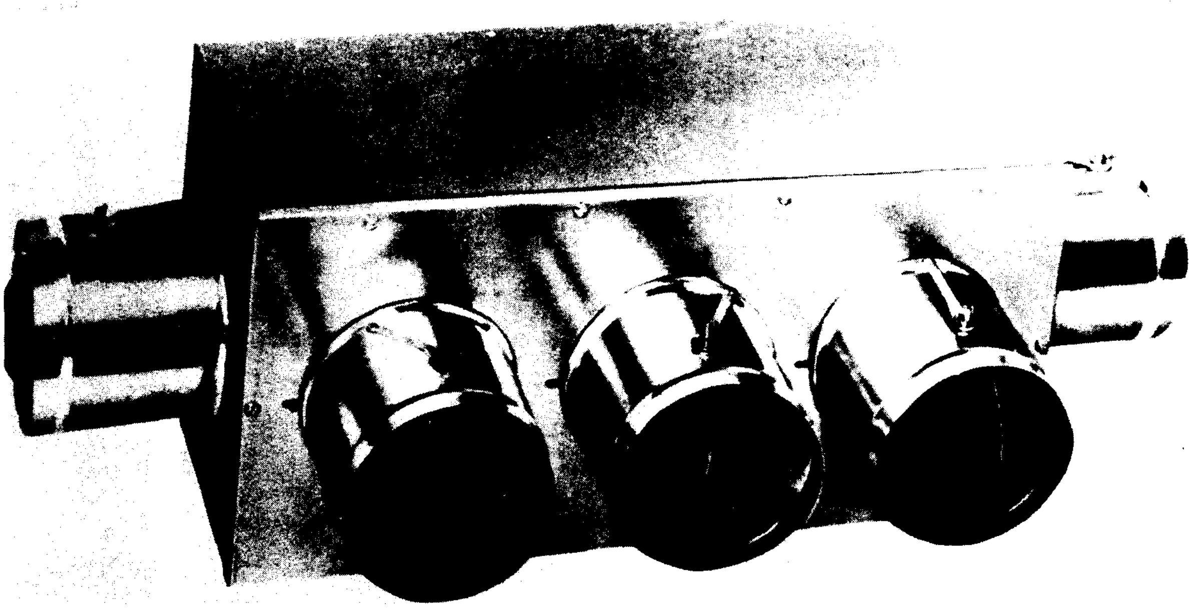
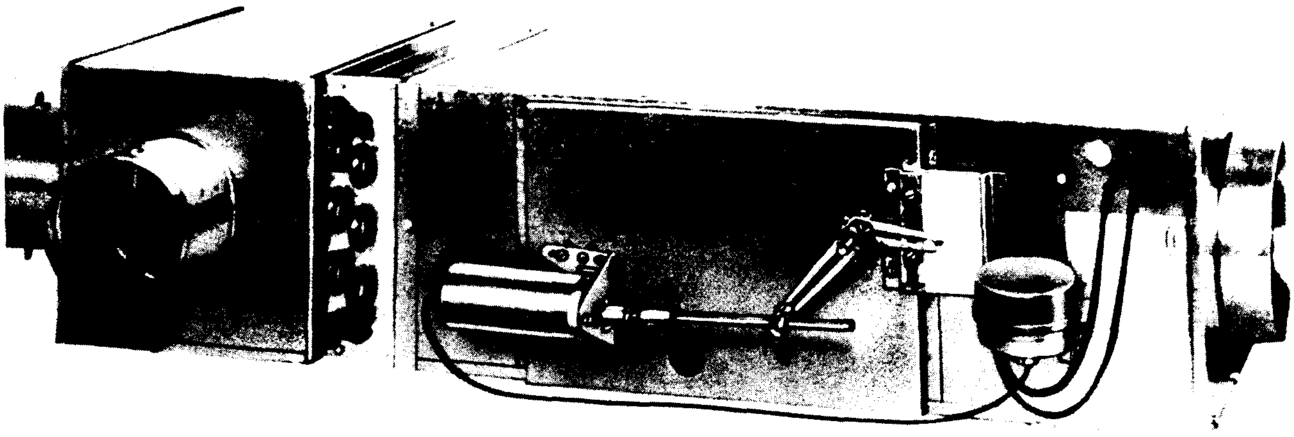


PHOTO ILLUSTRATION

SOURCE: COURTESY Cf UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DISTRIBUTOR WITH BUTTERFLY VALVES		
HEATING AND VENTILATION DUCKWORK AND ACCESSORIES (CSI 15890)	Revision No.	Issue Date 5/93	Drawing No. A080309-1



5 4 3 2 1

1. VOLUME CONTROLLER
2. DAMPER LINKAGE
3. PNEUMATIC ACTUATOR
4. HOT WATER COIL
5. BUTTERFLY VALUE

PHOTO ILLUSTRATION

SOURCE: COURTESY a UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL VAV BOX WITH HOT WATER COIL		
HEATING AND VENTILATION **DUCKWORK** AND ACCESSORIES **(CSI 15890)**	Revision No.	Issue Date 5/93	Drawing No. A080309-2

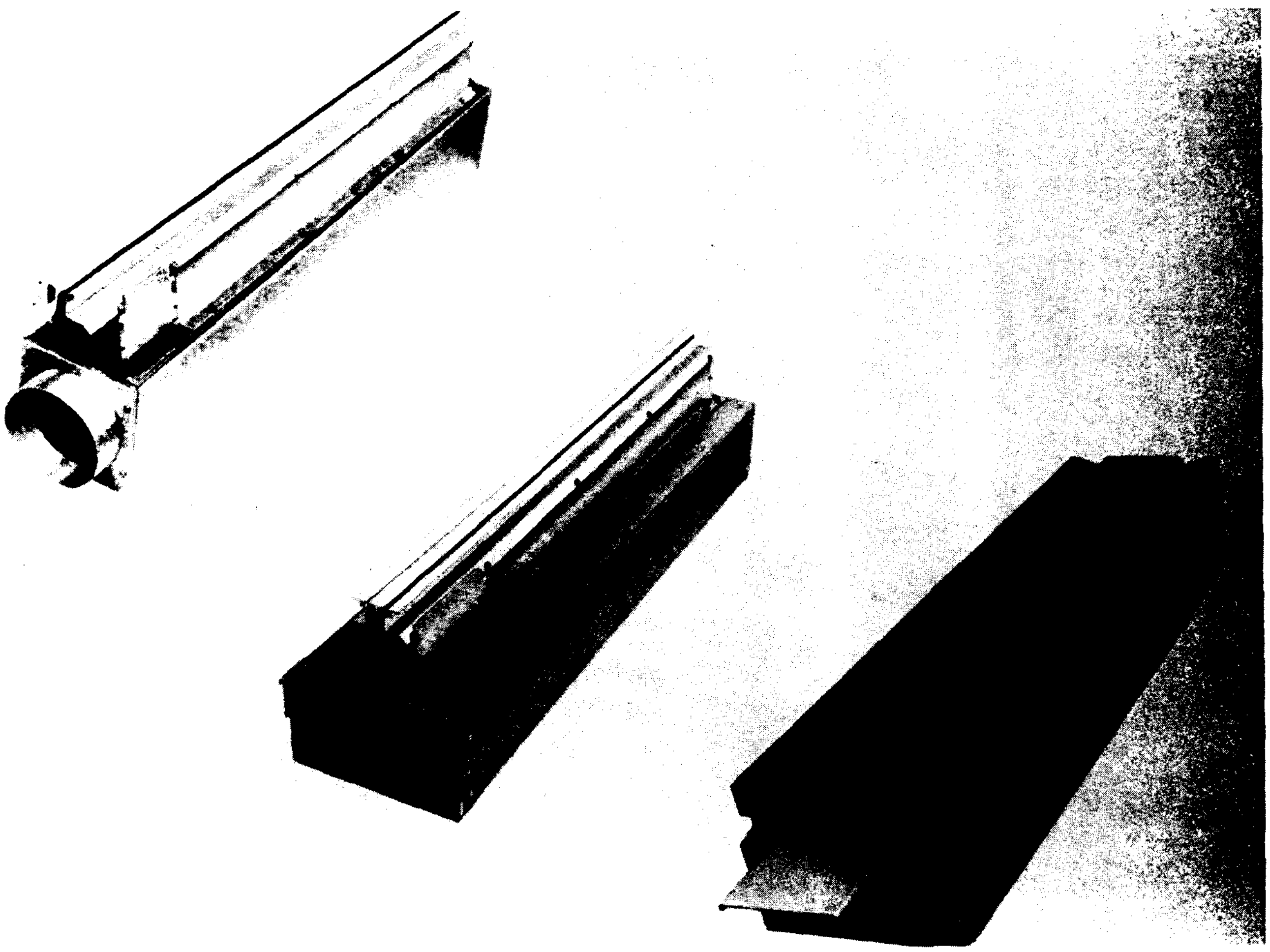


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DIFFUSER BOXES		
HEATING AND VENTILATION **DUCKWORK** AND ACCESSORIES **(CSI 15890)**	**Revision No.**	Issue Date 5/93	**Drawing No.** A080309-3

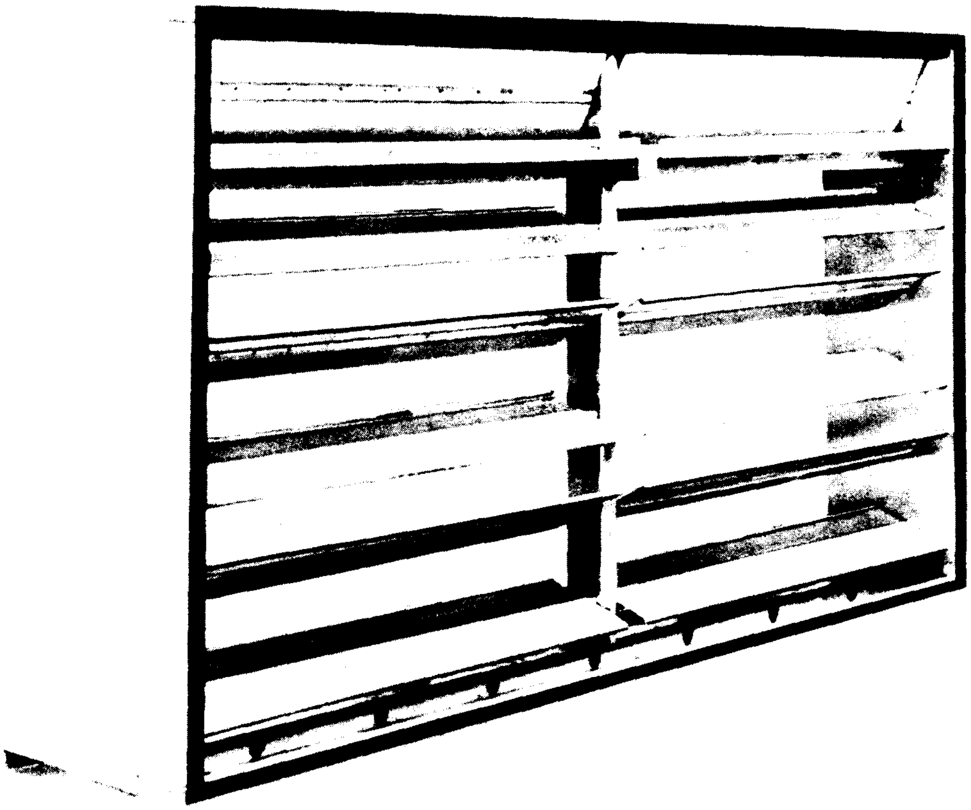


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS HEATING AND VENTILATION DUCKWORK AND ACCESSORIES (CSI 15890)	TYPICAL DAMPER ASSEMBLY		
	Revision No.	issue Date 5/93	Drawing No. A080309-4

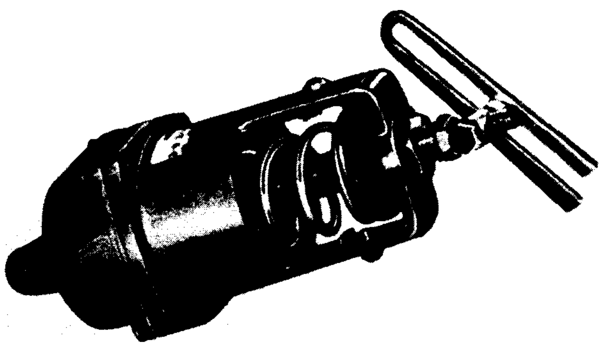


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL PNEUMATIC ACTUATOR		
HEATING AND VENTILATION **DUCKWORK** AND ACCESSORIES **(CSI 15890)**	**Revision No.**	**Issue** Date 5/93	**Drawing** No. A080309-5

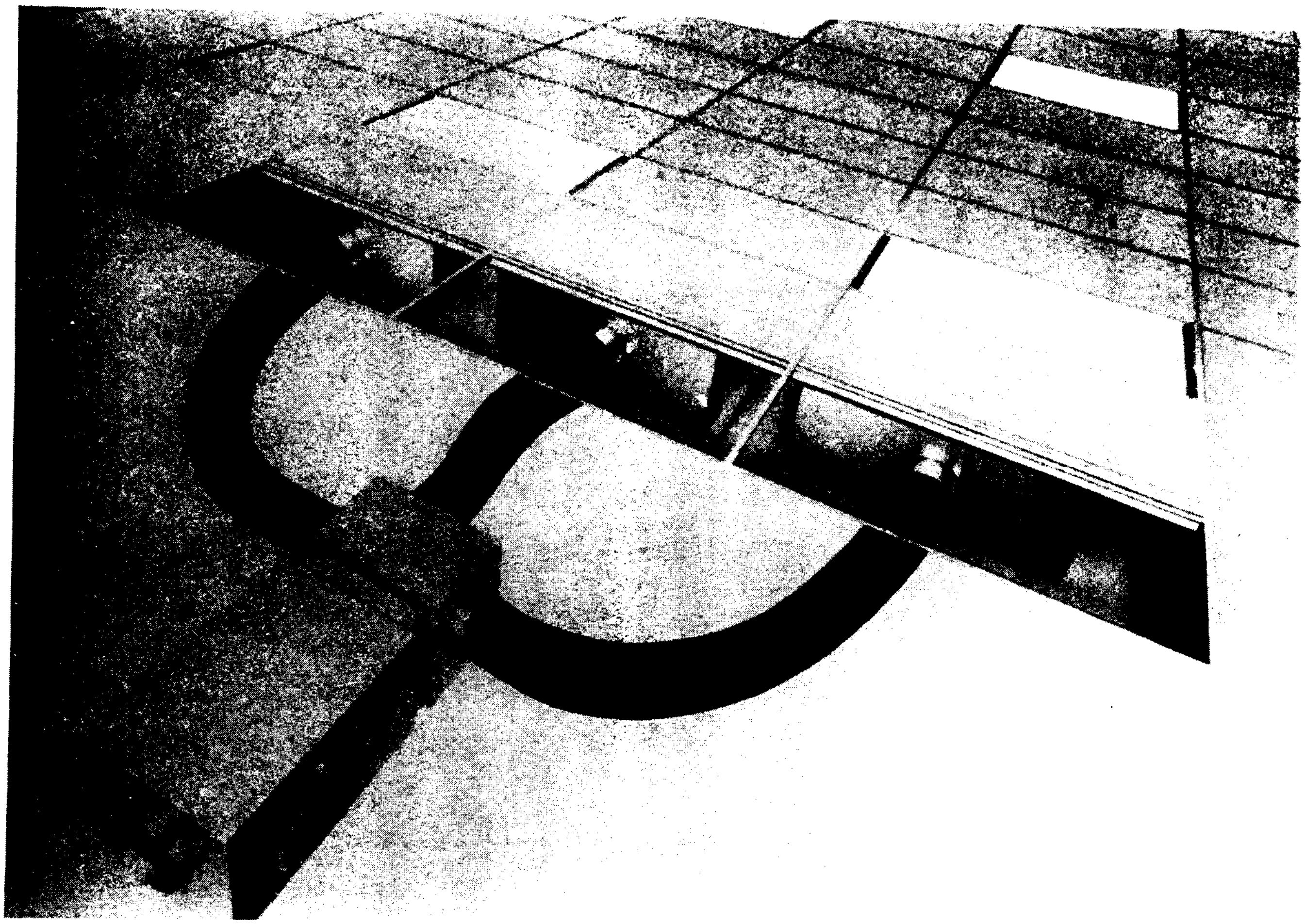


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL VAV BOX WITH HOT WATER COIL AND DISTRIBUTOR		
HEATING AND VENTILATION DUCKWORK AND ACCESSORIES (CSI 15890)	Revision No.	Issue Date 5/93	Drawing No. A080309-6

DEFICIENCY FACTORS
0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

PROBABLE FAILURE POINTS

- Duct leakage due to corrosion, vibration, loose fasteners, torn fabric.
- Inadequate air flow at terminal points **due to duct or fittings damage, improper balancing.**

SYSTEM ASSEMBLIES/DEFICIENCIES

Ductwork **& Fittings**

Excessive Noise:	Improper air flow, loose or missing fasteners.
Physical Damage:	Bent, broke, crimped, crushed, torn connectors.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Condensation, inadequate insulation.
Dampers Inoperative:	Corrosion, physical damage.
Damaged Expansion Joints:	Poor maintenance, abuse, over-pressurization.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.

Air Cleaners

Frame Damage:	Corrosion, physical damage, inadequate support, improper joining.
Roll Mechanism Inoperative:	Corrosion, physical damage, missing parts.

Insulation

Missing:	Corroded or missing fasteners.
Damaged:	Abuse, poor maintenance.
Wet:	Excessive condensation.

Variable Air Volume Boxes

Excessive Noise:	Improper air flow, loose or missing fasteners.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Condensation, inadequate insulation.
Dampers Inoperative:	Corrosion, physical damage.
Missing Recirculating Fan:	Removed for maintenance, not replaced.
Inoperative Recirculating Fan:	Failed windings, bearings, etc.

Air Inlets & Outlets

Missing:	Vandalism, poor maintenance.
Inoperative:	Corrosion, abuse.
Severe Corrosion:	Aging, lack of maintenance.

DEFICIENCY FACTORS
0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Supports & Anchors

Missing:	Improper installation, poor maintenance.
Inadequate Allowance for Expansion:	Improper installation, poor maintenance.
Misalignment:	Improper installation, poor maintenance.

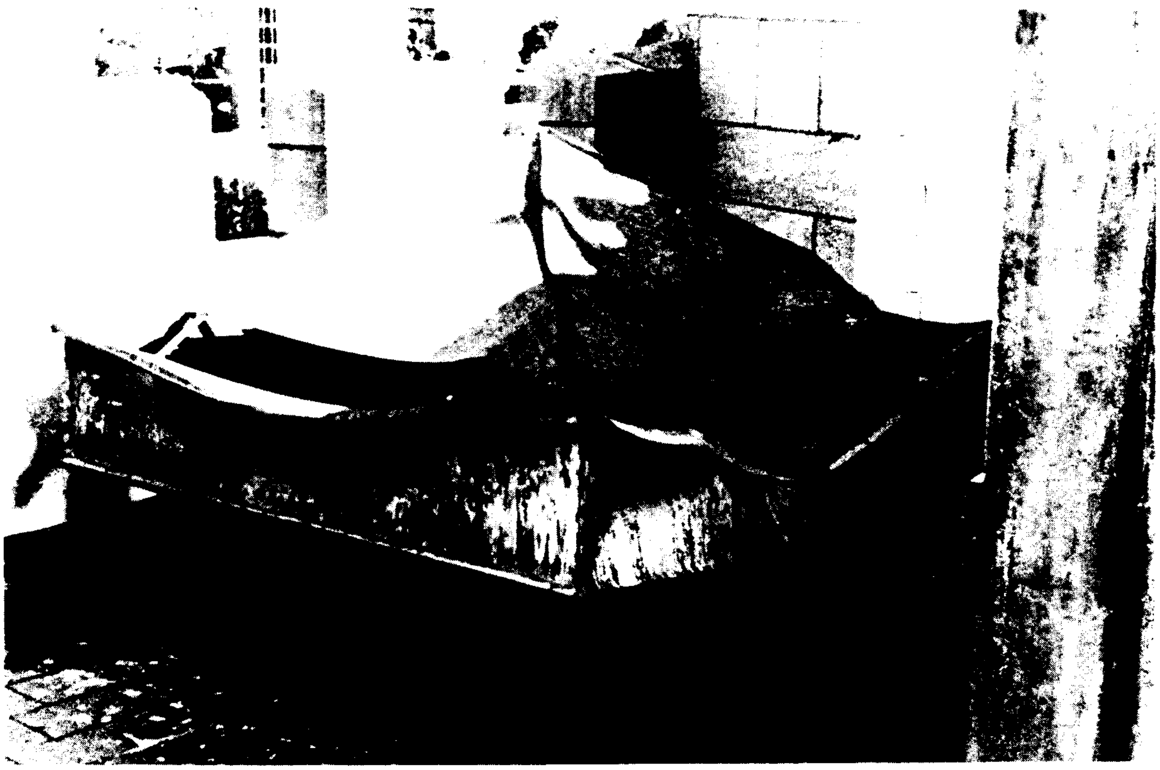


PHOTO ILLUSTRATION

SYSTEM **ASSEMBLY DEFICIENCY DETAILS-MECHANICAL** SYSTEMS	DAMAGED VENT HOUSING		
HEATING AND VENTILATION **DUCKWORK** 'AND ACCESSORIES **(CSI 15850)**	Revision No.	Issue Date 5/93	Drawkg No. 0080309-I

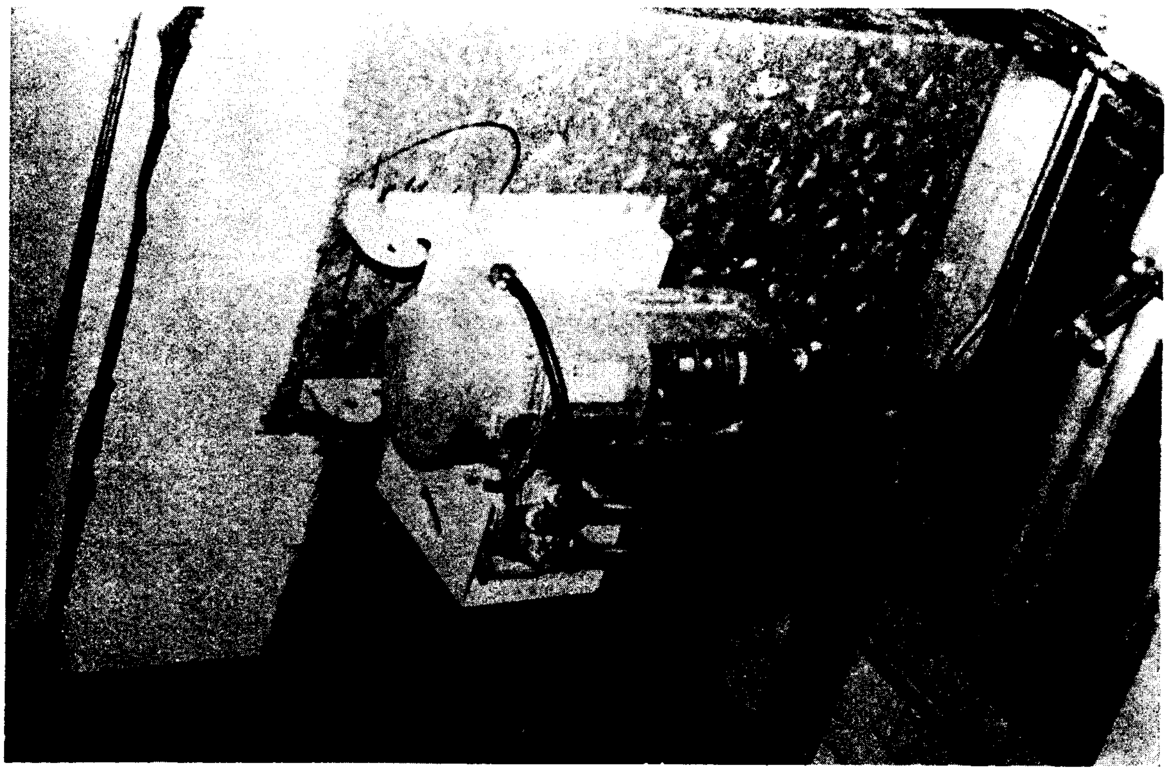


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL **SYSTEMS**	PNEUMATIC ACTUATOR **DISCONNECTED FROM LINKAGE**		
HEATING AND VENTILATION **DUCKWORK** AND ACCESSORIES **(CSI 15850)**	Revision No.	Issue Date 5/93	Drawing No. D080309-2

DEFICIENCY FACTORS
0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

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DEFICIENCY FACTORS
0.08.03.09 DUCTWORK & ACCESSORIES (CSI 15890)

END OF SUBSECTION

0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15885)

DESCRIPTION

A Centrifugal Chiller System removes heat from its associated chilled water system and rejects it to an associated condenser water system. It employs a refrigerant compression and expansion cycle where the compression force is supplied by a centrifugal device similar to a large, multi-stage centrifugal pump. The typical system consists of a centrifugal compressor, drive assembly, motor, condenser, economizer, evaporator, purge system, and the connecting piping, fittings, instrumentation, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Centrifugal Compressors (CSI 15685)

Typical compressors consist of a large split casing enclosing a shaft, with one or more impellers, coupled to an external drive motor. The suction side of the compressor casing is piped to the system evaporator, and the discharge side connects to the condenser. Some designs have additional piping to allow interstage circulation.

Impellers may be castings or fabricated units with rivets and weld beads. Bearings are usually split-sleeve construction or babbitted with steel backing. A common variation encloses the drive motor in the same housing as the compressor providing hermetic sealing.

Most systems include a variable position vane(s) mounted in the discharge piping to control compressor loading. (On hermetic systems, the vanes are enclosed in the compressor housing.) Vane position is varied in response to system temperature and pressure sensors. Newer systems employ variable speed drives, vanes, or a combination for control.

Bearing seals are critical on all centrifugal compressors, but especially on external drive units. Inadequate seals could allow refrigerant to escape to the atmosphere and/or air (non-condensable) and moisture infiltration. Common sealing devices include bellows or spring-loaded mechanical seals and labyrinth rings.

Bearing lubrication is provided with a oil sump and an integral oil pump, usually gear-driven off the compressor shaft. A separate, electric oil pump is usually provided for system start-up. There must be an oil heater (shut-down), cooler, and filter in the system.

Drive Assemblies (CSI 15170)

External drive units are typically joined with the compressor using a flexible, steel splined coupling(s) and/or a gear transmission. The latter is usually a single or double helical gear assembly.

Motors (CSI 15170)

Most motors for externally driven compressors are open AC induction motors, operating in a relatively narrow speed range. However, many older units employ resistance banks and rheostats to effect changes in motor speed to large DC motors. Modern units employ variable frequency controllers to modify motor speed. External drive motors are quite large and their bearings are usually lubricated with independent oilers.

Large units may employ independent fan-operated cooling systems to remove heat generated by the motor. Particular attention must be paid to air filtration on all external units.

Internal drive motors (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.

0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15885)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Condensers (CSI 15740)

Condensers in a centrifugal chilling plant serve to condense the high pressure refrigerant gas. In this process, the latent heat of evaporation 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.

Economizers (CSI 15660)

The evaporative section is separated from the condenser section by a metering device that controls refrigerant flow. This is typically a single float operating valve. When more than one float-operated valve is used in a separate chamber, it is called an economizer. The chamber is divided and a section is piped to an intermediate stage of the compressor. The low pressure connection allows partial flashing and subcooling of the refrigerant for improved system efficiency. Some systems may employ an orifice for metering control in lieu of the float valves.

Evaporators (CSI 15730)

Evaporators in a centrifugal chilling plant evaporate the low pressure refrigerant gas. In this process, the latent heat of evaporation 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. It 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 15660)

The purge system removes non-condensable gases that enter the refrigerant system through charging or 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. The system allowed a lot of refrigerant to escape during venting.

A recovery 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 recycling of refrigerant 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.

0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15885)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Piping & Fittings (CSI 15060)

Most centrifugal 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 ACR hard type copper tubing.

Chilled and condensed water piping are covered in separate sections of this manual

Instrumentation (CSI 15130)

Pressure gauges are typically provided for oil pressure, condenser pressure, evaporator pressure, and liquid refrigerant pressure in the economizer if included in the system.

Multiple temperature gauges are provided on the evaporator and condenser to determine the amount of subcooling and the presence of excessive non-condensable gases.

Ammeters and voltmeters are provided to monitor the system electrical load.

Equipment Controls & Panels (CSI 15950)

Centrifugal 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 loading is usually controlled by vane positioning in response to chilled water temperature. Demand limits are employed to restrict the load on the machine to some percentage (40, 60, 80%) of full load capacity.

Compressor cut-out 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

See the following subsections for related components:

NOTE. Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15685)

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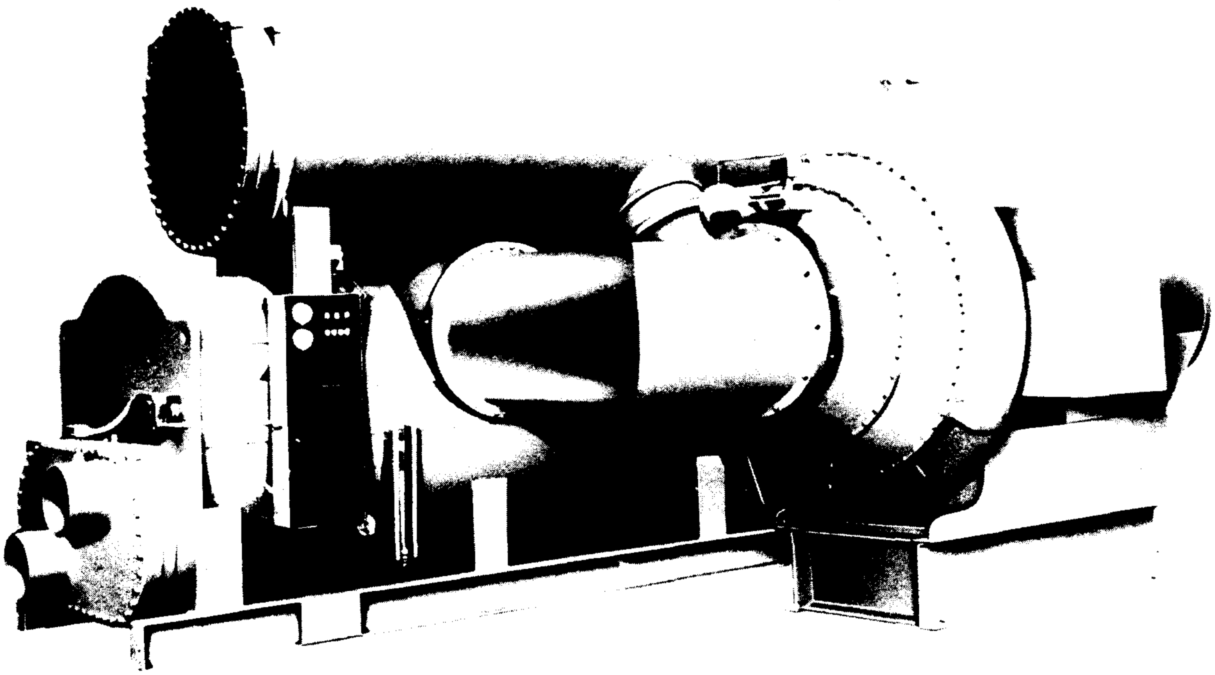
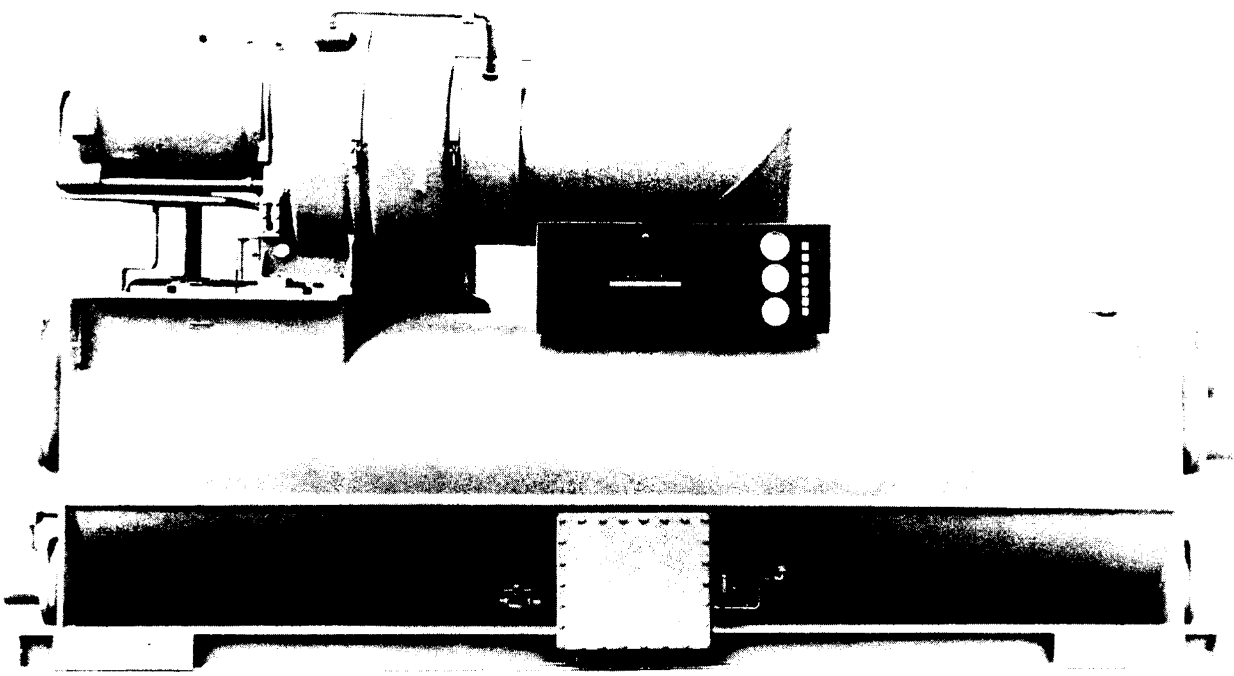


HERMETIC CENTRIFUGAL LIQUID CHILLER

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL CENTRIFUGAL CHILLER		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-1



HERMETIC CENTRIFUGAL LIQUID CHILLER (SOLID STATE CONTROLS)

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL CHILLER/ SOLID STATE CONTROLS		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-2

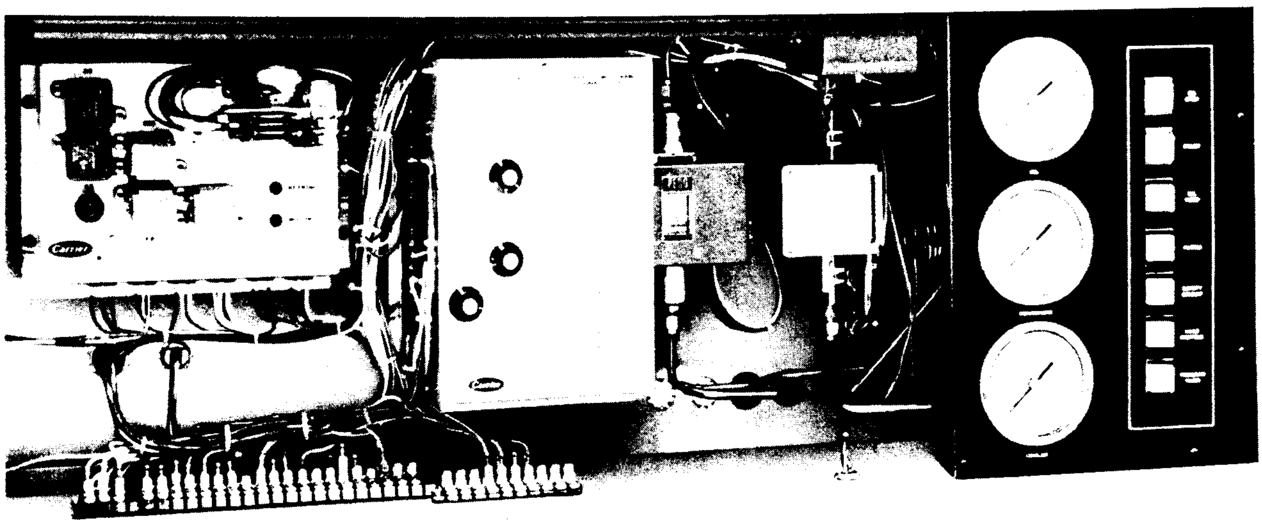


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	SOLID STATE CONTROL PANEL		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-3

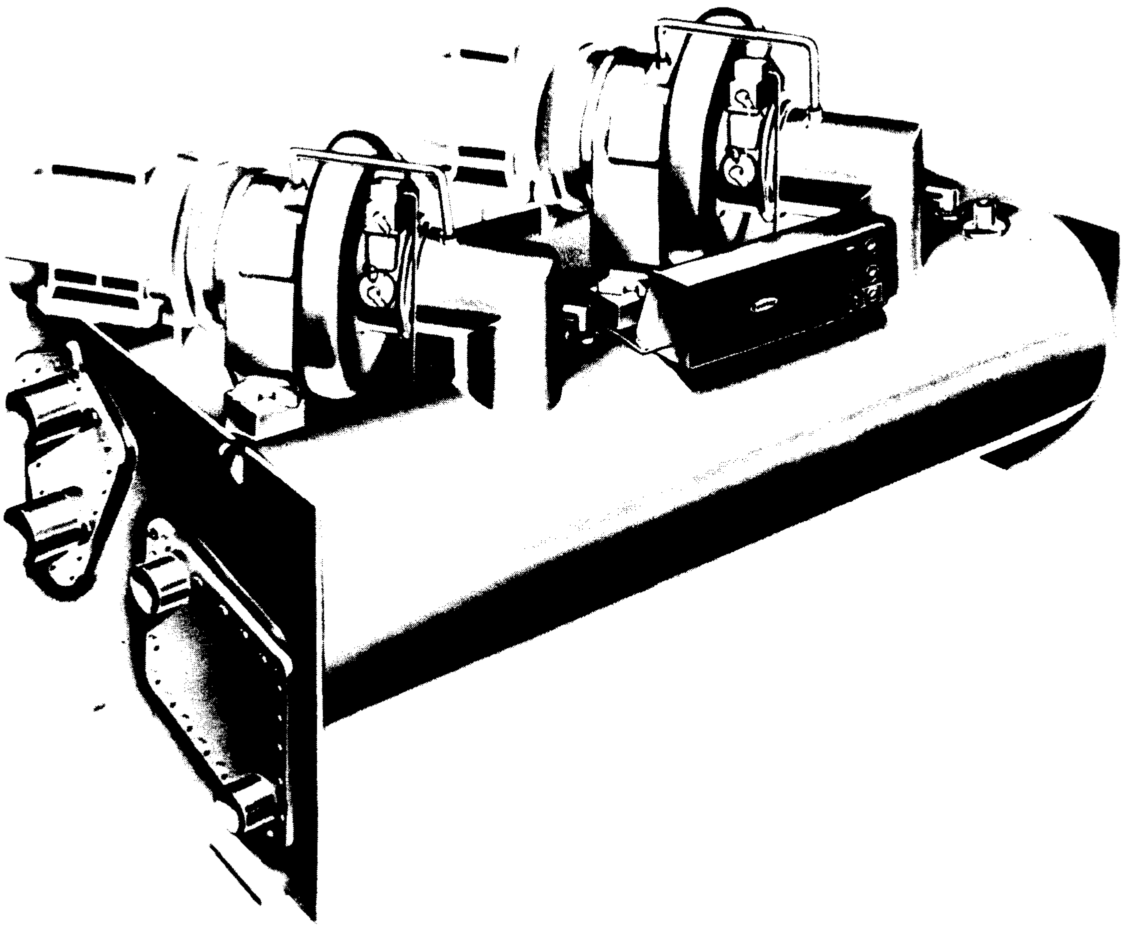


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL CHILLER WITH DUAL COMPRESSORS		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-4

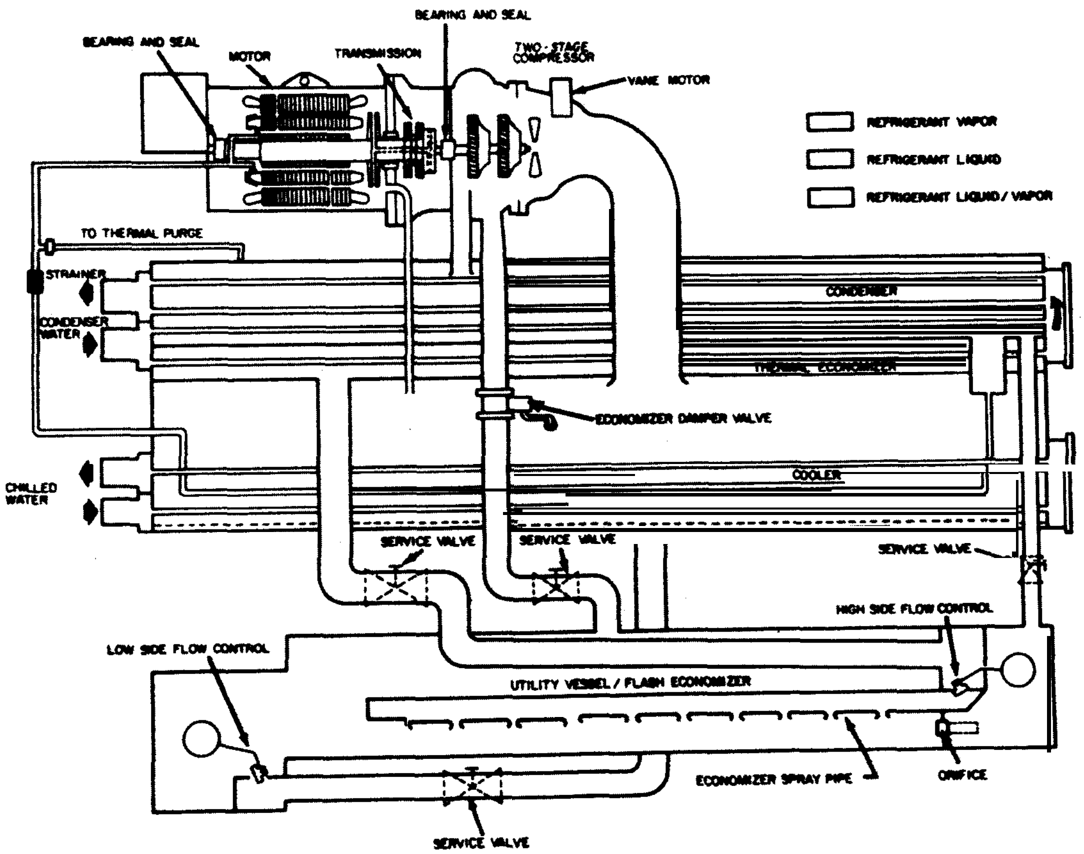
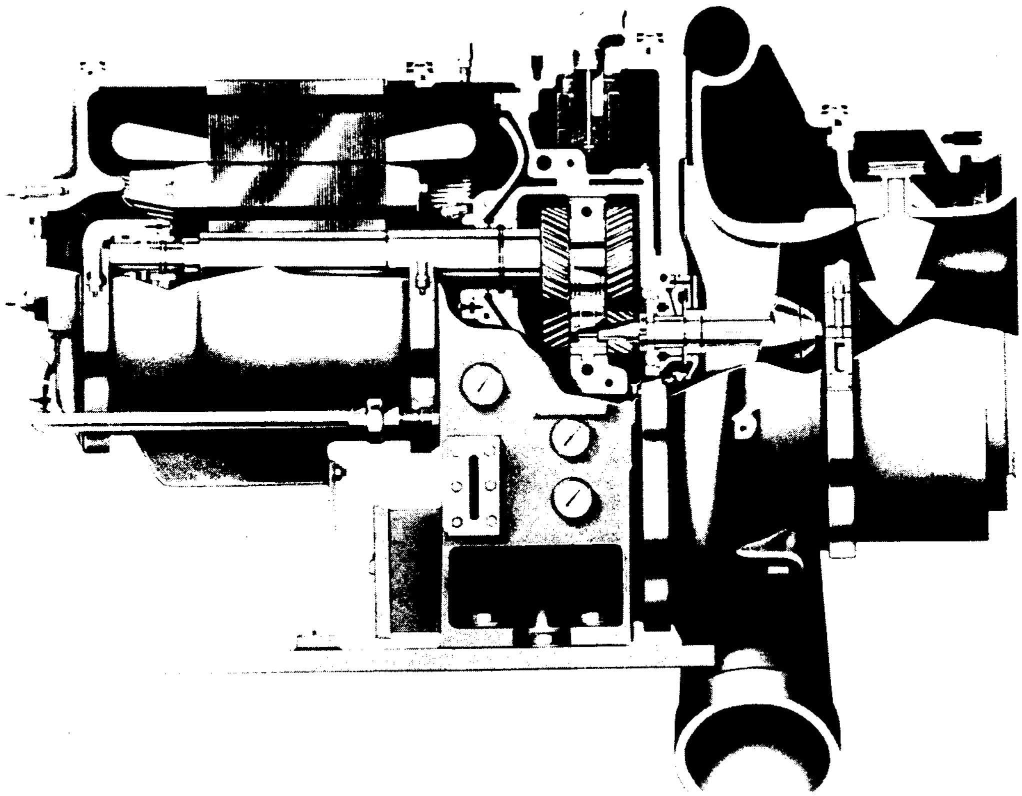


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	WATER FLOW THROUGH A CENTRIFUGAL CHILLER		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-5

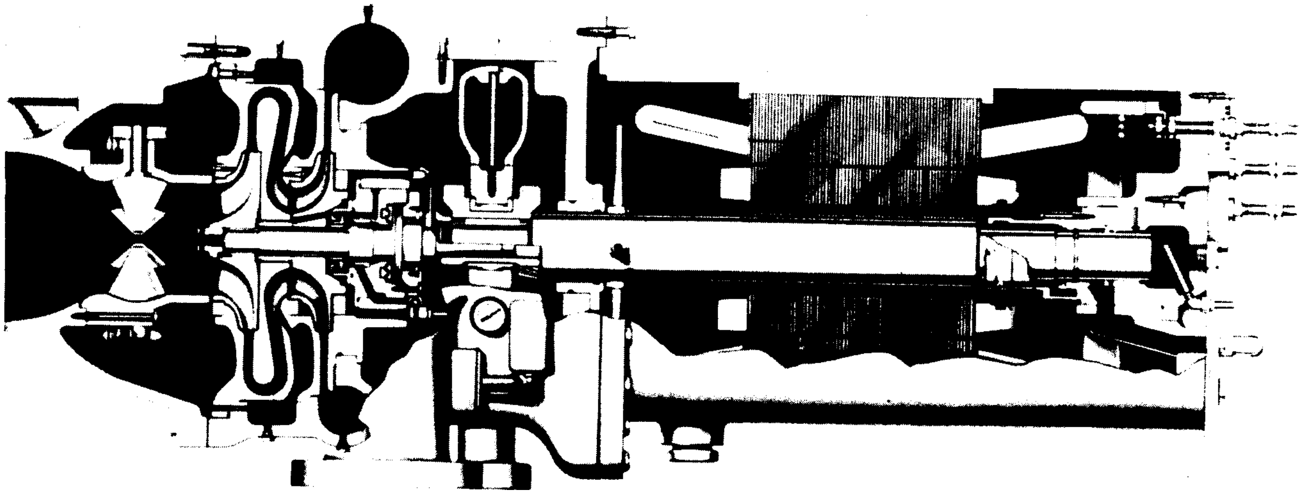


CENTRIFUGAL COMPRESSOR

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF TYPICAL CENTRIFUGAL COMPRESSOR		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-6



HERMETIC CENTRIFUGAL COMPRESSOR

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF HERMETIC CENTRIFUGAL COMPRESSOR		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-7

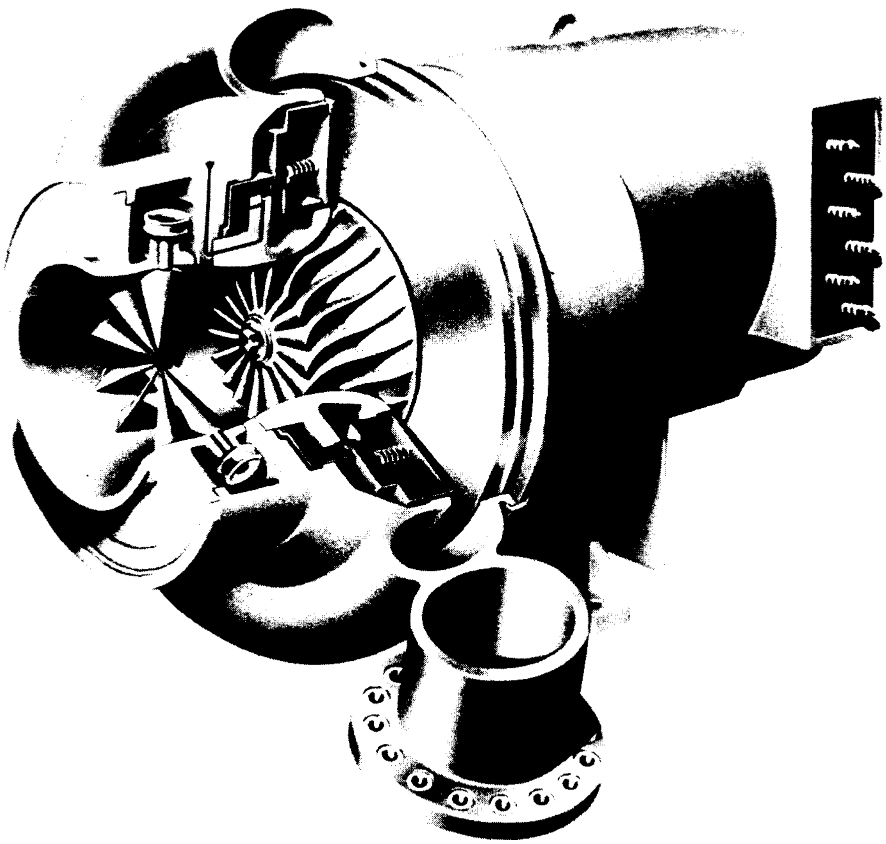


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF CENTRIFUGAL COMPRESSOR		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-8

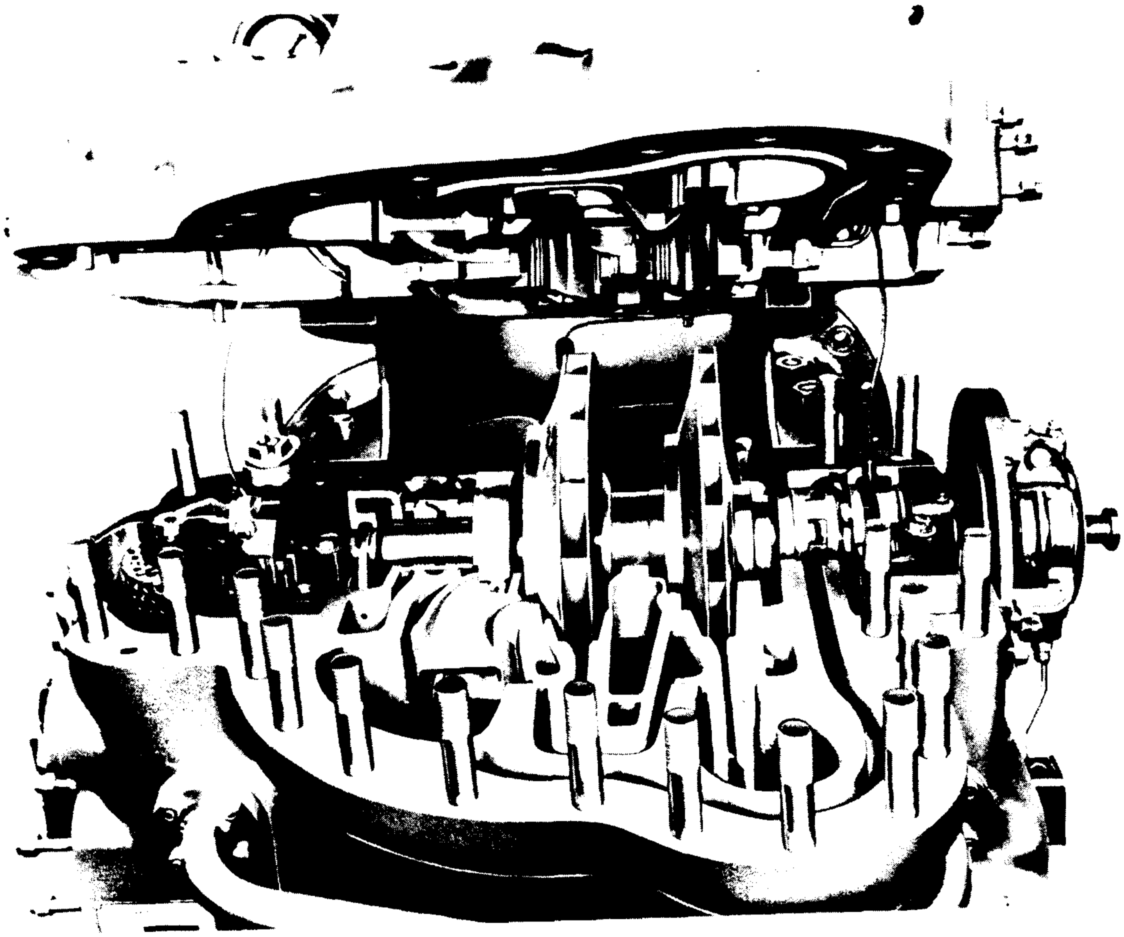


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF MULTISTAGE CENTRIFUGAL COMPRESSOR		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-9

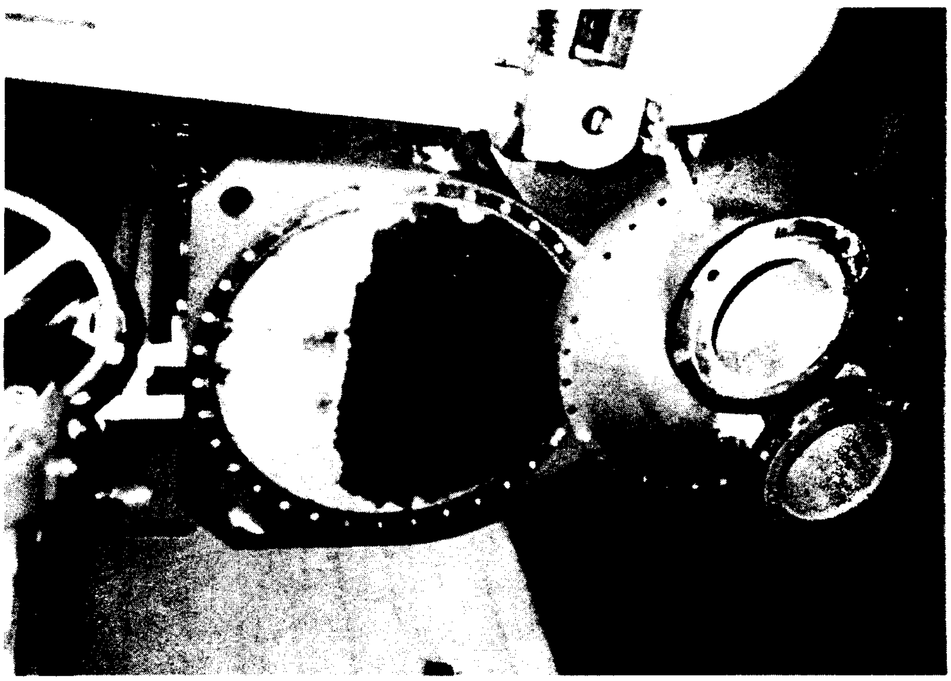


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CHILLER WITH CONDENSER TUBES EXPOSED FOR MAINTENANCE		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-10

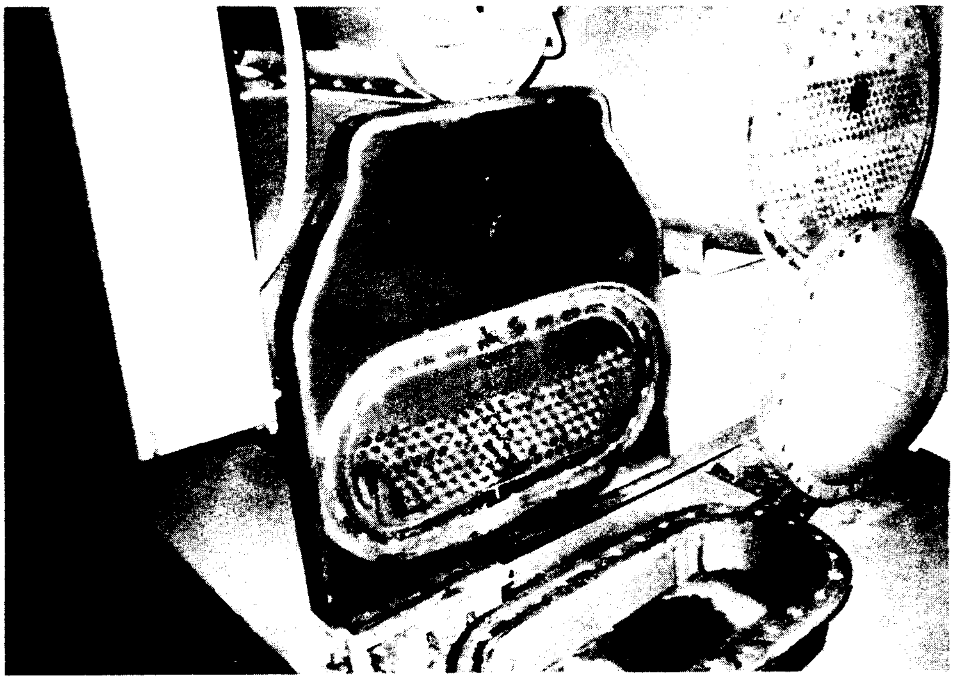


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CONDENSER AND EVAPORATOR TUBES EXPOSED FOR MAINTENANCE		
COOLING-CENTRIFUGAL CHILLERS (CSI 15685)	Revision No.	Issue Date 5/93	Drawing No. A080401-11

DEFICIENCY FACTORS
0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15685)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; ruptured disk due to over-pressurization, condenser fouling.
- Bearing failure caused by loss of oil pressure due to compressor wear, lubrication system blockage, overheated oil.
- Tube failure in Heat Exchanger due to thermal stress, tube fouling.
- Motor failure caused by insulation deterioration due to excessive moisture, overloaded windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Compressors

Inoperative, Will Not Turn:	Failed bearings, locked rotor.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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 Assemblies

Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, gear imbalance, misalignment.
Excessive Corrosion:	Poor maintenance.
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 Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.

DEFICIENCY FACTORS
0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15885)

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors (Continued)	
Damaged :	Abuse, poor maintenance, stress.
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 or Head Excessive Corrosion:	Poor maintenance.
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.
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 or Head Excessive Corrosion:	Poor maintenance.
Insulation Wet, Damaged or Missing:	Environment, leaks, poor maintenance.
purge System	
Compressor Missing:	Taken out for service, not returned.
Compressor Inoperative, Will Not 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:	Aging, 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:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

DEFICIENCY FACTORS
0.08.04.01 CENTRIFUGAL CHILLERS (CSI 15685)

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping **& Fittings** (Continued)

Improper Wall Penetration:	Missing seals, flanges, escutcheons.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

DEFICIENCY FACTORS
0.08.04.01 CENTRIFUGAL CHILLERS (CSI 158851

END OF SUBSECTION

0.08.04.02 ABSORPTION CHILLERS (CSI 15880)

DESCRIPTION

An Absorption Chiller System removes heat from its associated chilled water system and rejects that heat to an associated condenser water system. It uses water as the primary refrigerant and employs an absorbent as a secondary fluid. Unlike a reciprocating system or centrifugal unit, it uses a physiochemical process and employs little mechanical energy.

The typical system consists of an evaporator, absorber, generator, condenser, pumps, piping and fittings, valves, instrumentation, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Evaporators (CSI 15730)

Evaporators (coolers) in an absorption chilling plant evaporate the low pressure refrigerant (water). In this process, the latent heat of evaporation is conducted from the chilled water circuit.

Most evaporators are shell and tube (water vapor to water) heat exchangers. To facilitate the evaporative process, incoming refrigerant is passed through spray nozzles to break up the fluid and increase the heat transfer surface area. The bottom of the evaporator serves as a collection basin and source for recycled refrigerant. Makeup water comes from a condenser return pipe.

The evaporator heads are usually designed for easy removal to permit routine inspection and cleaning. A common arrangement places the evaporator in the same shell as the absorber.

Evaporators are usually insulated with fiberglass to prevent condensation and improve efficiency.

Absorbers (CSI 15880)

Absorbers absorb the low pressure refrigerant (water vapor). In this process, the partial pressure of the refrigerant in the absorber is lowered, maintaining the vacuum required to maintain heat transfer (evaporation) slightly below the desired chilled water temperature.

Most absorbers are shell and tube (solution to water) heat exchangers. To facilitate the absorption process, incoming solution (strong solution) is passed through spray nozzles to break up the fluid and increase the absorptive surface area. As the strong solution absorbs water vapor, it passes over the absorber tubes where it is cooled by the condenser water therein.

The absorber heads (or tube bundles) are usually designed for easy removal to permit routine inspection and cleaning. A common arrangement places the evaporator in the same shell as the absorber.

Absorbers are usually insulated with fiberglass to prevent condensation and improve efficiency.

Generators (CSI 15880)

Generators (concentrators) in an absorption chilling plant reconcentrate the weak absorption fluid, driving off the water vapor. In this process, the latent heat of evaporation is provided by an external heat source. In most applications this is low pressure exhaust steam or other waste heat source, but may be an independently fired unit.

Most generators are shell and tube (steam to solution) heat exchangers. The generator heads (or tube bundle) are usually designed for easy removal to permit annual cleaning. Rupture disks are generally included where the heat source is hot water, high pressure steam or are direct fired units.

Condensers (CSI 15740)

Condensers in an absorption chilling plant condense the primary refrigerant vapor produced by the generator and return it to the evaporator for reuse. In this process, the latent heat of evaporation is conducted to the condenser water circuit.

0.08.04.02 ABSORPTION CHILLERS (CSI 158801

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Condensers (CSI 15740) (Continued)

Most condensers are shell and tube (water vapor to water) heat exchangers. The condenser heads (tube bundles) are usually designed for easy removal to permit annual cleaning. 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.

Pumps (CSI 15540)

There are two or three pumps in every large absorption chiller plant. Because of problems with air entrainment, all pumps are typically hermetic units, enclosing the motor in the pump housing. All pumps are centrifugal.

The refrigerant pump is used to cycle the refrigerant from the evaporator catch basin to the spray nozzles.

The solution pump receives strong solution from the generator and discharges to the absorber spray nozzles. In some installations this function is split into two, using a solution pump to recycle the weak solution between absorber catch basin and nozzles, and another (concentrator pump) to send a small percentage of the weak solution to the generator (concentrator).

Motors (CSI 15170)

Most motors for refrigerant and solution pumps are direct-drive AC induction motors.

Purge System (CSI 15650)

The purge system removes non-condensable gases that enter the refrigerant system through charging or through leaks during normal low pressure operations.

A typical system consists of a small reciprocating or vane air compressor and controls. The compressor removes the gases from the top of the main condenser and discharges them to the atmosphere.

Piping & Fittings (CSI 15060)

Most absorption chiller plants are either packaged systems or have the major components located close to one another. There is little refrigerant piping, simply the pump piping and major component connections.

Chilled and condenser water and steam and condensate piping are covered in separate sections of this manual.

Valves (CSI 15100)

Valving is primarily used for load control and to isolate components for maintenance.

Load control is generally accomplished by moderating the amount of weak solution recycle to the generator (concentrator) and/or by moderating the concentration effect (changing the heating input in the concentrator). These are easily implemented with motor controlled valves or solenoid valves. Valving is also used to control the return rate of refrigerant from the condenser to the evaporator.

Instrumentation (CSI 15130, 15150)

Vacuum gauges are typically provided at various location on the absorption chiller to show status in the evaporator, absorber, condenser, and generator.

Temperature gauges are provided on the chilled water and condenser water lines, the weak and strong solution lines, and on the evaporator.

0.08.04.02 ABSORPTION CHILLERS (CSI 15680)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Equipment Control8 & Panel8 (CSI 15950)

Absorption chiller systems usually include a master panel for all instrumentation and controls.

System load control generally employs chilled water temperature sensors to moderate the position of the heat source control valves or operation of generator burner controls. Demand lir liters are frequently installed to restrict unit capacity.

Gas-fired units should have a high temperature limit switch.

Low chilled water temperature cutouts are employed to prevent water freezing.

Low evaporator refrigerant level cutouts are required.

Flow control interlocks are typical in the chilled water and condenser water circuits.

Solution concentration sensors are employed to limit the capacity of the absorber, generator, or both to prevent the absorbent crystallizing.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.04.02 ABSORPTION CHILLERS (CSI 15880)

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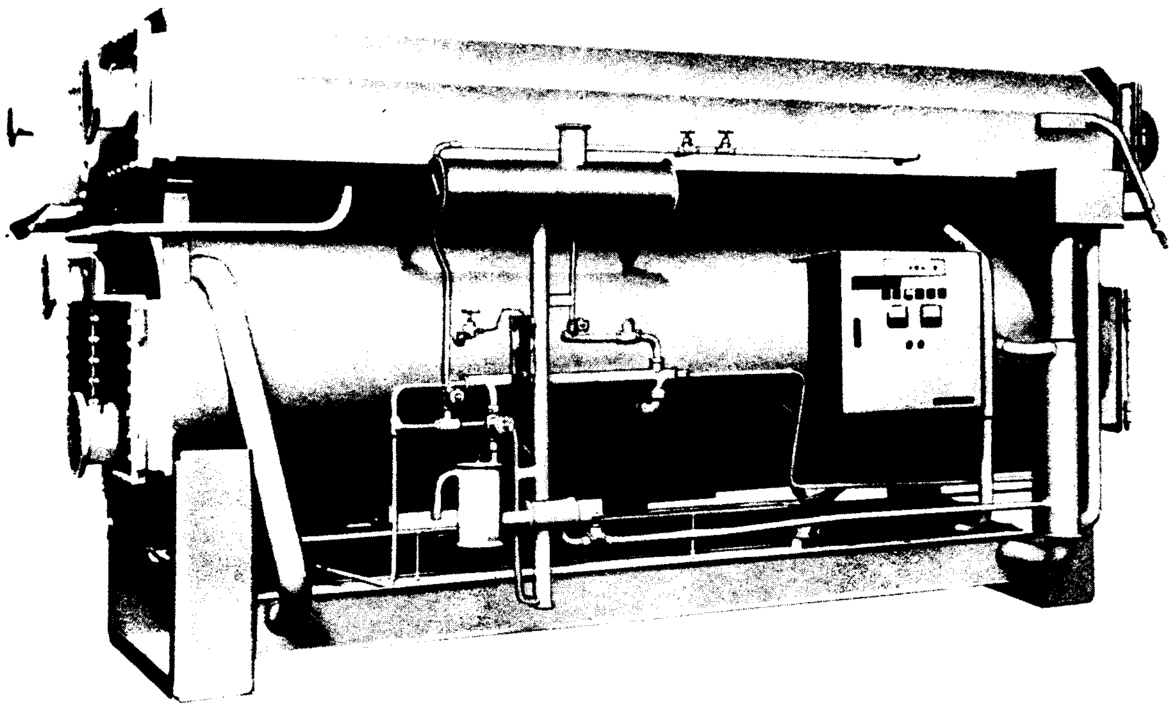

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ABSORPTION CHILLER		
COOLING-ABSORPTION CHILLERS (CSI 15680)	Revision No.	Issue Date 5/93	Drawing No. A080402-1

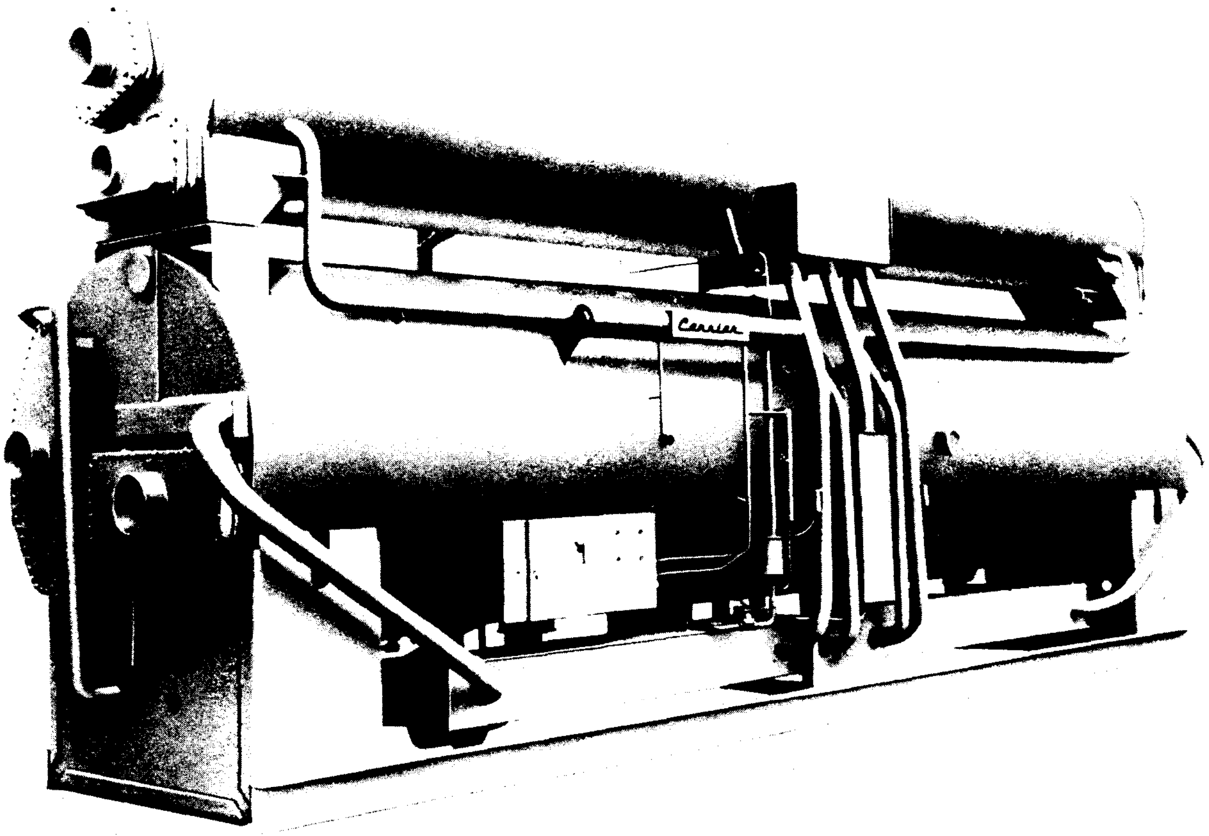

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL ABSORPTION CHILLER		
COOLING-ABSORPTION CHILLERS (CSI 15680)	Revision No.	Issue Date 5/93	Drawing No. A080402-2

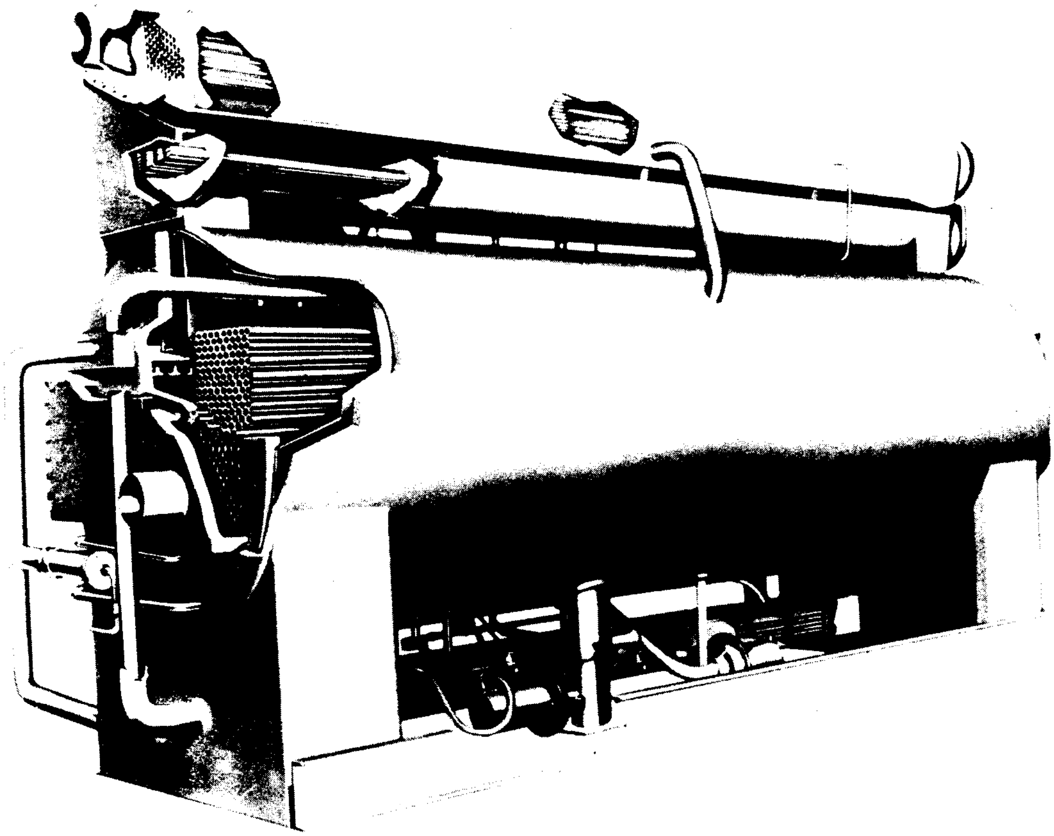

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	ABSORPTION CHILLER WITH CUTAWAY VIEW OF TUBES		
COOLING-ABSORPTION CHILLERS (CSI 15680)	Revision No.	Issue Date 5/93	Drawing No. A080402-3

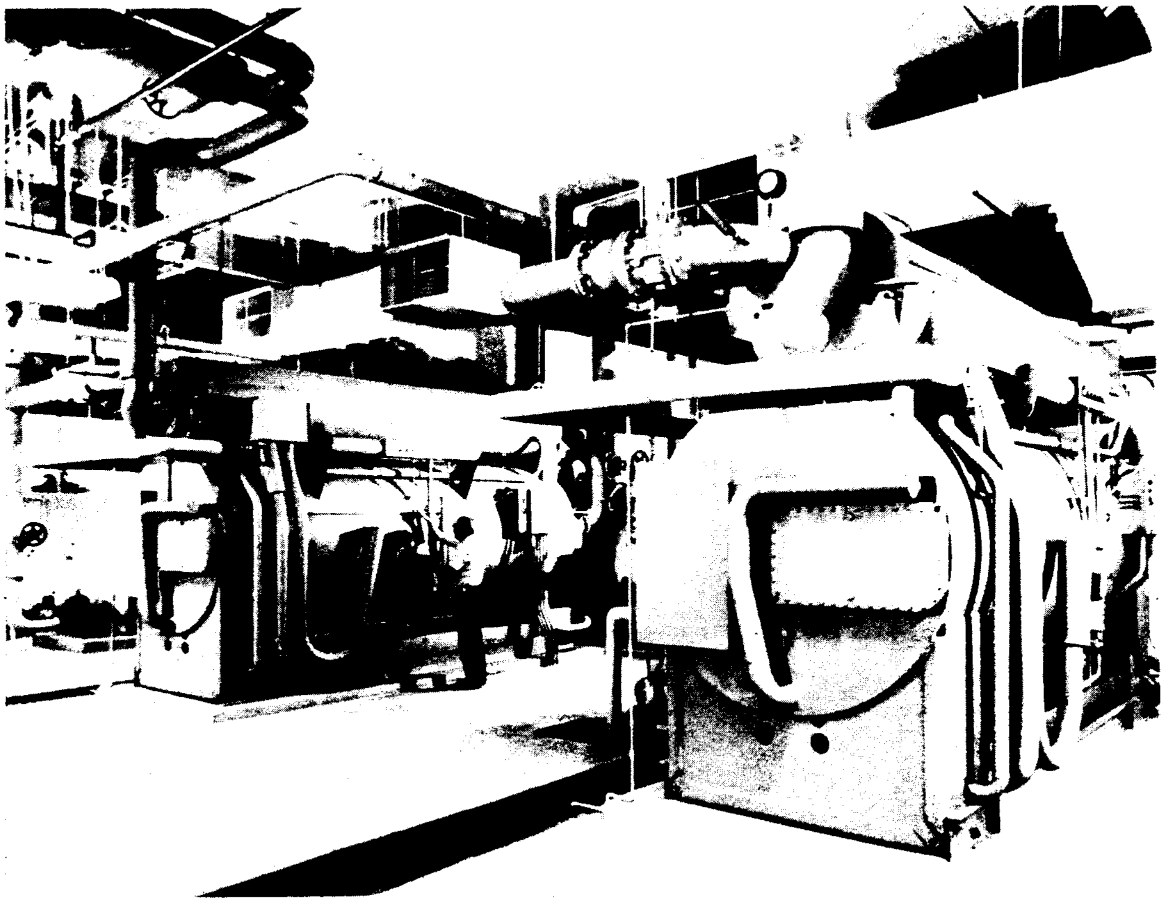

PHOTO ILLUSTRATION

SOURCE: COURTESY a UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL CHIILED WATER PLANT USING ABSORPTION CHILLERS		
COOLING-ABSORPTION CHILLERS (CSI 15680)	Revision No.	Issue Date 5/93	Drawing No. A080402-4

DEFICIENCY FACTORS
0.08.04.02 ABSORPTION CHILLERS (CSI 15680)

PROBABLE FAILURE POINTS

- **Absorbent crystallization** due to concentration limiter failure, primary refrigerant leakage.
- Tube failure in heat exchanger due to thermal stress, tube fouling.

SYSTEM ASSEMBLIES/DEFICIENCIES

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 or Head Excessive Corrosion:	Poor maintenance.
Spray Nozzle Damage:	Blockage by corrosion, nozzle erosion.
Leakage:	Damaged seals, corrosion.
Insulation Wet, Damaged or Missing:	Leaks, environment, poor maintenance.

Absorbers

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 or Head Excessive Corrosion:	Poor maintenance.
Spray Nozzle Damage:	Blockage by corrosion, nozzle erosion.
Leakage:	Damaged seals, corrosion.
Insulation Wet, Missing, Damaged:	Leaks, environment, poor maintenance.

Generators

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 or Head Excessive Corrosion:	Poor maintenance.
Leaking Rupture Disk:	Over-pressurization, vibration.
Leakage:	Damaged seals, corrosion.
Insulation Wet, Damaged, or Missing:	Leaks, environment, poor maintenance.

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 or Head Excessive Corrosion:	Poor maintenance.
Leakage:	Damaged seals, corrosion.

DEFICIENCY FACTORS
0.08.04.02 ABSORPTION CHILLERS (CSI 15880)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.

Motors

Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.

Purge System

Compressor Missing:	Taken out for service, not returned.
Compressor Inoperative, Will Not 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:	Aging, lack of maintenance.
System Leakage:	Worn mechanical seal, defective packing.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.

DEFICIENCY FACTORS
0.08.04.02 ABSORPTION CHILLERS (CSI 15680)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Corrosion:	Contamination, 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.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

DEFICIENCY FACTORS
0.08.04.02 ABSORPTION CHILLERS (CSI 158801

END OF SUBSECTION

0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15883)

DESCRIPTION

A Packaged Reciprocating Chiller System removes heat from its associated chilled water system and rejects it to an integral, air-cooled condenser water system. It employs a refrigerant compression and expansion cycle where the compressive force is supplied by a reciprocating device similar to a large, multi-stage piston air compressor. The typical system consists of one or more reciprocating compressors, motors, a condenser, an evaporator and the connecting piping, fittings, instrumentation, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Housing (CSI 15780)

The packaged reciprocating chiller is usually installed as a self-contained unit in a single enclosure. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The housing is lined with insulation for noise abatement. The unit is typically mounted on a concrete pedestal with vibration eliminators.

Reciprocating **Compressors** (CSI 15883)

Typical compressors consist of a large split casing enclosing a shaft, with one or more pistons, coupled to an external drive motor. The suction side of the compressor is piped to the system evaporator, and the discharge side connects to the condenser. Some designs have additional piping to allow interstage cooling.

The upper half (head) of the casing contains the suction and discharge valves, which control the pumping action of the compressor. A variation places the suction valves in the top of the pistons. The lower half (block) forms the cylinders and holds the crankshaft and pistons. The cylinder frequently contains replaceable liners. A common variation encloses the drive motor in the same housing as the compressor to provide hermetic sealing.

Bearings are typically steel-backed babbitt.

Bearing lubrication is provided by a splash or flooded system in small packaged system. In larger systems, especially where the components may be some distance apart, lubrication is force-fed with an oil sump and an integral oil pump, which is usually gear-driven off the compressor shaft. An oil heater usually minimizes refrigerant entrainment during system shutdown.

Compressor capacity control varies depending on size. Small units employ on-off system cycling. Medium systems include multiple compressors and cycle these units as needed. Larger units employ unloading devices that hold the suction valves open or recycle some of the discharge gas to the suction. Other variations include varying clearances and speeds.

Air-Cooled Condensera (CSI 15740)

Condensers in a reciprocating chilling plant condense the high pressure refrigerant gas. In this process, the latent heat of evaporation is conducted to surrounding air.

Packaged reciprocating chillers usually employ an air-cooled condenser, eliminating the need for a condenser water circuit. These units are fan-cooled, finned tube (gas to air) heat exchangers.

Fans are typically cycled/staged to control condenser head pressure.

Evaporators (CSI 15730)

Evaporators (coolers) in a reciprocating chilling plant evaporate the low pressure refrigerant gas. In this process, the latent heat of evaporation is conducted from the chilled water circuit.

Most evaporators are shell and tube (gas to water) heat exchangers. Direct expansion units are usually used in reciprocating systems. In these, the refrigerant liquid evaporates in the tubes versus outside.

0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15683)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Evaporators (CSI 15730) (Continued)

Evaporators are usually insulated with fiberglass to prevent condensation and improve efficiency.

Motors (CSI 15170)

Packaged systems generally employ hermetic or semi-hermetic systems in which the motor is enclosed in the compressor housing. Small open AC motors are typically used to drive the air-cooled condenser fans.

Piping & Fittings (CSI 15050)

Packaged reciprocating chiller plants have the major components located close to one another. There is little refrigerant piping, simply the compressor to condenser and evaporator connections. Hot gas bypasses are sometimes installed between the compressor suction and discharge.

Typical fittings include liquid line filter dryers, sight glass, and moisture indicators. Piping for refrigerant controls and indicators is typically type ACR hard tubing. All suction piping should be insulated.

Chilled and condenser water piping are covered in separate sections of this manual.

Valves (CSI 15100)

Valving is primarily used for load control and to isolate components for maintenance.

The primary valve in any direct expansion system is the thermal expansion valve. It controls liquid refrigerant metering into the evaporator. The valve is usually backed up by a liquid line solenoid valve and a manual shutoff. These allow pumping the unit down and isolating the evaporator or condenser for maintenance.

Each compressor usually has manual isolation valves at both the suction and discharge. A hot gas bypass valve is sometimes installed between the compressor suction and discharge to allow operation of the unit below the minimum step of unloading.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the condenser, evaporator, and oil pressure. Temperature gauges are provided for chilled water.

Equipment Controls & Panels (CSI 15950)

Chiller systems usually include a master panel for all instrumentation and controls.

Compressor control is performed via a motor assembly (motor, starter, and disconnect). Compressors frequently have oil pressure limits interlocked with the starter that can trip compressor operation.

Compressor loading is usually controlled by suction valve positioning in response to chilled water temperature and/or staging of compressors. Demand limiters are employed to restrict the load on the machine to some percentage (40, 60, 80%) of full load capacity.

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.

0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15683)

OTHER RELATED COMPONENTS

See the following subsection for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.04.03 PACKAGED RECIPROCATING CHILLERS **(CSI 156831**

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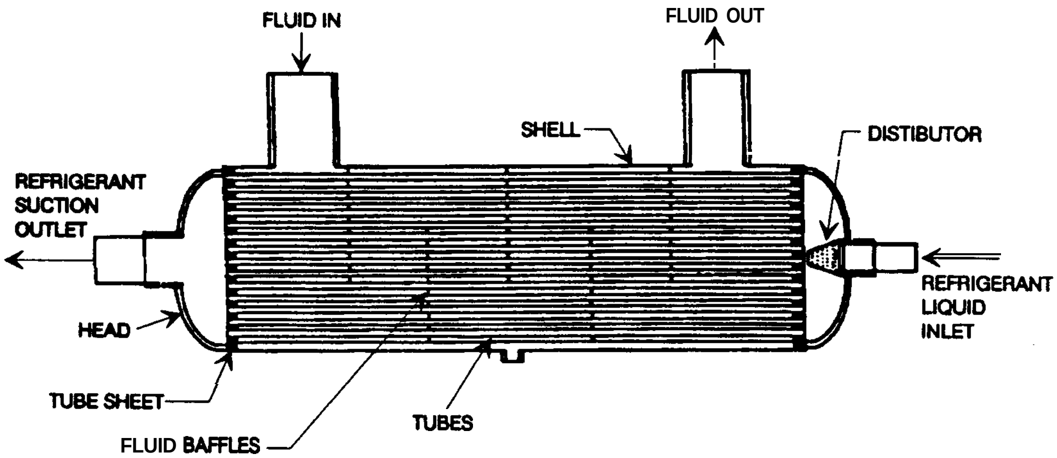
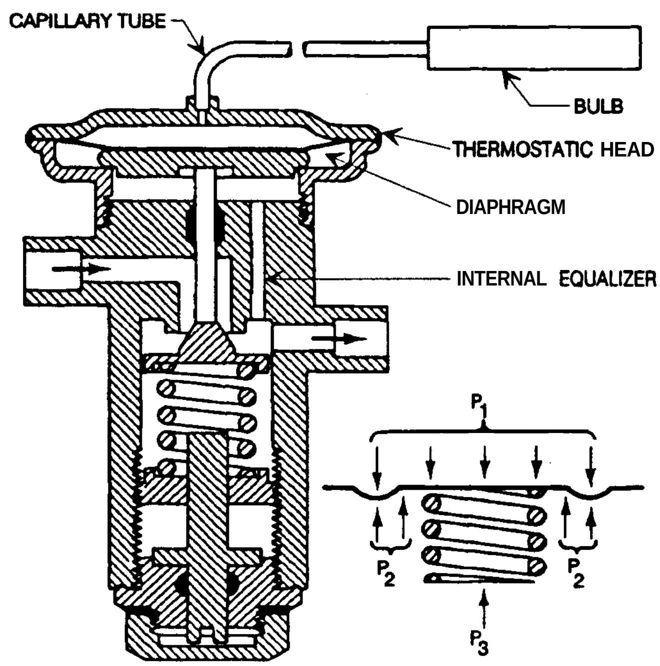


SOURCE: ASHRAE, 1988 ASHRAE HANDBOOK, EQUIPMENT

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DIRECT-EXPANSION SHELL-AND-TUBE COOLER		
COOLING-PACKAGED **RECIPRO-** CATION CHILLERS **(CSI** 15683)	**Revision** No.	Issue Date 5/93	Drawing No. A080403-1



P1 - THERMOSTATIC ELEMENT-S VAPOR PRESSURE

P2 -EVAPORATOR PRESSURE

P3 - PRESSURE EQUIVALENT OF THE SUPERHEAT SPRING FORCE

(COURTESY, ASHRAE)

SOURCE: AIR-CONDITIONING AND REFRIGERATION INSTITUTE, REFRIGERATION AND AIR-CONDITIONING

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	DIAPHRAGM TYPE THERMOSTATIC EXPANSION VALVE		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	Issue Date 5/93	Drawing No. A080403-2

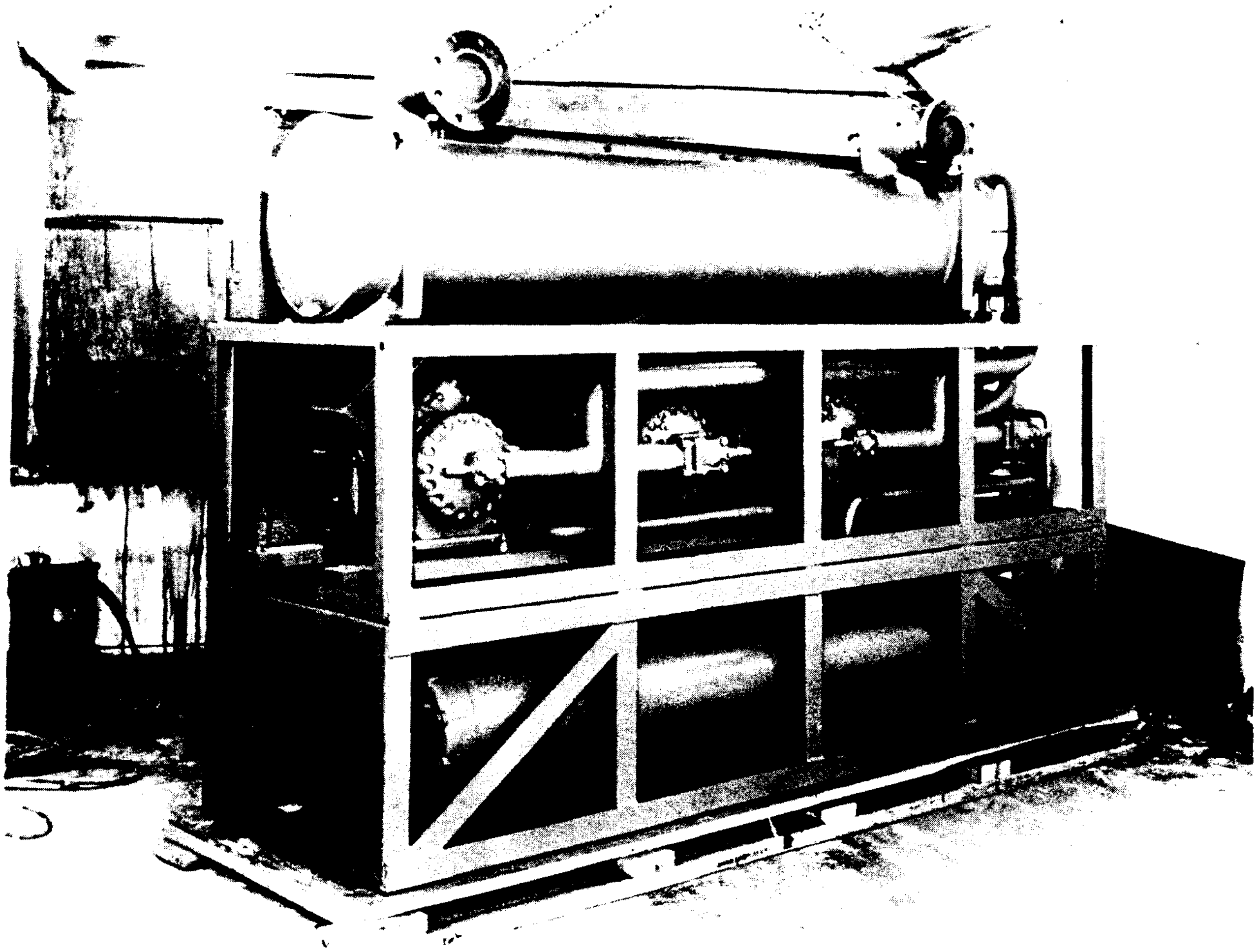


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL PACKAGED RECIPROCATING CHILLER ASSEMBLY		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	Issue Date 5/93	Drawing No. A080403-3

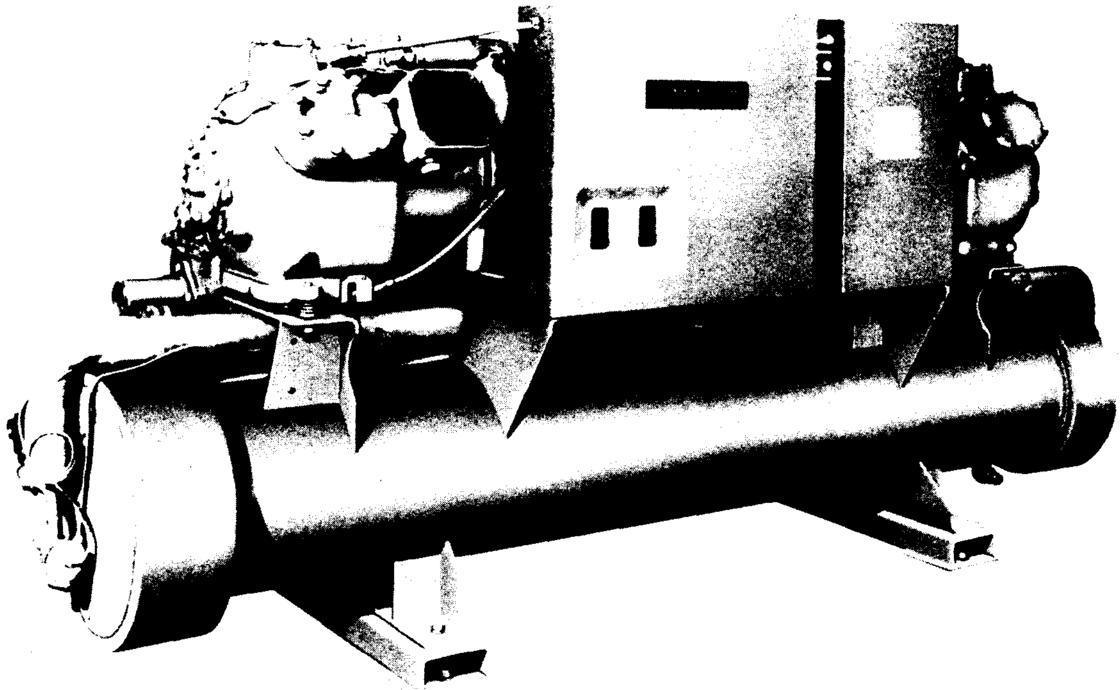


PHOTO ILLUSTRATION

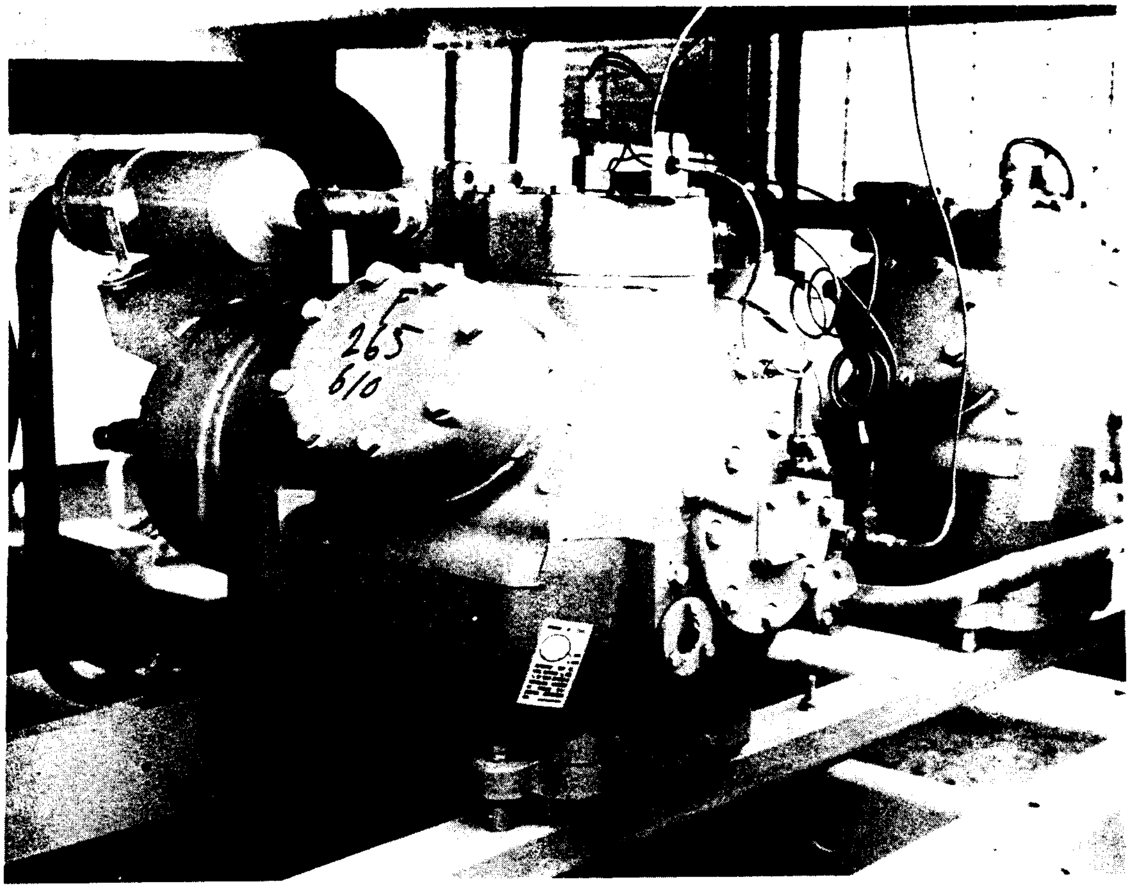
SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PACKAGED RECIPROCATING CHILLER		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	Issue Date 5/93	Drawing No. A080403-4

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	RACK MOUNTED COMPRESSOR FOR A PACKAGED RECIPROCATION CHILLER		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	Issue Date 5/93	Drawhg No. A080403-5



NOTE: VIBRATION ISOLATORS ON MOUNTING AND OIL LEVEL VIEW GLASS

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL RECIPROCATING COMPRESSOR PACKAGED RECIPROCATION CHILLER		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	Issue Date 5/93	Drawing No. A080403-6

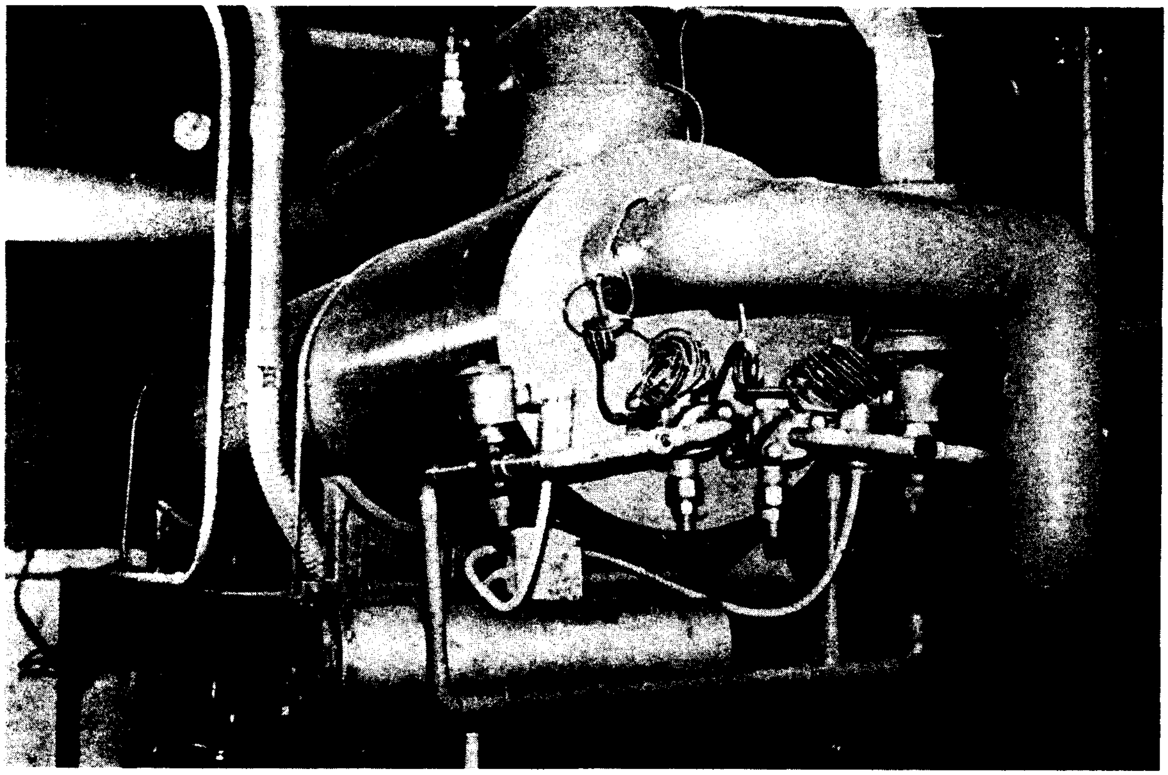


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	EVAPORATOR		
COOLING-PACKAGED RECIPRO-CATION CHILLERS (CSI 15683)	Revision No.	issue Date 5/93	Drawing No. A080403-7

DEFICIENCY FACTORS
0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15683)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; relief failure due to over-pressurization, condenser fouling.
- Bearing failure caused by loss of oil pressure due compressor wear, lubrication system blockage, overheated oil.
- Tube failure in heat exchanger due to thermal stress, fouling of tubes.
- Motor failure caused by insulation deterioration due to excessive moisture, overloaded windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Housing	
Severe Corrosion:	Normal aging, wear, environment, poor maintenance.
Physical Damage:	Missing covers, access plates; defective dampers.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Insulation:	Wet, missing, damaged.
Reciprocating Compressors	
Inoperative, Will Not Turn:	Failed bearings, locked crankshaft.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.
Oil Filter Inadequate:	Missing, damaged.
Air **Cooled Condensers**	
Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin damage.
Excessive Corrosion:	Poor maintenance, local environment.
Leakage:	Defective seals, corrosion.
Fan Inoperative:	Corrosion, defective controls, poor maintenance.
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.
Excessive Corrosion:	Poor maintenance, local environment.
Leakage:	Defective seals, corrosion.

DEFICIENCY FACTORS
0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15883)

SYSTEM ASSEMBLIES/DEFICIENCIES

Evaporators (Continued)

insulation Wet, Missing, Damaged:	Leaks, environment, poor maintenance.

Motors

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

piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
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, 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.

Instrumentation

Missing:	Taken out for service or repair and 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
0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15663)

SYSTEM ASSEMBLIES/DEFICIENCIES

Equipment Control8 **&** Panels

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

DEFICIENCY FACTORS
0.08.04.03 PACKAGED RECIPROCATING CHILLERS (CSI 15683)

END OF SUBSECTION

0.08.04.04 PACKAGED HVAC UNITS (CSI 15780)

DESCRIPTION

A Packaged HVAC System provides heating, cooling, and ventilation functions in a single package, incorporating the heating and cooling sources in the same housing. The unit circulates tempered air through the controlled building space and does not have external refrigeration lines or chilled water circuits. This arrangement is classified as a year-round single package unitary air conditioner by ASHRAE. Units are installed either directly in the conditioned space or on the rooftop immediately above the space.

The typical system consists of the housing, one or more reciprocating compressors, a condenser, an evaporator, a main blower, a heating source, a filtration unit, motors and the connecting ductwork, piping, fittings, instrumentation, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Housing (CSI 15780)

The packaged HVAC unit is usually installed as a self-contained unit in a single enclosure. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The housing is lined with insulation for noise abatement, and in the evaporator compartment, to control heat gain or loss. The unit is typically mounted on a concrete pedestal with vibration eliminators. The housing may incorporate manual or motorized dampers to control outside air intake.

Reciprocating Compressors (CSI 15883)

Typical compressors are hermetic or semi-hermetic reciprocating units.

Bearing lubrication is provided by a splash or flooded system. Semi-hermetic units have a bulls-eye for oil level indication.

Compressor capacity control varies depending on size. Single hermetic compressor systems employ system on-off cycling. Medium systems include multiple compressors and cycle these units as needed. Larger, semi-hermetic units employ unloading devices that hold the suction valves open or recycle some of the discharge gas to the suction. Other variations include varying clearances and speeds.

Air-Cooled Condensers (CSI 15740)

Condensers in a packaged HVAC unit condense the high pressure refrigerant gas. In this process, the latent heat of evaporation is conducted to surrounding air.

This units employ an air-cooled condenser, eliminating the need for a condenser water circuit. These units are usually fan cooled, finned tube, gas to air heat exchangers.

Condenser fans are typically cycled/staged to control condenser head pressure.

Evaporators (CSI 15730)

Evaporators (coolers) serve to evaporate the low pressure refrigerant gas. In this process the latent heat of evaporation is conducted from the conditioned air.

Most evaporators are finned tube (gas to air) heat exchangers. Direct expansion units are usually used with a thermal expansion valve.

Main Blower (CSI 15880)

Centrifugal fans, typically squirrel cage units, are used to circulate air through the evaporator coil, heater, and the conditioned space. These units may be direct driven (smaller units) or connected through V-belts. Many installations will incorporate several fans on a common shaft.

0.08.04.04 PACKAGED HVAC UNITS (CSI 15780)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Heaters (CSI 15620)

The simplest heaters employed are in-duct electric resistance units, common when the HVAC unit is located indoors.

Outdoor units will frequently use a gas- or oil-fired heater. They may be natural draft units or incorporate an independent combustion air fan.

Filtration Unit (CSI 15885)

Circulated air is normally filtered inside the HVAC unit. Prefabricated, throwaway, media filters are used in most installations. Special applications may call for bag or HEPA filters. Automated roll filters are rarely used.

Motors (CSI 15170)

Packaged systems generally employ hermetic or semi-hermetic systems in which the motor is enclosed in the compressor housing.

An open AC induction motor with V-belts is normally used to drive the main blower (evaporator fan). Small, open, direct-drive, AC motors are typically used to drive the air-cooled condenser fans as well as combustion air fans.

Piping & Fittings (CSI 15060)

Packaged HVAC units have all major components located close to one another. There is little refrigerant piping, simply the compressor to condenser and evaporator connections. Hot gas bypasses are sometimes installed between the compressor suction and discharge. Typical fittings include liquid line filter dryers, sight glass, and moisture indicators.

Piping for refrigerant controls and indicators is typically type ACR hard tubing. All suction piping should be insulated.

Chilled and condenser water piping are covered in separate sections of this manual.

Valves (CSI 15100)

Valving is primarily used for load control and to isolate components for maintenance.

The primary valve in any direct expansion system is the thermal expansion'valve. It controls liquid refrigeraht metering into the evaporator. The valve is usually backed up by a liquid-line solenoid valve and a manual shutoff. These allow pumping down the unit and isolating the evaporator or condenser for maintenance.

Each compressor usually has manual isolation valves at both the suction and discharge. A hot gas bypass valve is sometimes installed between the compressor suction and discharge to allow operating the unit below the minimum step of unloading.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the condenser, evaporator, and oil pressure. Temperature gauges are 'provided for air supply and return, and manometers are sometimes installed across the filter bank to indicate filter condition.

Equipment Controls & Panels (CSI 15950)

Packaged systems usually include a master panel for all instrumentation and controls.

Compressor control is performed via a motor assembly (motor, starter, and disconnect). Compressors frequently have oil pressure limits interlocked with the starter that can trip compressor operation.

0.08.04.04 PACKAGED HVAC UNITS (CSI 15780)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Equipment Controls & Panels (CSI 15950) (Continued)

Compressor loading is usually controlled by a liquid line/hot gas bypass valve positioning in response to air temperature and/or staging of compressors. Demand limiters are employed to restrict the load on the machine to some percentage (40, 60, 80%) of full load capacity. Compressor cutout controls are also provided by high condenser pressure switch, low compression suction, and motor overload.

Condenser fans are staged or cycled in response to condenser pressure and ambient temperature sensors.

OTHER RELATED COMPONENTS

See the following subsection for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.04.04 PACKAGED HVAC UNITS (CSI 15780)

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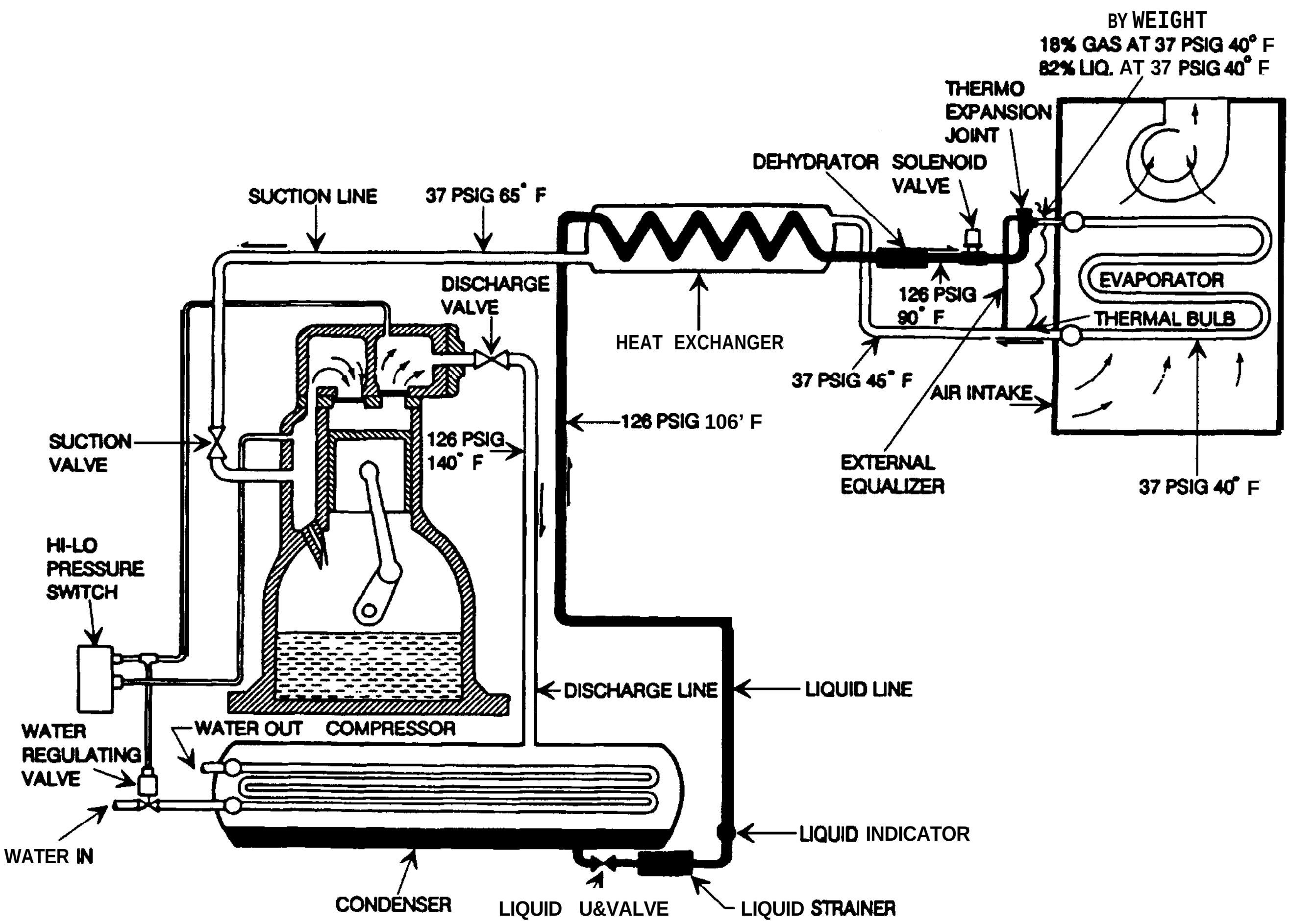
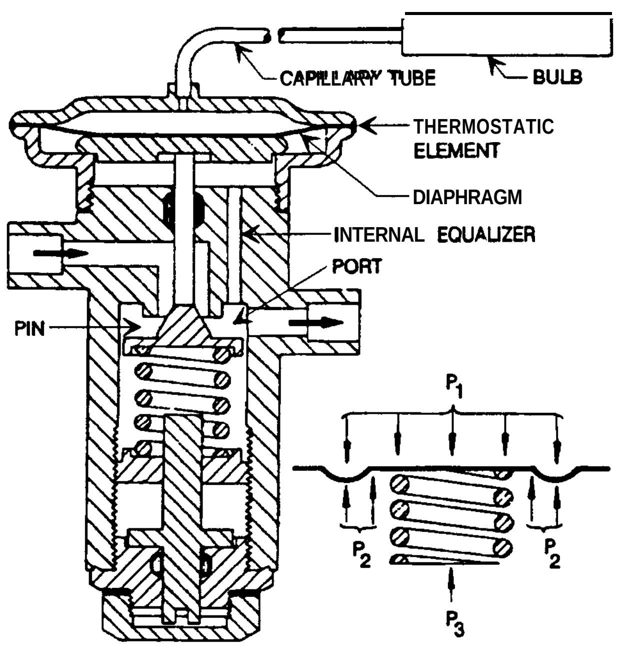


SOURCE: AIR-CONDITIONING AND REFRIGERATION INSTITUTE, REFRIGERATION AND AIR-CONDITIONING

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF PACKAGED UNIT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-1



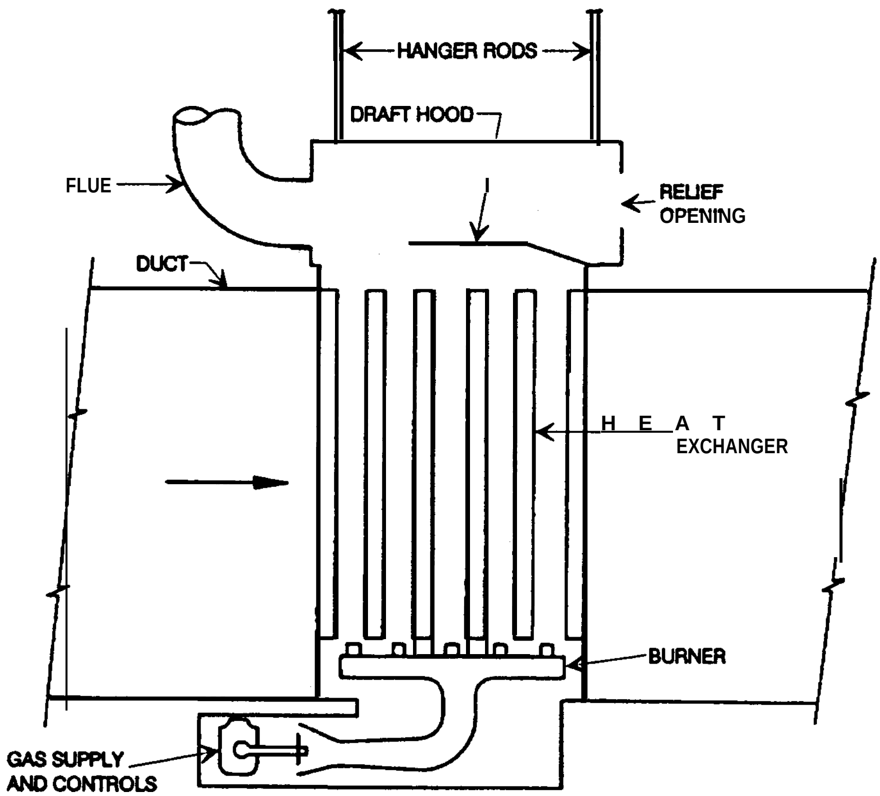
P_1 - THERMOSTATIC ELEMENT'S VAPOR PRESSURE

P_2 -EVAPORATOR PRESSURE

P_3 - PRESSURE EQUIVALENT OF THE SUPERHEAT SPRING FORCE

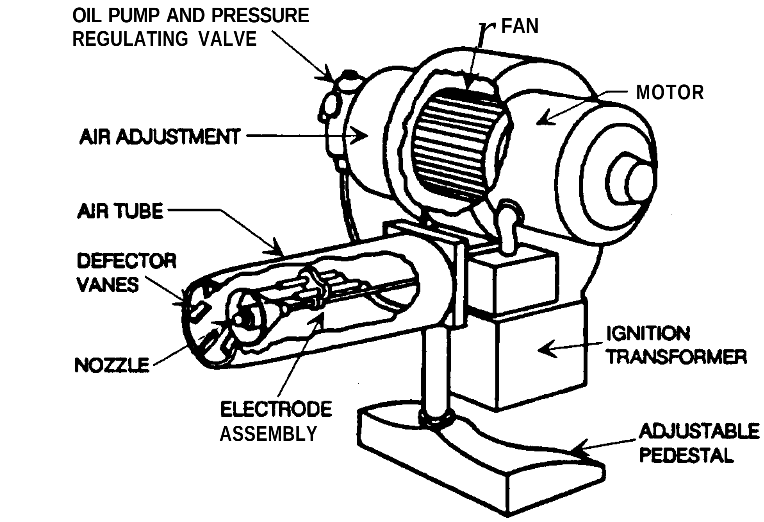
SOURCE 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT REPRINTED WITH PERMISSION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL THERMOSTATIC EXPANSION VALVE		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-2

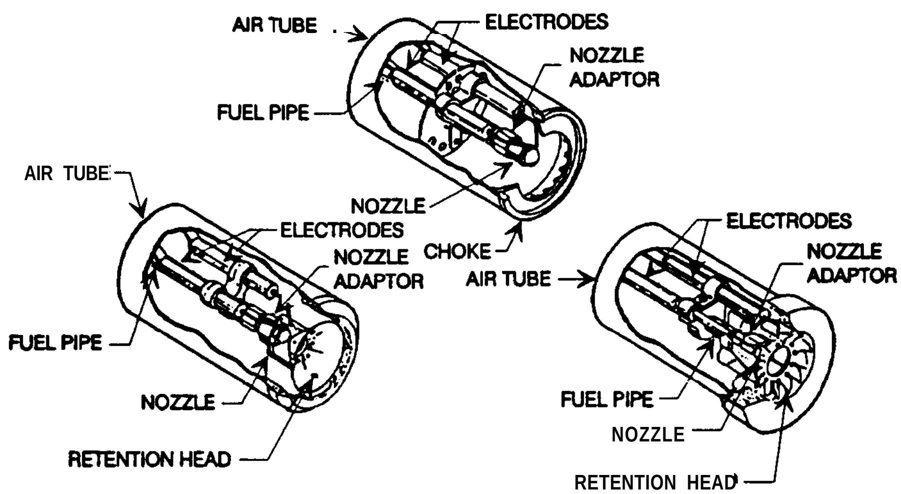


SOURCE: 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	INDIRECT GAS FIRED HEATER		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-3



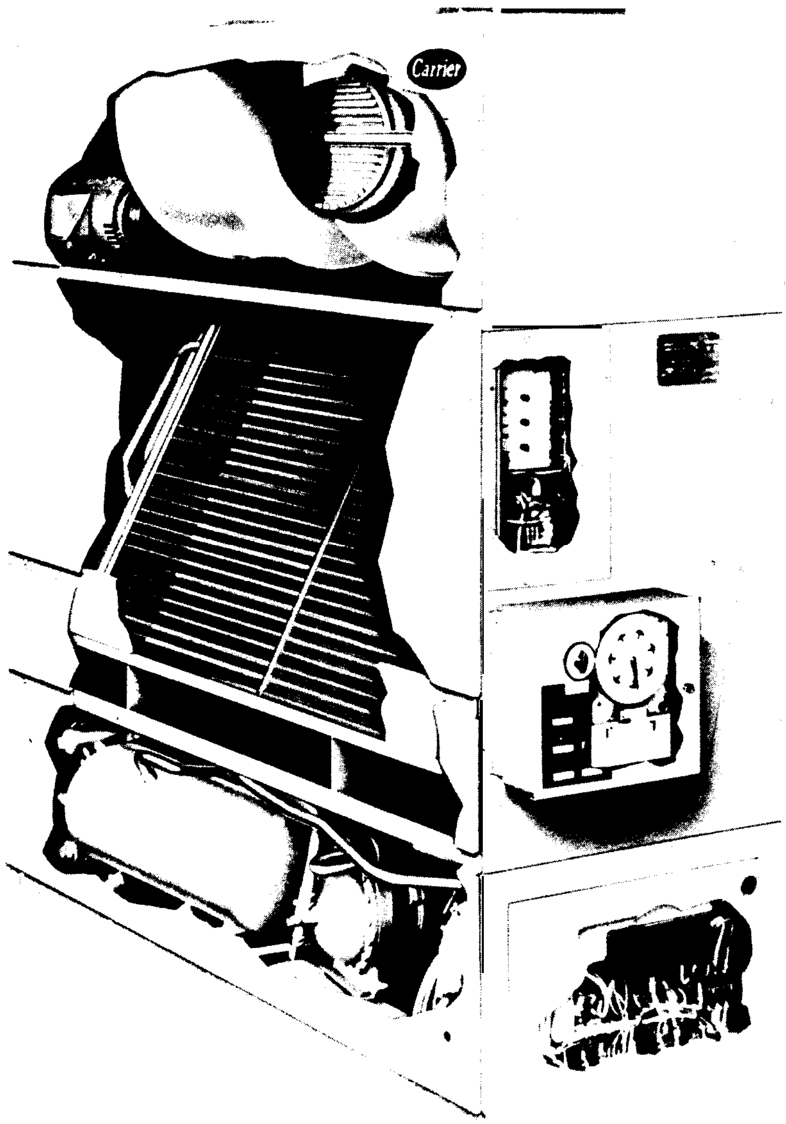
HIGH PRESSURE ATOMIZING OIL BURNER



DETAILS OF A HIGH-PRESSURE ATOMIZING OIL BURNER

SOURCE: 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	OIL BURNER DETAILS		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-4



TYPICALLY FOUND IN COMPUTER ROOMS

PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF PACKAGED UNIT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-5

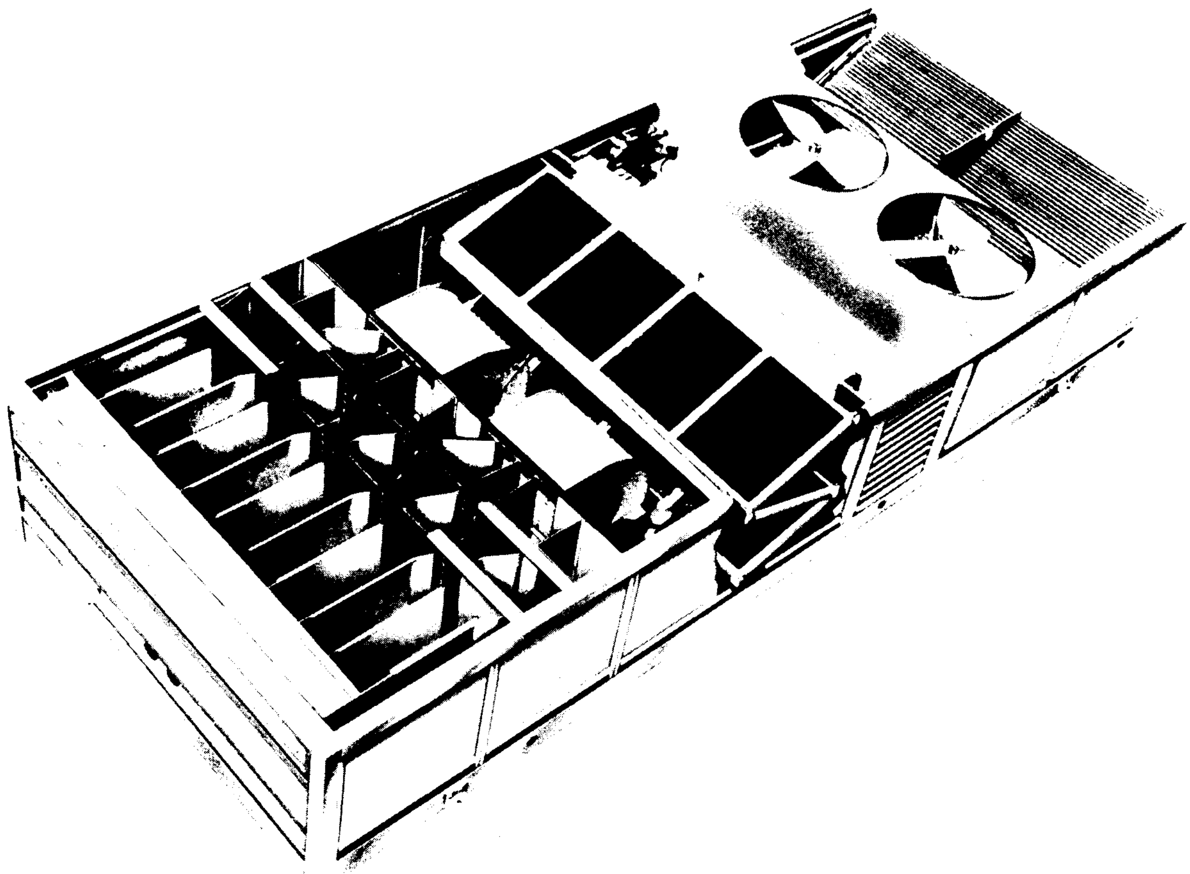


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF A TYPICAL ROOFTOP MOUNTED PACKAGED UNIT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-6

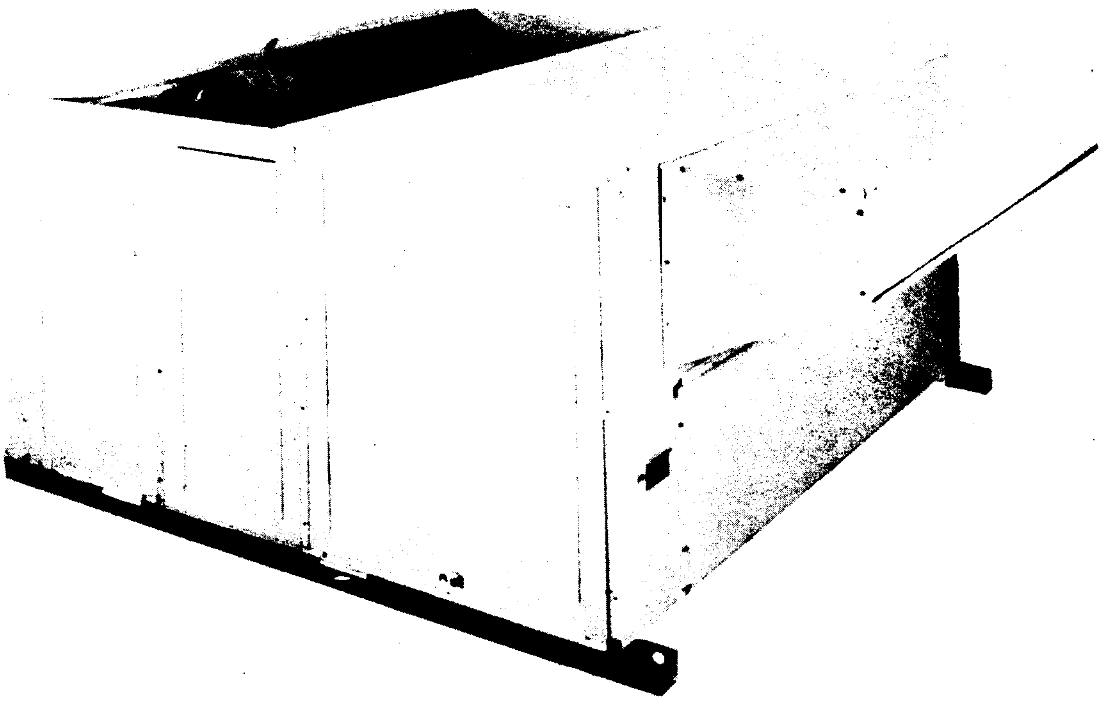


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL PACKAGED UNIT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-7

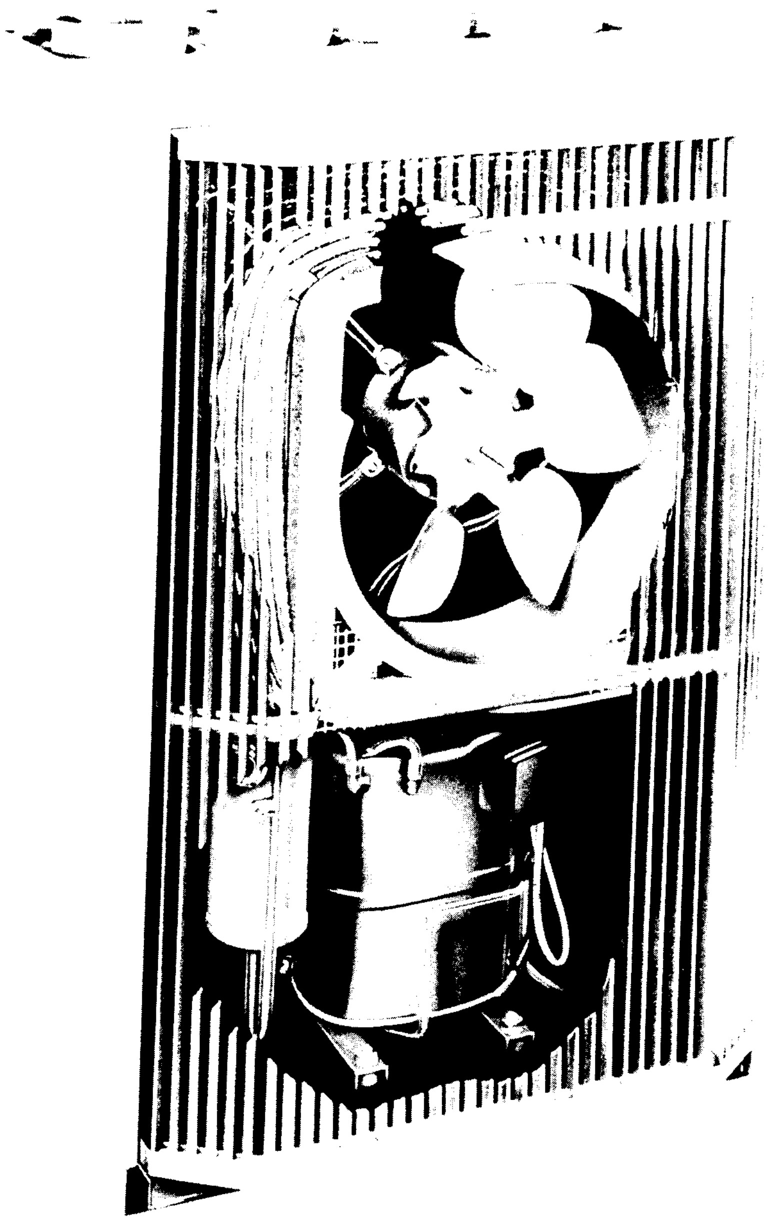


PHOTO ILLUSTRATION

SOURCE COURTESY a UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PACKAGED HVAC UNIT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	issue Date 5/93	Drawing No. A080404-8

NOTE: FLUE PIPE

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PACKAGED UNIT WITH NATURAL GAS HEAT		
COOLING-PACKAGED HVAC UNIT (CSI 15780)	Revision No.	Issue Date 5/93	Drawing No. A080404-9

DEFICIENCY FACTORS
0.08.04.04 PACKAGED HVAC UNIT (CSI 15780)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; relief failure due to over-pressurization, condenser fouling.
- Bearing failure caused by oil pressure loss due to compressor wear, lubrication system blockage, overheated oil.
- Tube failure in heat exchanger due to thermal stress, fouling of tubes.
- Motor failure caused by insulation deterioration due to excessive moisture, overloaded windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Housing

Severe Corrosion:	Normal aging, wear, environment, poor maintenance.
Physical Damage:	Missing covers, access plates; defective dampers.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Insulation:	Wet, missing, damaged.

Reciprocating Compressors

Inoperative, Will Not Turn:	Failed bearings, locked rotor/crankshaft/vanes.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.

Air-Cooled Condensers

Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin damage.
Excessive Corrosion:	Poor maintenance.
Leakage:	Defective seals, corrosion.
Fan Inoperative:	Corrosion, defective controls, poor maintenance.

Evaporators

Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin. damage.
Excessive Corrosion:	Poor maintenance.

Main Blowers

Missing:	Taken out for maintenance and not returned.
Inoperative:	Control failure, defective fan, defective wiring

DEFICIENCY FACTORS
0.08.04.04 PACKAGED HVAC UNIT (CSI 157801

SYSTEM ASSEMBLIES/DEFICIENCIES

Main Blowers (Continued)

Excessive Noise:	Loose fasteners, improper speed, damper malfunctions.
Excessive Vibration:	Fan imbalance, poor alignment.
Imbalanced:	Blading damage, excessive corrosion.
Corrosion:	Normal aging, poor maintenance.
Physical Damage:	Cracks, distortion due to physical abuse, fatigue.

Heaters

Inoperative:	Control failure, defective fan, defective wiring.
Corrosion:	Normal aging, poor maintenance.
Physical Damage:	Cracks, distortion due to physical abuse, fatigue.

Filters

Frame Damage:	Corrosion, physical damage, inadequate support, improper joining.

Motors

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, incompatible materials.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.

DEFICIENCY FACTORS
0.08.04.04 PACKAGED HVAC UNIT (CSI 15780)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Inadequate Seating:	Worn parts, blocked by scale.
Defective Reliefs:	Missing, leaking, gagged.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

DEFICIENCY FACTORS
0.08.04.04 PACKAGED HVAC UNIT (CSI 15780)

END OF SUBSECTION

0.08.04.05 PACKAGED CONDENSING UNITS (CSI 15870)

DESCRIPTION

A Packaged Condensing Unit System provides refrigerant compression and condensation functions. It is generally used to complement a unitary system using an indoor air handler(s) with DX coils. Condensing units also support commercial refrigeration application such as walk-in boxes (refrigerators). The typical system consists of a housing, one or more reciprocating compressors, motors, a condenser and the connecting piping, fittings, instrumentation and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Housing (CSI 15780)

The packaged condensing unit is usually installed as a self-contained unit in a single enclosure. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The housing is lined with insulation for noise abatement. The unit is typically mounted on a concrete pedestal with vibration eliminators.

When the condensing unit supports commercial refrigeration, the components are frequently located indoors and might not include a separate housing.

Reciprocating Compressors (CSI 15883)

Typical compressors are hermetic or semi-hermetic reciprocating units.

Bearing lubrication is provided by a splash or flooded system. Semi-hermetic units have a bulls-eye for oil level indication.

Compressor capacity control varies depending on size. Single hermetic compressor systems employ on-off system cycling. Medium systems include multiple compressors and cycle these units as needed. Larger, semi-hermetic units employ unloading devices that hold the suction valves open or recycle some of the discharge gas to the suction. Other variations include varying clearances and speeds.

Air-Cooled Condensers (CSI 15740)

Condensers condense the high pressure refrigerant gas. In this process, the latent heat of evaporation is conducted to surrounding air.

Condensing units usually employ an air-cooled condenser, eliminating the need for a condenser water circuit. These units are fan-cooled, finned tube (gas to air) heat exchangers. Fans are typically cycled/staged to control condenser head pressure.

Commercial applications frequently employ water-cooled, shell and tube condensers in their condensing units. These normally use one-pass, thermal regulated city water for cooling (which is subsequently dumped to drain).

Motors (CSI 15170)

Packaged systems generally employ hermetic or semi-hermetic systems in which the motor is enclosed in the compressor housing.

Piping & Fittings (CSI 15080)

Condensing units have the major components located close to one another. There is little internal refrigerant piping, simply the compressor to condenser and evaporator connections. Hot gas bypasses are sometimes installed between the compressor suction and discharge. However, considerable piping connects the condenser to the DX coils in the air handlers.

Typical unit fittings include liquid line filter dryers, sight glass, and moisture indicators,

0.08.04.05 PACKAGED CONDENSING UNITS (CSI 15670)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Piping & Fittings (CSI 15050) (Continued)

Piping for refrigerant lines and indicators is typically type ACR hard tubing. All suction piping should be insulated.

Valves (CSI 15100)

Valving is primarily used for load control and to isolate components for maintenance.

Although the thermal expansion valves are located with respective air handlers, local supply line valves include a liquid line solenoid valve and a manual shutoff. These allow pumping down the unit and isolating the evaporator or condenser for maintenance. Each compressor usually has manual isolation valves at both the suction and discharge.

A hot gas bypass valve is sometimes installed between the compressor suction and discharge to allow operating the unit below the minimum step of unloading.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the compressor suction, discharge pressure, and oil pressure.

Equipment Controls & Panels (CSI 15950)

Condensing units usually include a master panel for all instrumentation and controls. Compressor control is performed via a motor assembly (motor, starter, and disconnect). Compressors frequently have oil pressure limits interlocked with the starter that can trip compressor operation.

Compressor loading is usually controlled by suction valve, liquid line valve, hot gas bypass positioning in response to temperature and/or staging of compressors. Demand limiters are employed to restrict the load on the machine to some percentage (40, 60, 80%) of full load capacity.

Compressor cutout controls are also provided by high condenser pressure switch, low compressor suction pressure, motor overload.

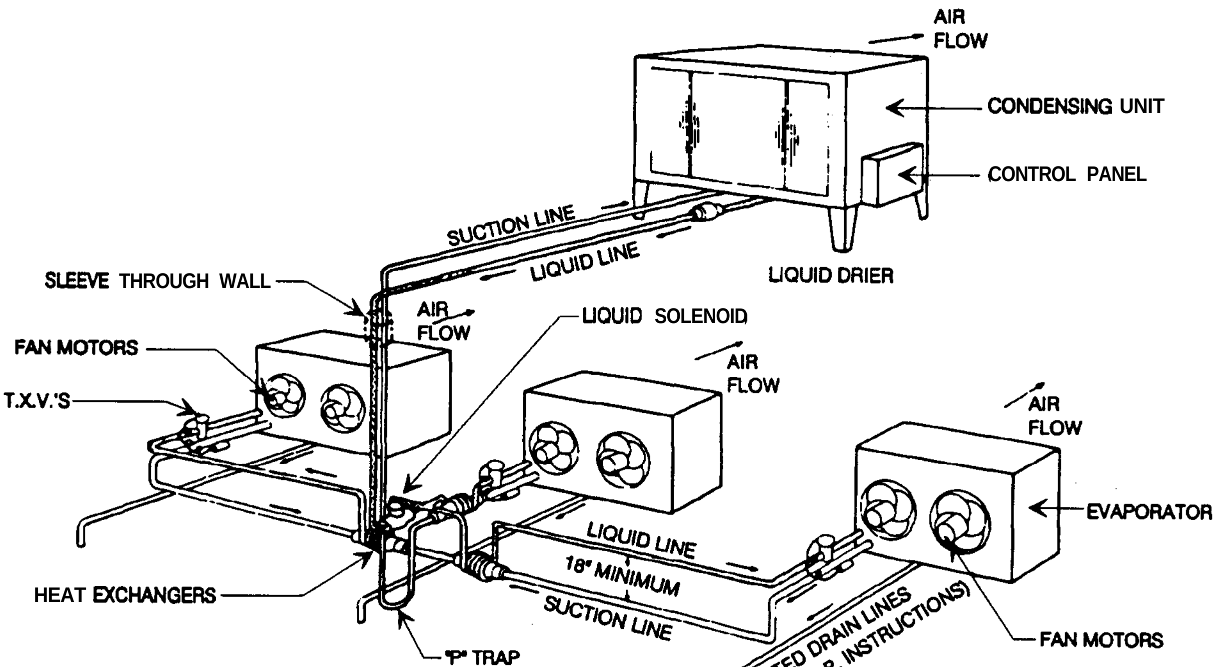
Condenser fans are staged or cycled in response to condenser pressure and ambient temperature sensors.

OTHER RELATED COMPONENTS

See the following subsections for related components:

0.08.03.08 Air Handlers & Fans.. .... .2.3.8-1
0.08.04.12 Terminal Cooling Units.. .... .2.4.12-1

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

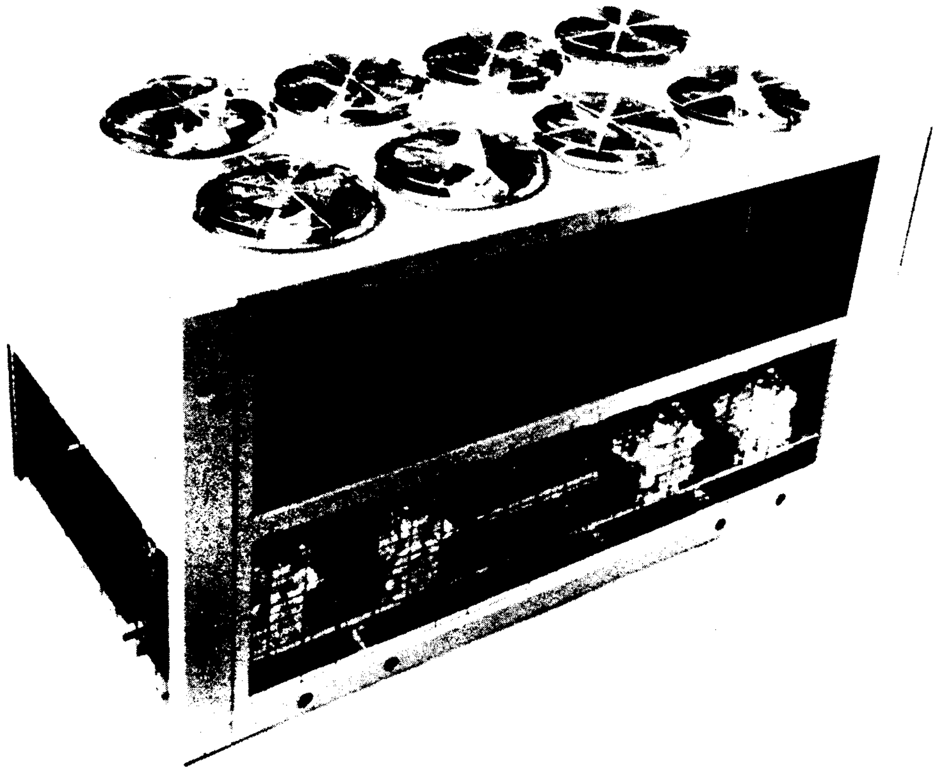


NOTE:
-CONDENSER AIR FLOW MUST BE SAME AS PREVAILING WINDS.
-INSTALL HEAT EXCHANGER (INSIDE OF BOX OR ROOM) AS CLOSE AS POSSIBLE TO REFRIGERATOR WALL.

SCHEMATIC PIPING DIAGRAM FOR CONDENSING UNITS USING TWO OR MORE EVAPORATORS (COURTESY. KRAMER TRENTON COMPANY)

SOURCE AIR-CONDITIONING AND REFRIGERATION INSTITUTE, REFRIGERATION AND AIR-CONDITIONING

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	APPLICATION OF CONDENSING UNITS		
COOLING-PACKAGED CONDENSING UNITS (CSI 15670)	Revision No.	Issue Date 5/93	Drawing No. A0804051



NOTE: THE 4 MOUNTED COMPRESSORS. ONE FOR EACH SET OF COILS.

PHOTO ILLUSTRATION

SOURCE COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL PACKAGED CONDENSING UNIT		
COOLING-PACKAGED CONDENSING UNITS (CSI 15670)	Revision No.	Issue Date 5/93	Drawing No. A080405-2

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	OUTDOOR AIR COOLED CONDENSERS		
COOLING-PACKAGED CONDENSING UNITS (CSI 15670)	Revision No.	issue Date 5/93	Drawing No. A0804053

DEFICIENCY FACTORS
0.08.04.05 PACKAGED CONDENSING UNITS (CSI 15670)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; relief failure due to over-pressurization, condenser fouling.
- Bearing failure caused by loss of oil pressure due to compressor wear, lubrication system blockage, overheated oil.
- Tube failure in heat exchanger due to thermal stress, fouling of tubes.
- Motor failure caused by insulation deterioration due to excessive moisture, overloaded windings,

SYSTEM ASSEMBLIES/DEFICIENCIES

Housing

Severe Corrosion:	Normal aging, wear, environment, poor maintenance.
Physical Damage:	Missing covers, access plates; defective dampers.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Insulation Wet, Missing, Damaged:	Leaks, environment, poor maintenance.

Reciprocating Compressors

Inoperative, Will Not Turn:	Failed bearings, locked rotor.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
Inadequate Capacity:	Low pressure, low flow caused by wear.

Air-Cooled Condensers

Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin damage.
Excessive Corrosion:	Poor maintenance.
Leakage:	Defective seals, corrosion.
Fan Inoperative:	Corrosion, defective controls, poor maintenance.

Motors

Missing:	Taken out for service, not returned.
inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.

DEFICIENCY FACTORS
0.08.04.05 PACKAGED CONDENSING UNITS (CSI 15870)

SYSTEM ASSEMBLIES/DEFICIENCIES

Motors (Continued)

Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, 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.
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.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

END OF SUBSECTION

0.08.04.06 REFRIGERATION COMPRESSORS (CSI 15855)

DESCRIPTION

Some refrigeration compressors are stand-alone units, installed separately from their complementary components (condensers and evaporators). These are rarely, if ever, centrifugal or absorption units. This standard is therefore limited to stand-alone reciprocating refrigeration compressors. The typical installation consists of one or more reciprocating compressors, motors, and the connecting piping, fittings, instrumentation, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Reciprocating Compressors (CSI 15683)

Typical compressors consist of a large split casing enclosing a shaft, with one or more pistons, coupled to an external drive motor. The suction side of the compressor is piped to the system evaporator, and the discharge side connects to the condenser. Some designs have additional piping to allow interstage cooling.

The upper half (head) of the casing contains the suction and discharge valves that control the pumping action of the compressor. A variation places the suction valves in the top of the pistons. The lower half (block) forms the cylinders and holds the crankshaft and pistons. The cylinder frequently contains replaceable liners. A common variation encloses the drive motor in the same housing as the compressor providing hermetic sealing.

Bearings are typically steel-backed babbitt.

Bearing lubrication is provided by a splash or flooded system in small units. Larger units use a force feed with a oil sump and an integral oil pump, usually gear-driven off the compressor shaft. An oil heater usually minimizes refrigerant entrainment during system shutdown.

Compressor capacity control varies depending on size. Small units employ on-off cycling of the system. Medium systems include multiple compressors and cycle these units as needed. Larger units employ unloading devices that hold the suction valves open or recycle some of the discharge gas to the suction. Other variations include varying clearances and speeds.

Motors (CSI 15170)

Small commercial units generally employ hermetic or semi-hermetic systems in which the motor is enclosed in the compressor housing. Larger compressors are externally driven by an open AC motor.

piping & Fittings (CSI 15060)

Stand-alone compressors are by nature remotely located from related major components (evaporators and condensers). Significant refrigerant piping connects these components, but little additional pipe or fittings are installed locally.

Piping for refrigerant controls and indicators is typically type ACR hard tubing. All suction piping should be insulated.

Valves (CSI 15100)

Valving is primarily used for load control and to isolate components for maintenance. Each compressor usually has manual isolation valves at both the suction and discharge.

A hot gas bypass valve is sometimes installed between the compressor suction and discharge to allow operating the unit below the minimum step of unloading.

0.08.04.06 REFRIGERATION COMPRESSORS (CSI 15855)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the compressor suction, discharge, and oil pressure.

Equipment Controls & Panels (CSI 15950)

Stand-alone reciprocating compressors rarely have an instrument and control panel; Control is performed via a motor assembly (motor, starter, and disconnect).

Compressors frequently have oil pressure limits interlocked with the starter that can trip compressor operation.

Compressor loading is usually controlled by suction valve positioning in response to chilled water temperature and/or compressor staging.

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, low suction pressure, and motor overload.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

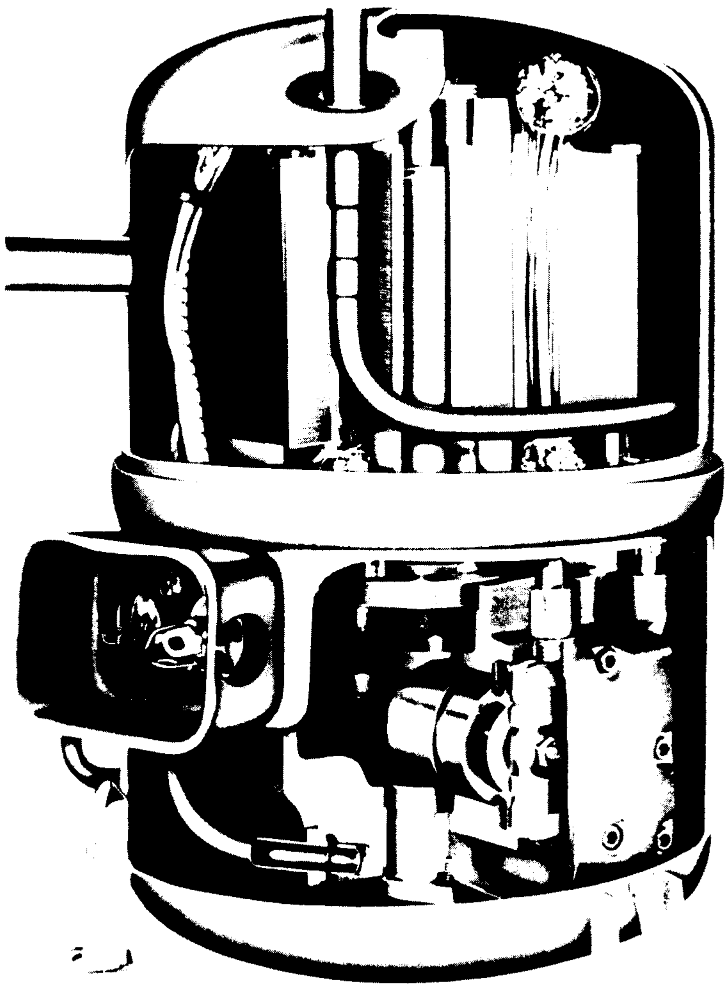


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HERMETICALLY SEALED COMPRESSOR		
COOLING-REFRIGERATION COMPRESSORS (CSI 15655)	Revision No.	Issue Date 5/93	Drawing No. A080406-1

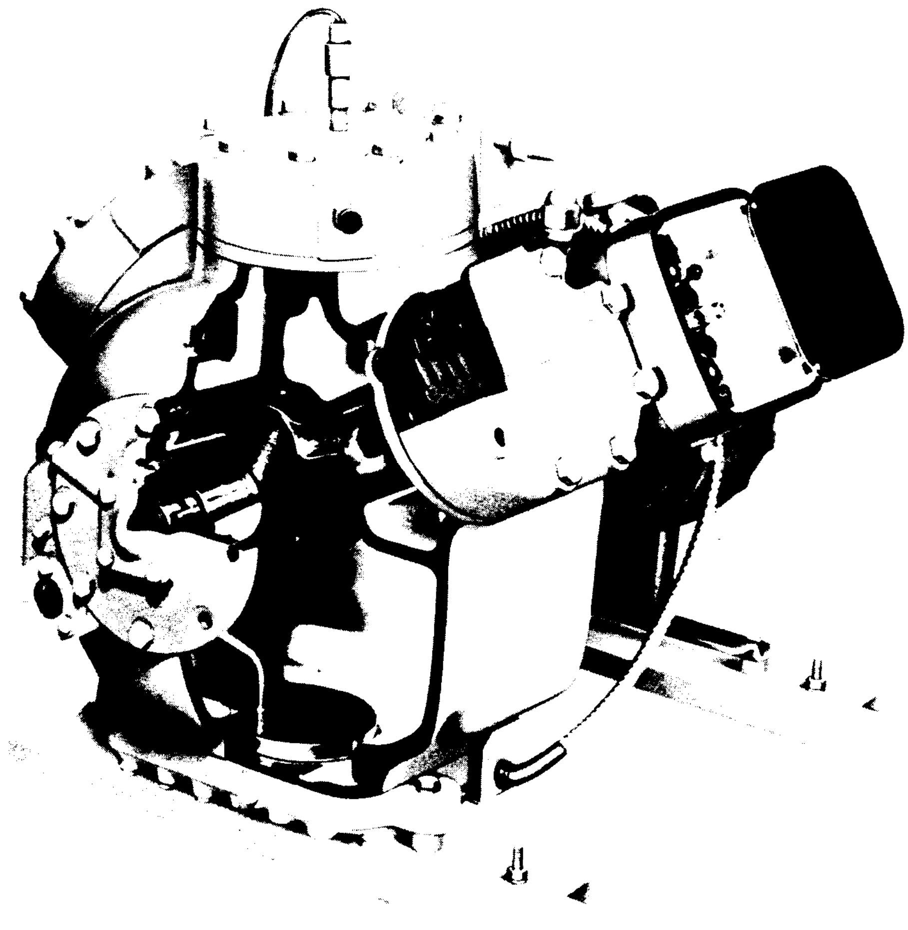


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CUTAWAY VIEW OF A TYPICAL RECIPROCATING COMPRESSOR		
COOLING-REFRIGERATION COMPRESSORS (CSI 15655)	Revision No.	Issue Date 5/93	Drawing No. A080406-2

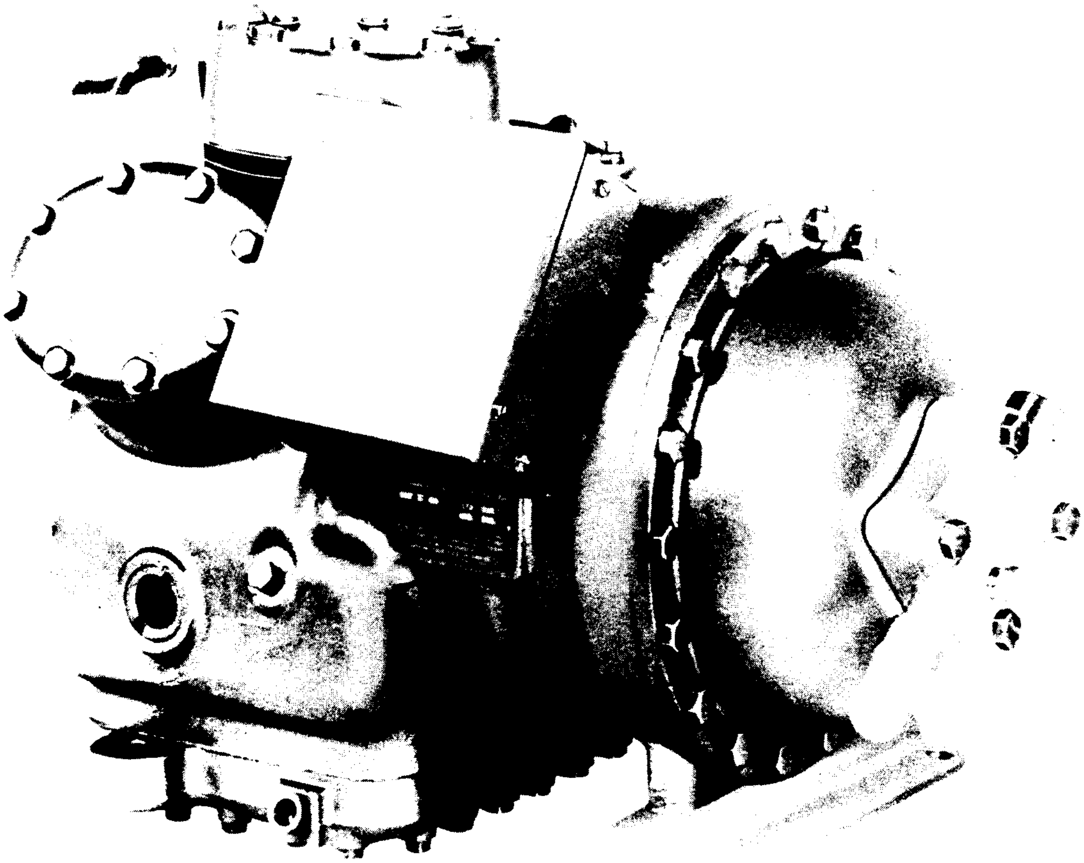


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL RECIPROCATING COMPRESSOR		
COOLING-REFRIGERATION COMPRESSORS (CSI 15655)	Revision No.	Issue Date 5/93	Drawing No. A080406-3

DEFICIENCY FACTORS
0.08.04.06 REFRIGERATION COMPRESSORS (CSI 15855)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; relief failure due to over-pressurization, condenser fouling.
- Bearing failure caused by loss of oil pressure due to compressor wear, lubrication system blockage, overheated oil.
- Motor failure caused by insulation deterioration due to excessive moisture; overloaded windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Reciprocating Compressors

Inoperative, Will Not Turn:	Failed bearings, locked rotor.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Piping **& Fittings**

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.

DEFICIENCY FACTORS
0.08.04.06 REFRIGERATION COMPRESSORS (CSI 15655)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Corrosion:	Contamination, 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.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

END OF SUBSECTION

0.08.04.07 CONDENSERS (CSI 15740)

DESCRIPTION

Condensers are used to condense high pressure refrigerant gasdischarged by a compressor into high pressure refrigerant liquid. In many applications these units are stand-alone (i.e., are remotely located from both the compressors and the evaporators). This standard covers those installations and should not be used for other packaged systems or large centrifugal or absorption systems.

The typical system consists of a housing, one or more condensers, motors, and the connecting piping, fittings, and controls.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Housing (CSI 15780)

Large air-cooled condensers and evaporative condensers are usually installed as self-contained units in single enclosures. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The unit is typically mounted on a concrete pedestal with vibration eliminators.

Condensers (CSI 15740)

There are three major condenser configurations: water-cooled, air-cooled, and evaporative (air- and water-cooled.)

Water-cooled condensers are generally shell and tube configurations using water inside the tubing and gas in the shell. The water may be single-pass, one use, thermal regulated city water (smaller units), or more commonly, tower water from a related cooling tower. Water-cooled condensers are generally pedestal mounted and have no independent housing.

Air-cooled condensers are finned tube (gas to air) heat exchangers, normally employing forced flow condenser fans. Very small units may not include the fans.

Evaporative condensers combine water cooling with a finned tube (gas to air) heat exchanger. The enclosure typically contains a fan assembly, water sump, level controls, spray pump, and nozzles in addition to the finned heat exchanger. Counter flow of air and water across the heat exchanger causes partial water , improving overall heat exchange efficiency compared to an air-cooled unit.

Fans (CSI 15880)

Air-cooled condensers normally use multiple, simple, direct-drive propeller fans mounted above the coils to create an updraft through the coils. Variations include multiple fan housing mounted on a common shaft under the HX coils. These units are usually belt driven.

Evaporative condensers use multiple fan housings mounted on a common shaft under the HX coils. These units are usually belt driven.

Motors (CSI 15170)

Small open AC motors are typically used to drive the air-cooled condenser fans, and laryer, closed AC motors are used to drive evaporative condenser fans.

Piping & Fitting8 (CSI 15080)

Stand-alone condensers are by nature remotely located from related major components (evaporators and compressors). Significant refrigerant piping connect these components, but little additional pipe or fittings are installed locally.

Piping for refrigerant controls and indicators is typically type ACR hard tubing. All suction piping should be insulated.

Chilled and condenser water piping are covered in separate sections of this manual.

0.08.04.07 CONDENSERS (CSI 15740)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Valves (CSI 15100)

Valving is normally installed to allow isolation of components for maintenance

A thermal regulating valve is frequently used to control water flow through water-cooled condensers.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the condenser pressure and for water inlet and outlet pressures. Temperature gauges are provided for condenser water.

Equipment Controls & Panels (CSI 15950)

Condenser systems usually do not include a master panel for all instrumentation and controls

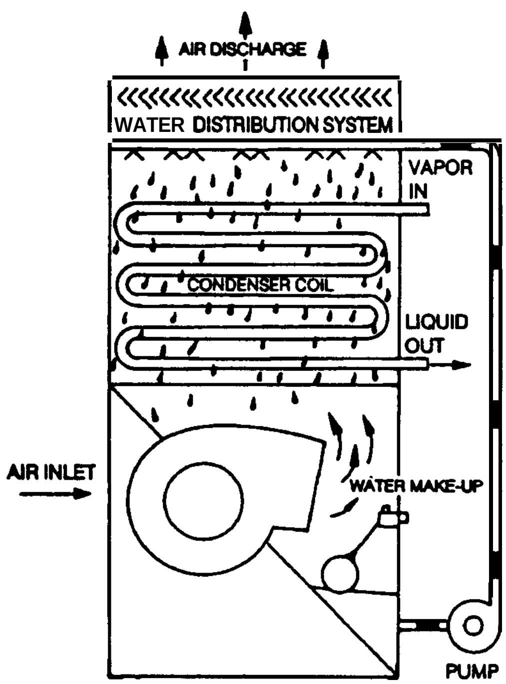
Condenser fan motor/pump motor control is performed via a motor assembly (motor, starter, and disconnect).

Condenser fans are staged or cycled in response to condenser pressure and ambient temperature sensors.

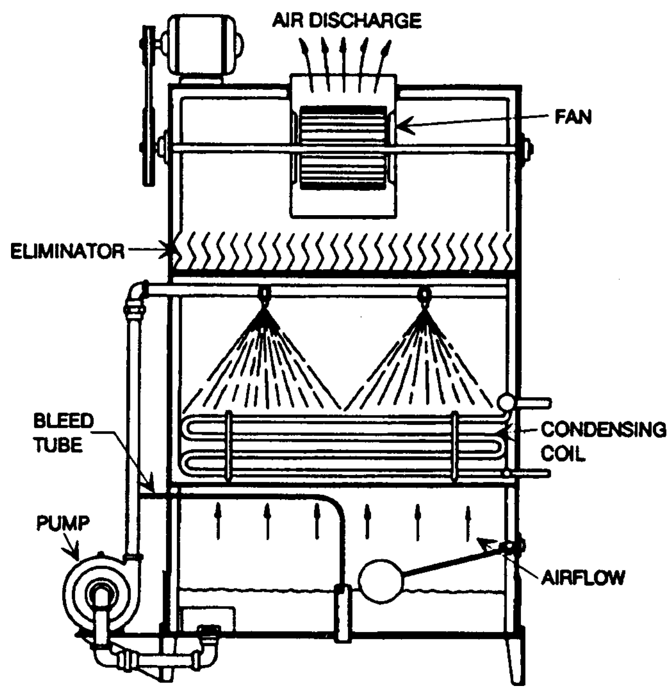
OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.



BLOW-THROUGH-TYPE



DRAW-THROUGH-TYPE

SOURCE: 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FUNCTIONAL VIEW OF EVAPORATIVE CONDENSER		
COOLING-CONDENSERS (CSI 15740)	Revision No.	Issue Date 5/93	Drawing No. A080407-1

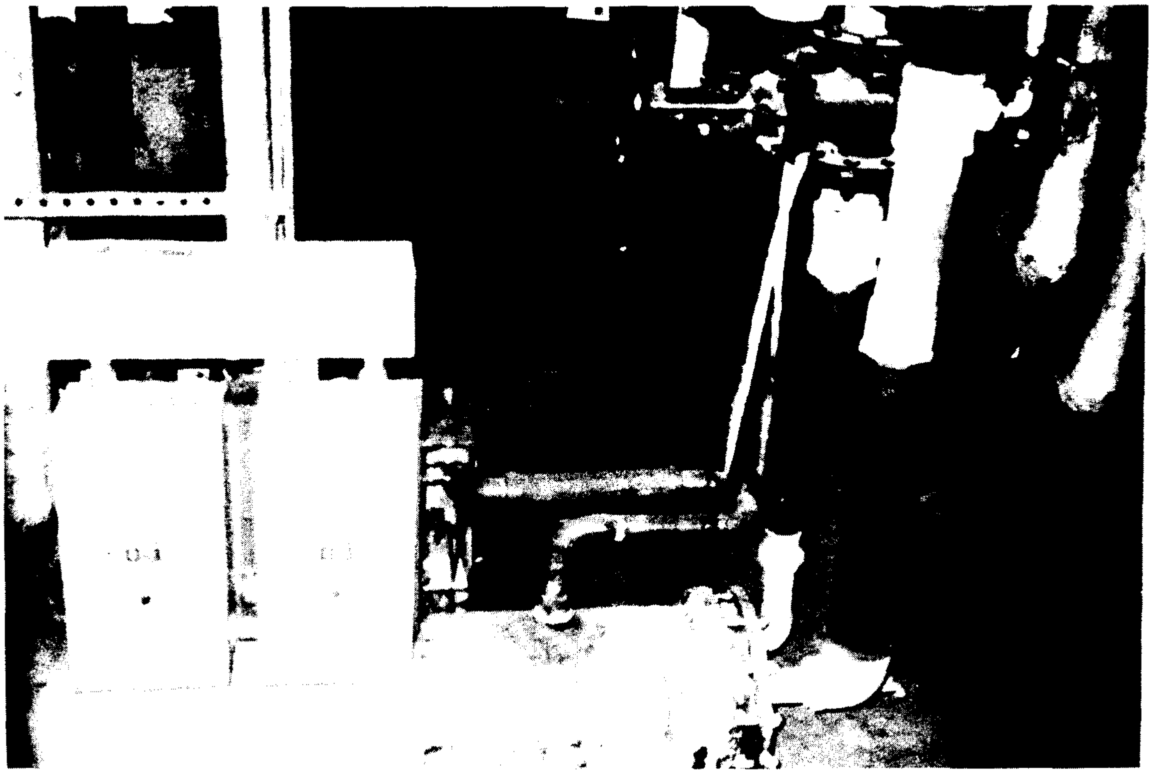


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	WATER COOLED CONDENSER FOR DX COIL OF AIR HANDLER		
COOLING-CONDENSERS (CSI 15740)	Revision No.	Issue Date 5/93	Drawing No. A080407-2

DEFICIENCY FACTORS
0.08.04.07 CONDENSERS (CSI 15740)

PROBABLE FAILURE POINTS

- Loss of system charge caused by leakage in seals and fittings due to wear, corrosion; relief failure due to over-pressurization, condenser fouling.
- Tube failure in heat exchanger due to thermal stress, fouling of tubes.
- Motor failure caused by insulation deterioration due to excessive moisture, overloaded windings.

SYSTEM ASSEMBLIES/DEFICIENCIES

Housing	
Severe Corrosion:	Normal aging, wear, environment, poor maintenance.
Physical Damage:	Missing covers, access plates; defective damper.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Condensers	
Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin damage.
Excessive Corrosion:	Poor maintenance.
Leakage:	Defective seals, corrosion.
Fan Inoperative:	Corrosion, defective controls, poor maintenance.
Pump Inoperative:	Corrosion, defective controls, poor maintenance.
Motors	
Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, ‘misalignment.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Piping & Fittings	
Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Valves	
Inoperative:	Corrosion, physical damage to operating mechanism.

DEFICIENCY FACTORS
0.08.04.07 CONDENSERS (CSI 15740)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, 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.

Instrumentation

Missing:	Taken out for service or repair and 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 or Burned:	Normal aging, overloading.
Bypassed Controls:	Poor maintenance.
Damaged Wiring:	Corrosion, overheating, age.
Housing Corrosion:	Age, poor maintenance.

END OF SUBSECTION

0.08.04.08 COOLING TOWERS (CSI 15710)

DESCRIPTION

Cooling Towers are used to reject condenser heat from water-cooled chilled water plants, some DX systems, and large process cooling systems. The process generally employs some means of breaking up high temperature water into small droplets and exposing it to an air flow. This stimulates evaporation, reducing the temperature of the water. Towers may be natural or mechanical draft. The typical tower consists of a housing, a water distribution system, dampers, fans, drive assembly, motors and the connecting piping, fittings, and controls.

This standard does not cover evaporative condensers, a hybrid cooling tower in which the system condenser is part of the tower. Those units are covered under Condensers.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Housing (CSI 15710)

Cooling Towers are usually installed as self-contained units in single enclosures. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The bottom of the tower forms a catch basin for condenser return water. One or more sides are generally open to allow air intake across the tower fill. The top of the tower is typically punched to allow for an even incoming water distribution across the tower fill. The top also usually has removable covers that minimize the effect of sunlight on tower water (algae buildup). The structure is typically mounted on a concrete pedestal with vibration eliminators. Large installations are fabricated by joining several small cooling tower enclosures in a bank.

An older, very common alternative to the steel cooling tower is the wooden tower. Construction is essentially the same except for the material. Although they can be constructed to resist fire, few new ones are installed. Another variation is the ceramic tower, a construction used for large tonnage systems where aesthetics are a prime consideration.

The housing will normally have ladders and handrails to permit access and maintenance.

Distribution System (CSI 15710)

Condenser water piping is routed to the top of the tower, arranged to allow even distribution across the tower surface. In multi-cell units, valving is used to isolate cells and/or to proportion flow rates. Distribution is further enhanced using troughs and baffles.

Removable inserts, typically plastic or ceramic nozzles, are placed in the holes punched (drilled) in the tower top. These can be varied in size to control the quantity of water released to the tower fill.

Water falling into the tower encounters a fill material (steel, plastic, or wood) designed to ensure its breakup into droplets. The fill is wave-shaped (plastic or steel) or cross-hatched (wood) to cause a rapid change in direction as the water falls to the basin. Additional inserts are used to control water loss due to air movement (drift eliminators).

Water collects in the basin and is returned to the condenser through a basin suction screen and strainer. Water loss due to drift and evaporation is replaced by a basin level control system.

A water bleed control is normally installed to reduce the solids buildup in the tower water due to evaporation. In many installations, this is simply a manually operated drain valve. Newer installations include automatic water sampling circuits with electronic bleed metering.

Dampers (CSI 15710)

Dampers are used to control air flow and to provide linear control of tower capacity. These are employed in centrifugal fan towers only. Dampers may be manual or motorized to respond to changes in system load. Motorized dampers may be pneumatically or electrically operated.

0.08.04.08 COOLING TOWERS (CSI 15710)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Fans (CSI 15880)

Mechanical draft towers use fans to force or induce air flow across the tower fill. Units are classified as either cross flow (air moves perpendicular to water flow) or counter flow (air moves 180° to water flow - generally straight up).

Perhaps the most common tower installation uses a cross flow, induced draft approach with a propeller fan mounted in the top of the tower. In large, site-fabricated installations, these are usually slow speed, gear-driven units.

A newer packaged unit, typically factory-fabricated, uses a counter flow, forced draft approach with a centrifugal (squirrel cage) fan mounted in the base of the enclosure. These fans tend to be high speed, belt-driven units.

Because these fans are part of the unit, they generally do not have independent enclosures. However, all have guards and access covers.

Drive Assemblies (CSI 15170)

Many of the large, slow-speed propellers used on site-fabricated units are gear driven. The propeller is mounted directly on the gear reducer shafting. The gear reducer is typically connected to the motor using a drive shaft mounted on pedestal bearings.

Motors (CSI 15170)

Large, enclosed AC induction motors are typically used to drive the propeller fans found in induced draft towers. These motors are generally totally exposed to the environment.

Drip-proof or fan-cooled AC induction motors are the norm for driving the centrifugal fans. These units are somewhat better protected, generally in and under the tower.

Piping & Fittings (CSI 15080)

Pipe and fittings for condenser water are covered separately under Condenser Water Systems in this manual.

Pipe mounted directly on the tower is generally large diameter steel or plastic. A small matrix is generally employed to distribute flow evenly to all tower quadrants and to distribute water between cells.

Valves (CSI 15100)

Valves are primarily used to balance flow in the distribution piping, to provide some capacity control by isolating cells, and to permit tower isolation for maintenance. Valves are normally installed at low points in the basin for system drainage.

Water level regulating valves are used to control the water level in the catch basin. These are typically mechanical float-operated valves or electric float switches with solenoid valves.

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

Equipment Controls & Panels (CSI 1 5950)

Tower systems rarely include a master panel for all instrumentation and controls. Tower fan control is performed via a motor assembly (motor, starter, and disconnect).

Fans (cells) are staged or cycled in response to leaving water temperature and ambient temperature sensors. Fans sometimes employ a vibration limit switch.

Dampers are cycled in response to leaving water temperature and ambient temperature sensors.

0.08.04.08 COOLING TOWERS (CSI 15710)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Equlpment Controls & Panels (CSI 15950) (Continued)

Towers that are used year-round will often employ a basin heater. These may be steam or hot water coils or electric immersion elements.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

0.08.04.08 COOLING TOWERS (CSI 15710)

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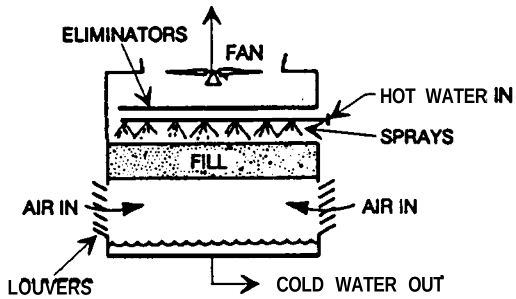
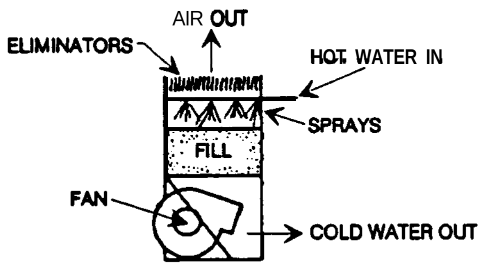
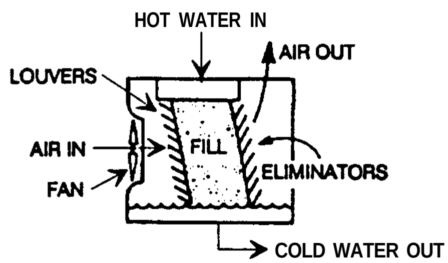


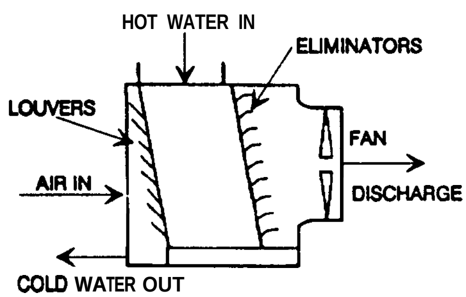
INDUCED DRAFT
COUNTERFLOW



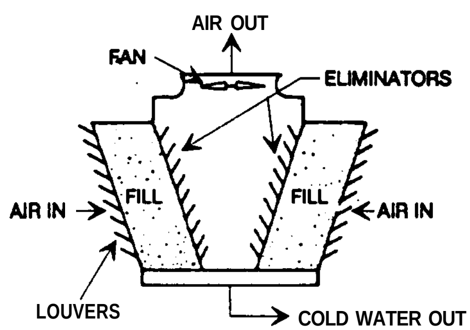
FORCED DRAFT
COUNTERFLOW



FORCED DRAFT
CROSSFLOW



INDUCED DRAFT
(SINGLE FLOW TOWER)



INDUCED DRAFT CROSSFLOW
(DOUBLE AIR ENTRY)

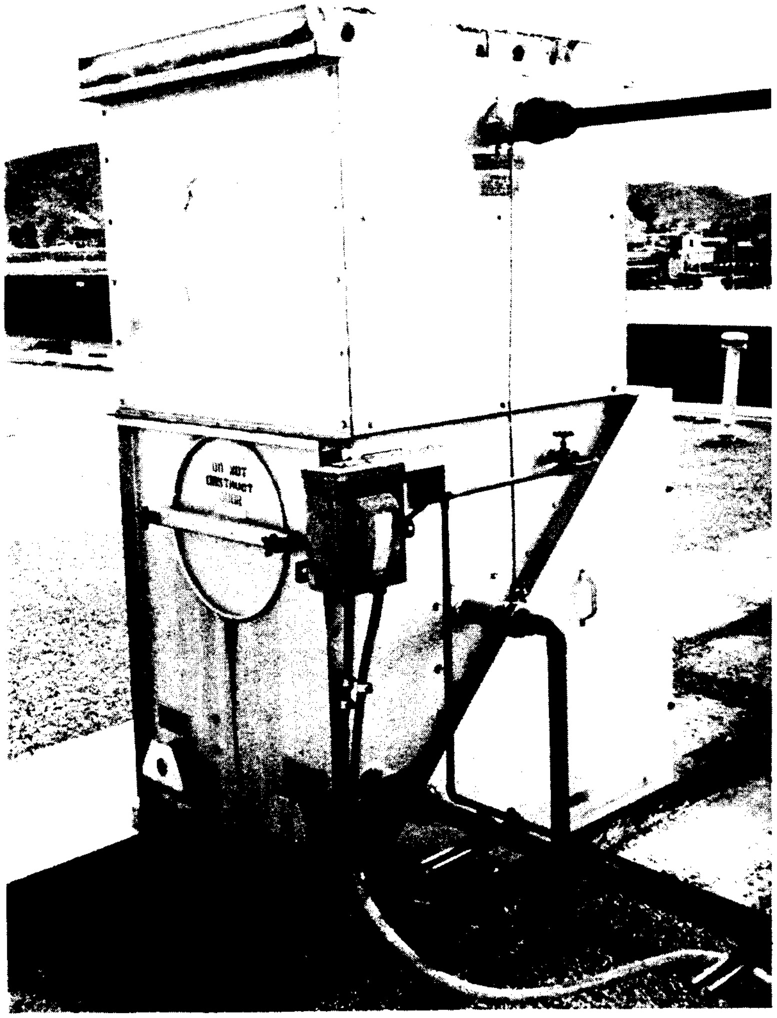
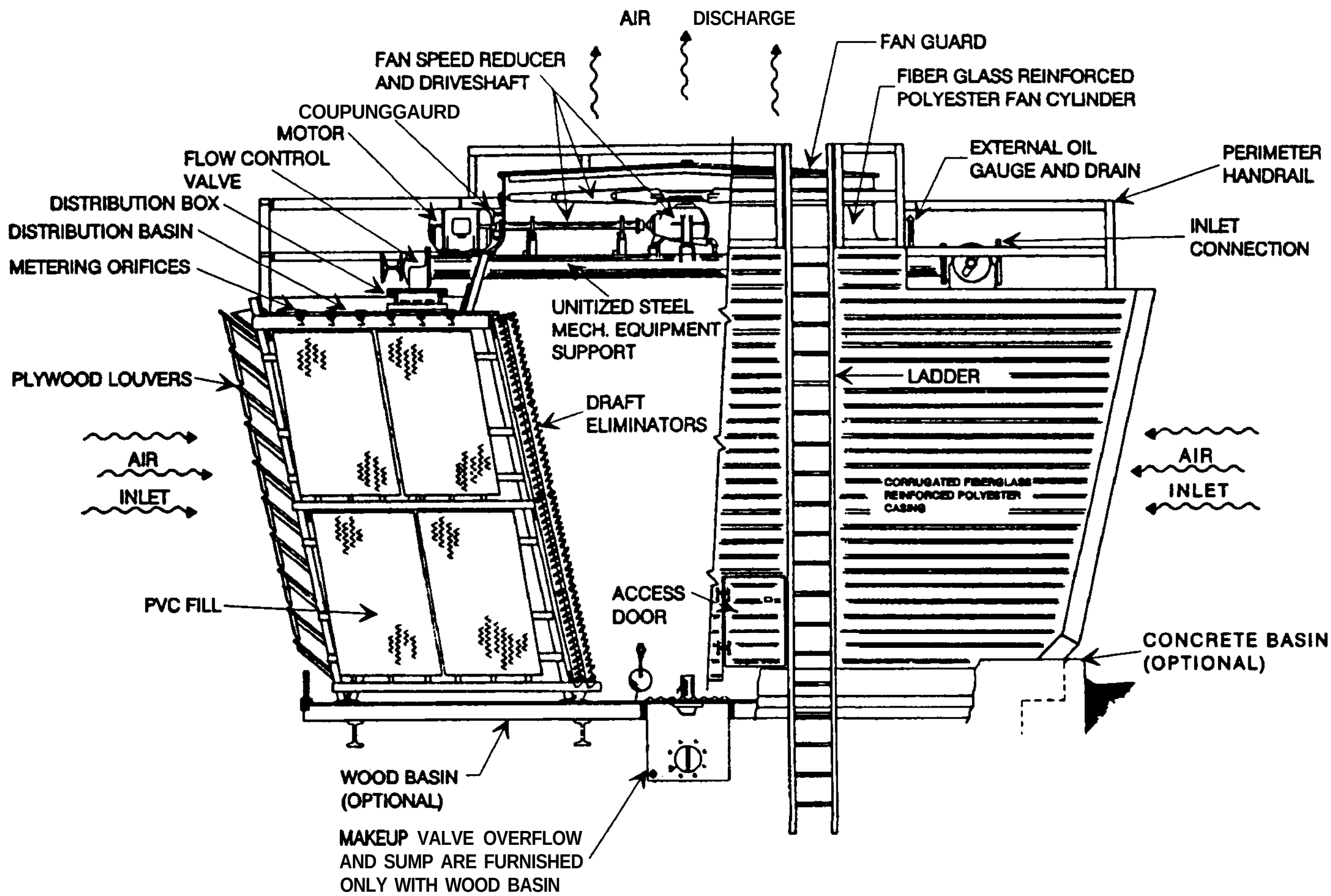


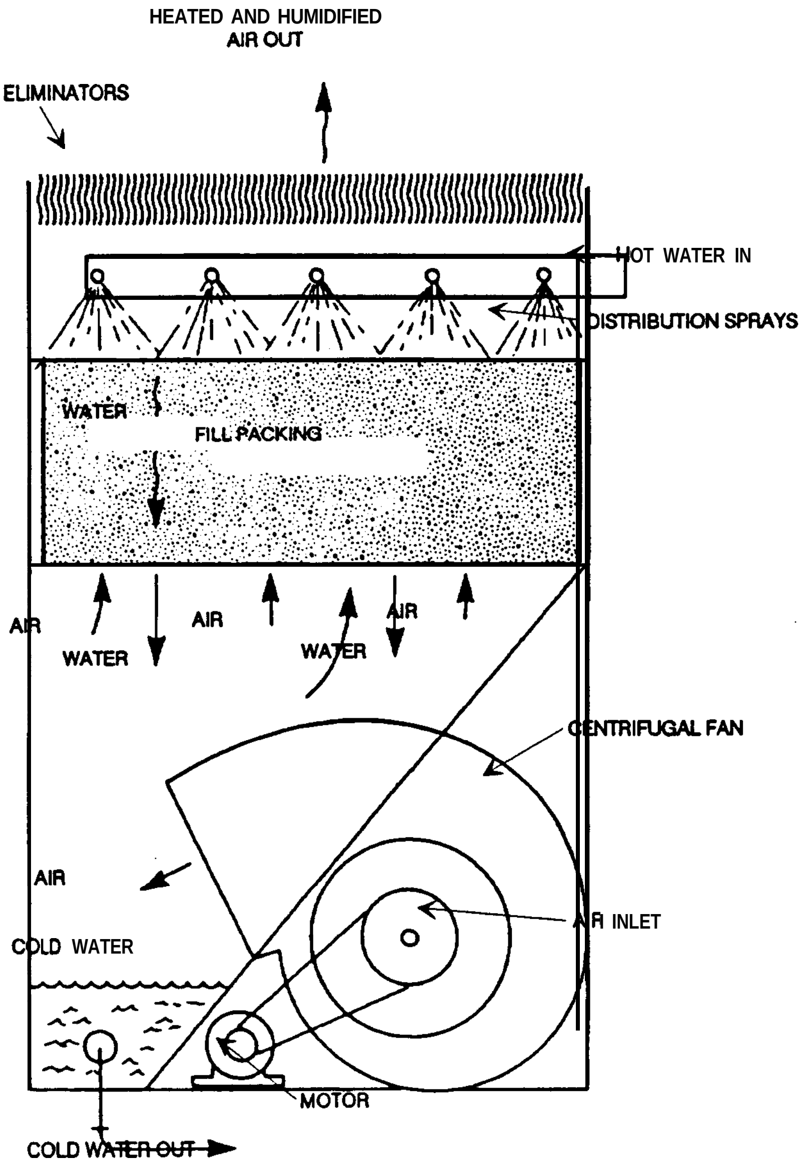
PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	CORROSION ON FAN SHROUD AND ACCESS COVER LEAKING		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	Drawing No. D080408-1



SOURCE 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CROSSFLOW MECHANICAL DRAFT TOWER		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	Drawing No. A080408-2



SOURCE. 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	COUNTERFLOW FORCED DRAFT TOWER		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	Drawing No. A080408-3

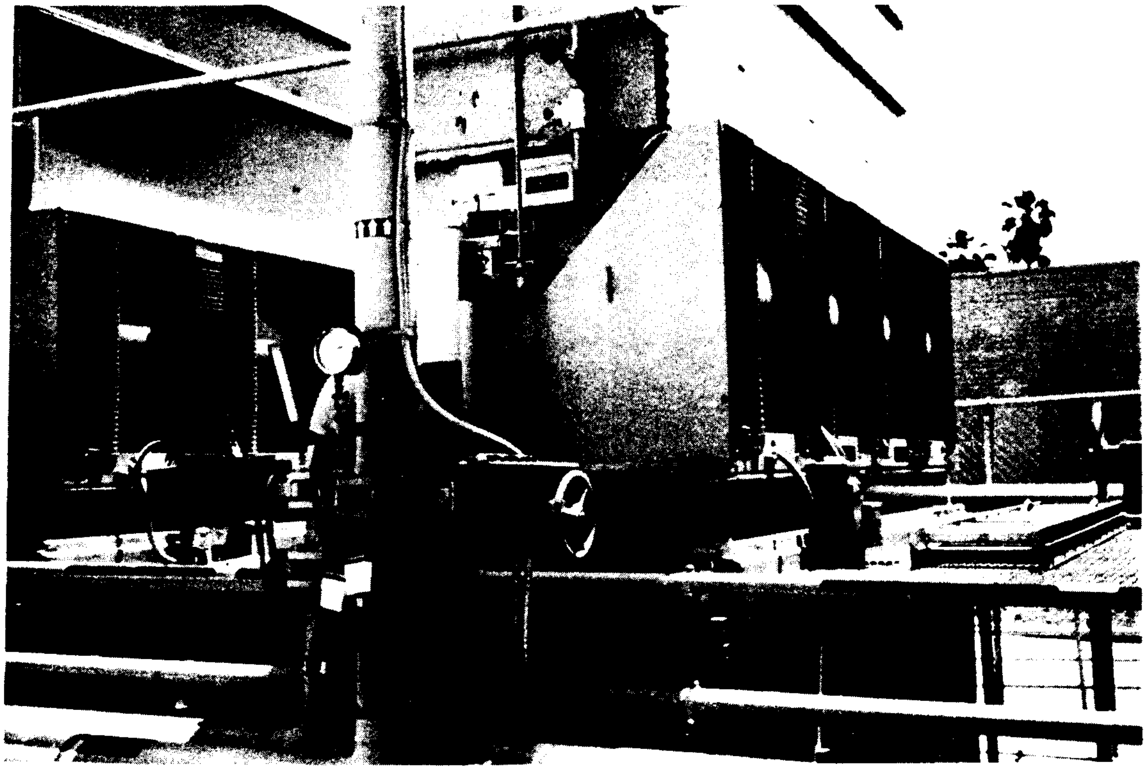


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	COUNTERFLOW FORCED DRAFT TOWERS WITH MOTORIZED CONTROL VALVES		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	Drawing No. A080408-4

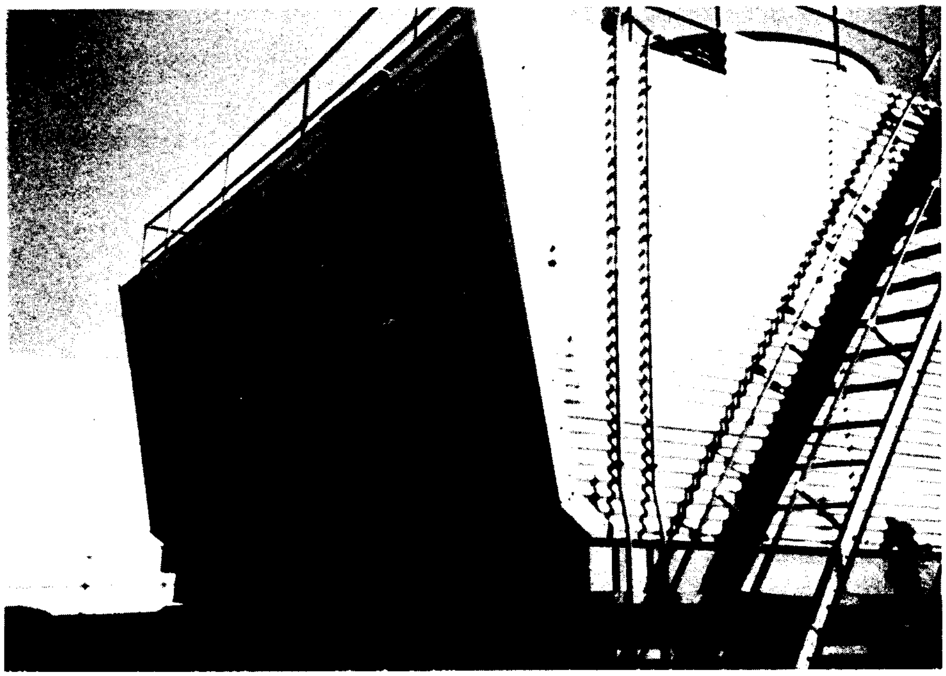


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CROSSFLOW COOLING TOWER		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	**Drawing No.** A080408-5

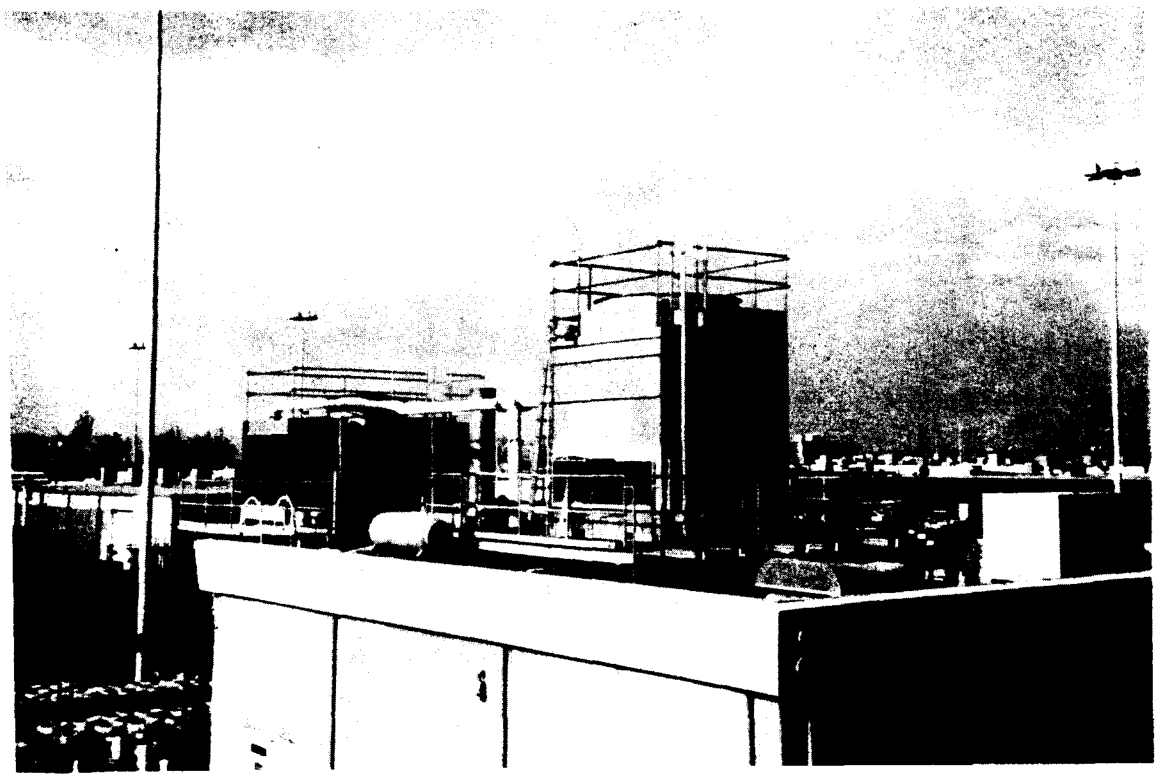


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	COOLING TOWER		
COOLING-COOLING TOWERS (CSI 15710)	Revision No.	Issue Date 5/93	Drawing No. A080408-6

DEFICIENCY FACTORS
0.08.04.08 COOLING TOWERS (CSI 15710)

PROBABLE FAILURE POINTS

- **Housing deterioration** due to severe corrosion, wood deterioration.
- Fill collapse due to deteriorated supports, fill material cracks due to thermal stress, wood deterioration.
- Fan failure due to loose fasteners, wear in reduction gears or bearings, control failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Housing	
Leakage:	Defective joints/seals, corrosion.
Severe Corrosion, Rotting:	Normal aging, wear, environment, poor maintenance.
Physical Damage:	Missing covers, access plates; defective dampers, ladders.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Distribution System	
Nozzles, Distributors Missing:	Removed for service, not replaced.
Fill Damage:	Collapsed, fouling, cracks, wood deterioration.
Louvers, Eliminators Damaged:	Corrosion, poor maintenance, missing fasteners.
Excessive Corrosion:	Poor maintenance.
Dampers	
Inoperative:	Corrosion, defective controls, poor maintenance.
Severe Corrosion:	Aging, lack of maintenance.
Severe Physical Damage:	Abuse.
Fans	
Missing:	Taken out for maintenance and not returned.
Inoperative:	Corrosion, defective controls, poor maintenance.
Excessive Noise:	Loose fasteners, improper speed, damper malfunctions.
Excessive Vibration:	Fan imbalance, poor alignment.
Imbalanced:	Blading damage, excessive corrosion.
Severe Corrosion:	Aging, lack of maintenance.
Severe Physical Damage:	Abuse.
Drive Assemblies	
Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, gear imbalance, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.

DEFICIENCY FACTORS
0.08.04.08 COOLING TOWERS (CSI 15710)

SYSTEM ASSEMBLIES/DEFICIENCIES

Drive Assemblies (Continued)

Defective Bearings:	Age, normal wear, improper lubrication.
Gears Worn:	Normal wear, improper lubrication, poor alignment.

Motors

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

Valves

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

Equipment Controls & Panels

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

DEFICIENCY FACTORS
0.08.04.08 COOLING TOWERS (CSI 15710)

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DEFICIENCY FACTORS
0.08.04.08 COOLING TOWERS (CSI 15710)

END OF SUBSECTION

0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 15510)

DESCRIPTION

The typical Chilled Water System removes heat from coils in air handlers and terminal cooling devices and circulates it through a chiller's evaporator for heat rejection. The system consists of circulating pumps, motors, expansion tanks, and the connecting piping, fittings, valves, insulation, and supports.

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 (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)

System water temperature variations 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 typically 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. Currently DOE requires that chilled water distribution 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), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

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.

Pipe sleeve seals should be provided at foundation and basement wall penetrations. Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 15510)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Valves (CSI 15100)

Valves are primarily used to permit switching pumps and isolating air handlers, terminal units, evaporators, and other components for maintenance.

Drain valves are installed at low points in mains 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 system flow reversal in the chilled water circulation lines.

At any cross-connect between the potable water system and other systems (heating, drainage, chilled water, etc.), a backflow preventer is used to prevent potable water contamination. All valves should be installed in accessible locations, and protected from physical damage. Valves should be tagged.

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 and seismic activity. They should be securely attached to building construction at sufficiently close intervals.

Insulation (CSI 15250)

Chilled water piping should be insulated to reduce pipe surface condensation and improve energy efficiency.

Equipment Controls & Panels (CSI 15950)

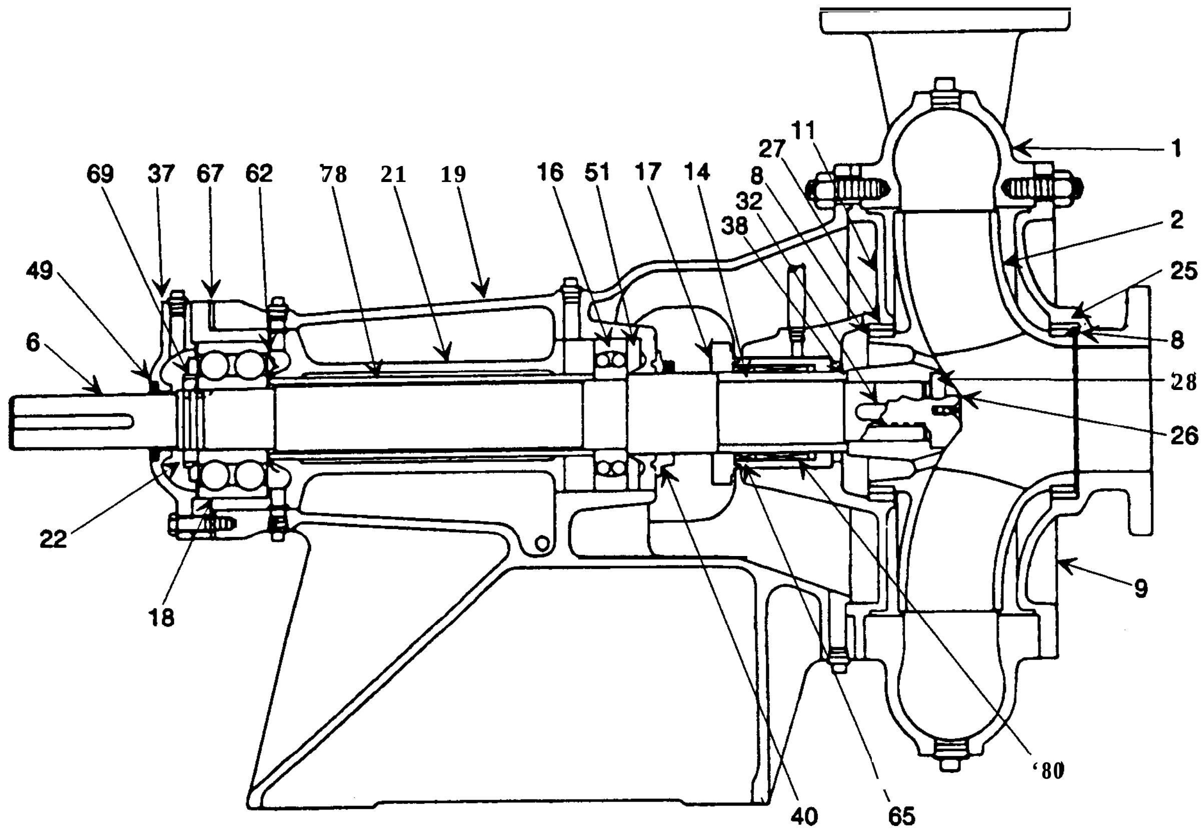
Few controls are required in the typical chilled water system. The system is usually cycled when HVAC systems are started, and switches are located on the associated chiller or Packaged HVAC unit.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Flow switches are typically installed and interlocked with the chiller.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

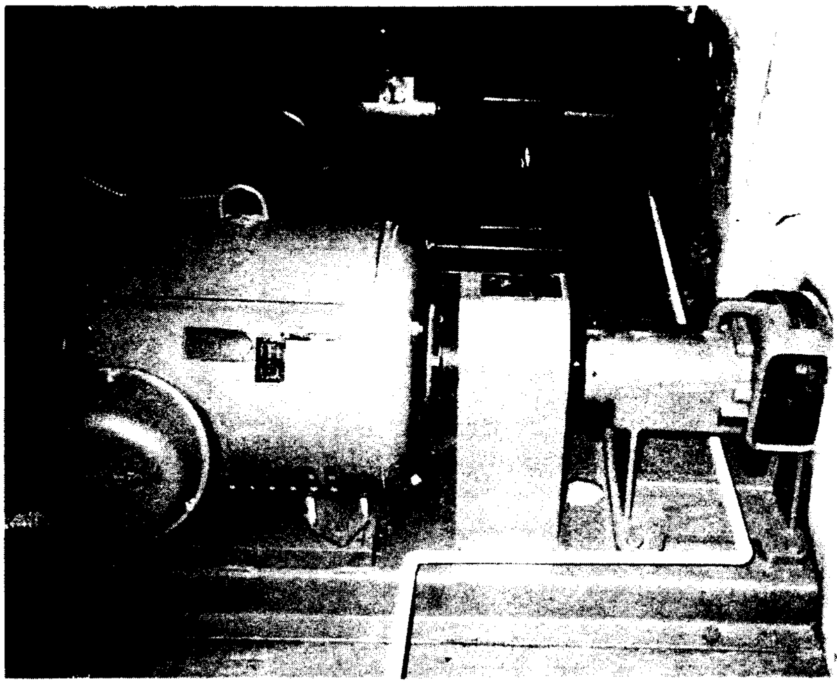


1	CASING	17	GLAND	28	GASKET. IMPELLER SCREW	62	THROWER, OIL OR GREASE
2	IMPELLER	19	BEARING, OUTBOARD	32	KEY, IMPELLER	65	SEAL, MECHANICAL, STATIONARY ELEMENT
6	SHAFT, PUMP	19	FRAME	37	COVER, BEARING, OUTBOARD		
9	RING, IMPELLER	21	LINER, FRAME	39	GASKET, SHAFT-SLEEVE	67	SHIM, FRAME-LINER
9	COVER, SUCTION	22	LOCKNUT, BEARING	40	DEFLECTOR	69	LOCKWASHER
11	COVER, STUFFING BOX	25	RING. SUCTION COVER	49	SEAL, BEARING COVER, OUTBOARD	78	SPACER, BEARING
14	SLEEVE, SHAFT	26	SCREW, IMPELLER			80	SEAL, MECHANICAL, ROTATING ELEMENT
16	BEARING, INBOARD	27	RING, STUFFING COVER	51	RETAINER. GREASE		

NUMBERS DO NOT REPRESENT STANDARD PART NUMBERS IN USE BY ANY MANUFACTURER

SOURCE: 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL CROSS SECTION OF AN END SUCTION PUMP		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080409-1



NOTE: INSULATED BOX AROUND PUMP HOUSING

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL PUMP CHILLED WATER		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	issue Date 5/93	Drawing No. A080409-2

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BRONZE IMPELLER, CHILLED WATER PUMP		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080409-3

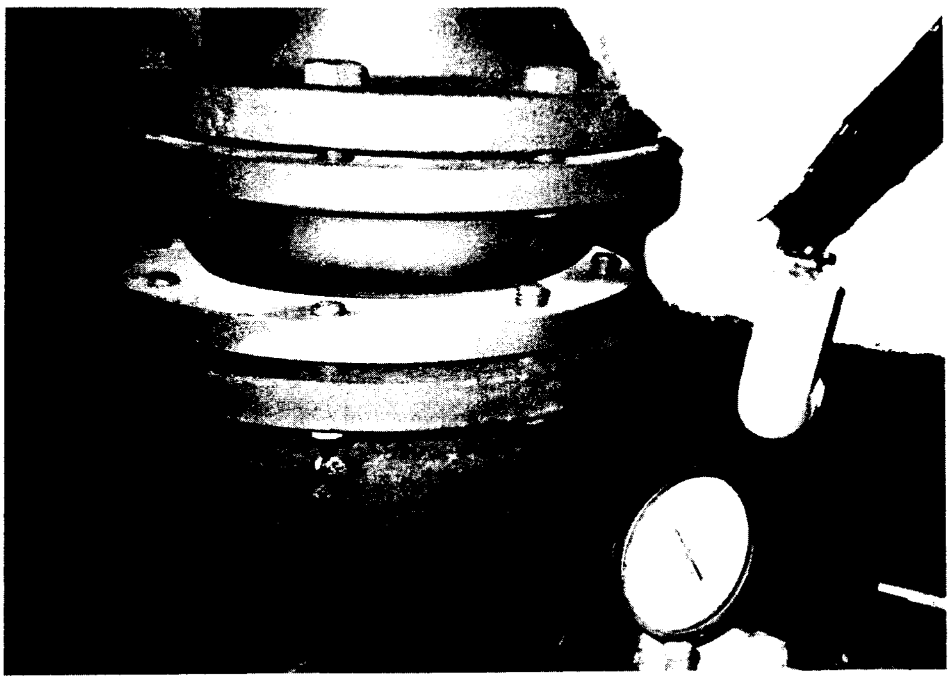


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	VIBRATION ISOLATOR		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080409-4

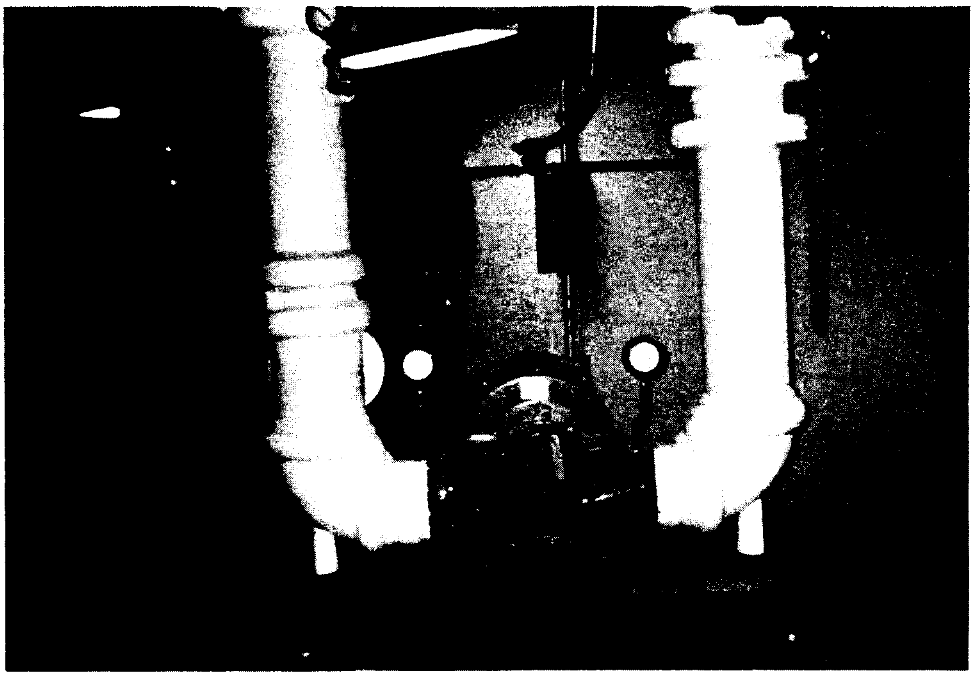


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HORIZONTAL SPLIT CASE CENTRIFUGAL CHILLED WATER PUMP		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080409-5

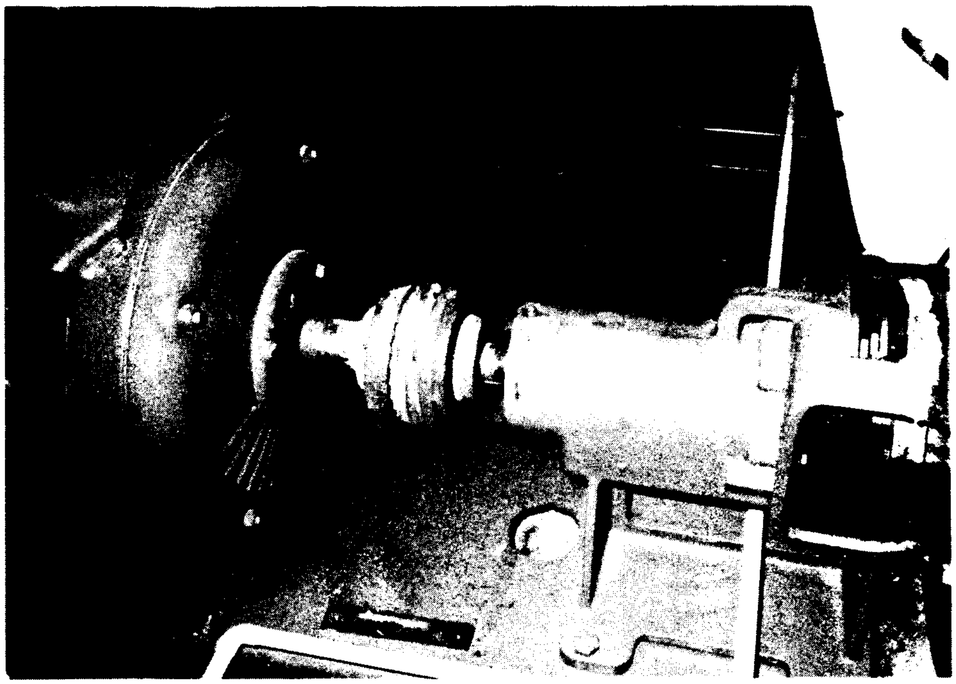


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	FLEXIBLE COUPLING		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. A080409-6

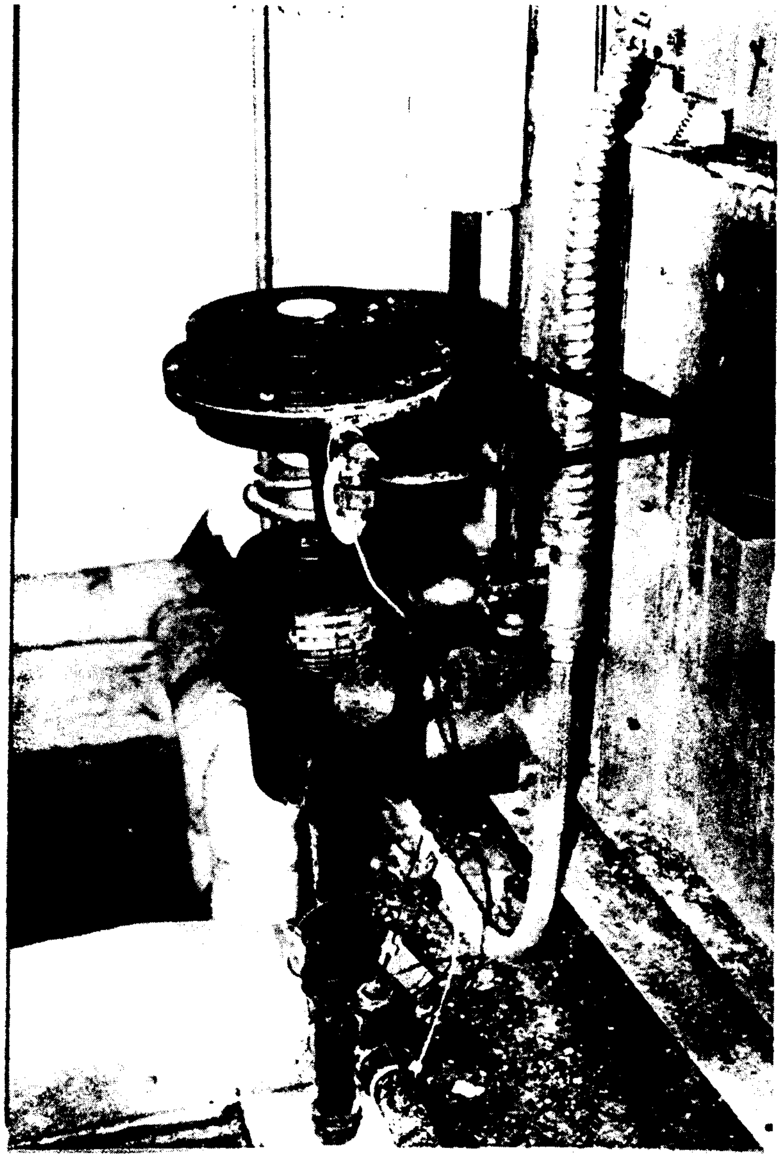


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	REGULATING VALVE		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM [redacted]	Revision No.	Issue Date 5/93	Drawing No. A080409-7

DEFICIENCY FACTORS
0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 15510)

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion.
- System unable to deliver rated capacity to condensers due to internal scaling of the distribution network, pumping failures.

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps	
Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
Expansion Tanks	
Severe Corrosion:	Poor maintenance, inadequate water treatment.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Inadequate Pressure:	Makeup valve failure.
Plping & Fittings	
Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.

DEFICIENCY FACTORS
0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 155101

SYSTEM ASSEMBLIES/DEFICIENCIES

Piping & Fittings (Continued)

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, 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.

Instrumentation

Missing:	Taken out for service or repair and not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
illegible:	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 removed and not replaced.
Wet:	System leakage or external causes.
Damaged:	Physical abuse.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.
Missing:	Taken out for service, not replaced.

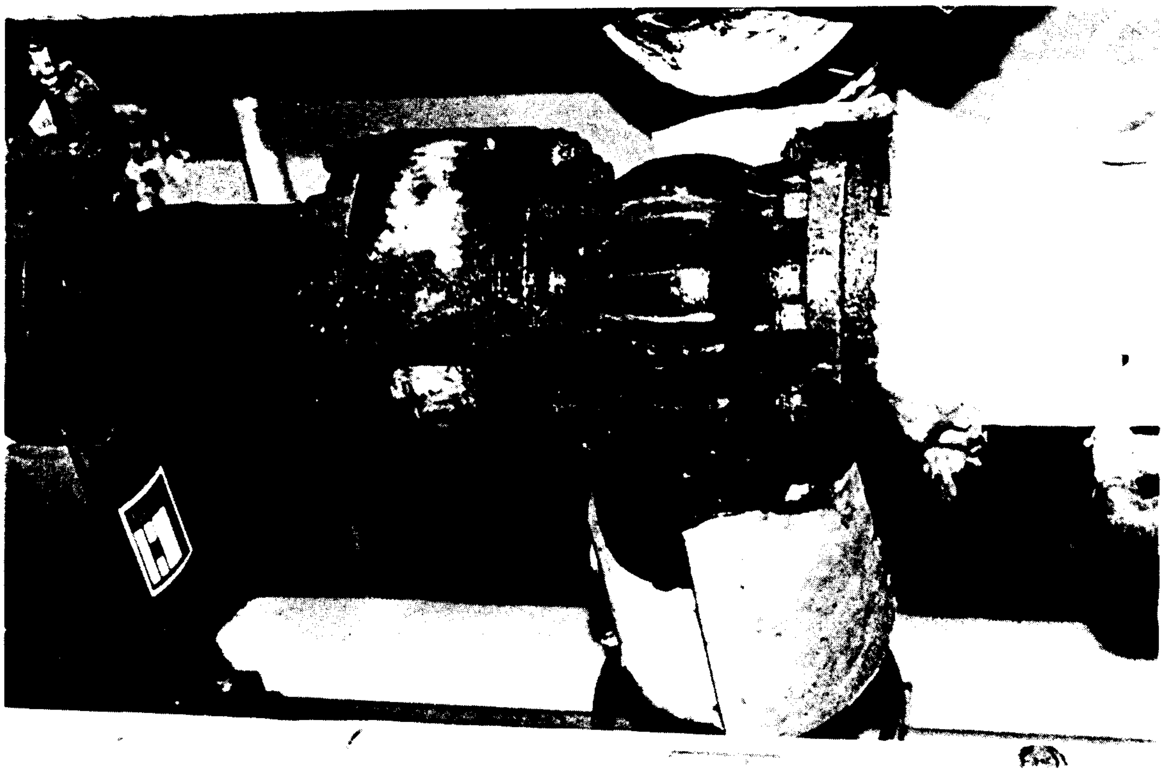


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	INSULATION MISSING, LEAKING CHECK VALVE		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. 0080409-I

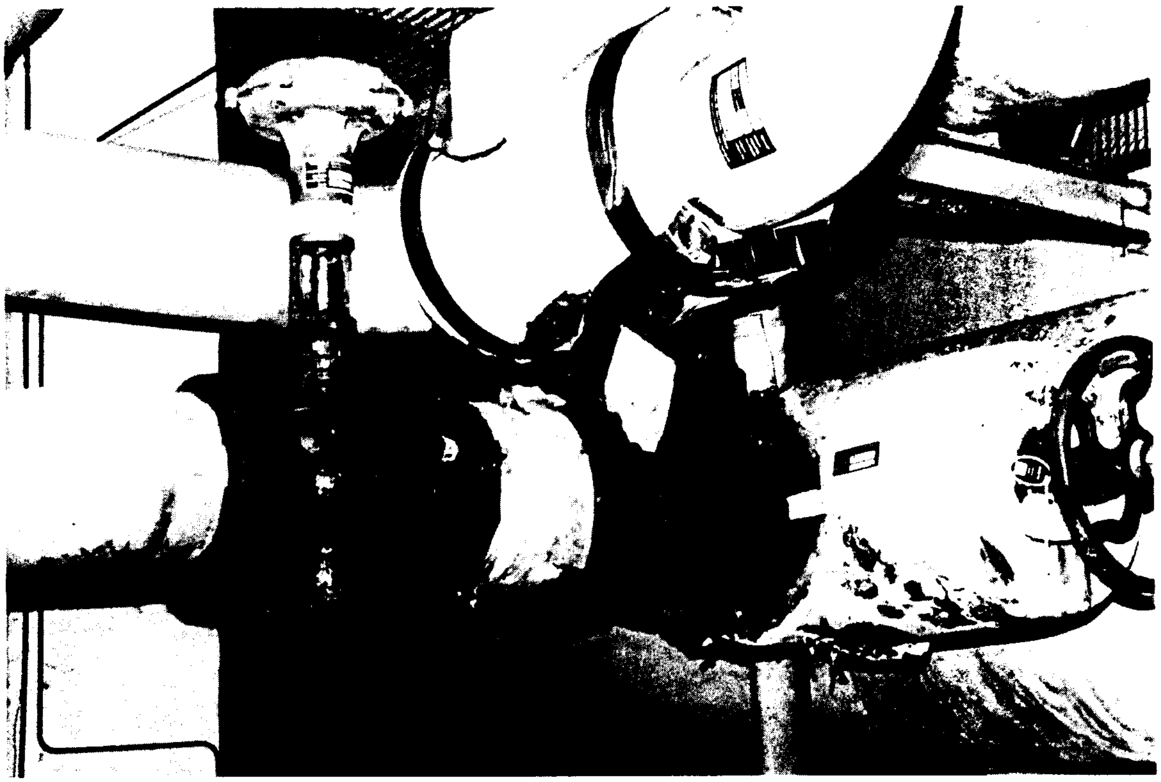


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	MISSING INSULATION, REGULATING VALVE AND CHECK VALVE

	Revision No.	Issue Date	Drawing No.
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)		5/93	D080409-2

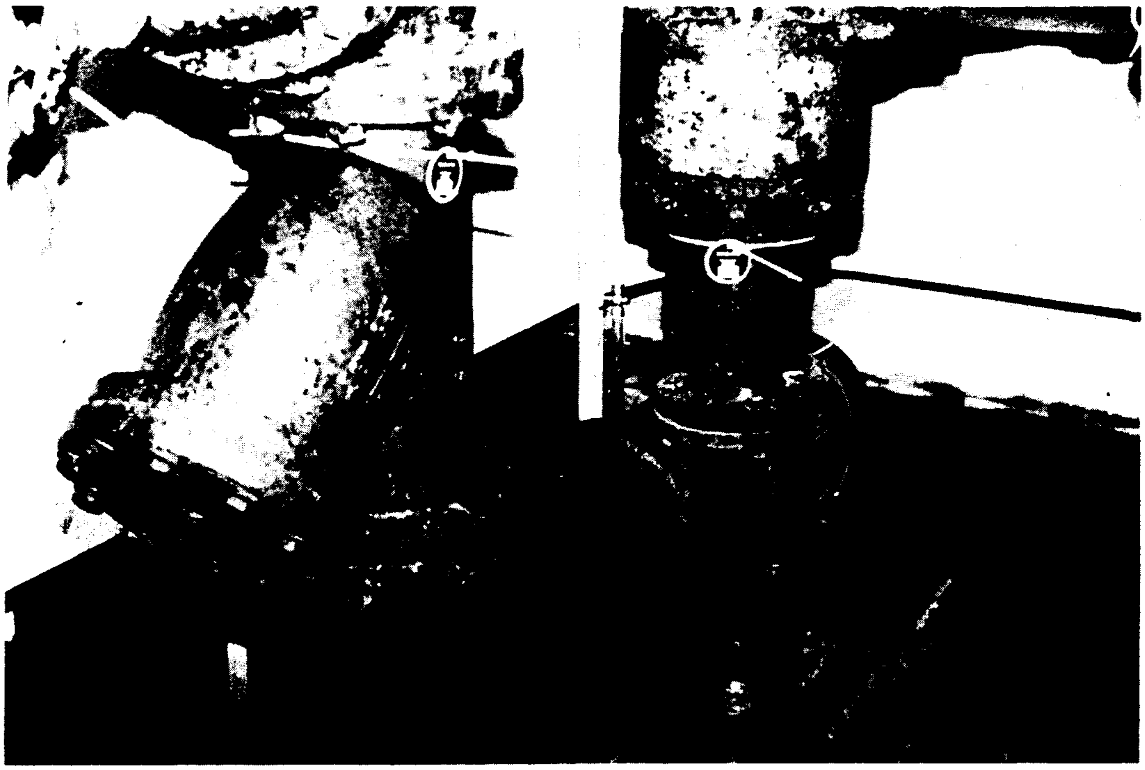


PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DEFICIENCY DETAILS-MECHANICAL SYSTEMS	MISSING INSULATION, PIPE CORRODED, INLINE STRAINER AND CHECK VALVE		
COOLING-CHILLED WATER DISTRIBUTION SYSTEM (CSI 15510)	Revision No.	Issue Date 5/93	Drawing No. D080409-3

DEFICIENCY FACTORS
0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 15510)

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DEFICIENCY FACTORS
0.08.04.09 CHILLED WATER DISTRIBUTION (CSI 15510)

END OF SUBSECTION

0.08.04.10 CONDENSER WATER SYSTEM (CSI 15740)

DESCRIPTION

The typical Condenser Water System removes heat from a chiller or a Packaged HVAC unit condenser and circulates it through a cooling tower, cooling pond, or similar system for heat rejection. The system consists of circulating pumps, motors, and the connecting piping, fittings, valves, insulation, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Pumps (CSI 15540)

Condenser pumps provide for condenser water circulation 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. A common variation for very large condenser units is a vertical turbine centrifugal pump.

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.

The condenser water system is open, exposed to the atmosphere. It also operates at elevated temperatures. Scaling, corrosion, and contamination by environmental pollutants is more prevalent than in a closed system.

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

Motors (CSI 15170)

Motors are used to drive the circulating pumps (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, alternative couplings (close, fluid, or eddy current).

Piping & Fittings (CSI 15411)

Piping and fittings provide the distribution network for the condenser water system. Current DOE requires that condenser water distribution 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), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Strainers are typically provided at the suction of the water pumps. These are used 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.

Pipe sleeve seals should be provided at foundation and basement wall penetrations. Pipe penetrations of fire barriers should be sealed using fire barrier penetration sealers.

0.08.04.10 CONDENSER WATER SYSTEM (CSI 15740)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Valves (CSI 15100)

Valves are primarily used to permit switching pumps and isolating condensers, cooling tower cells, and other components for maintenance.

Drain valves are installed at low points in mains 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 the pump to prevent windmilling of idle pumps and to prevent system flow reversal in the condenser water circulation lines.

At any cross-connect between the potable water system and other systems (heating, drainage, chill water, etc.), a backflow preventer is used to prevent potable water contamination.

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

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 building construction at sufficiently close intervals.

Insulation (CSI 15250)

Interior condenser water piping rarely exceeds 1 00°F and is therefore frequently not insulated. Any outdoor piping should be insulated to provide freeze protection.

Equipment Controls & Panels (CSI 15950)

Few controls are required in the typical condenser water system. The system is usually cycled when HVAC systems are started, and switches are located on the associated chiller or Packaged HVAC unit.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Flow switches are typically installed and interlocked with the chiller.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

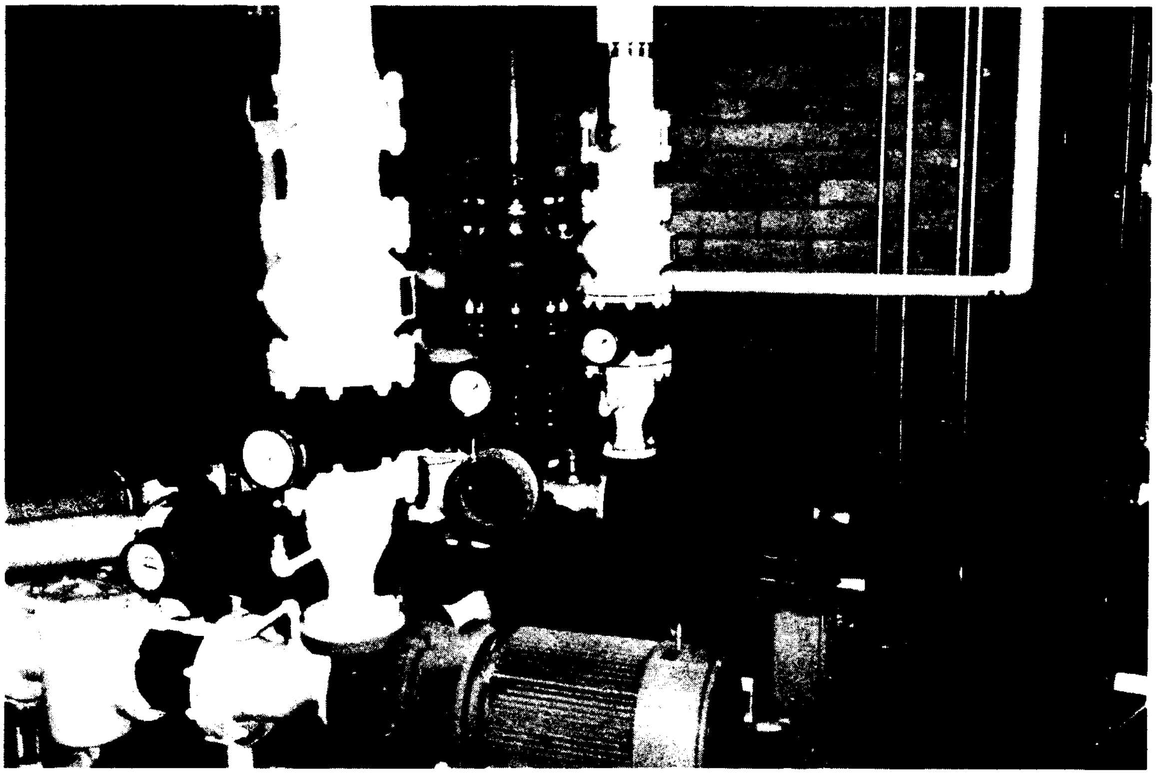

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL PUMPS IN PARALLEL CONFIGURATION		
COOLING-CONDENSER WATER SYSTEM (CSI 15740)	Revision No.	Issue Date 5/93	Drawing No. A080410-1

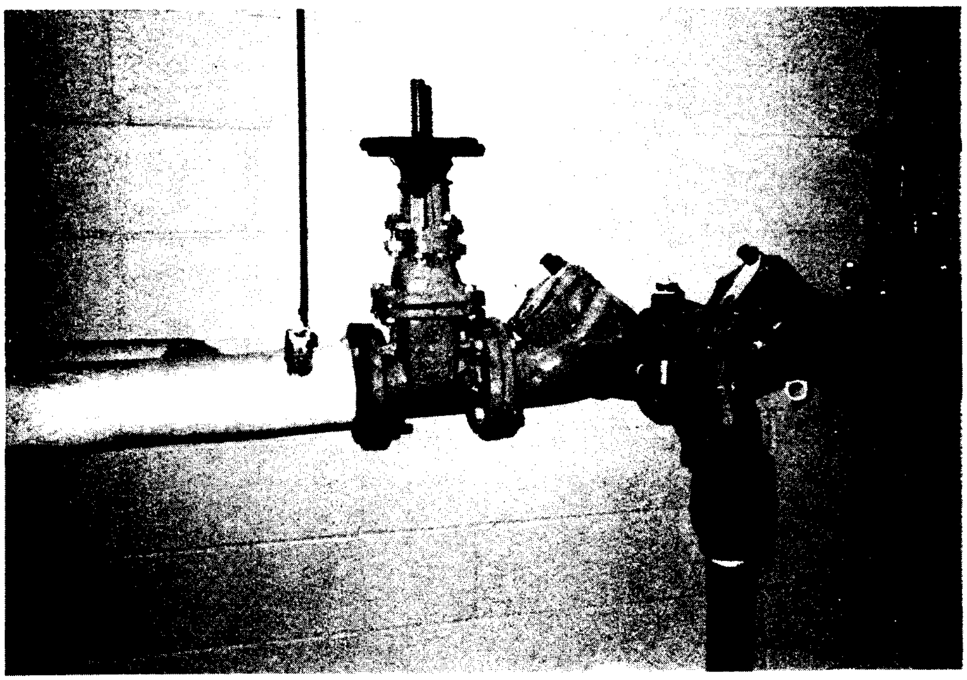

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	BACKFLOW PREVENTER		
COOLING-CONDENSER WATER SYSTEM (CSI 15740)	Revision No.	Issue Date 5/93	Drawing No. A080410-2

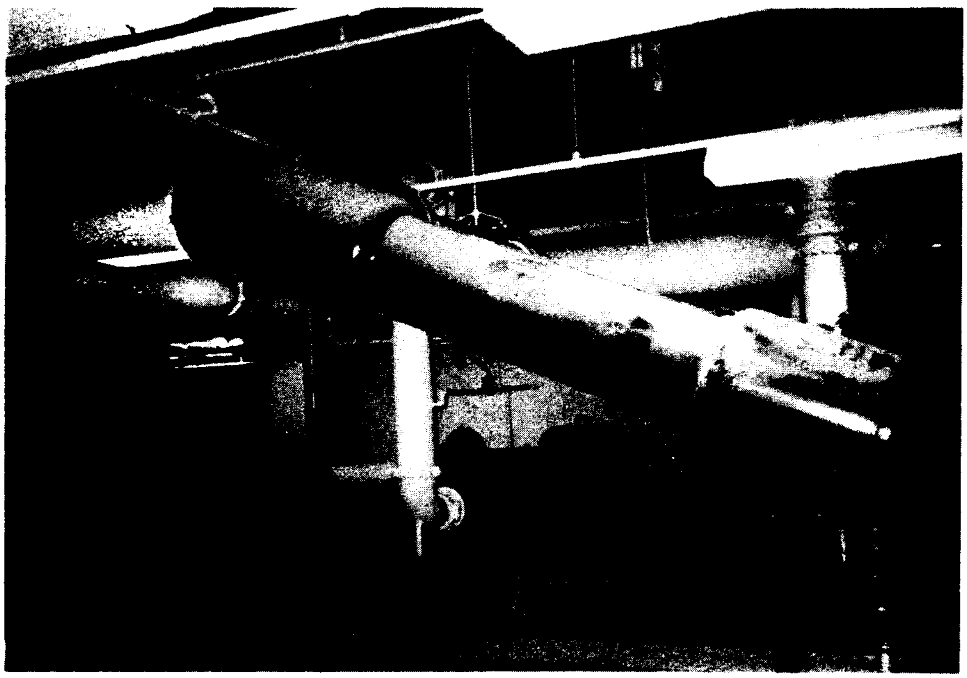

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CENTRIFUGAL SEPARATOR WITH AUTOMATIC BLOWDOWN		
COOLING-CONDENSER WATER SYSTEM (CSI 15740)	Revision No.	Issue Date 5/93	Drawhg No. A080410-3

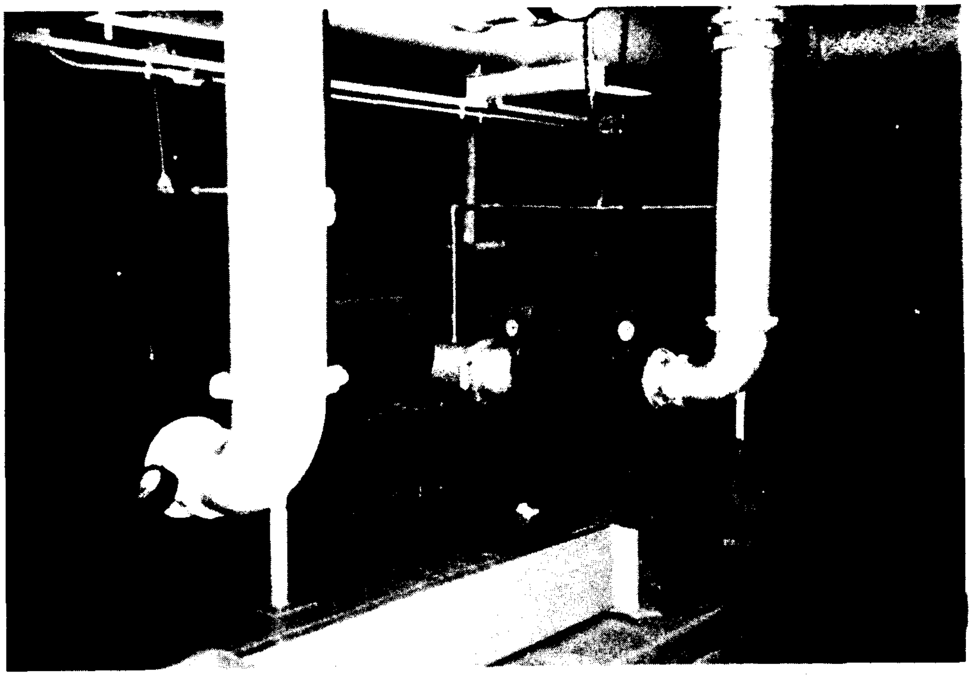

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	HORIZONTAL SPLITCASE CENTRIFUGAL PUMPS IN PARALLEL		
COOLING-CONDENSER WATER SYSTEM (CSI 15740)	Revision No.	Issue Date 5/93	Drawing No. A080410-4

DEFICIENCY FACTORS
0.08.04.10 CONDENSER WATER SYSTEM (CSI 15740)

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion, especially in an open hot water circuit where chemical reaction rate is greater.
- System unable to deliver rated capacity to condensers due to internal scaling of the distribution network, pumping failures.

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps

Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Turn:	Failed bearings, locked impeller.
Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment.
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.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, 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.

DEFICIENCY FACTORS
0.08.04.10 CONDENSER WATER SYSTEM (CSI 15740)

SYSTEM ASSEMBLIES/DEFICIENCIES

Valves (Continued)

Corrosion:	Contamination, incompatible materials.
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.
Defective Backflow Preventer:	Worn parts, scale blockage, leakage.

Instrumentation

Missing:	Taken out for service or repair and not replaced.
Inoperative:	Failed internal mechanism, corrosion, loss of sensing medium.
Inaccurate:	Wear, corrosion, imbalance in internal components, miscalibration.
Illegible:	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 removed and not replaced.
Wet:	System leakage or external causes.
Damaged:	Physical abuse.

Equipment Controls & Panels

Motor Starter Inoperative:	Linkage wear, coil open, overloading.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.
Missing:	Never installed or removed and not replaced.

END OF SUBSECTION

0.08.04.11 CHEMICAL WATER TREATMENT (CSI 15545)

DESCRIPTION

The typical Chemical Water Treatment provides mixing, metering, and distribution of required treatment materials to facility water systems such as condenser water and chilled water systems. Their purpose is to inhibit the development of scale, corrosion, and biological growth. The typical system consists of mixing tank, agitator, metering pump, and the connecting piping, fittings, valves, and instrumentation.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Mixing Tanks (CSI 15450)

The typical mixing tank for water treatment is a simple plastic drum with an agitator mounted on the side. Chemicals and any mixing water are added manually by the operator. Separate tanks are provided for each system, and in some cases, separate drums are used for each chemical to allow independent metering. The agitators are typically slow-speed motors with blading mounted on shaft extensions.

Another approach is to feed chemicals directly into system in-line reservoirs known as "shot-feeders." Part of the normal circulating water is fed through the reservoir. to introduce the chemicals to the system. Shot feeders are typically 5-gallon capacity, constructed of cast iron or steel, and provide funnel with shutoff valve on top, air release valve on top, drain valve on bottom, and recirculating shutoff valves on side.

Metering pumps (CSI 15160)

Pumps meter the chemical mixture into the treated system. Metering pumps are generally positive displacement type, usually employing a piston pump (diaphragm pumps are also common). Metering is accomplished by varying pump speed and/or stroke. Due to the corrosive effects of some chemicals, exposed pump sections (suction and discharge valves, piston, rings, etc.) are frequently made of stainless steel to extend pump life.

Motors (CSI 15170)

Motors are usually used to drive the chemical addition pump. Although some are belt driven, most are direct or gearhead motors.

Piping & Fittings (CSI 15411)

Piping and fittings provide the distribution network for the chemical treatment system. The systems are generally small, with treatment tanks located close to the treated system.

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), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Valves (CSI 15100)

Valves are primarily used to isolate mixing tanks, reservoirs, and other components for maintenance. Check valves are used on the discharge side of pumps if not already incorporated into pump design. All valves should be installed in accessible locations, protected from physical damage. Valves should be tagged.

0.08.04.11 CHEMICAL WATER TREATMENT (CSI 15545)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Instrumentation (CSI 15135, 15150)

Few gauges are used in the chemical treatment systems. Pressure gauges are sometimes provided at the discharge of metering pumps or pump groups. However, several meters are frequently found; flow meters are common to validate feed quantities. Conductivity and pH meters are commonly used to determine need for adjustments in the treatment process.

Equipment Controls & Panels (CSI 15980)

Few controls are used in the typical chemical treatment system. The agitator on the mixing tank is usually small enough to allow control by a light switch.

In some newer systems, sensors (pH, conductivity, TDS) are employed in the treated systems and are interlocked with the feeders to automatically adjust chemical addition. The devices may also be used to control the blowdown and bleed off rates for cooling towers.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.

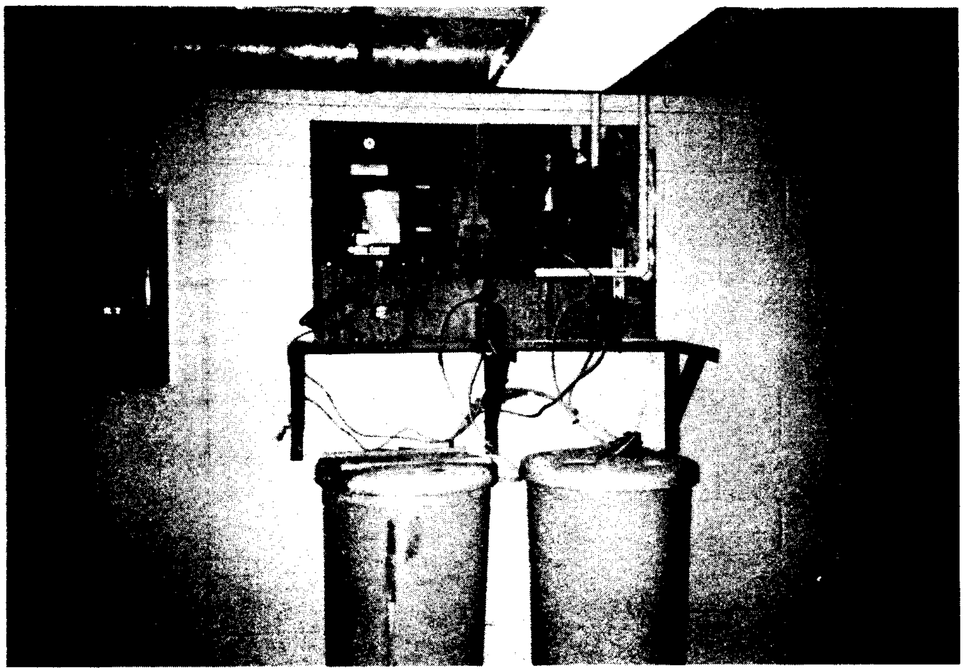

PHOTO ILLUSTRATION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	CHEMICAL ADDITION POINT WITH AUTOMATIC MONITORING SYSTEM		
COOLING-CHEMICAL WATER TREATMENT (CSI 15545)	Revision No.	Issue Date 5/93	Drawing No. A080411-1

DEFICIENCY FACTORS
0.08.04.11 CHEMICAL WATER TREATMENT (CSI 15545)

PROBABLE FAILURE POINTS

- Leakage in piping due to corrosion, especially in water circuit where chemical reaction content is great.
- System unable to deliver rated capacity to terminal points due to feeder mechanism failure.

SYSTEM ASSEMBLIES/DEFICIENCIES

Mixing Tanks	
Tank, Pipe, or Fitting Leakage:	Age, physical damage, severe internal or external corrosion: gasket failure at manhole or other fittings.
Excessive Corrosion:	Normal use.
Agitator Inoperative:	Normal wear.
pump8	
Missing:	Taken out for service or repair, not returned.
Inoperative, Will Not Run:	Failed bearings, locked piston.
Excessive Vibration:	Generally due to wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
inadequate Capacity:	Low pressure, low flow caused by wear, defective diaphragm.
Motors	
Missing:	Taken out for service, not returned.
Inoperative:	Damaged bearings, corrosion.
Excessive Noise, Vibration:	Bearing wear, fan imbalance, misalignment.
Excessive Load:	Bearing wear, misalignment.
Excessive Corrosion:	Poor maintenance.
Damaged:	Abuse, poor maintenance, stress.
Defective Coupling:	Age, normal wear, improper lubrication.
Defective Bearings:	Age, normal wear, improper lubrication.
piping & Fittings	
Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
Physical Damage:	Bent, broke, crimped, crushed.
Improper Wall Penetration:	Missing seals, flanges, escutcheons.

DEFICIENCY FACTORS
0.08.04.11 CHEMICAL WATER TREATMENT (CSI 15545)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Valves

Inoperative:	Corrosion, physical damage to operating mechanism.
Leakage:	Corrosion, physical damage, improper joining, worn packing or seal.
Corrosion:	Contamination, 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.

Instrumentation

Missing:	Taken out for service or repair and 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.
Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

END OF SUBSECTION

0.08.04.12 TERMINAL COOLING UNITS (CSI 158301

DESCRIPTION

Terminal Cooling Units transfer heat from the air in the conditioned space to the cooling media (refrigerant, chilled water, or condenser water). They are called terminal units because they are physically placed at the end (terminus) of the distribution system at the point where cooling is actually required. Terminal Cooling Units include fan coil, induction, and small packaged cooling units tied to a condenser water system. This standard is also extended to cover stand-alone cooling units (not tied into an existing HVAC distribution system) such as window air conditioners, Through-The-Wall Units (TTWs), swamp coolers.

Terminal Cooling Units consist of the units themselves, associated controls, filters, and the connecting ductwork, piping, fittings, valves, and supports.

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Terminal Cooling Units (CSI 15830)

Fan Coil Units:

One of the oldest terminal cooling units is the fan coil unit. It consists of a housing with one or more finned tube heat exchangers and a small blower, usually the same units provided for heating. In a two-pipe system, chilled water is substituted for the heating media during the cooling system. In a four-pipe system, a separate coil is provided for cooling requirements.

The blower forces room air directly across the heat exchanger. Makeup air is generally provided through ductwork from a perimeter air handler dedicated to the fan coils. Accessories include fan speed control, thermal controlled regulating valves, filters, and noise baffles.

Induction Units:

A more recent addition to terminal cooling units is the induction unit, consisting of a housing with one or more finned tube heat exchangers. There are no fans. These units use externally supplied forced air delivered through a bank of nozzles to induce air flow across the heat exchangers. They are usually the same units provided for heating. In a two-pipe system, chilled water is substituted for the heating media during the cooling system. In a four-pipe system, a separate coil is provided for cooling requirements. Accessories include thermal controlled regulating valves, filters, and noise baffles.

Small Packaqed Coolina Units:

Some facilities use packaged units that are hybrids of a window air conditioner and a fan coil unit. They have a full refrigeration system, but employ a tube-to-tube water-cooled condenser versus air-cooled. A building condenser water system is tied to each unit. Many heat pump installations fall into this category. These units frequently have electric heating elements or employ a heat pump to allow year-round air conditioning.

Unlike windows air conditioners, these units are floor- or ceiling-mounted. Makeup air is generally provided though an outdoor air vent damper.

Window Air Conditioners:

Many older buildings and utility spaces in newer buildings still employ window air conditioners. These units include a complete refrigeration system with finned tube evaporator and condensers, and in most cases, separate evaporator and condenser fans.

0.08.04.12 TERMINAL COOLING UNITS (CSI 15830)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Terminal Cooling Units (CSI **15830)** (Continued)

Throuah-the-Wall Units:

A common variation of the small packaged cooling units is the TTW. These units are typically heat pump units mounted in a wall penetration instead of against the wall or through the window. They require no building ventilation or HVAC water system tie-in. Makeup air is provided by an outside air intake damper.

Motors (CSI 15170)

Almost all motors used in terminal units are very small, fractional horsepower units.

Fan coil motors are typically open, AC induction, multi-speed units with extended shafts for fan mounting. Fans are typically squirrel cage, centrifugal units.

Fan motors in packaged units and TTWs are even smaller. Again, they are usually open, AC motors with extended shafts. Condenser fans are generally propeller fans; the evaporator fans may be propeller or centrifugal.

Equipment Controls **& Panels** (CSI 15950)

Few Terminal Unit installations use central control panels. Power is normally supplied from local lighting and power circuitry, generally placing multiple units on one circuit. The typical system disconnect is a small 20 Amp circuit breaker.

Individual units employ on-off switches, some with integral fan speed controls. Thermal switches are used to cycle refrigerant packages, andin some cases, control chilled water regulating valves.

Piping **&** Afflngs **(CSI** 15411)

Most piping and fitting requirements are covered with their respective distribution systems (chilled water, refrigerant, condenser water). However, because the terminal units are high maintenance items compared to the distribution piping, they are more likely locations for failure. The inspector should be particularly alert for problems in this area.

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), which-effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Flanges or escutcheons should be fitted over pipe penetrations through walls in public areas.

Valves (CSI **15100)**

Manual valves are primarily used to permit isolating units and other components for maintenance.

Regulating valves are also used to control water flow through the terminal units. These valves may be two or three way (bypass) units modulated by local thermal bulbs or remote thermostats. They may be mechanical, electrical and/or pneumatic.

Manual and/or automatic vent/drain valves are common on terminal units. They are used to purge/drain the units after shutdown for maintenance or seasonal outages.

0.08.04.12 **TERMINAL** COOLING UNITS **(CSI 15830)**

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS (Continued)

Insulation (CSI 15250)

A minimal amount of insulation is used for thermal efficiency in terminal units, primarily on chilled water piping. However, almost every unit will employ insulation batting for noise reduction.

Ductwork (CSI 15890)

Like piping, most ductwork items are covered under their respective distribution systems. However, because the terminal units are high maintenance items (compared to the duct), duct joint failures are more likely at the terminal units themselves. The joints are typically fabric that ages and cracks or tears. The inspector should be particularly alert for problems in this area.

All induction units and some fan coil units receive air from the building's central air handling system. There are one or more reductions in duct size at each terminal unit and therefore several duct joints. These items are frequently disconnected for maintenance. At the point of entry, baffles are frequently installed for noise reduction. These "hidden" devices are common sources of reduced terminal unit performance.

OTHER RELATED COMPONENTS

See the following subsections for related components:

NOTE: **Similar parts are addressed in separate sections for individual piping system sections of CSI Division 15.**

0.08.04.12 TERMINAL COOLING UNITS (CSI 15830)

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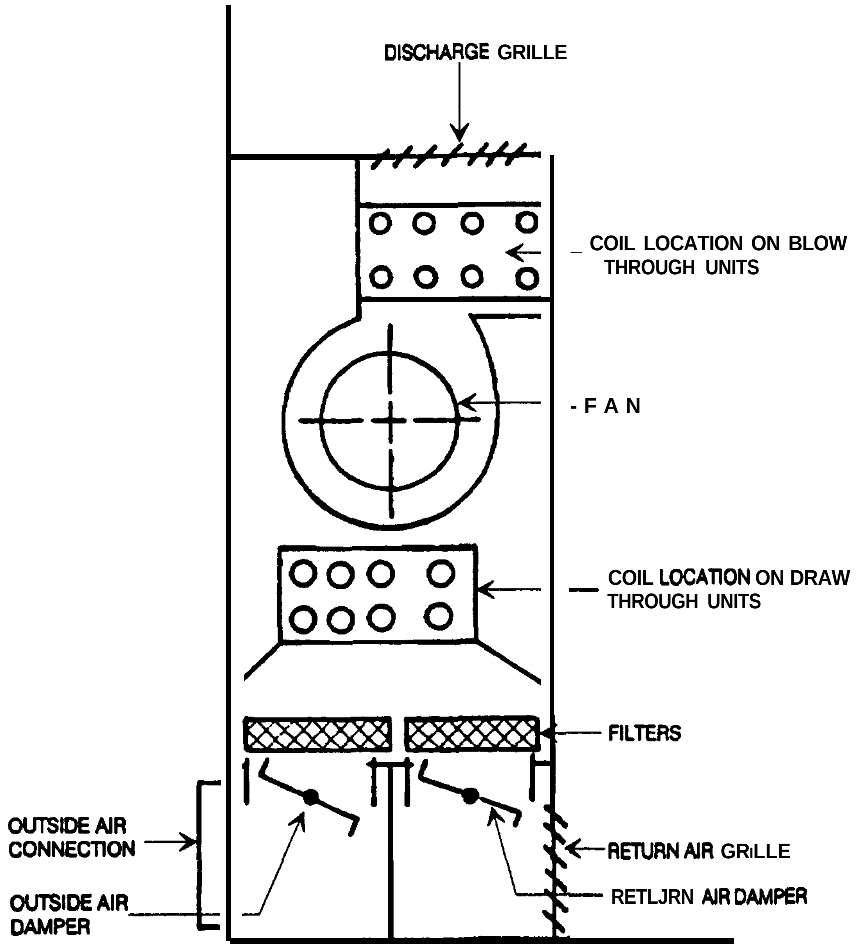
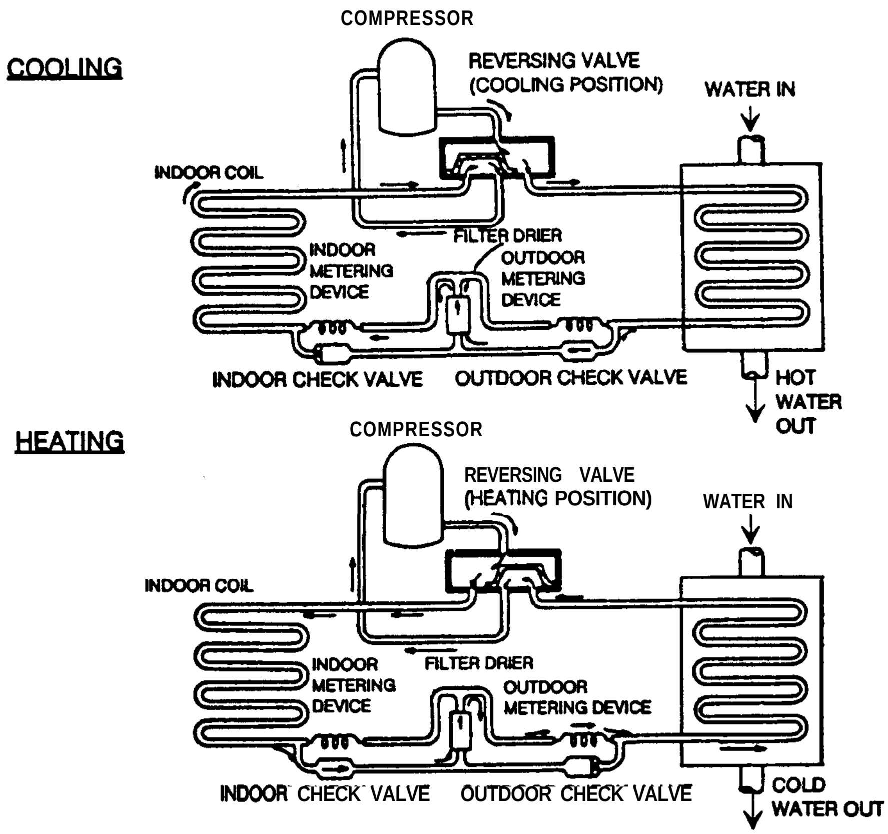


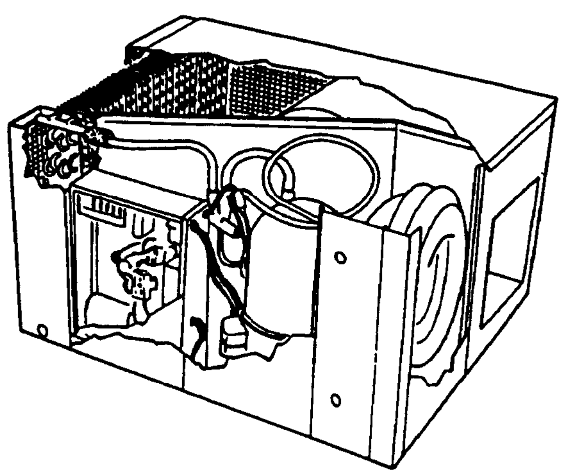
UNIT VENTILATOR ARRANGEMENT

SOURCE 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT. REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	UNIT VENTILATOR ARRANGEMENT		
COOLING-TERMINAL COOLING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080412-1

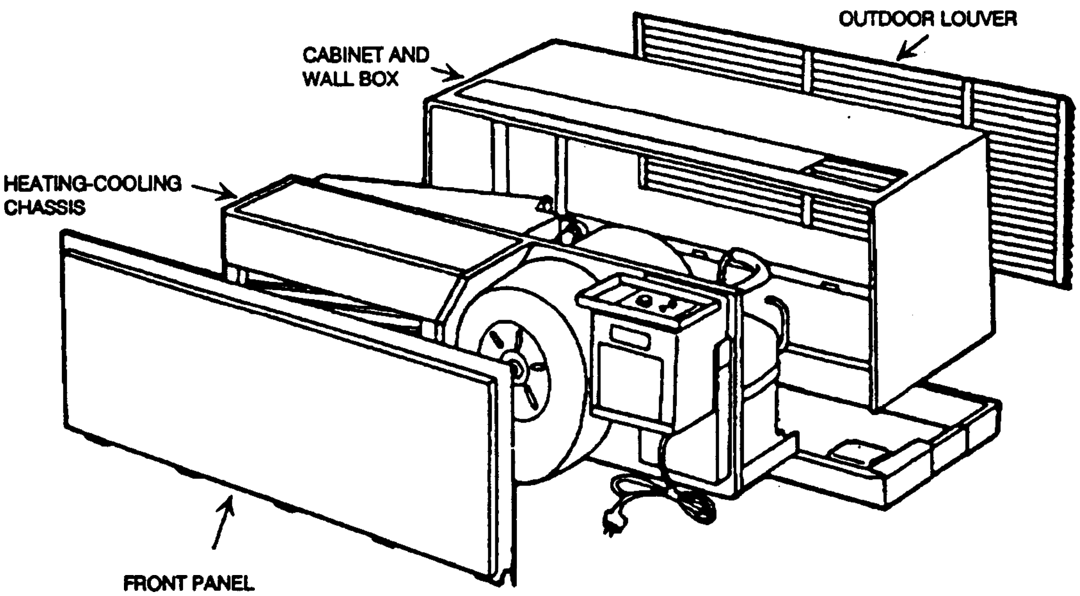


TYPICAL SCHEMATIC OF A WATER-SOURCE HEAT-PUMP SYSTEM



SOURCE: 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT, REPRINTED WITH PERMISSION.

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL HORIZONTAL WATER-SOURCE HEAT PUMP		
COOLING-TERMINAL COOLING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080412-2



SOURCE 1992 ASHRAE HANDBOOK, HVAC SYSTEMS AND EQUIPMENT REPRINTED WITH PERMISSION

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	PACKAGED TERMINAL **AIR-** CONDITIONER-INTEGRATED TYPE		
COOLING-TERMINAL COOLING UNITS **(CSI 15830)**	**Revision No.**	**Issue Date** 5/93	**Drawing** No. A080412-3

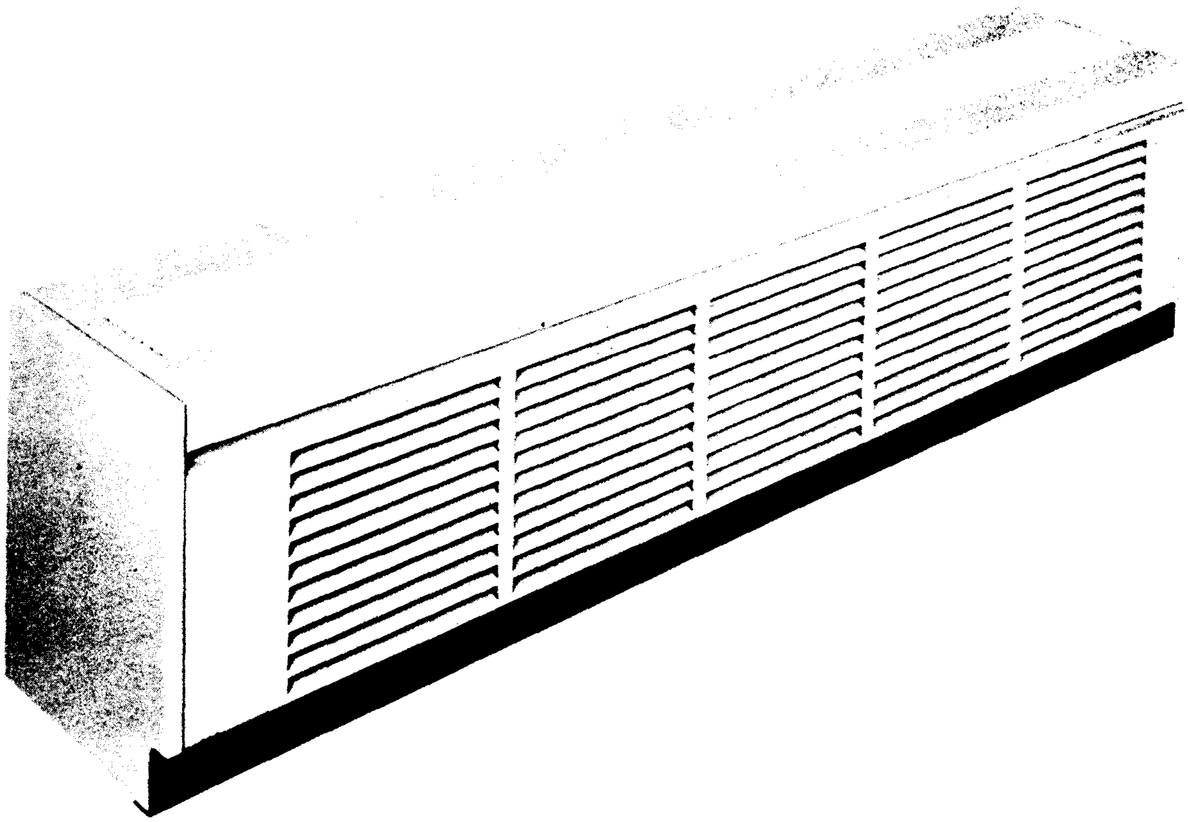


PHOTO ILLUSTRATION

SOURCE COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL COOLING UNIT		
COOLING-TERMINAL COOLING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080412-4

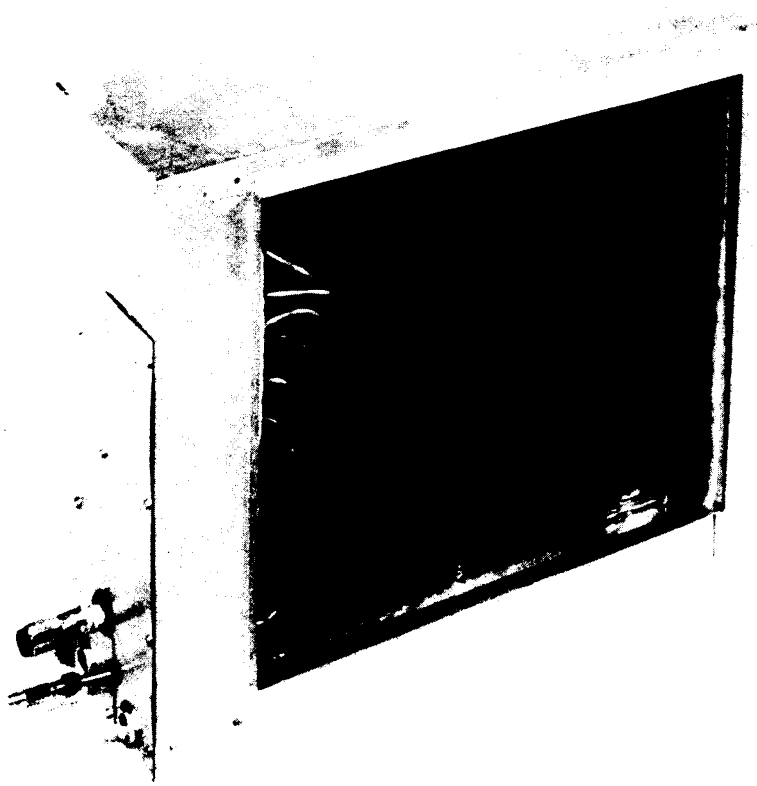


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL DX COIL WITH DISTRIBUTOR		
COOLING-TERMINAL COOLING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080412-5

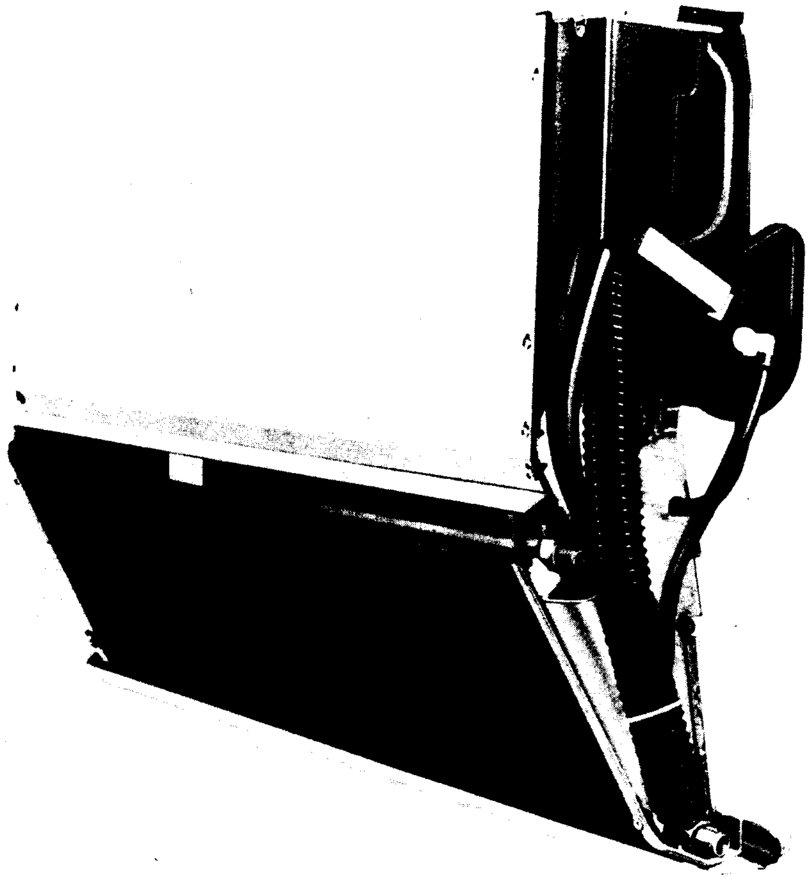


PHOTO ILLUSTRATION

SOURCE: COURTESY OF UNITED TECHNOLOGIES/CARRIER

SYSTEM ASSEMBLY DETAILS-MECHANICAL SYSTEMS	TYPICAL INDUCTION **UNIT WITH** CHILLED WATER **COIL**		
COOLING-TERMINAL COOLING UNITS (CSI 15830)	Revision No.	Issue Date 5/93	Drawing No. A080412-6

DEFICIENCY FACTORS
0.08.04.12 TERMINAL COOLING UNITS (CSI 15830)

PROBABLE FAILURE POINTS

- Reduction in heat transfer capability due to piping and/or HX coil blockage.
- Leakage in piping or heat exchanger due to corrosion, especially in condensate circuits.
- Loss of air flow due to fan failure.
- Poor temperature control due to physical damage, poor maintenance.

SYSTEM ASSEMBLIES/DEFICIENCIES

Terminal Units

Inoperative:	Control failure, defective fan, frozen valves, defective wiring.
HX Coil Leakage:	Age, corrosion, physical damage.
Severe Corrosion:	Aging, lack of maintenance.
Missing Fan:	Taken out for maintenance and not returned.
Severe Physical Damage to Cabinet:	Abuse.

Motors

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

Equipment Controls & Panels

Control Housing Corrosion:	Aging, poor maintenance.
Bypassed Controls:	Defective or inaccurate.
Damaged Wiring:	Frayed, burned.
Relays Pitted or Burned:	Normal wear, overloading.

Piping & Fittings

Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Age, poor maintenance, leakage.
Physical Damage:	Abuse, stress, poor maintenance.

DEFICIENCY FACTORS
0.08.04.12 TERMINAL COOLING UNITS (CSI 15830)

SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Valves

Leakage:	Improper packing, corrosion.
Inoperative:	Corrosion, damaged operating mechanism.
Excessive Corrosion:	Age, poor maintenance, leakage.
Physical Damage:	Abuse, stress, poor maintenance.
Poor Regulation:	Worn off seat/disc, defective sensing mechanism, blocked lines.

Insulation

Missing:	Poor maintenance.
Wet:	Improper drainage, leaks in coils.
Damaged:	Poor maintenance, corroded fasteners.

Ductwork

Excessive Noise:	Improper air flow, loose or missing fasteners.
Physical Damage:	Bent, broke, crimped, crushed.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Condensation, inadequate insulation.
Dampers Inoperative:	Corrosion, physical damage.
Damaged Expansion Joints:	Poor maintenance, abuse, over-pressurization.
Missing Penetration Seals, Covers:	Seals not installed or damaged, flanges/escutcheons removed.

END OF SUBSECTION

0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

DESCRIPTION

Most facilities provide chilled drinking water for tenants by installing independent upright or wall-mounted refrigeration units that either tie into the domestic water supply or use replaceable water bottles. However, many older buildings used a centralized cooling system to fulfill this need.

The typical central drinking water cooling system uses a small packaged chiller consisting of a housing, one or more refrigerant compressors, an evaporator, and a condenser. In addition, the system includes circulating pumps, motors, drinking fountains, and the connecting piping, fittings, instrumentation, and controls.

ASSOCIATED **ASSEMBLY\STANDARD** COMPONENTS

Housing (CSI 15680)

The packaged chilling unit is usually installed as a self-contained unit in a single enclosure. This structure is generally made of steel with galvanized steel panels, and painted sheet metal access plates and covers. The housing is lined with insulation for noise abatement. The unit is typically mounted on a concrete pedestal with vibration eliminators.

Refrigeration Compressors (CSI **15655)**

Compressors are typically hermetic or semi-hermetic reciprocation units.

Bearing lubrication is provided by a splash or flooded system. Semi-hermetic units have a bulls-eye for oil level indication.

Compressor capacity control varies depending on size. Single hermetic compressor systems employ on/off cycling of the system. Medium size systems include multiple compressors and cycle these units as needed. Larger, semi-hermetic units employ unloading devices that hold the suction valves open or recycle some of the discharge gas to the suction.

Evaporators (CSI 15730)

Evaporators serve to expand the high-pressure refrigerant liquid and in the process remove its latent heat of evaporation from the chilled water circuit. Evaporators in chillers are typically shell and tube heat exchangers.

Condensers (CSI 15740)

Condensers in a packaged chiller serve to condense the high-pressure refrigerant gas. In this process, its latent heat of evaporation is conducted to the condenser water circuit in a water-cooled application or to the ambient air in an air-cooled application.

Packaged chillers for drinking water normally employ water-cooled, tube-in-tube condensers. These frequently employ one-pass, thermal regulated city water for cooling (which is subsequently dumped to drain). Others may be tied into an existing condenser water circuit for building cooling, or use a fan-cooled condenser.

Pumps (CSI 15160)

Pumps provide for chilled water circulation throughout the drinking water distribution system to minimize the wait time involved when chilled water is required at a far point in the system (and also eliminates the associated water waste). Pumps are also used to booster system pressure in tall buildings or where the building is far from the water source.

Drinking water pumps are typically single-stage, centrifugal pumps. They are usually small (fractional horsepower) in-line units, although some large systems may use larger, pedestal-mounted units.

0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Pumps (CSI 15160) (Continued)

The circulating pumps are typically located outside the chiller package. Pumps should be arranged to provide easy access for periodic maintenance and repair.

Motors (CSI 15170)

Motors are used to drive the drinking water pumps. Small circulator pumps are typically driven via spring-coupled, open AC motors. Larger booster pumps are typically driven via rigid or flex-coupled, drip-proof AC motors.

The refrigerant compressor drive motor are typically AC units enclosed in the compressor housing (hermetic and semi-hermetic units).

Piping **&** Rfflngs (CSI 15050)

Packaged chilling units have the major components located close to one another. Therefore there is little refrigerant piping, simply the compressor to condenser and evaporator connections. Typical unit fittings include liquid line filter dryers, sight glass, and moisture indicators.

Piping for refrigerant lines and indicators is typically type ACR hard tubing. All suction piping should be insulated. Piping and fittings also provide the distribution network for the drinking water system. This is usually a two-pipe system, providing for chilled water recirculation.

Piping is typically copper tubing, brass, copper, or galvanized steel.

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), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

Lead sc!der is not allowed for joining potable water piping.

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

Piping should be sloped to assist in oil return to the compressors.

Valves (CSI 15100)

Refrigeration valving is primarily used to effect load control and to isolate components for maintenance.

Thermal expansion valves are used to control (respond to) load changes. Other local supply line valves include a liquid line solenoid valve and a manual shutoff. These allow pumping down the unit and isolating the evaporator, condenser, and compressor for maintenance. Each compressor usually has manual isolation valves at both the suction and discharge. In the distribution network, valves are primarily used to permit isolating components and terminal fixtures for maintenance.

Drain valves are installed at low points 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 and to prevent reversal of system flow in the chilled water circulation lines.

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

Insulation (CSI 15250)

Chilled water piping should be insulated to provide condensate protection and energy efficiency.

0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

ASSOCIATED ASSEMBLY/STANDARD COMPONENTS

Fixtures (CSI 15440)

The fixtures covered in this section are primarily wall-mounted porcelain fountains. The only fittings are an isolation valve, a spring return operating valve, and a drain trap.

Instrumentation (CSI 15130)

Pressure gauges are typically provided for the compressor suction and discharge pressure and for pump suction and discharge. Temperature gauges are provided on the chilled water supply and return lines.

Equipment Controls **& Panels** (CSI 15950)

Packaged chiller units usually include a master panel for all instrumentation and controls. Compressor control is performed via a motor assembly (motor, starter, and disconnect). Compressors frequently have oil and gas pressure limits as well as chilled water temperature limits interlocked with the starter that can trip compressor operation.

Few additional controls are used in the distribution system. The system is usually turned on and left running except for routine maintenance services.

Pump control is performed via a typical motor assembly (motor, starter, and disconnect). Small in-line circulators may use a simple light switch for control.

OTHER RELATED COMPONENTS

See the following subsection for related components:

0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

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DEFICIENCY FACTORS
0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

PROBABLE FAILURE POINTS

- Loss of system charge - leakage in seals and fittings due to wear, corrosion; failure of a relief due to over pressurization, condenser fouling.
- Bearing failure - loss of oil pressure due to wear of compressor parts, blockage in lubrication system, overheated oil.
- Tube failure in heat exchanger due to thermal stress, tube fouling..
- Motor failure - insulation deteriorates due to excessive moisture, overloaded windings.

SYSTEM ASSEMBLY/DEFICIENCIES

Housing

Severe Corrosion:	Normal aging, wear, poor maintenance.
Physical Damage:	Missing covers, access plates, defective dampers.
Defective Mounts:	Corroded, collapsed, damaged fasteners.
Insulation wet, missing, damaged:	Leaks, abuse, poor maintenance.

Compressors

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

Evaporators

Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion.
Excessive Corrosion:	Poor maintenance, local water conditions.
Leakage:	Defective seals, corrosion.

Condensers

Tube Damage:	Fouling, cracks, pitting due to erosion, corrosion, fin damage.
Excessive Corrosion:	Poor maintenance.
Leakage:	Defective seals, corrosion.

pumps

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

DEFICIENCY FACTORS
0.08.05.01 DRINKING WATER COOLING SYSTEMS (CSI 15480)

SYSTEM ASSEMBLIES/DEFICIENCIES

Pumps (Continued)

Excessive Noise:	Wear, imbalance, misalignment.
Excessive Vibration:	Wear, imbalance, misalignment.
Severe Corrosion:	Aging, lack of maintenance.
Seal Leakage:	Worn mechanical seal, defective packing.
Defective Bearing:	Age, normal wear, improper lubrication.
Excessive Load:	Bearing wear, misalignment,
Inadequate Capacity:	Low pressure, low flow caused by wear.

Motors

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

Piping & Fittings

Strainers Unremovable:	Corrosion of fittings, lack of maintenance.
Leakage:	Corrosion, physical damage, inadequate support, improper joining.
Excessive Corrosion:	Incompatible materials, contamination, lack of maintenance.
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, incompatible materials.-
Physical Damage:	Bent stem, broken linkage, cracked housing.
Poor Regulation:	Defective sensors, worn parts.
Inadequate Seating:	Worn parts, blocked by scale.

Insulation

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

DEFICIENCY FACTORS
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SYSTEM ASSEMBLIES/DEFICIENCIES (Continued)

Fixtures

Inadequate Pressure:	Damaged piping, excessive scaling in distribution system, valve or pump failure.
Damaged:	Physical abuse.

Instrumentation

Missing:	Taken out for service or repair and 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 & panel8

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

DEFICIENCY FACTORS
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END OF SUBSECTION