RECLAMATION

Managing Water in the West

Design Standards No. 6

Hydraulic and Mechanical Equipment

Chapter 14: Auxiliary Mechanical Systems
Phase 4 (Final)

U.S. Department of the Interior
Bureau of Reclamation

December 2016

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Design Standards Signature Sheet

Design Standards No. 6

Hydraulic and Mechanical Equipment

DS-6(14): Phase 4 (Final)
December 2016

Chapter 14: Auxiliary Mechanical Systems

Foreword

Purpose

The Bureau of Reclamation (Reclamation) design standards present technical requirements and processes to enable design professionals to prepare design documents and reports necessary to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Compliance with these design standards assists in the development and improvement of Reclamation facilities in a way that protects the public's health, safety, and welfare; recognizes needs of all stakeholders; and achieves lasting value and functionality necessary for Reclamation facilities. Responsible designers accomplish this goal through compliance with these design standards and all other applicable technical codes, as well as incorporation of the stakeholders' vision and values, that are then reflected in the constructed facilities.

Application of Design Standards

Reclamation design activities, whether performed by Reclamation or by a non-Reclamation entity, must be performed in accordance with established Reclamation design criteria and standards, and approved national design standards, if applicable. Exceptions to this requirement shall be in accordance with provisions of *Reclamation Manual - Policy*, FAC P03, "Performing Design and Construction Activities."

In addition to these design standards, designers shall integrate sound engineering judgment, applicable national codes and design standards, site-specific technical considerations, and project-specific considerations to ensure suitable designs are produced that protect the public's investment and safety. Designers shall use the most current edition of national codes and design standards consistent with Reclamation design standards. Reclamation design standards may include exceptions to requirements of national codes and design standards.

Proposed Revisions

Reclamation designers should inform the Technical Service Center (TSC), via Reclamation's Design Standards Website notification procedure, of any recommended updates or changes to Reclamation design standards to meet current and/or improved design practices.

Chapter Signature Sheet
Bureau of Reclamation
Technical Service Center

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Hydraulic and Mechanical Equipment

Chapter 14: Auxiliary Mechanical Equipment

DS-6(14): Phase 4 (Final)
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Chapter 14 – Auxiliary Mechanical Equipment is a new chapter within Design Standards No. 6 and includes design of equipment and/or plumbing for the following systems:

- Cooling water
- Compressed air
- Fire suppression
- Oil filtration and dandling
- Potable water and sanitary waste
- Drainage, etc.

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Chapter 14

Auxiliary Mechanical Systems

14.1 Scope

This chapter identifies the design criteria to be used to design auxiliary mechanical systems. Auxiliary mechanical systems are defined as mechanical equipment, piping, and appurtenances distributed throughout a dam, powerplant, pumping plant, or other Bureau of Reclamation (Reclamation) building to provide service, support, and/or protection of other systems within a facility. This design standard provides assistance in designing new systems or replacing deteriorated components in existing auxiliary mechanical systems to maximize the service life of each system.

14.2 General Considerations

The design of auxiliary mechanical systems, along with other building design features, should combine to produce a building that meets the requirements of the most recent version of the U.S. Department of the Interior's (DOI) Guiding Principles requirements. It is recommended that Reclamation facilities also meet the codes and standards of site-specific municipal, county, or State authorities when feasible.

14.3 Codes and Standards

The publications and standards listed below are intended to be used as guidelines for design. The most recent edition of codes and standards should be specified in project documents. Publications and standards are mandatory only where referenced as such in the text of this chapter or in applicable codes. This list is not meant to restrict the use of additional guides or standards. When publications and standards are referenced as mandatory, any recommended practices or features should be considered as "required." When discrepancies between requirements are encountered, Reclamation will determine which requirement to use:

- American Society of Civil Engineers (ASCE):
    - ASCE 7: Minimum Design Loads for Buildings and Other Structures
- American Society of Mechanical Engineers (ASME):
    - Boiler and Pressure Vessel Code (BPVC)

    - Code for Pressure Piping B31:
        - Power Piping (ASME B31.1)
        - Fuel Gas Piping (ASME B31.2)
        - Process Piping (ASME B31.3)
        - Liquid Petroleum Transportation Piping Systems (ASME B31.4)
        - Refrigeration Piping (ASME B31.5)
        - Gas Transmission and Distribution Piping Systems (ASME B31.8)
        - Building Service Piping (ASME B31.9)
- DOI's Guiding Principles
- International Code Council (ICC):
    - International Plumbing Code (IPC)
- International Association of Plumbing and Mechanical Officials (IAPMO):
    - Uniform Plumbing Code (UPC)
- National Fire Protection Association (NFPA):
    - NFPA 10: Portable Fire Extinguishers
    - NFPA 12: Carbon Dioxide Extinguishing Systems
    - NFPA 13: Installation of Sprinkler Systems
    - NFPA 14: Installation of Standpipe and Hose Systems
    - NFPA 15: Water Spray Fixed Systems
    - NFPA 20: Installation of Stationary Fire Pumps
    - NFPA 70: National Electrical Code (NEC)
    - NFPA 101: Life Safety Code

  - NFPA 850: Electric Generating Plants and High Voltage Direct Current Converter Stations

  - NFPA 2001: Clean Agent Fire Extinguishing Systems

- Occupational Safety and Health Administration (OSHA) standards including, but not limited to:

  - OSHA CFR 29 1926: Safety and Health Regulations for Construction

- Reclamation Safety and Health Standards

14.4 Levels of Design

Auxiliary mechanical equipment selection is largely determined by site-specific facility operation and maintenance (O&M) requirements, as well as available utilities. Considerations should be given to space availability, electrical load demands, and structural requirements for supporting equipment. At each level of design, coordination between the mechanical systems designer, project architect, electrical engineer, and structural engineer is imperative and should be conducted to prevent cost overruns and modifications during construction.

Designers of auxiliary mechanical systems should be professional engineers experienced in the type of design they are providing to Reclamation project offices. Mechanical designers should request design data from Reclamation project offices as early as feasible in the design process. When providing design data information to designers, Reclamation project offices should provide any other project-specific requirements that must be satisfied by each auxiliary mechanical system.

The three general levels of design are appraisal level, feasibility level, and final design. These three design levels are discussed in further detail below.

14.4.1 Appraisal Level

14.4.1.1 General

Appraisal level designs are preliminary assessments of potential solutions to address the needs of a project. Designs at this level are conceptual solutions with minimal detail. During this phase, multiple alternatives should be considered. Information regarding project conditions is often either unavailable or difficult to determine.

14.4.1.2 Equipment Sizing and Selection

Preliminary sizing of equipment should be made based on existing design data provided by Reclamation project offices. Utility sources should be investigated to determine the availability of necessary equipment and/or whether alternative or supplemental sources are required. When selecting equipment sizes, consideration should be given to relevant loads (both environmental and equipment-related). The type of equipment selected is determined by a facility's specific needs (such as the need for large equipment), as well as by actual site conditions. For example cooling water may require a strainer to remove debris from a fresh water source, or a large pump may require sediment debris removal for seal water applications which would require filtration equipment. After equipment types and sizes have been determined, associated distribution systems should be evaluated so that proper placement of equipment and space allocation can be determined.

14.4.1.3 Construction Documents

14.4.1.3.1 Drawings

Preliminary drawings should be made showing equipment space requirements and clearances. Layouts should quantify the amount of piping needed, as well as determine if building features, such as dedicated pipe or air chases, will be required.

14.4.1.3.2 Specifications

Specifications are not generated during appraisal level designs for auxiliary mechanical systems. Rather, a design summary is provided, which outlines system descriptions, including brief descriptions of alternative systems that were evaluated but deemed infeasible.

14.4.1.3.3 Quantity Estimates

Appraisal level quantity estimates should provide adequate system information and pricing to reflect the major components and estimated piping for each auxiliary mechanical system.

Contingency factors associated with material quantities should be avoided because these factors are typically assigned at the project level by the cost estimating group and, therefore, would only be compounded.

14.4.2 Feasibility Level

14.4.2.1 General

The feasibility level design phase narrows the project focus to compare and determine the feasibility of a few design options. With an initial design and draft drawings, the feasibility cost estimate can be used for congressional authorization.

Unlisted items are typically in the range of 10 to 15 percent, and contingencies are approximately 20 percent of the estimated contract costs.

14.4.2.2 Equipment Sizing and Selection

Preliminary sizing of equipment should be made based on existing design data provided by Reclamation project offices. Utility sources should be investigated to determine the availability of necessary equipment and/or if alternative or supplemental sources are required. When selecting equipment sizes, consideration should be given to relevant loads (both environmental and equipment-related). After equipment types and sizes have been determined, associated distribution systems should be evaluated so that proper placement of equipment and space allocation can be determined.

14.4.2.3 Construction Documents

14.4.2.3.1 Drawings

Preliminary drawings should be made showing equipment space requirements and clearances. Layouts should be quantify the amount of piping needed, as well as determine if building features, such as dedicated pipe or air chases, will be required.

14.4.2.3.2 Specifications

Specifications are not generated during feasibility level designs for auxiliary mechanical systems. Rather, a design summary is provided, which outlines system descriptions, including brief descriptions of alternative systems evaluated but deemed infeasible.

14.4.2.3.3 Quantity Estimates

Feasibility level quantity estimates should provide adequate system information and pricing to reflect the major components and estimated piping for each auxiliary mechanical system.

Contingency factors associated with material quantities should be avoided because these factors are typically assigned at the project level by the cost estimating group and, therefore, would only be compounded.

14.4.3 Final Design

14.4.3.1 General

Final design packages include signed design drawings, specification paragraphs, and both a prevalidation and an Independent Government Cost Estimate (IGCE). Prevalidation estimates are similar to a 90-percent level estimate. The IGCE is the final Government cost estimate used in bid opening to determine fair and reasonable bids. The IGCE is considered a 100-percent design estimate with no unlisted items or contingencies.

14.4.3.2 Equipment Sizing and Selection

Selection of final equipment sizes should be based on project-specific O&M requirements, as well as influencing environmental conditions. Specified systems should meet current U.S. Department of the Interior requirements for efficiency and sustainability. Maintenance, reliability, and equipment life should also be major considerations when selecting equipment.

14.4.3.3 Construction Documents

14.4.3.3.1 Drawings

Drawings should be of sufficient detail to construct the specified design. Schedules should be developed for mechanical equipment provided. Typical drawings include but are not limited to: equipment layout drawings, embedded and exposed piping plans and sections, and specific details which may not be captured in the specification paragraphs.

14.4.3.3.2 Specifications

Specifications should be developed using the current adopted Construction Specifications Institute (CSI) format.

Specifications should indicate the type, size, capacity, material of construction, and special features or options required for auxiliary mechanical equipment and piping systems. Codes, standards, or requirements for the design, manufacture, factory testing, and installation should also be clearly defined. It is also important to reference sections of the specifications which are important to the procurement and installation of the equipment and piping such as coatings, electrical, and/or structural requirements which may be necessary for a complete installation.

14.4.3.3.3 Quantity Estimates

Reclamation project offices generally require multiple levels of quantity estimates: 30-percent, 60-percent, 90-percent, prevalidation, and 100-percent (IGCE). Occasionally, the interim estimates at the 60-percent design phase are omitted. IGCE quantities are used in bid opening and in determining fair and reasonable bids, and they should represent the final plans, specifications, and any amendments.

Contingency factors associated with material quantities should be avoided because these factors are typically assigned at the project level by the estimating group and, therefore, would only be compounded.

14.5 Submission Requirements

These design submission requirements have been developed to ensure a rational, well-documented design process and to facilitate reviews by Reclamation staff as the design develops. The submission requirements listed here apply to all projects, regardless of whether design services are performed by architects and engineers under contract to Reclamation or by Reclamation staff.

14.5.1 Equipment and Material Cut Sheets

Provide manufacturer's product data marked to indicate equipment operation, material properties, capacities, and loads.

14.5.2 Drawings

14.5.2.1 Drawing Size

Drawings of a single project should be a uniform standard size, as designated by the American National Standards Institute (ANSI) and shown below:

Designation	Size (inches)
ANSI B (half size)	11 x 17
ANSI D (full size)	22 x 34

14.5.2.2 Drawing Lettering

Lettering on drawings should be legible when drawings are reduced to half the original size. This applies to concept and design development drawings, as well as construction documents.

14.5.2.3 Drawing Scale

Drawings are to be created at full scale and plotted at a selected scale. The drawings or views (details) should include numeric and graphic scales. The scale selected should be appropriate for high resolution and be legible when reduced, such as half-sized copies.

14.5.2.4 Computer-Aided Design Standards

National Computer-Aided Design (CAD) standards should be followed for all CAD drawings. Reclamation-specific CAD standards are available through the Reclamation project manager.

14.5.2.5 Diagrams

Diagrams are prepared to illustrate the configuration and characteristics of a complete system in a nondimensioned, nonscaled, schematic form. Diagrams should identify valve, instrumentation, and equipment designations which correspond to the respective designations shown on the nameplate schedule drawings.

14.5.2.6 Layouts

Layout drawings are detailed, dimensioned, and scaled drawings of equipment, piping, and appurtenances. These drawings identify installation locations and orientations relative to building features or other equipment.

14.5.2.7 Detail Drawings

Detail drawings show a single section of pipe and its associated appurtenances or equipment connection. They are shown assembled in place within the outline of a building or portion thereof. Detail drawings should be completely detailed, drawn to scale, and dimensioned for fabrication and installation.

14.5.2.8 Embedded Pipe Drawings

These drawings are used for the installation of embedded pipe during the placement of concrete. Space permitting, embedded inserts may also be shown on these drawings.

14.5.2.9 Schedules

Mechanical equipment schedules contain a complete list of mechanical equipment, excluding piping and instruments, specified for a facility which includes: system name, location of equipment, quantity, size, power requirements, performance characteristics, weight, manufacturer, and model number for each piece of equipment installed.

Piping materials should be consistent throughout each system, corrosion resistant for the intended service, and of proper pressure rating and quality to ensure long life and low maintenance of each system. Pipe schedules should include the name of the system, pipe material used, pipe ratings, and the type of fittings and connections.

Nameplate schedules for control valves and instrumentation should be developed after system design, piping diagrams, and approval of submittal data have taken place. Each item designation listed on the schedule should be shown next to the applicable valve or instrumentation symbol on the appropriate piping diagram.

14.5.3 System Design

14.5.3.1 Fire Suppression

NFPA standards shall be consulted when designing fire suppression systems. Devices and equipment in these systems shall be Underwriters Laboratory (UL) and Factory Mutual (FM) approved.

Water-based fire suppression systems shall be in accordance with:

- NFPA 13: Installation of Sprinkler Systems
- NFPA 14: Installation of Standpipe and Hose Systems
- NFPA 15: Water-Spray Fixed Systems
- NFPA 20: Installation of Stationary Fire Pumps

Design and installation of carbon dioxide fire extinguishing systems shall be in accordance with NFPA 12: Carbon Dioxide Extinguishing Systems.

Portable hand-held and wheeled fire extinguishers shall be installed in accordance with NFPA 10: Portable Fire Extinguishers.

Where a dry chemical fire extinguishing agent discharge has the potential to damage electrical equipment, clean agent extinguishers shall be furnish and installed in accordance with NFPA 2001: Clean Agent Fire Extinguishing Systems.

14.5.3.2 Cooling Water

Typical Reclamation cooling water systems include: generator air cooling, bearing oil cooling, transformer cooling, pump motors, and other large equipment that require a cooling water system. Cooling water flow, pressure, temperature, and quality requirements are determined by equipment manufacturers.

Local seasonal climate extremes at a project site shall be considered when determining available cooling water temperatures. Maximum design temperatures of a cooling water system should be verified to meet the equipment manufacturer’s recommendations.

14.5.3.3 Potable Water and Sanitary Waste

Potable water and sanitary waste plumbing systems shall be in accordance with IPC or the UPC.

Typical equipment and system components include: plumbing fixtures, water supply piping, sanitary floor drains, waste and vent piping, and sewage ejectors and pumps.

- Piping and components shall be in accordance with ASME B31.1 and be NSF/ANSI 61 certified.

- Potable water piping systems shall contain backflow prevention in accordance with local requirements.

- Hot water storage tanks shall contain means for thermal expansion in accordance with ASME BPVC.

14.5.3.4 Service Water

Service water systems provide water from service water hose outlets for uses such as general operations; cooling water supply; supplying water to equipment, such as evaporative coolers in a heating and ventilation system; etc. These systems may be comprised of pumping units, hydropneumatic tanks, strainers, filters, corrosion resistant piping and valves, and hose outlets. Service water systems are typically provided for O&M facilities, pumping plants, powerplants, and/or where required by the Reclamation client office.

14.5.3.5 Compressed Air

Compressed air systems are typically provided for maintenance service, generator brake air, governor air, and/or water depression air systems. Equipment for compressed air systems includes: air compressors, air receivers, air dryers, instrumentation, pressure piping, air hose outlets, and control valves.

Compressed air system designs should emphasize reliability, flexibility, and safety. To ensure the availability of compressed air at all times, each system should have separate, designated air receivers. Moving parts, belts, and flywheels shall be fully protected by guards and enclosures. For small self-contained units, locate the belt side next to a wall.

Pressure containing vessels shall be in accordance with ASME BPVC. Pressure piping shall be in accordance with ASME B31. Plastic piping is not permitted.

14.5.3.6 Sump Pumping

Where a facility drains to a sump, an automatic sump pumping system should be provided to remove drainage water. Pumps and controls shall be designed to accommodate facility preference, as well as to maintain recommended pump manufacturer run times. Where sump discharge has the potential of oil contamination, a means for sump oil detection and removal shall be provided. Pump controls shall monitor and indicate sump levels.

14.5.3.7 Oil Handling

Oil handling systems shall be designed to prevent the mixing of filtered and unfiltered oil, and/or different types of oils. Complete systems shall be provided for each type of oil, and should consist of separate storage tanks, transfer pumps, supply and return piping, and valves necessary to transfer or filter oil and service equipment, etc.

14.5.3.8 Oil Filtration

Oil filtration systems are typically used to filter transformer oil and/or generator bearing lubrication systems within Reclamation facilities. Filtration piping systems should be designed in accordance with ASME B31.1: Pressure Piping Code. The piping system should be sized to accommodate flows equal to that of the selected oil transfer pump. Oil purifiers should accommodate each type of oil used in a facility that will require filtration. Piping should be clearly marked with the type of oil the pipe conveys and the directional flow of the oil within the pipe. Filtration services may also be provided by contractors, which would eliminate equipment and piping necessary to filter oil onsite.

14.5.3.9 Unwatering

Unwatering piping systems shall be designed, installed, and examined in accordance with ASME B31.1: Pressure Piping.

14.5.3.10 Gravity Drainage

Gravity drainage systems shall be designed in accordance with either the IPC or UPC. Drains shall be heavy duty and suitable for expected traffic loading. Embedded piping shall consist of hub and spigot, cast iron soil pipe that is typically not less than 4 inches in diameter. Exposed piping shall consist of no-hub, cast iron soil pipe. A minimum slope of 1/8 inch per foot for horizontal piping shall be maintained.

14.5.3.11 Mechanical Seal Water

Large pumps and turbines used in Reclamation pumping and power plants may require filtered and pressurized water to operate the mechanical seals. Typical mechanical seal systems require 50 microns or less of sediment removal from fresh water. If domestic water is available, filtration equipment should not be required. A booster pump is typically required to maintain seal water pressurization requirements, which are determined by the large pump manufacturer.

14.5.4 Pipe Design

Piping systems for auxiliary mechanical equipment shall be designed, installed, and examined in accordance with applicable sections of ASME B31 (dependent on structure and system type), the IPC, and/or the UPC.

Piping materials should be selected based on design temperatures and pressures for the piping system, as well as fluid properties (e.g., water quality), to maximize the service life of the piping system. Provisions for corrosion and condensation protection shall be made based on actual project conditions. It is recommended that a water quality analysis be conducted to assist with piping material selection and sizing.