UFC 3-420-01
01 April 2021

UNIFIED FACILITIES CRITERIA (UFC)

PLUMBING SYSTEMS

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UNIFIED FACILITIES CRITERIA (UFC)

PLUMBING SYSTEMS

Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes UFC 3-420-01, dated 25 October 2004, with Change 10, dated 26 October 2015.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://www.wbdg.org/ffc/dod.

Refer to UFC 1-200-01, *DoD Building Code*, for implementation of new issuances on projects.

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UNIFIED FACILITIES CRITERIA (UFC)
REVISION SUMMARY SHEET

Document: UFC 3-420-01, *PLUMBING SYSTEMS*

Superseding: UFC 3-410-01, *PLUMBING SYSTEMS*, dated 25 October 2004, with Change 10, dated 26 October 2015.

Description: This UFC is the core document for plumbing design. It is intended as a reference for all plumbing work. It is organized to provide the top-level minimum mandatory plumbing design and analysis requirements and refers to other criteria as appropriate.

Reasons for Document:

- This UFC provides a central point reference for all plumbing design criteria.
- Establishes minimum design analysis and drawing requirements in support of design activities
- Helps direct designers to the appropriate plumbing discipline criteria document.

Impact:

- There are negligible cost impacts. Creation of a single-source reference for mechanical design discipline helps clarify requirements for the design of DoD facilities.

Unification Issues

- There are no unification issues.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC provides guidance in the design of plumbing systems, together with the criteria for selecting plumbing materials, fixtures, and equipment and is applicable to all elements of the Department of Defense (DoD) charged with planning military construction. This UFC provides minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operation, and use of plumbing systems. It is not the intent of this manual to duplicate information contained in the standards cited herein, but to reference them as appropriate. See Chapter 4.

1-2 APPLICABILITY.

This UFC applies to all service elements and contractors involved in the design and construction of plumbing systems for use in facilities of all branches of service. A plumbing system consists of the water supply distribution system; fixtures, and fixture traps; soil, waste, and vent piping; storm water drainage; acid and industrial waste disposal systems; special gases (medical and oxygen) systems; and water heaters. The plumbing system extends from connections within a structure to a point 5 feet (1.5 m) outside the structure. Additions, alterations, renovations, or repairs to a plumbing system must conform to requirements for a new plumbing system without requiring the existing plumbing system to comply with all the requirements of this manual. Do not execute additions, alterations, or repairs that cause an existing plumbing system to become unsafe, hazardous, or overloaded.

1-3 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code*. UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

Service water heating systems must meet American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. Refer to UFC 1-200-02, *High Performance and Sustainable Building Requirements* for publication year of ASHRAE.

1-3.1 Environmental Severity and Humid Locations.

In corrosive and humid environments, provide design detailing, and use materials, systems, components, and coatings that are durable and minimize the need for preventative and corrective maintenance over the expected service life of the component or system. Follow the guidance of UFC 1-200-01, Chapter 4 to address corrosion control and apply the requirements for the appropriate Environmental Severity

Classification (ESC) for the specific installation as identified in UFC 1-200-01 Appendix A.

1-4 SAFETY.

The Designer of Record must follow the concepts from the most current ANSI/ASSE Z590.3, *Prevention Through Design: Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes*. Through the application of Prevention through Design (PtD) concepts, decisions pertaining to occupational hazards and risks can be incorporated into the process of design and redesign of work premises, tools, equipment, machinery, substances, and work processes, including their construction, manufacture, use, maintenance, and ultimate disposal or reuse. This standard also provides guidance for a life-cycle assessment and design model that balances environmental and occupational safety and health goals over the life span of a facility, process, or product.

All DoD facilities must comply with DoDI 6055.01 and applicable Occupational Safety and Health Administration (OSHA) safety and health standards.

1-5 CYBERSECURITY.

All control systems (including systems separate from an energy management control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems* and as required by individual Service Implementation Policy.

1-6 NON-GOVERNMENT STANDARD MODIFICATION.

1-6.1 Primary voluntary consensus standard reference.

The DoD uses the International Code Council™ International Plumbing Code® as the primary voluntary consensus standard for DoD facility plumbing systems.

1-6.1.1 International Plumbing Code® copyright.

1-6.1.2 International Plumbing Code® modifications.

Chapter 4 modifies the IPC and is organized by the chapter of the IPC that each section modifies. The modifications are one of four actions, according to the following legend:

- [Addition] – Add new chapter or section, including new chapter or section numbers.
- [Deletion] – Delete chapter, section, paragraph, or sentence.
- [Replacement] – Delete chapter, section, paragraph, or sentence noted and replace it with the narrative shown.
- [Supplement] – Add narrative shown as a supplement to the narrative shown in the referenced chapter, section, or paragraph.

The format of Chapter 4, including English and metric unit references, does not follow the UFC format, but instead follows the format established in the IPC, to the extent possible.

When and if these supplemental technical criteria are adopted into the IPC, they will be removed from this document. When interpreting the IPC, the advisory provisions must be considered mandatory; interpret the word “should” as “shall”.

1-6.2 Conflicts in criteria.

Where, in any specific case, different sections of this guidance or referenced standards specify different materials, methods of construction, or other requirements, the most restrictive requirement will govern. In leased facilities where the local jurisdiction controlling the lessor has adopted a different plumbing code, the more restrictive requirement will govern.

1-7 GLOSSARY.

Appendix A contains acronyms, abbreviations, and terms.

1-8 REFERENCES.

Appendix B contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 TECHNICAL CRITERIA

Not used.

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CHAPTER 3 GENERAL DESIGN REQUIREMENTS

3-1 GENERAL POLICY.

3-1.1 Energy Efficiency and Water Conservation.

Plumbing system energy usage and equipment efficiencies must comply with UFC 1-200-02. Employ strategies that in aggregate use a minimum of 20 percent less potable water than the indoor water use baseline calculated for the building after meeting the Energy Policy Act of 1992 and the IPC fixture performance requirements. Use ultra-water-efficient plumbing fixtures including low flow faucets, showerheads, and ultra-low consumption (e.g., 1/8 gallon (0.5 liters) per flush) flushing urinals or (if approved) waterless urinals, in accordance with UFC 1-200-02. Mission requirements and operating points to prevent Legionella will take priority over meeting energy and conservation targets.

3-1.2 Reliability.

Provide dual-fuel capability and/or redundant system components to Mission Critical facilities.

3-1.3 Piping Arrangement.

Conceal piping in permanent-type structures. In limited life structures, piping may be installed exposed, except when specific project criteria justify concealment or where concealment does not increase the cost of the project. Exposed piping attached to or near fixtures or equipment, or subject to high heat or frequent washing, must be copper, brass, or chromium plate. Prime other exposed piping with paint suitable for metal surfaces and finish-paint with color to match background. Arrange piping runs parallel or perpendicular to primary walls and to minimize interference with personnel and equipment. For critical piping services such as medical gas systems, route piping so that it is not on exterior walls or walls shared with mailrooms in accordance with UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*. Provide efficient piping designs. Efficient designs consist of, but are not limited to, minimized changes of direction of horizontal sanitary piping and reduced number of vents by use of venting methods that serve multiple fixtures.

3-1.4 Siting.

Whenever possible, site and design buildings, sewers, and water mains to avoid the need for sewage lifts or water booster pumps.

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CHAPTER 4 SUPPLEMENTAL IPC TECHNICAL CRITERIA

Note: Chapter, section and paragraph numbers reference IPC-2018.

4-1 GENERAL SUBSTITUTIONS.

- All references to "approved" materials must be materials allowed by the applicable Unified Facilities Guide Specification (UFGS).
- All references in the IPC to the IBC must be considered to be references to UFC 1-200-01.
- All references in the IPC to the International Fuel Gas Code must be considered to be references to NFPA 54, *National Fuel Gas Code* and NFPA 58, *Liquefied Petroleum Gas Code*.
- All references in the IPC to the International Mechanical Code must be considered to be references to UFC 3-410-01, *Heating, Ventilating, and Air Conditioning Systems*.
- All references in the IPC to the International Energy Conservation Code must be considered to be references to UFC 1-200-02.
- Where the IPC references the International Fire Code (IFC), the IFC must be replaced with NFPA 1, *Fire Code* except where superseded by UFC 3-600-01, *Fire Protection Engineering for Facilities*.
- All references in the IPC to NFPA 70, *National Electric Code* must be considered to be references to UFC 3-501-01, *Electrical Engineering*.

4-2 CHAPTER 1 - SCOPE AND ADMINISTRATION. [DELETION]

Delete chapter in its entirety. Scope administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) and by the authority granted to the Contracting Officer in administering the contract and this UFC.

4-3 CHAPTER 2 – DEFINITIONS.

4-3.1 Section 202 - GENERAL DEFINITIONS.

Code [Replacement]

Delete the code definition and replace it with the following:

The IPC, revision year approved by UFC 1-200-01 and subsequent amendments thereto, as modified by this UFC.

Code Official [Replacement]

Delete the code official definition and replace it with the following:

Refer to UFC 1-200-01, paragraph entitled Implementation, Administration, and Enforcement.

Owner or Owner's Representative [Addition]

Add the following definition:

OWNER OR OWNER'S REPRESENTATIVE. For Government-owned facilities, the Contracting Officer assigned by the Government to administer the construction contract. For leased facilities, the leaser of the facility.

Permit Holder [Addition]

Add the following definition:

PERMIT HOLDER. The contractor accomplishing the project.

4-4 CHAPTER 3 - GENERAL REGULATIONS.

4-4.1 Section 301 – GENERAL.

301.6 Prohibited Locations. [Supplement]

Insert the following before the first sentence:

No plumbing system components may be installed within any Air Handling Unit (AHU), ductwork, or room used as a plenum conveying supply air, return air, outside air, or mixed air. This will not prohibit connection of AHU components, such as humidifiers, to the water supply system, nor prohibit connection of trapped condensate pans and humidifier drains indirectly to the drainage system. This will also not prohibit plumbing system components in ceiling spaces used as return air plenums, nor prohibit drains in raised floor supply plenums.

301.8 Protection of Building Materials. [Addition]

Where the seasonal design temperature of the cold water entering a building is below the seasonal design dew point of the indoor ambient air, and where condensate drip will cause damage or create a hazard, insulate plumbing piping with a vapor barrier type of insulation to prevent condensation. All chilled water piping from a central drinking water cooling system should be insulated with vapor barrier type insulation to prevent condensation.

301.9 Protection of Computers, Telephone Switches, Terminal Equipment, Record Storage, and other Electronic Equipment from Water Damage. [Addition]

Neither water nor drainage piping shall be located over electrical wiring or equipment unless adequate protection against water (including condensation) damage has been provided. Insulation alone is not adequate protection against condensation. Locate these areas to minimize exposure to water and other listed hazards from adjoining areas and activities.

301.9.1 Prohibited piping. Water, sanitary, indirect waste, special waste, gas, fuel oil, condensate drain, roof drains, conductors, and other utility piping not serving these areas within building are prohibited.

301.9.2 Restricted piping. Utilities containing water or other fluids, which serve these areas within the building, must not pass directly over electronic equipment, telephone switches, or stored records, whether the utilities are installed over or below the finished ceiling.

301.9.3 Waterproof floor above. The floor above these areas should be waterproofed to prevent passage of accidental spillage. As an alternative, allow no prohibited pipe in the rooms above the electronic equipment and record storage areas.

4-4.2 Section 303 – MATERIALS.

303.3 Plastic pipe, fittings and components. [Supplement]

Add the following after the last sentence:

Installation procedure for plastic piping materials shall be in accordance with the Plastic Pipe Institute (PPI) *Handbook of Polyethylene Pipe*. Design parameters such as thermal movement, chemical resistance, flow characteristics, and pressure ratings are covered in PPI publications. The designer should be aware that some Schedule 40 plastic pipes do not have the strength of a Schedule 40 steel pipe; therefore, the desired working temperature and pressure ratings for any plastic piping specified must be indicated either in the specifications or on the drawings.

4-4.3 Section 305 – PROTECTION OF PIPES AND PLUMBING SYSTEM COMPONENTS.

305.4 Freezing. [Supplement]

Add the following after the last sentence:

Although insulating water pipes, tanks, and cooling towers may not prevent water from freezing, these devices are to be insulated and, if noted on the drawings, heat traced for protection against damage. The proper thickness or conductivity factor for this insulation and the watts/linear foot (watts/linear meter) for heat tracing are to be determined by the design engineer. Do not provide water or waste piping in exterior walls or attic spaces where there is danger of freezing where practicable. Provide proper design to prevent freezing when not practicable.

Section 308 – PIPING SUPPORT.

308.5 Interval Support. [Replacement]

Replace first sentence with the following:

Above ground piping and below ground piping shall be supported from structure in accordance with Table 308.5.

4-4.4 Section 313 – EQUIPMENT EFFICIENCIES.

313.2 Energy conservation. [Addition]

Design systems containing electric water heaters, gas water heaters, solar water heaters, air-to-water heat pump water heaters, and water-to-water heat pump water heaters in accordance with the ASHRAE Handbook Series (appropriate Chapters), ASHRAE Standard 90.1 and Department of Energy – Federal Energy Management Program (DOE-FEMP), *Buying Energy Efficient Products* (appropriate recommendations).

4-4.5 Section 316 – ALTERNATIVE ENGINEERED DESIGN.

316 Alternative engineered design. [Deletion]

Delete section its entirety.

4-5 CHAPTER 4 - FIXTURES, FAUCETS AND FIXTURE FITTINGS.

4-5.1 Section 401 – GENERAL.

401.2 Prohibited fixtures and connections. [Supplement]

Add the following after the last sentence:

Fixtures employing continuous flow devices and fixtures that are subject to backflow are prohibited. Continuous flow devices cannot be used for water conservation reasons.

401.3 Water conservation. [Supplement]

Add the following after the last sentence:

Water conservation fixtures conforming to the IPC shall be used except where the sewer system will not adequately dispose of the waste material on the reduced amount of water. DOE-FEMP water conservation recommendations are, for certain fixtures, more restrictive than Section 604.4. Designers have the option to design to DOE-FEMP water conservation recommendations for areas of the country that restrict water usage. The owner or owner's representative should be consulted before specifying water conservation fixtures that are more restrictive than Section 604.4.

4-5.2 Section 402 – FIXTURE MATERIAL.

402.1 Quality of fixtures. [Supplement]

Add the following after the last sentence:

Fixture materials are to be selected from those specified in UFGS 22 00 00, *Plumbing, General Purpose*. Porcelain-enameled cast-iron lavatories shall be provided in enlisted personnel barracks or dormitories or other gang toilet in similar facilities.

4-5.3 Section 403 – MINIMUM PLUMBING FACILITIES.

403.1 Minimum number of fixtures. [Replacement]

Delete the last sentence and replace with the following:

Use the actual number of occupants for whom each occupied space, floor or building is designed to calculate the design occupant load. The designer must document the calculations for the design occupant load. These calculations must be reviewed and approved for the project to ensure that the number of plumbing fixtures is appropriate.

Table 403.1 Minimum Number of Required Plumbing Fixtures. [Deletion]

Delete the last sentence:

“The number of occupants shall be determined by the *International Building Code*.”

Table 403.1 Minimum Number of Required Plumbing Fixtures. [Supplement]

For the business classification, add the following to the description:

training rooms, support areas (such as for the administrative and supervisory offices for industrial shops and warehouses), and locker rooms in coliseums, arenas, skating rinks, pools, and tennis courts for indoor sporting events and similar activities

4-5.4 Section 404 – ACCESSIBLE PLUMBING FACILITIES.

404.1 Where required. [Replacement]

Replace the first sentence with the following:

Accessible plumbing facilities and fixtures must be provided in accordance with the Architectural Barriers Act (ABA), *Accessibility Standards for Department of Defense Facilities* and the IBC, whichever is more stringent.

4-5.5 Section 405 – INSTALLATION OF FIXTURES.

405.3 Setting. [Supplement]

Add the following after the last sentence:

Lavatories and urinals in enlisted men's barracks or dormitories and in men's gang-toilet facilities (three or more water closets) are subject to heavy damage. Verify wall bolts are tight and properly installed.

405.3.1 Water closets, urinals, lavatories and bidets. [Supplement]

Add the following after the last sentence:

Lavatories provided in enlisted personnel barracks or dormitories or other gang toilet facilities shall be installed to prevent uplifting.

4-5.6 Section 410 – DRINKING FOUNTAINS.

410.6 Central drinking water systems. [Addition]

Central drinking water systems should be evaluated as an alternative to unitary water coolers in facilities where 15 or more drinking stations are required. Evaluation should include potential heat recovery from central condenser, addition of heat to building envelope by unitary condensers, differences in anticipated energy usage, and differences in first cost.

4-5.7 Section 411 – EMERGENCY SHOWERS AND EYEWASH STATIONS.

411.4 Design guidance for emergency shower and eyewash stations. [Addition]

Refer to Appendix C of UFC 3-420-01, *Design: Plumbing Systems* for additional requirements associated with emergency shower and eyewash stations.

4-5.8 Section 413 – FLOOR AND TRENCH DRAINS.

413.5 Required locations and construction. [Addition]

Floor drains are not required in service sink rooms and transformer rooms.

Provide floor drains to serve, but not be limited to, the following areas and equipment:

1. Gang toilets, which are those having three or more water closets; and gang shower drying rooms, which are those serving two or more showers.

2. Subsistence buildings, as follows:

    (a) Dishwashing, scullery or pot washing, and food-cart washing areas.
    (b) Vegetable peelers and vegetable preparation areas.
    (c) Steam table and coffee urn areas.
    (d) Soda fountain area.
    (e) Adjacent areas to ice chests, ice-making machines, and walk-in or reach-in, freezers and refrigerators.

(f) Steam cookers and steam-jacketed kettles.

3. Cold-storage buildings, as follows:

   (a) Fat-rendering, processing, salvage, and receiving rooms.
   (b) Receiving and issuing vestibules.
   (c) Adjacent areas to meat coolers and milk, butter, and egg rooms.

4. Mechanical rooms with steam, condensate, chilled ,or hot water systems.

5. Laundry rooms.

When automatic priming is through a device connected to the water system, ensure that device is equipped with a vacuum breaker.

412.6 Floor drains for emergency shower and eyewash stations. [Addition]

Refer to Appendix C of UFC 3-420-01 for additional requirements for use of floor drains associated with emergency shower and eyewash stations.

4-5.9 Section 416 – FOOD WASTE DISPOSER.

416.5 Food waste disposer design. [Addition]

Food waste disposers are authorized in DoD permanent quarters, hospitals, and dining facilities when the sewage treatment plant can handle the additional load. Design of new sewage treatment plants and additions to existing plants shall be based on the increase in load that will result from food waste disposers installed in hospital, dining facilities, and the ultimate projected number of family quarters to be constructed. Food waste disposers installed in hospital kitchens and dining facilities shall be sized as shown in Table 413.5. Food waste disposers will not discharge into a grease interceptor.

Table 413.5
SIZE OF FOOD WASTE DISPOSERS

PERSONS SERVED	POT WASHER HORSEPOWER	DISHWASHER HORSEPOWER
Up to 200	2	3
200 to 500	3	5
501 to 1,000	5	7-1/2
Over 1,000	7-1/2	10

4-5.10 Section 419 LAVATORIES.

419.6 Tempered water for private hand-washing facilities. [Addition]

Tempered water shall be delivered from lavatories located in private toilet facilities. *Tempered water* shall be delivered through an *approved* water-temperature limiting device that conforms to ASSE 1070/ASME A112.1070/CSA B125.70, *Water Temperature Limiting Devices* or CSA B125.3, *Plumbing Fittings*.

4-5.11 Section 422 - SINKS.

422.4 Tempered water for kitchen sinks. [Addition]

Tempered water shall be delivered from kitchen sinks located in break rooms. *Tempered water* shall be delivered through an *approved* water-temperature limiting device that conforms to ASSE 1070/ASME A112.1070/CSA B125.70 or CSA B125.3.

4-5.12 Section 424 – URINALS.

424.1 Approval. [Supplement]

Add the following after the last sentence:

Waterless/waterfree urinals must conform to American Society of Mechanical Engineers (ASME) A112.19.2, *Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals*, but not conform to the hydraulic performance requirements.

Approval for the use of waterless/waterfree urinals is the responsibility of the Facilities Engineering Command (FEC) Technical Discipline Coordinator (TDC), Base Civil Engineer (BCE) or the Department of Public Works and Utilities (DPW) to ensure life cycle costs and operation and maintenance (O&M) requirements are acceptable.

4-6 CHAPTER 5 - WATER HEATERS.

4-6.1 Section 501 – GENERAL.

501.2 Water heater as space heater. [Replacement]

Replace the first sentence with the following:

Where a combination potable water heating and space heating system requires water for space heating at temperatures of 140°F (60°C) or higher, a master thermostatic mixing valve complying with ASSE 1017, *Temperature Activated Mixing Valves for Hot Water Distribution Systems,* must be provided to limit the water to the potable hot water distribution system. The valve must be set to deliver 131°F (55°C) water to the fixtures except where higher temperatures are required by specialized equipment as indicated in ASHRAE Handbook, *Applications*. If the master thermostatic mixing valve is near the point of use at the fixtures, then lower potable domestic hot water distribution temperatures, less than 131°F (54.4°C), may be acceptable.

501.9 Multiple water heaters. [Addition]

Provide hospitals, laundry buildings, subsistence buildings, bachelor officers' quarters with mess, and enlisted men's barracks with mess with multiple water heaters and storage tanks. Provide other facilities with a single water heater and storage tank. Multiple units, however, may be justified by circumstances such as:

1. facility configuration
2. space limitations
3. limited access to tank room
4. hot water requirements necessitating an unusually high capacity heating and storage unit.

When two units are provided for hospitals, laundry buildings, subsistence buildings, bachelor officers' quarters with mess, and enlisted men's barracks with mess, each will have a capacity equal to two thirds of the calculated load. When more than two units are provided, their combined capacity shall be equal to the calculated load.

501.10 Solar water heating. [Addition]

At least 30 percent of domestic hot water demand shall be provided by the use of solar water heating, if life cycle cost effective. Solar water heating systems must be in accordance with UFC 3-440-01, *Facility Scale Renewable Energy Systems*. Conventional back-up heating equipment shall be provided for periods when high demand or an extended period of cloudy days exceeds the capacity of the solar energy system.”

4-6.2 Section 502 – INSTALLATION.

502.1 General. [Supplement]

Add the following after the last sentence:

The local Public Works/Base Civil Engineer should be contacted to determine if scale will be an issue based on the chemical analysis of the potable water or historical data. If so, provide a commercial scale prevention system.

4-6.3 Section 504 – SAFETY DEVICES.

504.2 Vacuum relief valve. [Supplement]

Add the following after the last sentence:

Provide a vacuum relief valve on each copper-lined storage tank to prevent the creation, within the tank, of a vacuum which could cause loosening of the lining.

4-6.4 Section 505 – INSULATION.

505.1 Unfired vessel insulation. [Supplement]

Add the following after the last sentence:

The insulation requirements stated in this section are minimum design requirements. The quality of insulation should be upgraded if the designer can show an improvement in the system performance or that insulation improvements are cost effective.

4-6.5 Section 507 – SIZING HOT WATER SYSTEMS.

507.1 Sizing Calculations. [Addition]

Design in accordance with ASHRAE Handbook, *HVAC Applications*, “Service Water Heating” chapter; and in accordance with ASHRAE Standard 90.1. In addition to criteria provided in the ASHRAE Handbook, consideration should be given to differences in costs of building area required to support systems when calculating life cycle costs. For low-rise residential buildings, design in accordance with the ICC International Residential Code. Size domestic hot water system and set service water heater (SWH) storage temperature set point for not less than 140°F (60°C) to limit the potential for growth of *Legionella pneumophila*. Provide temperature control (master mixing valve) to lower temperature to 131°F (55°C) immediately downstream of the SWH storage tank in accordance with ASSE 1017. Where a recirculation pump is required the hot water temperature shall be at least 122°F (50°C) throughout the recirculation piping. Deliver a minimum of 122°F (50°C) water to the fixtures and drop the temperature at the fixture through a water-temperature limiting device in accordance with Section 424, except where higher temperatures are required by specialized equipment as indicated in ASHRAE Handbook, *Applications.*

Take steps to both limit the risk of Legionella bacteria growth and scalding in the domestic water system. Therefore, if the master mixing valve is near the point of use at the fixtures, then lower domestic hot water distribution temperatures, less than 131°F (55°C), and lower recirculation loop temperatures, less than 122°F (50°C), may be acceptable. On existing systems take necessary steps to avoid scalding occupants when distributing at 131°F (55°C). For example, existing lavatories may have to add ASSE 1070 temperature reducing devices at all applicable existing fixtures and shower valve limit stops on all existing showers may have to be adjusted.

507.1.1 Sizing central service water heater systems. [Addition]

Use ASHRAE Handbook, HVAC Applications, “Service Water Heating” chapter, “Hot-Water Demand per Fixture for Various Types of Buildings” table to size central SWH systems, except revise the numbers in row “9. Showers” by multiplying by the correction factor (CF) calculated in Section 506.1.4. The revision reflects Public Law 102-486 maximum fixture flow of 2.5 gpm (9.5 L/s), ASHRAE recommended service water storage temperature minimum of 140°F (60°C), personnel safety maximum fixture delivery temperature of 110°F (43°C), and the appropriate supply design cold water temperature, which varies according to location and season. Use the Hotel column to size central SWH systems for Navy bachelor housing and lodges, due to occupant’s schedules resembling those of hotel and motel occupants – the rooms are inhabited mostly between 5 p.m. and 7 a.m. Use Appendix D of UFC 3-420-01 for sizing the domestic water heaters in Army barracks.

507.1.2 Hot water mixing equation. [Addition]

Conversion Factors: 1 gpm = 3.8 L/s; °F = 9/5 °C + 32

Let:

Q_f = Fixture flow in gpm = 2.5 gpm per Public Law 102-486
Q_s = Flow from SWH storage tank in gpm
Q_c = Flow from cold water supply in gpm
T_f = Temperature at fixture in °F = 110°F for personnel safety
T_s = Temperature at SWH storage tank in °F, 140°F minimum for Legionella
T_c = Temperature at cold water supply in °F, varies due to location and season

Mixing Equation:

$$(Q_f \times T_f) = (Q_s \times T_s) + (Q_c \times T_c)$$

Substituting $Q_c = Q_f - Q_s$ gives the following:

$$(Q_f \times T_f) = (Q_s \times T_s) + \left((Q_f - Q_s)T_c\right)$$
$$(Q_f \times T_f) = (Q_s \times T_s) + (Q_f - T_c) - (Q_s \times T_c)$$
$$(Q_f \times T_f) - (Q_f \times T_c) = (Q_s \times T_s) - (Q_s \times T_c)$$
$$Q_f \times (T_f - T_c) = Q_s(T_s - T_c)$$
$$Q_s = Q_f \times \left(\frac{T_f - T_c}{T_s - T_c}\right)$$

Substituting Q_f = 2.5 gpm, T_f = 110°F, T_s = 140°F, and T_c = 50°F gives the following:

$$Q_s = 2.5 \times \left(\frac{110 - 50}{140 - 50}\right)$$

$Q_s = 1.667\ gpm$ of hot water from storage tank

$Q_c = Q_f - Q_s = 2.5\ gpm - 1.667\ gpm = 0.833\ gpm$ of cold water from supply

The mixing equation may be used to evaluate the effect of variation of T_c temperatures on Q_s. At T_s = 140°F, for T_c = 40°F, Q_s = 1.75 gpm; and for T_c = 80 F, T_c = 1.25 gpm.

The mixing equation may also be used to evaluate the required size of SWH storage tanks as T_s varies. Higher storage temperatures allow smaller tank sizes to deliver equal water to fixtures.

507.1.3 ASHRAE Handbook, *HVAC Applications*, "Service Water Heating" chapter, "Hot-Water Demand per Fixture for Various Types of Buildings" table. [Supplement]

Row 9, Showers, indicates 225 gallons per hour (gph) per fixture for hot water flow in Gymnasiums, Industrial Plants, Schools, and YMCA's. Assume this represents continuous flow of shower fixture, what is the design fixture flow rate?

Since 225 gph/60 minutes per hour = 3.75 gpm of hot water flow = Q_s, calculate the fixture flow Q_f from the mixing equation, using T_f = 110°F, T_s = 140°F, and T_c = 50°F. Observe that $Q_f = Q_s + Q_c$, therefore $Q_c = Q_f - Q_s$. Substituting:

$$
\begin{aligned}
Q_f \times T_f &= (Q_s \times T_s) + (Q_c \times T_c) \\
Q_f \times T_f &= (Q_s \times T_s) + \left((Q_f \times Q_s)T_c\right) \\
Q_f \times T_f &= \left(Q_f \times T_c\right) + \left(Q_f \times T_c\right) - (Q_s \times T_c) \\
\left(Q_f \times T_f\right) - \left(Q_f \times T_c\right) &= (Q_s \times T_s) - (Q_s \times T_c) \\
Q_f \times \left(T_f - T_c\right) &= Q_s(T_s - T_c) \\
Q_f &= Q_s\left(\frac{T_s - T_c}{T_f - T_c}\right) \\
&= 3.75\left(\frac{(140-50)}{(110-50)}\right) \\
&= 5.625\ \text{gpm}
\end{aligned}
$$

Therefore, the proper CF for Chapter 50, Table 10, Row 9 is equal to 2.5 gpm per fixture (per Public Law 102-486) divided by 5.625 gpm (calculated above), which results in CF = 0.444 for T_c of 50°F. This may also be calculated as Q_s = 1.667 divided by Q_s = 3.75 equals CF = 0.444.

Thus, the gymnasium shower at 225 gph x CF corrects to 225 gph x 0.444 = 100 gph for T_c of 50°F.

507.1.4 Domestic hot water recirculation pumps. [Addition]

See Appendix E-3.2.5 of UFC 3-420-01, *Design: Plumbing Systems*.

507.2 Life cycle cost analysis. [Addition]

Evaluate alternative energy source options, such as electric, steam, oil-fired, and gas-fired SWH. Evaluate SWH storage tank capacity and electric heater element sizing to minimize electric demand charges to the government. Larger storage tanks with smaller heater elements may be cost effective due to reduced demand charges, although the longer storage recovery time and the additional costs for providing non-standard tank and element selections should also be considered. Do not exceed the ASHRAE recommended 8-hour maximum recovery time. Also consider the incremental cost of additional electric service capacity versus the incremental costs of providing steam or gas service or providing fuel oil storage and delivery. Include the costs of providing combustion air and flue gas exhaust for fuel-fired water heaters. Do not consider the cost of the tempering valve in the life cycle costs analysis, it is required by the 140°F (60°C) storage temperature to avoid Legionella. However, since it is required, consider the life cycle cost advantages of storing hot water at higher temperatures, if the source is electric, steam, or natural gas, and the tank insulation is increased to maintain equal total heat loss. A smaller SWH storage tank may reduce the size of the mechanical room and the building, which will reduce the energy and capital costs of the facility. Consider a pre-heat tank upstream of the SHW storage tank for applications recovering heat from refrigerant hot gas, steam condensate, process waste cooling, solar collectors, and diesel engines. Provide a tempering valve for all heat recovery SWH systems to limit the supply temperature, because the recovered heat can heat the storage tank above the normal storage temperature. A pre-heat tank may increase the amount of heat usably recovered prior to allowing the water to be heated by prime energy. Consider sealed combustion chambers for natural gas-fired SWH’s, with combustion air ducted directly from and flue gases ducted directly to the outside air. This may reduce the possibility of carbon monoxide poisoning within the occupied spaces. Ensure adequate clearances of inlet and outlet during snow, icing, flood, and heavy wind-driven rain conditions.

507.3 Minimizing the risk of Legionellosis in building water systems [Addition]

The following are suggested references that provide guidance on minimizing the risk of Legionellosis: U.S. Army Corps of Engineers Engineering Manual (EM) 200-1-13, *Environmental Quality: Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installations*; ASHRAE Guideline 12-2000, *Minimizing the Risk of Legionellosis with Building Water Systems;* and ANSI/ASHRAE Standard 188-2015, *Legionellosis: Risk Management for Building Water Systems.*

For **Navy** projects only:

For projects that meet the scope as defined by Section 2 “Scope” of the ASHRAE Guideline 12-2000, designs must incorporate the design recommendations in the “Recommended Treatment” paragraphs and the Public Works Department must provide the services to meet the maintenance recommendations in the “Recommended Treatment” paragraphs, for the applicable systems.

For projects that meet the scope as defined by Section 2 “Scope” of the ANSI/ASHRAE Standard 188-2015 designs must incorporate the requirements in Section 4.1 “Building Designer Requirements” and the Public Works Department must provide the services to meet the requirements in Section 4.2 “Building Owner Requirements.”

4-7 CHAPTER 6 - WATER SUPPLY AND DISTRIBUTION.

4-7.1 Section 601 – GENERAL.

601.6 Storage tank materials. [Addition]

Storage tanks shall be constructed of one of the following combinations of materials and methods:

1. Ferrous metals lined with nonferrous metals and provided with cathodic protection.
2. Ferrous metals lined with glass and provided with cathodic protection.
3. Ferrous metals lined with cement and provided with cathodic protection.
4. Fiberglass reinforced plastic for atmospheric pressure applications.

4-7.2 Section 602 - WATER REQUIRED.

602.2 Potable water required. [Supplement]

Add the following after the last sentence:

Exception: A nonpotable water supply, when used in an entirely separate system and when approved by the local health department, may be used for flushing water closets and urinals and for other approved purposes where potable water is not required.

602.2.1 Water for landscaping. [Addition]

Wall faucets, wall hydrants, lawn faucets, and yard hydrants shall be located so that, with 100 feet (30 m) of garden hose, the area can be watered without crossing the main entrance of public buildings or barracks. The branch to the lawn faucets and yard hydrants shall be equipped with stop and waste valves. The means of watering lawn areas, flowerbeds, and gardens shall be provided as follows:

1. Wall faucets with vacuum breaker backflow preventer on outside walls in nonfreezing climates.
2. Non-freeze wall hydrants with vacuum breaker backflow preventer on outside walls in freezing climates.
3. Lawn faucets with vacuum breaker backflow preventer for garden and lawn areas in nonfreezing climates.

4. Yard non-freeze hydrants for garden and lawn areas in freezing climates. Yard non-freeze hydrants have an automatic drain feature that can allow ground water to enter the service line. To protect the water supply the designer can either isolate the supply to the yard non-freeze hydrants with a double check valve backflow preventer, or specify sanitary yard hydrants. Sanitary yard hydrants are self-contained and do not drain to the surrounding ground, eliminating the possibility of cross-contamination. The designer should select the most cost effective option; sanitary yard hydrants are about three times the cost of standard non-freeze yard hydrants.

4-7.3 Section 604 – DESIGN OF BUILDING WATER DISTRIBUTION SYSTEM.

604.1 General [Supplement]

Add the following after the last sentence:

Service lines will enter the building in accessible locations. Large and mission critical facilities shall be provided with two or more water services to ensure constant delivery to all fixtures and equipment. Coordinate with user. A drain valve must be installed inside the building and downstream of both the building backflow preventer and the building service valve. Drain valve must be placed in a location with access to waste drains.

604.3 Water distribution system design criteria [Supplement]

Add the following after the last sentence:

Provide piping water velocities not to exceed 10 feet per second (3.28 m/s).

604.9 Water hammer [Supplement]

Add the following after the last sentence:

Only specify commercial-type water hammer arresters; vertical capped pipe columns are not permitted. Size and locate commercial water hammer arresters in accordance with PDI WH 201, *Water Hammer Arresters Standard* and manufacturer’s recommendations. Provide access doors or removable panels when water hammer arresters are concealed.

4-7.4 Section 606 – INSTALLATION OF THE BUILDING WATER DISTRIBUTION SYSTEM.

606.5.11 Sizing booster systems and pumps [Addition]

Water pressure may be increased by using a hydro-pneumatic system consisting of a tank, pumps, compressed air system, and associated control devices.

606.5.11.1 Tank Pressure. The minimum pressure maintained within the tank is at low-water level and is equal to the pressure required to meet the fixture demands. The high pressure at high water level depends on the operating pressure differential selected for the system. A reasonable and most commonly selected pressure differential is 20 psi (138 kPa).

606.5.11.2 Pumps. Provide factory prefabricated pump package. Use variable speed pumping unless approved by the Authority Having Jurisdiction. For mission critical projects or for contingency operations provide triplex pumps, otherwise provide duplex pumps. . Each pump is sized to meet the requirements of the facility. Pump capacities in gallons per minute (L/s) shall be in accordance with Table 606.5.11-1. Pump head is to be equal to the high pressure maintained within the hydro-pneumatic tank.

606.5.11.3 Tank Capacity. For constant speed pumping, tank capacity is to be based upon a withdrawal, in gallons (liters), of 2-1/2 times the gallon per minute (L/s) capacity of the pump and a low water level of not less than 10 percent of total tank capacity or 3 inches (76 mm) above top of the tank outlet, whichever is greater. Table 606.5.11.3 indicates high water levels and withdrawals for efficient operation of tanks with bottom outlets and a 10 percent residual. Using this table, the tank capacity may be determined as per Example 1. Pressure ranges are given in pounds per square inch (psi) and kilopascals (kPa)

Example 1: Determine the tank capacity when pump capacity is 150 gpm and tank operating pressure range is 40 to 60 psi. (Referring to Table 606.5.11.3, the withdrawal from the tank is 24 percent of the tank capacity.)

Total tank capacity = 2.50 x 150 gpm / 0.24 = 1,563 gallons

or

Total tank capacity = 2.50 x 568 L/s / 0.24 = 5916 liters

For variable speed pumping, follow manufacturer's recommendations for tank size or calculate tank size based on 4% minimum flow and a 5-minute minimum off time.

606.5.11.4 Compressed Air. Compressed air is supplied for tank operation according to the tank capacities. Satisfactory operation has been attained by providing 1.5 cubic feet per minute (cfm) for tank capacities up to 500 gallons (1893 L) and 2 cfm (0.0566 cubic meters/min.) for capacities from 500 to 3,000 gallons (1893 to 11 355 L). For each additional 3,000 gallons (11 355 L) or fraction thereof, add 2 cfm (0.0566 cubic meters/min.). (Quantities are expressed in cubic feet (cubic meter) per minute free air at pressure equal to the high pressure maintained within the hydro-pneumatic tank.)

606.5.11.5 Controls. The controls of a hydro-pneumatic system are to maintain the predetermined pressures, water levels, and air-water ratio within the tank. Specify manufacturer's packaged controls. Specify commissioning of booster pump systems to ensure proper on/off set points and pump ramp speed settings under various conditions i.e. high demand/low incoming pressure and low demand/high incoming pressure.

606.5.11.6 Booster Pumps. Booster pumps must be the "on-off".

606.5.11.6.1 On-Off Type. The installation of an "on-off" type of pumping system should be considered when relatively long periods of pump-on or pump-off are anticipated. Pumps are to be activated, only when pressure is inadequate. Flow normally is through a single full-size pump bypass with check valve and two normally open (N.O.) isolating valves, whether the installation has one pump or multiple pumps. Provide each pump with a check valve on the discharge and two N.O. isolating valves.

Table 606.5.11.3
TANK FILL PUMPS

LOCATION	NUMBER OF FIXTURES	FLOW RATE PER FIXTURE gpm (L/s)	MIN. PUMP CAPACITY gpm (L/s)
Administration Building	1-25	1.23 (0.08)	25 (1.5)
	26-50	0.9 (0.06)	35 (2.2)
	51-100	0.7 (0.045)	50 (3.2)
	101-150	0.65 (0.04)	75 (4.7)
	151-250	0.55 (0.03)	100 (6.3)
	251-500	0.45 (0.03)	140 (7.8)
	501-750	0.35 (0.02)	230 (15.0)
	751-1,000	0.3 (0.02)	270 (17.0)
	1,000-up	0.275 (0.02)	310 (20.0)
Apartments	1-25	0.6 (0.04)	10 (0.6)
	26-50	0.5 (0.03)	15 (0.9)
	51-100	0.35 (0.02)	30 (1.9)
	101-200	0.3 (0.02)	40 (2.5)
	201-400	0.28 (0.02)	65 (4.1)
	401-800	0.25 (0.015)	120 (7.6)
	801-up	0.24 (0.015)	210 (13.0)
Hospitals	1-50	1.0 (0.06)	25 (1.6)
	51-100	0.8 (0.05)	55 (3.5)
	101-200	0.6 (0.04)	85 (5.4)
	201-400	0.5 (0.03)	135 (7.9)
	401-up	0.4 (0.025)	210 (13.0)
Industrial Buildings	1-25	1.5 (0.10)	25 (1.6)
	26-50	1.0 (0.06)	40 (2.5)
	51-100	0.75 (0.05)	60 (3.8)
	101-150	0.7 (0.045)	80 (5.0)
	151-250	0.65 (0.04)	110 (7.0)
	251-up	0.6 (0.04)	165 (10.5)
Quarters And Barracks	1-50	0.65 (0.04)	25 (1.6)
	51-100	0.55 (0.03)	35 (2.2)
	101-200	0.45 (0.03)	60 (3.8)
	201-400	0.35 (0.20)	100 (6.3)
	401-800	0.275 (0.02)	150 (9.5)

	801-1200	0.25	(0.015)	225	(14.5)
	1,200-up	0.2	(0.01)	300	(19.0)
Schools	1-10	1.5	(0.09)	10	(0.06)
	11-25	1.0	(0.06)	15	(0.9)
	26-50	0.8	(0.05)	30	(1.9)
	51-100	0.6	(0.04)	45	(2.8)
	101-200	0.5	(0.03)	65	(4.1)
	201-up	0.4	(0.025)	110	(7.0)

Table 606.5.11-2
HYDRO-PNEUMATIC TANK HIGH WATER LEVELS AND WITHDRAWALS
(Based on bottom outlet tanks and a 10 percent residual)

PRESSURE RANGE psi (kPa)	HIGH WATER LEVEL (percent of total tank capacity)	WITHDRAWAL (96% of total tank capacity)
20-40 (140-275)	43	33
30-50 (205-345)	38	28
40-60 (275-415)	34	24
50-70 (345-480)	32	22
60-80 (415-550)	28	18
20-45 (140-310)	48	38
30-55 (205-380)	42	32
40-65 (275-450)	37	27
50-75 (345-520)	35	25
60-85 (415-590)	32	22

4-7.5 Section 607 – HOT WATER SUPPLY SYSTEM.

607.1.3 *Legionella pneumophila* (Legionnaires' disease) [Addition]

The bacterium that causes Legionnaires' disease when inhaled has been discovered in the service water systems of various buildings in the United States and abroad. It has been determined that *Legionella pneumophila* can colonize in hot water systems maintained at temperatures of 115°F (46°C) or lower. Service water segments subject to stagnation (e.g., faucet aerators, shower heads and certain portions of storage–type water heaters) could provide an ideal location for bacteria to breed. Service water temperatures in the range of 140°F (60°C) are recommended in order to limit the growth potential of the bacteria. However, care must be taken to avoid scalding. Anti-scald devices must be incorporated in designs in which the service water temperature is in the range described above. For hospital and health care facilities, periodic supervised flushing of fixture heads with water at or above 170°F (77°C) are recommended.

607.2 Hot or tempered water supply to fixtures [Replacement]

Remove the last sentence and replace with the following:

Recirculating system piping shall be considered to be sources of *hot* and *tempered water*.

Size hot water recirculation pump in accordance with ASHRAE Handbook, *HVAC Applications*.

A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe is prohibited.

607.2.1 Circulation systems and heat trace systems for maintaining heated water temperature in distribution systems. [Replacement]

Delete the first paragraph and replace with the following:

Provide recirculating systems for temperature maintenance. Heat trace systems are not permitted for temperature maintenance.

In buildings operated on a nominal 40-hour week or on a nominal two-shift basis (either a 5- or a 7-day week), a clock or other automatic control will be installed on domestic hot-water circulating pumps to permit operation only during periods of occupancy plus 30 minutes before and after.

607.2.1.2 Demand recirculation controls for distribution systems [Deletion]

Delete section in its entirety.

607.5 Insulation of piping [Supplement]

Add the following after the last sentence:

Insulate service hot water piping to meet the more restrictive minimum requirements of the following:

1. IPC.
2. ASHRAE Standard 90.1
3. UFGS 23 07 00, *Thermal Insulation for Mechanical Systems*.

The insulation requirements are minimum design requirements. The quality of insulation should be upgraded if the designer can show an improvement in the system performance or that insulation improvements are cost effective.

4-7.6 Section 608 – PROTECTION OF POTABLE WATER SUPPLY.

608.1 General [Supplement]

Add the following after the last sentence:

Single check valves are not considered adequate protection against backflow. Backflow prevention devices must be approved by the State/local regulatory agencies. If there is no State/local regulatory agencies requirements, all backflow prevention devices must be listed by the Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies. Testing frequencies will follow the requirements set forth by the State/local regulatory agencies or DoD policy, whichever is more stringent.

4-7.7 Section 611 – DRINKING WATER TREATMENT UNITS.

611.2 Reverse osmosis systems [Supplement]

Add in front of the first sentence:

Reverse osmosis water treatment systems shall be installed when water of a higher purity than that produced by the domestic water is required, such as for deionized or distilled water systems used in hospitals. A water quality analysis shall be performed and water treatment design shall proceed based on that analysis. Reverse osmosis is a general term covering equipment that can have various types of filter elements and membranes and polishing components. The reverse osmosis membrane selection is critical and the operating pressure depends upon the membrane selected. Pump pressures can range from 80 to 800 psi (552 to 5516 kPa). The reverse osmosis unit is only part of the required treatment systems, which may include pretreatment facilities and organic filters. In some cases, booster pumps may be required for final water distribution. Materials for piping, pumps, valves, and other components must be carefully selected due to the corrosive nature of the high-purity water produced.

4-7.8 Section 614 – ION EXCHANGE WATER SOFTENING TREATMENT EQUIPMENT [ADDITION].

614.1 Ion exchange

Softening requirements are application-specific; it is typically required where precipitation of calcium carbonate can damage boiler/water heating equipment, block conduits or for aesthetic reasons. Ion exchange water softening is a suitable process for these purposes. However, each category has its own recommended limits for maximum hardness. Water hardness for laundries should not exceed 2.5 grains per gallon (43 ppm) and water hardness is usually reduced to zero. Large mess halls should have a water hardness not exceeding that provided for laundries; whereas, hospitals can utilize water of up to 3 grains per gallon (51 ppm) water hardness. Ion exchange water softening equipment consists of a softener unit and a regeneration brine tank utilizing common salt (NaCl) for regeneration of the softener exchange material. Softening units can be multiple units where two or more units utilize the same regenerating brine tank to provide for continuity of treatment during regeneration of a softening unit.

4-8 CHAPTER 7 - SANITARY DRAINAGE.

4-8.1 Section 704 – DRAINAGE PIPING INSTALLATION

704.5 High efficiency water closets [Addition]

For both new construction and renovations, high efficiency flushometer valve water closets with flush valves less than 1.28 gpf must be installed downstream of additional long-duration flows from other water-consuming appliances, plumbing fixtures, (e.g., lavatory faucets, flushing urinals, showerheads), and other devices that are able to assist with the drain line transport of solid wastes. For new construction, drain line slopes of greater than 1% must be provided.

704.6 Waterless/waterfree urinals [Addition]

When multiple waterless/waterfree urinals are ganged together, the most upstream urinal shall not be a waterless/waterfree urinal to assure flushing of the sanitary drain line.

4-8.2 Section 712 - SUMPS AND EJECTORS.

712.3.1 Sump pump [Supplement]

Add the following after the last sentence:

Sump pumps shall be installed in pits below the lowest floor. Subsoil drains may discharge into this pit. Provide a single pump unit where the function of the equipment is not critical, and provide duplex pump units where the function of the equipment is mission critical. When duplex pump units are provided, the capacity of each pump is to be sufficient to meet the requirements of the facility..

712.3.2 Sump pit [Supplement]

Add the following after the last sentence:

Sumps are to contain, in gallons, between the high level and low level operating switch settings approximately twice the capacity of the sump pump, in gallons per minute. The depth of the pit, below the finished floor, shall be in even feet to conform to standard lengths of submerged pump shafts.

712.3.4 Maximum effluent level [Supplement]

Add the following after the last sentence:

A high water alarm actuator is to be installed within sump and operate an audible or visual alarm when the normal high-water level within sump has been exceeded.

712.3.6 Controls [Addition]

Automatic controls are to be provided for each pump. Duplex pump units are to be equipped with controls to alternate the operation of the pumps under normal conditions and to operate pumps simultaneously when one pump cannot handle the flow.

712.4 Sewage pumps and sewage ejectors [Supplement]

Add the following after the last sentence:

Detailed requirements for pumps and ejectors shall be in accordance with the standards of the Hydraulic Institute. Where sewers are not of sufficient depth to drain the lower floor fixtures by gravity, the main toilet rooms should be located on higher floors. Sewage ejectors shall be of the duplex pneumatic type and shall be located in a concrete pit below the lowest floor. Ejectors will utilize a high-velocity steam, air, or water jet for ejecting the sewage. When the sewage must be pumped, duplex units shall be provided below the lowest floor in a concrete sump protected by a safety railing. Duplex sewage pumps shall be installed in a separate pump house when the sewage from a group of buildings must be pumped and where it is not possible to install sewage pumps in the buildings. Pump motors shall be located so as not to become submerged by an electrical service interruption. Packaged pumping systems installed in vertical dry or wet basins with non-clog centrifugal pumps are acceptable, if the influent line leads directly to the discharge line of both pumps and all incoming sewage passes through self-cleaning screens. Auxiliary screens shall be installed in influent lines within wet wells, since built-in, self-cleaning screens of the pump discharge lines may not be able to handle extreme peak flow conditions. Combination "T" and check valve arrangements shall be provided in the influent line to each pump to prevent raw sewage from backing into incoming sewer lines, when pumps are operating.

712.4.2 Capacity [Supplement]

Add the following after the last sentence:

The capacity shall be determined by the fixture unit method described in Section 710.

4-8.3 Section 715 - BACKWATER VALVES.

714.3 Location [Supplement]

Add the following after the last sentence:

A gate valve must be installed on the sewer side of each backwater valve, and both shall be installed in a manhole.

4-8.4 Section 716 – VACUUM DRAINAGE SYSTEMS [DELETE]

Delete section in its entirety.

4-9 CHAPTER 8 - INDIRECT/SPECIAL WASTE.

4-9.1 Section 802 - INDIRECT WASTES.

802.1.5 Nonpotable clear-water waste [Supplement]

Add the following after the last sentence:

Clear water discharge from hydraulic elevator sump pumps shall be connected to the sanitary sewer drainage system through an indirect waste pipe by means of a 2-inch (50 mm) air gap or directly through an oil/water separator to storm sewer, or to grade outside the building, each in accordance with discharge permits, regulations, and statutes.

802.1.9 Arms vault and storage areas [Addition]

Through-the-wall drains with discharge to grade shall be provided in arms vaults and storage areas requiring dehumidification, to dispose of condensate water from dehumidifiers. When such drains are not practicable, floor drains shall be installed inside the vaults or storage areas to provide for water removal.

4-10 CHAPTER 9 – VENTS.

4-10.1 Section 901 – GENERAL.

901.1 Scope [Supplement]

Add the following after the last sentence:

A Philadelphia (one pipe), engineered vent system, or a sovent (aerator) type system are not be permitted.

901.3 Chemical waste vent systems [Replacement]

Replace with the following:

The vent system for a chemical waste system must be independent of the sanitary vent system and must terminate separately through the roof to the open air.

4-10.2 Section 917 - SINGLE STACK VENT SYSTEM [DELETE].

Delete section in its entirety.

4-10.3 Section 918 - AIR ADMITANCE VALVES [SUPPLEMENT].

Add the following before the first sentence:

Air admittance valves may be used on a limited basis for renovation projects only after approval from the FEC, TDC, BCE, or DPW

4-10.4 Section 919 - ENGINEERED VENT SYSTEM [DELETE].

Delete section in its entirety.

4-11 CHAPTER 10 – TRAPS, INTERCEPTORS AND SEPARATORS.

4-11.1 Section 1002 - TRAP REQUIREMENTS.

1002.4 Trap Seals [Supplement]

Add the following after the last sentence:

Where a trap seal is subject to loss by evaporation, the trap seal shall be protected by a deal seal trap consisting of a 4-inch (100 mm) seal and one of the other trap seal protection methods listed in Sections 1002.4.1.1 through 1002.4.1.4.

4-11.2 Section 1003 - INTERCEPTORS AND SEPARATORS.

1003.1 Where required [Supplement]

Add the following after the last sentence:

Interceptors shall be installed underground outside the building. The area surrounding interceptors shall be paved and provided with suitable drainage facilities. Where design temperatures are less than 0°F (–18°C), interceptors should be located within the building, remote from the kitchen area.

4-12 CHAPTER 11 - STORM DRAINAGE.

4-12.1 Section 1101 – GENERAL.

1101.1 Scope [Supplement]

Add the following after the last sentence:

Storm drainage will include roof drains, leaders, and conductors within the building and to a point 5 feet (1.5 m) outside the building.

4-12.2 Section 1104 - CONDUCTORS AND CONNECTIONS.

1104.3 Insulation of rainwater conductors [Addition]

To prevent condensation, insulate horizontal piping runs, roof drains, and roof drain sumps inside the building with a minimum of 1-inch (25 mm) thick insulation.

4-12.3 Section 1107 – SIPHONIC ROOF DRAINAGE SYSTEMS [DELETE]

4-13 CHAPTER 12 - SPECIAL PIPING AND STORAGE SYSTEMS.

1201.1 Scope [Supplement]

Add the following before the last sentence:

Refer to UFC 4-510-01, *Design: Military Medical Facilities,* for additional medical gas systems requirements.

4-14 CHAPTER 15 - REFERENCED STANDARDS.

Delete the last sentence of the first paragraph.

4-15 APPENDIX A.

4-15.1 PLUMBING PERMIT FEE SCHEDULE [DELETE].

Delete appendix in its entirety.

4-16 APPENDIX C.

4-16.1 STRUCTURAL SAFETY [DELETE].

Delete appendix in its entirety.

4-17 APPENDIX D.

4-17.1 DEGREE DAY AND DESIGN TEMPERATURES [SUPPLEMENTAL].

Where data conflicts with UFC 3-400-02, *Engineering Weather Data*, UFC 3-400-02 takes precedence.

CHAPTER 5 DESIGN ANALYSIS

5-1 DESIGN ANALYSIS.

The Design Analysis must be submitted at a preliminary design stage equivalent to 35% design for concurrence of the results. The Design Analysis must consist of a Basis of Design Narrative and Calculations. The analysis must be updated as necessary as the design progresses. The results of this analysis are used for design decision-making in reducing total life cycle cost, while meeting mission objectives.

5-1.1 Basis of Design.

5-1.2 Provide a Basis of Design Narrative.

Include the following:

- Building population (number of males and number of females)
- Plumbing fixture determination, listing quantity and types of fixtures
- Fixture units for drainage, venting, cold and hot water piping
- Roof areas used in determining storm drainage pipe sizes
- Capacities of all equipment and tanks

5-1.2.1 Criteria/Codes.

Identify the governing codes and criteria utilized for the design. Include the titles and the date of the applicable edition or publication.

5-1.2.2 Site Conditions.

Conduct detailed field investigation and interview the appropriate field personnel. Do not rely solely on the as-built drawings.

Determine energy sources available at the project site. Describe the source of thermal energy that will be used (i.e. extension of central high pressure steam, natural gas, or standalone heat source with the type of fuel utilized).

5-1.2.3 System Selection.

Provide a narrative description of all system alternatives considered. Describe in detail all systems and components selected at a preliminary design stage equivalent to 35% design to include the results of the LCCA and modeled energy use.

5-1.2.4 Special Plumbing Systems.

Provide a description of special plumbing systems such as compressed air, medical gas, etc.

5-1.3 Calculations.

Show calculations and assumptions supporting equipment selections in a clear and organized manner. When charts or tables are used in the design analysis, cite the source and date of the publication.

5-1.3.1 Sizing Calculations.

Provide calculations for sizing equipment, piping, and all accessories which includes pressure calculations. Provide the model number and manufacturer of each major piece of equipment used as the basis for the design.

5-1.3.2 LCCA.

Provide LCCA on optimized system level alternatives modeled in accordance with UFC 1-200-02. Provide energy model, including model inputs and outputs, on optimized system level alternatives by energy type in accordance with UFC 1-200-02.

5-1.3.3 Energy Compliance Analysis (ECA).

If required by UFC 1-200-02, provide a computerized Energy Compliance Analysis. The ECA is a building level analysis which takes into account the interaction between architectural, electrical and mechanical components of the facility design and confirms compliance with the energy reduction goals.

5-2 FINAL DRAWING REQUIREMENTS.

The drawings will be accurate, to scale and follow the Tri-Service A/E/C CADD Standard. Drawings must show equipment and piping sufficiently to indicate all aspects of installation. Provide each set of drawings with a legend covering symbols and abbreviations as indicated in ASHRAE Handbook, *Fundamentals*. Where practical, group all notes, legends, and schedules at the right of the drawings above the title block.

5-2.1 Drawing Units.

Unless otherwise authorized, the IP System of measurement must be used on CONUS projects and the SI system of measurement must be utilized on OCONUS projects.

5-2.2 Legend.

Provide legends to clarify all symbols and abbreviations used on the drawings.

5-2.3 Seismic and ATFP Bracing

Show all pertinent seismic and ATFP bracing details for the plumbing systems on the contract drawings.

5-2.4 Demolition Plans.

Demolitions plans must be separate and distinct from new work plans.

5-2.5 Floor and Site Plans.

Exercise judgment to avoid overly congested drawings. Provide north arrows an all building and site plans. The orientation of drawings must be arranged with the north arrow toward the top of the plotted sheets, unless overriding circumstances dictate otherwise. The orientation of all partial building or site plans must be identical to that of the larger plan from which it is derived or referenced. Consistency in drawing orientation must be maintained with all disciplines. Provide drawings with dimensions locating all work relative to structural features of the building. For floor plans show fixtures, equipment, and piping in their proper locations. For site plans show connections to existing systems, location of propane and oil tanks, and layout of ground coupled heat pump well fields. Calculate the grade of drain lines and show established invert elevations.

5-2.6 Enlarged Floor Plans.

Provide large-scale details of congested area on the drawings, with dimensions locating all work relative to structural features of the building. Provide separate waste/vent and domestic water enlarged floor plans. Enlarged floor plans must be drawn at no less than 1/4” = 1’-0” (1:50).

5-2.7 Sections and Elevations.

Provide as required to supplement plan views.

5-2.8 Access Space.

Identify space necessary to access and replace items that require maintenance, such as heat exchangers, on the drawings.

5-2.9 Riser Diagrams

Show riser diagrams of soil, waste, drain, and vent stacks. Indicate cleanouts. Show water risers for all buildings in excess of one story. Indicate shutoff valve and water hammer arrester locations. Indicate pipe sizes.

5-2.10 Water Service.

Unless directed otherwise, place the following note on the applicable drawing: "Water pipe sizes are based on a minimum working pressure of ___ [psig (kPa)] at a flow rate of ___ [gpm (L/s)] at the location where the main service enters the building." When water pressure is not known, it must be measured.

5-2.11 Equipment Schedules.

Unless directed otherwise, include equipment schedules on the drawings. The following are typical schedules and data provided on these schedules:

5-2.11.1 Hot water circulating pump.

Provide a hot water circulating pump schedule. Include as a minimum:

- Capacity in gpm (L/s)
- Total head in feet (m)
- Minimum horsepower
- Volts, phase, hertz
- RPM

5-2.11.2 Ejector or sump pump.

Provide an ejector or sump pump schedule. Include as a minimum:

- Capacity in gpm (L/s)
- Total dynamic head in feet (m)
- Minimum horsepower
- Volts, phase, hertz
- RPM

5-2.11.3 Water heater.

Provide a water heater schedule. Include as a minimum:

- Heating capacity in gph (L/s)
- Temperature rise in degrees Fahrenheit (°F) (Celsius (°C))
- Storage capacity in gallons (liters)
- Energy Factor (defined by Gas Appliance Manufacturers Association (GAMA))

5-2.11.4 Hot water storage tank.

Provide a water heater storage tank schedule. Include as a minimum:

- Dimensions
- Capacity in gallons (liters)
- Minimum insulation

5-2.11.5 Hot water generator.

Provide a hot water generator schedule. Include as a minimum:

- Dimensions
- Storage capacity in gallons (liters)

- Heating surface area
- Design pressure
- Heat source (i.e. steam, HTHW, natural gas, electric)
- GPH @ entering water temperature and leaving water temperature

5-2.11.6 Drinking water dispenser:

Provide a drinking water dispenser schedule. Include as a minimum:

- Cafeteria: Type, size
- Electric drinking water cooler: Type, size (Note: Water coolers must use HFC refrigerants.)

5-2.11.7 Grease interceptor.

Provide a grease interceptor schedule. Include as a minimum:

- Fat capacity in pounds (kilograms)
- Flow rating in gpm (L/s)
- Maximum leaving water grains (ppm)

5-2.11.8 Reverse osmosis water treatment equipment.

Provide a reverse osmosis water treatment equipment schedule. Include as a minimum:

- Minimum flow rating in gpm (L/s)
- Design and operating temperature in °F (°C)
- Maximum leaving water grains (ppm)

5-2.11.9 Water softening treatment equipment.

Provide a water softening treatment equipment schedule. Include as a minimum:

- Minimum flow rating in gpm (L/s)
- Grains (grams) hardness to which water is to be softened
- Amount of water metered in gallons (liters) to start automatic regeneration of a softener unit

5-2.11.10 Booster pump.

Provide a booster pump schedule. Include as a minimum:

- Capacity in gpm (L/s)
- Total head in feet (m)
- Minimum horsepower
- Volts, phase hertz
- RPM

5-2.12 Details.

Details must be edited to reflect the configurations and construction materials shown on the plans.

5-2.13 Access Panels.

Indicate location and size of access panels in floors, walls, and ceilings (except in lay-in tile applications) as required to access valves, wall cleanouts, etc. on drawings. Sufficiently sized, safe access must be provided for the maintenance of valves and other components.

APPENDIX A GLOSSARY

A-1 ACRONYMS

A/E	Architect and Engineer
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASSE	American Society of Safety Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society of Testing and Materials
CFR	Code of Federal Regulations
DoD	Department of Defense
ES/EWS	Emergency Shower and Eyewash Station
FCCHR	Foundation for Cross-Connection Control and Hydraulic Research
FM	Factory Mutual Corporation
ICC	International Code Council
IPC	International Plumbing Code®
ISEA	International Safety Equipment Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PDI	Plumbing and Drainage Institute
PPI	Plastic Pipe Institute
SWH	Service Water Heater
UEPH	Unaccompanied Enlisted Personnel Housing
UFC	Unified Facilities Criteria

UL	Underwriter's Laboratory
UOPH	Unaccompanied Officers Personnel Housing

APPENDIX B REFERENCES

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

http://www.ansi.org

ANSI/ASHRAE/IES 90.1 (ASHRAE 90.1), *Energy Standard for Buildings Except Low-Rise Residential Buildings*

ANSI/ASHRAE Standard 188-2015, *Legionellosis: Risk Management for Building Water Systems.*

ANSI/ASSE Z590.3, *Prevention Through Design: Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes.*

ANSI/ISEA Z358.1, *Emergency Eyewash and Shower Equipment*

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE)

http://www.asse.org

ASSE 1017, *Temperature Activated Mixing Valves for Hot Water Distribution Systems*

ASSE 1070/ASME A112.1070/CSA B125.70, *Water Temperature Limiting Devices*

ASSE Z87.1, *Occupational Eye and Face Protection (formerly ANSI Z87.1)*

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

http://www.ashrae.org

Handbook, *Fundamentals*

Handbook, *HVAC Applications*

ASHRAE Guideline 12-2000, *Minimizing the Risk of Legionellosis with Building Water Systems*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

http://www.asme.org

ASME A112.19.2, *Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals*

CSA GROUP

http://www.csagroup.org

CSA B125.3, *Plumbing Fittings*

DEPARTMENT OF ENERGY

https://energy.gov/eere/femp/downloads/how-buy-energy-and-water-efficient-products-federal-government

Federal Energy Management Program (DOE-FEMP), *Buying Energy Efficient Products*

ENVIRONMENTAL PROTECTION AGENCY (EPA)

http://www.epa.gov

40 CFR 261, *Identification and Listing of Hazardous Waste*

INTERNATIONAL CODE COUNCIL (ICC)

http://www.iccsafe.org

International Plumbing Code®

International Plumbing Code® Commentary

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

http://www.iccsafe.org

The National Standard Plumbing Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

http://www.nfpa.org

NFPA 1, *Fire Code*

NFPA 54, *National Fuel Gas Code*

NFPA 58, *Liquefied Petroleum Gas Code*

NFPA 70, *National Electric Code*

PLASTIC PIPE INSTITUTE (PPI)

http://plasticpipe.org/index.html

Handbook of Polyethylene Pipe

PLUMBING AND DRAINAGE INSTITUTE (PDI)

http://www.pdionline.org

PDI WH 201, *Water Hammer Arresters Standard*

UNITES STATES ACCESS BOARD

http://www.access-board.gov

Architectural Barriers Act, *Accessibility Standards for Department of Defense Facilities*

UNITED STATES ARMY CORPS OF ENGINEERS

http://www.usace.army.mil/

Engineering Manual (EM) 200-1-13, *Environmental Quality: Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installations*

UNITED STATES DEPARTMENT OF DEFENSE, UNIFIED FACILITIES CRITERIA (UFC)

http://dod.wbdg.org

UFC 1-200-01, *DoD Building Code (General Building Requirements)*

UFC 1-200-02, *High Performance and Sustainable Building Requirements*

UFC 3-230-02, *O&M: Water Supply Systems*

UFC 3-230-03, *Water Treatment*

UFC 3-400-02, *Engineering Weather Data*

UFC 3-410-01, *Heating, Ventilating, and Air Conditioning Systems*

UFC 3-440-01, *Facility-Scale Renewable Energy Systems*

UFC 3-501-01, *Electrical Engineering*

UFC 3-600-01, *Fire Protection Engineering for Facilities*

UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*

UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems*

UFC 4-440-01, *Warehouses and Storage Facilities*

UFC 4-510-01, *Design: Military Medical Facilities*

UNITED STATES DEPARTMENT OF DEFENSE, UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)

http://dod.wbdg.org

UFGS 22 00 00, *Plumbing, General Purpose*

UFGS 23 03 00.00 20, *Basic Mechanical Materials and Methods*

UFGS 23 07 00, *Thermal Insulation for Mechanical Systems*

APPENDIX C DESIGN GUIDANCE FOR EMERGENCY SHOWER AND EYEWASH STATIONS

C-1 EMERGENCY SHOWER AND EYEWASH STATION (ES/EWS).

Provide ES/EWS meeting ANSI/ISEA Z358.1, *Emergency Eyewash and Shower Equipment,* where required by Occupational Safety and Health Administration (OSHA) regulations or by other competent authority, such as UFC's, Military Handbooks, or Design Manuals. Consult with the local station and engineering authorities, including the process, environmental, and safety engineers, and the Industrial Hygienist about ES/EWS locations, materials present, waste treatment systems available, and permits required. Locate ES/EWS as close to the hazard as possible, within 10 to 20 feet (3 to 6 m) for highly corrosive chemicals, but not more than 10 seconds or 100 feet (30 m) of unobstructed travel away, whichever is lesser.

For personnel protection within water-reactive hazardous materials storage and handling areas, provide ASSE Z87.1, *Occupational Eye and Face Protection* chemical splash goggles. Consider providing portable ANSI/ISEA Z358.1 personal eyewash protection for use within the water-reactive area. Provide ES/EWS immediately outside the water-reactive area, but not more than the 10 seconds or 100 feet (30 m) away from the work location. Ensure water from ES/EWS will not enter the water-reactive area; this may require provision of partitions, walls, berms, trenches, or curbs. The personal eyewash must be of the smallest reasonable volume necessary to enable initial flushing on the way to the ES/EWS, to minimize the water-reactive hazard due to spillage of the flushing fluid. A water-reactive material spill is the most probable cause of the need for flushing, and the spillage of the flushing fluid provides the other chemical needed to initiate the reaction. Carefully consider whether to provide personal eyewash or not, and document the decision analysis. Personal eyewash fluid presence may increase the risk of a water-reactive chemical event due to risk of accidental personal eyewash fluid spill, and due to valid usage of personal eyewash. Water-reactive materials are defined in UFC 4-440-01, *Warehouses and Storage Facilities*.

C-2 ALARMS.

Provide a water flow-initiated alarm for each ES/EWS. For locations where potable water is not available, provide personal eyewash protection and a manually initiated alarm. Provide a local audible signal device, a silencing switch, and a flashing strobe light for each ES/EWS and for each manual alarm, and optionally provide central reporting of the alarm to a 24 hour per day manned location. Alarm installations must be waterproof per National Electrical Manufacturers Association (NEMA) Class 3. ES/EWS alarm systems in hazardous (classified) locations, per National Electric Code, must be listed and labeled for that purpose. Alarm audible signal devices must have a distinct sound, different from other alarms in this and adjacent facilities. Mount alarm audible signal device, silencing switch, and strobe light on wall or ES/EWS column, immediately above the level of the showerhead.

Alarms protect people by promptly summoning help, and protect stored materials, equipment, and facilities by indicating or reporting ES/EWS activation, with its attendant water flow.

C-3 FLOOR DRAINS.

Floor drains for ES/EWS are not required by the IPC. See Section 411.

C-3.1 Occupant Preference.

Owners and occupants prefer floor drains, for housekeeping and for material and facility protection reasons.

The floor drain may become a source of illicit disposal of prohibited substances. Careful supervision will be necessary.

C-3.2 De Minimis Losses.

Floor drains may be provided. The Environmental Protection Agency regulation, 40 CFR 261, *Identification and Listing of Hazardous Waste*, describes " ...the following mixtures of solid wastes and hazardous wastes listed in Subpart D are not hazardous wastes..." "..."de minimis" losses include ..." "...discharges from safety showers and rinsing and cleaning of personal safety equipment;...". Therefore, ES/EWS discharges may be drained to the sanitary sewer system, as they are "de minimis" losses.

C-3.3 Sizing.

C-3.3.1 Capacity.

Minimum capacity 45 gpm (2.8 L/s) water flow, based upon 1.5 times the ANSI/ISEA Z358.1 standard water flow minimum requirement.

The floor drain must accommodate the full flow of the ES/EWS to avoid spilling water over the containment curb, into the hazardous material storage area, and to avoid damage to the material and the facility in case of continuous ES/EWS operation.

C-3.3.2 Traps.

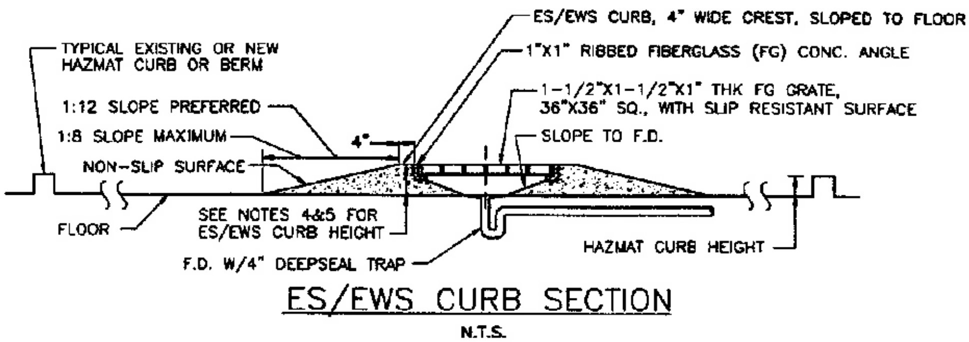
Floor drains must be provided with 4-inch (100 mm) deep seal traps. Frequent testing of the ES/EWS, as required by ANSI/ISEA Z358.1, will refill the trap seal.

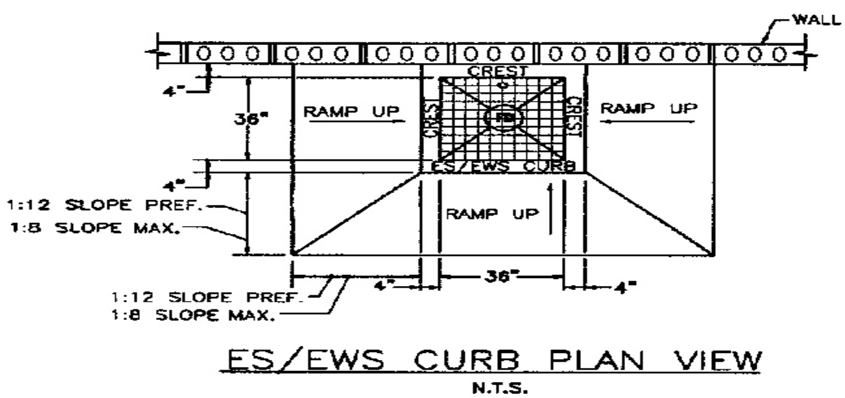
The deep seal trap is provided to reduce the problem of the unused trap drying out and allowing the back flow of sewer gases, fumes, and vermin into the space. Weekly testing of the ES/EWS will be usage enough to refill the trap seal; otherwise, provide an automatic trap priming valve connected to the cold water supply to maintain the trap seal.

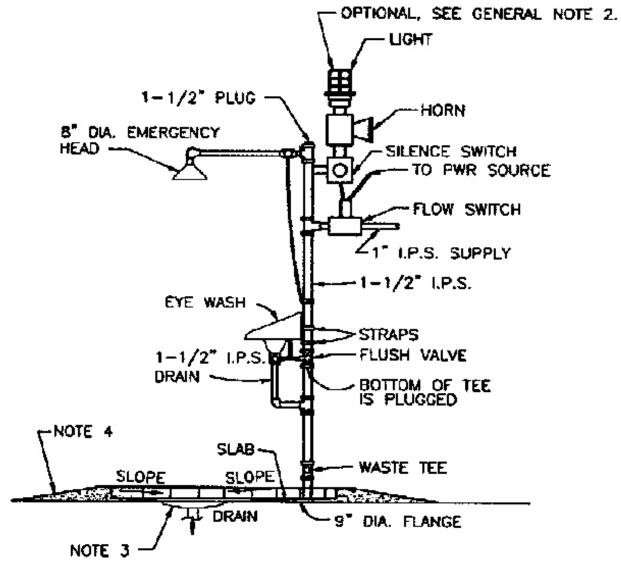
C-3.3.3 Containment Curb.

For hazardous material (HAZMAT) areas, provide a 1.5 inch (37 mm) high ES/EWS containment curb completely around the ES/EWS, slope the exterior (approach) face of the curb up at a slope of 1/12 rise, but not more than 1/8 rise per *ABA Accessibility Standards for DoD Facilities*, mark the ES/EWS curb as a trip hazard per OSHA regulations, and inform the personnel that the ES/EWS curb exists. Where ES/EWS with floor drains are located within hazardous material (hazmat) spill containment bermed or curbed areas, provide the crest of the ES/EWS curb to be 1.5 inch (37 mm) higher than the surrounding HAZMAT area curb, to ensure spills do not enter the floor drain. See Figure D-1.

Figure C-1 Emergency Eyewash and Shower Details







EMERGENCY SHOWER & EYE WASH (ES/EWS) DETAIL
N.T.S.

The ES/EWS containment curb protects the floor drain from accidental spills in the surrounding HAZMAT area. The ES/EWS curb also protects the stored HAZMAT materials and facility from accumulated ES/EWS water flow by directing the flow into the floor drain.

C-3.3.4 Placard.

In HAZMAT areas, post a placard at each ES/EWS stating: "NO DUMPING. This drain discharges untreated into the sanitary sewer, contact Activity Environmental Office for proper disposal of spilled material or waste."

The placard provides the occupants with sufficient information to avoid inadvertent "spills" caused by using the floor drain as a convenient sink for cleanup of spilled materials. Revise the wording to correctly indicate the discharge destination and any treatment system it passes through, such as a neutralization tank or an oil-water separator.

C-3.4 Connection.

All drain connections must comply with all national, State, local, and DoD regulations.

C-3.4.1 Extraordinary hazard materials.

Extraordinary hazard materials - such as poisons, must not discharge into a drain system. Utilize the HAZMAT spill containment curb system to contain the ES/EWS water flow. Provide remote alarm reporting to a central manned station. Immediate action is required to prevent poison contaminated water from spreading throughout the facility.

The floor drain is omitted to prevent inadvertent exposure of persons downstream of the floor drain from unknowingly contacting the potentially poisonous runoff. The hazardous material spill response team answering the alarm will be aware of the hazards and capable of taking appropriate measures for self-protection. If the HAZMAT spill containment curbed area has insufficient volume to hold a minimum of 30 minutes of ES/EWS water flow, provide a floor drain to an above ground holding tank sized to hold at least 30 minutes of flow. Properly label the piping and the tank as holding poisonous fluids. Provide a HAZMAT spill containment berm around the holding tank. Provide an ES/EWS containment curb around the floor drain to preclude fire protection water from flooding the floor drain holding tank and tank berm. ES/EWS curb to be 1.5 inches (37 mm) higher than the HAZMAT curb.

C-3.4.2 Plating shops.

Drain to the proper industrial waste treatment system. Segregate cyanide wastes, including ES/EWS drainage, from all acid wastes. Segregate hexavalent chromium wastes, including ES/EWS drainage, from all caustics and cyanides. Where the shower is located in a multiple use area, such as a material handling or shipping/receiving area, drain to the proper industrial waste treatment system.

C-3.4.3 Battery rooms or shops.

Drain to the proper neutralization tank, if provided; otherwise, drain to the sanitary sewer system. Segregate caustics from the Nickel- Cadmium-Alkali battery area, including ES/EWS drainage, from acids. Segregate acids from the Lead- Acid battery area, including ES/EWS drainage, from caustics. Do not allow mixing of acid and alkali wastes in the drains.

C-3.4.4 Oily waste shops.

Drain to the oil/water separator, if provided; otherwise, drain to the sanitary sewer system. Typical oily waste shops include the following: paint shops and hangers, paint mix rooms, paint equipment rooms, engine shops, ground support equipment shops, refueler shops, Public Works automotive shops, locomotive and crane shops.

C-3.4.5 Miscellaneous materials.

Drain to the sanitary sewer system.

C-3.4.6 Exterior ES/EWS in HAZMAT areas.

Slope impervious-surfaced grade to drain to a bermed or curbed impervious-surfaced area to allow cleanup without “spillage” to the environment; or provide a floor drain connected to an appropriate drain system, and an enclosure with roof to preclude storm water entry into the floor drain. Provide the ramp, curb, and grate around the floor drain, to preclude surface drainage into the floor drain.

C-4 PIPED DRAINS.

Piped drains for eyewash stations (EWS) are not required by the IPC. See Section 411.

C-4.1 Occupant Preference.

Owners and occupants prefer piped drains for EWS for housekeeping purposes.

C-4.2 De Minimis Losses.

Piped drains for EWS may be provided. The Environmental Protection Agency regulation, 40 CFR 261, describes " ...the following mixtures of solid wastes and hazardous wastes listed in Subpart D are not hazardous wastes..." "..."de minimis" losses include ..." "...discharges from safety showers and rinsing and cleaning of personal safety equipment;...". Therefore, EWS discharges may be drained to the sanitary sewer system, as they are "de minimis" losses.

C-4.3 Sizing.

Pipe full size from waste tee. See Figure D-1.

C-4.3.1 Traps.

Piped drains must be provided with 4 inch (100 mm) deep seal traps. Frequent testing of the EWS, as required by ANSI/ISEA Z358.1, will refill the trap seal.

The deep seal trap is provided to reduce the problem of the unused trap drying out and allowing the back flow of sewer gases, fumes, and vermin into the space. Weekly testing of the EWS will be usage enough to refill the trap seal; otherwise, provide an automatic trap priming valve connected to the cold water supply to maintain the trap seal.

C-4.4 Connection.

All drain connections must comply with all national, State, local, and DoD regulations.

C-4.4.1 Extraordinary hazard materials.

Extraordinary hazard materials - such as poisons, must not discharge into a drain system. Utilize the HAZMAT spill containment curb system to contain the EWS water flow. Provide remote alarm reporting to a central manned station. Immediate action is required to prevent poison contaminated water from spreading throughout the facility.

The piped drain is omitted to prevent inadvertent exposure of persons downstream of the piped drain from unknowingly contacting the potentially poisonous runoff. The hazardous material spill response team answering the alarm will be aware of the hazards and capable of taking appropriate measures for self-protection. If the HAZMAT spill containment curbed area has insufficient volume to hold a minimum of 30 minutes of EWS water flow, provide a piped drain to an above ground holding tank sized to hold at least 30 minutes of flow. Properly label the piping and the tank as holding poisonous fluids. Provide a HAZMAT spill containment berm around the holding tank.

C-4.4.2 Plating shops.

Drain to the proper industrial waste treatment system. Segregate cyanide wastes, including EWS drainage, from all acid wastes. Segregate hexavalent chromium wastes, including EWS drainage, from all caustics and cyanides. Where the EWS is located in a multiple use area, such as a material handling or shipping/receiving area, drain to the proper industrial waste treatment system.

C-4.4.3 Battery rooms or shops.

Drain to the proper neutralization tank, if provided; otherwise, drain to the sanitary sewer system. Segregate caustics from the Nickel- Cadmium-Alkali battery area, including EWS drainage, from acids. Segregate acids from the Lead- Acid battery area, including EWS drainage, from caustics. Do not allow mixing of acid and alkali wastes in the drains.

C-4.4.4 Oily waste shops.

Drain to the oil/water separator, if provided; otherwise, drain to the sanitary sewer system. Typical oily waste shops include the following: paint shops and hangers, paint mix rooms, paint equipment rooms, engine shops, ground support equipment shops, refueler shops, Public Works automotive shops, locomotive and crane shops.

C-4.4.5 Miscellaneous materials.

Drain to the sanitary sewer system.

C-4.4.6 Exterior EWS in HAZMAT areas.

Slope impervious-surfaced grade to drain to a bermed or curbed impervious-surfaced area to allow cleanup without “spillage” to the environment; or provide a piped drain connected to an appropriate drain system.

Note: All drain connections must comply with all national, State, local, and DoD regulations. Coordinate this issue with the local authorities per paragraph 1 above.

C-5 ELECTRICAL.

Provide ground fault circuit interrupter (GFCI) protection for dedicated heat tape circuits and for all electrical power outlets within 6 feet (1.8 m) of an ES/EWS and below the elevation of the showerhead.

For heat tape systems, provide a ground fault equipment protection (GFEP) device on each heating cable branch circuit. Conventional circuit breakers may not prevent arcing from damaged or improperly installed heat trace cables. Coordinate heat tape system requirements with electrical engineer.

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APPENDIX D DOMESTIC WATER HEATER FOR ARMY BARRACKS

D-1 PURPOSE.

This appendix provides basic design guidance for the sizing of domestic water heaters for barracks buildings at Army installations.

D-2 BACKGROUND.

There have been questions regarding the sizing for domestic water heaters for barracks. Designers have often used ASHRAE design criteria for motels or dormitories with some over sizing. However the peak demand for domestic hot water in barracks is significantly larger than motels or dormitories due to the concentrated shower pattern of the occupants. This appendix provides a uniform approach to determine domestic water heating requirements for Army barracks, and will be used for the planning, design and construction of new and renovated facilities.

D-3 GUIDANCE.

D-3.1 General.

D-3.1.1 Storage Temperature.

As with any domestic water heating system, storage tank temperature must be maintained at a minimum of 140°F (60°C) to reduce the potential for *Legionella pneumophila* (Legionnaires' disease). Note that higher storage temperatures will result in a lower recovery rate to satisfy the peak demand. Include a cross connection with a mixing valve between the domestic water supply and hot water supply lines (leaving the storage tank) to control the temperature of water distributed to plumbing fixtures to a minimum of 131°F (55°C). Require a strainer upstream of the thermostatic mixing valve on both the hot- and cold-water connections to protect the small orifice in the mixing valve from debris that may be in either line. Where a recirculation pump is required, the minimum hot water return temperature shall be 122°F (50°C) at the connection to the cold water inlet of the water heater/storage tank, at the master mixing valve. The water temperature shall be reduced at the fixture as required through a water temperature limiting device in accordance with Section 424, except where higher temperatures are required by specialized equipment as indicated in ASHRAE Handbook, *Applications* or Table 506.1.

D-3.1.2 Thermal Expansion.

If a backflow preventer is installed in the domestic water main entering a building or in the line supplying the domestic hot water system, include provisions to accommodate thermal expansion. In barracks this can be critical as occupants often shower at the same time and after this peak usage event, the hot water loop will be at a relatively low temperature. During the subsequent recovery phase the water temperature will rise causing the water to expand. If little hot water is being used, this expansion will cause a pressure increase that may activate a relief valve or rupture the storage tank. The best method to alleviate this excess pressure is to install an expansion tank, sized in accordance with "Hydronic

Heating and Cooling" chapter in the ASHRAE Handbook, *Systems and Equipment*.

D-3.1.3 Central Plant.

Normally if a central energy plant is available it will be life cycle cost effective (an analysis must be performed) to generate domestic hot water using distributed media as the heat source. If there is no central plant or if the plant does not operate during the non-heating season, provide a separate domestic hot water source. If the site consists of several barracks buildings, evaluate the life cycle cost of these alternatives:

- A single boiler to provide low temperature hot water, 200°F (94°C) to heat exchangers in each barracks for domestic hot water generation.
- A single heating source for domestic hot water in each individual barracks separately.

If the barracks building is not part of a building complex and there is no central plant or distribution system available then a single heating source must be provided.

D-3.2 Calculations.

The following information applies to all types of domestic water heating systems for barracks.

D-3.2.1 Peak Demand.

Design for the case where all occupants are taking showers at essentially the same time. Public law limits the maximum flow from of each showerhead and private lavatory faucet to 2.5 gpm (0.16 L/s). It is assumed during peak demand that the shower runs for 7.5 minutes and the lavatory runs for 2 minutes. As a result, the peak domestic hot water demand (at T_s) can be found by the following equation:

$$V_p = (h)(occ)(P)\left(\frac{T_d - T_c}{T_s - T_c}\right) \quad \textbf{(Equation E-1)}$$

where:

V_p = volume of domestic hot water required at peak, L (gal).
h = number of shower heads, ea.
occ = number of occupants using each shower, ea.
T_d = temperature of water delivered to shower valve, 43°C (110°F).
T_s = temperature of water in storage tank, °C (°F).
T_c = temperature of cold water supply.
P = amount of water used per occupant during peak demand, 90.0 L/occupant (23.75 gal/occupant).

Note that there is no diversity in the number of occupants in the building. The peak volume of domestic hot water is calculated assuming 100 percent building occupancy. Also note that Equation E-1 does not take laundry or dining facilities into account. Add additional hot water requirements if laundry or dining facilities will be requiring hot water during the peak demand period.

D-3.2.2 Tank Size.

Once the peak demand is known, the tank capacity and corresponding recovery rate can be determined. Since space in the mechanical room is frequently limited, select the desired tank capacity first. An initial estimate of tank size can be determined by using 12.5 gal per occupant (50 L per occupant). Normally a selection of 12.5 gal (50 L) will provide acceptable operation at a reasonable cost but it must be noted that other factors including larger tank sizes and higher storage temperatures will reduce amount of recovery required. Larger tank sizes and increased storage temperatures will also result in greater heat loss from the storage tank. Compare selected tank size to standard tank capacities available commercially and with the space available in the mechanical room.

D-3.2.3 Recovery Rate.

Once the tank capacity is known, the recovery rate can be calculated. The recovery rate is the quantity of water to be heated from the inlet temperature to the desired storage temperature. The difference between the inlet water temperature and the water storage temperature is often assumed to be 100°F (55°C). However, this temperature difference must be coordinated with local conditions and revised as necessary. The required recovery rate can be found using the following equation:

$$R = \left(\frac{V_p - (MS_t)}{d}\right) \qquad \textbf{(Equation E-2)}$$

where:

R = recovery rate at the required temperature, L/s, (gph).

M = ratio of usable water to storage tank capacity, 60-80%.

S_t = storage tank capacity (initial estimate), L (gal) = $(h)(occ)\frac{50\ L}{occupant}$.

d = duration of the peak, (hours) = $\frac{9.5\ min}{occupant}\ (occ)\ \frac{1\ hour}{60\ min}$.

The duration is calculated assuming that the peak usage period will be 9.5 minutes per occupant. Therefore, if two occupants share a bathroom the duration is 19 minutes, 3 occupants would be 28.5 minutes, etc.

The recovery rate is an output condition. Insure that manufacturer's data for the hot water generation unit indicates sufficient input capacity to satisfy the recovery rate with actual design inlet water and storage temperatures.

The tank size may be adjusted up or down to accommodate available tank sizes or available recovery capacities. A smaller tank size yields a higher recovery rate. Simply enter the desired tank size into Equation E-2 and solve for the required recovery rate. Verify that the combination of tank size and recovery rate is commercially available.

D-3.2.4 Pipe Sizes.

The next component to be sized in the system is the domestic hot water distribution piping. Appendix A of *The National Standard Plumbing Code*, "Service Water Heating" chapter of the ASHRAE Handbook, *Applications,* and "Pipe Sizing" chapter of the ASHRAE Handbook, *Fundamentals* provide an ample set of resources on this topic. Therefore, this appendix will not discuss this process.

D-3.2.5 Domestic Hot Water Circulation Pump.

After the domestic hot water distribution piping has been sized, the domestic hot water circulation pump can be sized. This pump is used to circulate the domestic hot water through the distribution piping system. Size the pump using equation below:

$$Q_p = \frac{q}{c\ \rho\ c_p\ \Delta T}$$ **(Equation E-3)**

where:

Q_p = pump capacity, L/s (gpm).

q = heat loss in the piping system, kW (Btuh).

c = constant, 1 $\frac{kW \cdot sec}{kJ}$ $\left(60\frac{min}{hr}\right)$.

ρ = density of water, 0.9971 $\frac{kg}{L}$ $\left(8.33\ \frac{lb}{gal}\right)$.

c_p = specific heat of water, $4.18\ \frac{kJ}{kg \cdot K}$ $\left(1\ \frac{Btu}{lb \cdot {}^\circ F}\right)$.

ΔT = allowable temperature drop through the system, K (°F).

Equation E-3 can be simplified to:

$$Q_p = \frac{q}{\left(4.1679\frac{kW \cdot sec}{L \cdot K}\right)\Delta T}$$ **(Equation E-4 (SI))**

$$Q_p = \frac{q}{\left(500\frac{Btuh}{gpm \cdot {}^\circ F}\right)\Delta T}$$ **(Equation E-4 (IP))**

Heat loss in the piping system (q) can be calculated using ASHRAE Handbook, *Applications*. However, a common rule of thumb is 0.032 kW/m (30 Btuh/ft.).

The allowable temperature drop through the piping system (ΔT) is usually 2 to 5K (5 to 10°F). It is recommended to use 2K (5°F) to assure that sufficient hot water is provided for all occupants under peak conditions.

D-3.3 Separate Storage Tank.

Systems using a separate hot water generation unit and storage tank: The following information applies to systems using a separate storage tank and forced circulation type water heater, boiler or heat exchanger to generate and store domestic hot water. A forced circulation type water heater is similar to a boiler in that it is designed to heat domestic water as it passes through a series of coils rather than heating water in a storage tank but is designed for generating domestic hot water only.

D-3.3.1 Tank Location

Locate the storage tank and hot water generation unit in the same mechanical room whenever possible. This keeps the head requirements at a minimum for the pump circulating water between the hot water generation unit and the storage tank.

D-3.3.2 Connection

Require the domestic water supply be connected in the line supplying hot water to the storage tank. This allows the cold water to mix with the warmer water in the storage tank before entering the boiler, minimizing problems associated with condensation and thermal stress and improving overall system efficiency. Require a submittal from the manufacturer addressing whether a thermostatically controlled bypass line between the boiler supply and return lines or other means are needed to preclude the possibility of thermal shock to the boiler.

D-3.3.3 Forced Circulation

If a forced circulation type water heater or boiler is used, Equation E-3 again can be used to size the circulation pump between the heater and the storage tank. In this case limit the temperature differential to no greater than 30°F (16K) to minimize problems with condensation and thermal stress and improve overall system efficiency. Also note that the sizing of the circulation pump must account for the heating of the domestic cold water being provided. Therefore, the value of q required to use Equation E-3 can be found using the following equation:

$$q = q_{pipe} + (R\ c\ \rho\ c_p\ \Delta T) \quad \textbf{(Equation E-5)}$$

where:

q_{pipe} = heat loss in the piping between the boiler and the storage tank, kW (Btuh)

ΔT_t = temperature difference between the tank water and the make-up water, K (°F)

Determine actual storage tank and domestic water supply temperatures based on local requirements. If the water in the tank is assumed to be 60°C (140°F) and the make-up water is 4°C (40°F), Equation E-5 can be simplified to:

$$q = q_{pipe} + \left(R \times 233.402 \frac{kW \cdot sec}{L}\right)$$ (Equation E-6 (SI))

$$q = q_{pipe} + \left(R \times 50{,}000 \frac{Btuh}{gpm}\right)$$ (Equation E-6 (IP))

The new value of q can then be inserted into Equation E-3 to determine the required flow rate for the pump. Compare this flow rate with the minimum flow rates required for boiler or water heater operation and require the larger of the two values. Once the required flow rate is known, the pressure drop for the circulation pump can be determined. The resources listed in E-3.2.4 (Pipe Sizes) give adequate information on calculating the pressure drop through the piping. However, several manufacturers must be contacted to determine the pressure drop through the water heater or boiler. This value will vary widely between different manufacturers. Therefore, the circulation pump must be sized to overcome the highest pressure drop.

However, flow rates over or under those required by the boiler or water heater manufacturer can reduce the efficiency of the unit. As a result, the drawings must indicate the pump characteristics used for the design. Then add a note indicating that the pump is to be sized by the boiler or water heater manufacturer with the horsepower requirements not to exceed those listed in the schedule.

D-3.3.4 Heat Exchanger.

If a heat exchanger is used, size the circulation pump based on the flow required for the heat exchanger to meet the recovery calculated in Equation E-3 and the heat lost through the piping.

D-3.4 Sample Calculations.

D-3.4.1 Given.

h = 36 shower heads
occ = 2 occupants per shower
T_d = 43°C (110°F)
T_s = 60°C (140°F)
T_c = 4.4°C (40°F)
M = 75% useable tank capacity
ΔT = 5K (9°F) Maximum temperature drop through distribution system.
ΔT_t = 54K (97°F)

Piping system consists of:

- 9 meters of DN50 pipe
- 6 meters of DN25 pipe
- 15 meters of DN20 pipe

A separate tank and hot water boiler will be used.

q_{pipe} = 0.10 kW = 341.18 Btuh

D-3.4.2 Find.

(a) Peak domestic hot water demand, L (gal).
(b) Storage tank size, L (gal).
(c) Recovery rate required given the tank size selected, L/s (gph).
(d) Flow rate required for domestic hot water circulation pump.
(e) Flow rate required for boiler circulation pump.

D-3.4.3 Solution.

(a) Peak Domestic Hot Water Demand:

$$V_p = (h)\,(occ)\,\left(\frac{90}{occupant}\right)\left(\frac{T_d - T_c}{T_s - T_c}\right)$$

$$= (36\ heads)\left(\frac{2\ occupants}{head}\right)\left(\frac{90\ L}{occupant}\right)\left(\frac{43°C - 4.4°C}{60°C - 4.4°C}\right)$$

$$= 4499\ L\ (1{,}188\ gal)$$

(b) Initial Storage Tank Size:

$$S_t = (36\ heads)\left(\frac{2\ occupants}{head}\right)\left(\frac{50\ L}{occupant}\right)$$

$$= 3600\ L\ (951\ gal)$$

Use 2 tanks of 1893 L (500.0 gal) each to fit into the available space.

(c) Initial Recovery Rate:

$$d = \left(\frac{9.5\ min}{occupant}\right)(2\ occupants)\left(\frac{60\ sec}{min}\right)$$

$$= 1140\ sec$$

$$R = \frac{4499L - (75\% \times 2\ each \times 1893L)}{1140\ sec}$$

$$= 1.46\ Lps\ (1{,}388\ gph\ or\ 23\ gpm)$$

(d) Flow rate for domestic hot water circulation pump (heat loss through piping is 0.629 kW):

$$Q_p = \frac{0.629\ kW}{\left(4.1679\ \frac{kW\ \cdot sec}{L\ \cdot K}\right)\ 5K}$$

$$= 0.0302\ L/s\ (0.48\ gpm)$$

(e) Flow rate for boiler circulation pump:

$$q = q_{pipe} + \left(R \times 233.402 \frac{kW\ \cdot sec}{L}\right)$$

$$= 0.1\ kW + \left(1.46 \frac{L}{sec} \times 233.402 \frac{kW\ \cdot sec}{L}\right)$$

$$= 340.87\ kW$$

$$Q_p = \frac{340.87\ kW}{\left(4.1679 \frac{kW\ \cdot sec}{L\ \cdot K}\right) 16K}$$

$$= 5.11\ L/s\ (81.0\ gpm)$$