UFC 3-230-01
1 September 2018
Change 1, 1 October 2018

UNIFIED FACILITIES CRITERIA (UFC)

WATER STORAGE AND DISTRIBUTION

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

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UNIFIED FACILITIES CRITERIA (UFC)

WATER STORAGE AND DISTRIBUTION

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

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

Change No.	**Date**	**Location**
1	1 Oct. 2018	1. Updated reference to OEBGD in paragraph 1-3.2. 2. Added the word requirements in paragraph 2.1.1.1. 3. Updated UFC reference in paragraph 4-1.7.3. 4. Updated paragraph numbering in B-3.1.1. 5. Deleted the reference to the 10 State Standards in Appendix B.

This UFC supersedes UFC 3-230-01 dated November 2012.

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 should be sent to the respective service proponent office by the following electronic form: Criteria Change Request. The form is also accessible from the Internet sites 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://dod.wbdg.org/.

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

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UNIFIED FACILITIES CRITERIA (UFC)
REVISION SUMMARY SHEET

Title: UFC 3-230-01, *Water Storage and Distribution*

Superseding: UFC 3-230-1, Change 2, *Water Storage, Distribution and Transmission*.

Description: This revision provides updated technical content and includes the adoption of additional industry standards. It also addresses design order of precedence, cybersecurity, advanced metering, direct digital controls, and several criteria change requests.

Reasons for Document:

- This revised UFC provides requirements for the design of water distribution systems. It includes piping, storage and pumping requirements.
- Coordinates fire protection engineering, advanced meeting, direct digital controls and cybersecurity requirements.
- Establishes a design order of precedence for both foreign projects and projects in the United States.

Impact:

- This revision will have minimal impacts on design cost.

Unification Issues: This UFC includes Navy only requirements for overseas drinking water requirements in accordance with CNICINST 5090.1A. This UFC also includes Navy only requirements for airfield lighting and marking requirements for water towers and other similar structures in NAVAIR 51-50AAA-2.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This Unified Facilities Criteria (UFC) provides requirements for typical storage, distribution systems for domestic water, fire protection and non-potable water for the Department of Defense (DoD). These minimum technical requirements are based on UFC 1-200-01. Where other statutory or regulatory requirements are referenced in the contract, the more stringent requirement must be met.

1-2 APPLICABILITY.

This UFC applies to service elements and contractors involved in the planning, design and construction of permanent DoD facilities worldwide. It is applicable to all methods of project delivery and levels of construction.

1-3 OTHER CRITERIA.

1-3.1 General Building Requirements.

Comply with UFC 1-200-01, DoD Building Code (General Building Requirements). 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, physical security, cybersecurity, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFC and government criteria referenced therein.

1-3.2 Foreign Countries.

DoD 4715.05-G, Overseas Environmental Baseline Guidance Document \1\(OEBGD)/1/ applies when there are no FGSs in place. Therefore, in foreign countries this UFC will be used for DoD projects to the extent that it is allowed by and does not conflict with the applicable international agreements and the applicable FGS or OEBGD.

1-3.3 Safety.

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

The Designer of Record (DoR) must follow the concepts from ASSE Z590.3. By applying the concepts in ASSE Z590.3 occupational hazards and risks related to work premises, tools, equipment, machinery, substances, and work processes including their construction, use, maintenance, and ultimate disposal or reuse can be reduced. 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.

1-3.4 Antiterrorism and Security.

Security must be an integral part of drinking water system design. Facility layout must consider critical system assets and the physical security of these assets. Planners, engineers, security and antiterrorism personnel must determine site specific threats to develop the antiterrorism and security protective measures for water storage and distribution systems. Use UFC 4-020-01 to establish protective measures for water storage and distribution systems. The engineering risk analysis, conducted as part of UFC 4-020-01, should be consistent with the terrorism risk analysis conducted by installation security or antiterrorism staff.

Refer to Best Practice documents, *Policy Statement On Infrastructure Security for Public Water Supplies*, found in the Policy Statements section of *Recommended Standards for Water Works* and ASCE 56-10/57-10, for guidelines on the protection of water utility systems.

1-3.5 Cybersecurity.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

Cybersecurity is implemented to mitigate vulnerabilities to all DoD real property facility-related control systems to a level that is acceptable to the System Owner and Authorizing Official. UFC 4-010-06 provides requirements for integrating cybersecurity into the design and construction of control systems.

1-3.6 Plumbing.

UFC 3-420-01 is a Core UFC which cites the use of the International Plumbing Code (IPC). Where the requirements in this UFC or UFGS 33 11 00 conflict with exterior plumbing components in the IPC use the requirements in this UFC or UFGS 33 11 00. Where the IPC will be used to provide the minimum requirement, the DoR must submit a list of the conflicts and proposed solution to the Government Project Manager for review and approval prior to completing design.

1-4 REFERENCES.

Appendix A 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.

1-5 BEST PRACTICES.

Appendix B identifies background information and practices for accomplishing certain water supply design and engineering services. The DoR is expected to review and interpret this guidance as it conforms to criteria and contract requirements, and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from the Unified Facilities Guide Specifications (UFGS) or UFC, the UFGS and the UFC must prevail. If a Best Practices document has guidelines or requirements that are not discussed in the Unified Facilities Guide specification (UFGS) or UFC, the DoR must submit a list of the guidelines or requirements being used for the project with sufficient documentation to the Government Project Manager for review and approval prior to completing design.

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CHAPTER 2 GENERAL DESIGN REQUIREMENTS

2-1 DESIGN.

Use UFC 3-201-01 for topics such as surveying, site development, grading and storm drainage systems.

2-1.1 Design Criteria.

Design water supply systems to meet the potable water regulations and requirements of applicable federal, state and local government agencies or overseas equivalent.

2-1.1.1 Within The United States.

For projects located in the United States and its territories and possessions design the water supply system in accordance with the following criteria precedence:

1. State waterworks regulations or local regulations for the project location.
2. Utility provider’s \1\requirements/1/.
3. *Recommended Standards for Water Works* (also known as the Ten State Standards) as noted herein.
4. Energy and sustainability: Use UFC 1 200-02.
5. Exceptions or additions to the above criteria as indicated in this UFC.
6. Refer to references in Appendix B for design guidance.

2-1.1.2 Foreign Countries.

For projects located outside of the United States and its territories and possessions design the water supply system in accordance with the following criteria precedence:

1. The Forward of this UFC (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.)).
2. Final Governing Standards.
3. "DoD 4715.05-G, Overseas Environmental Baseline Guidance Document.
4. Navy Only: CNICINST 5090.1A.
5. Utility provider’s requirements.
6. Recommended Standards for Water Works, (also known as the Ten State Standards) as noted herein.

7. Energy and sustainability: Use UFC 1 200-02.

8. Exceptions or additions to the above criteria as indicated in this UFC.

9. Refer to references in Appendix B for design guidance.

2-1.2 Design Approval.

The DoR must identify, assist, and provide, as applicable, all permits, approvals, and fees required for the design and construction of the new project from Federal, state and local regulatory authorities or overseas equivalent. The Civil Engineering DoR must be a Professional Civil Engineer experienced and licensed. Licensure in the location of the project may be required to obtain permits and approvals. For new potable water supply systems, extensions to new areas, rehabilitation, or replacement of existing potable water supply systems, coordinate with the Safe Drinking Water Act primacy agency, as applicable, to determine primacy agency requirements. In the United States and its territories and possessions the Government will review permits for acceptability. In locations outside of the United States and its territories and possessions with Host nation agreements, follow permit approval procedure as directed in project scope and by the Government Project Manager. In locations outside of the United States and its territories and possessions without Host nation agreements, the Government will review and approve plans for compliance.

Consult with the Government Project Manager to determine the appropriate signatories for permit applications.

2-1.3 Planning for Non-War Emergencies.

Refer to Best Practices document AWWA M19, for non-war emergencies such as earthquakes, hurricanes, tornadoes, floods and vandalism.

2-2 PRELIMINARY SITE ANALYSIS.

Use UFC 3-201-01 for preliminary site analysis.

2-2.1 New Service Areas.

Utilize Installation's existing utility maps and planning documents to develop new service areas for present and future (minimum 5 year) conditions. Where adequate planning documents are not available, estimate future growth as described in UFC 3-230-03, Chapter titled *System Sources and Flows*.

2-2.2 Existing Conditions.

Use UFC 3-201-01 for geotechnical site investigation, surveying, and topographic surveying.

2-2.2.1 Geotechnical Site Investigation –Soil Corrosivity.

Require geotechnical evaluation for soil corrosivity when existing operating records, visual observations, inspections or testing indicate a need for corrosion control. Provide an evaluation of existing soils at the proposed depths and locations of the water piping in accordance with AWWA M27, Chapter titled *Evaluating the Potential for Corrosion* and provide recommendations on materials and positive corrosion protection systems.

2-3 SYSTEM SOURCES AND FLOWS.

Use UFC 3-230-03, Chapter titled *System Sources and Flows*.

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CHAPTER 3 PUMPING FACILITIES

3-1 GENERAL.

Design pumping facilities in accordance with Chapter 2, paragraph titled *Design Criteria* and use *Recommended Standards for Water Works,* Chapter titled *Pumping Facilities*.

3-2 PUMPING STATIONS.

Pumps, piping and equipment must be protected from the weather. In cold climates pumps and piping must be protected from freezing temperatures. The pump station building must comply with 1-200-01, be constructed of noncombustible materials and meet applicable building standoff distances. Building layouts must be designed to accommodate the installation of new equipment, maintenance and future expansion. Equipment layouts must provide vertical and horizontal clearances for the repair or replacement of equipment without interrupting pump station operation. Provide personnel access and equipment access for maintenance and repair operations. Ensure pumping stations and equipment are easily accessible and not located in an OSHA defined permit required confined space. Provide a minimum of one double leaf door with a width of 6 feet (1.8 m) for maintenance and repair operations. Access points must be lockable and meet Installation security requirements. Use Best Practice document, Pumping Station Design for guidance on designing pump stations.

3-3 PUMPS.

Select pumps to supply varying demands and meet pressure requirements based on a hydraulic analysis. Pumps must be capable of providing the varying demands and minimum pressures for the full range of system flows. Investigate surge potential for all pumps. When investigation indicates the potential for flows or velocities that increase surge potential provide a surge analysis. A surge analysis is required for large pump stations (i.e., flows greater than 3,200 gpm (202 L/s).

3-3.1 Redundancy.

Provide a minimum of two pumps at each pump station.

3-3.2 Pumps With Elevated Storage.

Pumps for water storage are selected to meet the average day demand, maximum day demand and maximum day demand plus partial fire flow demand (i.e., fire flow demand not delivered by storage) as need to equalize system pressures. Pumping capacity must be able to discharge the peak flow with the largest pump out of service.

3-3.3 Pumps Without Storage.

Pumps are selected to meet flow, pressure, and efficiency requirements. Pumps must accommodate the maximum daily demand, the peak hourly rate plus fire flow demand, and the estimated minimum hourly rate. The location and required capacity of a water pumping system must be determined by a hydraulic analysis of the distribution system.

Pumping capacity must be adequate to discharge the peak flow with the largest pump out of service.

3-3.4 Pump Drives.

The factors affecting selection of the type of power used to drive potable water pumps include dependability, availability and economic considerations. Provide emergency power operation, such as a dedicated standby emergency generator or a portable generator, in conformance with applicable regulatory and utility provider requirements.

3-3.5 Motor Capacity.

Motors must be selected with sufficient capacity to drive the pump under service required and to be non-overloading over the entire impeller curve without motor overload or failure. Provide motors in accordance with NEMA MG1 and NEMA MG2.

3-4 APPURTENANCES.

3-4.1 Controls.

Remote monitoring and control systems must meet the Installation's Information Technology security requirements and standards and UFC 4-010-06.

3-5 FIRE PUMPS.

Use UFC 3-600-01 paragraph titled *Fire Pumps*.

CHAPTER 4 FINISHED WATER STORAGE

4-1 GENERAL.

Design finished water storage in accordance with Chapter 2, paragraph titled *Design Criteria* and use *Recommended Standards for Water Works,* Chapter titled *Finished Water Storage*.

4-1.1 Water Storage.

Water storage serves the following objectives:

- to allow a balanced flow through pipelines and serve as a buffer between the source and the treatment plant or distribution system.
- to supply water during peak demand periods.
- to maintain pressure in the distribution system.
- to minimize interruptions of supply water due to power outages, repair of pumps, failures of mains, pumps, or other plant or well equipment.
- to provide an emergency supply for fire protection.
- Provide water storage when:
- it will serve as a secondary source for distribution systems having a single source.
- the distribution system cannot provide the design flow as indicated in UFC 3-230-03, Section titled *Design Flow*; except where upgrades to the distribution system are feasible and capable of providing the design capacity.

Where design flow and system pressure can be maintained for all demands except fire demand, refer to UFC 3-600-01 for water storage requirements.

4-1.2 Sizing.

Water storage volume must be adequate to meet required operational, fire and emergency demands. At a minimum, the volume of water storage required is the sum of fifty percent of the average total daily domestic requirements, plus any industrial demand that cannot be reduced during a fire period, and the required fire demand.

Compute fire demand in accordance with UFC 3-600-01.

4-1.3 System Storage.

Calculate water storage capacities based on the full operating levels of the water storage structure as measured to highest design water elevation of the system. The highest design water elevation of the system may not necessarily equal the effective volume available to the water system. Effective storage volume is equal to the total volume less any dead storage built into the system. For example, part of the system’s capacity is typically designed as dead storage. Below this water surface elevation, the pressure delivered to the water distribution system falls below minimum pressure requirements. If a water system's source cannot deliver a design flow rate above a certain water surface elevation within the tank, this upper volume of the tank is considered unavailable to the water system and is not a part of the water storage volume.

Additional guidance to water storage may be found in Best Practices documents, AWWA *OPFLOW* and *Hydraulic Design of Water Distribution Storage Tanks*. These alternative approaches may be used if the water storage provided is greater than the minimum storage requirement. The storage required may be adjusted in accordance with UFC 3-600-01, Section titled *Facility On-Site Water Storage*.

4-1.4 Location of Reservoirs.

During the planning and preliminary design process determine the optimum location and type of storage. Use a hydraulic analysis to assist in determining the best type of storage reservoir and location for each system to ensure flow, pressure and water quality. Locate storage tanks to allow space for the types of vehicles and equipment required to operate and maintain the system.

Design of structures must be in accordance with UFC-3-220-01 and UFC 3-301-01.

4-1.4.1 Underground Storage Tanks.

Use elevated or above ground tanks before considering underground storage tanks. Underground storage tanks are the least preferred design option because of the high cost and limited technical advantages. Consider using underground storage tanks when:

- Elevated storage or above ground storage are impracticable.
- Where economy of construction result, such as, when architectural considerations make an aboveground tank very costly.
- Where protection against freezing is required.
- Where the area above the underground tank is to be utilized (e.g., a pedestrian plaza or park area).
- Where the hydraulic grade at a tank site requires the tank to be below grade.
- Where protection against sabotage and destruction warrant concealment.

4-1.5 Construction Materials.

Use materials for water storage structures that protect the quality of the stored water. For potable water storage select materials in accordance with Unified Facilities Guide Specifications, AWWA Standards and NSF 61 or the host nation standard.

4-1.5.1 Concrete Tanks.

Provide concrete water tanks in accordance with AWWA D110, or AWWA D115.

4-1.5.2 Steel Tanks.

Provide steel tanks in accordance with AWWA D100 or AWWA D103.

4-1.5.3 Composite Tanks.

Provide elevated composite tanks in accordance with AWWA D107.

4-1.6 Freezing.

Equipment used for freeze protection that will come into contact with the potable water must meet NSF 61 or the host nation standard.

4-1.7 Painting and Cathodic Protection.

Use paint systems that meet NSF 61 or the host nation standard.

4-1.7.1 Interior Coatings.

Use AWWA D102 and AWWA M42 as applicable. Consult with local and state Health Departments or Host nation for lists of approved interior coating systems. Interior coating systems must comply with NSF 61 or the host nation standard. Use Best Practices document *Coatings for Potable Water Tank Interiors* by the Steel Structures Painting Council for design guidance.

4-1.7.2 Exterior Coatings.

Use AWWA D102, AWWA D103, AWWA M27 Chapter titled *Corrosion Control of Water Storage Tanks* and AWWA M42 as applicable.

4-1.7.3 Cathodic Protection.

Provide cathodic protection for all steel tanks and tanks containing structural steel components. \1\Use UFC 3-570-10 and AWWA D106 for a sacrificial anode cathodic protection systems. Use UFC 3-570-10 and AWWA D104 for an impressed current systems./1/

4-1.8 Disinfection.

Use AWWA C652 for disinfection requirements.

4-2 DISTRIBUTION SYSTEM STORAGE.

Remote monitoring and control systems must meet the Installation's Information Technology security requirements and standards.

Instrumentation and control in foreign countries may have unique requirements. Coordinate with the Installation's utility personnel to identify unique Installation practices or control requirements.

4-2.1 Drainage.

Design tank drainage area to minimize soil erosion when draining the tank for operations or maintenance.

4-2.2 Level Controls.

Provide instrumentation to monitor and control water storage volumes in the water system. Sequence pump operation (start and stop) controls to minimize water hammer. Use altitude valves or equivalent level controls to control water levels. Pump controls must be automated and turned on and off in response to signals corresponding to pressure or water levels in storage tanks. Use high and low level sensing switches corresponding to water levels in storage tanks for pump controls and alarm status monitoring. Select a level control system which allows pumps to accomplish the hydraulic requirements of the system but does not include additional control features that are not necessary for operation and monitoring.

Control and monitoring systems must have the capability to provide the range of flow rates, pressures and liquid levels. Select a control and monitoring system that will provide protection from pump and piping system damage and to serve as a tool to find system problems which may need operational adjustment, repair or maintenance.

4-2.2.1 Remote Monitoring.

Provide remote monitoring equipment for pump alarm conditions. Remote monitoring equipment must be able to relay power failure, pump failure (seal failure and start failure), and generator start failure at minimum. Remote monitoring equipment must transmit storage levels and alarms to a location where qualified personnel are available for surveillance on a 24-hour basis. A paging system may be used in locations where no 24-hour manning location exists.

4-2.2.2 Alarms.

Alarms must include high level, low level, and pump malfunctions. Provide for remote monitoring, such as telemetry, in conformance with applicable regulatory and utility provider requirements. If required, provide off site operation capability from a central location.

4-3 AIRFIELD REQUIREMENTS.

Comply with 14 CFR Part 77.

4-3.1 Airfield Notification.

Provide Federal Aviation Administration (FAA) notification in accordance with 14 CFR Part 77.9.

14 CFR Part 77.9 (February 1, 2018) provides the following notification requirements:

> If requested by the FAA, or if you propose any of the following types of construction or alteration, you must file notice with the FAA of:
>
> a) Any construction or alteration exceeding 200 feet above ground level at its site.
>
> b) Any construction or alteration that exceeds an imaginary surface extending outward and upward at any of the following slopes:
>
> (1) 100 to 1 for a horizontal distance of 20,000 ft. from the nearest point of the nearest runway of each airport described in 14 CFR 77.9 paragraph (d) of this section with its longest runway more than 3,200 ft. in actual length, excluding heliports.
>
> (2) 50 to 1 for a horizontal distance of 10,000 ft. from the nearest point of the nearest runway of each airport described in 14 CFR 77.9 paragraph (d) of this section with its longest runway no more than 3,200 ft. in actual length, excluding heliports.
>
> (3) 25 to 1 for a horizontal distance of 5,000 ft. from the nearest point of the nearest landing and takeoff area of each heliport described in paragraph (d) of this section.
>
> c) Any highway, railroad, or other traverse way for mobile objects, of a height which, if adjusted upward 17 feet for an Interstate Highway that is part of the National System of Military and Interstate Highways where overcrossings are designed for a minimum of 17 feet vertical distance, 15 feet for any other public roadway, 10 feet or the height of the highest mobile object that would normally traverse the road, whichever is greater, for a private road, 23 feet for a railroad, and for a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it, would exceed a standard of paragraph (a) or (b) of this section.
>
> d) Any construction or alteration on any of the following airports and heliports:

(1) A public use airport listed in the Airport/Facility Directory, Alaska Supplement, or Pacific Chart Supplement of the U.S. Government Flight Information Publications;

(2) A military airport under construction, or an airport under construction that will be available for public use;

(3) An airport operated by a Federal agency or the DOD.

(4) An airport or heliport with at least one FAA-approved instrument approach procedure.

e) You do not need to file notice for construction or alteration of:

(1) Any object that will be shielded by existing structures of a permanent and substantial nature or by natural terrain or topographic features of equal or greater height, and will be located in the congested area of a city, town, or settlement where the shielded structure will not adversely affect safety in air navigation;

(2) Any air navigation facility, airport visual approach or landing aid, aircraft arresting device, or meteorological device meeting FAA-approved siting criteria or an appropriate military service siting criteria on military airports, the location and height of which are fixed by its functional purpose;

(3) Any construction or alteration for which notice is required by any other FAA regulation.

(4) Any antenna structure of 20 feet or less in height, except one that would increase the height of another antenna structure.

4-3.2 Airfield Criteria Coordination.

4-3.2.1 Siting Coordination.

Coordinate with UFC 3-260-01.

4-3.2.2 Obstruction Lighting.

Coordinate with UFC 3-535-01.

4-3.2.3 Paint Markings.

Coordinate with UFC 3-260-01 for Army and Air Force and NAVAIR 51-50AAA-2 for Navy.

CHAPTER 5 DISTRIBUTION SYSTEM PIPING AND APPURTENANCES

5-1 GENERAL.

Design the distribution system in accordance with Chapter 2, paragraph titled *Design Criteria* and use *Recommended Standards for Water Works,* Chapter titled *Distribution System Piping and Appurtenances*.

5-2 MATERIALS.

Provide materials, equipment, components, manufactured units and appurtenances of the potable water system in accordance with Unified Facilities Guide Specifications and NSF 61 or host nation standard. Any part of the water piping system such as, valves, joining materials, gaskets or appurtenances that comes in contact or has the potential to come in contact with potable water is considered part of the potable water system. Provide components of the non-potable water system in accordance with AWWA standards or host nation standards.

5-2.1 Standards and Materials Selection.

Select materials and use of coatings to preserve high hydraulic efficiency to control tuberculation, slime formation and encrustations. During material and coating selection evaluate control potential, structural strength, field conditions, cost and maintenance requirements.

5-2.1.1 Exposed Pipe.

Exposed pipe may be placed on bridges for crossing streams or ravines, piers or pipe supports for crossing fault lines. Exposed nonmetallic pipe may only be used in climates not subject to freezing. Exposed iron or steel pipe subjected to freezing must be insulated or otherwise protected. Any pipe material subject to ultraviolet degradation must be protected.

5-2.1.2 Polyethylene Pressure Pipe.

Use TN-44 2015, and compute service life for potable water systems based on project conditions.

5-2.1.3 Fusible Pipe.

5-2.1.3.1 Fusible Polyethylene Pressure Pipe.

Use AWWA M55 to calculate safe pull and bending forces.

5-2.1.3.2 Fusible Polyvinyl Chloride Pressure Pipe.

Calculate safe pull and bending forces using a minimum factor of safety of 2.5.

5-3 SYSTEM DESIGN.

The distribution system must be designed to provide the design flow, in accordance with UFC 3-230-03 Section titled *Design Flow* and maintain the minimum system pressure. Estimate future growth as required by UFC 3-240-02, Section titled *Capacity Considerations.* Use AWWA M31 and AWWA M32 in combination with UFC 3-600-01 for system analysis.

5-3.1 Calculations.

Provide calculations indicating the proposed design provides adequate flow and pressure and reduces or eliminates impacts to water quality. Manual calculations are acceptable for small projects that provide water to a single facility and where compliance with AWWA M32 and this UFC can be demonstrated.

5-3.2 Distribution System Pressure.

This maximum working pressure depends on new and existing piping materials and appurtenances. Specify piping materials and appurtenances with a pressure class that exceeds the maximum working pressure of the water distribution system plus surge pressure. The recommended maximum working pressure is 100 psi (689 kPa).

Higher pressures are required for fire sprinkler systems, ship berthing and drydock facilities in accordance with UFC 3-600-01, UFC 4-150-02 and UFC 4-213-12.

5-3.2.1 Without Fire Demand.

For water service connections, design the water distribution system to maintain a minimum pressure of 25 psi (172 kPa) or the minimum pressure required by UFC 3-420-01 for the design flow.

5-3.2.2 With Fire Demand.

Design the water distribution system to maintain a minimum residual pressure of 40 psi (276 kPa) at fire hydrants for the average day demand and 30 psi (207 kPa) during the design flow. Minimum residual pressures at fire hydrants must be at least 20 psi (138 kPa) while supplying fire flow and hose stream demand.

5-3.3 Diameter.

Where water distribution mains provide fire flow, the minimum pipe size is 6 inches (150 mm).

The minimum pipe size for distribution mains is 3 inches (75 mm). A hydraulic analysis and explicit authorization by the Government is required for distribution mains with a pipe size equal to or greater than 3 inches (75 mm) but less than 6 inches (150 mm).

5-3.3.1 Velocity.

Flow velocities should range from 2 to 5 feet per second (0.6 to 1.5 meters per second) in distribution mains for the design flow. The maximum velocity depends on new and existing piping materials and appurtenances. Ensure that the maximum pressure of the piping materials and appurtenances exceeds the maximum pressure of the system, including the potential for surge pressure.

5-3.4 Fire Protection.

Water distribution systems providing water and fire service must be capable of supplying the fire flow specified in UFC 3-600-01 plus any other demand that cannot be reduced during the fire period at the required residual pressure for the required duration. Analysis will determine whether the capacity of the system is fixed by the domestic, industrial, or fire demands, or some combination of the three demands. Compute fire demand in accordance with UFC 3-600-01.

Higher fire flow and pressure demands are required for aircraft hangers, storage facilities, unprotected facilities (buildings without fire sprinkler systems), and other high risk DoD facilities in accordance with UFC 3-600-01. Where it is determined that the utility water distribution systems are not capable of supporting the required fire flow, provide a cost benefit analysis. This analysis must compare design options, such as upgrades to the water distribution system or a separate fire water storage system to supply fire demand, and indicate the most cost effective solution. Consult with the project fire protection and consider appropriate design options.

5-3.5 System Layout.

The configuration of the water system is primarily determined by location of water demands, street patterns, location of water treatment facilities, water storage facilities and topography. Provide a pipe network with flow from two or more water sources and locate distribution piping to minimize connection costs. Reduce head loss and thrust restraint requirements by minimizing changes in direction and the number of bends. Do not connect fire hydrants to water mains not designed to carry fire flows (e.g., mains less than six inches). New underground pipelines must be at least 10 feet (3.05 m) from facility or building foundations, except for building service connections.

When flow demands or pressure requirements require upgrading segments of the distribution system, it is preferable that new pipelines parallel to existing pipelines be sized for the total capacity so that the existing pipeline may be properly abandoned.

5-3.5.1 Branch or Dead End Pattern.

The branch or dead end pattern evolves when distribution mains are extended along streets as the service area expands. Avoid dead ends and stagnant areas in the distribution system to the greatest extent possible. Where dead ends are unavoidable provide a fire hydrant or blow off assembly for flushing.

5-3.5.2 Grid or Loop Pattern.

The grid or loop pattern has the hydraulic advantage of delivering water to any location from more than one direction, thereby avoiding dead ends.

5-3.6 Capacity.

Estimate future growth as required by UFC 3-240-02, Section titled *Design Population.* Refer to UFC 3-230-03, Chapter titled *System Sources and Flows* for additional criteria.

Evaluate effect of long detention time on decay of chlorine residual in accordance with latest EPA guidance.

5-3.7 Surge Analysis and Control.

Use the rules of thumb in AWWA M32 Chapter titled *Transient Analysis* to identify vulnerable systems and determine when a surge analysis may be required. Once a surge protection device or method is selected, complete an additional analysis to verify the adequacy of the proposed surge protection solution. Surges may be prevented by using water line appurtenances like shutoff valves, pressure relief valves, vacuum relief valves, check valves on pump discharge lines, and surge tanks. Provide appropriate devices to dampen or eliminate surge pressure.

5-3.8 Corrosion.

5-3.8.1 External Corrosion.

For corrosive soils, select materials, coatings, or cathodic protection systems to protect from external corrosion. Use AWWA M27; however, explicit approval by the Government is required prior to providing a cathodic protection system on a buried pipeline.

5-3.8.2 Internal Corrosion.

Use AWWA M58.

5-4 VALVES.

Refer to Appendix B for a general discussion of valves and their uses.

5-4.1 Shutoff Valves.

Provide shutoff valves capable of isolating the pipe network during a single point failure in the distribution system to maintain fire flows and domestic demands. Shutoff valves must be installed at reasonable locations to allow isolation of any particular section during repair and testing. The spacing between shutoff valves must not exceed 5,000 feet (1,524 m) on long lines and 1,500 feet (457 m) on loops.

5-4.2 Blowoff Valves.

Provide a blowoff or fire hydrant at each depression in the distribution system for draining the pipe. The minimum size of blowoff valve must be 2 inches (50 mm) for every 1 foot (300 mm) of diameter of pipeline size. Ensure that the blowoff does not drain into the vault in which it is placed.

5-5 FIRE HYDRANTS.

Comply with the requirements of UFC 3-600-01, Section titled *Hydrants*.

5-6 AIR RELIEF VALVES.

5-6.1 Air-Valves: Air-Release, Air/Vacuum and Combination.

Use AWWA M51 for the design and selection of air-valves. Provide air-valves as required based on an analysis of the system. For flexible pipe, which might collapse under a vacuum, place vacuum release valves based on the analysis of the system, recommendations of the pipe manufacturer and adjacent to each shutoff valve on the uphill side.

5-7 INSTALLATION OF WATER MAINS.

5-7.1 Minimum Cover.

Minimum cover over pipes must be the most stringent of the following requirements:

a) Minimum required by the applicable AWWA Standard,

b) a minimum of 2.5 feet (750 mm),

c) greater than frost penetration according to UFC 3-301-01,

d) sufficient to support imposed dead and live loads for the pipe materials used.

Evaluate temporary conditions during construction and final conditions. Provide calculations for minimum cover.

5-7.2 Minimum Trench Width.

Provide a minimum trench width of 18 inches (450 mm) or the outside pipe diameter plus 12 inches (300 mm), whichever is greater.

5-7.3 Separation from Other Utilities.

Provide adequate horizontal and vertical separation between water pipelines and other utilities (e.g., electrical, telecommunications, natural gas) for installation, maintenance, and repair or replacement of utilities. The trench width may vary based on the soils encountered and depth. At a minimum, maintain the minimum trench width and bedding depth for the adjacent utilities. Based on site constraints and soil conditions, additional separation may be required to allow the replacement of one utility without impacting the adjacent utility.

5-7.3.1 Separation for Thrust Blocking.

Additional separation is required to ensure thrust blocking is not compromised. Use the following equation to compute length of separation.

$$L = D\tan(45^\circ + \frac{\emptyset}{2})$$

L = separation length

D = depth of cover

∅= Frictional angle of soil

5-7.4 Thrust Restraint.

Use thrust blocks for thrust restraint before considering the use of restrained joints. Use DIPRA for design procedures. Provide calculations for thrust restraint using a minimum safety factor of 1.5. Use the geotechnical investigation report and consult with the Geotechnical Engineer to determine soil bearing capacity.

5-7.4.1 Connections to Existing Pipe.

Use thrust blocks when connecting to existing pipe. Where thrust blocking does not provide the required thrust restraint, require supplemental thrust restraint. Supplemental thrust restraint may include a combination of thrust blocks and restrained joints for the existing pipe. It may be necessary to expose the existing pipe to install the supplemental restrained joints.

5-7.4.2 Fusible Pipe.

Additional restraint may be necessary on fusible pipe at the connection to appurtenances or transitions to different pipe materials. Provide joint restraint as recommended by the fusible pipe manufacturer.

5-7.5 Testing.

Refer to AWWA C600 series for testing requirements for each type of pipe material. Require water mains and water service lines providing fire service or water and fire service to be pressure tested in accordance with NFPA 24.

5-7.6 Disinfection.

For disinfection testing requirements refer to AWWA Standard C651, *Disinfecting Water Mains*.

5-8 SEPARATION DISTANCES FROM CONTAMINATION SOURCES.

5-8.1 Parallel Installation.

Provide a horizontal separation distance of 10 feet (3 m) between water pipelines and new or existing gravity sanitary, storm sewer, septic tank, or subsoil treatment system. Measure the separation distance from the closest sides of the two pipes, outside edge to outside edge.

5-8.1.1 Normal Condition.

If site conditions do not allow minimum separation distances, both pipelines should be built in casing pipes of AWWA approved pressure rated pipe material designed to withstand a minimum static pressure of 150 psi (1,034 kPa).

5-8.1.2 Unusual Condition.

When local conditions prevent a horizontal separation of 10 feet (3 m) horizontally, the water pipeline must have a vertical separation of at least 18 inches (450 mm) above the new or existing gravity sanitary, or storm sewer. When local conditions prevent a vertical separation distance of 18 inches (450 mm), construct the sanitary piping of AWWA approved pressure rated pipe material designed to withstand a minimum static pressure of 150 psi (1,034 kPa).

5-8.2 Crossings.

Measure the separation distance from the bottom of the top pipe to the top of the bottom pipe, outside edge to outside edge.

5-8.2.1 Normal Condition.

Provide a vertical separation distance of 18 inches (450 mm) between the water pipeline and the new or existing gravity sanitary, or storm sewer. The water pipeline may be located either above or below the new or existing gravity sanitary, or storm sewer. Locate the water pipeline above the sanitary sewer piping when possible.

5-8.2.2 Unusual Condition.

When local conditions prevent a vertical separation distance of 18 inches (450 mm), construct the new or existing gravity sanitary, or storm sewer of AWWA approved pressure rated pipe material designed to withstand a minimum static pressure of 150 psi (1,034 kPa). Center the pressure rated pipe so that joints are 10 feet (3 m) from the crossing.

5-9 CROSS-CONNECTIONS AND INTERCONNECTIONS.

5-9.1 Backflow Prevention and Cross Connection Control.

Use AWWA M14 for backflow prevention principles. Comply with the requirements of UFC 3-420-01. Comply with the requirements of UFC 3-600-01 for fire protection systems. Use AWWA C510 for double check valves and AWWA C511 for reduced-pressure principle backflow prevention.

5-10 WATER SERVICES AND PLUMBING.

Use AWWA M22 to size water service lines. Refer to AWWA C800 for underground service connection materials with a diameter of 2 inches (50 mm) or less. Use water distribution materials for services with a diameter greater than 2 inches (50 mm).

5-10.1 Fire Service.

Where the service lateral provides fire service or water and fire service use UFC 3-600-01. UFC 3-600-01 requires flow from two or more directions in the distribution system unless otherwise directed by the Government Civil Engineer or UFC 3-600-01, Chapter titled *Fire Protection Systems*.

5-10.2 Boosters.

Use UFC 3-420-01 for water service boosting systems and pumps.

5-10.3 Water Service Meters.

Use AWWA M6 and AWWA M22 for water meter selection and sizing. Locate meters after the fire service connection so that only non-fire building flows are metered. Meters are typically located near the curb line. Locate meters in grass areas to avoid exposure to vehicular traffic where feasible. In some cases, a meter may be located inside of a building. Locate meters no greater than 4 feet above the floor when inside a building. All meters must be easily accessible for manual reading, maintenance and repair.

5-10.3.1 Advanced Metering Infrastructure.

Comply with UFC 1-200-02 for advanced water meter requirements. Provide water meters compatible with the Installation’s advanced metering infrastructure (AMI) systems. Connect the water meter signal to the AMI network. Coordinate advanced metering with UFC 3-520-01.

5-10.3.2 Remote Reading Systems.

Provide metering systems that are compatible with the Installation’s remote water meter reading systems.

5-10.4 Sub-meters.

Sub-meters must conform to the same requirements as water service meters when used to comply with UFC 1-200-02.

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APPENDIX A REFERENCES

AMERICAN SOCIETY OF SAFETY PROFESSIONALS

http://www.assp.org/

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

AMERICAN WATER WORKS ASSOCIATION

http://www.awwa.org

AWWA M6, *Water Meters - Selection, Installation, Testing, and Maintenance*

AWWA M14, *Backflow Prevention and Cross-Connection Control Recommended Practices*

AWWA M19, *Emergency Planning for Water Utilities*

AWWA M22, *Sizing Water Service Lines and Meters*

AWWA M27, *External Corrosion Control for Infrastructure Sustainability*

AWWA M31, *Distribution Systems Requirements for Fire Protection*

AWWA M32, *Computer Modeling of Water Distribution Systems*

AWWA M42, *Steel Water Storage Tanks*

AWWA M51, *Air-Valves: Air-Release, Air/Vacuum and Combination*

AWWA M55, *PE Pipe - Design and Installation*

AWWA M58, *Internal Corrosion Control of Water Distribution Systems*

AWWA C510, *Double Check-Valve Backflow Prevention Assembly*

AWWA C511, *Reduced-Pressure Principle Backflow Prevention Assembly*

AWWA C651, *Disinfecting Water Mains*

AWWA C652*, Disinfection of Water-Storage Facilities*

AWWA C800, *Underground Service Line Valves and Fittings*

AWWA D100, *Welded Carbon Steel Tanks for Water Storage*

AWWA D102, *Coating Steel Water-Storage Tanks*

AWWA D103, *Factory-Coated Bolted Carbon Steel Tanks for Water Storage*

AWWA D104, *Automatically Controlled, Impressed Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Tanks*

AWWA D106, *Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks*

AWWA D107, *Composite Elevated Tanks for Water Storage*

AWWA D110, *Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks*

AWWA D115, *Circular Prestressed Concrete Water Tanks*

COMMANDER, NAVY INSTALLATIONS COMMAND (NAVY ONLY)

https://cnic.navy.mil/about/cnic-instructions.html

CNICINST 5090.1A, CNIC Instruction 5090.1A, Navy Overseas Drinking Water Program Ashore

DEPARTMENT OF DEFENSE (DOD)

DoD 4715.05-G, *Overseas Environmental Baseline Guidance Document, http://www.dtic.mil/whs/directives/corres/pdf/471505g.pdf*

DoDI 6055.01, *DoD Safety and Occupational Health (SOH) Program, http://www.dtic.mil/whs/directives/corres/pdf/605501p.pdf*

DEPARTMENT OF DEFENSE (DOD), 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 3-201-01, *Civil Engineering*

UFC 3-230-03, *Water Treatment*

UFC 3-220-01, *Geotechnical Engineering*

UFC 3-260-01, *Airfield and Heliport Planning and Design*

UFC 3-301-01, Structural Engineering

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

UFC 3-420-01, Plumbing Systems

UFC 3-520-01, *Interior Electrical Systems*

UFC 3-535-01, *Visual Air Navigation Facilities*

UFC 3-570-01*, Cathodic Protection*

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

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

UFC 4-150-02, *Dockside Utilities for Ship Service*

UFC 4-213-12, *Drydocking Facilities Characteristics*

DEPARTMENT OF DEFENSE (DOD), UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)

http://dod.wbdg.org/

UFGS 33 11 00, *Water Utility Distribution Piping*

EXECUTIVE ORDER

Executive Order *13693, Planning for Federal Sustainability in the Next Decade, March 19, 2015*

GREAT LAKES – UPPER MISSISSIPPI RIVER BOARD OF STATE AND PROVINCIAL PUBLIC HEALTH AND ENVIRONMENTAL MANAGERS

http://10statesstandards.com/

Recommended Standards for Water Works, Policies for the Review and Approval of Plans and Specifications for Public Water Supplies, A Report of the Water Supply Committee of the Great Lakes--Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers

INTERNATIONAL CODE COUNCIL

http://www.iccsafe.org

IPC, International Plumbing Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

http://www.nema.org

NEMA MG1, *Motors and Generators*

NEMA MG2, Safety Standard and Guide for Selection, Installation, and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION

http://www.nfpa.org

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*

NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NAVAL AIR SYSTEMS COMMAND

NAVAIR 51-50AAA-2, *General Requirements for Shorebased Airfield Marking and Lighting*

NSF INTERNATIONAL

http://www.nsf.org

NSF 61, *Drinking Water System Components – Health Effects*

PLASTIC PIPE INSTITUTE

http://plasticpipe.org

TN-44 2015, *Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants*

APPENDIX B BEST PRACTICES

Appendix B identifies background information and practices for accomplishing certain water supply design and engineering services. The Civil Engineering Designer of Record (DoR) is expected to review and interpret this guidance and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from the UFGS or Unified Facilities Criteria, the UFGS and the UFC must prevail. If a Best Practices document has guidelines or requirements that are not discussed in the Unified Facilities Guide specification (UFGS) or UFC, the DoR must submit a list of the guidelines or requirements being used for the project with sufficient documentation to the Government Project Manager for review and approval prior to completing design.

B-1 WHOLE BUILDING DESIGN GUIDE.

The Whole Building Design Guide provides additional information and discussion on practice and facility design, including a holistic approach to integrated design of facilities.

The WBDG provides access to all Construction Criteria Base (CCB) criteria, standards and codes for the DoD Military Departments, National Aeronautics and Space Administration (NASA), and others. These include, Unified Facilities Criteria (UFC), Unified Facilities Guide Specifications (UFGS), Performance Technical Specifications (PTS), design manuals, and specifications. For approved Government employees, it also provides access to non-government standards.

B-2 WATER AUDITS AND LEAK LOSS CONTROL.

The loss of treated water can be a substantial economic loss to any water distribution system. Practice water audits and leak loss control following AWWA M36.

B-3 PUMPING FACILITIES.

B-3.1 Planning.

Pumping may be required to move stored water through the piping system to the customers. Planning factors include: availability of electric power, roadway access for maintenance and operation purposes, security and adverse impact to surrounding facilities. Refer to Table B-1 for additional planning factors.

B-3.1.1 Pumps.

The location of a pump station and intake structure, and the anticipated heads and capacities are the major factors in the selection of pumps. The function of a pump station in the overall distribution system operation can also affect the determination of capacities. Consider pump operating costs during pump selection.

Use Hydraulic Institute pump standards for guidelines on pump selection. Basic pump hydraulic terms, formulas, pump fundamentals, applications, instructions for installation, and operation and maintenance are given in the Hydraulic Institute pump standards.

Table B-1 Pumping Installation Planning

Category	Detailed Data and Information
Purpose of Service	Transmission of water from water source. Pumping in the distribution system. Pumping to elevated storage tank. Pumping for fire protection. Booster pumping. Pumping service at treatment plant. Other miscellaneous pumping.
Piping Layout	Length, sizes, fittings.
Demand Requirements	Maximum day demand: mgd or gpm. Average day demand: mgd or gpm. Minimum day demand: mgd or gpm. Peak hourly demand: gpm Variation in demand. Effect of storage on demand rates.
Static Lift Requirements	Static suction head or lift
Liquid Characteristics	Static discharge heads Specific gravity Temperature Vapor pressure Viscosity pH Chemical characteristics Solids content
Power Available	Type Characteristics

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B-3.1.1.1 Pump Drives.

Refer to Table B-2 for preferential choice and applications of various pump drive power systems.

B-3.1.1.2 Valves.

Valves used in pump station systems may include: gate valves, globe and angle valves, cone valves, butterfly valves, ball valves, check valves and relief valves.

B-3.1.2 Pump Station Layout.

Refer to Table B-3 for limitations of pumping arrangements.

Table B-2 Preferential Choice and Application of Pump Drive

Power	Choice	Drive	Application
Electricity	First	AC Motors	Primary power in stationary pumping
Diesel Oil	First	Internal combustion engines	In isolated area for stationary pumping. As emergency standby power source. Portable pumping source.
Natural Gas	Second	Gas turbine or internal combustion engine	In isolated area for stationary pumping. As emergency standby power source.
Air Compressor driven by motors or internal combustion engine	Second	Compressed air	At small installations for airlift pumps and for other pneumatic pumps.

Table B-3 Limitations of Pumping Arrangements

Type of Arrangement	Where to Use	Limitations
Bypassing the discharge (all or part)	Not used for normal operation in a large installation, but during emergency when other arrangements are inoperative	Waste of power
Multiple pumps operating in parallel	Use this arrangement as a normal installation	Requires multiple pumps, and possibly jockey pump to pressurize system at low demands
Intermittent pumping with elevated water storage	Use in areas where water pressure decreases due to either long runs or increases in elevation	May increase water pressure or require different pressure zones in areas with high water pressure or decreases in elevation
Intermittent pumping with ground water storage	Use when additional flow is required	Uses additional energy to run pumps and maintain water pressure
Manual or automatic speed variation to control pump discharge	Use in complex situations where multiple constant speed pumps would be more expensive.	Manual speed control will require personnel to monitor the system and make adjustments.

B-4 FINISHED WATER STORAGE.

B-4.1 Distribution System Storage.

In medium and large distribution systems, water storage is generally located near centers of heavy demand.

B-4.1.1 Ground Storage Tanks.

Ground storage is typically used to reduce treatment plant peak production rates, assist in supplying the design flow during periods of high usage and as a supplemental supply source for pumping to a higher pressure level. Ground storage for pumping is common in distribution systems covering a large area, because the outlying service areas are beyond the reasonable range of the primary pumping facilities.

Ground storage tanks will likely require the installation of variable speed pumps to meet frequent daily fluctuations in demand and eliminate the potential for water hammer.

B-4.1.2 Elevated Storage Tanks.

Elevated storage may be provided to help supply the design flow during periods of high usage and equalize system pressures. In general, elevated storage is more effective and economical than ground storage because of the reduced pumping requirements and the storage can also serve as a source of emergency supply since system pressure requirements can still be met temporarily when pumps are out of service.

B-4.1.2.1 Composite Tanks.

Elevated composite tanks are known to have lower maintenance costs because of the reduction in steel surfaces. In corrosive environments maintenance costs may be reduced by using composite tanks in lieu of steel tanks. Consider the use of composite tanks where corrosive environments are present, including areas like coastlines where saltwater environments increase corrosion potential.

B-4.2 Underground Storage Tanks.

The use of underground storage tanks should be avoided.

B-4.3 Level Controls.

Factors to be considered in selecting a system include cost, efficiency, reliability, structural requirements, ease of operation and degree of maintenance necessary. The ease of operation and degree of maintenance are critical at military installations where adequate personnel cannot always be provided.

B-4.3.1 Variable Speed Control.

In general, variable speed control devices are more expensive, less efficient, and require a higher degree of maintenance than constant speed controls. However, in some instances, variable speed pumping is the best approach. Consider variable speed drives when conditions are too complex for using multiple constant speed pumps and starting scenarios. Prior to installing variable speed pumps, coordinate with and get approval from the Installation’s utility provider.

B-5 DISTRIBUTION SYSTEM PIPING AND APPURTENANCES.

B-5.1 Materials.

B-5.1.1 Polyethylene Pressure Pipe.

Polyethylene (PE) pipe is subject to oxidative degradation by many variables including pH, the concentration and type of disinfectant, water temperature, installation procedure and conditions. Disinfectants like chlorine, chloramines, chlorine dioxide, ozone and others may create an Oxidation Reduction Potential (ORP) in PE Pipe.

B-5.1.2 Fusible Pipe.

Rapid crack propagation (RCP) can occur in many types of materials. Many variables including pipe damage during construction and air in the water line may cause rapid crack propagation (RCP). When RCP occurs in bell & spigot (B&S) pipe, the length of the failure is limited to the length of the pipe. Once pipes are fused together RCP can pass through the fused joints and may result in lengthy pipe failures. RCP has previously occurred in fusible PVC (fPVC) water piping on rare occasions. Ensuring air release valves are used where air may be trapped and pipe is adequately protected from damage during construction are two ways to help avoid RCP.

B-5.2 Distribution System Pressure.

Areas of excessively high or low pressures may be divided into multiple pressure zones. In some cases, the use of pressure reducing valves may be required to protect specific locations.

B-5.3 Valves.

See Tables B-4, B-5 and B-6 for the application of check valves, shutoff valves and gate valves.

B-5.4 Thrust Restraint.

Online thrust restraint calculators can assist in performing thrust restraint calculations. See EBAA IRON Restraint Length Calculator located at http://rcp.ebaa.com/ or the DIPRA Thrust Restraint Design for Ductile Iron Pipe located at https://www.dipra.org/ductile-iron-pipe-resources/calculators/thrust-restraint-of-ductile-iron-pipe. Consider the bearing surface of the fitting when designing thrust blocks. Compact fittings reduce the bearing surface of the thrust block.

B-5.5 Water Services and Plumbing.

Consider using the buildings internal water supply for building additions.

B-5.6 Meters.

Meters may serve multiple purposes. Billing, monitoring and diagnosing the health of the systems are and important operational functions. Metering data provides system operators with important information, such as where additional flow capacity is needed, where water quality may be a concern, and how the distribution system may be impacted from additional population growth. Properly designed meters that are installed using standard industry settings should find rather cost effective solutions exist for accurate metering. Properly sized meters can accurately measure the ranges of expected flows that it provides service to. Sub-metering can increase operational costs without increases in additional income.

Table B-4 Application of Check Valves

Check Valves	Application	Remarks
Swing Checks	All horizontal applications	Refer to AWWA C508
Ball Checks	On reciprocating pumps	Small diameter
Vertical Checks	All vertical applications	Refer to AWWA C507
Cone Checks	Surge relief	Requires automatic operator
Cushioned Checks	Surge relief	Slow closing
Foot Valves	Prevents loss of prime in suction lines	-
Flap Valves	At pipe outlets	-

Table B-5 Application of Shutoff Valves

Shutoff Valves	Application	Remarks
Gate Valves[a]	All applications	Refer to AWWA C500 and AWWA C509
Butterfly Valves	All applications	Largest size 72 in. Refer to AWWA C504
Plug Valves, Eccentric	All applications	Suitable for water containing solids and for three-way valves
Globe Valves	All applications	Small diameter
Needle Valves	All applications	Small diameter
Hydraulic Needle Valves	Reservoir outlets	Very large size requiring hydraulic operators
Mud Valves	Bottom drain opening of basins	-

[a] Except for low pressure, service gate valves 16 in (400 mm) -20 in (500 mm), and larger should be equipped with bypass. Refer to AWWA C500 and AWWA C509.

Table B-6 Application of Gates

Gates	Application	Remarks
Radial Gates	Channel and reservoir outlets	-
Slide Gates	Channel and reservoir outlets	Low heads
Sluice Gates	Wall openings	Refer to AWWA C560
Shear Gates	Wall openings (low head)	Size up to 24 in. (600 mm)

B-6 BEST PRACTICE REFERENCES.

AMERICAN SOCIETY OF CIVIL ENGINEERS

ASCE 56-10/57-10, Guidelines for the Physical Security of Water Utilities; Guidelines for the Physical Security of Wastewater/Stormwater Utilities

AMERICAN WATER WORKS ASSOCIATION

http://www.awwa.org

AWWA M27, *External Corrosion Control for Infrastructure Sustainability*

AWWA M36, *Water Audits and Loss Control Programs*

AWWA C500, *Metal-Seated Gate Valves for Water Supply Service*

AWWA C504, *Rubber-Seated Butterfly Valves*

AWWA C507, *Ball Valves, 6 in. through 60 in. (150 mm through 1500 mm)*

AWWA C508, *Swing-Check Valves for Waterworks Service, 2-In. through 24-In. (50-mm through 600-mm) NPS*

AWWA C509, *Resilient-Seated Gate Valves for Water Supply Service*

AWWA C560, *Cast-Iron Slide Gates*

AWWA OPFLOW, *Determining Distribution System Storage Needs*

By Murat Ulasir, Robert Czachorski, Vyto Kaunelis, Vol. 31 Issue 9, September 2005

DUCTILE IRON PIPE RESEARCH ASSOCIATION

http://www.dipra.org

DIPRA Thrust Restraint Design for Ductile Iron Pipe

HYDRAULIC INSTITUTE

http://www.pumps.org

Pump Standards

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Pumping Station Design

By Garr M. Jones with Co-Editors Robert L. Sanks, George Tchobanoglous and Bayard Bosserman

STEEL STRUCTURES PAINTING COUNCIL

http://www.sspc.org

Coatings for Potable Water Tank Interiors

Hydraulic Design of Water Distribution Storage Tanks

By Rasheed Ahmad

APPENDIX C GLOSSARY

C-1 ACRONYMS.

AFCEC	Air Force Civil Engineering Center
AT&L	Acquisition, Technology, and Logistics
AWWA	American Water Works Association
B&S	Bell & Spigot
BIA	Bilateral Infrastructure Agreement
CCB	Construction Criteria Base
DDC	Direct Digital Controls
DoD	Department of Defense
DoR	Designer of Record
e.g.	*Exempli Gratia* (one or more possible examples)
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FGS	Final Governing Standards
fPVC	Fusible Polyvinyl Chloride
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreements
i.e.	*Id Est* (clarifies, more precisely)
IPC	International Plumbing Code
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act

OEBGD	Overseas Environmental Baseline Guidance Document
ORP	Oxidation Reduction Potential
OSHA	Occupational Safety and Health Administration
PE	Polyethylene
PVC	Polyvinyl Chloride
SOFA	Status of Forces Agreements
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications
U.S.	United States
WBDG	Whole Building Design Guide

C-2 DEFINITION OF TERMS.

Distribution Mains: All pipelines of the potable water distribution system, except the service lines (e.g., water, fire, irrigation).

Pipe Size: The nominal internal diameter of the pipe.

Surge pressure: The maximum hydraulic transient pressure increase (also known as water hammer) above the anticipated operating pressure in the system as the result of sudden changes in velocity of the water column. Two types of surge pressures are recurring (cyclic) surge pressure and occasional (emergency or transient) surge pressure.

Working pressure: The maximum sustained operating pressure applied to the pipe exclusive of surge pressures.

For additional definitions refer to the definitions given in the applicable standard.