UNIFIED FACILITIES CRITERIA (UFC)

WATER STORAGE, DISTRIBUTION, AND TRANSMISSION

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UNIFIED FACILITIES CRITERIA (UFC)

WATER STORAGE, DISTRIBUTION, AND TRANSMISSION

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

This UFC supersedes UFC 3-230-03A, UFC 3-230-04A, UFC 3-230-07A, UFC 3-230-09A, UFC 3-230-10A, UFC 3-230-11A, UFC 3-230-13A, all dated January 2004, UFC 3-230-19N, dated June 2005 and EM 1110-2-503, dated February 1999.

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 Center for Engineering and the Environment (AFCEE) 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/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

JOSEPH E. GOTT, P.E.
Chief Engineer
Naval Facilities Engineering Command

TERRY G. EDWARDS, P.E.
Director, Air Force Center for Engineering and the Environment
Department of the Air Force

MICHAEL McANDREW
Director, Facilities Investment and Management
Office of the Deputy Under Secretary of Defense (Installations and Environment)

UNIFIED FACILITIES CRITERIA (UFC)
NEW REVISION SUMMARY SHEET

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

Superseding: UFC 3-230-03A, UFC 3-230-04A, UFC 3-230-07A, UFC 3-230-09A, UFC 3-230-10A, UFC 3-230-11A, UFC 3-230-13A, UFC 3-230-19N, and EM 1110-2-503.

Description: This new UFC 3-230-01 consolidates into one Tri-Service document the civil engineering criteria applicable to water supply that were formerly in the superseded documents. This UFC – through succinct reference to industry and government standards, codes and references – makes possible the replacement and/or consolidation of numerous criteria documents.

The complete list of water engineering documents referenced in this UFC can be found in Appendices A and B.

Reasons for Document:

- The new UFC updates the guidance and requirements for water supply contained in several existing engineering documents and efficiently consolidates them into a single UFC.

- The superseded UFC documents included requirements that were not consistent with industry standards or utilized different industry standards.

Impact:

This unification effort will result in the more effective use of DoD funds in the following ways:

- By significantly improving the design process for DoD projects and facilities, through a more efficient application of facilities criteria and enabling more efficient maintenance of facilities criteria.

- The consolidation of the UFC 3-230-01 will positively impact the project costs incurred, as a result of the following direct benefits:

    - Reduction in the number of civil references used for military construction provides more clear and efficient guidance for the design and construction of DoD facilities.

    - Improved clarity and convenience results in reduced time required for execution of project designs.

    - Reduction in ambiguity and the need for interpretation reduces the potential for design and construction conflicts.

    - The reduction in the number of documents and the use of industry standards improves the ease of updating and revising this reference document as better information becomes available.

Non Unified Issues: No major unification issues.

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TABLES

CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This Unified Facilities Criteria (UFC) provides requirements for typical storage, distribution and transmission 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 DoD facilities worldwide. It is applicable to all methods of project delivery and levels of construction, but is not applicable to public-private ventures (PPV).

All design and construction outside of the United States and United States territories is governed by international agreements, such as the Status of Forces Agreements (SOFA), Host Nation-Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA), and country-specific Final Environmental Governing Standards (FGS) or the DoD *Overseas Environmental Baseline Guidance Document,* DoD 4715.05G. The OEBGD 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 OTHER CRITERIA.

1-3.1 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, security, sustainability, low impact development (LID) and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein. Note that UFC 1-200-01 incorporates core UFCs, in particular UFC 3-600-01, *Fire Protection Engineering for Facilities*, which includes applicable criteria to this UFC.

1-3.2 Safety.

All DoD facilities must comply with DODINST 6055.1 and applicable Occupational Safety and Health Administration (OSHA) safety and health standards.

1-3.3 Antiterrorism and Security.

Specific security concerns for water supply systems are addressed in the “Policy Statement on Infrastructure Security for Public Water Supplies” of the *Ten State*

Standards. Use Best Practices document, ASCE/AWWA Draft American National Standard for Trial Use, *Guidelines for the Physical Security of Water Utilities*, for latest guidelines for protection of water utility systems.

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. In general, the latest available issuance of the reference is used.

1-5 BEST PRACTICES.

Appendix B identifies background information and practices for accomplishing certain water supply design and engineering services. The Designer of Record (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.

CHAPTER 2 GENERAL DESIGN REQUIREMENTS

2-1 DESIGN.

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.

Design the water supply system in accordance with the following criteria precedence:

1. State waterworks regulations for the project location;

2. Utility provider's requirements;

3. *Recommended Standards for Water Works*, latest edition, 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 (known hereafter as the "Ten State Standards");

4. Conservation: Consider water and energy conservation alternatives to meet current DoD conservation policy such as the Energy Policy Act of 1992/2006: Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*; and Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*. ASHRAE 90.1 and Federal Energy Management Plan (FEMP) websites have guides for conservation.

Exceptions or additions to the above criteria noted herein. Refer to all applicable standards and the Manuals of Practice (M) prepared by the American Water Works Association (AWWA) for additional design criteria not indicated above, as applicable to the project.

2-1.2 Design Approval.

The Designer of Record must identify and obtain all permits required by federal, state, and local regulatory agencies or overseas equivalent. The Civil Engineering Designer of Record must be a Professional Civil Engineer experienced and licensed; licensure in the location of the project may be required to obtain permits and approvals. Recommend coordination with SDWA primacy agency on any construction and/or modification to public water systems as applicable under primacy agency requirements. In CONUS locations the Government will review and approve plans for new potable water supply systems, extensions to new areas, or rehabilitation/replacement of existing potable water supply systems. In OCONUS locations with Host nation agreements, follow design approval procedure as directed in project scope and by Government Project Manager. In OCONUS locations without Host nation agreements, the Government will review and approve plans for new potable water supply systems, extensions to new areas, or rehabilitation/replacement of existing potable water supply systems.

2-1.3 Planning for Non-War Emergencies.

Refer to Best Practices document AWWA Manual M19, *Emergency Planning for Water Utility Management*, for non-war emergencies such as earthquakes, hurricanes, tornadoes, floods and vandalism.

2-2 EXISTING CONDITIONS.

2-2.1 Field Investigation.

2-2.1.1 Existing and Proposed Service Areas.

Utilize Installation's existing utility maps and proposed planning documents to develop existing and proposed 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 3 entitled "Waterworks Supply Sources and Flows".

2-2.1.2 Topographic Survey.

Provide a topographic survey of project area including locations of existing utilities in accordance with UFC 3-201-01.

2-2.1.3 Soils.

Evaluate geotechnical data on existing soils, including corrosivity, if existing operating records, visual observations, inspections or testing indicate a need for corrosion control. If recommended by the Government Civil or Geotechnical Reviewer, provide an evaluation of existing soils at the proposed depths and locations of the water mains in accordance with AWWA Manual M27, *External Corrosion: Introduction to Chemistry and Control* (Chapter 3 entitled "Evaluating the Potential for Corrosion") and provide recommendations on materials and positive corrosion protection systems.

2-2.1.4 Environmental Considerations.

Contact the Installation's Environmental Reviewer prior to design and evaluate site for environmental concerns and known contamination. Notify Government Project Manager of known environmental contamination to ensure adequate funding in current project.

2-3 WATERWORKS SUPPLY SOURCES AND FLOWS

Refer to UFC 3-230-03, Chapter 3 entitled "Waterworks Supply Sources and Flows".

2-3.1 Fire Flows

Fire system demands must be derived from UFC 3-600-01.

CHAPTER 3 STORAGE

3-1 OBJECTIVES OF STORAGE.

Storage reservoirs serve 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 supply water during power outage or repair of pumps.
- to provide an emergency supply for fire protection.

3-2 STORAGE REQUIREMENTS.

Water storage volume must be adequate to meet required operational, fire and emergency demands. Fire demand must be determined in accordance with UFC 3-600-01 and consider mission critical functions. At 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. Alternative approaches to water storage requirements may be found in Best Practices document, AWWA's *Opflow* article entitled *"Determining Distribution System Storage Needs"*. These alternative approaches may be used if storage is greater than the above minimum storage requirement. The storage required may be adjusted in accordance with UFC 3-600-01, Section entitled "Water for Fire Protection".

3-3 SITE CONSIDERATIONS.

Provide a computer hydraulic analysis to determine the best storage reservoir locations for each system to ensure flow, pressure and water quality. In medium and large distribution systems, storage reservoirs are generally located near centers of heavy demand.

3-4 TYPES OF STORAGE TANKS.

Consider mission critical functions in selection of type of storage tank.

3-4.1 Ground Storage Tanks.

Ground storage can be located remote from the treatment plant and connected to the distribution system. Whether the storage tank is located remotely or locally at the treatment plant must be determined during the design process. Ground storage is used to reduce treatment plant peak production rates and also as a source of supply for pumping to a higher pressure level. Such storage for pumping is common in distribution systems covering a large area, because the outlying service areas are beyond the range of the primary pumping facilities.

3-4.2 Elevated Storage Tanks.

Elevated storage is provided within distribution systems to supply peak demand rates 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.

3-4.3 Underground Storage Tanks.

Consider underground storage tanks when any of the following conditions exist:

- 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 ground is to be utilized otherwise, such as, for 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.

3-5 MATERIALS AND CONSTRUCTION.

Provide tank materials and construction in accordance with the current available AWWA standards as noted below:

3-5.1 Concrete Tanks.

Concrete water tanks must be provided in accordance with AWWA Standard D110, *Wire & Strand Wound, Circular, Prestressed Concrete Water Tanks* or AWWA Standard D115, *Tendon-Prestressed Concrete Water Tanks*.

3-5.2 Steel Tanks.

Structural design, materials and construction for steel tanks must be provided in accordance with AWWA Standard D100, *Welded Carbon Steel Tanks for Water Storage* or AWWA Standard D103, *Factory-Coated Bolted Steel Tanks for Water Storage.*

3-5.3 Underground Tanks.

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

3-5.4 Composite Tanks.

Consider the use of composite tanks where extreme environmental conditions may exist. A composite tank of reinforced concrete supports with a steel containment vessel may be warranted in coastline areas subject to saltwater corrosion.

3-6 PROTECTION.

3-6.1 Cathodic Protection.

An impressed current cathodic protection system must be designed in accordance with AWWA Standard D104, *Automatically Controlled, Impressed Current Cathodic Protection for the Interior of Steel Water Tanks*, and UFC 3-570-02A.

3-6.2 Coating Systems.

3-6.2.1 Interior Coatings.

Use AWWA Standard D102, *Coating Steel Water Storage Tanks.* Consult local and state Health Departments and/or Host nation for lists of approved interior coating systems. Interior coating systems must comply with NSF Standard 61. Use Best Practices document *Coatings for Potable Water Tank Interiors* by the Steel Structures Painting Council for design guidance. Use Best Practices document AWWA Manual M42, *Steel Water Storage Tanks*, for guidance on coating steel tanks.

3-6.2.2 Exterior Coatings.

Use AWWA Standards D102, *Coating Steel Water Storage Tanks*, and D103, *Factory-Coated Bolted Carbon Steel Tanks for Water Storage*. Use Best Practices documents from the Steel Structures Painting Council and AWWA Manual M27, *External Corrosion: Introduction to Chemistry and Control (*Chapter 6 entitled “Corrosion Control of Water Storage Tanks”) for design guidance. Use Best Practices document AWWA Manual M42, *Steel Water Storage Tanks*, for coating steel tanks.

3-7 INSTRUMENTATION AND CONTROL.

Provide a system to monitor and control storage volumes in the water supply and distribution system. Altitude valves or equivalent level controls will be required. High and low level pressure sensitive switches corresponding to water levels in storage tanks may be used for pump controls and alarm status monitoring. Alarms must include high level, low level, and pump malfunctions (see paragraph entitled “*Controls*” for additional criteria). The control system must transmit storage levels/volumes 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.

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. Remote monitoring and control systems must meet the Installation’s IT security requirements and standards.

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CHAPTER 4 DISTRIBUTION SYSTEMS

4-1 DISTRIBUTION SYSTEMS.

4-1.1 Design.

Distribution mains must provide for peak flows and fire demands. When sizing mains design flow must be based on the maximum hourly demand or the maximum daily demand plus the fire flow requirement, whichever is greater. Account for industrial demand. Unless otherwise directed by the Government Project Manager, provide a pipe network, where flow to a single source is available from two (2) or more directions since it is more economical for pipe size determination and provides redundancy. Evaluate pipe networks using computer hydraulic modeling. Base demand projections on not less than 5 years in the future. Where adequate planning documents are not available, estimate future demands as described in UFC 3-230-03, Chapter 3 entitled “Waterworks Supply Sources and Flows”. Refer to Best Practices documents, AWWA Manual M32, *Distribution Network Analysis for Water Utilities* and AWWA Manual M31, *Distribution System Requirements for Fire Protection* for additional guidance.

4-1.2 Pipe Sizes.

In addition to operating within pressure limits noted, select pipe sizes so that flow velocities will range from 2 to 5 feet per second (0.6 to 1.5 meters per second) at maximum daily demand and the largest fire flow requirement. However, many regulatory agencies insist on certain minimum pipe diameters.

At velocities above 5 feet per second (1.5 m/s), particularly in PVC pipe, the design must address surge pressures and conditions.

4-1.3 Fire Flows.

Minimum hydrant flow values and residual pressures must be as directed by the Installation’s Fire Department. Provide calculations indicating that the proposed improvements have adequate flow and pressure without negatively impacting the existing water distribution system.

The water distribution system must be capable of supplying the fire flow specified plus any other demand that cannot be reduced during the fire period at the required residual pressure and for the required duration. Analysis will determine whether the capacity of the system is fixed by the domestic/industrial requirements, by the fire demands, or by a combination of both.

Higher flows are required for fire suppression systems for aircraft hangers and other DoD facilities in accordance with UFC 3-600-01. A separate fire storage and pumping system may also be required. Since separate systems are appropriate only in special circumstances, approval of the Government Civil is required prior to design.

4-1.4 System Pressure.

Minimum ground-level residual pressures at fire hydrants must be at least 40 pounds per square inch (psi) (276 kPa) during normal flow conditions and 30 psi (207 kPa) during hourly maximum demand. Minimum ground-level residual pressures at fire hydrants must be at least 20 psi (138 kPa) while supplying fire flow and hose stream demand. Maximum pressures of 100 psi (689 kPa) can be allowed in small, low-lying areas not subject to high flow rates and surge pressures. Areas of excessively high or low pressures require that the system be divided into multiple pressure levels. In some cases the use of pressure reducing valves may be required to protect specific locations.

Higher pressures are required for ship berthing and drydock facilities in accordance with UFC 4-150-02 and UFC 4-213-12.

4-1.5 Thrust Restraint.

Provide calculations for restrained joints. Use Best Practices document, DIPRA's *Thrust Restraint Design for Ductile Iron Pipe* for guidance..

4-1.6 System Layout.

The configuration of the distribution system is determined primarily by size and location of water demands, street patterns, location of treatment and storage facilities and topography. Two patterns of distribution main system commonly used are the branch/dead end pattern and the grid/loop pattern. Reduce sharp turns and elbows. Reduce mechanical stresses such as water hammer. Avoid uneven heat distribution. Avoid installation in paved areas whenever possible.

4-1.6.1 Branch/Dead End Pattern.

The branch 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.

4-1.6.2 Grid/Loop Pattern.

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

4-2 MATERIALS AND CONSTRUCTION.

Provide components of a distribution system in accordance with current AWWA standards and in compliance with NSF Standard 61. For corrosive soils, select materials, coatings, and/or a positive corrosion protection system to protect from external corrosion. Use AWWA Manual M27, *External Corrosion – Introduction to Chemistry and Control*; however, explicit approval by the Government is required prior to providing a cathodic protection system on a buried pipeline.

4-2.1 Fire Hydrants.

Comply with the requirements of UFC 3-600-01, paragraph entitled “*Hydrants*”.

4-2.2 Pipe.

Minimum cover over pipes must be 2.5 feet (750 mm); greater than frost penetration according to UFC 3-301-01; or sufficient to support imposed dead and live loads for the pipe materials used; whichever is more stringent**.**

4-2.3 Service Connections.

Refer to AWWA Standard C800, *Underground Service Line Valves & Fittings (Also included: Collected Standards for Service Line Materials)*, for service connection materials and valves.

4-2.4 Disinfection and Testing.

Refer to AWWA Standard C600 series for testing requirements for each type of pipe material. For disinfection testing requirements refer to AWWA Standard C651, *Disinfecting Water Mains*. Investigate any state or local requirements which may require more stringent testing and disinfection.

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CHAPTER 5 TRANSMISSION SYSTEMS

5-1 TRANSMISSION CONDUITS.

Transmission lines convey water from the source to the treatment plant and/or to the distribution system. This water may be treated or untreated, depending on the location of the treatment plant. Consider the following during route selection, consistent with economic considerations:

- Gravity line, if head is available;
- The shortest route from the point of intake to point of delivery;
- Bypassing rough or extremely difficult terrain and accessible for construction and repairs;
- Below the hydraulic grade line but as close to it as practicable;
- Avoid dangers of landslides and flood waters.

5-1.1 Location.

5-1.2 System Types.

5-1.2.1 Pipelines.

Use gravity or pressure pipelines for transmission except when special circumstances justify the use of aqueducts or tunnels.

5-1.2.2 Aqueducts.

Use aqueducts or canals not under pressure to convey large flows when the construction is economically justified under special circumstances.

5-1.2.3 Tunnels.

Use a tunnel of the gravity or pressure type to convey water underground, where there is no other alternative route and where its construction is economically justified.

5-1.3 Capacity.

Where distribution is pumped from storage, transmission mains must have capacities equal to maximum day demand plus industrial demand and fire flow requirement. Without such storage, transmission mains must meet maximum hour demand. Include reserve capacity for a minimum of 5 years in the future. Evaluate effect of long detention time on decay of chlorine residual. Refer to UFC 3-230-03, Chapter 3 entitled "Waterworks Supply Sources and Flows".

5-1.4 Design Velocity.

Avoid velocities above 5 feet per second (fps) **(**1.5 m/s) due to high friction losses.

At velocities above 5 feet per second (1.5 m/s), particularly in PVC pipe, the design must address surge pressures and conditions.

5-1.5 Sizes.

Provide allowance for the loss of carrying capacity during the expected service life.

5-1.6 Thrust Restraint.

Provide calculations for restrained joints. Use Best Practices document, DIPRA's *Thrust Restraint Design for Ductile Iron Pipe* for guidance.

5-1.7 Arrangements.

Provide multiple conduits, whenever possible, so that delivery of water need not be interrupted during repairs. If feasible, arrange the conduits to enter the Installation from opposite directions.

5-2 MATERIALS AND CONSTRUCTION.

Provide components of a transmission system in accordance with current AWWA standards and in compliance with NSF Standard 61. For corrosive soils, select materials, coatings, and/or a positive corrosion protection system to protect from external corrosion. Use AWWA Manual M27, *External Corrosion – Introduction to Chemistry and Control*; however, explicit approval by the Government is required prior to providing a cathodic protection system on a buried pipeline.

Preserve high hydraulic efficiency by controlling tuberculation, slime formation and encrustations by use of coatings and specific materials. During material and coating selection evaluate structural strength, field conditions, cost and maintenance requirements.

5-2.1 Pipelines.

The most common materials for water piping are as follows: concrete pressure pipe, steel pipe, PVC pipe, HDPE pipe and ductile iron pipe. Refer to applicable AWWA publications for specific selection criteria.

Minimum cover over pipes must be 2.5 feet (750 mm); greater than frost penetration according to UFC 3-301-01; or sufficient to support imposed dead and live loads for the pipe materials used; whichever is more stringent.

5-2.1.1 Exposed Pipe.

Exposed pipe may be placed on bridges or piers for crossing streams or ravines. Exposed nonmetallic pipe may be used only 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.

5-2.2 Tunnels.

Undertake a thorough geologic investigation in the design stage of a rock tunnel. Consult an engineer with specialized experience in rock tunnel design.

5-2.3 Valves.

Refer to Appendix B for a general discussion of valves and their uses. Consider the following for transmission main valves:

- Provide air release valves as required based on an analysis of the system. For flexible pipe which might collapse under a vacuum, place vacuum release valves as necessary, based on an analysis of the system and recommendations of the pipe manufacturer; also adjacent to each shutoff valve on the uphill side.
- Provide a blowoff at each depression 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.
- Shutoff valves must be installed at reasonable locations to allow isolation of any particular section during repair and testing. The spacing must not exceed 5,000 feet (1524 m) on long lines and 1,500 feet (457 m) on loops.
- Calculate the amplitudes of water hammer on long lines. Provide appropriate devices to dampen or eliminate any water hammer effects; such as, valves, valve controllers, surge tanks, etc.

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CHAPTER 6 PUMPING SYSTEMS

Use Best Practices document, *Pumping Station Design* for guidance on designing water booster pump station systems.

6-1 PUMP EQUIPMENT.

6-1.1 Pumps.

Pumps are selected to meet flow, pressure, and efficiency requirements. Pumps must accommodate the maximum daily demand, the peak hourly rate plus fire load demand, and the estimated minimum hourly rate. The location and required capacity of a potable water pumping installation must be determined by a computer hydraulic model and network analysis of the distribution system. Pumping capacity must be adequate to discharge the peak flow with the largest pump out of service. Components in contact with potable water must be in compliance with NSF Standard 61.

6-1.2 Pump Drives.

The factors affecting selection of the type of power used to drive potable water pumps include dependability, availability and economic considerations.

Provide for emergency power operation, such as a dedicated standby emergency generator or a portable generator, in conformance with applicable regulatory and utility provider requirements.

6-1.2.1 Speed Control System.

The simplest system which allows pumps to accomplish the required hydraulic effects must be chosen for design. Factors to be considered in selecting a system include cost, efficiency, reliability, structural requirements, ease of operation and degree of maintenance necessary. The last two items are critical at military installations where adequate personnel cannot always be provided. 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. Variable speed drives must be considered when there are conditions that are more complex to solve using multiple constant speed pumps and starting scenarios. Consideration for variable speed pumps must be coordinated with the facility utility provider.

6-1.2.2 Motor Capacity.

Motors must be selected with sufficient capacity to drive the pump under service required and to be nonoverloading over the entire impeller curve without motor overload or failure. Motors must be provided in accordance with National Electrical Manufacturers Association (NEMA) *Standard for Motors and Generators* (MG1).

6-1.1

6-1.3 Metering.

Pump station flows must be metered to calculate distribution system losses, such as from leakage, by subtracting the total of meter readings from total supply; to monitor pump efficiency; and to determine gross billings for water supplied. Each pump must have a means of measuring its discharge. The pump station must have metering equipment capable of indicating, totalizing and recording the total water amount pumped.

6-1.4 Controls.

Controls of pumps must be automated. Pumps must be turned on and off in response to signals corresponding to pressure or water levels in storage tanks. Remote monitoring of pump alarm conditions must be provided to relay at minimum: power failure, pump failure (seal failure and start failure), and generator start failure. Pump controls and monitoring must have the capability to provide the desired flow rates, pressures and liquid levels; to 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. See paragraph entitled "*Instrumentation and Control*" for additional criteria.

6-1.5 Surge Analysis and Control.

Utilization of computer programs for water hammer analysis of large pump stations is required. Large pump stations have flows greater than 3200 gpm (202 L/s)

6-2 PUMP STATION.

Pumps, piping and equipment must be protected from the weather as dictated by local climatic conditions. In cold climates pumps and piping must be protected from freezing and are usually completely housed in structures. In warm climates portions of stations may be located in outside enclosures which must provide protection from moisture and other weather related conditions. Structures must be fire-resistant construction. Buildings must be designed in compliance with local codes and regulations. Building layouts must be designed logically considering the sequence of installation of initial and future equipment if future expansion is planned. Space must be provided for removing equipment for repair without interrupting other equipment. Equipment layouts must provide vertical and horizontal clearances and access openings for maintenance and repair operations. Access points must be lockable and meet Base Security requirements.

6-3 FIRE PUMPS.

Provide fire pumping systems in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

APPENDIX A REFERENCES

GOVERNMENT PUBLICATIONS

UNIFIED FACILITIES CRITERIA (UFC), DEPARTMENT OF DEFENSE (DoD)
http://dod.wbdg.org/

UFC 1-200-01, *General Building Requirements*

UFC 3-201-01, *Civil Engineering,* target publication date, October 2012. Use UFC 3-210-01A and UFC 3-200-10N as interim criteria until publication of UFC 3-201-01.

UFC 3-230-03, *Water Treatment*

UFC 3-220-01N, *Geotechnical Engineering Procedures for Foundation Design of Buildings and Structures*

UFC 3-301-01, *Structural Engineering*

UFC 3-570-02A, *Cathodic Protection*

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

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

UFC 4-020-01, *DoD Security Engineering: Facilities Planning Manual*

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

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

DEPARTMENT OF DEFENSE (DoD)
http://www.wbdg.org/ccb/browse_cat.php?o=29&c=76

DoD 4715.5-G, *Overseas Environmental Baseline Guidance Document*

DODINST 6055.1, *DoD Safety and Occupational Health (SOH) Program*

NON-GOVERNMENT PUBLICATIONS

AMERICAN WATER WORKS ASSOCIATION, 6666 W. QUINCY AVENUE, DENVER, CO 80235

AWWA Manual M27, *External Corrosion – Introduction to Chemistry and Control*

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

AWWA Standard C651, *Disinfecting Water Mains*

AWWA Standard C800, *Underground Service Line Valves & Fittings (Also included: Collected Standards for Service Line Materials)*

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

AWWA Standard D102, *Coating Steel Water Storage Tanks*

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

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

AWWA Standard D110, *Wire & Strand Wound, Circular, Prestressed Concrete Water Tanks*

AWWA Standard D115, *Tendon-Prestressed Concrete Water Tanks*

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

Recommended Standards for Water Works, latest edition

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA), 1300 NORTH 17TH STREET, SUITE 1752, ROSSLYN, VIRGINIA 22209

MG1, *Standard for Motors and Generators*, latest edition

NATIONAL FIRE PROTECTION ASSOCIATION, 1 BATTERYMARCH PARK, QUINCY, MASSACHUSETTS 02169-7471

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

NSF INTERNATIONAL, P.O. BOX 130140, 789 N. DIXBORO ROAD, ANN ARBOR, MICHIGAN 48113-0140

NSF Standard 61, *Drinking Water System Components,* latest edition

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 CIVIL ENGINEERING RELATED GUIDANCE.

GOVERNMENT PUBLICATIONS: None.

NON-GOVERNMENT PUBLICATIONS

AMERICAN WATER WORKS ASSOCIATION, 6666 W. QUINCY AVENUE, DENVER, CO 80235

AWWA Manual M19, E*mergency Planning for Water Utility Management*

AWWA Manual M27, *External Corrosion: Introduction to Chemistry and Control*

AWWA Manual M31, *Distribution System Requirements for Fire Protection*

AWWA Manual M32, *Distribution Network Analysis for Water Utilities*

AWWA Manual M36, *Water Audits and Loss Control Programs*

AWWA Manual M42, *Steel Water Storage Tanks*

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

AWWA Standard C501, *Cast-Iron Sluice Gates*

AWWA Standard C504, *Rubber-Seated Butterfly Valves, 3 In. (75mm) through 72 In. (1800mm)*

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

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

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

AWWA Opflow, *Determining Distribution System Storage Needs*, by Murat Ulasir, Robert Czachorski, Vyto Kaunelis, Vol. 31 Issue 9, September 2005

BUTTERWORTH-HEINEMANN, 30 CORPORATE DRIVE, SUITE 400, BURLINGTON, MA 01803

Pumping Station Design, edited by Garr M. Jones with Robert L. Sanks, George Tchobanoglous and Bayard Bosserman, latest edition

DUCTILE IRON PIPE RESEARCH ASSOCIATION, 245 RIVERCHASE PARKWAY EAST, SUITE O, BIRMINGHAM, AL 35244-1856

Thrust Restraint Design for Ductile Iron Pipe, latest edition.

HYDRAULIC INSTITUTE, 6 CAMPUS DRIVE, FIRST FLOOR NORTH, PARSIPPANY NJ, 07054-4406

Pump Standards, latest edition

STEEL STRUCTURES PAINTING COUNCIL, 40 24TH STREET, PITTSBURGH, PA 15222-4643

Coatings for Potable Water Tank Interiors, latest edition

B-3 ADDITIONAL BEST PRACTICES.

B-3.1 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 Manual M36, *Water Audits and Loss Control Programs*.

B-3.2 Storage.

B-3.2.1 Ground Storage Tanks.

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-3.2.2 Underground Storage Tanks.

Avoid underground storage tanks.

B-3.3 Distribution/Transmissions Systems.

B-3.3.1 Valves.

See Table B-1 for the availability of types of valves and their applications.

Table B-1: Application of Valves

Type	Application	Remarks
Check Valves		
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	-
Shutoff Valves		
Gate Valves[a]	All applications	Refer to AWWA C500 and/or 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	-
Gates		
Radial Gates	Channel and reservoir outlets	-
Slide Gates	Channel and reservoir outlets	Low heads
Sluice Gates	Wall openings	Refer to AWWA C501
Shear Gates	Wall openings (low head)	Size up to 24 in. (600 mm)

[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/or AWWA C509.

B-3.4 Pumping Systems.

B-3.4.1 System Planning.

Typically pumping is required to remove raw water from its source, process it and deliver potable water to the ultimate users. Major planning factors include: availability of electric power, roadway access for maintenance and operation purposes, security and adverse impact, if any, on surrounding occupancies. Site development will depend upon a site soils analysis showing adequate support for foundations or possible ground water problems, and a grading and drainage plan of the area showing that runoff away from the structures can be obtained.

B-3.4.2 Design Considerations.

Refer to Table B-2 for a detailed listing of the data needed for the design of water pumping installations.

Table B-2: Information Required for 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 demand: mgd or gpm. Average demand: mgd or gpm. Minimum demand: mgd or 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 Soilds content
Power Available	Type Characteristics

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. Basic pump hydraulic terms and formulas, pump fundamentals and applications and instructions for installation, operation and maintenance are given in the *Hydraulic Institute Pump Standards.*

B-3.4.3 Pump Equipment.

B-3.4.3.1 Pumps.

For guidelines to follow to determine the correct type of pump to use refer to the *Hydraulic Institute Pump Standards*.

B-3.4.3.2 Pump Drives.

Refer to Table B-3 for preferential choice and applications of various pump drive power systems. Refer to *Hydraulic Institute Pump Standards* for discussions on types of electric motors.

Table B-3: 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.

B-3.4.3.3 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-3.4.4 Pump Station Layout.

Refer to Table B-4 for applications and limitations of pumping arrangements.

Table B-4: Application and 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 in parallel operation	Use this arrangement as a normal installation	Requires multiple pumps, and possibly jockey pump to pressurize system at low demands
Intermittent pumping with storage reservoirs riding on hydraulic gradient	Use this arrangement wherever possible	
Manual or automatic speed variation to control pump discharge	Use in complex situations where multiple constant speed pumps would be more expensive.	