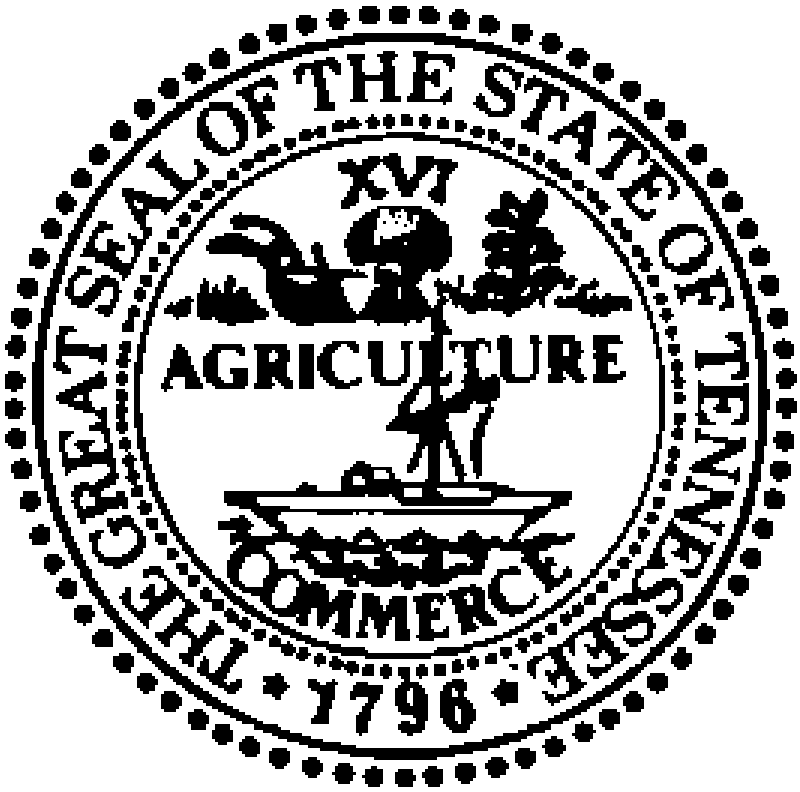
Distribution Systems Course #1103



TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Fleming Training Center
January 14 - 18, 2013

http://www.tn.gov/environment/fleming/

Distribution Systems

Course #1103

January 14 - 18, 2013

Monday, January 14:

8:30	Registration	Amanda Carter
8:45	Overview of Distribution System	Amanda
10:00	System Design and Materials/Piping	Amanda
11:00	Lunch	
12:00	Distribution Math Review	Amanda

Tuesday, January 15:

8:30	Distribution Math Review	Amanda
9:00	Safety - Confined Space, Trenching, PPE	Amanda
10:00	Valves	Amanda
11:00	Corrosion	Amanda
12:00	Lunch	
1:00	Fire Hydrants and Maintenance	Ernie Milteer

Wednesday, January 16:

8:30	Hydrant Flushing	Amanda
9:00	Water Tanks - Preventative Maintenance	Amanda
10:00	Disinfection	Amanda
12:00	Lunch	
1:00	Cross Connection Control	Amanda
2:00	Sampling and Water Analysis	Amanda

Thursday, January 17:

8:30	Pumps and Maintenance	Amanda
9:30	Water Loss	Amanda
10:00	Regulations and Design Criteria	Amanda
11:30	Lunch	
1:00	Tennessee One Call	Holly Austin
1:45	Water Services and Meters	Kevin Brown

Friday, January 18:

8:30	Exam and Course Evaluation	Amanda

State of Tennessee

Fleming Training Center
2022 Blanton Dr.
Murfreesboro, TN 37129

Phone: 615-898-6507
Fax: 615-898-8064
E-mail: Amanda.Carter@tn.gov

Fleming Training Center

Your Partner in Clean Water

http://tn.gov/environment/fleming

* Instructors are subject to change

Distribution Systems

Section 1	Overview	3
Section 2	System Design & Pipes	13
Section 3	Math Review	39
Section 4	Water Tanks	75
Section 5	Disinfection	89
Section 6	Lab Tests and Sampling	103
Section 7	Valves	115
Section 8	Hydrants	125
Section 9	Corrosion	155
Section 10	Water Meters	165
Section 11	Pumps	187
Section 12	Cross-Connections	203
Section 13	Safety & Trenching	223
Section 14	Rules and Regs & Sanitary Survey	257

Section 1

Overview

Common Abbreviations

ASTM – America Society for Testing and Materials
AWWA – America Water Works Association
CCR – consumer confidence report
CWS – community water system
DBP – disinfection byproduct
DO – dissolved oxygen
EBCT – empty bed contact time
GAC – granular activated carbon
HAA – haloacetic acids
HPC – heterotrophic plate count
HTH – high-test hypochlorite; calcium hypochlorite
LCR – lead and copper rule
LSI – Langelier saturation index
MCL – maximum contaminant levels
MCLG – maximum contaminant level goal
MF – membrane filter
MGD – million gallons per day
MPN – most probable number
MRDL – maximum residual disinfection level
MSDS – material safety data sheets
MTF - multiple-tube fermentation
NCWS – non-community water system
NOM – natural organic material
NSF – National Sanitation Foundation
NTNCWS – non-transient non-community water system
NTU – nephelometric turbidity units
OSHA – Occupational Safety and Health Act
P-A – presence-absence
PAC – powder activated carbon
PN – public notification
PPE – personal protective equipment
PPM – parts per million; mg/L
PSI – pounds per square inch
PWS – public water system
RPBP – reduced pressure backflow preventer
SCBA – self-contained breathing apparatus
SCD – streaming current detector
SDWA – Safe Drinking Water Act
sMCL – secondary maximum contaminant level
SOC – synthetic organic carbon
SOP – standard operating procedures
TCR – total coliform rule
TDS – total dissolved solids
THM – trihalomethane
TOC – total organic carbon
TWS – transient non-community water system
USEPA – United States Environmental Protection Agency
UV – ultraviolet
VOC – volatile organic chemical

Grade 1 Distribution Systems Operator
Need-To-Know Criteria (Subject Areas)

The following list of categories suggests topics of information which are important to know in order to be a successful and proficient Grade 1 Distribution Systems Operator. The list may not be all inclusive, and knowledge of additional topics may be of benefit.

Category of Information: Processes

Conveyance	Piping Valves Hydrants Service Connections
Pressure Control	Booster Pumps Regulators & Gauges
Storage	Ground Tanks Elevated Tanks Standpipes Hydropneumatic Pressure Tanks
Metering	Displacement Velocity Differential Pressure
Leak Detection and Repair	Sonic Devices Pressure Devices Volume Visual
Disinfection	Tanks Lines
Cross Connections	Air Gap Reduced Pressure Principle Assembly Double Check Valve Assembly Vacuum Breakers Backflow Backpressure Backsiphonage Cross Connection

Category of Information: Support Systems

Motors	Single Phase Three-Phase Variable Speed
Drives	Coupled Direct
Pumps	Centrifugal Positive Displacement (Piston Plunger; Diaphragm) Turbine Metering
Generators	AC
Pipes	Ductile Iron PVC Asbestos Cement
Joints	Flanged Compression/Dresser Gas Threaded
Valves	Ball Check Globe Gate Pressure Control Vacuum Relief Butterfly Air Release Foot (on pump at intake) Altitude
Fittings	Coupling Union Plug/Caps Corporation Curb Stop
Cathodic Protection Devices	Anode Rod/Bags Cathode Rod/Bags Rectifiers Galvanic Corrosion Dissimilar Metals
Measuring and Control	Signal Generators (Magnetic Flowmeter; Venturi; Propeller Meter; Ultrasonic; Pitot tube) Signal Transmitters (Electric; Pneumatic; Mechanical; Telemetry) Signal Receivers (Counters; Indicators, Totalizers; Recorders)

Category of Information: Support Systems (continued)

Measuring and	Meters (Electrical - Amp; Electrical - Watt; Electrical - Multi - VOM; Electrical - Multi - MA)
	Alarms
	Controls (Pneumatic; Float; Hydraulic; Electrical; Telemetry; Timers)
Chemical Feeders	Booster Chlorinator
	Hypochlorinators
	Gas
Rolling Stock	Service Vehicles
	Trucks
	Lawn Mowers
	Loaders
	Portable Pumps
	Generators
Safety	Personal Protection Gear
	Traffic Control (Warning Devices; Barricades)
	Hazard Detection
	First Aid/Hygiene
	Confined Space
Security	Attack
	Prevention
	Detection
	Recovery

Category of Information: Lab Tests

Lab Tests	Disinfectant residual
	Disinfectant demand
	Coliform
	Orthophosphate
	pH
	Temperature
	Sample Collection
	THM
	HAA5
	Lead and Copper

Category of Information: General Information

Units of Expression	Definition
	Conversion
Sources and Characteristics	Quality/quantity
Electrical Concepts	Basic concepts
Hydraulic Concepts	Basic concepts
Maps/Plans	

Grade 2 Distribution Systems Operator
Need-To-Know Criteria (Subject Areas)

The following list of categories suggests topics of information which are important to know in order to be a successful and proficient Grade 2 Distribution Systems Operator. The list may not be all inclusive, and knowledge of additional topics may be of benefit.

Category of Information: Processes

Conveyance	Piping Valves Hydrants Service Connections
Pressure Control	Booster Pumps Regulators & Gauges
Storage	Ground Tanks Elevated Tanks Standpipes Hydropneumatic Pressure Tanks
Metering	Displacement Velocity Differential Pressure
Leak Detection and Repair	Sonic Devices Pressure Devices Volume Visual
Disinfection	Tanks Lines
Cross Connections	Air Gap Reduced Pressure Principle Assembly Double Check Valve Assembly Vacuum Breakers Backflow Backpressure Backsiphonage Cross Connection

Category of Information: Support Systems

Motors	Single Phase Three-Phase Variable Speed
Drives	Coupled Direct
Pumps	Centrifugal Positive Displacement (Piston Plunger; Diaphragm) Turbine Metering
Generators	AC
Joints	Flanged Compression/Dresser Gas Threaded
Valves	Ball Check Globe Gate Pressure Control Vacuum Relief Butterfly Air Release Foot (on pump at intake) Altitude
Fittings	Coupling Union Plug/Caps Corporation Curb Stop
Cathodic Protection Devices	Anode Rod/Bags Cathode Rod/Bags Rectifiers Galvanic Corrosion Dissimilar Metals
Measuring and Control	Signal Generators (Magnetic Flowmeter; Venturi; Propeller Meter; Ultrasonic; Pitot tube) Signal Transmitters (Electric; Pneumatic; Mechanical; Telemetry) Signal Receivers (Counters; Indicators; Totalizers; Recorders)

Category of Information: Support Systems (continued)

Measuring and Control	Meters; Electrical - Amp; Electrical - Watt; Electrical - Multi - VOM; Electrical - Multi - MA) Alarms Controls (Pneumatic; Float; Hydraulic; Electrical; Telemetry; Timers)
Chemical Feeders	Booster Chlorinator Hypochlorinators Gas
Rolling Stock	Service Vehicles Trucks Tractors Trailers Lawn Mowers Loaders Portable Pumps Generators
Safety	Personal Protection Gear Traffic Control (Warning Devices; Barricades) Hazard Detection First Aid/Hygiene Confined Space MSDS Information
Security	Attack Prevention Detection Recovery

Category of Information: Lab Tests

Lab Tests	Disinfectant residual Disinfectant demand Coliform Orthophosphate pH Temperature THM HAA5 Lead and Copper

Category of Information: General Information

Units of Expression	Definition Conversion
Sources and Characteristics	Quality/quantity
Electrical Concepts	Basic concepts
Hydraulic Concepts	Basic concepts
Maps/Plans	

Suggested Distribution System Exam References

The following are approved as reference sources for the distribution examinations. Operators should use the latest edition of these reference sources to prepare for the exam.

Textbooks

American Water Works Association (AWWA) www.awwa.org

- Water Transmission and Distribution
- Water Distribution Operator Training Handbook
- Basic Science Concepts and Applications
- Water System Security, A Field Guide
- Water Quality
- AWWA Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances (ANSI/AWWA C600-93),

Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA) www.asdwa.org

- Security Vulnerability Self Assessment Guide for Small Drinking Water Systems

California State University, Sacramento (CSUS) Foundation, Office of Water Programs (www.owp.csus.edu)

- Water Distribution System Operation and Maintenance
- Small Water System Operation and Maintenance
- Manage for Success

Regulations

- Code of Federal Regulations, Labor (CFR 29), Part 1926 (www.gpo.gov)
- Code of Federal Regulations, Title 40 Part 141, www.gpo.gov)
- Community Public Water Systems Design Criteria, State of Tennessee, Department of Environment and Conservation, Division of Water Supply, Nashville, 2008.
- Regulations for Public Water Systems and Drinking Water Quality, State of Tennessee, Department of Environment and Conservation, Division of Water Supply, Nashville. June 2009.
- Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, TN, December 2009, Section 1200-5-3.

Study Guides

American Water Works Association: Operator Certification Study Guide, Fifth Edition: A Guide to Preparing for Water Treatment and Distribution Operator Certification Exams.

TOSHA Standards Requiring Annual Training

Class	Regulation	Who should attend?
Medical & Exposure Records	1910.20(g)(1)	All employees (inform-existence, person responsible, location, right of access
Emergency Action	1910.38(a)(5) 1910.38(b)(4)	All employees – based upon other standards and requirements
Noise	1910.95(k)	All employees exposed to an 8 hour TWA or greater of 85dBA
Emergency Response	1910.120(q)	Employees who respond to spills of hazardous chemicals
Personal Protective Equipment	1910.132(f)	Employees who wear PPE
Permit-Required Confined Space	1910.146(g)	Employees who enter, attend or supervise P.R. confined spaces
Lock-Out/Tag-Out	1910.147(c)(7)	Employees who work on machinery
First Aid	1910.151(b)	At least one employee on each shift, annual as required by other standards
Fire Brigade	1910.156(c)	All fire brigade members (quarterly and annually)
Portable Fire Extinguishers	1910.157(g)	All employees expected to use fire extinguishers
Fork Lift Trucks	1910.178(1)	Fork lift truck operators
Mechanical Power Presses	1910.217(f)(2)	Operators
Asbestos	1910.1001(j)(1)	All employees exposures at or above PEL or excursion limit
Lead	1910.1025(1)	Anyone with a potential for exposure at any level – copy of appendix A&B. If exposed at or above action level, must be trained
Bloodborne Pathogens	1910.1030(g)(2)	Employees who render first aid
Hazard Communication	1910.1200(h) TDL 800-1-9-.07	Employees exposed or potentially exposed to any type of chemicals
Hazardous Chemicals in Laboratories	1910.1450(f)(2)	Employees exposed to chemicals

Record Maintenance
Water and Distribution Systems
State of Tennessee

Record	Must be kept for	Source
Bacteriological Analysis	5 years	1200-5-1-.20(1)(a)
Chemical Analysis	10 years	1200-5-1-.20(1)(a)
Actions to correct violations	3 years after last action	1200-5-1-.20(1)(b)
Written reports, summaries, communications relating to sanitary surveys	10 years after sanitary survey	1200-5-1-.20(1)(c)
Variances/exemptions	5 years after expiration	1200-5-1-.20(1)(d)
Turbidity	Next sanitary survey	1200-5-1-.20(1)(f)
Daily worksheets and shift logs	Next sanitary survey	1200-5-1-.20(1)(g)
Cross connection plans & inspection records	5 years	1200-5-1-.20(1)(h)
Complaint logs	5 years	1200-5-1-.20(1)(h)
Facility maintenance records	5 years	1200-5-1-.20(1)(h)
Storage tank inspections	5 years (required) life of tank recommended	1200-5-1-.20(1)(h)
Lead & copper	12 years	1200-5-1-.33(12)
Bacteriological records indicating disinfection of mains, tanks, filters, wells	5 years	1200-5-1-.17(8)
Flush and free chlorine residual for new taps where main is uncovered	Next sanitary survey or 3 years	1200-5-1-.17(33)
MSDS	At least 30 years	29 CFR1910.1020

Section 2

System Design & Pipes

TDEC - Fleming Training Center

Distribution System Design

DISTRIBUTION COURSE

1

TDEC - Fleming Training Center

Learning Objectives

- Types of public water systems
- Common configurations used in distribution system design
- Principal considerations involved in sizing water mains
- Considerations made for selecting piping materials

2

TDEC - Fleming Training Center

Types of Water Systems

- Surface water supply
- Groundwater
- Purchased water
- Rural Systems

3

TDEC - Fleming Training Center

Surface Water Systems

- Usually provides water for large communities with a lot of industrial and commercial usage
- Requires more treatment than groundwater
- Water usually enters the distribution system from one side and requires large transmission mains
- Water use on high-use days may be several times the amount on average day

4

TDEC - Fleming Training Center

Groundwater Systems

- Usually has limited withdrawal rates
- Requires less treatment than surface water
- Wells are dispersed in some systems, require less transmission mains
- Water may be corrosive or scale-forming
- Rate of water use sometimes exceeds the water source (aquifer)
- If single entry point, distribution system must be furnished with transmission mains as in the case of surface water system

5

TDEC - Fleming Training Center

Purchased Water Systems

- 3 principal reasons utilities purchase water
  - Well supply becomes inadequate
  - Water sources found to be contaminated
  - Regulatory compliance makes supply and treatment too difficult
- Operator's job is limited to primarily the distribution system
  - In some cases additional disinfection may be required
- Tight water accountability must be maintained in the distribution system

6

TDEC - Fleming Training Center

Factors Affecting Distribution Design

- Water availability and reliability
- Soil conditions and climate
  - How deep to put lines
  - What kind of pipe to use
- Terrain
- Water quality

7

TDEC - Fleming Training Center

Factors Affecting Distribution Design

- State and Federal requirements
- Future growth
- Costs: materials, labor, overhead, profit, land acquisition, legal expenses and engineering

8

TDEC - Fleming Training Center

Factors Affection System Layout

- System planning
- Configuration
- Mapping
- Valving

9

TDEC - Fleming Training Center

System Planning

- Design should be done by city engineer or consultant
- Operators should be included in the process
- Important to include operators because they will have to make it work

10

TDEC - Fleming Training Center

System Configuration

- Usually one of three types
  - Arterial-loop
  - Grid
  - Tree
- Most systems are combination of grid and tree (branching system)

11

TDEC - Fleming Training Center

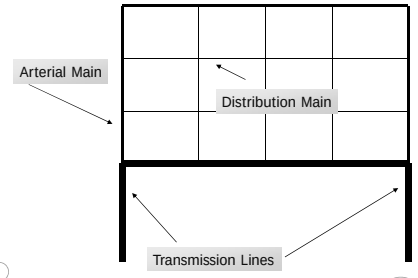
Arterial-Loop System Characteristics

- Attempts to surround the distribution area with large diameter mains
- Mains contribute water supply within the grid from several directions
- All major demand areas should be served by an arterial system
- Minimizes dead ends
- Branch mains project inward
- Fewer service interruptions with line breaks

12

TDEC - Fleming Training Center

Arterial-Loop System



13

TDEC - Fleming Training Center

Grid System Characteristics

- Depends on the fact that all mains are interconnected
- Water can flow from several different directions
- Mains are usually 6 - 8 inches
- Reinforced with larger arterial mains
- General area is fed by larger transmission mains
- All ends of mains are connected to eliminate dead ends

14

TDEC - Fleming Training Center

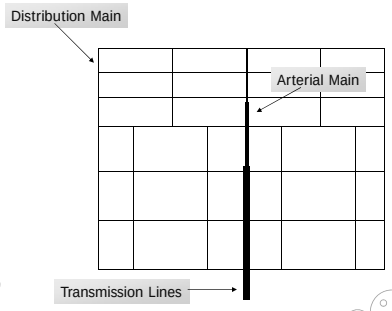
Grid System Characteristics

- Minor distribution lines or mains make up secondary system which is the major portion of the grid which supply fire hydrants & domestic and commercial consumers

15

TDEC - Fleming Training Center

Grid System



16

TDEC - Fleming Training Center

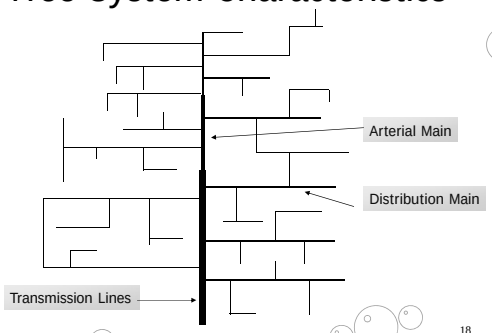
Tree System Characteristics

- Not highly recommended
- Few loops - flows often in one direction
- Difficult to supply a continuous flow of water to all parts of the system
- Customers are without water while repairs made to line breaks

17

TDEC - Fleming Training Center

Tree System Characteristics



18

Dead Ends

- Water flows in one direction
- Provides limited fire protection flow
- Mains are usually oversized for fire flow
- Domestic use is not enough to prevent stagnation and water degradation
- Customers beyond repair site are without water during work

19

Dead Ends

- Should have hydrant installed for flushing and fire protection
- Flush with a minimum velocity of 2 ft/sec
- Should be avoided whenever possible

20

Types of Water Mains

- Transmission
- Distribution
- Service Lines

21

Transmission Mains

- Carry water from source of treatment to distribution system
- Generally straight
- No service connections
- Usually made of large pipe
- Size depends upon flow demand and available operational storage facilities
- Concrete with a steel cylinder is suitable because less expensive in larger sizes

22

Distribution Mains

- Carry water from transmission main
- Main arteries that carry water to neighborhoods
- Tapped for customer connections

23

Service Lines

- Small diameter pipe
- Connect from distribution main to customer
- Start with a corporation stop (shutoff valve)
- Various material are used commonly plastic pipe, PVC, Polyethylene, and Polybutylene
- Lead service lines no longer acceptable and should be replaced

24

TDEC - Fleming Training Center

Factors for Sizing Water Mains

- Quantity requirements depends on consumption and fire flow requirements
- Recommended that no main be less than 6 inches in diameter for fire protection
- High value districts should have minimum pipe size of 8-12 inches

25

TDEC - Fleming Training Center

Factors for Sizing Water Mains

- Residential areas: 6-8 inch lines
- Mains smaller than 6 inches used only when completing a grid
- Varying elevation areas usually require two or more pressure zones
- Higher pressures contribute to more main and service line leaks

26

TDEC - Fleming Training Center

Water Pressure Requirements and Considerations

- Normal working pressure 50 - 75 psi for residential areas
- Minimum: 20 psi (under all flow conditions)
- Maximum: 100 psi
- Pressure reducing valves used if greater pressure exists (some building codes require in newer subdivisions)

27

TDEC - Fleming Training Center

Water Pressure Requirements and Considerations

- High pressure contributes to main and service leak problems
- Booster pumps often required for larger systems
- Ideal system would rely completely on gravity

28

TDEC - Fleming Training Center

Flow Velocity Requirements and Considerations

- Determines pipe capacity and required size
- Normally limited to about 5 ft/sec
- Higher velocities cause excessive friction loss as water flows through pipe
- Large variations of flow can adversely affect water quality

29

TDEC - Fleming Training Center

Flow Velocity Requirements and Considerations

- Sediments can be carried to customer with flow velocity changes
- Low circulation can result in growth of organisms, corrosion products, depletion of oxygen and increased rates of taste and odor
- Turbulence can cause air in system which produces milky water

30

TDEC - Fleming Training Center

Pipe Material Selection Consideration

- What qualities should the pipe have?
- What are the performance ratings of the pipe?
- What pipe material is available?
- What materials are currently used in distribution system?
- Are existing materials compatible?
- COST $$$$$$

31

TDEC - Fleming Training Center

Pipe Qualities Selection Considerations

- Can it handle external load from backfill?
- Can it handle internal pressures within pipe?
- Normally within 40-100 psi range
- Water hammer and surges
- Tensile strength
- Flexible or flexural strength
- Pipe shear breakage when earth shifts
- Beam breakage

32

TDEC - Fleming Training Center

Piping Terms

- **External load** - the pressure exerted on a pipe after it has been buried in a trench
- **Internal pressure** - the hydrostatic pressure from within the pipe
- **Tensile strength** - the resistance of a material to longitudinal (lengthwise) pull
- **Flexural strength** - the ability of a material to bend or flex without breaking

33

TDEC - Fleming Training Center

Pressure Rating of Pipe Material

- Pressure ratings can be calculated using AWWA standards
- Distribution pipe should have pressure rating 2.5 - 4 times normal operating pressure
- Replacement pipe must have a pressure rating greater than or equal to that replaced

34

TDEC - Fleming Training Center

Other Considerations

- Durability & life span
- Corrosion resistance
- Smoothness of inner surface - C Factor
- Ease of installation
- Ease of tapping & repair
- Ability to maintain water quality
- Compatibility
- Local conditions
- Installation COSTS
- All pipe must meet AWWA Standards
- Tennessee Design Criteria for Distribution Systems

35

TDEC - Fleming Training Center

Pipes

Materials, Installation & Maintenance

1

TDEC - Fleming Training Center

Types of Pipe

- CIP (Cast Iron Pipe)
- DIP (Ductile-Iron)
- Steel Pipe
- Asbestos-cement pipe (AC)
- Plastic
- Concrete

2

TDEC - Fleming Training Center

Gray Cast-Iron Pipe

- Used as early as 1664 in France
- Called sand-cast pipe
- Some systems are over 100 years old in US
- Strong but brittle
- Older pipe can be identified by rough texture on outside wall
- Since 1920, produced by centrifugal process - outside walls smoother and uniform in size
- Beam break most common
- No longer used for manufacturing pipe
- Still used to make some valves and fittings

3

TDEC - Fleming Training Center

Ductile-Iron Pipe (DIP)

- Became popular in 1960's
- More modern, tougher type of cast iron pipe
- Produced in same type mold as CIP
- Has "ductile iron" stenciled to distinguish from CIP
- Graphite distributed in the metal
- Much stronger than CIP

4

TDEC - Fleming Training Center

Advantages of DIP

- Good durability
- Flexural strength
- Smooth interior (C140)
- Carrying capacity
- Fracture resistance
- External corrosion good in most type soils
- Withstand high pressure
- Long term economical
- Diversity when combined with different fittings, joints, valves

5

TDEC - Fleming Training Center

Disadvantages of DIP

- External corrosion in aggressive environments if not protected
- Reliant upon special linings to protect against corrosion
- Costly to maintain
- Greater weight increases difficulty of installation

6

TDEC - Fleming Training Center

Ductile-Iron Pipe Joints

- Flanged
- Mechanical
- Ball-and-Socket (Submarine)
- Push-on
- Restrained
- Grooved and Shouldered

7

TDEC - Fleming Training Center

Flanged Joints

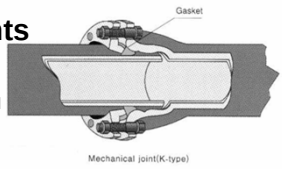
- Two machined surfaces tightly bolted together with a gasket between them
- Used in exposed locations
- Should not be used underground
- Lack of flexibility to compensate for ground movement
- Used at treatment plant & pump stations

8

TDEC - Fleming Training Center

Mechanical Joints

- Movable follower ring on the spigot to the flange on the bell
- Follower ring compresses a rubber gasket to form a seal
- More expensive
- Make a very positive seal and require little technical expertise to install
- Allow for some deflection of the pipe
- Provide flexibility in event of ground settlement after pipe installation



9

TDEC - Fleming Training Center

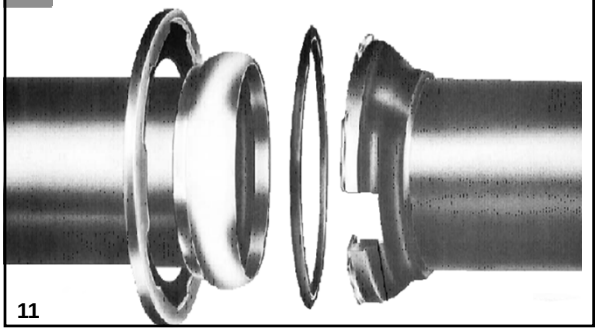
Ball-Socket Joint

- Special purpose joints used for intakes and river crossings
- Provide large deflection
- Used in rough terrain
- Joint consists of bell with special recess to accept a rubber ring gasket
- Available in several designs
- Deflections up to 15°
- Available in bolted and unbolted

10

TDEC - Fleming Training Center

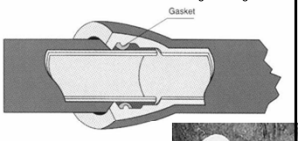
Ball-Socket Joint



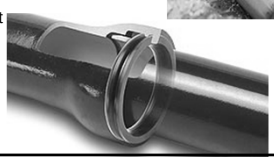
11

TDEC - Fleming Training Center

Push-On Joints



- Most popular
- Easier installation
- Lower cost
- Consists of a special bell fitted with a greased gasket
- Spigot end must have beveled edge to prevent tearing the rubber ring gasket
- Available in several designs
- Internal water pressure compresses the gasket making tight seals

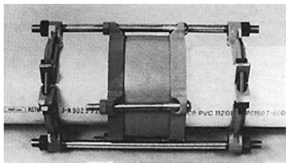


12

TDEC - Fleming Training Center

Restrained Joint

- Used to ensure joints do not separate such as elbows
- Used in areas where concrete thrust blocks cannot be used
- Some have special restraining feature

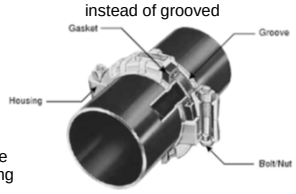


13

TDEC - Fleming Training Center

Grooved & Shoulder Joints

- Grooved
  - Utilizes bolted, segmental, clamp-type, mechanical coupling
  - Housing encloses a U-shaped rubber gasket
  - Housing locks the pipe ends together
  - Compresses the gasket against outside of pipe ends
  - Ends of pipe are machine grooved to accept housing
- Shoulder
  - Similar to grooved
  - Pipe ends are shouldered instead of grooved



14

TDEC - Fleming Training Center

Steel Pipe Characteristics

- More often for high-pressure situations
- Relatively light weight
- Competitively priced (i.e. over 16” diameter)
- Will bend without buckling
- High tensile strength
- Is subject to internal and external corrosion

15

TDEC - Fleming Training Center

Steel Pipe Characteristics

- Has cement mortar or epoxy lining
- Partial vacuum can cause pipe distortion or collapse
- Exterior requires corrosion and abrasion protection
- Frequently used for in-plant piping
- May have cathodic protection

16

TDEC - Fleming Training Center

Steel Pipe Joints and Fittings

- Pipe lengths often joined by welding
- Mechanical joints used
- Cast iron or ductile-iron fittings

17

TDEC - Fleming Training Center

Asbestos-Cement Pipe Characteristics

- Often preferred in areas with corrosive soil
- Lightweight, low initial cost
- Made of asbestos fibers, silica sand, and Portland cement
- Asbestos fibers provide much of the strength
- Not subject to metallic corrosion, tuberculation, and C factor usually stays high

18

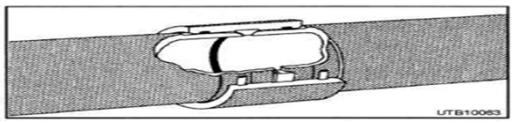
Asbestos-Cement Pipe Characteristics

- Should not be used with very aggressive or soft water, or aggressive soils
- Proper bedding is required to prevent breaks
- Easily punctured during excavations
- Low flexural strength
- Requires safety PPE (personal protective equipment)
- Cannot be located with pipe locators

19

Asbestos-Cement Pipe Joints

- Joined by sleeved couplings, also asbestos cement
- Sleeve has 2 interior rubber rings
- Cast-iron or ductile-iron fittings used, except couplings
- Asbestos in water does not cause health effects
- PVC is replacing AC pipe



20

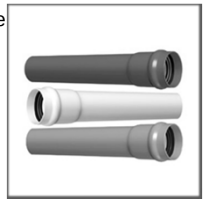
Plastic Pipe Characteristics

- Inert - will not react or corrode
- Widely used in water utility industry
- Will not leach out taste and odor causing substances
- Smooth interior
- Must be NSF International Standard 61 certified and marked on exterior surface
- Organic compounds can permeate (gas, fuel, oil)
- Should not be installed where contamination from organic compounds is probable

21

PVC (Polyvinyl Chloride) Pipe Characteristics and Advantages

- Most commonly used plastic pipe
- Generally lower cost
- Cheaper to ship
- Easier to handle
- Cuts easier
- C Factor of at least 150
- Chemically inert
- Moderately flexible and will adapt to ground settling



22

PVC Disadvantages

- Susceptible to damage from UV
- Permeable by organics
- Requires careful bedding to prevent damage
- Difficult to locate because nonconductive
- Inability to be thawed electrically
- Susceptible to permeation
- Buckles under a vacuum
- Must adhere to use of proper tools and procedures when service taps are made

23

Concrete Pipe Types

- Pre-stressed Cylinder
- Pre-tensioned
- Reinforced
- Reinforced non-cylinder

24

TDEC - Fleming Training Center

Prestressed Concrete Cylinder Pipes

- Two types manufactured
  - Lined-cylinder available in diameters from 16 - 60 inches
  - Embedded-cylinder available in diameters from 24 - 144 inches
- Manufactured with a full length of welded steel cylinder
- Concrete core in the interior

25

TDEC - Fleming Training Center

Pretensioned (Rod-Wrapped) Concrete Cylinder Pipe

- Similar to pre-stressed, but cylinder is wrapped with smooth hot-rolled steel bar
- Core protected with mortar coating
- Normally available in diameters of 10 - 54 inches

26

TDEC - Fleming Training Center

Advantages of Concrete Pipe

- Manufactured inexpensively in large sizes
- Withstands high internal pressure and external load
- Resistant to both internal and external corrosion
- Very long and trouble-free life span, if properly installed
- Minimal bedding requirements

27

TDEC - Fleming Training Center

Disadvantages of Concrete Pipe

- Very heavy weight
- Shipping costs high
- Special handling equipment required
- Exact pipe fittings and lengths required for installation
- Must be carefully planned and laid out in advance

28

TDEC - Fleming Training Center

Installation

29

TDEC - Fleming Training Center

Pipe Shipping and Unloading

- Can be shipped via truck, railroad or barge
- Pipe should be inspected upon arrival
- Handle carefully
- Inspect lining and coating
- Plastic pipe inspected closely if arriving in cold weather
- Use proper equipment to unload

30

TDEC - Fleming Training Center

Stacking Pipe

- If pipe is to be stacked and stored - ensure it is stored off the ground
- Secure pipe to prevent rolling
- Secure the storage area
- Protect plastic pipe from sunlight - but allow air circulation

31

TDEC - Fleming Training Center

32

TDEC - Fleming Training Center

33

TDEC - Fleming Training Center

34

TDEC - Fleming Training Center

Stringing Pipe

- Pipe should be laid as near to the trench as possible to minimize handling
- String pipe on opposite side of spoil pile
- Place bells in direction of installation
- Secure each section to prevent rolling into trench
- String only enough for one days work to prevent vandalism
- May need to cover ends to keep dirt out and prevent contamination

35

TDEC - Fleming Training Center

Excavation

- Plans are prepared by project engineer and submitted for State approval
- Plans should show location and depth of main, valves, hydrants and fittings
- Plans should show location and depth of sewer and gas pipes, buried telephone lines, electric and cable lines
- Ensure selection of proper sized excavation equipment
- Notification to public
- Tennessee One Call

36

TDEC - Fleming Training Center

Excavation

- Water and Sewer lines separation at least ***18 in*** between the bottom of the water main and top of the sewer line
- Water mains should be at least ***10 ft*** horizontally from any sewer line

37

TDEC - Fleming Training Center

Trenching

- Most expensive part of main installation
- Minimize width and depth as much as possible without compromising safety
- Width should be no more than 1-2 ft more than pipe diameter, wider around curves
- Trench depth depends on maximum depth of frost penetration, minimum of 2.5 feet
- Minimum distance from trench to spoil pile is 2 feet

38

TDEC - Fleming Training Center

Trenching

- Must have egress if 4 feet or deeper - stairway, ladders
- Trench must be shored or sloped at 5 feet or deeper
- If 20 feet or deeper, must be designed by an engineer
- Left open as short a time as possible
- Mark with barricades, warning tape, lights, etc to prevent accidents

39

TDEC - Fleming Training Center

Pipe Laying Procedures

- Inspect before laying and placing in trench
- Check for damage to the spigot end and lining
- Tap gently with a hammer (should ring)
- Wash, hose, or swab with hypochlorite if excessively dirty

40

TDEC - Fleming Training Center

Pipe Laying Procedures

- Keep gaskets clean and dry
- Use a sling or pipe tong to place into trench - never roll
- Cover pipe with plug at the end of each work day
- Ensure pipe bedding is level and compacted
- Compact the backfill beneath the pipe curvature (Haunching)

41

TDEC - Fleming Training Center

Pipe Joints

- Ensure gasket and spigot are clean before being attached
- Bell holes or recesses in bedding dug to allow for joint installation
- Spigot end must be inserted to the painted line
- Full-length pipes are beveled at end to facilitate connection
- Level pipe for cutting
- Insert pipe straight

42

Connecting to an Existing Main

- Shut off water to existing main and ensure valve will hold
- Must know the size and type of main to get proper fittings and gaskets
- Connecting to main using pressure taps
  - Does not require shutting off water and
  - Less chance of contaminating water
  - Also, fire protection remains in service for the area

43

Thrust Restraints in Pipe Installation

- Water under pressure and water in motion exerts tremendous pressure inside a pipe
- All tees, bends, reducers, caps, plugs, valves and hydrants should be restrained or blocked
- 4 general methods
  - thrust blocks
  - thrust anchors
  - restraining joints or fittings
  - batter piles

44

Thrust Restraints in Pipe Installation

- Thrust blocks are made of concrete or other permanent material and are cast in place between fittings and undisturbed soil in the trench
- Thrust anchors can be used when there is no undisturbed solid structure to block against so a thrust block is not usable
  - steel rods hold the pipe and are attached to a block of concrete

45

Thrust Restraints in Pipe Installation

- Tie rods are used to restrain mechanical joint fittings that are located close together
  - nuts on either side of each joint take the place of the MJ bolt that they replace
- Restraining fittings use clamps and anchor screws
  - useful where other existing utilities or structures are so numerous that thrust blocks aren't usable

46

Piping Air Relief

- Air gets trapped in water mains laid on uneven ground
- Constricts water flow
- In small mains, can be removed by flushing
- Removal possible in corporation stops
- Automatic air-relief can be installed at each high point in pipeline

47

Backfilling and Testing

48

TDEC - Fleming Training Center

Purpose of Backfilling

- Provide for pipe and fitting support
- Provides lateral stability between pipe and trench walls
- Prevents pipe movement during water hammer
- Carries and transfers surface loads

49

TDEC - Fleming Training Center

Placing Backfill

- Only clean sand or selected soil should be used for first layer
- Moist enough for compaction
- Should not contain peat, large rocks, debris or frozen material
- First layer placed equally on both sides of pipe, up to center, and compacted
- Do by hand or pneumatic tamper
- Second layer should be good quality backfill material
- Remaining backfill can be excavated spoils

50

TDEC - Fleming Training Center

Compacting

Tamping Soil

- Three methods for compacting soil
  - Tamping
  - Vibration
  - Saturation with water
- Depends upon the type of soil or material used

51

TDEC - Fleming Training Center

Pressure and Leak Testing

- Performed before completing backfill
- Allow at least five days for concrete to cure
- Close all appropriate valves
- After pressure is maintained for at least two hours a leakage test may be conducted
- Should be very little leaking from push-on and mechanical joints with rubber gaskets

52

TDEC - Fleming Training Center

Pressure and Leak Testing

- Test pressure and allowable leakage are in AWWA Standards
- Pressure of 1.5 times working pressure or 150 psi for 30 minutes is minimum
- Any leaking joints, valves, etc should be adjusted or repaired
- Possible causes for leaks are
  - debris lodging a valve, improperly tightened joints, partially open corporation stops, or damage to pipe

53

TDEC - Fleming Training Center

Pipe Flushing

- New lines must be flushed, disinfected, and tested for bacteriological quality before placing into service
- Velocity of at least 2.5 ft/sec
- For large diameter mains, more than one hydrant may be used
- A blow off connection may be used if installed
- A pig may be used if water plant capacity not sufficient to provide the quantity of water required for flushing line

54

TDEC - Fleming Training Center

Disinfection

- Calcium or sodium hypochlorite
- Ensure chlorinated water in pipe for 24 hours
- All valves and hydrants operated to ensure disinfection of all parts
- Should bleed periodically to ensure water movement
- Inject liquid bleach through corporation stop
- When completed, high chlorinated water is flushed out
- Coordinate with waste water plant before discharging highly chlorinated water into sewer
- Contact State if environmental effects occur

55

TDEC - Fleming Training Center

Methods of Disinfecting

- Tablet Method
- Continuous Feed Method
- Slug Method

56

TDEC - Fleming Training Center

Water Main Cleaning

- Mechanical cleaning may be necessary to clear tuberculation and deposits of older pipes
- Should first try to clean by flushing
- Devices such as swabs or pigs may be needed
- Cleaning operations can increase the flow rates through pipe
- Valves and hydrants should be checked prior to cleaning

57

TDEC - Fleming Training Center

Water Main Cleaning

- Customers notified
- Temporary water service for customers
- Must be able to control pressure surges in system
- Flush until water clear
- Conduct flow test

58

TDEC - Fleming Training Center

Bacteriological Testing

- State requires two consecutive sets of samples taken 24 hours apart **OR** one set 48 hours after disinfecting new lines
- Samples shall be taken from each 2500 feet of main with samples near the beginning and at the end point
- Requires 24 hour incubation
- Must be absent of coliforms
- Must retest if positive for coliforms
- If sample positive two times, must disinfect line again
- DO NOT TAKE SAMPLE FROM HYDRANT OR HOSE

State Rules 1200-5-1-.17(8)(b)

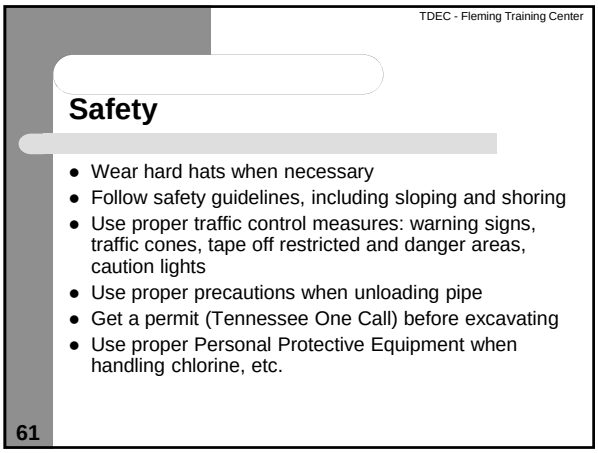
59

TDEC - Fleming Training Center

Site Restoration

- Restored to original condition as soon as possible
- Grass restored, curbs replaced, pavement repaired
- Final inspection should include marked location of valves, hydrants and all in full open position
- Note number of turns to open valves, direction to open
- Check drainage ditches for debris which would facilitate flooding
- Private property must be returned to original condition

60


TDEC - Fleming Training Center
Safety
Wear hard hats when necessary
Follow safety guidelines, including sloping and shoring
Use proper traffic control measures: warning signs, traffic cones, tape off restricted and danger areas, caution lights
Use proper precautions when unloading pipe
Get a permit (Tennessee One Call) before excavating
Use proper Personal Protective Equipment when handling chlorine, etc.
61

Distribution Systems
Pipe Vocabulary

A. Angle of Repose
B. Appurtenance
C. Arterial-Loop System
D. Bedding
E. Continuous-feed Method
F. Corrosion
G. C Value
H. Distribution Main
I. External Load
J. Flexural Strength
K. Grid System
L. Hydrostatic Pressure
M. Internal Load
N. Pig
O. Service Connection
P. Shielding
Q. Shoring
R. Sloping
S. Slug Method
T. Spring Line
U. Stringer
V. Surge Pressure
W. Swab
X. Tablet Method
Y. Tensile Strength
Z. Thrust
AA. Thrust Anchor
BB. Thrust Block
CC. Transmission Line
DD. Tree System
EE. Trench Brace
FF. Upright
GG. Water Hammer

_____1. A select type of soil used to support a pipe or other conduit in a trench.
_____2. The gradual deterioration or destruction of a substance or material by chemical action, frequently induced by electrochemical processes. The action proceeds inward from the surface.
_____3. The horizontal member of a shoring system, running parallel to the trench, to which the trench braces are attached. They hold the uprights against the soil.
_____4. (a) A force resulting from water under pressure and in motion. This force pushes against fittings, valves and hydrants; it can cause couplings to leak or to pull apart entirely. (b) In general, any pushing force.
_____5. The ability of a material to bend (flex) without breaking.
_____6. The horizontal member of a shoring system that runs across a trench, attached to the stringer.
_____7. A method of disinfecting new or repaired mains in which chlorine is continually added to the water being used to fill the pipe, so that a constant concentration can be maintained.
_____8. A framework of wood and/or metal constructed against the walls of a trench to prevent cave-ins.
_____9. Auxiliary equipment, such as valves and hydrants, attached to the distribution system to enable it to function properly.
_____10. A method of disinfecting new or repaired water mains in which calcium hypochlorite tablets are placed in a section of pipe.
_____11. Any pipe in the distribution system other than a service line.
_____12. The horizontal centerline of a pipe.

_____13. A number used in the Hazen-Williams formula, which is used to determine flow capacities of pipelines. It depends on the condition of the inside surface of the pipe. The smoother the surface of the pipe wall, the larger the number and the greater the carrying capacity of the pipeline.
_____14. The pressure, expressed as feet of head or per unit of area (psi), exerted by water at rest (for example, in a nonflowing pipeline).
_____15. A distribution system layout involving a complete loop of arterial mains around the area being served, with branch mains projecting inward to minimize dead ends.
_____16. A method of disinfecting new or repaired water mains in which a high dosage of chlorine is added to a portion of the water used to fill the pipe. This water is allowed to pass through the entire length of pipe being disinfected.
_____17. A distribution system layout in which all ends of the mains are connected to eliminate dead ends.
_____18. A mass concrete cast in place between a fitting to be anchored against thrust and the undisturbed soil at the side or bottom of the pipe trench.
_____19. Polyurethane foam plug, similar to pig but more flexible and less durable.
_____20. The maximum angle or slope from the horizontal that a given loose or granular material, such as sand, can maintain without caving in or sliding; can vary considerably with changes in moisture content.
_____21. The pipeline or aqueduct used for water transmission (from water plant to the distribution system).
_____22. A method of preventing cave-ins by excavating the sides of the trench at an angle so the sides will be stable.
_____23. A method to protect workers against cave-ins through the use of a steel box open at the top, bottom and ends, which allows the workers to work inside the box.
_____24. A distribution system layout that centers around a single arterial main, which decreases in size with length. Branches are taken off at right angles with sub-branches from each branch.
_____25. The ability of pipe or other material to resist breakage when pulled lengthwise.
_____26. The load or force exerted by the water pressure on the inside of the pipe.
_____27. Any load placed on the outside of the pipe from backfill, traffic, or other source.
_____28. A block of concrete, often a roughly shaped cube, cast in place below a fitting to be anchored against vertical thrust, and tied to the fitting with anchor rods.
_____29. The potentially damaging slam, bang, or shudder that occurs in a pipe when a sudden change in water velocity creates a great increase in water pressure.
_____30. A momentary increase of water pressure in a pipeline due to a sudden change in water velocity or direction of flow.
_____31. The vertical member of a shoring system, which is placed against the trench wall.

_____32. That portion of the service line from the utility's water main to the curb stop at or adjacent to the street line or the customer's property line. It includes the curb stop and any other valves, fittings, etc., that the utility may require at or between the main and the curb stop, but does not include the curb box.

_____33. Bullet-shaped polyurethane foam plug, often with a tough, abrasive external coating, used to clean pipelines. It is forced through the pipe by water pressure.

Review Questions

1. List nine important points to be considered when pipe is to be strung at a jobsite.
    -
    -
    -
    -
    -
    -
    -
    -
    -

2. What eight factors usually determine the depth and width of a trench?
    -
    -
    -
    -
    -
    -
    -
    -

3. Why should wide trenches be avoided?

4. Name four danger signs that indicate potential trench failure.
    -
    -
    -
    -

5. What is the angle of repose of soil and why is it important?

6. List five typical causes of trench cave-ins.
    -
    -
    -
    -
    -

7. Why is the proper placement of bedding material important?

8. Explain why thrust blocks and anchors are important. Where should they be used?

9. What type of distribution system configuration is not recommended? Why?

10. What can happen if a valve is opened or closed too quickly?

11. Explain what is meant by the C value of a pipe.

12. List seven unusual pipe installation conditions that might have a bearing on the type of pipe used for a particular installation.
    -
    -
    -
    -
    -
    -

13. List some advantages and disadvantages of ductile-iron pipe.

14. List some advantages and disadvantages of PVC pipe.

Answers to Vocabulary:

1. D
2. F
3. U
4. Z
5. J
6. EE
7. E
8. Q
9. B
10. X
11. H
12. T
13. G
14. L
15. C
16. S
17. K
18. BB
19. W
20. A
21. CC
22. R
23. P
24. DD
25. Y
26. M
27. I
28. AA
29. GG
30. V
31. FF
32. O
33. N

Answers to Review Questions:

1.

- Lay or place pipe as near to the trench as possible to avoid excessive handling.
- If the trench is open, string pipe on the side opposite the spoil bank.
- If the trench is no open, string pipe along the side of the trench opposite the side where excavated material will be placed.
- Place pipe where it will be protected from traffic and heavy equipment.
- Place the bells in the direction of installation progress.
- Place and secure each pipe so there is no chance of it rolling into the trench.
- String only enough pipe for one day if there is danger of vandalism.
- Be aware of the danger of children injuring themselves playing around a strung pipe.
- Cover the ends of a pipe if there is danger of it becoming contaminated.

2.

- Ground frost conditions
- Groundwater conditions
- Traffic load that will be over the pipe
- Soil type
- Type of pipe to be installed
- Economics
- Surface restoration requirements
- Depth of other adjacent utilities

3. They are more expensive to excavate and the load on the pipe can be considerably increased.

4.
    - Tension cracks in the ground surface parallel to the trench
    - Material crumbling off the walls
    - Settling or slumping of the ground near the trench
    - Sudden changes in soil color indicating previous excavation

5. The angle of repose is the angle at which the trench wall should be excavated to prevent cave-ins (unless shoring is used). The angle varies depending on the type of earth material being excavated.
6.
    - Water pressure in the soil
    - External loads, such as equipment being moved close to the edge of the trench
    - The load of excavated soil stacked too closely to the edge of the trench
    - Trench walls excavated too steeply for the type of soil conditions
    - Cleavage planes in the soil caused by previous excavations

7. The pipe must be supported uniformly along its entire length or else breakage can occur when loads are imposed by backfill or traffic.

8. Thrust blocks and anchors are required to restrain joints from opening as a result of the force created when water changes direction. They should be used where flow will change direction at elbows, tees and crosses; where there is a change in pipe diameter; and wherever flow stops or is controlled, such as at valves and dead ends.

9. The tree-type system is not recommended because only a few loops are formed. This arrangement restricts circulation, making it difficult to supply a continuous flow of good-quality water to all parts of the system.

10. Water hammer may result from opening or closing a valve quickly. The increased pressure could then result in broken mains or water services, or it could cause fire hydrants to be pushed out of place if they are not firmly blocked.

11. The C value is an indication of how easily water can move through a pipe. A pipe with a very smooth interior will have a high C value. A pipe with rough interior walls will have a low value.
12. Unusual soil conditions
    Uneven terrain
    High groundwater
    High bedrock
    A river or highway crossing
    Proximity to sewer lines
    Close proximity to other utility services

13. Advantages: good durability, flexural strength, smooth interior (C140), carry capacity, fracture resistance, external corrosion good in most soils, withstand high pressure, long term economical, diversity when combined with different fittings, joints, and valves
    Disadvantages: external corrosion in aggressive environments if not protected, reliant upon special linings to protect against corrosion, costly to maintain, greater weight increases difficulty of installation

14. Advantages: lower cost, cheaper to ship, easier to handle, cuts easier, C Factor less than 150, chemically inert, moderately flexible and will adapt to ground settling
    Disadvantages: susceptible to damage from UV, permeable by organics, requires careful bedding to prevent damage, difficult to locate because nonconductive, inability to be thawed, buckles under a vacuum, must adhere to use of proper tools and procedures when service taps are made

Section 3

Math Review

Solving for the Unknown

TDEC - Fleming Training Center

Basics

- The unknown is a variable in the equation that we are trying to solve.
- The unknown variable is usually represented by a letter such as, ***x***.

2 TDEC - Fleming Training Center

Basics

When solving for an unknown variable, ***x***.

1. ***X*** must be in the numerator.
2. ***X*** must be by itself on one side of the equation

3 TDEC - Fleming Training Center

What if x is not in the numerator?

$\frac{2}{x} = \frac{4}{}$

$\frac{2}{4} = x$

$0.5 = x$

- If x is in the denominator it can trade places with a number on the other side of the = sign.
- Flip-flop
- This is the only time you can move x.
- If x is in the numerator <u>DO NOT MOVE</u> x.

4 TDEC - Fleming Training Center

Practice

$(23)(x)(7.48) = 542$

Step 1 yes
Step 2
$(23)\ (7.48) = 172.04$
$(172.04)\ (x) = 542$

Step 3
$(172.04)\ (x) = 542$

$x = \frac{542}{172.04}$

Step 4
$x = 3.15$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

5 TDEC - Fleming Training Center

Practice

$\frac{(8)(x)}{(3)(3)} = 21$

Step 1 yes
Step 2
$\frac{(8)(x)}{9} = 21$

Step 3
$\frac{(8)(x)}{9} = 21$ $\quad (8)(x) = (21)(9)$ $\quad x = \frac{(21)(9)}{8}$

Step 4
$x = 23.625$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

6 TDEC - Fleming Training Center

Practice

$\frac{80}{x} = 3700$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

Step 1
No
Step 2
Already simplified
Step 3

$\frac{80}{x} = 3700$ $\frac{80}{3700} = x$

Step 4

$0.0216 = x$

7 TDEC - Fleming Training Center

Solving for x^2

- The procedure for solving for x^2 is the same as solving for x.
- There is one extra step at the end.

Step 1. Determine if x^2 is in the numerator
Step 2. Simplify the numbers
Step 3. Get x^2 by itself
Step 4. Solve the equation
Step 5. Take the square root of both sides of the equation

8 TDEC - Fleming Training Center

Solving for x^2

$(x^2)(0.785) = 2826$

Step 1 Yes

Step 2 already simplified

Step 3

$(x^2)(0.785) = 2826$

$(x^2) = \frac{2826}{0.785}$

Step 4

$(x^2) = 3600$

Step 5

$\sqrt{x^2} = \sqrt{3600}$

$x = 60$

Step 1. Determine if x^2 is in the numerator
Step 2. Simplify the numbers
Step 3. Get x^2 by itself
Step 4. Solve the equation
Step 5. Take the square root of both sides of the equation

9 TDEC - Fleming Training Center

Things to remember

- **Only move x if it is the denominator.**
- If x is in the numerator leave x where it is and move the other numbers away from x.
- It does not matter if x is on the left side or the right side of the equation.
- $x = 5$
- $5 = x$
- They mean the same thing!

10 TDEC - Fleming Training Center

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

3. $\frac{233}{x} = 44$

4. $940 = \frac{x}{(0.785)(90)(90)}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

8. $2 = \frac{x}{180}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

11. $19{,}747 = (20)(12)(x)(7.48)$

12. $\dfrac{(15)(12)(1.25)(7.48)}{x} = 337$

13. $\dfrac{x}{(4.5)(8.34)} = 213$

14. $\dfrac{x}{246} = 2.4$

15. $6 = \dfrac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

16. $\dfrac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

17. $109 = \dfrac{x}{(0.785)(80)(80)}$

18. $(x)(3.7)(8.34) = 3620$

19. $2.5 = \dfrac{1{,}270{,}000}{x}$

20. $0.59 = \dfrac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

Finding x^2

21. $(0.785)(D^2) = 5024$

22. $(x^2)(10)(7.48) = 10{,}771.2$

23. $51 = \dfrac{64{,}000}{(0.785)(D^2)}$

24. $(0.785)(D^2) = 0.54$

25. $2.1 = \dfrac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

Area, Volume and Conversions

Fleming Training Center

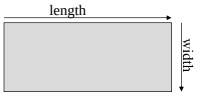
Area

- surface of an object
- two dimensional
- measured in
  - square inches (in^2),
  - square feet (ft^2),
  - square meters (m^2), etc.

Area Formulas

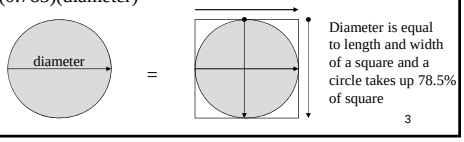
- Rectangle

A = (length)(width)



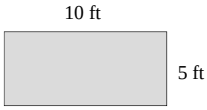
- Circle

$A = (0.785)(diameter)^2$



Diameter is equal to length and width of a square and a circle takes up 78.5% of square

Area of a Rectangle

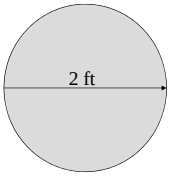


$A = (L)(W)$

$A = (10\ ft)(5\ ft)$

$A = 50\ ft^2$

Area of a Circle



Diameter = 2 ft

$A = (0.785)(D)^2$

$A = (0.785)(2ft)^2$

$A = (0.785)(4\ ft^2)$

$A = 3.14\ ft^2$

Volume

- The amount of space an object occupies
- Volume = (area)(third dimension) or

V = (l)(w)(d)

- Measured in
  - cubic inches (in^3),
  - cubic feet (ft^3),
  - gallons,
  - acre-feet, etc.

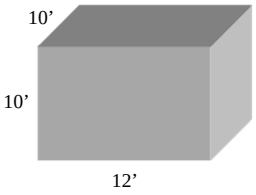
TDEC - Fleming Training Center

Volume of a Rectangular Tank

V = (length)(width)(depth)

V = (12 ft)(10ft)(10ft)

V = 1200 ft^3



7

TDEC - Fleming Training Center

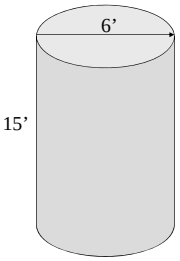
Volume of a Cylinder

V = (0.785)$(D)^2$(height)

V = (0.785)$(6\ ft)^2$(15 ft)

V = (0.785)$(36\ ft^2)$(15 ft)

V = 424 ft^3



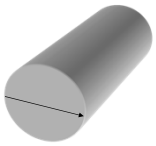
8

TDEC - Fleming Training Center

Note

- When calculating area and volume, if you are given a pipe diameter in inches, convert it to feet.

$$8\ \cancel{in.} \times \frac{1\ ft}{12\ \cancel{in}} = 0.6667\ ft$$



Diameter = 8 in

9

TDEC - Fleming Training Center

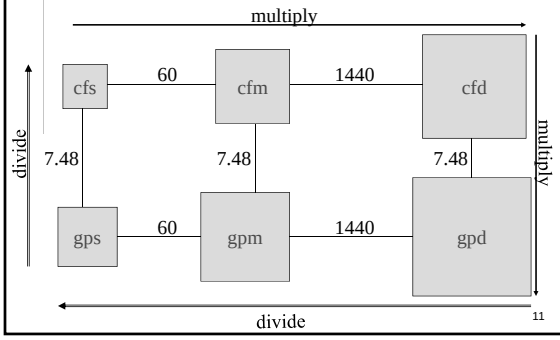
Conversions

- Need to know:
  - The number that relates the two units
  - Ex: 12 inches in a foot, 454 grams in a pound, 3785 mL in a gallon, etc
- Need to know:
  - Whether to multiply or divide
  - Ex: smaller to larger or larger to smaller

10

TDEC - Fleming Training Center

Flow Conversions – Box Method



11

TDEC - Fleming Training Center

Dimensional Analysis

- Dimensional analysis can be used to make sure a calculation is set up correctly
- The units on one side of the equal sign must equal the units on the other side

$$\frac{ft^3}{sec} = \frac{(ft)(ft)(ft)}{sec}$$

12

Dimensional Analysis

- Dimensional analysis can be used to make sure you are finished with your calculation
- If units are written in abbreviated form, write them out in vertical format, gpm=gal/min

$$\frac{\cancel{(ft)(ft)(ft)}}{min} \times \frac{gal}{\cancel{ft^3}} = \frac{gal}{min}$$

13

Math Problem Strategies

Use these rules of operation to approach math problems (*especially when working with formulas*):

1) Work from left to right.
2) Do all the work inside the parentheses first.
3) Do all the multiplication/division above the line (numerator) and below the line (denominator).
4) Then do all the addition and subtraction above and below the line.
5) Perform the division (divided the numerator by the denominator).

Strategy for solving word problems:

1) Read the problem, disregard the numbers (What type of problem is it? What am I asked to find?)
2) Refer to the diagram, if provided. If there isn't one, draw your own.
3) What information do I need to solve the problem, and how is it given in the statement of the problem?
4) Work it out.
5) Does it make sense?

It might be helpful to write out everything that is known in one column and the unknown (what am I asked to find?) in another column. Identify the correct formula and write it in the middle, plug in the numbers and solve.

Known

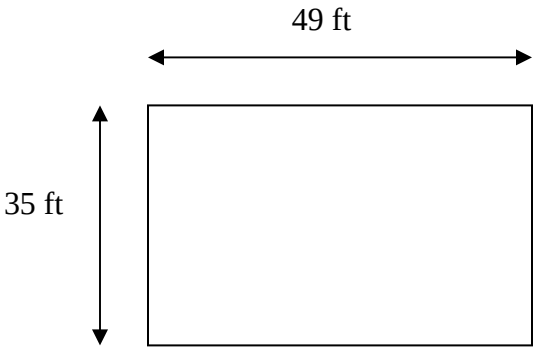
Length = 35 ft
Width = 49 ft

Unknown

Area = ?

$A = (l)(w)$

$A = (35\ ft)(49\ ft)$
$A = 1715\ ft^2$

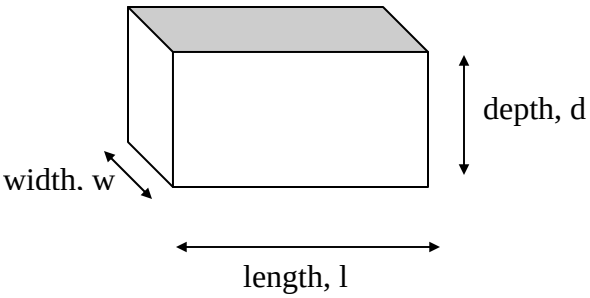


*****Remember: make sure measurements agree; if diameter of pipe is in inches then change to feet; if flow is in MGD and you need feet or feet/sec then change to ft^3/sec before you plug values into formula.***

mega (M)	..	kilo (k)	hecto (h)	deka (da)	no prefix	deci (d)	centi (c)	milli (m)	..	micro (μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

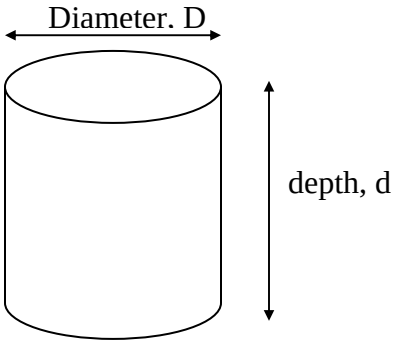
Tank Volume Calculations: Most tank volumes calculations are for tanks that are either rectangular or cylindrical in shape.

Rectangular Tank



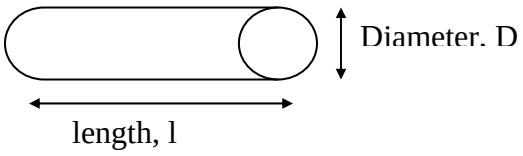
Volume = (l)(w)(d)

Cylindrical Tank



Volume = (0.785) (D)^2 (d)

Portion of a Pipeline



Volume = (0.785) (D)^2 (l)

Applied Math for Distribution
Flow Conversions
(round to the nearest tenth)

1. Express a flow of 5 cfs in terms of gpm.

2. What is 38 gps expressed as gpd?

3. Convert a flow of 4,270,000 gpd to cfm.

4. What is 5.6 MGD expressed as cfs? (round to nearest tenth)

5. Express 423,690 cfd as gpm.

6. Convert 2730 gpm to gpd.

Area, Volume and Conversions

AREA

1. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

2. A tank has a length of 90 feet, a width of 25 feet, and a depth of 10 feet. Calculate the surface area in ft^2.

3. Calculate the cross-sectional area (in ft^2) for a 2 foot main that has just been laid.

4. Calculate the cross-sectional area (in ft^2) for a 24” main that has just been laid.

5. Calculate the cross-sectional area (in ft^2) for a 2 inch line that has just been laid.

VOLUME

6. Calculate the volume (in ft^3) of a tank that measures 10 feet by 10 feet by 10 feet.

7. Calculate the volume (in gallons) of a basin that measures 22 feet by 11 feet by 5 feet deep.

8. Calculate the volume (in gallons) of water in a tank that is 254 feet long, 62 feet wide, and 10 feet deep if the tank only contains 2 feet of water.

9. Calculate the volume of water in a tank (in gallons) that is 12 feet long by 6 feet wide by 5 feet deep and contains 8 inches of water.

10. Calculate the maximum volume of water (in gallons) for a kids' swimming pool that measures 6 feet across and can hold 18 inches of water.

11. How much water (in gallons) can a barrel hold if it measures 3.5 feet in diameter and can hold water to a depth of 4 feet?

12. A water main has just been laid and needs to be disinfected. The main is 30” in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

13. A water main is 10” in diameter and has a length of 5,000 feet. How many million gallons of water will it hold?

14. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to figure 5% of the tank volume. How many gallons will this be?

15. What is 5% of a 1.2 MG tank?

CONVERSIONS

16. How many seconds in 1 minute?

17. How many minutes in 1 hour?

18. How many hours in 1 day?

19. How many minutes in 1 day?

20. The flow through a pipe is 3.6 cfs. What is the flow in gps?

21. The flow through a pipe is 2.4 cfs. What is the flow in gpm?

22. A pump produces 22 gpm. How many cubic feet per hour is that?

23. A treatment plant produces a flow of 6.31 MGD. What is the flow in gpm?

24. A pump produces 700 gpm. How many MGD will the pump flow?

25. A three-eights mile segment of pipeline is to be repaired. How many feet of pipeline is this?

26. If there is a 2,200 gallon tank full of water, how many pounds of water is in the tank?

ANSWERS:

1. 540 ft^2
2. 2,250 ft^2
3. 3.14 ft^2
4. 3.14 ft^2
5. 0.0218 ft^2
6. 1,000 ft^3
7. 9,050.8 gal
8. 235,590 gal
9. 359 gal
10. 317 gal
11. 288 gal
12. 48,442 gal
13. 0.02 MG
14. 150,000 gal
15. 60,000 gal or 0.06 MG
16. 60
17. 60
18. 24
19. 1440
20. 26.9 gps
21. 1,077 gpm
22. 176.5 ft^3/hr
23. 4,382 gpm
24. 1.008 MGD
25. 1,980 ft
26. 18,348 lbs

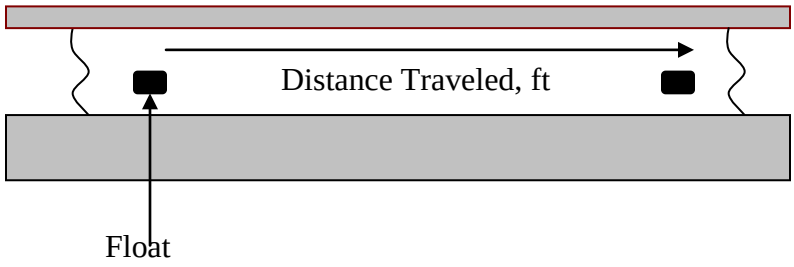
Applied Math for Distribution Systems
Flow and Velocity

Velocity

1. A cork is placed in a channel and travels 370 feet in 2 minutes. What is the velocity of the wastewater in the channel, ft/min?

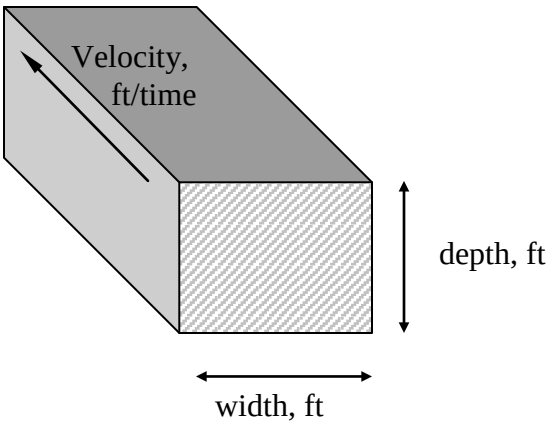
2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec?

3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min?



$$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$$

$$= \text{ft/min}$$



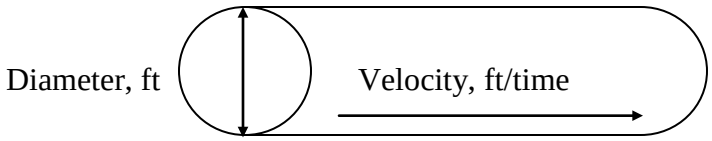
$$\underset{ft^3/time}{Q} = \underset{(ft)(ft)}{(A)} \quad \underset{(ft/time)}{(V)}$$

Flow in a channel

4. A channel 48 inches wide has water flowing to a depth of 1.5 feet. If the velocity of the water is 2.8 ft/sec, what is the flow in the channel in cu ft/sec?

5. A channel 3 feet wide has water flowing to a depth of 2.5 feet. If the velocity through the channel is 120 feet/min, what is the flow rate in cu ft/min? in MGD?

6. A channel is 3 feet wide and has water flowing at a velocity of 1.5 ft/sec. If the flow through the channel is 8.1 ft^3/sec, what is the depth of the water in the channel in feet?



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)} \quad \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\,(D)^2\,(vel)$$
$$(ft)(ft)\ (ft/time)$$

Flow through a full pipe

7. The flow through a 2 ft diameter pipeline is moving at a velocity of 3.2 ft/sec. What is the flow rate in cu ft/sec?

8. The flow through a 6 inch diameter pipeline is moving at a velocity of 3 ft/sec. What is the flow rate in ft^3/sec?

9. The flow through a pipe is 0.7 ft^3/sec. If the velocity of the flow is 3.6 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

Percent Practice Problems

Convert the following fractions to decimals:

1. ¾
2. ⅝
3. ¼
4. ½

Convert the following percents to decimals:

5. 35%
6. 99%
7. 0.5%
8. 30.6%

Convert the following decimals to percents:

9. 0.65
10. 0.125
11. 1.0
12. 0.05

Calculate the following:

13. 15% of 125
14. 22% of 450
15. 473 is what % of 2365?
16. 1.3 is what % of 6.5?

Answers for Solving for the Unknown

Basics – Finding x

1.	1.8	8.	360	15.	2817
2.	5.7	9.	1649	16.	49.03
3.	5.3	10.	244.7	17.	547,616
4.	5,976,990	11.	11	18.	117
5.	8256.6	12.	5	19.	508,000
6.	8.1	13.	7994	20.	0.35
7.	0.005	14.	590.4		

Finding x^2

21.	80	23.	40	25.	10.9
22.	12	24.	0.83		

Percent Practice Problems

1.	0.75	7.	0.005	13.	18.75
2.	0.625	8.	0.306	14.	99
3.	0.25	9.	65%	15.	20%
4.	0.5	10.	12.5%	16.	20%
5.	0.35	11.	100%		
6.	0.99	12.	5%		

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

$8.1 = (4.5)(x)$

$\frac{8.1}{4.5} = x$

$\boxed{1.8 = x}$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

$(0.0854865)(x) = 0.49$

$x = \frac{0.49}{0.0854865}$

$\boxed{x = 5.73}$

3. $\frac{233}{x} = 44$

$233 = (44)(x)$

$\frac{233}{44} = x$

$\boxed{5.29 = x}$

4. $940 = \frac{x}{(0.785)(90)(90)}$

$940 = \frac{x}{6358.5}$

$(940)(6358.5) = x$

$\boxed{5,976,990 = x}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

$x = \frac{4128.3}{0.5}$

$\boxed{x = 8256.6}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

$(56.5)(8.34)(x) = 3800$

$(471.21)(x) = 3800$

$x = \frac{3800}{471.21}$

$\boxed{x = 8.06}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

$114 = \frac{2205.93}{(3846.5)(x)}$

$(114)(3846.5)(x) = 2205.93$

$x = \frac{2205.93}{(114)(3846.5)}$

$\boxed{x = 0.005}$

8. $2 = \frac{x}{180}$

$(2)(180) = x$

$\boxed{360 = x}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

$46 = \frac{(875.7)(x)}{31400}$

$(46)(31400) = (875.7)(x)$

$\frac{(46)(31400)}{875.7} = x$

$\boxed{1649.4 = x}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

$(2.4)(x) = (0.785)(5)(5)(4)(7.48)$

$x = \frac{(0.785)(5)(5)(4)(7.48)}{2.4}$

$\boxed{x = 245}$

11. $19{,}747 = (20)(12)(x)(7.48)$

$19.747 = (1795.2)(x)$

$\frac{19747}{1795.2} = x$

$10.99 = x$

12. $\frac{(15)(12)(1.25)(7.48)}{x} = 337$

$(15)(12)(1.25)(7.48) = (337)(x)$

$\frac{(15)(12)(1.25)(7.48)}{337} = x$

$4.99 = x$

13. $\frac{x}{(4.5)(8.34)} = 213$

$x = (213)(4.5)(8.34)$

$x = 7993.89$

14. $\frac{x}{246} = 2.4$

$x = (2.4)(246)$

$x = 590.4$

15. $6 = \frac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

$\frac{(6)(65)(1.3)(8.34)}{(0.18)(8.34)} = x$

$2817 = x$

16. $\frac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

$90072 = (23.4)(0.785)(x)$

$90072 = (18.369)(x)$

$\frac{90072}{18.369} = x$

$4903.5 = x$

17. $109 = \frac{x}{(0.785)(80)(80)}$

$(109)(0.785)(80)(80) = x$

$547616 = x$

18. $(x)(3.7)(8.34) = 3620$

$x = \frac{3620}{(3.7)(8.34)}$

$x = 117$

19. $2.5 = \frac{1{,}270{,}000}{x}$

$(2.5)(x) = 1{,}270{,}000$

$x = \frac{1270000}{2.5}$

$x = 508{,}000$

20. $0.59 = \frac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

$0.59 = \frac{3431.076}{(16513.2)(x)}$

$(0.59)(16513.2)(x) = 3431.076$

$(9742.788)(x) = 3431.076$

$x = \frac{3431.076}{9742.788}$

$x = 0.35$

Finding x^2

21. $(0.785)(D^2) = 5024$

$$\frac{D^2}{0.785} = \frac{5024}{0.785}$$
$$\sqrt{D^2} = \sqrt{6400}$$
$$D = 80$$

22. $(x^2)(10)(7.48) = 10{,}771.2$

$$(x^2)(74.8) = 10771.2$$
$$(x^2) = \frac{10771.2}{74.8}$$
$$\sqrt{x^2} = \sqrt{144}$$
$$x = 12$$

23. $51 = \frac{64{,}000}{(0.785)(D^2)}$

$$(51)(0.785)(D^2) = 64{,}000$$
$$D^2 = \frac{64000}{(51)(0.785)}$$
$$\sqrt{D^2} = \sqrt{1598.6}$$
$$D = 39.98$$

24. $(0.785)(D^2) = 0.54$

$$D^2 = \frac{0.54}{0.785}$$
$$\sqrt{D^2} = \sqrt{0.6879}$$
$$D = 0.829$$

25. $2.1 = \frac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

$$2.1 = \frac{(88.077)(D^2)}{5024}$$
$$(2.1)(5024) = (88.077)(D^2)$$
$$\frac{(2.1)(5024)}{88.077} = D^2$$
$$\sqrt{119.786} = \sqrt{D^2}$$
$$10.94 = D$$

Percent Practice Problems

Convert the following fractions to decimals:

1. ¾ 0.75
2. ⅝ 0.625
3. ¼ 0.25
4. ½ 0.5

Convert the following percents to decimals:

5. 35% $\frac{35}{100} =$ 0.35
6. 99% $\frac{99}{100} =$ 0.99
7. 0.5% $\frac{0.5}{100} =$ 0.005
8. 30.6% $\frac{30.6}{100} =$ 0.306

Convert the following decimals to percents:

9. 0.65 (0.65)(100) = 65%
10. 0.125 (0.125)(100) = 12.5%
11. 1.0 (1.0)(100) = 100%
12. 0.05 (0.05)(100) = 5%

Calculate the following: "of" means multiply; "is" means equal to

13. 15% of 125 (0.15)(125) = 18.75
14. 22% of 450 (0.22)(450) = 99
15. 473 is what % of 2365? $473 = (\%)(2365) \rightarrow \frac{473}{2365} = x$

$0.2 = x$

$(0.2)(100) = x$

$20\% = x$

16. 1.3 is what % of 6.5? $1.3 = (x)(6.5)$

$\frac{1.3}{6.5} = x$

$0.2 = x$

$20\% = x$

Area, Volume and Conversions

AREA

1. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

Area = (length)(width)
$A = (45 ft)(12 ft)$
$A = 540 ft^2$

2. A tank has a length of 90 feet, a width of 25 feet, and a depth of 10 feet. Calculate the surface area in ft^2.

$A = (90 ft)(25 ft)$
$A = 2250 ft^2$

3. Calculate the cross-sectional area (in ft^2) for a 2 foot main that has just been laid.

$A = (0.785)(diameter)^2$
$A = (0.785)(2 ft)^2$
$A = 3.14 ft^2$

4. Calculate the cross-sectional area (in ft^2) for a 24" main that has just been laid.

$A = (0.785)(2 ft^2)$
$A = 3.14 ft^2$

24 in = 2 ft

5. Calculate the cross-sectional area (in ft^2) for a 2 inch line that has just been laid.

$A = (0.785)(0.1667 ft)^2$
$A = 0.022 ft^2$

$\frac{2 in \mid 1 ft}{12 in} = 0.1667 ft$

VOLUME

6. Calculate the volume (in ft^3) of a tank that measures 10 feet by 10 feet by 10 feet.

Volume = (length)(width)(depth)

Vol = (10 ft)(10ft)(10ft)

Vol = 1000 ft^3

7. Calculate the volume (in gallons) of a basin that measures 22 feet by 11 feet by 5 feet deep.

Vol = (22ft)(11ft)(5ft)

Vol = (1210 ft^3)(7.48 gal/ft^3)

Vol = 9050.8 gal

8. Calculate the volume (in gallons) of water in a tank that is 254 feet long, 62 feet wide, and 10 feet deep if the tank only contains 2 feet of water.

Vol = (254 ft)(62ft)(2 ft)

Vol = (31496 ft^3)(7.48 gal/ft^3)

Vol = 235,590.08 gal

9. Calculate the volume of water in a tank (in gallons) that is 12 feet long by 6 feet wide by 5 feet deep and contains 8 inches of water.

$\frac{8\,in}{12\,in}\left|\frac{1\,ft}{}\right. = 0.6667\,ft$

Vol = (12 ft)(6 ft)(0.6667 ft)

Vol = (48 ft^3)(7.48 gal/ft^3)

Vol = 359.04 gal

10. Calculate the maximum volume of water (in gallons) for a kids' swimming pool that measures 6 feet across and can hold 18 inches of water.

$\frac{18\,in}{12\,in}\left|\frac{1\,ft}{}\right. = 1.5\,ft$

Vol = (0.785)(6ft)^2(1.5 ft)

Vol = (42.39 ft^3)(7.48 gal/ft^3)

Vol = 317.1 gal

11. How much water (in gallons) can a barrel hold if it measures 3.5 feet in diameter and can hold water to a depth of 4 feet?

Vol = (0.785)(3.5)(3.5)(4.ft)

Vol = (38.465 ft^3)(7.48 gal/ft^2)

Vol = 287.7 gal

12. A water main has just been laid and needs to be disinfected. The main is 30" in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

$\frac{30\text{ in}}{1}\left|\frac{1\text{ ft}}{12\text{ in}}\right. = 2.5\text{ ft}$ $\quad \frac{0.25\text{ mi}}{1}\left|\frac{5280\text{ ft}}{1\text{ mi}}\right. = 1320\text{ ft}$

$Vol = (0.785)(2.5\text{ ft})(2.5\text{ ft})(1320\text{ ft})$

$Vol = (6476.25\text{ ft}^3)(7.48\text{ gal/ft}^3)$

$Vol = 48,442.35\text{ gal}$

13. A water main is 10" in diameter and has a length of 5,000 feet. How many million gallons of water will it hold?

$\frac{10\text{ in}}{1}\left|\frac{1\text{ ft}}{12\text{ in}}\right. = 0.83\text{ ft}$

$Vol = (0.785)(0.83\text{ ft})(0.83\text{ ft})(5000\text{ ft})$

$Vol = (3270.83\text{ ft}^3)(7.48\text{ gal/ft}^3)$

$Vol = \frac{24465.8\text{ gal}}{1,000,000} = 0.024\text{ MG}$

14. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to figure 5% of the tank volume. How many gallons will this be?

$(3,000,000\text{ gal})(0.05) = 150,000\text{ gal}$

15. What is 5% of a 1.2 MG tank?

$(1,200,000\text{ gal})(0.05) = 60,000\text{ gal}$

CONVERSIONS

16. How many seconds in 1 minute?

60

17. How many minutes in 1 hour?

60

18. How many hours in 1 day?

24

19. How many minutes in 1 day?

1440

21. The flow through a pipe is 2.4 cfs. What is the flow in gpm?

$(2.4)(7.48)(60) = 1077.12$ gpm

$$\frac{2.4\ ft^3}{sec} \left| \frac{7.48\ gal}{ft^3} \right| \frac{60\ sec}{min}$$

22. A pump produces 22 gpm. How many cubic feet per hour is that?

$$\frac{(22)(60)}{7.48} = 176.5\ ft^3/hr$$

$$\frac{22\ gal}{min} \left| \frac{ft^3}{7.48\ gal} \right| \frac{60\ min}{hr} =$$

23. A treatment plant produces a flow of 6.31 MGD. What is the flow in gpm?

$$\frac{(6.31)(1000000)}{1440} = 4381.9\ gal/min$$

$$\frac{6.31\ MG}{day} \left| \frac{1000000\ gal}{MG} \right| \frac{day}{1440\ min}$$

24. A pump produces 700 gpm. How many MGD will the pump flow?

$$\frac{(700)(1440)}{1000000} = 1.008\ MGD$$

$$\frac{700\ gal}{min} \left| \frac{1440\ min}{day} \right| \frac{MG}{1000000\ gal}$$

25. A three-eights mile segment of pipeline is to be repaired. How many feet of pipeline is this?

$$3/8 = 0.375\ mi \left| \frac{5280\ ft}{mi} \right. = 1980\ ft$$

26. If there is a 2,200 gallon tank full of water, how many pounds of water is in the tank?

$(2200)(8.34) = 18348$ lb

$$\frac{2200\ gal}{} \left| \frac{8.34\ lb}{gal} \right.$$

ANSWERS:

1. 540 ft^2
2. 2,250 ft^2
3. 3.14 ft^2
4. 3.14 ft^2
5. 0.0218 ft^2
6. 1,000 ft^3
7. 9,050.8 gal
8. 235,590 gal
9. 359 gal
10. 317 gal
11. 288 gal
12. 48,442 gal
13. 0.02 MG
14. 150,000 gal
15. 60,000 gal or 0.06 MG
16. 60
17. 60
18. 24
19. 1440
20. 26.9 gps
21. 1,077 gpm
22. 176.5 ft^3/hr
23. 4,382 gpm
24. 1.008 MGD
25. 1,980 ft
26. 18,348 lbs

Applied Math for Distribution
Flow Conversions

1. Express a flow of 5 cfs in terms of gpm.

$(5)(7.48)(60) = 2244$ gpm

$$\frac{5\ ft^3}{sec} \left| \frac{7.48\ gal}{ft^3} \right| \frac{60\ sec}{min}$$

2. What is 38 gps expressed as gpd?

$(38)(60)(1440) = 3,283,200$ gpd

$$\frac{38\ gal}{sec} \left| \frac{60\ sec}{min} \right| \frac{1440\ min}{day}$$

3. Convert a flow of 4,270,000 gpd to cfm.

$$\frac{(4,270,000)}{(1440)(7.48)} = 396\ ft^3/min$$

$$\frac{4,270,000\ gal}{day} \left| \frac{day}{1440\ min} \right| \frac{ft^3}{7.48\ gal}$$

4. What is 5.6 MGD expressed as cfs? (round to nearest tenth)

$$\frac{(5.6)(1000\,000)}{(1440)(60)(7.48)} = 8.7\ cfs$$

$$\frac{5.6\ MG}{day} \left| \frac{1000\,000\ gal}{MG} \right| \frac{day}{1440\ min} \left| \frac{min}{60\ sec} \right| \frac{ft^3}{7.48\ gal}$$

5. Express 423,690 cfd as gpm.

$$\frac{(423,690)(7.48)}{1440} = 2200.8\ gpm$$

$$\frac{423,690\ ft^3}{day} \left| \frac{7.48\ gal}{ft^3} \right| \frac{day}{1440\ min}$$

6. Convert 2730 gpm to gpd.

$(2730)(1440) = 3,931,200$ gpd

$$\frac{2730\ gal}{min} \left| \frac{1440\ min}{day} \right.$$

Applied Math for Distribution
Flow and Velocity

Velocity

1. A cork is placed in a channel and travels 370 feet in 2 minutes. What is the velocity of the wastewater in the channel, ft/min?

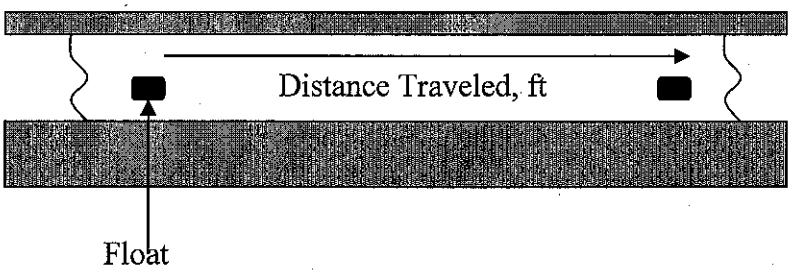
$$V = \frac{\text{distance}}{\text{time}} \qquad V = \frac{370\text{ ft}}{2\text{ min}} = 185\text{ ft/min}$$

2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec? 2 min 14 sec = 2(60) + 14 = 134 sec

$$V = \frac{300\text{ ft}}{134\text{ sec}} = 2.2\text{ ft/sec}$$

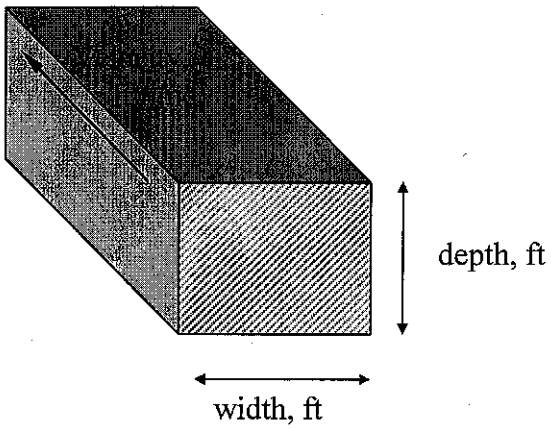
3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min? 30 sec = 0.5 min

$$V = \frac{105\text{ ft}}{0.5\text{ min}} = 210\text{ ft/min}$$



$$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$$

$$= \text{ft/min}$$



Q	=	(A)	(V)
ft^3/time		(ft)(ft)	(ft/time)

A = (width)(depth)

Flow in a channel

4. A channel 48 inches wide has water flowing to a depth of 1.5 feet. If the velocity of the water is 2.8 ft/sec, what is the flow in the channel in cu ft/sec? 48 in = 4 ft

$Q = (4ft)(1.5ft)(2.8\ ft/sec)$

$Q = 16.8\ ft^3/sec$

5. A channel 3 feet wide has water flowing to a depth of 2.5 feet. If the velocity through the channel is 120 feet/min, what is the flow rate in cu ft/min? in MGD?

$Q = (3ft)(2.5ft)(120\ ft/min)$

$Q = 900\ ft^3/min$ ⟶ use flow chart to convert

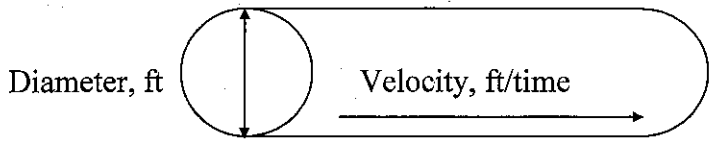
$Q = 9.69$ MGD

6. A channel is 3 feet wide and has water flowing at a velocity of 1.5 ft/sec. If the flow through the channel is 8.1 ft^3/sec, what is the depth of the water in the channel in feet?

$8.1\ ft^3/sec = (3ft)(depth)(1.5\ ft/sec)$

$\frac{8.1\ ft^3/sec}{(3ft)(1.5\ ft/sec)} = depth$

$1.8ft = depth$



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)}\ \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\ \underset{(ft)(ft)}{(D)^2}\ \underset{(ft/time)}{(vel)}$$

Flow through a full pipe

7. The flow through a 2 ft diameter pipeline is moving at a velocity of 3.2 ft/sec. What is the flow rate in cu ft/sec?

$Q = (0.785)(2ft)^2(3.2\ ft/sec)$

$Q = (0.785)(4ft^2)(3.2\ ft/sec)$

$Q = 10.05\ ft^3/sec$

8. The flow through a 6 inch diameter pipeline is moving at a velocity of 3 ft/sec. What is the flow rate in ft^3/sec? $6\ in = 0.5ft$

$Q = (0.785)(0.5)(0.5)(3\ ft/sec)$

$Q = 0.59\ ft^3/sec$

9. The flow through a pipe is 0.7 ft^3/sec. If the velocity of the flow is 3.6 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

$0.7\ ft^3/sec = (0.785)(D)^2(3.6\ ft/sec)$

$\frac{0.7\ ft^3/sec}{(0.785)(3.6\ ft/sec)} = D^2$

$\sqrt{0.2477\ ft^2} = \sqrt{D^2} \longrightarrow D = 0.50\ ft = 6\ in$

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

$8\ in \left|\frac{1\ ft}{12\ in}\right. = 0.667\ ft$

$Q = (0.785)(0.6667\ ft)^2(3.4\ ft/sec)$

$Q = 1.1862\ ft^3/sec \longrightarrow$ use flow chart

$Q = 532.4\ gal/min$

Section 4

Water Tanks

TDEC - Fleming Training Center

Storage Tanks

Disinfection
Rules and Regulations
Fleming Training Center

1

TDEC - Fleming Training Center

Storage Tanks

- Objectives:
  - Reasons for storing water
  - Operating storage and emergency storage
  - Size and location for storage tanks
  - Operation and maintenance
  - Rules and Regulations

2

TDEC - Fleming Training Center

Purpose of Water Storage

- Equalizing supply and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs

3

TDEC - Fleming Training Center

Purpose of Water Storage

- Providing water during power or pump failure
- Providing adequate water for fire fighting
- Providing surge relief
- Increasing detention times
- Blending water sources
- Decrease pumping costs

4

TDEC - Fleming Training Center

Capacity Requirements

- Based on maximum water demands in different parts of the system
- Too much storage can cause stagnant water and taste & odor problems
  - 20% turnover rate to prevent it from becoming septic
    - less sediment

5

TDEC - Fleming Training Center

Type of Service

- Operating Storage
  - Tank directly connected to distribution piping
  - Fills and empties based on system pressure
- Emergency Storage
  - Used on for emergency, e.g. fire protection
  - Not suitable for potable use
  - Subject to freezing due to lack of circulation

6

TDEC - Fleming Training Center

Configuration of Storage Tanks

- Elevated Tanks
- Ground-Level Reservoirs
- Standpipes
- Hydropneumatic System

7

TDEC - Fleming Training Center

Elevated Tanks

- Supported by steel or concrete tower
- Maintains adequate and uniform pressure
- Minimizes variations in pressure due to turning pumps on or off
- May require altitude valve to prevent overflow
- More expensive than ground tanks
- Need altitude valves
  - one way are best

8

TDEC - Fleming Training Center

Standpipes

- Tank rests on ground, has greater height than diameter
- Stores volumes at low pressure
- Water must be turned over frequently to avoid stagnation
  - 20% is bare minimum
- Located at high points in land elevation

9

TDEC - Fleming Training Center

Ground-Level Reservoirs

- For raw water - lakes, ponds, basins
- For finished water - ground level or underground tanks
  - Lower initial cost than elevated tank, but requires pumps to move water
  - Main disadvantage is cost of booster pump station that must be used with the tank

10

TDEC - Fleming Training Center

Ground-Level Reservoirs

This is an old open-topped reservoir that has been converted with a liner-cover

11

TDEC - Fleming Training Center

Hydropneumatic System

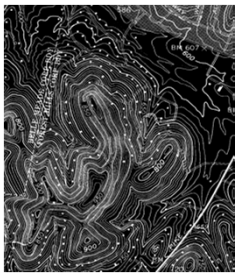
- Partially filled with water, partially filled with compressed air (2/3 to 1/3)
- Air helps maintain pressure in the tank
- Usually for very small water systems

12

TDEC - Fleming Training Center

Selection and Location of Storage

- Determined by hydraulics, water demand, elevation of terrain, purpose of tank, etc.
- Type of storage depends on purpose of tank



13

TDEC - Fleming Training Center

Tank Equipment

- Monitoring Devices
  - Pressure sensor at base of tank
    - altitude valve
  - Level sensor inside tank
  - Data transmitted to central location - alarms can alert operator of high or low levels

14

TDEC - Fleming Training Center

Tank Equipment

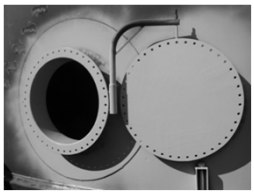
- Air Vents
  - Allow air to enter and escape as water level rises and falls
  - Require screens to keep out birds, other contaminants
  - Mesh should be #24 and stainless steel

15

TDEC - Fleming Training Center

Tank Equipment

- Access Hatches
  - For entry and ventilation during maintenance
  - Hatch on roof requires rim to prevent runoff from entering tank
  - Hatch at bottom of tank must withstand tank pressure
  - Must be secured to prevent vandalism; locks must be in place since 9/11



16

TDEC - Fleming Training Center

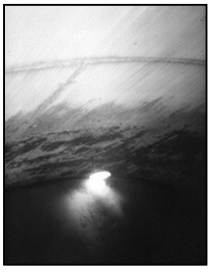
Tank Equipment

- Ladders
  - Most ladders begin about 8 ft from ground to deter unauthorized use
  - May extend to ground if heavy metal shield is locked in place to prevent unauthorized entry
  - All ladders must meet OSHA regs, including safety cage

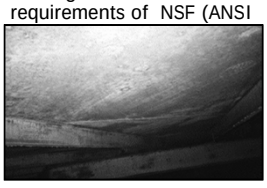
17

TDEC - Fleming Training Center

Tank Equipment



- Coatings
  - Protect interior and exterior of tank from corrosion without causing taste & odor problems
  - Coatings must meet the requirements of NSF (ANSI



18

TDEC - Fleming Training Center

Tank Equipment

- Cathodic Protection
  - Can assist in corrosion control
  - Electrodes placed in tank which corrode instead of tank and appurtenances
  - Inspect annually

19

TDEC - Fleming Training Center

Tank Inspections

- Must be professionally inspected every 5 years in accordance with State requirements (Rule 33)
  - inspection by draining or by using a diver

20

TDEC - Fleming Training Center

Tank Inspections

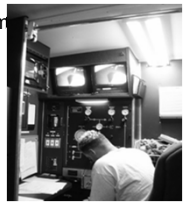
- Inspection reports must be on file and available for review by State Sanitary Inspectors
- Visual inspections recommended annually

21

TDEC - Fleming Training Center

Inspection

- Requires draining the tank or using divers
- Check vents, overflows, paint, altitude valves, etc.
- Check for corrosion inside & outside
- Considered confined space, get perm



22

TDEC - Fleming Training Center

Storage Tank Collapse

White City, Oregon

- Caused by massive leak in 42 inch water main (50,000 gallon per minute) which quickly drained the tank.
- Vacuum formed sucking in the roof.

23

TDEC - Fleming Training Center

Vandalism and Security

- Fencing, locks on access to manholes and other necessary precautions shall be provided to prevent trespassing, vandalism and sabotage

24

TDEC - Fleming Training Center

Records

- Every tank in your system should have a historical record file containing as a minimum the most current inspection report.
- Location, type of maintenance or repair performed, all contract documents and specifications for repair, paint and equipment submittals, etc.

25

TDEC - Fleming Training Center

Safety

- Follow regulations for confined spaces
- Inspect ladders and safety cages for damage
- Use protective equipment
- Provide ventilation inside tank when inspecting
- Provide adequate lighting with proper wiring to prevent shock hazard

26

TDEC - Fleming Training Center

AWWA Standard for Disinfection of Water-Storage Facilities

- Before placing into service, all storage tanks shall be disinfected
- There are standards for disinfecting storage tanks covered by ***AWWA C652*** which covers materials, tank preparation, disinfectant application and sampling for coliform bacteria

27

TDEC - Fleming Training Center

Forms of Chlorine for Disinfection

- Liquid Chlorine
  - 100% available chlorine
- Sodium Hypochlorite
  - 5-15% available chlorine
- Calcium Hypochlorite
  - 65% available chlorine

28

TDEC - Fleming Training Center

Methods of Chlorination

- Method 1
  - water-tank shall be filled to overflow level with enough chlorine added to maintain at least 10 mg/L residual for 24 hour period

29

TDEC - Fleming Training Center

Methods of Chlorination

- Method 2
  - a solution of 200 mg/L available chlorine is applied directly to the entire surface of the storage tank that comes in contact with water when it is full for at least 30 minutes
  - applied by brushing on or spraying on
  - tank should be flushed with potable water before put back into service
    - WARNING - experienced operators only; hazardous to attempt


TDEC - Fleming Training Center

Methods of Chlorination

- Method 3
  - Water and chlorine are added to the storage tank to make a 50 mg/L available chlorine that fills about 5% of the total storage volume.
  - This is held in the tank for no less than 6 hours.
  - The tank is then filled up to the overflow level and held for at least 24 hours.
  - There should be a 2 mg/L residual chlorine remaining after 24 hour period.
  - All highly chlorinated water needs to be drained.

31

TDEC - Fleming Training Center

Methods of Chlorination

Acceptable sampling station at foot of water tank

- Bacteriological Sampling and Testing
  - storage tanks must be tested for coliform bacteria after chlorination procedure and before it is put back into service
  - if positive sample occurs, sampling should be repeated until two consecutive samples are negative
    - if this does not occur, tank must be disinfected again and then tested

32

TDEC - Fleming Training Center

Rules and Regulations

- From Community Public Water Systems Design Criteria Division of Water Supply Tennessee Department of Environment and Conservation, 1997; Part 8

33

TDEC - Fleming Training Center

Rules and Regulations

8.0.2 Protection - All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.

8.0.3 Protection from Trespassers - Fencing, locks on access to manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

8.0.4 Drains - No drain on a water storage structure may have a direct connection to sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

34

TDEC - Fleming Training Center

Rules and Regulations

8.0.5 Overflow - The overflow pipe of a water storage structure should be brought down near the ground ... No overflow may be connected directly to a sewer or storm drain.

C. The overflow shall be protected with a 24 mesh non-corrodible screen with a flap valve.

8.0.6 Access - Manholes on scuttles above waterline.

a. shall be ... on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod

35

TDEC - Fleming Training Center

Rules and Regulations

8.0.7 Vents - Finished water storage structures shall be vented by special vent structures.

a. shall prevent the entrance of surface water

b. shall exclude birds and animals

d. shall on ground-level structures ... be covered with 24-mesh non-corrodible screen cloth

36

TDEC - Fleming Training Center

Rules and Regulations

8.0.10 Safety - safety shall be considered ...

a. ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

8.0.14 Painting and/or Cathodic Protection - Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. paint systems consistent with current AWWA standards, or ... all paints must be acceptable to FDA and EPA for contact with potable water

b. Cathodic protection should be designed and installed by competent technical personnel

37

TDEC - Fleming Training Center

Rules and Regulations

8.0.15 Turnover of water - If the storage reservoir is sized larger than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water tank and/or booster chlorination.

8.0.16 Sampling - A suitable sampling tap should be provided on all storage structures and be protected from public access.

8.0.17 Disinfection - Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put in service.

8.2.5 (Pressure Tanks) Auxiliary power - Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow.

38

TDEC - Fleming Training Center

Rules and Regulations Distribution Storage

8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage.

8.3.4 Level Controls - Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Telemeter equipment should be used when pressure-type controls are employed and any appreciable head loss occurs in the distribution system ...

b. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system

39

TANK DISINFECTION FORM

Employee Name: _____

Address/Location_____

Work Order Number_____

Project Name: _____ Project Number_____

Size of Water Tank: _____gallons (_____MG)

Disinfection Procedure: Method 1 Method 2 Method 3 Other: _____

#s of HTH: _____ Contact Time (hrs): _____

Source of Sample: Fire Hydrant No. _____ Blow-off location _____

Sample Collected by: _____ Sample Transported by: _____

Date Collected: _____ Time Collected: _____ AM/PM

Comments: _____

_____

Lab Sample Number: _____ Date Tested: _____ Time Tested: _____AM/PM

ALL UNITS ARE IN mg/L, UNLESS OTHERWISE NOTED

ANALYSIS REQUESTED	RESULTS	x	ANALYSIS REQUESTED	RESULTS	x
Field Measurements			MICROBIOLOGICAL		
Chlorine, Free Res.			Total Coliform		
Temperature F/C			Heterotrophic Plate Count		

Only methodologies as recommended and approved by the United States Environmental Protection Agency and by the most recent Federal Register have been used. The results obtained are true and accurate to the best of my knowledge.

LABORATORY OFFICIAL:_____ DATE:_____

Form accepted by TDEC representative _____ DATE: _____

Ground Storage Tank Inspection Report

Job No.: _____ Date: _____ Inspector: _____

Tank owner: _____ Owner's order #: _____

Owner's representative: _____ Title: _____

Mailing address: _____

Physical address: _____

City, State: _____ Zip: _____

County tank is located: _____ Seismic zone of county: _____

Telephone: _____ Fax: _____

Location of tank: _____

Original Contractor #: _____ Year built: _____

Original Manufacturer: _____ Capacity: _____

Date of last inspection: _____

Diameter: _____ Height: _____

Type of construction: Welded: _____ Riveted: _____

Who is customer's insurance carrier? _____

Storage Tank Vocabulary

A. Altitude Valve
B. Booster Disinfection
C. Cathodic Protection
D. Elevated Storage
E. Elevated Tank
F. Emergency Storage
G. Fire Demand
H. Ground-level tank
I. Hydropneumatic System
J. Overflow Level
K. Peak Hour Demand
L. Reservoir
M. Riser
N. Silt Stop
O. Standpipe
P. Tank

_____1. The required fire flow and the duration for which it is needed, usually expressed as gallons per minute for a certain number of hours. Also used to denote the total quantity of water needed to deliver the required fire flow for a specified number of hours.
_____2. The greatest volume of water in an hour that must be supplied by a water system during any particular time period.
_____3. A device placed at the outlet of water storage tanks to prevent silt or sediment from reaching the customer.
_____4. An electrical system for preventing corrosion to metals, particularly metallic pipes and tanks.
_____5. A system using an airtight tank in which air is compressed over water (separated from the air by a flexible diaphragm). The air imparts pressure to water in the tank and the attached distribution pipelines.
_____6. A structure used in a water system to contain large volumes of water or other liquids.
_____7. The maximum height that water or liquid will rise in a receptacle before it flows over the overflow rim.
_____8. A valve that automatically shuts off water flow when the water level in an elevated tank reaches a preset elevation then opens again when the pressure on the system side is less than that on the tank side.
_____9. Storage volume reserved for catastrophic situations, such as supply-line break or pump-station failure.
_____10. (a) Any tank or basin used for the storage of water. (b) A ground-level storage tank for which the diameter is greater than the height.
_____11. A ground-level water storage tank for which the height is greater than the diameter.
_____12. In the distribution system, storage of water in a tank whose bottom is at or below the surface of the ground.
_____13. In any distribution system, storage of water in a tank supported on a tower above the surface of the ground.
_____14. The vertical supply pipe to an elevated tank.
_____15. A water distribution storage tank that is raised above the ground and supported by posts or columns.
_____16. The practice of adding additional disinfectant in the distribution system.

Storage Tank Review Questions

1. List 9 reasons for providing water storage in a distribution system.
   -
   -
   -
   -
   -
   -
   -
   -
   -
2. List the 4 types of distribution storage tanks and a description of each.
   -
   -
   -
   -
3. What is the difference between operating storage and emergency storage?

4. Why should vent openings on storage tanks be screened?

5. What is the purpose of an altitude valve?

6. How often must storage tanks be inspected according to the Regulations for Public Water Systems and Drinking water Quality for the State of Tennessee?

7. After disinfection, what must be done before a tank is put back in service?

8. Name four things that should be considered when determining the type and the site for a new storage tank.
   -
   -
   -
   -

9. Why should the overflow pipe on a storage tank never be directly connected to a sewer or storm drain?

10. How are storage tanks protected from corrosion?

Storage Tank Vocabulary

1. G
2. K
3. N
4. C
5. I
6. P
7. J
8. A
9. F
10. L
11. O
12. H
13. D
14. M
15. E
16. B

Storage Tank Review Questions

1.
- Equalizing pressure and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs
- Providing water during source or power failure
- Providing adequate water for fire fighting
- Providing surge relief
- Increasing detention time
- Blending water sources

2.
- Elevated – tank on tower, provides pressure, minimizes pressure variations
- Standpipe – tank on ground, taller than diameter, stores large volumes of water at low pressure, safer than elevated tank, may require pump
- Ground-level reservoir – diameter greater than height, requires pump
- Hydro-pneumatic – 2/3 water, 1/3 air; air helps maintain pressure, usually used with wells; small tanks

3. Emergency storage is not considered to be potable water – for emergencies only, e.g. fire protection.
   Operating storage is directly connected to distribution system, fills and empties by distribution pressure.
4. To keep out birds, insects, animals, etc.
5. To keep tank from overflowing
6. Professionally every 5 years
7. Bacteriological samples must be taken and must pass.
8. Water demand; Hydraulics, terrain; Purpose of tank; Public opinion
9. That would be a cross connection
10. Cathodic protection, coatings

Section 5

Disinfection

Distribution Chlorination

Disinfecting Water Mains

AWWA Standards for Disinfecting Water Mains

- AWWA standard C651
- Sec. 1.1
  - All new water mains shall be disinfected before they are placed in service.
  - All water mains taken out of service for inspection, repair, or other activities that might lead to contamination of water shall be disinfected before they are returned to service.

Chlorine

- Most commonly used disinfectant in U.S.
- Maintains residual
- Chlorine gas, Cl_2
- Calcium hypochlorite (HTH), $Ca(OCl)_2$
- Sodium hypochlorite (bleach), NaOCl

Types of Chlorine

- Liquid chlorine (gas): 100% available Cl_2
- Sodium hypochlorite (bleach): 5-15%
- Calcium hypochlorite (HTH): 65%

Chlorine Gas

- Cl_2
- 100% pure
- 2.5 times as dense as air
- Pungent, noxious odor
- Greenish-yellow color
- Highly irritating to eyes, nasal passages, and respiratory tract

Chlorine Liquid

- Created by compressing chlorine gas
- Amber color
- 1.5 times as dense as water
- Expands easily into gas at room temperature 460 times

Hypochlorite (Liquid)

- Sodium Hypochlorite NaOCl
- Bleach
- Clear, light-yellow color
- Costs 3 times as much as chlorine gas
- Shelf life 60-90 days
  - 5.25% Chlorine Clorox
    to
  - 12.5% Chlorine Pool bleach

Hypochlorite (Solid)

- Calcium Hypochlorite $Ca(OCl)_2$
- Solid, granular, or tablet
- White or yellow-white in color
- Most dangerous - fire hazard
- High Test Hypochlorite (HTH)
- 65% pure

Chlorination Principles

- Five factors important to success of chlorination:
  - Chlorine concentration (C)
  - Contact time (T) > most important
  - Water temperature
  - Water pH
  - Foreign substances in the water

Disinfection

"kill" is proportional to C x T

- Destruction of organisms depends on the concentration of chlorine added and the amount of time the chlorine is in contact with the organisms
- If one is decreased, the other must be increased to ensure that kill remains the same

Interferences

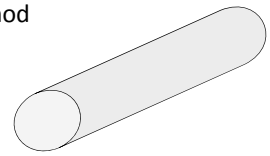
- Chlorine is only effective if it comes in direct contact with organisms
- Turbidity protects pathogens from chlorine
- Substances such as ammonia and organic matter reduce effectiveness of chlorine

Chlorine Safety and Exposure

- Safety
  - Keep head higher than leak
  - Never put water on a chlorine cylinder
  - Fusible plug leaks require special handling or training
- Exposure
  - 1000 ppm fatal
  - 40-60 ppm for 30-60 min may cause serious injury
  - 30 ppm IDLH (immediately dangerous to life or health)
  - 1 ppm is OSHA ceiling
  - 0.5 ppm without adverse effects

Methods of Line Disinfection

- Tablet Method
- Continuous-Feed Method
- Slug Method



Tablet Method

- Cl_2 dose of 25 - 50 mg/L (not less than 25)
- This method can only be used if pipes have been kept clean and dry during installation
  - if flushing is required before main can be used, this method is not applicable
- Place HTH granules or tablets in the main as it is being installed and filling with potable water after installation is complete
- Hold chlorinated water for 24 hours

Tablet Method

- Granules
  - Placement of granules
    - upstream end of first section
    - upstream end of branch main
    - at 500 ft intervals

Tablet Method

- Tablets
  - number of 5-g tablets shall be $0.0012(D)^2(L)$ rounded to next higher integer; where D=diameter in inches and
    L=length in feet
  - attached with food grade adhesive
  - placement of tablets
    - placed in each section of pipe
    - one in each hydrant, hydrant branch and other auxiliary equipment

Tablet Method

- Filling and contact
  - filled with water with velocity no greater than 1 ft/s
  - eliminates air pockets
  - remain in pipe for 24 hours
  - if water temperature is less than 41°F, then hold for 48 hours
  - a detectable chlorine residual should be found at each sampling point after the appropriate holding time and you must report results

Continuous-Feed Method

- Main is completely filled to remove air pockets
- Flushed to remove particulates at no less than 2.5 fps
- Filled with potable water that shall be chlorinated so that after 24 hours, a free chlorine residual of not less than 10 mg/L is present

Continuous-Feed Method

- Placement of HTH granules
  - upstream end of first section of pipe
  - upstream end of each branch main
  - every 500 feet intervals
- Chlorinating
  - water supplied from a temporary, backflow-protected connection
  - water shall receive a dose no less than 25 mg/L free chlorine at a point no more than 10 feet downstream from beginning of new main

Slug Method

- Place HTH granules in the main during construction
- Completely fill main to eliminate all air pockets
- Flush main to remove particulates
- Slowly flow through the main a slug of water dosed at 100 mg/L of chlorine for 3 hours

Textbook says 300 mg/L for 3 hours, but State Rules 1200-5-1-.17 says to use AWWA Standard C-651

Slug Method

- Chlorinating
  - water shall receive a dose of chlorine at no less than 100 mg/L, beginning at no more than 10 feet downstream from beginning of new main
  - take measurements at regular intervals
  - flow should be slow
  - all interior surfaces of the pipe should come in contact with a concentration of about 100 mg/L for at least 3 hours

Slug Method

- Chlorinating (continued)
  - if at any time the free chlorine falls below 50 mg/L
    - flow shall be stopped
    - chlorine equipment shall be relocated at head of slug
    - as flow is resumed, chlorine shall be applied to restore free chlorine in the slug to not less than 100 mg/L
  - as slug flows past fittings and valves, related valves and hydrants shall be operated so as to disinfect auxiliary equipment and pipe branches

Final Flushing of the Main

- Heavily chlorinated water should not remain in contact with the pipe and its auxiliary equipment longer than necessary
- If the highly chlorinated water will endanger the environment, a neutralizing chemical should be used

Bacteriological Testing

- ☐ After flushing and before the new main is connected to the distribution system, two consecutive sets of samples, taken at least 24 hours apart, shall be collected *
- ☐ At least one set of samples should be taken from each 1200 ft of new water main, plus one set from the end of line and at least one set from each branch
- ☐ The samples should be tested according to Standard Methods and should show absence of coliform organisms

More Disinfection Procedures

- When cutting into or repairing existing mains: (applies to existing mains that are wholly or partially dewatered)
  - after appropriate procedures have been completed, the existing main may be returned to service prior to completion of bacteriological tests
  - leaks or breaks that are repaired with clamping devices while the mains remain full of pressurized water present little danger of contamination and require no disinfection

More Disinfection Procedures

- Slug Chlorination for existing mains
  - same as previous method but dose may be increased to 300 mg/L with a contact time of 15 minutes
- If you disinfect, you must take bacteriological samples

Calculations

Dose and demand,
Disinfection of mains,
Solutions and dilutions

Cl_2 Demand

- Due to a main break, the chlorine residual in the distribution system has dropped from 1.5 mg/L to 0.6 mg/L. What is the chlorine demand?

Demand, mg/L = Dose, mg/L - Residual, mg/L
= 1.5 mg/L - 0.6 mg/L
= 0.9 mg/L

Water Main Disinfection

- A 300 ft section of a 12" main has been replaced. What is the volume of water in gallons that must be disinfected?

Volume = $(0.785)(\text{diameter})^2$ (length)
= $(0.785)(1\text{ft})^2$ (300ft)
= 235.5 ft^3
= (235.5 ft^3)(7.48 gal/ft^3)
= 1761.5 gal

Water Main Disinfection

- If the section of pipe in the previous problem is disinfected with 50 mg/L using 65% HTH, how many pounds of HTH will be required?

$$\text{lb HTH} = \frac{(\text{dosage, mg/L})(\text{volume, MG})(8.34\text{ lbs/gal})}{\%\text{ chemical purity, as decimal}}$$

$$= \frac{(50\text{ mg/L})(.0017615\text{ MG})(8.34\text{ lbs/gal})}{.65}$$

= 1.13 lbs

Solutions

- How many pounds of 65% HTH would be needed to make up 10 gallons of a 1% solution?

$$\text{HTH, lbs} = \frac{\text{(desired conc.)(desired vol.,gal)(8.34 lbs/gal)}}{\text{\% HTH, as decimal}}$$

$$= \frac{(.01)(10\text{ gal})(8.34\text{ lbs/ gal})}{.65}$$

$$= 1.28\text{ lbs}$$

TDEC - Fleming Training Center 31

Solutions

- How many gallons of 15% available bleach would be needed to make up 10 gallons of a 1% solution?

$$\text{Bleach, gal} = \frac{\text{(desired conc.)(desired vol.)}}{\text{\% bleach, as decimal}}$$

$$= \frac{(.01)(10\text{ gal})}{0.15}$$

$$= .67\text{ gallons}$$

TDEC - Fleming Training Center 32

Fleming Training Center

Pipe Disinfection Formulas for 50 mg/L of HTH

If a pipe is of size not listed below, the following formula will give the calculations needed to find the amount of HTH needed, if the length of line is given:

Calculation Formula = $0.000026007(X)^2(L)$

L= the length of the line in feet,
X = the diameter in inches

Or, Use the following Chart, if Pipe Diameter is listed

DIAMETER (INCHES)	LBS OF HTH
6	0.000935(L)
8	0.00166(L)
10	0.0026(L)
12	0.00374(L)
14	0.00509(L)
16	0.00665(L)
20	0.01038(L)
C24	0.01495(L)

Contact Amanda Carter at Fleming Training Center

(615) 898-8090

FIELD DISINFECTION FORM

Employee Name: _____

Address/Location_____

Work Order Number_____

Project Name: _____ Project Number_____

Type of Main: DIP Cast PVC Other: _____ Size: _____ Footage: _____

Disinfection Procedure: Spray Slug Continuous Feed Swab Other: _____

#s of HTH: _____ Contact Time (hrs): _____

Flushing Date: _____ Flushing Time (hrs): _____

Source of Sample: Fire Hydrant No. _____ Blow-off location _____

Sample Collected by: _____ Sample Transported by: _____

Date Collected: _____ Time Collected: _____ AM/PM

Comments: _____

_____

_____

Lab Sample Number: _____ Date Tested: _____ Time Tested: _____AM/PM

ALL UNITS ARE IN mg/L, UNLESS OTHERWISE NOTED

ANALYSIS REQUESTED	RESULTS	x	ANALYSIS REQUESTED	RESULTS	x
Field Measurements			MICROBIOLOGICAL		
Chlorine, Free Res.			Total Coliform		
Temperature F/C			Heterotrophic Plate Count		

Only methodologies as recommended and approved by the United States Environmental Protection Agency and by the most recent Federal Register have been used. The results obtained are true and accurate to the best of my knowledge.

LABORATORY OFFICIAL:_____ DATE:_____

Form accepted by TDEC representative _____ DATE: _____

Field Data for Newly Constructed or Repaired Water Distribution Lines

Work Order # _____ Project # _____

Date: _____ Time: _____

Location: _____

Type of Main: _____ Size: _____ Footage: _____

Pounds of HTH: _____

Disinfection procedure utilized: _____

_____

Flushing: _____

Comments: _____

_____

_____

Signature: _____ Date: _____

Common Waterborne Diseases

Waterborne Disease	Causative Organism	Source of Organism in Water	Symptom
Gastroenteritis	*Salmonella* (bacteria)	Animal of human feces	Acute diarrhea and vomitting
Typhoid	*Salmonella typhosa* (bacteria)	Human feces	Inflamed intestine, enlarged spleen, high temperature - **FATAL**
Dysentary	*Shigella* (bacteria)	Human feces	Diarrhea - rarely fatal
Cholera	*Vibrio comma* (bacteria)	Human feces	Vomitting, severe diarrhea, rapid dehydration, mineral loss – high mortality
Infectious Hepatitis	Virus	Human feces, shellfish grown in polluted waters	Yellow skin, enlarged liver, abdominal pain – low mortality, lasts up to 4 months
Amoebic Dysentery	*Entamoeba* histolytica (protozoan)	Human feces	Mild diarrhea, chronic dysentery
Giardiasis	*Giardia lamblia* (protozoan)	Animal or human feces	Diarrhea, cramps, nausea and general weakness – not fatal, lasts 1-30 weeks
Crytosporidiosis	*Cryptosporidium* (protozoan)	Human and animal feces	Acute diarrhea, abdominal pain, vomiting and low-grade fever
Legionellosis	*Legionella pneomophila* and related bacteria		Acute respiratory illness

Disinfection Vocabulary

A. Bacteria
B. Breakpoint
C. Chlorination
D. Chlorine Demand
E. Combined Residual
F. C x T Value
G. Disinfection Residual
H. Disinfection
I. Disinfection By-Product
J. DPD
K. Free Residual Chlorine
L. HTH
M. Organic Substance
N. Ozone Generator
O. Sterilization
P. Trihalomethane
Q. UV Disinfection
R. Waterborne Disease

_____1. The process of destroying all organisms in water.
_____2. The product of the residual disinfectant concentration C and the corresponding disinfectant contact time T.
_____3. The water treatment process that kills disease-causing organisms in water.
_____4. A device that produces ozone by passing an electrical current through air or oxygen.
_____5. The point at which the chlorine dose has met the demand.
_____6. Living organisms, microscopic in size, which usually consist of a single cell.
_____7. A chemical substance of animal or vegetable origin, having carbon in its molecular structure.
_____8. Disinfection using ultraviolet light.
_____9. The process of adding chlorine to water to kill disease-causing organisms.
_____10. The residual formed after the chlorine demand has been satisfied.
_____11. An excess of chlorine left in water after treatment. Indicates the adequate amount of disinfectant has been added to ensure complete disinfection.
_____12. Compound formed when organic substances such as humic and fulvic acids react with chlorine.
_____13. The difference between the amount of chlorine added to water and the amount of residual chlorine remaining after a given contact time.
_____14. Chemical compounds that are formed by the reaction of disinfectants with organic compounds in water.
_____15. High Test Hypochlorite; calcium hypochlorite or $Ca(OCl)_2$
_____16. The chlorine residual produced by the reaction of chlorine with substances in the water. It is not as effective as free residual.
_____17. A disease caused by waterborne organisms.
_____18. A method of measuring the chlorine residual in water. The residual may be determined by either titrating or comparing a developed color with color standards. Stands for N,N-diethyl-p-phenylene-diamine.

Answers

Vocabulary

1. O
2. F
3. H
4. N
5. B
6. A
7. M
8. Q
9. C
10. K
11. G
12. P
13. D
14. I
15. L
16. E
17. R
18. J

Section 6

Lab Tests and Sampling

Water Quality, Analysis and Sampling in Distribution System

Objectives

- Need for monitoring water quality
- Identify types of samples
- Collect proper samples
  - Preserving and storing techniques
- Perform lab/field tests

Water Quality Monitoring

- Monitored to ensure safety and integrity
- Monitored to meet state and federal requirements
- Water quality can degrade in distribution system due to contamination or growth of organisms

Prevent Quality Degradation

- Treated water is disinfected, not sterilized
- Disinfection kills or inactivates harmful organisms (pathogens)
- Organisms can grow in distribution system if conditions are right
- To prevent growth of organisms:
  - •Keep chlorine residual up
  - •Prevent stagnation
  - •Keep excess nutrients out
  - •Prevent cross-connections

Drinking Water Standards

- First established to control waterborne disease outbreaks around 1914
- Safe Drinking Water Act (SDWA) and its amendments require additional testing
  - 1974 - MCL's established for certain compounds and elements
  - States can revise and make more strict

Water Quality Analysis

- The first step in water quality analysis is collecting samples which accurately represent the water
  - Representative sample - sample which contains basically the same constituents as the body of water from which it was taken
  - Improper sampling is one of the most common causes errors in water quality analysis
- All chemical analysis records must be kept for 10 years

Types of Samples

❶ Grab sample
- Single volume of water
- Representative of water quality at exact time and place of sampling
- Coliform bacteria, residual chlorine, temperature, pH, dissolved gases

❷ Composite samples
- Representative of average water quality of location over a period of time
- Series of grab samples mixed together
- Determines average concentration
- Not suitable for all tests

Composite Samples

- Time composite - equal volumes at different times
- Flow-proportional composite - volume varies depending on flow rate

Sample Volume and Storage

- Volume depends on test requirements
- Use proper sampling container
- Follow recommended holding times and preservation methods
  - if bottle already has preservative or dechlorinator in it, don't over fill or rinse out

✓If you have questions regarding volume, container or holding times, check *Standard Methods* or contact the lab if you have an outside lab do your analysis

Sample Labeling

- Specific location (address)
- Date and time sampled
- Chlorine residual
- pH and temperature (if needed)
- Sample number or identification
- Name or initials of person taking sample

Sample Labeling

Site 196 E. Main Street Billieville, TN

Date / Time August 15, 2005 8:15 AM

Code B16089

Sampled by Billy Joe Smith

Comments pH < 2 with H_2SO_4 and stored at 4°C

Free residual chlorine = 2.1 mg/L

Distribution Sampling Points

- Distribution sampling is best indicator of system water quality
- Water quality changes in distribution system can be caused by:
  - Corrosion - increase in color, turbidity, taste & odor
  - Microbiological growth - slime
  - Cross-connections

Distribution Samples

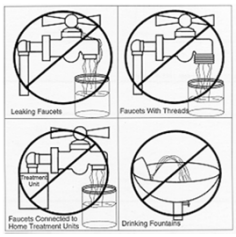
- Determine water quality at customers' taps
- Most common tests are chlorine residual and coliform bacteria
- Number of samples depends on size of system and water source

Bacteriological Samples

- Only approved containers should be used to collect sample
  - should have sodium thiosulfate in them to dechlorinate the water

Bacteriological Samples

- Bacteriological samples should never be taken from a hydrant or hose
- Only collect samples from approved faucets
- Don't collect samples from swivel faucets
- Only use cold water tap
- Front yard faucets on homes with short service lines



Bacteriological Samples

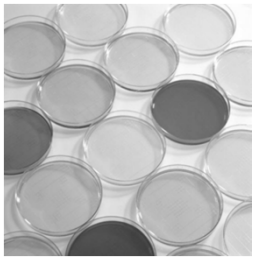
- Do not flame faucet with torch
- Turn on faucet to steady flow and flush service line (2 - 5 min)
  - getting water from main line
- Fill bottle to proper level (100 mL ± 2 mL)
- If container has screw-on lid, do not set it down on ground or put in your pocket
- Label bottle with pertinent information
- Test as soon as possible - within 30 hours

Microbiological Indicator Organism

- Always present in contaminated water
- Always absent when no contamination
- Survives longer in water than other pathogens
- Is easily identified
- Water treatment indicator organism
  - Coliform group (total coliforms)

Bacteriological Samples

- The MCL for coliform bacteria is based on presence or absence
- Finished and distributed water should be 0 (absent)
- Must keep results for 5 years



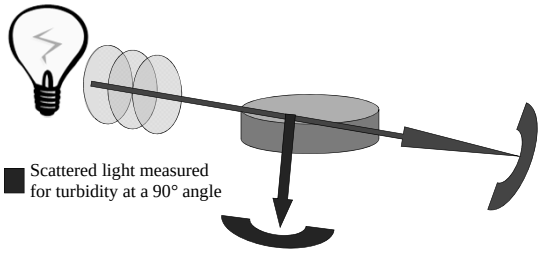
pH

- Measure of the hydrogen ion concentration
- Scale runs from 0 to 14
  - sample is acidic if pH < 7
  - sample is basic if pH >7
- Used to determine whether water is scale forming or corrosive
- pH meter must be calibrated daily with at least 2 standards (3 recommended)
- Samples measured on-site

Turbidity

- Physical cloudiness of water
- Due to suspended silt, finely divided organic and inorganic matter, and algae
- Nephelometric method measures scattered light (unit: NTU)
- SDWA stipulates specific monitoring requirements
- Measure samples ASAP; keep sample tubes clean and scratch free inside and out
- Records must be kept until next sanitary survey

Turbidimeter



Scattered light measured for turbidity at a 90° angle

Light source from tungsten lamp passing through three precisely aligned lenses, the light is focused in a narrow, collimated beam

Measuring Chlorine Residual

- Free chlorine residual must be tested and recorded when bacteriological samples are collected
- Analysis should be performed as soon as possible, exposure to sunlight or agitation of the sample will cause a reduction in the chlorine residual

Measuring Chlorine Residual

- DPD colorimetric method most commonly used
  - Match color of sample to a standard
  - Swirl sample for 20 seconds to mix
  - Within one minute of adding reagent, place it into colorimeter
- Must maintain a free residual of 0.2 mg/L throughout entire distribution system
  - chlorine residual must not be less than 0.2 mg/L in more than 5% of samples each month for any two consecutive months

Fluoride

- Added to drinking water for the reduction of dental caries (cavities)
- Interferences:
  - Phosphate has positive interference
  - Aluminum has negative interference
- Primary MCL = 4.0 mg/L
- Secondary MCL = 2.0 mg/L
- State of Tennessee recommends 0.7 mg/L

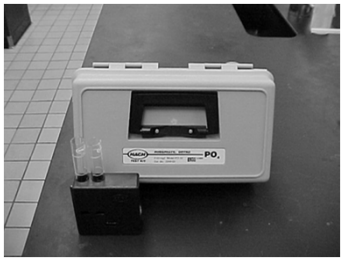
Fluoride

- Methods
  - SPADNS (interferences are more common with this test)
    - Can be done either in the field or in the lab
    - Alum or aluminum complexes can interfere
    - There is a 1 minute reaction time
  - Electrode
    - Done in the lab
    - TISAB removes most of the aluminum interferences
    - Store probe in a standard, the higher the better
    - Probes can last 3-5 years
    - Can clean with toothpaste

Phosphates

- Test for reactive (ortho-phosphates) phosphates if they are added at the water plant for corrosion control
- Polyphosphates work as sequestering agents - tie up iron and manganese to prevent color and taste complaints
- Orthophosphates work well for lead and copper protection

Phosphates



Color comparator method for field testing

Blue color indicates presence of phosphates

Lead and Copper Rule

- Established in by EPA in 1991
- All community and non-community water systems must monitor for lead and copper at customers' taps
- If aggressive water is dissolving these metals, system must take action to reduce corrosivity
- Samples must be taken at high risk locations - homes with lead service lines
- Water must sit in lines for at least 6 hours - first draw
- One liter of sample collected from cold water tap in kitchen or bathroom
- Test results must be maintained for 12 years

Lead and Copper Rule

- Action levels
  - Lead - 0.015 mg/L
  - Copper - 1.3 mg/L
- If action level is exceeded in more than 10% of samples, must take steps to control corrosion:
  - Corrosion control program
  - Source water treatment
  - Public education
  - And/or lead service line replacement

Standard Monitoring Requirements

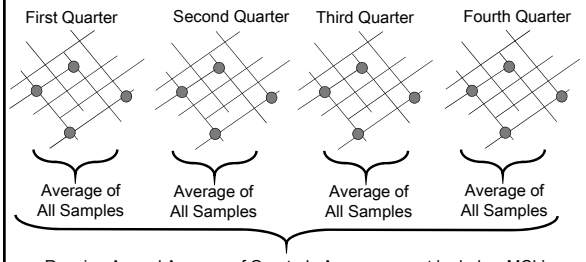
- What, where, and how often do I monitor?
  - Samples Collected
    - Dual sample set (both TTHM and HAA5) collected at all locations
  - Monitoring Locations
    - High TTHM levels
    - High HAA5 levels
    - Average Residence Time
    - Near Entry Points
  - Number of sites
    - Based on system type
  - Monitoring Frequency
    - 1, 4, or 6 monitoring periods during the year at each location
    - Number based on population served and source type

Standard Monitoring Requirements

- When do I sample?
  - Sample months
    - Peak historical month
      - Peak TTHM levels
      - OR
      - Peak HAA5 levels
      - OR
      - Month of warmest water temperature
    - All systems sample during this month
    - Systems sampling more than once will set sample months every 60 days or every 90 days around peak historical month (± 5 days)

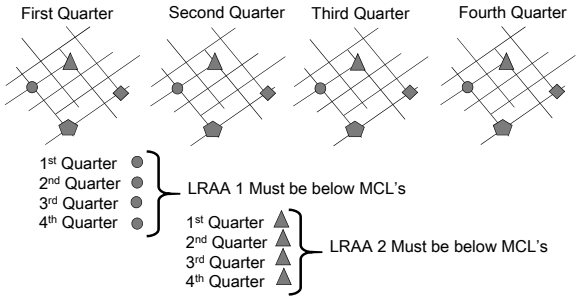
TDEC - Fleming Training Center 31

Stage 1 DBP Rule



TDEC - Fleming Training Center 32

Stage 2 DBP Rule



TDEC - Fleming Training Center 33

- **For groundwater systems or systems that purchase groundwater**

THM and HAA5 Standard Monitoring(1)

Population	Frequency	Total	Near EP	ART	High TTHM	High HAA5
< 500 consecutive	1 (during peak historical month)(2)	2	1	-	1	-
< 500 non-consecutive		2	-	-	1	1
500-9,999	4 (every 90 days)	2	-	-	1	1
10,000 – 99,999		6	1	1	2	2
100,000-499,999		8	1	1	3	3
≥ 500,000		12	2	2	4	4

(1) A dual sample set (i.e., a TTHM and an HAA5 sample) must be taken at each monitoring location during each monitoring period.
(2) The peak historical month is the month with the highest TTHM or HAA5 levels or warmest water temperature.

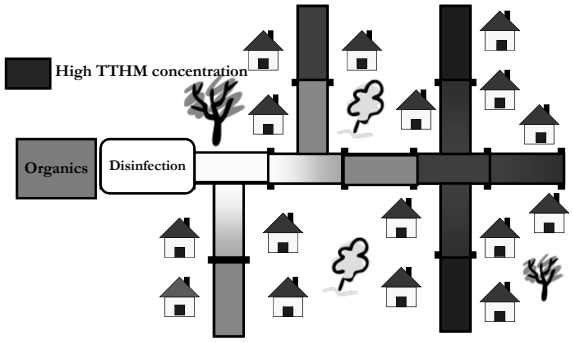
TDEC - Fleming Training Center 34

- **For Subpart H systems and systems that purchase Subpart H water**

THM and HAA5 Standard Monitoring(1)

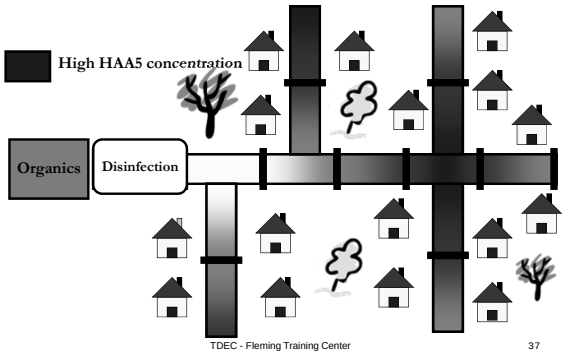
Population	Frequency	Total	Near EP	ART	High TTHM	High HAA5
<500 consecutive	1 (during peak historical month)(2)	2	1	-	1	-
<500 non-consecutive		2	-	-	1	1
500-3,300 consecutive	4 (every 90 days)	2	1	-	1	-
500-3,300 non-consecutive		2	-	-	1	1
3,301-9,999		4	-	1	2	1
10,000-49,999	6 (every 60 days)	8	1	2	3	2
50,000- 249,999		16	3	4	5	4
250,000-999,999		24	4	6	8	6
1,000,000-4,999,999		32	6	8	10	8
≥ 5,000,000		40	8	10	12	10

TTHM Formation



TDEC - Fleming Training Center 36

HAA5 Formation



TDEC - Fleming Training Center 37

Other Factors that Influence DBP Formation

Parameter (Increasing)	TTHM	HAA5
TOC	⇧	⇧
Time	⇧	⇔
Temperature	⇧	⇧
Disinfectant Dose	⇧	⇧
pH	⇧	⇩
Bromide	⇧	⇧

TDEC - Fleming Training Center 38

Term Review

- MCL -maximum contaminant level
  - Primary regulation, health hazard
- sMCL - secondary maximum contaminant level
  - Aesthetics
- MCLG - maximum contaminant level goal
  - Level at which no known or anticipated adverse health effect
- Action level - lead & copper
  - Level which requires certain action

TDEC - Fleming Training Center 39

Total Coliform Monitoring Frequency for Community Water Systems

Population Served	Minimum Number of Samples Per Month
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3
3,301 to 4,100	4
4,101 to 4,900	5
4,901 to 5,800	6
5,801 to 6,700	7
6,701 to 7,600	8
7,601 to 8,500	9
8,501 to 12,900	10
12,901 to 17,200	15
17,201 to 21,500	20
21,501 to 25,000	25
25,001 to33,000	30
33,001 to 41,000	40
41,001 to 50,000	50
50,001 to 59,000	60
59,001 to 70,000	70
70,001 to 83,000	80
83,001 to 96,000	90
96,001 to 130,000	100
130,001 to 220,000	120
220,001 to 320,000	150
320,001 to 450,000	180
450,001 to 600,000	210
600,001 to 780,000	240
780,001 to 970,000	270
970,001 to 1,230,000	300
1,230,001 to 1,520,000	330
1,520,001 to 1,850,000	360
1,850,001 to 2,270,000	390
2,270,001 to 3,020,000	420
3,020,001 to 3,960,000	450
3,960,001 or more	480

Sampling and Analysis Review Questions

1 What is the difference between a grab sample and a composite sample?

2 Why should you never use a composite sample for bacteriological analysis?

3 List and describe the two types of composite samples.

4 What types of faucets should be avoided when selecting sampling points?

5 What is the maximum number of hours a bacteriological sample can be held before testing?

6 How long should a service line be flushed before sampling?

7 What is the easiest method to test for chlorine residual in the field?

8 What information should be recorded on the label of a bacteriological sample?

9 What is the indicator organism used in the bacteriological test?

10 According to the Lead and Copper Rule, what is the action level for lead?

11 According to the Lead and Copper Rule, what is the action level for copper?

12 What determines the MCL for total coliforms in drinking water?

13 Name three causes of water quality degradation in the distribution system.

14 Define the following terms:

- MCL –
- sMCL –
- Action Level –

Answers

1. Grab sample – single volume collected at a specific place and time
   Composite sample – series of grab samples mixed together, determines average concentration, not suitable for all tests.

2. Must be taken in a sterile container, must be tested within 30 hours, cannot determine where the positive occurred.

3. Time composite – equal volumes at different times
   Flow-proportional composite – volume varies depending on flow rate

4. Leaking faucets, Faucets with home treatment units, Drinking fountains, Swivel faucets

5. 30 hours

6. 2-3 minutes (Standard Methods) or to uniform temperature

7. DPD test kit

8. Location, Date, Time, Chlorine residual, Sample # and type, Collector's name or initials

9. Total coliforms (coliform group)

10. 0.015 mg/L

11. 1.3 mg/L

12. Presence / Absence

13. Corrosion, Microbial growth, Cross-connections

14. MCL – Maximum Contaminant Level – maximum permissible level of a contaminant in drinking water as specified in the Safe Drinking Water Act. For primary regulations, health hazards.

    sMCL – Secondary Maximum Contaminant Level – based on aesthetic quality of water, non health hazard

    Action Level – Level of a contaminant which, if exceeded, requires specific action(s) to reduce risk of adverse health effects.

Section 7

Valves

Distribution System Valves

- Uses
- Types
- Operation
- Maintenance

Why Choose a Certain Valve?

- Location
- Type of liquid
- Pressure
- Average flow
- Frequency of operation
- Cost

Uses of Valves in Distribution System

- Isolation (gate, butterfly, globe, ball)
- Draining lines (blow-off)
- Throttling flow (butterfly, plug, globe, ball)
- Regulate water storage levels (altitude-control valve)

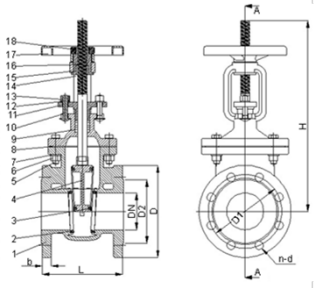
Uses of Valves in Distribution System

- Control water hammer (pressure-relief valve)
- Allow air in & out of lines (air-relief valve)
- Control backflow (check valve)

Gate Valves

Gate is raised or lowered by a screw, which is operated by a hand wheel or valve key

- **Rising Stem** - Outside Screw & Yoke (OS&Y) type have exposed screw extending above the valve bonnet



Gate Valves

- **Non-rising Stem**
- Lower end of the stem is threaded & screws into the disk
- The disk moves up or down while a thrust collar keeps the stem in place

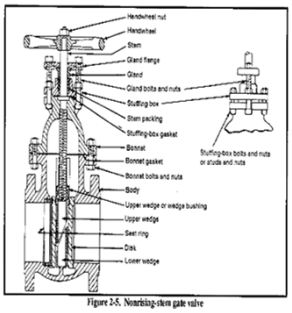


Figure 2-5. Nonrising-stem gate valve

Gate Valves in the Distribution System

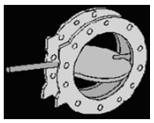
Generally used to isolate sections of the system

- **Hydrant Auxiliary Valve** – direct connection to a fire hydrant
- **Tapping Valves** – connection to a tapping tee & connection to tapping machine
- **Horizontal Gate Valves** – used in large diameter pipe and designed to lie on one side
- **Bypass Valves** – included in large gate valves

TDEC - Fleming Training Center 7

Butterfly Valves

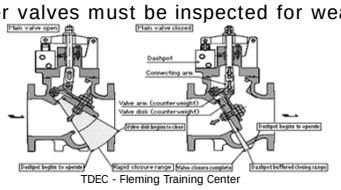
- Has a disk that is rotated on a shaft
  - Pros – operate easily and quickly; ¼ turn can fully open or shut them; less expensive than gate valves
  - Cons – greater head loss; closing too quickly may produce a serious water hammer; can be obstacle if cleaning main with pigs or swabs



TDEC - Fleming Training Center 8

Check Valves

- Allow flow in only one direction
- Commonly used on discharge pumps to prevent backflow
- Could have problems with the valve slamming shut and creating serious water hammer
- Older valves must be inspected for wear



TDEC - Fleming Training Center 9

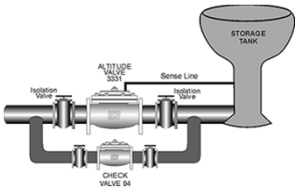
Pressure Reducing Valves

- Operate automatically to throttle flow and maintain a lower pressure
- Valve has 2 upper operating chambers sealed from each other by a flexible reinforced diaphragm
- The chambers receive pressure from the system and are adjusted to modulate the valve stem up and down to maintain the desired discharge pressure

TDEC - Fleming Training Center 10

Altitude Valves

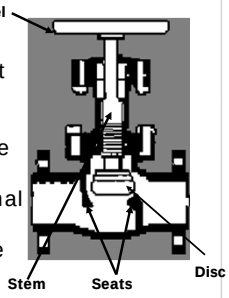
- Ground level reservoirs are usually filled through an altitude valve
- Allows water to fill a reservoir at a controlled rate
- Activated by the water pressure from the reservoir to close automatically when the reservoir is full
- Also control flow to elevated tanks



TDEC - Fleming Training Center 11

Pressure Relief Valves

- Valve stem raises or lowers a disc onto a seat
- **Globe Valve** with an adjustable spring to maintain pressure on the valve seat to keep the valve closed under normal pressure conditions
- Used to prevent damage from water hammer



TDEC - Fleming Training Center 12

Globe Valves

- Require little maintenance
- Disc and seat can be replaced or restarted quickly and easily
- Relatively high head loss when fully open
- Suitable for service in **small** pipelines only

TDEC - Fleming Training Center 13

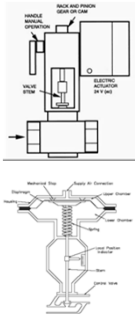
Air and Vacuum Relief Valves

- Float operated valve that allows air to escape when the float is down
- Commonly used on the discharge of a well pump
- Should be installed at high points in transmission pipelines

TDEC - Fleming Training Center 14

Valve Operation & Installation

- Valve Operators
  - **Electric Actuator** – Small electric motor to rotate the valve stem through a gear box
  - **Hydraulic Actuators** – operated by water pressure or hydraulic fluid
  - **Pneumatic Actuators** – operated with compressed air



TDEC - Fleming Training Center 15

Distribution System Valves

- **Manual Operation** - turning the 2-inch square nut with a valve key
- **Portable Power Operators** – electric or gasoline powered tools for operating valves
- **Valve Boxes** – constructed around the valve after it is installed

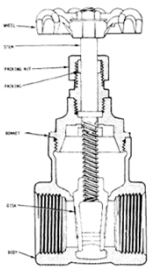
TDEC - Fleming Training Center 16

Valve Maintenance Program

- Inspect each valve on a regular basis (annually if possible)
  - more frequently for large valves (16 " or greater)
- Follow Manufacturer's guidelines

TDEC - Fleming Training Center 17

Valve Maintenance Program

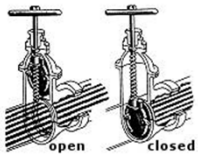


- Operate the valve; lubricate as needed
- Check condition of packing, stem, operating nut & gears (if any)
- Check location measurements

TDEC - Fleming Training Center 18

Valve Maintenance Program

- Was valve open or closed
- Number of turns to open or close
- Cycle all gate valves to full open/full close at least every two years
- Make prompt repairs
- Keep complete records of maintenance



TDEC - Fleming Training Center 19

Valve Vocabulary

A. Actuator
B. Air-and-vacuum relief valve
C. Air binding
D. Air-relief valve
E. Altitude-control valve
F. Backflow
G. Ball valve
H. Butterfly valve
I. Bypass valve
J. Check valve
K. Corporation stop
L. Curb box
M. Curb stop
N. Cut-in valve
O. Floorstand
P. Gate valve
Q. Globe valve
R. Inserting valve
S. Isolation valve
T. Nonrising-stem valve
U. Packing
V. Plug valve
W. Pressure-reducing valve
X. Pressure-relief valve
Y. Resilient-seated gate valve
Z. Seat
AA. Service valve
BB. Tapping valve
CC. Valve
DD. Valve box
EE. Valve key
FF. Vault
GG. Water hammer

_____1. A valve for joining a service line to a street water main. It can't be operated from the surface. Also called a corporation cock.
_____2. A valve that automatically shuts off water flow when the water level in an elevated tank reaches a preset elevation then opens again when the pressure on the system side is less than that on the tank side.
_____3. A valve installed in a pipeline to shut off flow in a portion of the pipe, for the purpose of inspection or repair. Such valves are usually installed in the main lines.
_____4. A gate valve with a disc that has a resilient material attached to it, to allow a leak-tight shutoff at high pressures.
_____5. A specially designed valve used with a sleeve that allows it to be placed in an existing main.
_____6. A special shut-off valve used with a tapping sleeve.
_____7. A device, usually electrically or pneumatically powered, that is used to operate valves.
_____8. A metal or concrete box or vault set over a valve stem at ground surface to allow access to the stem so the valve can be opened and closed.
_____9. An underground structure, normally made of concrete, that houses valves and other appurtenances.
_____10. A gate valve in which the valve stem does not move up and down as it is rotated.
_____11. A shutoff valve attached to a water service line from a water main to a customer's premises, usually placed near the customer's property line. Also called a curb cock.

_____12. A valve in which the closing element consists of a disc that slides across an opening to stop the flow of water.
_____13. A hydraulic condition, caused by a difference in pressures, in which nonpotable water or other fluids flow into a potable water system.
_____14. A dual-function air valve that (1) permits entrance of air into a pipe being emptied, to prevent a vacuum, and (2) allows air to escape in a pipe being filled or under pressure.
_____15. The portion of a valve that the disc compresses against to achieve shutoff of the water.
_____16. The potentially damaging slam, bang or shudder that occurs in a pipe when a sudden change in water velocity creates a great increase in water pressure.
_____17. A valve in which the movable element is a cylindrical or conical plug.
_____18. A shutoff valve that can be inserted by special apparatus into a pipeline while the line is in service under pressure.
_____19. The condition in which air has collected in the high points of distribution mains, reducing the capacity of the mains.
_____20. A cylinder placed around the curb stop and extending to the ground surface to allow access to the valve.
_____21. A valve in which the disc rotates on a shaft as it opens or closes. In the full open position, the disc is parallel to the axis of the pipe.
_____22. Any valve that is used to shut off water to individual customers.
_____23. A metal wrench with a socket to fit a valve operating nut.
_____24. A valve that opens automatically when the water pressure reaches a preset limit, to relieve the stress on a pipeline.
_____25. A mechanical device installed in a pipeline to control the amount and direction of water flow.
_____26. A valve designed to open in the direction of normal flow and close with reversal of flow. An approved check valve is of substantial construction and suitable materials, is positive in closing and permits no leakage in a direction opposite to normal flow.
_____27. An air valve placed at a high point in a pipeline to release air automatically, thereby preventing air binding and pressure buildup.
_____28. A small valve installed in parallel with a larger valve; it is used to equalize the pressure on both sides of the disc of the larger valve before the larger valve is opened.
_____29. A device for operating a gate valve (by hand) and indicating the extent of opening.
_____30. Rings of graphite impregnated cotton, flax, or synthetic material, used to control leakage along a valve stem.
_____31. A valve having a round, ball-like shell and horizontal disc.
_____32. A valve with horizontal disc for reducing water pressures in a main automatically to a preset value.
_____33. A valve consisting of a ball resting in a cylindrical seat. A hole is bored through the ball to allow water to flow when the valve is open; when the ball is rotated 90°, the valve is closed.

Review Questions

1. List six uses for valves in a water distribution system.
    -
    -
    -
    -
    -
    -

2. For each valve use listed in question 1, name one valve type suitable for that use.
    -
    -
    -
    -
    -
    -

3. List the three most common types of joints used to install valves.
    -
    -
    -

4. What is the primary purpose of a bypass valve?

5. How often should distribution system isolation valves be operated or inspected?

6. What can happen if a valve is opened or closed to quickly?

7. List at least three items to check during routine inspection of a valve.
   -
   -
   -

Answers

Vocabulary:

1. K	12. P	23. EE
2. E	13. F	24. X
3. S	14. B	25. CC
4. Y	15. Z	26. J
5. N	16. GG	27. D
6. BB	17. V	28. I
7. A	18. R	29. O
8. DD	19. C	30. U
9. FF	20. L	31. Q
10. T	21. H	32. W
11. M	22. AA	33. G

Review Questions:

1. isolation, draining lines, throttling flow, regulating water-storage levels, controlling water hammer, bleeding off air and allowing air into lines, and preventing backflow
2. isolation: gate, butterfly, globe, plug, ball
   drain: blow-off
   throttle: butterfly, plug, globe, ball
   regulate storage levels: altitude-control valve
   control water hammer: pressure-relief valve
   allow air in and out of lines: air-relief valve
   control backflow: check valve
3. flanged, mechanical, push-on
4. To help equalize pressure on a large valve, making it easier to open and close.
5. annually at least; more often for important valves
6. water hammer
7. location measurements; whether found open or closed; condition of packing, stem, operating nut, gears (if any), box or vault, box cover; number of turns to open and close

Section 8

Hydrants

TDEC - Fleming Training Center

Hydrants

Installation, Field Testing & Maintenance of Fire Hydrants

1

TDEC - Fleming Training Center

Objectives

- Uses of hydrants in distribution system
- Components of dry-barrel and wet-barrel hydrants
- Installation, operation, inspection, and maintenance procedures
- Record keeping and safety

2

TDEC - Fleming Training Center

What is a Fire Hydrant?

- State Rules 1200-5-1-.17(18)
  - Must be installed on a 6 inch main
  - Must flow 500 gpm at 20 residual psi
  - If hydrants don't meet these requirements, it's considered a blow-off
    - These hydrants should also have their bonnets pained red
    - Classified as a Class C Hydrant

3

TDEC - Fleming Training Center

Fire Hydrant Uses

- Fire fighting
  - Main purpose of fire hydrants
  - Fire Dept. is usually responsible for flow testing
  - Utility usually responsible for maintaining hydrants
- Flushing water mains
  - Fully opening a hydrant to remove sediment
  - Recommended twice a year
  - Velocity in excess of 2.5 ft/sec

4

TDEC - Fleming Training Center

Fire Hydrant Uses

- Flushing sewers
- Filling tank trucks
- Providing temporary water sources for construction work via hydrant meter

5

TDEC - Fleming Training Center

Fire Hydrant Uses

- All community water systems having more than 50 service connections shall establish and maintain an adequate flushing program
  - State Rule 1200-5-1-.17(10)
- All dead end water mains shall be equipped with a blow off or other suitable flushing mechanism

6

Fire Hydrant Uses

- Unauthorized use of hydrants should be prohibited because:
  - Hydrants can be damaged
  - Water is not paid for
  - User may not shut valve completely, resulting in leakage
  - Cross connection

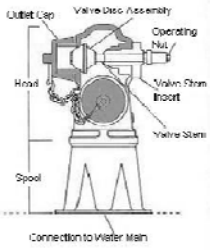
7

Design of Wet-Barrel Hydrants

- AWWA Standard C503
  - Completely filled with water at all times
  - Has no main valve; each nozzle equipped with a valve
  - Large amounts of water may flow from broken hydrant

8

Types of Hydrant



- Wet Barrel C503

9

Design of Dry-Barrel Hydrants

- AWWA Standard C502
  - Bonnet shall have “open” cast on or near top to indicate direction to open
  - Must have caps for each outlet nozzle, secured to hydrant with chain
  - Operating nut shall be pentagonal in shape and open counterclockwise

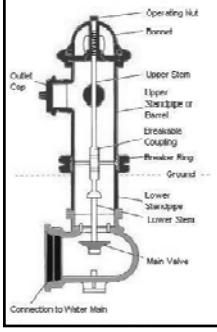
10

Dry-Barrel Hydrants

- Valve Types
  - Standard Compression
  - Slide Gate Hydrant
  - Toggle (Corey) Hydrant
  - Flush Hydrant

11

Types of Hydrant

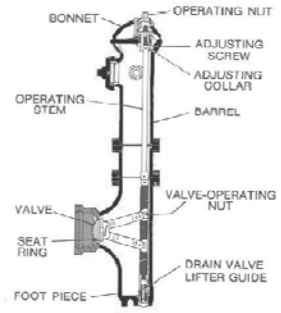


- Dry Barrel Compression C502

12

TDEC - Fleming Training Center

Types of Hydrants

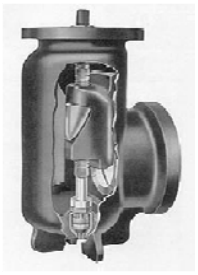


- Corey Toggle Hydrant

13

TDEC - Fleming Training Center

Types of Hydrant



- Dry Barrel Gate Hydrant

14

TDEC - Fleming Training Center

Flush Hydrants

- Entire standpipe and head are below ground
- Operating nut and outlet nozzles are encased in a box with a cover at ground level
- Usually dry-barrel type
- Could also be a fire hydrant on a main less than 6 inches or can not provide 500 gpm with 20 psi

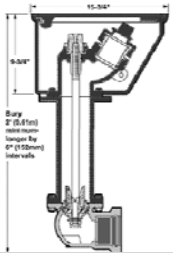
15

TDEC - Fleming Training Center

Types of Hydrant

Post

- Flush & Post Hydrants



Flush – Underground in Meter Box

16

TDEC - Fleming Training Center

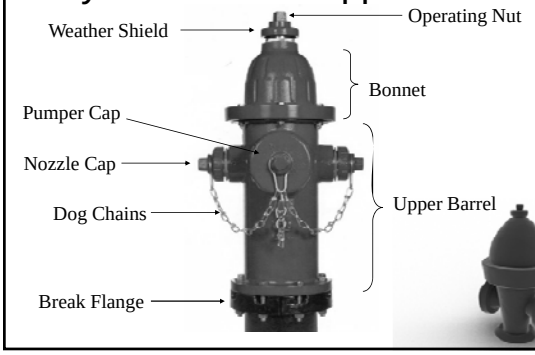
Traffic Model

- AWWA Standard C502, latest revision
  - The main valve on the hydrant shall remain closed should the hydrant nozzle section be broken off in a traffic accident

17

TDEC - Fleming Training Center

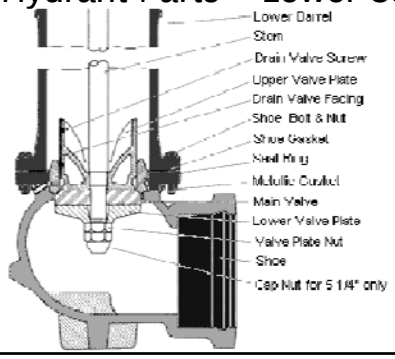
Hydrant Parts – Upper Section

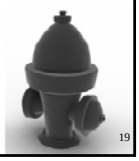


18

TDEC - Fleming Training Center

Hydrant Parts – Lower Section



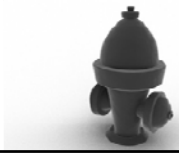


19

TDEC - Fleming Training Center

Operation of Hydrants

- Anyone using a hydrant should be instructed on proper operation of the hydrant



20

TDEC - Fleming Training Center

Operation of Hydrants

- The main valve should always be opened completely, never throttled
- Hydrants should always be opened and closed slowly to prevent water hammer and damage to valves

21

TDEC - Fleming Training Center

Inspection of New Hydrants

- Checklist Items:
  - Direction to open operating nut
  - Size and shape of operating nut
  - Depth of bury
  - Size and type of inlet connection
  - Main valve size
  - Outlet nozzle size, configuration, and thread dimensions

22

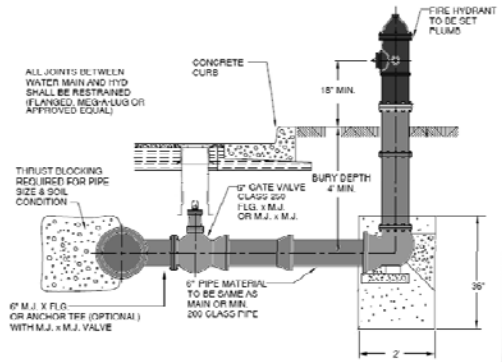
TDEC - Fleming Training Center

Installation

- Refer to AWWA Manual M17 for procedures
  - Install hydrants plumb
  - Locate to local fire codes
  - Minimum of 16” pumper to ground height
  - Provide thrust restraint for hydrant & valve
  - Always install auxiliary valve
  - Lead & main same material
  - Gravel sump behind hydrant

23

TDEC - Fleming Training Center



24

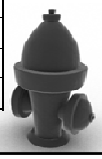
TDEC - Fleming Training Center

Installation

- Adoption of color scheme to indicate flow is optional, but if used, it should follow the uniform color coding system:

Class	Flow, gpm	Color
AA	Greater than 1500	**Blue**
A	1000-1499	**Green**
B	500-999	**Orange**
C	Less than 500	**Red**

Per National Fire Code 921:2-1 and 2-2



25

TDEC - Fleming Training Center

Testing

- Hydrants should not be pressure tested at the same time as the main
- When testing the hydrant:
  - Open hydrant fully and fill with water
  - Vent air by loosening one of the caps
  - Apply pressure up to 150 psi
  - Check for leaks at flanges, outlet nozzles, operating stem

26

TDEC - Fleming Training Center

Hydrant Operation

- Hydrants are designed to be operated by one person using a 15-inch long wrench

- Valve should be fully open or fully closed, never throttled
- Hydrants open and close the main valve against water pressure

27

TDEC - Fleming Training Center

Hydrant Maintenance

- All hydrants should be inspected at least annually
- If a hydrant is inoperable and cannot be immediately repaired, the fire department should be notified

28

TDEC - Fleming Training Center

Hydrant Lubrication

- To insure the readiness for instantaneous use, all fire hydrants should be inspected and tested at six-month intervals
- Oil
  - Follow manufacturers recommendations
  - Mineral oil may be substituted
- Grease
  - No grease containing calcium acetate
  - Food grade preferred
  - No Havoline 10W40

29

TDEC - Fleming Training Center

Inspection Procedures

- Verify upper barrel connected
- Check ground around hydrant
- Check valves for ease of operation
- Check for leakage at joints
- Flush line to remove foreign material
- Close main valve completely

30

TDEC - Fleming Training Center

Inspection Procedures

- Check for proper drainage
- Use a hydrant wrench
- Check breakaway mechanism
- Check nozzles for cross threading
- Clean and lubricate threads per hydrant specs
- Lubricate operating nut threads

31

TDEC - Fleming Training Center

Hydrant Repair

- Notify fire department
- Refer to M17 manual for model cutaway
- Close auxiliary valve
- Repair hydrant to manufacturer recommendations
- Test hydrant and open auxiliary valve

32

TDEC - Fleming Training Center

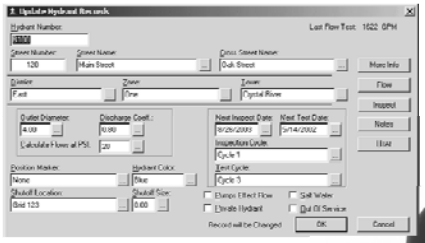
Hydrant Records

- Record make, model, location of hydrant at installation
- Record inspection and repair info - proof of condition of hydrant

33

TDEC - Fleming Training Center

Hydrant Records



34

TDEC - Fleming Training Center

Hydrant Safety

- Force and volume of water from a hydrant can cause injuries
  - Stand behind hydrant
- Provide a non-rigid flow diffuser
  - May cause traffic accidents, hazards
  - Take steps to minimize property damage
- If flow is diverted to a sewer, it must not create a cross-connection

Rigid Diffuser

35

TDEC - Fleming Training Center

Flushing Safety

- Local regulations may require dechlorination of flushed water
- Devices that are used to control erosion may also be useful to ensure adequate dechlorination

36

FIRE HYDRANT MAINTENANCE

Ernie Milteer, District Sales Manager
M&H / Kennedy Valve Company
P- 615.347.5815 F- 615.382.9079 E- e.milteer@comcast.net

GENERAL

All fire hydrants currently being installed in the south are in compliance with the American Water Works Association (AWWA) C502 standard for dry barrel hydrants, latest addition. Center stem compression hydrants are designed to both minimize maintenance needs as well as facilitate maintenance operations when necessary.

The following general information covers key mechanical components that may apply to all AWWA C502 hydrants. It is suggested to reference the manufacturers maintenance manual that is specific to each hydrant model for further servicing information.

When replacement parts are required, it is essential to provide detailed information specific to the subject hydrant. The following Information for identification will be on the barrel section: 1) name of manufacturer, 2) model number, 3) year of manufacture, and 4) main valve size. Direction to open and depth of trench may also be applicable.

MAIN VALVE

The most common maintenance need relates to obstructions in the seating area and resulting damage to the main valve. This is detectable by continued flow with the hydrant in the closed position.

When obstructions to seating of the main valve occur, it is important to avoid the use of excessive force in attempts to achieve closure. Excessive closure torques can accelerate damage to the main valve or induce damage to other related parts. The suggested procedure is to reopen the hydrant and flush the obstructions clear and attempt to re-close. If this is unsuccessful, the main valve assembly will need to be removed for further analysis.

Since we are going to remove the main valve, we must first turn off the auxiliary valve. Some maintenance functions can be performed under water pressure, however, when using a seat removal wrench we must confirm that the hydrant is not under pressure.

DISASSEMBLY - To access the main valve, the hydrant is disassembled starting from the bonnet. In the case of a grease-lubricated hydrant, we remove the bonnet bolts and thread off the bonnet unit off the stem. Next we remove the seal plate if applicable. In the case of an oil-lubricated hydrant, the manufacturer recommends removal of the operating nut assembly and procedures for retaining the oil in the bonnet.

Next, use the appropriate seat wrench (again with the water off) to remove the seat assembly. For recent production hydrants, this wrench engages on the cast iron break coupling below the break point or to an upper stem drive pin.

Most new model hydrants have bronze to bronze seating (seat ring to sub-seat). Also, the current use of O-ring seals provides servicing advantages verse old gasket seals. This allows for torque applied to the stem assembly to be sufficient drive out the seat ring.

For older models with a seat ring threaded into cast iron shoe, a longer seat wrench that drives directly on seat ring drive lugs is required to deliver disassembly torque. When encountering excessive resistance to seat removal, safety considerations increase in importance - especially when excessive manual force is employed. The wrench can be secured to the seat ring drive lugs by a retention device threaded to the upper stem. This can prevent the wrench from releasing while manual force is employed. Use of gear or power driven wrenches are preferable to the use of manual forces.

Main valve replacement is accomplished after removal of the bottom plate. Match the corresponding tapered seating surfaces of the main valve and the seat ring. At this point, also check the bronze-seating surface for damage. Minimal roughness can generally be buffed out with an emery cloth.

DRAIN VALVE SYSTEM

Function of the drain valve system needs to be checked for proper operation. There are two primary issues that can cause a need for related maintenance.

1) Hydrant barrel fails to drain after use - which subjects it to freeze damage.
2) During full open hydrant operation, continuous discharge of water is taking place which can undermine support for the installation.

To accommodate barrel drainage, a gravel sump is installed around the base of the hydrant to accept water from the drain ports. To check for proper drainage, view the water level drop and/or feel for the suction created at the nozzle outlet. If the hydrant barrel fails to drain there are several possibilities to review:

A) Improper installation of a concrete thrust block over the drain ports is somewhat common with new installations. It is also possible that the poly-wrap used to encase the piping system does not allow for drainage. In either case the need for re-excavation makes the remedy somewhat difficult.

B) There also have been cases where a high water table is the culprit.

C) It is possible the weep holes have become plugged with sand etc over time or during construction. There are two ways to check or remedy this situation.

1) The first option is to attempt to force flush the drain system clear with water pressure. To attempt this, remove a hose cap and open the hydrant slightly and fill hydrant barrel as much as possible. (This step is intended to minimize hazards associated with compressed air inside the hydrant.) Turn off hydrant and tightly secure all hose caps. Open the hydrant approximately 3 turns - standing behind and not over when operating. This allows

line pressure to enter the hydrant while the drain system is open creating an opportunity for line pressure to blow the drain system clear.

2) If problems persist, CLOSE the auxiliary valve and remove the main valve assembly as noted above. Pump the remaining water from the hydrant barrel. Using a long narrow pole with a nail thru the end, locate the drain ports that exit the shoe and attempt to mechanically clear the drain ports.

If the above least difficult remedies are not successful, it is sometimes chosen to designate a hydrant to be pumped out after each use - rather than excavating to address the external drain area. A so designated hydrant should be regularly inspected - since very minor seat leakage may be retained in the barrel section and is subject to freezing.

If during hydrant operation, continuous discharge of water is taking place, note the following possibilities:

A) Hydrant needs to be operated in the full open position only. This assures that the drain valve facing is fully blocking the drain valve port.

B) The drain valve facing is damaged or missing. This is most common with older style hydrants using leather drain valve facings, which are subject to wear, swelling, shrinking & cracking.

The newer pressure activated rubber drain valve facings have been a great improvement to hydrant operations & maintenance. These allow for operational tolerances, which have virtually eliminated wear and resulting, service needs.

C) Inspect the drain valve assembly. This can be subjected to damage from disassembly torques being transmitted thru - and twisting of - the drain ears.

REASSEMBLY - To reinstall the main valve assembly, inspect the O-ring seals and replace if necessary. For hydrants with older style gasket type seals, gasket replacement with each servicing is recommended. Clean the threads and apply food grade grease to the O-rings or gaskets and seat ring threads.

Lower the stem and main valve assembly into the barrel - using caution to avoid scrapping or dislodging the O-rings or gaskets. To assure proper starting of the threads, use the wrench to rotate assembly backwards one or two turns to align seat ring threads before threading into place. On models with O-ring seals, only a moderate amount of torque is required to seal the O-rings.

Before applying pressure to the main valve assembly, the bonnet assembly must first be reinstalled. This permits valve closure to be regulated by the operating nut. Do not flush a partially disassembled hydrant without the restraint of the operating nut assembly – since this would allow flow to drive the main valve closed and create a water hammer situation.

STEMS

Bronze upper stem sleeves should be inspected. The stem sleeve is bronze - since bronze is non corrosive and won't cut the bonnet / seal plate O-rings as the stem rises & descends during operation. However, bronze is a relatively soft material and subject to mechanical damage. To inspect, shut off the hydrant lead gate valve – remove the pumper cap - and open the hydrant. At this point the stem sleeve is just about fully visible and any damage should be detectable.

BREAKAWAY SYSTEM

The breakaway system is the weak point designed to fracture upon impact. This minimizes potential damage to the hydrant, the vehicle, and its occupants. Alternately, the break system must have enough structural integrity to facilitate high flow fire fighting operation. Due to potential for minor impact or bump damage, it is very important to perform a visual check of break flanges or break lugs as part of routine maintenance.

Finish grade shall be a minimum of 16 inches from center on pumper nozzle. This is essential for proper performance in the event of a collision. A well supported installation plays a key role in proper break function – in that the impact stress will be more fully focused on the cast iron break away components in a ridged installation rather than transferred to other points in the hydrant assembly.

After a collision - repair can be accomplished as follows:

1) Removing broken coupling and standpipe break rings or break lugs.
2) Unscrew the upper stem from the operating nut
3) Install the new break coupling and replace upper stem.
4) Remove the cap/bonnet assembly.
5) Reassemble upper barrel of hydrant to lower barrel - checking to assure proper gasket/o-ring gasket installation.
6) Install breaker rings or break lugs - tighten evenly to manufacturer's recommended torques.
7) Replace the cap / bonnet assembly by fully threading onto the upper stem and tighten bolts/nuts.
8) Add lubrication as recommended by the manufacturer.

EXTENSIONS

If the break system is not located in the recommended range, an extension should be added to help assure its breakaway function. This also permits the fire department to efficiently use cap wrenches and attach hoses.

Please use original manufacturer extensions to assure proper stem assembly tolerances. Upward thrust (especially at higher pressures) can cause stem deflection. An extended hydrant with two (or more) stem couplings that are too loose or have improper pins will greatly increase the potential for stem deflection and operational failure.

LUBRICATION & OPERATING NUT

The stuffing box area - located between the stem lock nut and the machined bonnet - contains the thrust collar of the operating stem nut. Line pressure provides resistance to initial opening of the main valve - which is transmitted as upward thrust to the op nut thrust collar - forcing it up against the stem lock nut.

Teflon thrust washers have been used over the past 35 +/- years to reduce operating friction. Hydrants with full travel stiff operation are usually older hydrants lacking a thrust washer and/or weather-shield protection of the op nut. Retrofitting a thrust washer is a relatively easy and inexpensive way to greatly improve operation of older hydrants.

Access to the operating nut is achieved after removing the stem lock nut. The stem lock nut is designed with backwards threading (for open left hydrants) - which tends to tighten while absorbing the thrust of opening of the hydrant against water pressure.

Before installing the retrofit washer, clean the stuffing box area. If contacting surfaces have become excessively scored, the bronze parts may need to replaced or refaced. After installation of the washer, be sure enough tolerance exists for operation without binding. Slight machining of the stem lock nut can provide additional tolerance for installation, if required.

After reinstalling the operating nut and stem lock nut, be sure the stem lock nut is fully threaded into the bonnet and retention hardware is engaged. This will prevent the lock nut from backing out while closing the hydrant.

Other possible causes of stiff operating would relate to the remaining operational contact points. These should be limited to:

A) Damaged op nut threads
B) Stem interference through the bonnet or seal plate.
C) Drain valve components that travel within the seat ring.

Hydrant manufactures recommend lubrication of the operating nut either by grease or oil. Regardless of the type of lubricant, use of a NSF food grade lubricant is essential. (Be sure to use a food grade lubricant that *DOES NOT* contain Calcium Acetate.) The need for a food NSF grade lubricant is driven by concerns relating to possible contamination of the water system from the use of an automotive petroleum product. Lubrication access is provided by either an alemite fitting or fill plug.

NOZZLES and CAPS

There are many types of mechanical retention systems used to secure the nozzles to the hydrant upper. Current production models use stainless steel set screws, pins or wedges - in conjunction with 1/4 turn or threaded nozzles.

Caps should be checked to be sure they are not seized to the nozzles. Nozzles (and adaptors) need to be checked to be sure they are properly secured to the hydrant. Also, confirm the nozzle threads match the equipment used by the local fire department.

Removal & replacement of nozzles can be challenging on older hydrants with corrosion and/or dysfunctional retention systems. If all else fails, carefully cut into the bronze only with a saw-saw and collapse the old nozzle with a hammer. Follow the manufacturer’s recommendations for nozzle replacement and retention.

O-ring seals are generally used for sealing to the nozzle section. Gaskets are used to provide a seal to the caps.

Hydrant Maintenance Report and Test Data

Hydrant No. _____ MVO _____" Mfgr. _____ Year Cast _____ Installed ___/___/___

Location _____

Hose Caps Missing _____ Replaced _____ Greased _____ Gaskets _____

Pumper Caps Missing _____ Replaced _____ Greased _____ Gasket _____

Cap Chains Missing _____ Replaced _____ Freed _____

Nose Noz Threads 2 1/2" NST _____ Other _____ Recaulk _____ Replaced _____

Pump Noz Threads 4 1/2" NST _____ Other _____ Recaulk _____ Replaced _____

Operating Nut Condition _____ Greased _____ Replaced _____ No. Turns _____

Valve & Seat Condition _____ Replaced _____

Stem Packing/O-Rings Condition _____ Tightened _____ Replaced _____

Drainage Condition _____ Corrected _____

Paint Condition _____ Repainted _____

Branch Valves Condition _____ _____

Other Defects/Corrections _____

_____

_____

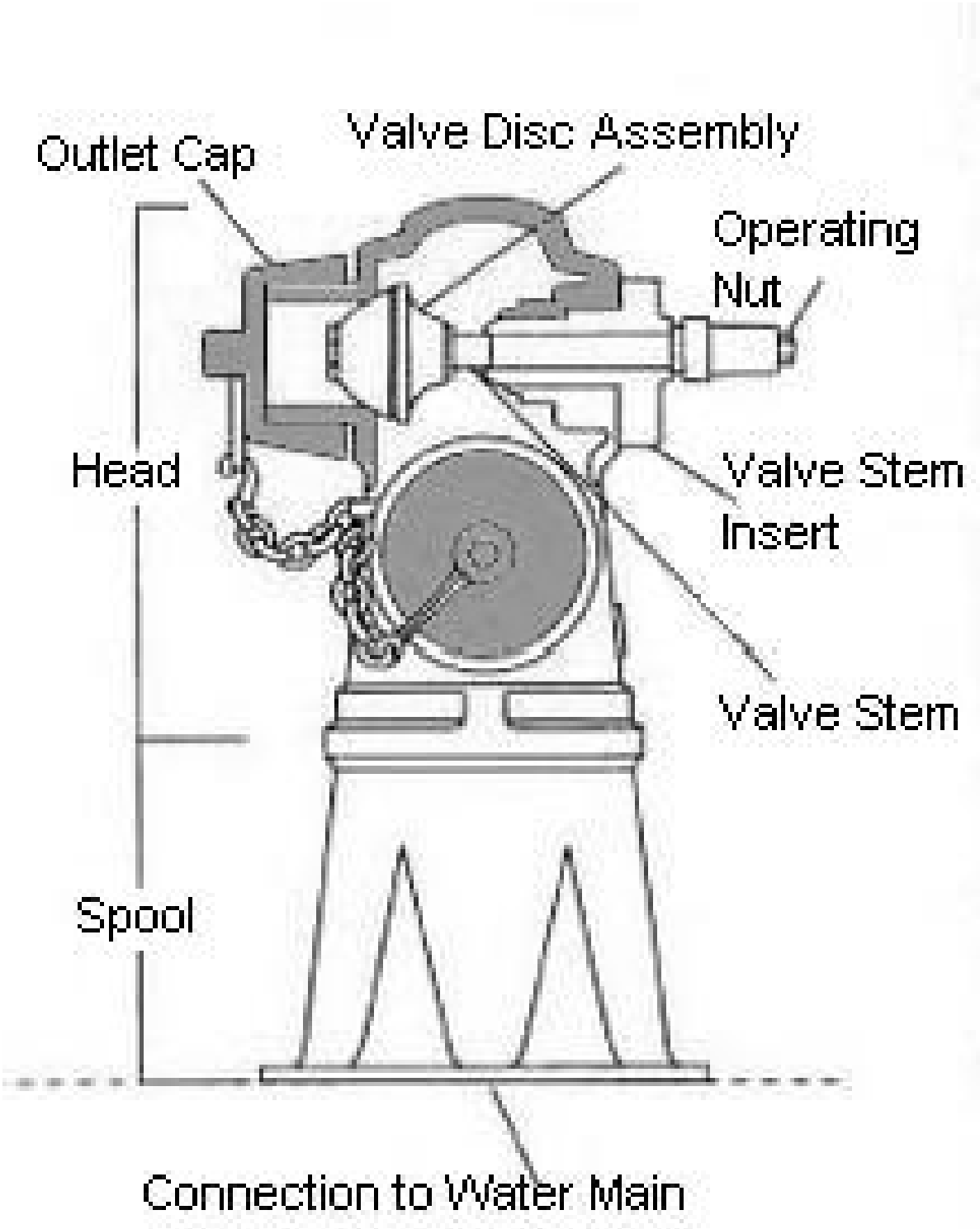
Flushed Minutes _____ Nozzle Open _____

Pressure Static _____ psi Residual _____ psi Flow _____ gpm Flow _____ psi

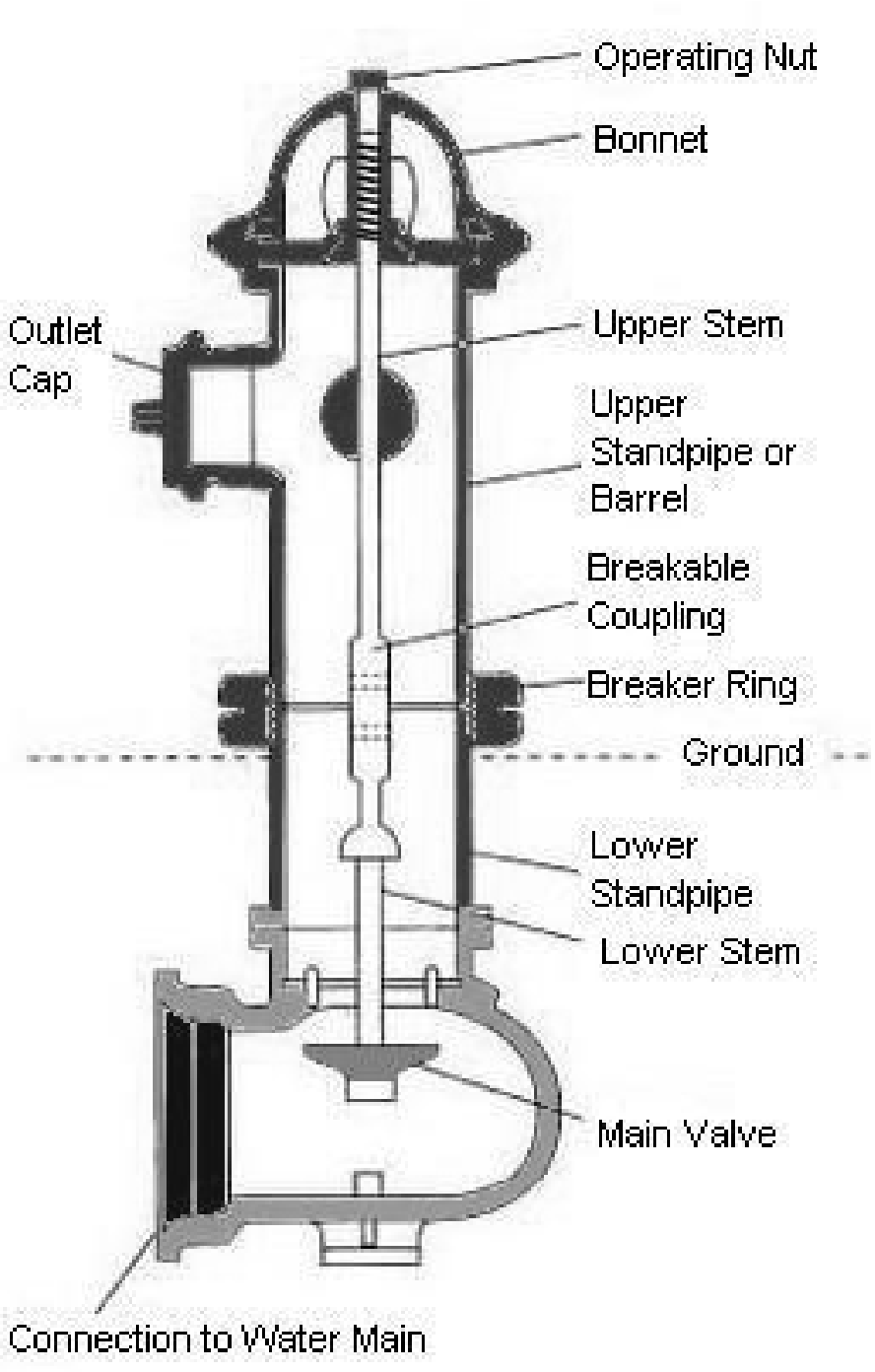
Inspected By: _____ Date: _____

Corrections By: _____ Date: _____

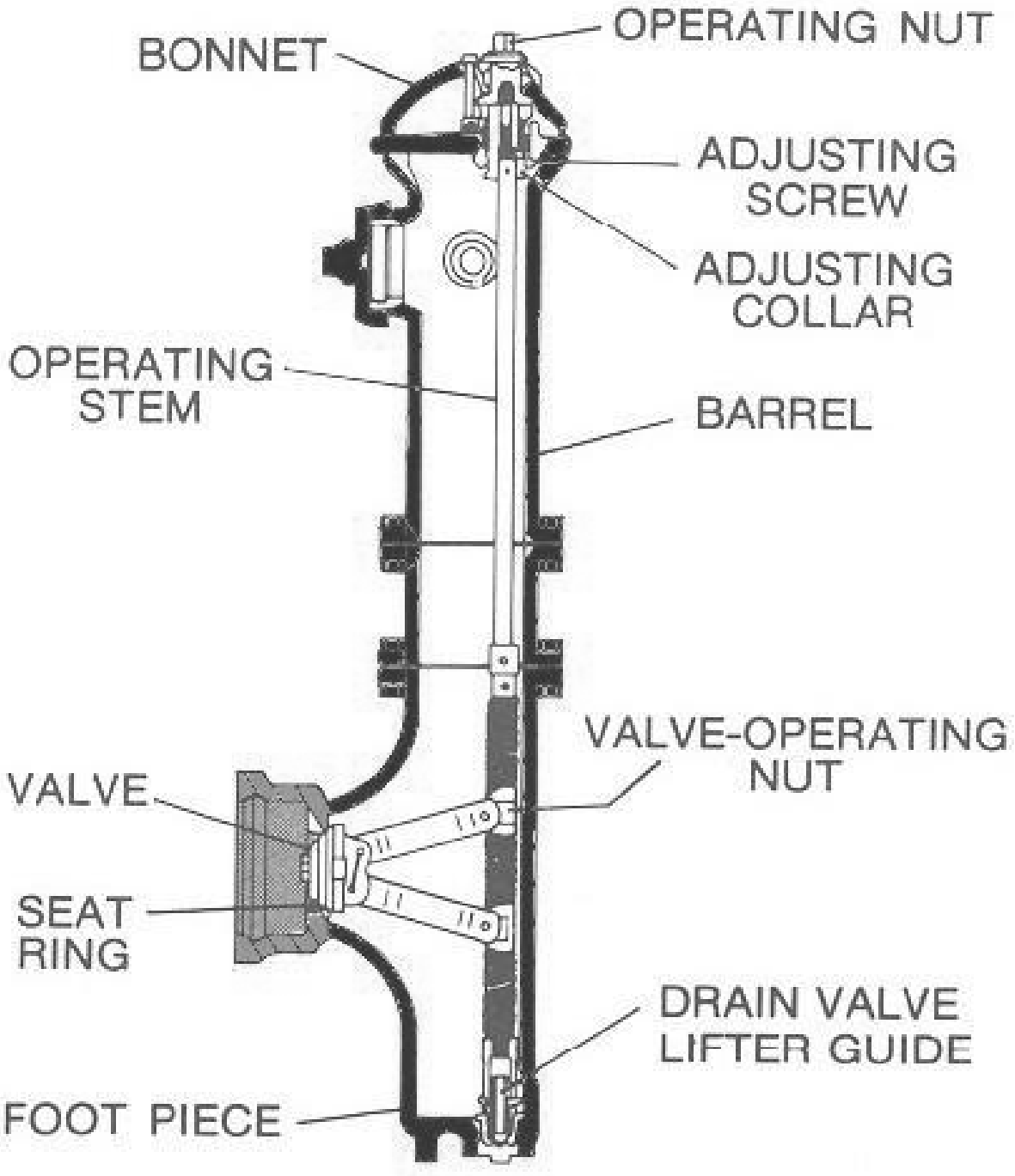
Wet Barrel Hydrant



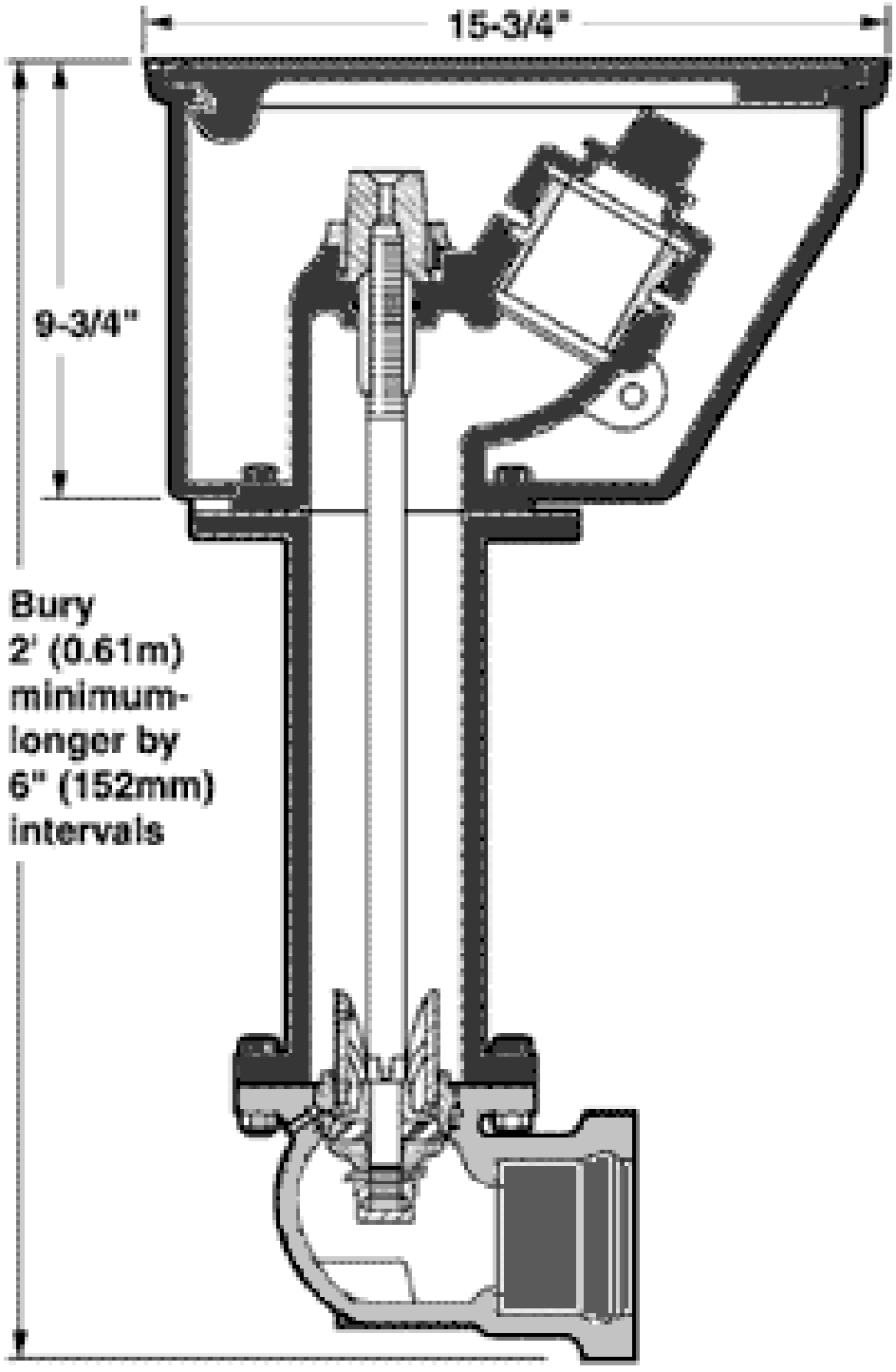
Dry Barrel Hydrant



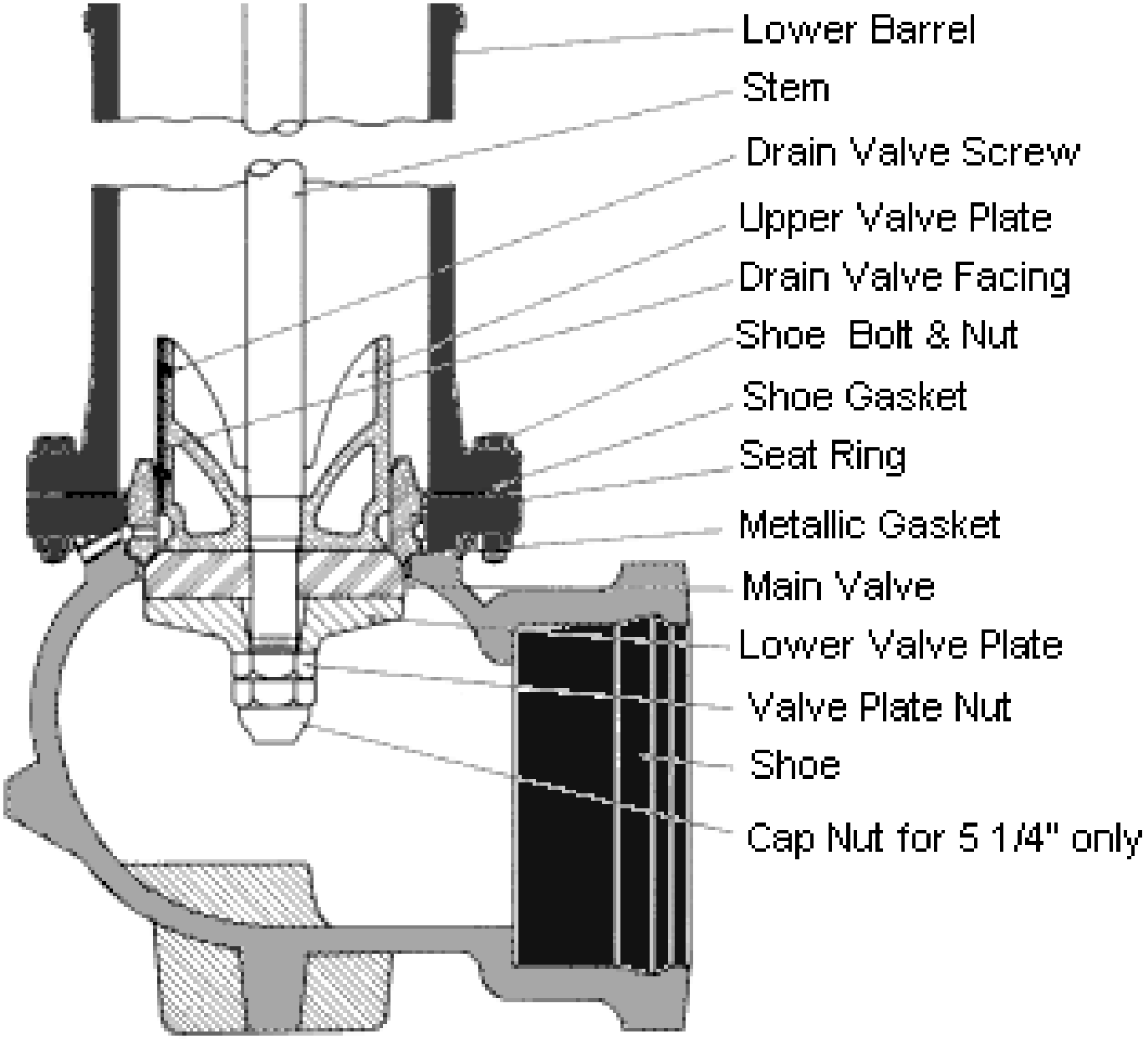
Corey Hydrant



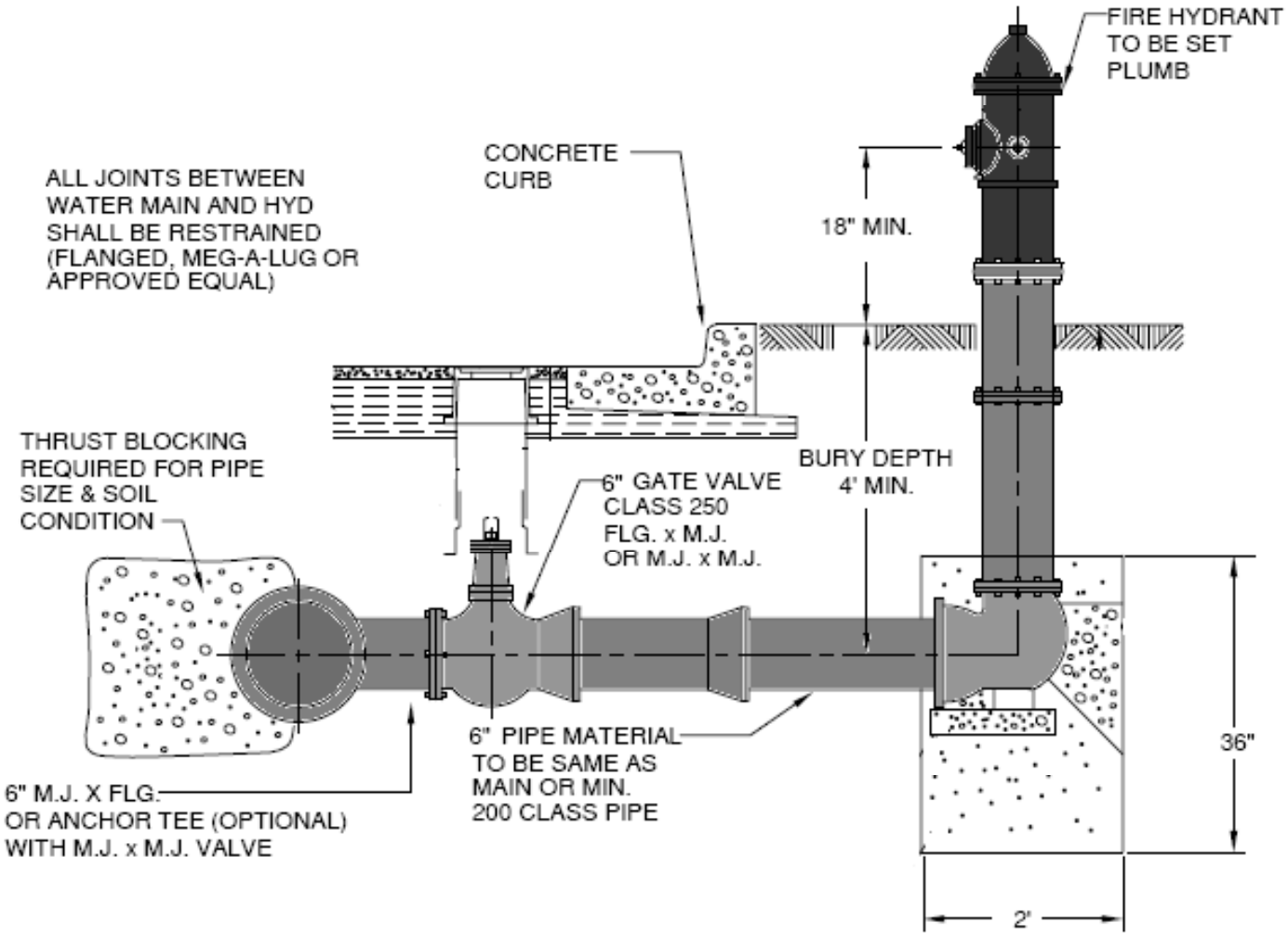
Flush Hydrant



Lower Section



Installation



Fire Hydrant Vocabulary

A. Barrel
B. Base
C. Bonnet
D. Breakaway Hydrant
E. Cap Nut
F. Corey Hydrant
G. Dry Barrel Hydrant
H. Fire Flow
I. Fire Hydrant
J. Operating Nut
K. Outlet Nozzle
L. Pitot Gauge
M. Pumper Outlet Nozzle
N. Residual Pressure
O. Water Hammer
P. Wet Barrel Hydrant

_____1. A device connected to a water main and provided with the necessary valves and outlet nozzles to which a fire hose may be attached.
_____2. A two-part, dry barrel post hydrant with a coupling or other device joining the upper and lower sections. The hydrant is designed to prevent water loss in the even it is struck by a vehicle.
_____3. A type of dry barrel hydrant in which the main valve closes horizontally and the barrel extends well below the connection to the pipe.
_____4. The body of a fire hydrant.
_____5. A nut, usually pentagonal or square, rotated with a wrench to open or close a valve or fire hydrant valve.
_____6. The inlet structure of a fire hydrant; it is an elbow shaped piece that is usually constructed as a gray cast-iron casting.
_____7. The potentially damaging slam that occurs in a pipe when a sudden change in water velocity creates a great increase in water pressure.
_____8. A hydrant with the main valve located at the base. The barrel is pressurized with water only when the main valve is open.
_____9. A threaded bronze outlet on the upper section of a fire hydrant, providing a point of hookup for hose lines or suction hose from hydrant to pumper truck.
_____10. A large fire hydrant outlet, usually 4.5 inches in diameter, used to supply the suction hose for fire department pumpers.
_____11. The top cover or closure on the hydrant upper section, which is removable for the purpose of repairing or replacing the internal parts of the hydrant.
_____12. A device for measuring the velocity of flowing water by using a velocity head of the stream as an index of velocity.
_____13. A fire hydrant with no main valve. Under normal, nonemergency conditions the barrel is full and pressurized.
_____14. Connects a standard-compression hydrant valve assembly to the hydrant main rod.
_____15. The pressure remaining in the mains of a water distribution system when a specified rate of flow, such as needed for fire fighting purposes, is being withdrawn from the system.
_____16. The rate of flow, usually measured in gallons per minute, that can be delivered from a water distribution system at a specified residual pressure for fire fighting.

Review Questions

1. List four commonly authorized uses for fire hydrants, other than for fire protection:
   - ➢
   - ➢
   - ➢
   - ➢
2. List four reasons why strict controls should be exercised over hydrant uses:
   - ➢
   - ➢
   - ➢
   - ➢
3. How can operation of a fire hydrant cause water quality problems?

4. Explain the principal difference between a dry barrel and a wet barrel hydrant.

5. In relation to the street, what direction should the pumper nozzle be pointed?

6. List two ways hydrants can be protected from damage by traffic:
   - ➢
   - ➢
7. What is the purpose of a color-coding scheme for hydrant tops or caps?

8. Why is the speed at which hydrant valves are operated important?

9. Name three preventative measures that should be taken in cold climate areas to ensure that hydrants will remain operable during the winter.
   - ➢
   - ➢
   - ➢

10. List three items of information about the distribution system that can be obtained from hydrant flow test.
    - ➢
    - ➢
    - ➢

11. List seven items of information that should be included on a hydrant record form:
    - ➢
    - ➢
    - ➢
    - ➢
    - ➢
    - ➢
    - ➢

12. Name five safety precautions that should be taken during hydrant flushing and testing to prevent injury to personnel and the public and to minimize damage to property.
    - ➢
    - ➢
    - ➢
    - ➢
    - ➢

Answers

Vocabulary

1. I
2. D
3. F
4. A
5. J
6. B
7. O
8. G
9. K
10. M
11. C
12. L
13. P
14. E
15. N
16. H

Review Questions

1. flushing water mains, flushing sewers, filling tank trucks, providing temporary water source for construction work
2. **(I)** To limit the amount of water that is wasted or not paid for
   (II) To keep a close control on unmetered water to limit the amount of unaccounted-for water
   (III) To minimize damage to hydrants caused by improper operation, such as incomplete valve closing or use of an improper wrench
   (IV) To reduce the possibility of distribution system demand due to such improper hydrant operation as closing a hydrant too quickly and causing water hammer
3. Increased flow in the main can stir up sediment, causing discolored or cloudy water.
4. The dry barrel hydrant has its main valve in the base. The barrel is dry until the valve is opened. When the main valve is closed, the barrel drains to prevent freezing.
   The wet barrel hydrant has no main valve in the hydrant (although there is usually an auxiliary valve). Each outlet nozzle has an independent valve that controls its discharge. The barrel is full of water under pressure at all times when the hydrant is in service.
5. The pumper nozzle should always be pointed toward the street so that the fire department can use a hard suction hose connected to the pumper truck.
6. Set hydrants back from the edge of the pavement and install hydrant guard posts.
7. A color-coding scheme is commonly used to indicate the hydrant flow capacity or the size of the water main. It is not used to indicate main pressure.
8. Hydrants should be opened and closed slowly in order to prevent pressure surges (water hammer) in the mains.
9. (I) Inspect hydrants in the fall to make sure their barrels are drained.
   (II) Inspect hydrants after each use in freezing weather, and pump out the barrel of any hydrant that does not drain properly.
   (III) If any hydrants are found to be inoperable, mark them by putting something over them, and notify the fire department of the locations.
10. (I) The need for additional feeder or looping mains
    (II) The need to clean existing pipes
    (III) Identify system valves that have been inadvertently left closed

11. name of the manufacturer; type or model; date installed; location (street address, plus distance ties to several permanent markers); buried depth; outlet-nozzle sizes and thread types; inlet pipe size
12. (I) Take care that the water force does not injure workers or pedestrians.
    (II) Consider possible traffic hazards.
    (III) Take special precautions if the water may freeze.
    (IV) If flow is diverted with a hose to a sewer, take care not to create a cross-connection.
    (V) If flow is diverted with a hose, the end of the hose must be securely anchored.

TDEC - Fleming Training Center

Water Main Flushing Program

Fleming Training Center

1

TDEC - Fleming Training Center

Flushing Program

- Why do we do this?
  - Important preventative maintenance
    - •Removes particulate matter and corrosion from lines
  - Improve water quality
    - •Low chlorine residual
    - •Brown water
    - •Positive bacterial counts
    - •Poor taste
    - •Bad odor
  - Customer complaints
    - •Taste and odor problems
    - •Turbid or colored water
    - •Reduced pressure
  - Basically it improves overall water quality

2

TDEC - Fleming Training Center

Flushing Programs

- How frequently should you flush?
  - Surface waters systems are usually going to flush more often due to increased nutrients in the water
  - Water quality indicators can be used to increase flushing:
    - Temperature, increase
    - Chlorine residual, decrease
    - Corrosion inhibitor, decrease
    - pH, decrease
    - Taste and odor, increase in complaints

3

TDEC - Fleming Training Center

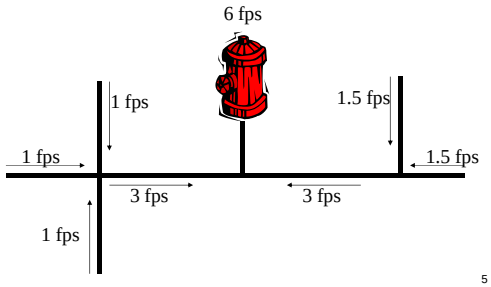
Flushing Program

- 2 types:
  - Unidirectional
    - water system valves are operated to create a one-way flow of the water, this increases the speed and scours the lines removing biofilm and corrosion
  - Conventional
    - the water used to flush the main does not always begin at a clean water source and the speed is low therefore more water is needed to clean mains

4

TDEC - Fleming Training Center

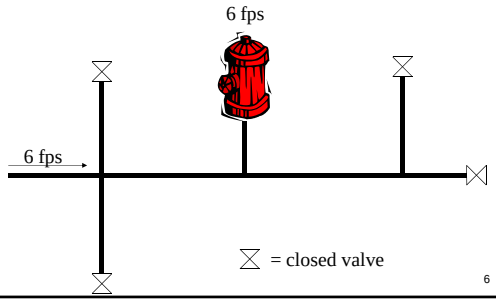
Conventional Flushing



5

TDEC - Fleming Training Center

Unidirectional Flushing



6

Unidirectional Flushing

- Needs some engineering
- You control
  - flow
  - direction
    - where the water is coming from and where it is going
- You have to know your system
  - know location of all mains, valves and hydrants

Unidirectional Flushing

- Pros
  - uses 40% less water than conventional flushing
  - scours and cleans pipes up to 2 years
  - more localized
  - tests most valves and hydrants
    - identifies those that need repair or replacement

Unidirectional Flushing

- Requirements:
  - Distribution maps and plans
  - chart flow directions
  - examine depletion and replenishment patterns of storage tanks
  - review components
    - tanks, hydrants, blow off valves, pipe material and pump stations

Unidirectional Flushing

- Divide into sections (manageable loops) that will be flushed in sequence
  - flushing runs
  - set target for flushing velocities 2-5 fps
    - remove biofilm
    - don't stress weak areas
- Develop step-by-step flushing sequence
  - which hydrant or blow off valve to open and which valve to open or close

Unidirectional Flushing

- Start from beginning - treatment plant or storage tank
- Isolate pipes you want to flush - close valves
- Flush from clean to dirty pipes
- Force water from bigger main to smaller main
- Sample water before, during and after

Unidirectional Flushing

- Safety
  - use a diffuser to decrease water velocity
  - dechlorinate if chance of getting into surface water
  - open valves and close them slowly so you don't create water hammer
  - wear appropriate clothing so people will see you
  - watch traffic
  - be careful when flushing hydrant, you don't know what could come out of it

Unidirectional Flushing

- Restored disinfectant residual
- Reduces disinfectant demand
- Reduces bacterial growth
- Dislodges biofilms
- Removes sediments and deposits
- Restores flows and pressures
- Eliminates taste and odor problems

13

Documentation

- You should document each time you flush a line
  - location
  - beginning of flush
    - color of water
    - residual chlorine
  - end of flush
    - color of water
    - residual chlorine
  - time flushed
  - rate of flow

14

Notify Customers

- You should notify your customers that you will be flushing lines in their area
  - bill stuffers
  - media - news papers, new stations
- They should be told that their water may be discolored but to let their cold water run until water is clear
  - they shouldn't use colored water for laundry, cooking or drinking
  - don't use hot water to flush lines, they could end up with colored water getting into their water heaters

15

Flushing Program Record

Date	Time	Location or Address	Type of Valve or Hydrant	Time to Clear	Total Time	Flow (gpm)	Free Chlorine Residual	Persons Responsible

Section 9

Corrosion

Stabilization

Corrosion and Scaling Control in the Distribution System

Stabilization

- **The process for controlling corrosion and scale deposits on pipelines and plumbing fixtures.**
- **Corrosion and scale deposits in the distribution system can be very costly for utility.**
- **Problems range from excessive customer complaints to increased pumping costs, to replacement of mains due to leaks and breaks.**
- **Corrosion control is also important in protecting consumers from the dangers of excess lead and copper.**

Purpose of Stabilization

1 **To protect public health**

- **Corrosive water can leach toxic metals from distribution piping and household plumbing - lead and copper**
- **Corrosion of cast-iron mains causes tubercules (iron deposits) that can protect bacteria from chlorine, allowing them to grow and thrive**

Purpose of Stabilization

2 **To improve water quality**

- **Corrosive water attacking metal pipes can cause color, taste & odor problems**
- **red-water from cast-iron mains**
  - **the iron will stain a customer's plumbing fixtures and laundry and make the water's appearance unappealing for drinking and bathing**
- **corrosion of copper pipes can cause metallic taste and blue-green stains on plumbing fixtures and laundry**

Purpose of Stabilization

3 **To extend life of plumbing equipment**

- **Aggressive water reduces life of valves, unprotected metal, asbestos-cement pipe, plumbing fixtures, water heaters**
- **Buildup of scale and corrosion products reduces capacity of pipes, which reduces distribution system efficiency and increases pumping costs**
- **If scale deposits go unchecked, pipes can become completely plugged**

Purpose of Stabilization

4 **To meet federal and state regulations**

- **Lead and Copper Rule - 1991**
- **Systems must check if their water is corrosive enough to cause lead and copper to be present**
- **Samples taken at high-risk locations; homes with lead pipes, service lines or lead solder**

Lead and Copper Rule

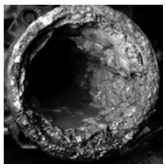
- Samples are to be collected after water has sat in lines for at least 6 hours - first draw
- 1 liter taken from cold water tap in kitchen or bathroom
- Action level for lead is 0.015 mg/L, copper is 1.3 mg/L
- If a system exceeds action level in more than 10% of samples, must take steps to control corrosion

Corrosion

Definition of Corrosion
Factors Affecting Corrosion
Types of Corrosion

Water System Corrosion

- Corrosion - the gradual deterioration or destruction of a substance or material by chemical reaction with the water
- Water that promotes corrosion is called corrosive or aggressive water




Corrosive Water

- Dissolved Oxygen
  - as dissolved oxygen increases, rate of corrosion increases
- Total Dissolved Solids
  - increase electrical conductivity of water
- Alkalinity
  - buffers a change in pH, decreases corrosion
- pH
  - low pH promotes corrosion, high pH can be scale-forming

Corrosive Water

- Hardness-
  - a small amount can form protective layer of scale on pipes to prevent corrosion
- Temperature -
  - corrosion occurs faster in warmer waters
- Flow Velocity-
  - increased velocity can increase rate of corrosion if water is corrosive
  - increased velocity can decrease rate of corrosion if adding corrosion inhibitor

Corrosive Water

- Type of metals
  - galvanic corrosion is corrosion of dissimilar metals
- Electrical Current
  - improperly grounded household electrical systems can accelerate corrosion
  - electric railway systems can be a cause of this also
- Sulfate Reducing Bacteria
  - H_2S gas released - causes rotten egg odor
  - can react with water to form H_2SO_4, which is highly corrosive
  - Produce black sulfide deposits

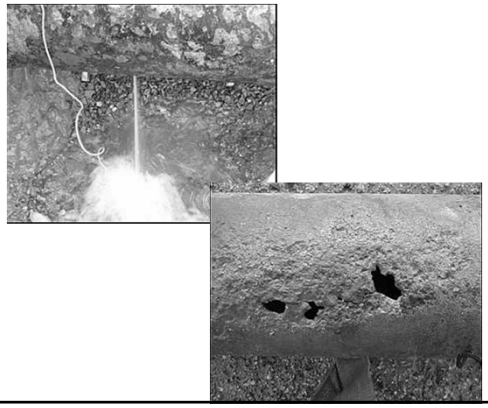
Corrosive Water

- Iron Bacteria
  - Convert dissolved iron into precipitate causing red-water complaints
  - Produce slime which protects against chlorine and prevents accumulation of $CaCO_3$
  - Bacteria can slough off causing tastes & and odors
  - Bacteria can change pH and alkalinity of water as they give off gases, mainly CO_2

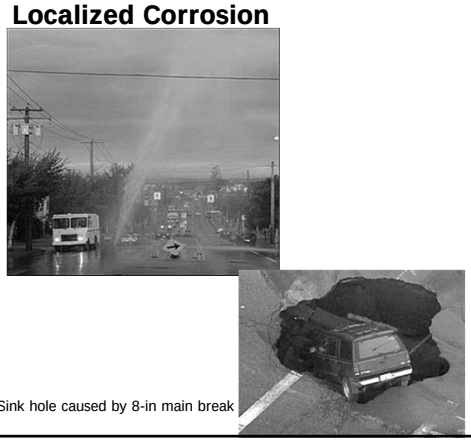
Types of Corrosion

- Localized
  - Most common, most serious
  - Attacks surface unevenly, leads to rapid failure of metal
  - two types
    - galvanic corrosion - caused by the connection of dissimilar metals in an electrolyte such as water
    - concentration cell corrosion - forms deep pits or turbercules
- Uniform
  - Occurs evenly over all surface
  - Due to low pH and alkalinity

Localized Corrosion

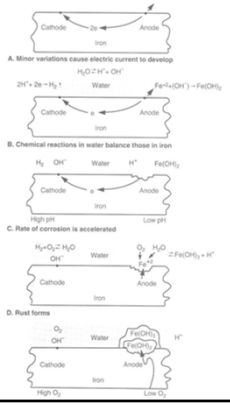


Localized Corrosion



Sink hole caused by 8-in main break

Galvanic Corrosion



Galvanic Corrosion

Corroded End (anode)	Most Active
Magnesium	+
Magnesium alloys	
Zinc	
Aluminum	
Mild Steel	
Wrought (black) Iron	
Cast Iron	Corrosion Potential
Lead-tin Solders	
Lead	
Tin	
Brass	
Copper	
Stainless Steel	-
Protected End (cathode)	**Least Active**

Scale Formation

Definition of Scale Formation
Factors Affecting Scale Formation
Types of Scale Formation

Scale Formation

- Scale formation - the precipitation of certain hardness-causing ions with other minerals to form a coating on pipe walls
- The formation of a small amount of scale can help protect the pipe form corrosion
- Uncontrolled deposits reduce the carrying capacity of the pipe
- Can also decrease the efficiency of boilers, hot water heaters, etc

Scale-forming Compounds

- $CaCO_3$
- $MgCO_3$
- $CaSO_4$
- $MgCl_2$

Scale Formation

- Saturation point - the point at which a solution can no longer dissolve any more of a particular chemical; precipitation of the chemical will occur past this point
- Solubility varies with temp, pH, TDS, etc
- Solubility of $CaCO_3$ in water decreases as temperature increases; the higher the temperature in hot water heaters causes $CaCO_3$ to precipitate out and build up on pipe, tank walls and heating element

Control Methods

1. pH and alkalinity adjustment
2. Formation of $CaCO_3$ coating
3. Use of corrosion inhibitors and sequestering agents

pH and Alkalinity Adjustment

- Soft waters with pH less than 7 and poorly buffered (low alkalinity) will be corrosive to lead and copper.
- Water with too much alkalinity can also be corrosive.
- A moderate increase in pH and alkalinity can reduce corrosion.
- A moderate decrease in pH and alkalinity can prevent scale formation.

Stability Scale

Corrosive Water	←	Stable water	→	Scale-Forming

Water is considered stable when it is just saturated with calcium carbonate. It will neither deposit nor dissolve calcium carbonate.

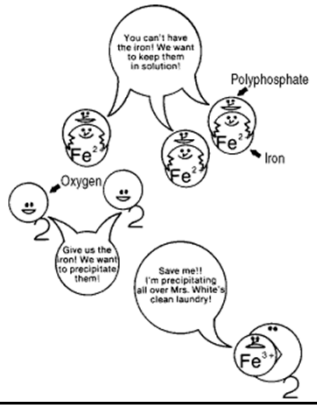
Use of Coatings

- **A protective coating on pipe surfaces can inhibit corrosion.**
  - **Lime, alone or in combo with soda ash or sodium bicarb, can be added to precipitate a $CaCO_3$ scale on the pipe walls**
  - **A coating of cement, epoxy, etc. can be applied to interior pipe surfaces.**
  - **Polyphosphates and sodium silicate can be used for corrosion control and stabilization.**

Polyphoshates

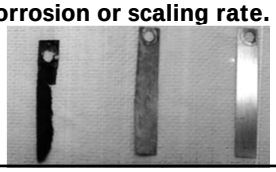
- **Polyphoshates work as sequestering agents - tie up iron and manganese to prevent color and taste complaints**
  - **They also tie up calcium carbonate to prevent excess scale**
  - **Calcium (from alkalinity) is required as a catalyst**
  - **If low alkalinity, need a blend of polyphosphate and orthophosphate**
  - **Orthophosphate coats pipe, polyphosphate sequesters**
- **Orthophosphates work well for lead and copper protection**

Phosphates



Coupon Testing

- **Measures the effects of the water on a small section of metal (the coupon) inserted in a water line.**
- **After a minimum of 120 days, the inserts are removed, cleaned, weighed and examined.**
- **The weight loss or gain of the coupon can provide an indication of the corrosion or scaling rate.**



Best Stabilization Treatment

- **In the distribution system:**
  - **Evaluate effects of corrosion and scaling**
  - **Records of main breaks and leaks - corrosion**
  - **Info on how well older valves operate - if difficult to operate, may be coated with scale**
  - **Info on reduced flow rates in mains - buildup of scale**
  - **When possible, pieces or sections of pipe removed should be tagged and evaluated.**

Best Stabilization Treatment

- In customers' plumbing:
  - Customer complaints
    - Red water, brown water, loss of pressure
    - Location where problems occur
    - Time of year
- For meeting regulation requirements:
  - Lead and Copper Rule
    - Must take steps to reduce corrosion if action levels are exceeded

Best Stabilization Treatment

- Water quality data:
  - Determine if there is an increase in metals in distribution system (copper, zinc, cadmium)
  - Before initiating a corrosion control program, check with others in the field who can give sound advice.
  - Using the wrong stabilization method can increase problems.

Operational Controls

- Water quality analyses
  - Lab data for calculating Langelier Index
- In-plant monitoring
  - Continuously recording pH meter
- Distribution system monitoring
  - Check for presence of metals indicating corrosion
- Pipe and coupon testing
  - Small section of metal is placed in a pipe, checked for corrosion or scaling

Records

- Amount of chemicals used - state report
- Lab test, Langelier Index calculations
- Maintenance records
- Results of coupon tests, other tests
- Customer complaints related to corrosion or scaling

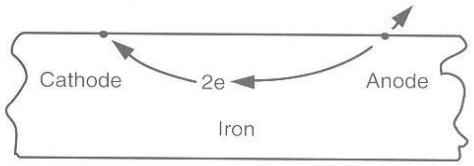
Corrosion Vocabulary

A. Aggressive
B. Anode
C. Cathode
D. Concentration Cell Corrosion
E. Corrosion
F. Corrosive
G. Coupon Test
H. Galvanic Corrosion
I. Galvanic Series
J. Iron Bacteria
K. Langlier Index
L. Localized Corrosion
M. Milk of Lime
N. Red Water
O. Saturation Point
P. Sequestering Agent
Q. Slaker
R. Stabilization
S. Tubercules
T. Uniform Corrosion
U. Unstable

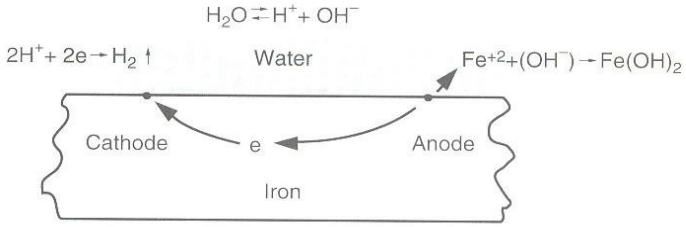
_____ 1. A chemical compound such as EDTA or certain polymers chemically tie up other compounds or ions so they can't be involved in chemical reactions.
_____2. To deteriorate material, such as pipe, through electrochemical processes.
_____3. Bacteria that use dissolved iron as an energy source.
_____4. The lime slurry formed when water is mixed with calcium hydroxide.
_____5. Knobs of rust formed on the interior of cast iron pipes due to corrosion.
_____6. Corrosive.
_____7. A term used to describe rust-colored water due to the formation of ferric hydroxide from iron naturally dissolved in the water or as a result of the action of iron bacteria.
_____8. A listing of metals and alloys according to their corrosion potential.
_____9. To be corrosive or scale-forming.
_____10. Positive end (pole) of an electrolytic system.
_____11. The point at which a solution can dissolve no more of a particular material.
_____12. A numerical index that indicates whether calcium carbonate will be deposited or dissolved in a distribution system.
_____13. The water treatment process intended to reduce the corrosive or scale-forming tendencies of water.
_____14. Negative end (pole) of an electrolytic system.
_____15. A form of localized corrosion that can form deep pits or tubercules.
_____16. A form of corrosion that attacks a small area.
_____17. The part of the quicklime feeder that mixes the quicklime with water to form hydrated lime.
_____18. A form of localized corrosion caused by the connection of dissimilar metals in an electrolyte such as water.
_____19. The gradual deterioration or destruction of a substance or material by chemical reaction. The action proceeds inward from the surface.
_____20. A form of corrosion that attacks material at the same rate over the entire area of its surface.
_____21. A method of determining the rate of corrosion or scale formation by placing metal strips of a known weight in the pipe.

Answers to Corrosion Vocabulary

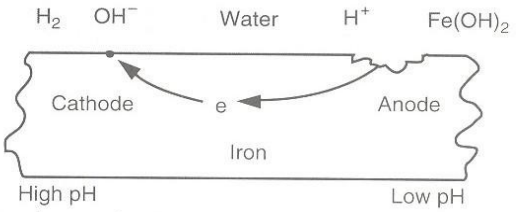
1. P	8. I	15. D
2. F	9. U	16. L
3. J	10. B	17. Q
4. M	11. O	18. H
5. S	12. K	19. E
6. A	13. R	20. T
7. N	14. C	21. G



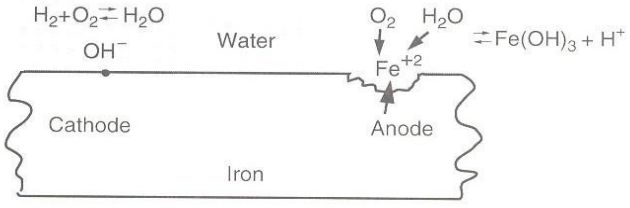
A. Minor variations cause electric current to develop



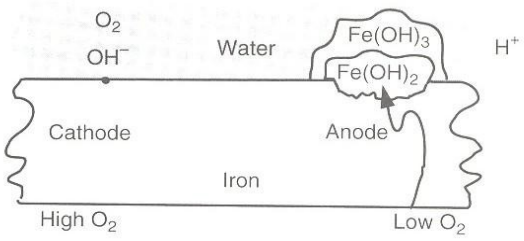
B. Chemical reactions in water balance those in iron



C. Rate of corrosion is accelerated



D. Rust forms



Section 10

Water Meters

TDEC - Fleming Training Center

Water Services

TDEC - Fleming Training Center

Water Service Lines

Water service lines are the pipes that lead from a connection on a water main to a connection on a customer's plumbing.

2

TDEC - Fleming Training Center

Service Line Sizes

- Depends on:
  - Maximum water demand
  - Main pressure under peak demand conditions
  - Elevation difference between main and the highest portion of the building to be served
  - Distance from main to building plumbing

3

TDEC - Fleming Training Center

Service Line Sizes

- Single family residences usually have ¾-inch service line
- Other customers have service line sized for max demand

4

TDEC - Fleming Training Center

Types of Service Line Pipe

- Lead pipe
- Galvanized iron pipe
- Copper tubing
- Plastic tubing

5

TDEC - Fleming Training Center

Lead Pipe

- Most older systems still have some lead service connections in use
  - Usually replaced, not repaired
  - The principal reason for such a policy is that evidence points to health risks due to lead leached from plumbing materials

6

TDEC - Fleming Training Center

Galvanized Iron

- Connected with gooseneck for flexibility
- Subject to galvanic corrosion, corrosion from soil
  - especially at a pipe connected with brass fittings
- Usually replaced rather than repaired

7

TDEC - Fleming Training Center

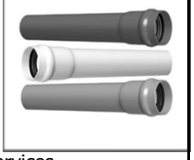
Copper Tubing

- Popular replacement for lead and galvanized iron because:
  - It is flexible
  - Easy to install
  - Corrosion resistance in most soils
  - Able to withstand high pressure
- Aggressive water may dissolve copper, to cause green stains on plumbing fixtures

8

TDEC - Fleming Training Center

Plastic Tubing



- Three generally used for water services
  - PVC (polyvinyl chloride)
  - PE (polyethylene)
  - PB (polybutylene)
- Low friction, lightweight, corrosion resistant
- Permeable by gasoline, solvents, etc.
- Cannot be located by electronic pipe finder
- Must have NSF approval seal

9

TDEC - Fleming Training Center

Adapters and Connectors

Flare fittings

Compression fittings

10

TDEC - Fleming Training Center

Corporation Stops

- Valve used to connect a small-diameter service line to a water main
- Also known as
  - Corporation cock
  - Corporation tap
  - Corp stop
  - Corporation
  - Corp
  - Stop
- Available with a ball valve or plug valve

11

TDEC - Fleming Training Center

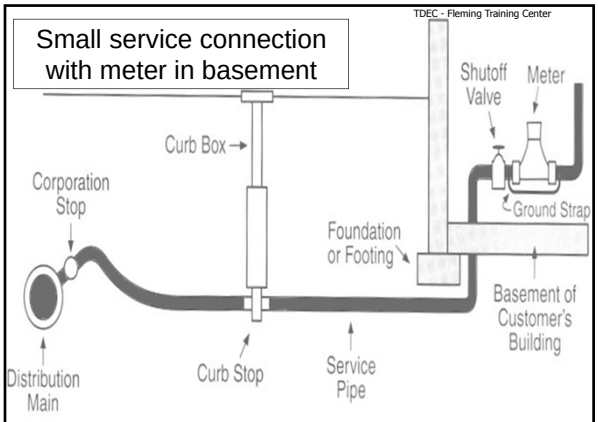
Curb Stops and Boxes

- Curb stop
  - shutoff valve to meter
- Curb box
  - pipe extending from curb stop to surface
  - allows access to curb stop with a key
- Plug or ball valve

12

TDEC - Fleming Training Center

Small service connection with meter in basement



TDEC - Fleming Training Center

Water Service Taps

- Dry taps
  - Made during installation of new main
  - Main is empty
- Wet taps
  - Addition to an in-service main
  - Connection made without shutting off water
  - No contamination of line

14

TDEC - Fleming Training Center

Direct Tapping

- Corporation stop is directly screwed into a threaded hole in pipe wall
- For PVC and A-C, carefully follow manufacturer's instructions
- Tapping machine drills, taps (threads), and inserts the corporation stop

15

TDEC - Fleming Training Center

Direct Tapping Process

- Pipe excavated and cleaned, machine clamped into place
- Machine bores hole in pipe wall, tap cuts threads
- Boring bar retracted, flapper valve closes to contain pressurized water

16

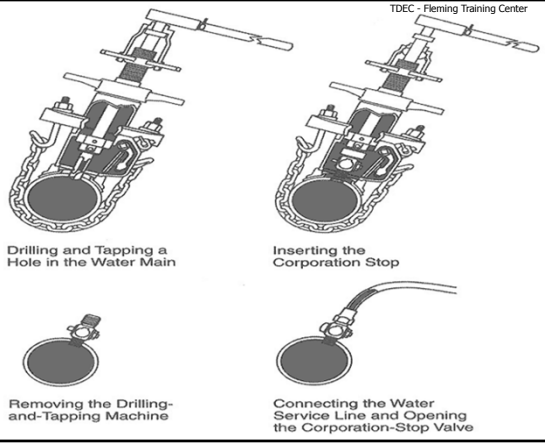
TDEC - Fleming Training Center

Direct Tapping Process

- Drill-and-tap tool removed, corporation stop threaded into hole in closed position
- Bar is reinserted into the machine and the corporation stop is screwed into the threaded hole
- Machine is removed; corporation stop is ready for attachment of service line

17

TDEC - Fleming Training Center



TDEC - Fleming Training Center

Service Clamps

- Also known as service saddles
- For taps larger than 1 inch on PVC or A-C, a service clamp should be used instead of a direct tap
- Eliminates chance of pipe splitting

TDEC - Fleming Training Center

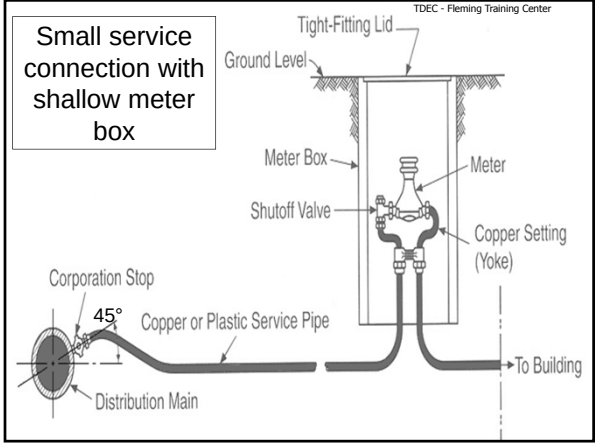
Tap Location

- 45° angle down from top of main
  - A tap directly on top is more liable to draw air in the service
  - A tap near the bottom could draw in sediment
- On same side of main as building

20

TDEC - Fleming Training Center

Small service connection with shallow meter box



TDEC - Fleming Training Center

Leaks and Breaks

- Lead and galvanized iron pipe likely to leak if disturbed
- Copper and plastic more durable
  - Can break during excavation or settling

22

TDEC - Fleming Training Center

Thawing

- Prevent freezing by burying below frost line
- Metallic pipe can be thawed by electric current
  - By experienced operator
- Hot water can be used for any pipe
- Hair dryer or heat gun will thaw meter or service line in meter box

23

TDEC - Fleming Training Center

Service Line Records

- File by address - card or computer
  - Exact location of tap
  - Type & size of pipe & tap
  - Bury depth
  - Location of curb stop or meter box
  - Location of pipe entry to building
  - Date of installation

24

TDEC - Fleming Training Center

- Good records on plastic pipe are especially important because they cannot be located by electronic equipment

25

TDEC - Fleming Training Center

Water Meters

TDEC - Fleming Training Center

Water Meters

- Measure and record the amount of water passing through
- Primary functions are
  - To help water utility account for water pumped to system
  - Charge customers for the water they use

27

TDEC - Fleming Training Center

How do we measure water?

- By volume
  - Filling and emptying a calibrated space
  - Positive displacement meters
    - 2" and smaller meters only
- By velocity
  - Measuring the speed water moves
  - All sizes, residential and commercial

28

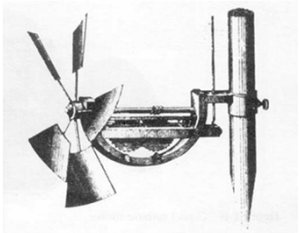
TDEC - Fleming Training Center

A Little History

- Modern water measurement did not begin until the late 18th century
- The first practical meter was invented by Reinhold Woltman in 1790

29

TDEC - Fleming Training Center



In this form, the Woltman meter could measure flows only in an open stream. The revolutions of the waterwheel were transmitted to a register by a gear train. For a stream of known cross section, the register could be calibrated to give accurate measurements of flow.

Figure 1-7 Original form of the Woltman meter

30

A Little History

- The Woltman meter could only measure water in an open channel
- It was 1850 before a meter was developed that could be used in a closed pipe
- Class I turbines, developed in the late 1800s are modified Woltman meters that allow a top mounted register by using a vertical axis measuring element

31

Meter Purpose

- Every water service should have a meter on it
  - Payment purposes
  - Account for water pumped to distribution
  - Help locate water leaks

Incorrect metering accounts for the second greatest loss of water to a utility

32

AWWA Standards

- C700 - Displacement Meters
- C701 - Turbine Meters
- C702 - Compound Meters
- C703 - Fireline Meters
- C708 - Multi-Jet Meters

33

Positive-Displacement Meters

- Most commonly used meter for residences and small commercial
- Reliable and accurate for low flow rates
- Measure exact quantity of water passing through it

34

Positive-Displacement Meters

- Positive displacement meters use a calibrated space that is filled and emptied to measure water
  - Measuring cup
- There are 2 types of positive displacement meters
  - Nutating Disc
  - Oscillating Piston

35

Positive-Displacement Meters

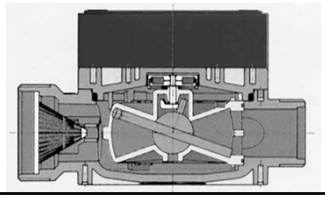
- Piston meter - volume of water is measured as water moves the piston
- Nutating disk - sweeps out specific volume for each rotation (wobble)

36

TDEC - Fleming Training Center

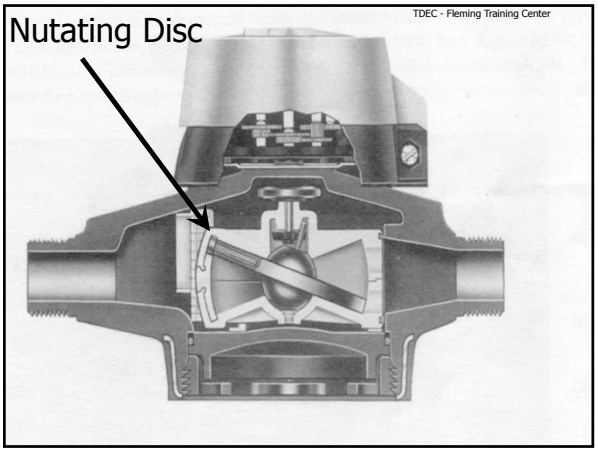
Nutating Disc

- Nutation - n(y)Ü-`tā-shen: Oscillatory movement of a rotating object: wobble



37

TDEC - Fleming Training Center



TDEC - Fleming Training Center

How does it work?

- As water moves into the inlet, it forces the disc to wobble on its axis
- The calibrated space fills and empties with each nutation

39

TDEC - Fleming Training Center

Positive-Displacement Meters

- Advantages
  - Accurate over wide range of flows
  - Easy to repair or replace due to availability
- Disadvantages
  - High head loss at high flow rates
  - Under register when worn; max usage should be half of capacity

40

TDEC - Fleming Training Center

Large Water Meters

- Customers that use large quantities of water
  - Transfer or Utility purchases
  - Industries
    - Great deal of cleaning
    - Incorporate water into manufactured products
  - Businesses
    - Hospitals
    - Large public buildings
    - Apartments
  - Irrigation at golf courses

41

TDEC - Fleming Training Center

Large Water Meters

- Large meters fall into several types
  - Positive Displacement (1-1/2 and 2" only)
  - Multijet (1-1/2 and 2" only)
  - Compound and Fireline Compound (2" - 10")
  - Turbine (2" - 16")
  - Propeller (4" - 72")
  - Magnetic Flow Meters (1/8" - 42")
  - Ultrasonic Meters (Doppler)

42

TDEC - Fleming Training Center

Compound Meters

- For customers with wide variations in water use
- Turbine meter and a positive-displacement meter in one
- Automatic valve controls water flow through meter
  - High flows go through the turbine side with little restriction
  - Under low flows, the valve shuts and directs water through a small displacement meter
- High maintenance requirement, expensive

43

TDEC - Fleming Training Center

Compound Meters

- As name denotes
  - 2-measuring chambers housed in a single meter body or assembly
- One chamber captures low flows
- One chamber captures high flow

44

TDEC - Fleming Training Center

AWWA Compound Meter Flow Ranges

- 2″ - 1/4 gpm to 160 gpm
- 3″ - 1/2 gpm to 320 gpm
- 4″ - 3/4 gpm to 500 gpm
- 6″ - 1-1/2 gpm to 1000 gpm
- 8″ - 2 gpm to 1600 gpm

45

TDEC - Fleming Training Center

Where are Compound Meters Used?

For Low to High Continuous Flow Rates

- Apartment Buildings
- Motels
- Hotels
- Condominiums
- Mobile Home Parks
- Hospitals
- Schools
- Restaurants
- Dormitories
- Department Stores
- Shopping Malls
- Public Transportation Centers

Where people live and work!!

46

TDEC - Fleming Training Center

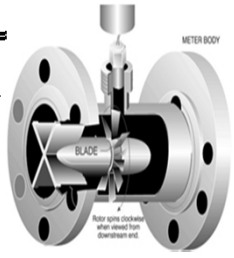
Current Meters

- Also called velocity meters
  - Turbine, multijet, propeller meters
  - Measure velocity of flow past a cross-section of known area
  - Low head loss
  - Inaccurate at low flow rates

47

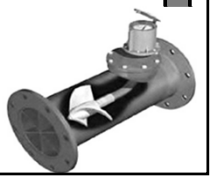
TDEC - Fleming Training Center

Turbine Meter



Venturi Meter

Propeller Meter



TDEC - Fleming Training Center

Multijet Meters

- Multijet meters measure the speed of water passing through the calibrated measuring chamber
  - Velocity Meter

49

TDEC - Fleming Training Center

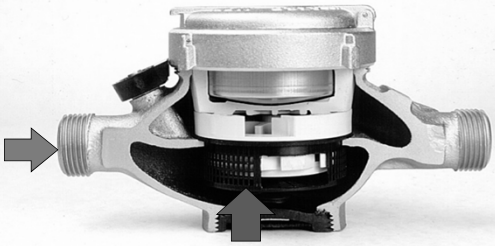
Multijet Meters

- Multijet meters use a horizontal rotor attached to a vertical spindle
- Water moves through orifices in the measuring chamber wall and causes the rotor to spin

50

TDEC - Fleming Training Center

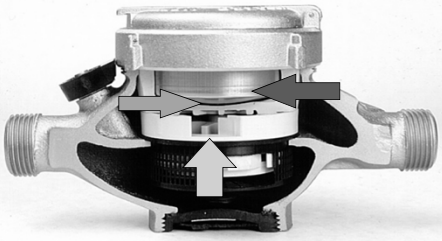
Multijet Meters



From Inlet Water Flows
Thru A 360° Strainer

TDEC - Fleming Training Center

Multijet Meters



The Magnetic Drive links the Measuring Element to the Sealed Register

TDEC - Fleming Training Center

Detector-Check Meters

- For emergency high-use services
  - Example: fire sprinkler systems
- Weight-loaded check valve in main line is closed under normal flow, opens for emergency
- Bypass around check valve has displacement meter

53

TDEC - Fleming Training Center

Selecting the Right Meter

- Meter selection is the responsibility of the utility
- First, consider the application
  - Single family residence
  - Small commercial
  - Light industrial
  - Irrigation
- Each application should be considered by it's individual requirements

54

TDEC - Fleming Training Center

Selecting the Right Meter

- Meter is usually one size smaller than service line
- For residential, start with ⅝ or ¾ inch meter
- AWWA Manual M6 for sizing meters

55

TDEC - Fleming Training Center

Selecting the right meter

- Proper sizing is important for accurate measurement
- Projected water use should be the primary selection criteria
  - Flow rate
    - What is the maximum and minimum expected flow
    - Maximum flow requirement is critical to meter selection
- Total usage should be considered
  - How much water per month is expected to be used

56

TDEC - Fleming Training Center

Selecting the right meter

- Meter manufactures' literature provides flow ranges of their meters

SIZE	SAFE MAXIMUM OPERATING CAPACITY	NORMAL TEST FLOW	REQUIRED ACCURACY	MINIMUM TEST FLOW	REQUIRED ACCURACY
5/8"	20 GPM	1-20 GPM	98.5-101.5%	1/4 GPM	95%
3/4"	30 GPM	2-30 GPM	98.5-101.5%	1/2 GPM	95%
1"	50 GPM	3-50 GPM	98.5-101.5%	3/4 GPM	95%
1-1/2"	100 GPM	5-100 GPM	98.5-101.5%	1-1/2 GPM	95%
2"	160 GPM	8-160 GPM	98.5-101.5%	2 GPM	95%

TDEC - Fleming Training Center

Meter Selection

- Determine the customer's actual requirements
  - A restaurant, for example
    - Do they wash dishes?
    - How many restrooms?
    - How many employees?
    - Do they irrigate landscape areas?
    - Will they have fire protection?

58

TDEC - Fleming Training Center

Meter Selection

- Historical data from a business could help
  - If the customer is part of a chain or franchise operation, data from another store should help
  - Similar businesses can be used to help determine potential usage
- Remember, an oversized or misapplied meter will give away water!

59

TDEC - Fleming Training Center

Meter Location

- Climate determines, in part, the location of a meter
  - Non-freezing climates require protection for meters from vandalism, other damage
  - Freezing climates require meter boxes to protect meters

60

TDEC - Fleming Training Center

Meter Location

- Easier to access meter box than entering a building
- Deep meter pits may be subject to flooding
- In buildings - install in basement; make sure the homeowner cannot illegally tap line ahead of meter

61

TDEC - Fleming Training Center

Installation

- Meter should not be subject to flooding
- Upstream and downstream shutoff valves for isolation
- Always install horizontally
- Reasonably accessible for service and inspection
- Location should provide for easy reading
  - Either directly or via a remote reading device

62

TDEC - Fleming Training Center

Installation

- Needs protection against frost, vandalism, tampering
- Large meters should be supported to prevent stress on the pipe
- Large installations require bypass for uninterrupted service during maintenance

63

TDEC - Fleming Training Center

Installation

- Depth of meter box depends on maximum frost depth
- Requires straight pipe lengths upstream and downstream
- Mountainous regions may require pressure-reducing valve at meter

64

TDEC - Fleming Training Center

Manifold Installation

- For customers requiring high flows
- Allows continuous service during maintenance or replacement
- All meters and valves are same size
- All but one must have spring-loaded check valve
  - When the flow is small, only one meter will operate

65

TDEC - Fleming Training Center

Meter Connections

- Meter sizes up to 1 inch usually have screw-type connections
- Flanged connections for larger meters

66

TDEC - Fleming Training Center

Indoor Installations

- Locate meter immediately after point where service line enters through floor or wall
- Location must be kept clear for easy access

67

TDEC - Fleming Training Center

Outdoor Installations

- Small meters -
  - Meter pit standard size, located near property line
  - Lid flush with ground, tight-fitting, tamper resistant
  - Riser pipes should be 2 inches from walls
  - Location and type of curb stop specified
  - Recommend use of meter yoke to prevent damage over time, and facilitate removal

68

TDEC - Fleming Training Center

Outdoor Installations

- Large meters -
  - No uniform standard
  - Must provide support to prevent service line damage
  - Test valves should be provided to allow for volumetric tests
  - Refer to manufacturer's recommendations

69

TDEC - Fleming Training Center

Meter Reading

- Flow recorded in gallons or cubic feet
- Record all numbers including fixed zeros or multiplier
  - The multiplier such as 10x or 1000x will be noted on the meter register face

70

TDEC - Fleming Training Center

Direct Readout

- Get reading from each meter
  - Inside homes
  - Outside in meter pits

71

TDEC - Fleming Training Center

Remote Reading Devices

- Signal transmitted electrically from meter to a counter outside
- Can plug a reading device into a receptacle on the outside of a building
- Scanning probe picks up signal from meter, transmits readout to handheld device

72

TDEC - Fleming Training Center

Testing and Maintenance

- Water meters should be tested:
  - Before installation
  - After maintenance
  - At customer's request

73

TDEC - Fleming Training Center

Meter Testing

- Testing new meters allows utilities to limit metering errors
- Over time, meter efficiency decreases; meters begin to under register
- ⅝-inch meters should be tested every 5 to 10 years; test large meters annually

74

TDEC - Fleming Training Center

Testing Procedures

- Determine overall efficiency by testing at a variety of flow rates
  - Small meters - test minimum, average, and maximum flow rates
  - Large meters - test at 5 different flow rates

75

TDEC - Fleming Training Center

Maintenance and Repair

- Dismantle meter
- Clean all parts
- Inspect parts for damage
- Replace or repair as necessary
- Reassemble and retest

76

TDEC - Fleming Training Center

Record Keeping

- Location of meters
- Keep track of meter age and condition
- Should have a card for each meter

77

TDEC - Fleming Training Center

Mainline Metering

- Meter at treatment plant discharge allows comparison of water produced and water sold in distribution system
- Keeps track of water bought from or sold to another utility

78

Types of Mainline Meters

- Current meters (velocity meters)
  - For lines 3" and larger
  - Turbine meter - rotor is turned by water flow
  - Multijet meter - turbine wheel is spun by jets of water from around circumference
  - Propeller meter - propeller turned by water flow

79

Types of Mainline Meters

- Proportional meters
  - A portion of the water is diverted and measured with a turbine or displacement meter
  - Diverted flow is proportional to total flow
  - Accurate except for low flows

80

Types of Mainline Meters

- Venturi meters
  - Pressure measured at two points in the flow
  - Translates pressure differential to a flow
  - Accurate over good range of flows

81

Types of Mainline Meters

- Orifice meters
  - Thin plate with a restriction in flow
  - Compares pressure upstream with reduced pressure at restriction
  - Has considerable head loss

82

Types of Mainline Meters

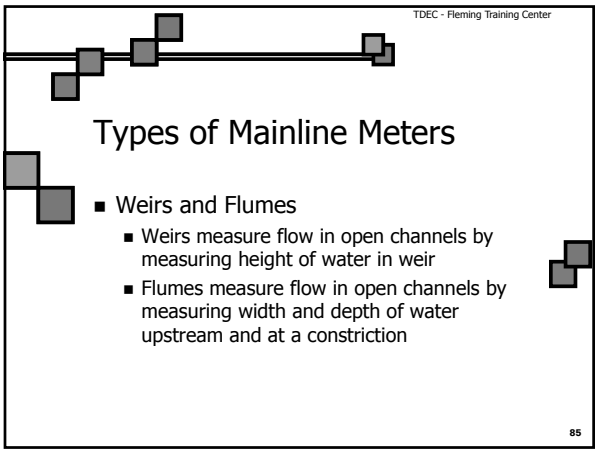
- Magnetic meters
  - Water flowing through magnetic field creates a current proportional to flow
  - No head loss
  - Requires certain distance upstream and downstream with no obstructions (elbows, etc.)

83

Types of Mainline Meters

- Ultrasonic meters
  - An electronic transducer sends a beam of ultrasonic sound waves through water
  - Frequency changes with velocity - Doppler Effect
  - Requires certain distance upstream and downstream with no obstructions (elbows, etc.)

84


TDEC - Fleming Training Center
Types of Mainline Meters
Weirs and Flumes
Weirs measure flow in open channels by measuring height of water in weir
Flumes measure flow in open channels by measuring width and depth of water upstream and at a constriction
85

Meter Change Out Procedures

1. Find out reason for change out
2. Notify customer that their water will be off for short time and ask them to cut it off at house
3. Get the tools that will be needed
4. Cut water off at curb stop
5. Remove meter
6. Spray new meter with chlorine
7. Put new meter in making sure arrow is facing house
8. Instruct customer to turn water on at house but not to draw any water
9. Cut water back on at curb stop
10. Turn outside faucet on and flush line
11. Take chlorine samples
12. Fill out meter job ticket and work order with:
    - ♦ New and old meter number
    - ♦ New and old reading
    - ♦ Chlorine reading
    - ♦ Crew and supplies used
    - ♦ Address and reason for change out

METERS AND SERVICES
REVIEW QUESTIONS

1. What is the function of a gooseneck in a service line?

2. What is the function of a curb stop?

3. Identify the two most popular materials used for residential water services.

4. Explain why lead and wrought iron are no longer used for residential services.

5. What is a possible problem when iron services are installed with bronze curb stops?

6. What two factors must water suppliers consider when determining the depth and location of a service line.

7. What are three reasons for metering water customers?

8. Identify three meters commonly used in the water distribution system.

9. Name and describe the operation of two major types of positive displacement meters.

10. What is the most common application for a small positive displacement meter?

11. Compound meters are generally used under what conditions?

12. What types of meters might be used for main line or pump station measurements?

13. What are the requirements for acceptable meter installations?

14. What is a meter yoke?

15. Explain the need for maintaining electrical continuity around the meter during removal.

16. When should water meters be tested?

17. List three basic elements in a meter test.

18. What hazards are associated with electrically thawing a frozen service line?

19. What items should be recorded on a service connection record card?

20. What items should be recorded on a meter history card?

Answers

1. A flexible connection that provides for ease of installation and allows for any settlement of the overlying material, or expansion and contraction of the service line due to temperature variations.
2. A meter shut off located in the water service pipe near the curb between the water main and building in which the meter is located.
3. Copper and plastic
4. Lead joints are difficult to install properly and there is some question concerning safety (in terms of the water quality) or lead services. Wrought iron is rigid and requires threading, making it difficult to install. Wrought iron services may also have short lives due to corrosion.
5. Use of dissimilar materials often forms a galvanic cell and causes corrosion of the pipe.
6. Frost penetration and location of other utility lines.
7. Collecting revenues. Encourages customer to use water wisely. Provide indication of water demand.
8. 1. Positive displacement. 2. Compound. 3. Current.
9.
    - Piston-type meter, water flows into the chamber, which houses the piston. As it flows through the chamber, the piston is displaced. The motion of the piston is transmitted to the register, via magnets in newer models or gears in older models. This records the volume of water flowing through the meter.
    - The nutating disc meter uses a measuring chamber containing a hard rubber disc instead of a piston. When water flows through the chamber, the disc wobbles in proportion to the volume. This motion is transmitted to a register that records the volume of water flowing through the meter.
10. Metering residential services.
11. Where water demand varies considerably from high and low flows.
12. Propeller, venturi, proportional and turbine type meters might be used
13.
    - Not be subject to flooding with non-potable water.
    - Provide up and down stream shut-off valve of high quality to isolate the meter for repairs.
    - Position meter in horizontal plane for optimum performance.
    - Reasonably accessible for service and inspection.
    - Provide for easy reading.
    - Protected from frost and mechanical damage.
    - Not an obstacle or hazard to customer or public safety.
    - Meter is sealed to prevent tampering.
    - Proper support for large meters to avoid stress on pipe.
    - There be a by-pass or multiple meters on large installations.

14. A device that holds the stub ends of the pipe in proper alignment and spacing. It cushions the meter against stress and strain in the pipe and provides electrical continuity if metal pipe is used.
15. Reduces the chance of electrical shock during meter removal due to stray current or electrical grounding to the service pipe.
16. Meters should be tested before use, removal from service, after repairs, and upon customer complaint or request.
    Running different rates of flow to determine overall meter efficiency.
17. Passing known quantities of water through the meter at various test rates to provide a reasonable determination of meter registration. Meeting accuracy limits on different rates for acceptable use.
18. Damage to the service line, plumbing, and electrical appliances. Stray current can cause fire or electrical shock.
19. Permanent service number, applicant's name and address, dates of application and installation, size of corporation and curb stop used, size and type pipe used, depth of installation, and detailed measurements of locations.
20. Size, make, type, date of purchase, location, test data, and any repairs on the meter should be included on a meter history card.

Section 11

Pumps

PUMPS

DISTRIBUTION SYSTEMS COURSE

1

OBJECTIVES

- To learn the different kinds of pumps used in water and wastewater systems
- To learn proper operating procedures
- To learn the mechanical parts of pumps
- To learn preventive maintenance and safety concerning pumps

NECESSITY OF PUMPS

- Pumps are required when gravity cannot supply water with sufficient pressure to all parts of the distribution system
- Pumps account for the largest energy cost for a water supply operation

TYPES OF PUMPS

- Velocity Pumps

- Positive-Displacement Pumps

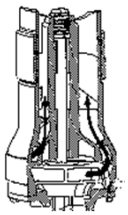
VELOCITY PUMPS

- Spinning impeller or propeller accelerates water to high velocity in pump casing

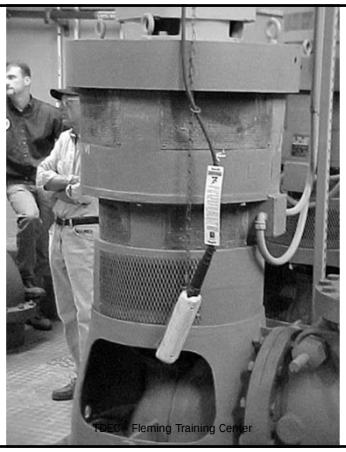
Centrifugal Pump

VELOCITY PUMPS

- High velocity, low pressure water is converted to low velocity, high pressure water



Diffuser

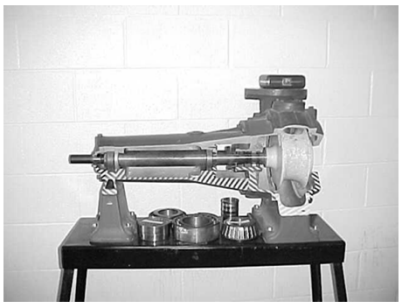


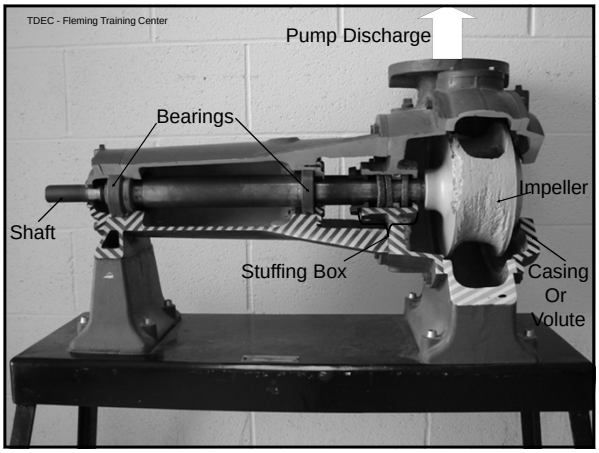
VELOCITY PUMP DESIGN CHARACTERISTICS

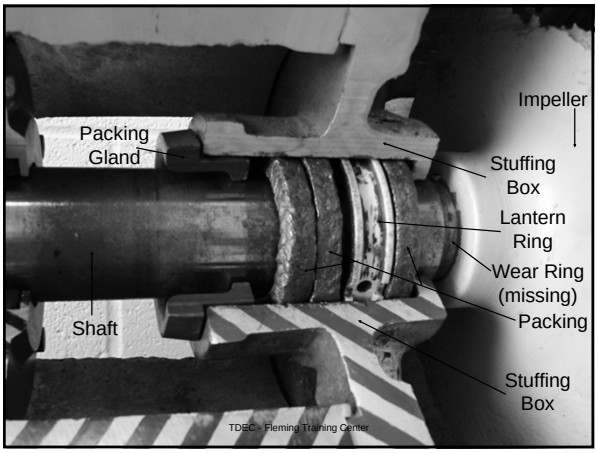
- Axial - flow designs
  - Propeller shaped impeller adds head by lifting action on vanes
  - Water moves parallel to pump
  - High volume, but limited head
  - Not self-priming

VELOCITY PUMP DESIGN CHARACTERISTICS

- Radial - flow designs
  - Water comes in through center (eye) of impeller
  - Water thrown outward from impeller to diffusers that converts velocity to pressure
- Mixed - flow designs
  - Has features of axial and radial flow
  - Works well for water with solids







TYPES OF VELOCITY PUMPS

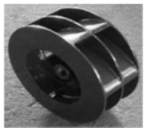
- Centrifugal (volute) pumps
- Turbine pumps
- Jet pumps

CENTRIFUGAL PUMPS

- Volute-casing type most commonly used in water utilities
- Impeller rotates in casing - radial flow
- Single or multi-stage
- By varying size, shape, and width of impeller, a wide range of flows and pressures can be achieved

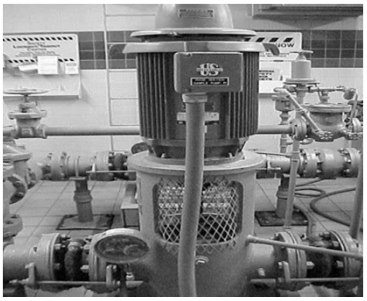
IMPELLERS

Open Impeller



Double Suction Closed Impeller

VERTICAL TURBINE PUMP



VERTICAL TURBINE PUMPS

- Deep-well pump - drive unit at surface, lower shaft and impeller are submerged
  - Requires careful alignment at installation
- Submersible pump - Can operate while submerged; entire unit below water (in a well)
- Booster pump - Increase pressure in distribution system, supply water to storage tank

VERTICAL TURBINE PUMPS

- Impeller rotates in a channel of constant cross-sectional area
- Mixed or radial flow
- Create highest head available from velocity pumps
- Backflow limited
- Efficiencies up to 95% possible
- Water must be very clean

JET PUMPS

- Part of discharge is used to help run ejector
- Lower efficiency, used for small wells

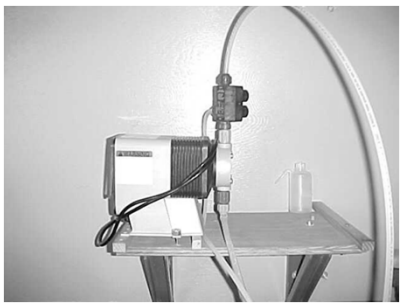
POSITIVE-DISPLACEMENT PUMPS

- Less efficient than centrifugal pumps
- Used for smaller volume of liquid, more precise
- Mostly used for chemical feed

PERISTALTIC CHEMICAL PUMP

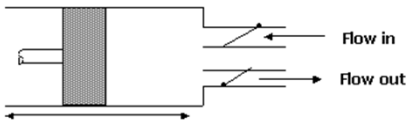
POSITIVE DISPLACEMENT DIAPHRAGM PUMP

DIAPHRAGM PUMP FOR POLYMERS



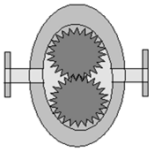
POSITIVE-DISPLACEMENT PUMPS

- Reciprocating (piston) pump - piston moves back and forth in cylinder, liquid enters and leaves through check valves



POSITIVE-DISPLACEMENT PUMPS

- Rotary pump - Uses lobes or gears to move liquid through pump



CENTRIFUGAL PUMP OPERATION

- Pump Starting and Stopping -
  - Impeller must be submerged for a pump to start
  - Foot valve helps hold prime
  - Discharge valve should open slowly to control water hammer
  - In small pumps, a check valve closes immediately when pump stops to prevent flow reversal
  - In large pumps, discharge valve may close before pump stops

FLOW CONTROL

- Flows usually controlled by starting and stopping pumps
- Throttling flow should be avoided - wastes energy
- Variable speed drives or motor are best way to vary flow

MONITORING OPERATIONAL VARIABLES

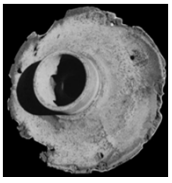
- Suction and Discharge Heads
  - Pressure gauges
- Bearing and Motor Temperature
  - Temp indicators can shut down pump if temp gets too high
  - Check temp of motor by feel

MONITORING OPERATIONAL VARIABLES

- Vibration
  - Detectors can sense malfunctions causing excess vibration
  - Operators can learn to distinguish between normal and abnormal sounds

MONITORING OPERATIONAL VARIABLES

- Speed
  - Cavitation can occur at low and high speeds
  - Cavitation is the creation of vapor bubbles due to partial vacuum created by incomplete filling of the pump



MONITORING OPERATIONAL VARIABLES

- If a pump has packing glands, water should drip slowly
- If it has a mechanical seal, no leakage should occur

MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

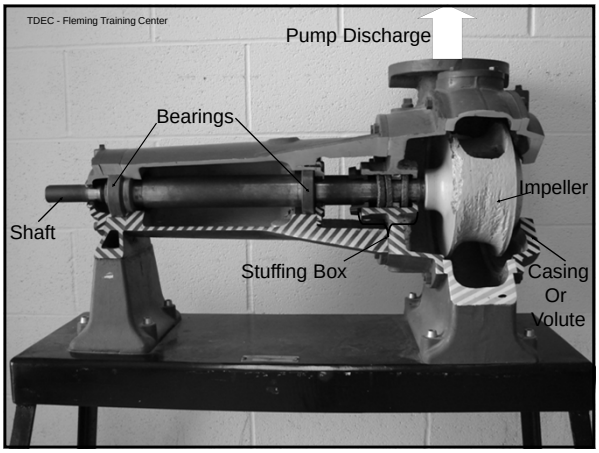
- Casing
  - Housing surrounding the impeller; also called the volute
  - Designed to minimize friction loss as water is thrown outward from impeller
  - Usually made of cast iron, spiral shape

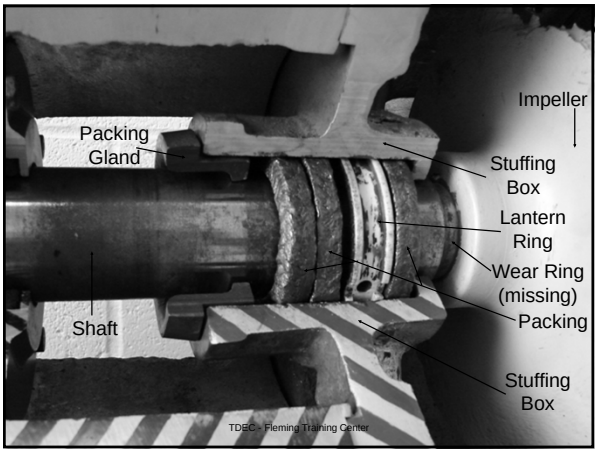
MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Single-Suction Pumps
  - Also called end-suction pumps, used for smaller water systems
  - Water inlet at one end, discharge at right angle
  - Water enters parallel to shaft, exits perpendicular to shaft
  - Two types, based on how impeller shaft is connected to motor

MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Double-Suction Pumps
  - Water enters from both sides, discharges outward from center
  - Commonly called horizontal split-case
  - Can pump over 10,000 gpm





MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Impeller
  - Rotating element in pump
  - Made of bronze or stainless steel
  - Usually closed design; some single-suction have semi open
- Wear rings
  - Restrict flow between impeller discharge and suction
  - Leakage reduces pump efficiency

TDEC - Fleming Training Center 37

MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Shaft
  - Connects impeller to pump; steel or stainless steel
- Shaft Sleeves
  - Protect shaft from wear from packing rings
- Packing Rings
  - Seal the space between shaft and casing
  - Has graphite or other lubricating substance

TDEC - Fleming Training Center 38

MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Lantern Rings
  - Perforated ring placed in stuffing box; forms seal around shaft, lubricates packing
- Mechanical Seals
  - Required instead of packing rings for suction head greater than 60 psi
  - Prevents water from leaking along shaft, keeps air out of pump

TDEC - Fleming Training Center 39

MECHANICAL DETAILS OF CENTRIFUGAL PUMPS

- Bearings
  - Anti-friction devices for supporting and guiding pump and motor shafts
  - Usually get noisy as they wear out
- Couplings
  - Connect pump and motor shafts
  - Available in dry or lubricated
    - Lubricated requires grease at 6 month intervals
    - Dry has a rubber or elastomer membrane, requires no lubrication

TDEC - Fleming Training Center 40

ADVANTAGES OF MECHANICAL SEALS

- Last longer; from 3 to 5 years
- More protection for shaft sleeve when they fail
- Continual adjusting, cleaning, or repacking is not required
- Less chance of flooding a lift station from failure

TDEC - Fleming Training Center 41

LIMITATIONS OF MECHANICAL SEALS

- High initial cost
- More competence and special tools to replace
- Pump must be shut down upon failure
- Pump dismantled to replace
- Seals often require special handling when installed

TDEC - Fleming Training Center 42

PUMP BEARINGS

- Usually last for years if serviced properly
- Causes of failure:
  - contamination
  - fatigue failure
  - thrust failure
  - misalignment
  - electric arching
  - lubrication failure - too much, too little, contaminated grease/oil, wrong type

STARTING A NEW PUMP

- Lubricate properly
- Turn shaft by hand to ensure rotation is free
- Check to see if the shafts of pump and motor are aligned and flexible coupling is aligned
- Check electric current characteristics of motor and inspect wiring
- Ensure pump is primed
- Never operate a positive displacement pump or progressive cavity type with the discharge line closed

PUMP SHUTDOWN

- For long periods ensure the motor disconnect switch is open, locked out, and tagged
- Close all valves on the suction and discharge side
- Completely drain the pump and remove the vent and drain plugs
- Do not permit sludge to remain in pumps or piping
- Inspect all bearings
- Drain the bearing housing and add fresh lubricant

INSPECTION AND MAINTENANCE

- Inspection and maintenance schedule prolongs life of pumps, necessary for warranty
- Keep records of all maintenance on each pump, keep log of operating hours

PUMP SAFETY

- Machinery should always be turned off and locked out/tagged out before any work is performed on it
- Make sure all moving parts are free to move and all guards in place before restarting

Pump Maintenance Record Sheet

Facility ID _____

Equipment _____ Manufacturer _____

Model No. _____ Serial No. _____

HP _____ Voltage _____ Amps _____ RPM _____

Frame _____ GPM _____ TDH _____ ft.

Impeller Size _____

Suction Pressure _____ Discharge Pressure _____

Pump Type _____

Additional Information:

_____

_____

_____

_____

Pump and Motor Facts

Pump Facts

High-service pump – discharges water under pressure to the distribution system.

Booster pump – used to increase pressure in the distribution system and to fill elevated storage tanks.

Impeller or centrifugal pump used to move water.

Likely causes of vibration in an existing pump/motor installation:

1. bad bearings
2. imbalance of rotating elements
3. misalignment from shifts in underlying foundation

Pump and motor should be tested and complete test results recorded as a baseline for the measurement of performance within the first 30 days of operations.

Calipers and thickness gauges can be used to check alignment on flexible couplings.

Packing/Seals Facts

If new packing leaks, stop the motor and repack the pump.

Pumps need new packing when the gland or follower is pulled all the way down.

The packing around the shaft should be tightened just enough to allow an occasional drop of liquid.

Joints of packing should be staggered at least 90°.

Mechanical seals consist of a rotating ring and stationary element.

The operating temperature on a mechanical seal should never exceed 160°F.

Motor Facts

Motors pull the most current on start up.

In order to prevent damage, turn the circuit off immediately if the fuse on one of the legs of a three-phase circuit blows.

An electric motor changes electrical energy into mechanical energy.

Power factors on motors can be improved by:
1. changing the motor loading
2. changing the motor type
3. using capacitors

Routing cleaning of pump motors includes:
1. checking alignment and balance
2. checking brushes
3. removing dirt and moisture
4. removal of obstructions that prevent air circulation

Cool air extends the useful life of motors.

A motor (electrical or internal combustion) used to drive a pump is called a prime mover.

The speed at which the magnetic field rotates is called the motor synchronous speed and is expressed in rpm.

If a variable speed belt drive is not to be used for 30 days or more, shift the unit to minimum speed setting.

Emory cloth should not be used on electric motor components because it is electrically conductive and may contaminate parts.

Ohmmeters used to test a fuse in a motor starter circuit.

The most likely cause of a three-phase motor not coming to speed after starting – the motor has lost power to one or more phases.

Transformer Facts

Transformers are used to convert high voltage to low voltage.

High voltage is 440 volts or higher.

Standby engines should be run weekly to ensure that it is working properly.

Relays are used to protect electric motors.

Pump Vocabulary

1. Velocity Pump – the general class of pumps that use a rapidly turning impeller to impart kinetic energy or velocity to fluids. The pump casing then converts this velocity head, in part, to pressure head. Also known as kinetic pumps.
2. Centrifugal Pumps – a pump consisting of an impeller on a rotating shaft enclosed by a casing having suction and discharge connections. The spinning impeller throws water outward at high velocity, and the casing shape converts this velocity to pressure.
3. Vertical Turbine Pump – a centrifugal pump, commonly of the multistage, diffuser type, in which the pump shaft is mounted vertically.
4. Submersible Pump – a vertical-turbine pump with the motor placed below the impellers. The motor is designed to be submersed in water.
5. Jet Pump – a device that pumps fluid by converting the energy of a high-pressure fluid into that of a high-velocity fluid.
6. Axial-Flow Pump – a pump in which a propeller-like impeller forces water out in the direction parallel to the shaft. Also called a propeller pump.
7. Radial-Flow Pump – a pump that moves water by centrifugal force, spinning the water radially outward from the center of the impeller.
8. Mixed-Flow Pump – a pump that imparts both radial and axial flow to the water.
9. Single-Suction Pump – a centrifugal pump in which the water enters from only one side of the impeller. Also called an end-suction pump.
10. Double-Suction Pump – a centrifugal pump in which the water enters from both sides of the impeller. Also called a split-case pump.
11. Closed-Coupled Pump – a pump assembly where the impeller is mounted on the shaft of the motor that drives the pump.
12. Frame-Mounted Pump – a centrifugal pump in which the pump shaft is connected to the motor shaft with a coupling.
13. Positive Displacement Pump – a pump that delivers a precise volume of liquid for each stroke of the piston or rotation of the shaft.
14. Reciprocating Pump – a type of positive-displacement pump consisting of a closed cylinder containing a piston or plunger to draw liquid into the cylinder through an inlet valve and forces it out through an outlet valve.
15. Rotary Pump – a type of positive-displacement pump consisting of elements resembling gears that rotate in a close-fitting pump case. The rotation of these elements alternately draws in and discharges the water being pumped.

16. Prime Mover – a source of power, such as an internal combustion engine or an electric motor, designed to supply force and motion to drive machinery, such as a pump.
17. Packing – rings of graphite-impregnated cotton, flax, or synthetic materials, used to control leakage along a valve stem or a pump shaft.
18. Packing Gland – a follower ring that compressed the packing in the stuffing box.
19. Wear Rings – rings made of brass or bronze placed on the impeller and/or casing of a centrifugal pump to control the amount of water that is allowed to leak from the discharge to the suction side of the pump.
20. Lantern Ring – a perforated ring placed around the pump shaft in the stuffing box. Water from the pump discharge is piped to this ring. The water forms a liquid seal around the shaft and lubricates the packing.
21. Mechanical Seal – a seal placed on the pump shaft to prevent water from leaking from the pump along the shaft; the seal also prevents air from entering the pump.
22. Stuffing Box – a portion of the pump casing through which the shaft extends and in which packing or a mechanical seal is placed to prevent leakage.
23. Impeller – the rotating set of vanes that forces water through the pump.
24. Casing – the enclosure surrounding a pump impeller, into which the suction and discharge ports are machined.
25. Volute – the expanding section of pump casing (in a volute centrifugal pump), which converts velocity head to pressure head.
26. Foot Valve – a check valve placed in the bottom of the suction pipe of a pump, which opens to allow water to enter the suction pipe but closes to prevent water from passing out of it at the bottom end. Keeps prime.
27. Bearing – anti-friction device used to support and guide a pump and motor shafts.
28. Diffuser Vanes – vanes installed within a pump casing on diffuser centrifugal pumps to change velocity head to pressure head.
29. Water Hammer – the potentially damaging slam that occurs in a pipe when a sudden change in water velocity (usually as a result of too-rapidly starting a pump or operating a valve) creates a great increase in water pressure.
30. Suction Lift – the condition existing when the source of water supply is below the centerline of the pump.
31. Cavitation – a condition that can occur when pumps are run too fast or water is forced to change direction quickly. A partial vacuum forms near the pipe wall or impeller blade causing potentially rapid pitting of the metal.

Pump and Motor Review Questions

1) Leakage of water around the packing on a centrifugal pump is important because it acts as a(n):
   a) Adhesive
   b) Lubricant
   c) Absorbent
   d) Backflow preventer

2) What is the purpose of wear rings in a pump?
   a) Hold the shaft in place
   b) Hold the impeller in place
   c) Control amount of water leaking from discharge to suction side
   d) Prevent oil from getting into the casing of the pump

3) Which of the following does a lantern ring accomplish?
   a) Lubricates the packing
   b) Helps keep air from entering the pump
   c) Both (a.) and (b.)

4) Closed, open and semiopen are types of what pump part?
   a) Impeller
   b) Shaft sleeve
   c) Casing
   d) Coupling

5) When tightening the packing on a centrifugal pump, which of the following applies?
   a) Tighten hand tight, never use a wrench
   b) Tighten to 20 foot pounds of pressure
   c) Tighten slowly, over a period of several hours
   d) Tighten until no leakage can be seen from the shaft

6) Excessive vibrations in a pump can be caused by:
   a) Bearing failure
   b) Damage to the impeller
   c) Misalignment of the pump shaft and motor
   d) All of the above

7) What component can be installed on a pump to hold the prime?
   a) Toe valve
   b) Foot valve
   c) Prime valve
   d) Casing valve

8) The operating temperature of a mechanical seal should not exceed:
   a) 140°F
   b) 150°F
   c) 160°F
   d) 170°F

9) What is the term for the condition where small bubbles of vapor form and explode against the impeller, causing a pinging sound?
   a) Corrosion
   b) Cavitation
   c) Aeration
   d) Combustion

10) The first thing that should be done before any work is begun on a pump or electrical motor is:
   a) Notify the state
   b) Put on safety goggles
   c) Lock out the power source and tag it
   d) Have a competent person to supervise the work

11) Under what operating condition do electric motors pull the most current?
   a) At start up
   b) At full operating speed
   c) At shut down
   d) When locked out

12) Positive displacement pumps are rarely used for water distribution because:
   a) They require too much maintenance
   b) They are no longer manufactured
   c) They require constant observation
   d) Centrifugal pumps are much more efficient

13) Another name for double-suction pump is
   a) Double-jet pump
   b) Reciprocating pump
   c) Horizontal split-case pump
   d) Double-displacement pump

14) As the impeller on a pump becomes worn, the pump efficiency will:
   a) Decrease
   b) Increase
   c) Stay the same

Answers:

1) B	6) D	11) A
2) C	7) B	12) D
3) C	8) C	13) C
4) A	9) B	14) A
5) C	10) C	

Section 12

Cross-Connections

Cross-Connection Control

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

TDEC, Fleming Training Center

Outline

- Basics of Cross-Connection Control
- Hydraulics
- Definitions
- Backflow Preventers
- Applications

TDEC, Fleming Training Center

Basics of Cross-Connection Control

United States Environmental Protection Agency
Cross-Connection Control Manual
www.epa.gov/ogwdw/pdfs/crossconnection/crossconnection.pdf

Tennessee Department of Environment & Conservation
Cross-Connection Control Manual & Design Criteria
www.tn.gov/environment/fleming/docs/crossconnection.pdf

TDEC, Fleming Training Center

Authority

- Who has responsibility for the water served to the customer?
- Who has the responsibility to protect the water from cross-connections?
- What can happen if the water supplier does not act responsibly in the area of cross-connection control?
- Where does authority for the cross-connection control program come from?
- What can the water provider do to protect their system from contamination?

TDEC, Fleming Training Center

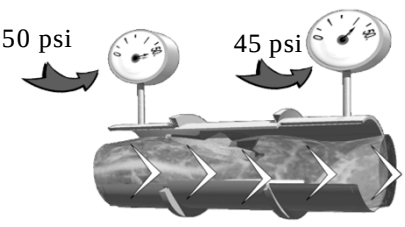
Hydraulics

- Water pressure naturally tends to equalize

- Therefore, water flows from high pressure regions to low pressure regions

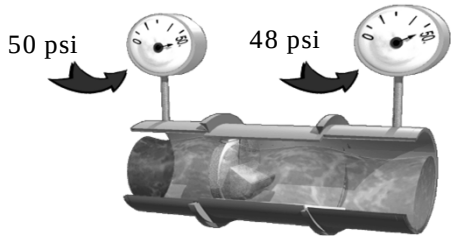
TDEC, Fleming Training Center

Normal Flow



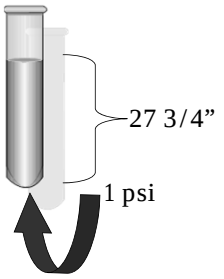
TDEC, Fleming Training Center

No Flow



TDEC, Fleming Training Center

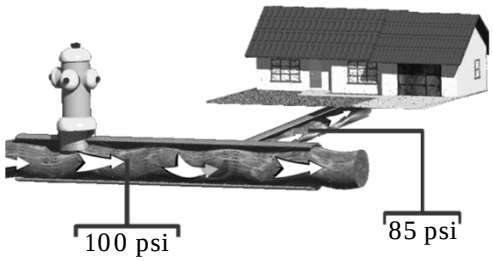
27 ¾" = 2.31 Feet of Head



- 27 3/4" of water generates a pressure of one pound per square inch (psi)

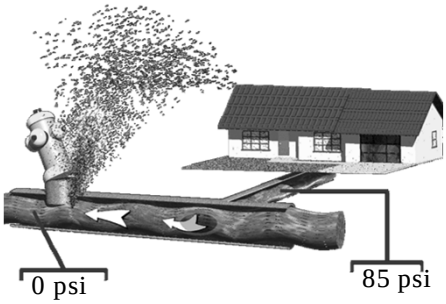
TDEC, Fleming Training Center

Normal Flow



TDEC, Fleming Training Center

Reverse Flow



TDEC, Fleming Training Center

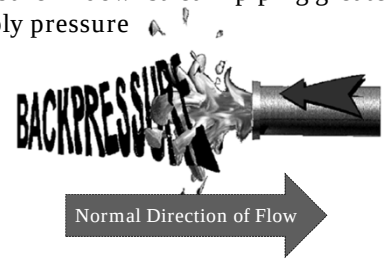
Backflow

- The undesirable reversal of flow of water or other substances into the potable water distribution supply
- Occurs due to:
  - Backpressure
  - Backsiphonage

TDEC, Fleming Training Center

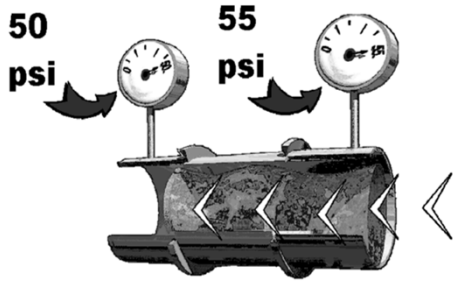
Backpressure

- Pressure in downstream piping greater than supply pressure



TDEC, Fleming Training Center

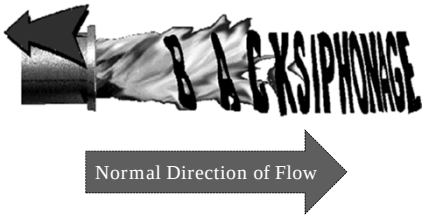
Backpressure



TDEC, Fleming Training Center

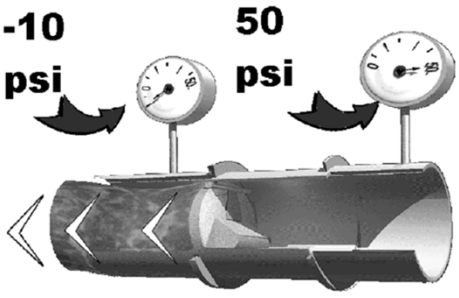
Backsiphonage

- Sub-atmospheric pressure in the water system



TDEC, Fleming Training Center

Backsiphonage



TDEC, Fleming Training Center

Cross-Connection

- An actual or potential connection between a potable water supply and any non-potable substance or source
- Cross-connection types:
  - Direct
  - Indirect

TDEC, Fleming Training Center

Direct Cross-Connection

- A direct cross-connection is subject to backpressure or backsiphonage

TDEC, Fleming Training Center

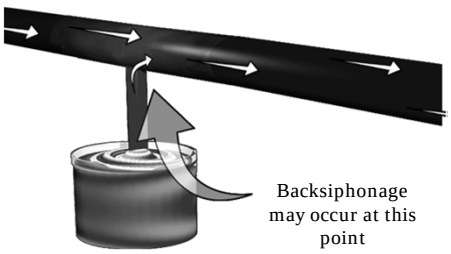
Indirect Cross-Connection

- An indirect cross-connection is subject to backsiphonage only

Submerged Inlet

TDEC, Fleming Training Center

Aspirator Effect



TDEC, Fleming Training Center

Degree of Hazard

- Non-Health Hazard
  - Low hazard
  - Will not cause illness or death
  - Pollutant
- Health Hazard
  - High hazard
  - Causes illness or death
  - Contaminant

TDEC, Fleming Training Center

The Backflow Incident

For backflow to occur three conditions must be met:

1. There must be a cross-connection. A passage must exist between the potable water system and another source.
2. A hazard must exist in this other source to which the potable water is connected.
3. The hydraulic condition of either backsiphonage or backpressure must occur.

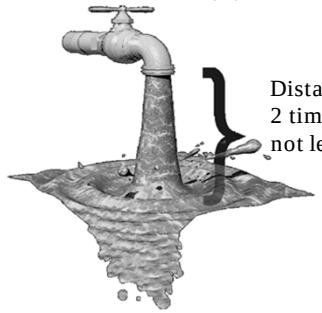
TDEC, Fleming Training Center

Five Means of Preventing Backflow

- Air Gap Separation
- Reduced Pressure Principle Assembly
- Double Check Valve Assembly
- Pressure Vacuum Breaker/ Spill-Resistant Vacuum Breaker
- Atmospheric Vacuum Breaker

TDEC, Fleming Training Center

Air Gap



TDEC, Fleming Training Center

Approved Air Gap Separation

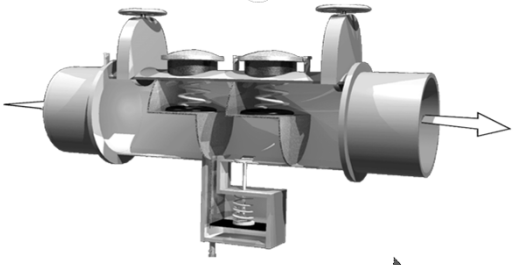
- Backsiphonage
- Backpressure
- Contaminant (health hazard)
- Pollutant (non-health hazard)

TDEC, Fleming Training Center

	Indirect		Direct
	Backsiphonage Only		Backpressure and Backsiphonage
	Continuous Use	Non-Continuous Use	
Health Hazard	**Air Gap**	**Air Gap**	**Air Gap**
Non – Health Hazard	**Air Gap**	**Air Gap**	**Air Gap**

TDEC, Fleming Training Center

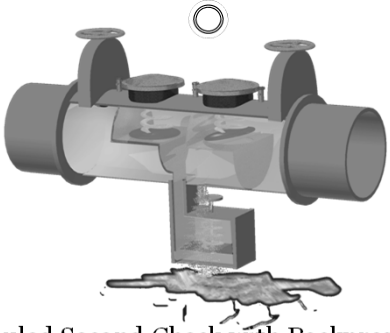
Reduced Pressure Principle Assembly



Normal Flow

TDEC, Fleming Training Center

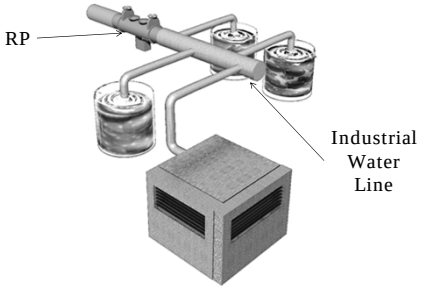
RP



Fouled Second Check with Backpressure

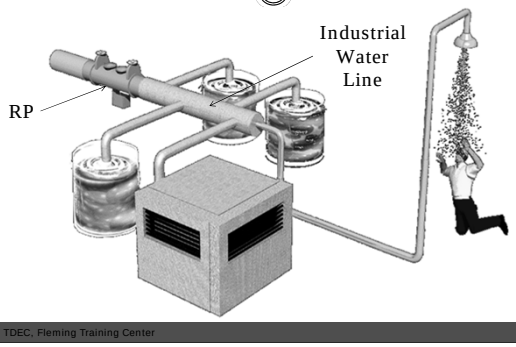
TDEC, Fleming Training Center

Where To Put an RP



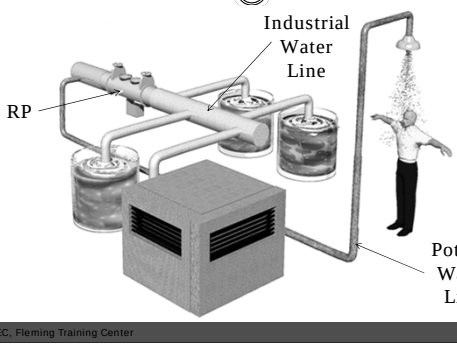
TDEC, Fleming Training Center

Where To Put an RP – Don't



TDEC, Fleming Training Center

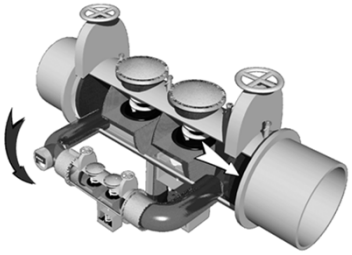
Where To Put an RP – Do



TDEC, Fleming Training Center

RP Detector Assembly

At least 3 GPM through bypass only



TDEC, Fleming Training Center

RP

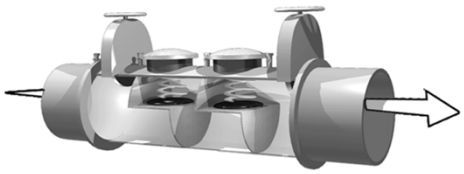
- Backsiphonage
- Backpressure
- Contaminant (health hazard)
- Pollutant (non-health hazard)

TDEC, Fleming Training Center

	Indirect		Direct
	Backsiphonage Only		Backpressure and Backsiphonage
	Continuous Use	Non-Continuous Use	
Health Hazard	Air Gap	Air Gap	Air Gap
	RP	**RP**	**RP**
Non – Health Hazard	Air Gap	Air Gap	Air Gap
	RP	**RP**	**RP**

TDEC, Fleming Training Center

Double Check Valve Assembly (DC)

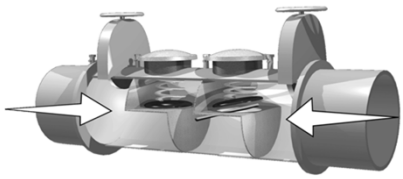


Normal Flow

TDEC, Fleming Training Center

Double Check Valve Assembly (DC)

- Second check fouled during backpressure



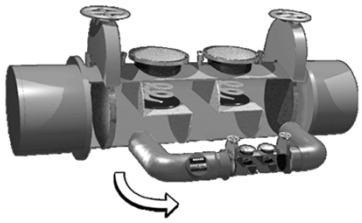
TDEC, Fleming Training Center

Double Check Valve Assembly (DC)

- Backsiphonage
- Backpressure
- Pollutant only

TDEC, Fleming Training Center

DC Detector Assembly



At least 3 GPM through bypass only

TDEC, Fleming Training Center

	Indirect		Direct
	Backsiphonage Only		Backpressure and Backsiphonage
	Continuous Use	Non-Continuous Use	
Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
Non – Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
	DC	**DC**	**DC**

TDEC, Fleming Training Center

Proper Installation for DC and RP

- USC Recommendations:
  - Minimum 12” above grade
  - Maximum 36” above grade
  - Accessibility for testing and repair
  - Weather/vandalism protection (if needed) with adequate drainage

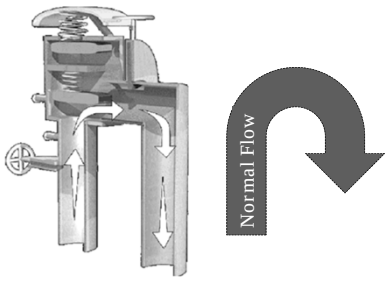
TDEC, Fleming Training Center

Proper Installation for DC and RP

- Backflow Preventers should only be installed vertically if they have been specifically approved for vertical orientation

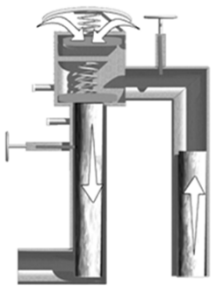
TDEC, Fleming Training Center

Pressure Vacuum Breaker (PVB)



TDEC, Fleming Training Center

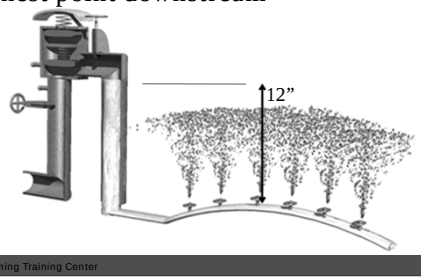
PVB Backsiphonage Condition



TDEC, Fleming Training Center

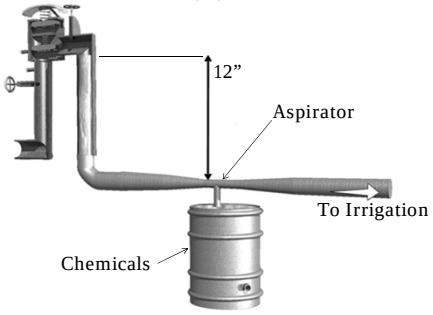
Installation of PVB

- Needs to be installed 12 inches above the highest point downstream



TDEC, Fleming Training Center

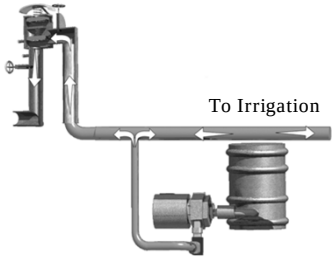
Pressure Vacuum Breaker



TDEC, Fleming Training Center

Pressure Vacuum Breaker

- Improper installation subject to backpressure



TDEC, Fleming Training Center

Pressure Vacuum Breaker

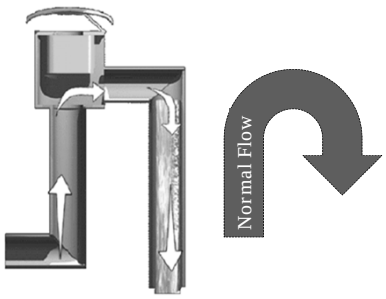
- Backsiphonage Only
- Contaminant (health hazard)
- Pollutant (non-health hazard)
- Elevation - at least 12”

TDEC, Fleming Training Center

	Indirect		Direct
	Backsiphonage Only		Backpressure and Backsiphonage
	Continuous Use	Non-Continuous Use	
Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
	PVB	**PVB**	
Non – Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
	DC	DC	DC
	PVB	**PVB**	

TDEC, Fleming Training Center

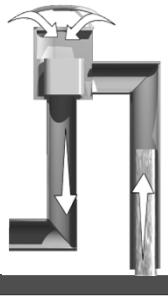
Atmospheric Vacuum Breaker (AVB)



TDEC, Fleming Training Center

Atmospheric Vacuum Breaker (AVB)

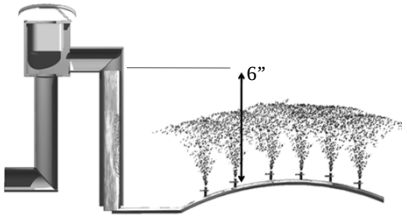
- Backsiphonage condition



TDEC, Fleming Training Center

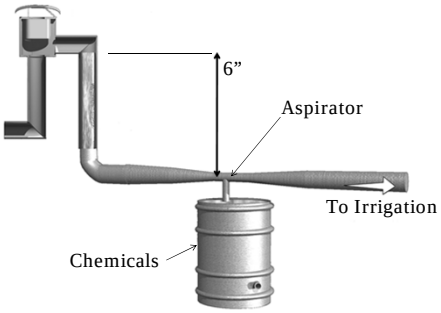
Installation of AVB

- Needs to be installed 6 inches above the highest point downstream



TDEC, Fleming Training Center

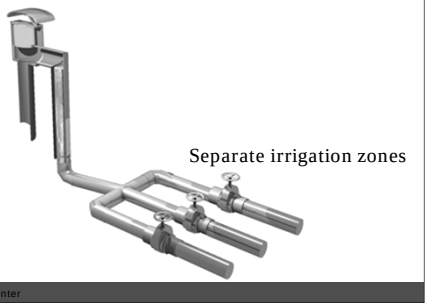
Atmospheric Vacuum Breaker



TDEC, Fleming Training Center

Atmospheric Vacuum Breaker

- Improper installation: downstream shutoff valves



TDEC, Fleming Training Center

Atmospheric Vacuum Breaker

- Backsiphonage Only
- Contaminant (health hazard)
- Pollutant (non-health hazard)
- Elevation - at least 6”
- Non-Continuous Use

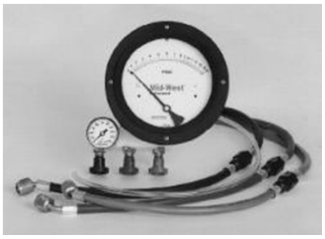
TDEC, Fleming Training Center

	Indirect		Direct
	Backsiphonage Only		Backpressure and Backsiphonage
	Continuous Use	Non-Continuous Use	
Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
	PVB	PVB	
		AVB	
Non – Health Hazard	Air Gap	Air Gap	Air Gap
	RP	RP	RP
	DC	DC	DC
	PVB	PVB	
		AVB	

TDEC, Fleming Training Center

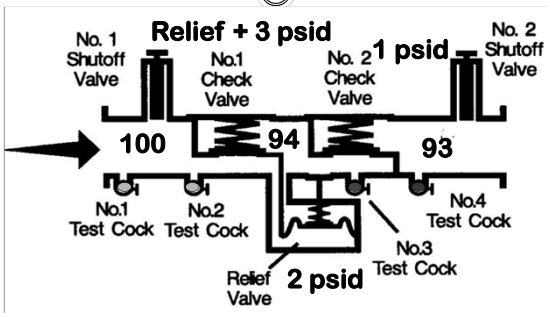
Testing of Assemblies

- Annual testing required
- Must be conducted by certified personnel



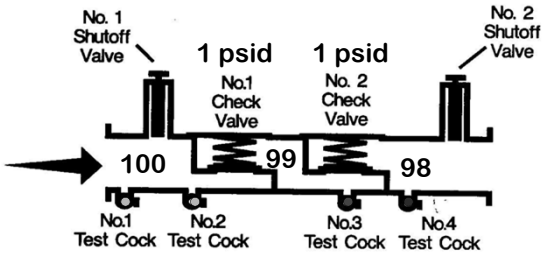
TDEC, Fleming Training Center

RP



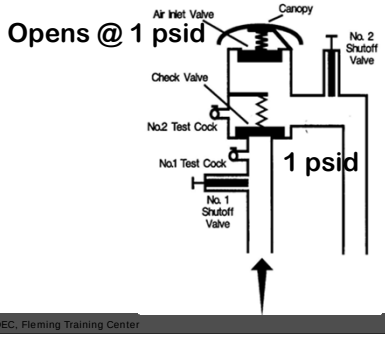
TDEC, Fleming Training Center

DC

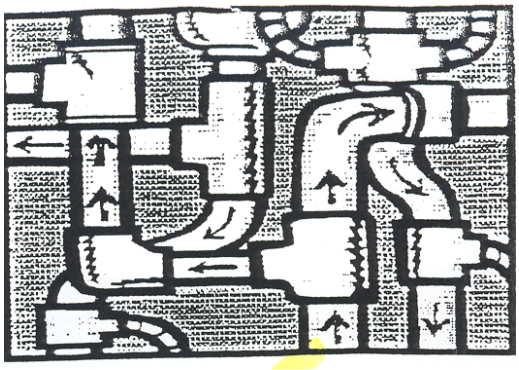


TDEC, Fleming Training Center

PVB



TDEC, Fleming Training Center



Vocabulary

Absolute Pressure – The total pressure; gauge pressure plus atmospheric pressure. Absolute pressure is generally measured in pounds per square inch (psi).

Air Gap – The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or outlet supplying water to a tank, plumbing fixture or other device, and the flood-level rim of the receptacle. This is the most effective method for preventing backflow.

Atmospheric Pressure – The pressure exerted by the weight of the atmosphere (14.7 psi at sea level). As the elevation above sea increases, the atmospheric pressure decreases.

Backflow – The reversed flow of contaminated water, other liquids or gases into the distribution system of a potable water supply.

Backflow Prevention Device (Backflow Preventer) – Any device, method or construction used to prevent the backward flow of liquids into a potable distribution system.

Back Pressure (Superior Pressure) – (1) A condition in which the pressure in a nonpotable system is greater than the pressure in the potable distribution system. Superior pressure will cause nonpotable liquids to flow into the distribution system through unprotected cross connections. (2) A condition in which a substance is forced into a water systems because that substance is under higher pressure than the system pressure.

Backsiphonage – (1) Reversed flow of liquid cause by a partial vacuum in the potable distribution system. (2) A condition in which backflow occurs because the pressure in the distribution system is less than atmospheric pressure.

Bypass – Any arrangement of pipes, plumbing or hoses designed to divert the flow around an installed device through which the flow normally passes.

Chemical – A substance obtained by a chemical process or used for producing a chemical reaction.

Containment (Policy) – To confine potential contamination within the facility where it arises by installing a backflow prevention device at the meter or curbstop.

Contamination – The introduction into water of any substance that degrades the quality of the water, making it unfit for its intended use.

Continuous Pressure – A condition in which upstream pressure is applied continuously (more than 12 hours) to a device or fixture. Continuous pressure can cause mechanical parts within a device to freeze.

Cross Connection – (1) Any arrangement of pipes, fittings or devices that connects a nonpotable system to a potable system. (2) Any physical arrangement whereby a public water system is connected, either directly or indirectly, with any other water supply system, sewer, drain, conduit, pool, storage reservoir, plumbing fixture or other waste or liquid of unknown or unsafe quality.

Cross Connection Control – The use of devices, methods and procedures to prevent contamination of a potable water supply through cross connections.

Degree of Hazard – The danger posed by a particular substance or set of circumstances. Generally, a low degree of hazard is one that does not affect health, but may be aesthetically objectionable. A high degree of hazard is one that could cause serious illness or death.

Direct Connection – Any arrangement of pipes, fixtures or devices connecting a potable water supply directly to a nonpotable source; for example, a boiler feed line.

Distribution System – All pipes, fitting and fixtures used to convey liquid from one point to another.

Double Check-Valve System Assembly – A device consisting of two check valves, test cocks and shutoff valves designed to prevent backflow.

Gauge Pressure – Pounds per square inch (psi) that are registered on a gauge. Gauge pressure measures only the amount of pressure above (or below) atmospheric pressure.

Indirect Connection – Any arrangement of pipes, fixtures or devices that indirectly connects a potable water supply to a nonpotable source; for example, submerged inlet to a tank.

Isolation (policy) – To confine a potential source of contamination to the nonpotable system being served; for example, to install a backflow prevention device on a laboratory faucet.

Liability – Obligated by law.

Negative Pressure – Pressure that is less than atmospheric; negative pressure in a pipe can induce a partial vacuum that can siphon nonpotable liquids into the potable distribution system.

Nonpotable – Any liquid that is not considered safe for human consumption.

Nontoxic – Not poisonous; a substance that will not cause illness or discomfort if consumed.

Physical Disconnection (Separation) – Removal of pipes, fittings or fixtures that connect a potable water supply to a nonpotable system or one of questionable quality.

Plumbing – Any arrangement of pipes, fittings, fixtures or other devices for the purpose of moving liquids from one point to another, generally within a single structure.

Poison – A substance that can kill, injure or impair a living organism.

Pollution – Contamination, generally with man-made waste.

Potable – Water (or other liquids) that are safe for human consumption.

Pressure – The weight (of air, water, etc.) exerted on a surface, generally expressed as pounds per square inch (psi).

Pressure Vacuum Breaker – A device consisting of one or two independently operating, spring-loaded check valves and an independently operating, spring-loaded air-inlet valve designed to prevent backsiphonage.

Reduced-Pressure-Principle or Reduced-Pressure-Zone Device (RP or RPZ) – A mechanical device consisting of two independently operating, spring-loaded check valves with a reduced pressure zone between the checks designed to protect against both backpressure and backsiphonage.

Refusal of Service (Shutoff Policy) – A formal policy adopted by a governing board to enable a utility to refuse or discontinue service where a known hazard exists and corrective measures are not undertaken.

Regulating Agency – Any local, state or federal authority given the power to issue rules or regulations having the force of law for the purpose of providing uniformity in details and procedures.

Relief Valve – A device designed to release air from a pipeline, or introduce air into a line if the internal pressure drops below atmospheric pressure.

Submerged Inlet – An arrangement of pipes, fittings or devices that introduces water into a nonpotable system below the flood-level rim of a receptacle.

Superior Pressure – See backpressure.

Test Cock – An appurtenance on a device or valve used for testing the device.

Toxic – Poisonous; a substance capable of causing injury or death.

Vacuum (Partial Vacuum) – A condition induced by negative (sub atmospheric) pressure that causes backsiphonage to occur.

Venturi Principle – As the velocity of water increases, the pressure decreases. The Venturi principle can induce a vacuum in a distribution system.

Waterborne Disease – Any disease that is capable of being transmitted through water.

Water Supplier (Purveyor) – An organization that is engaged in producing and/or distributing potable water for domestic use.

Some Cross-Connections and Potential Hazards

Connected System	Hazard Level
Sewage pumps	High
Boilers	High
Cooling towers	High
Flush valve toilets	High
Garden hose (sil cocks)	Low to high
Auxiliary water supply	Low to high
Aspirators	High
Dishwashers	Moderate
Car wash	Moderate to high
Photographic developers	Moderate to high
Commercial food processors	Low to moderate
Sinks	High
Chlorinators	High
Solar energy systems	Low to high
Sterilizers	High
Sprinkler systems	High
Water systems	Low to high
Swimming pools	Moderate
Plating vats	High
Laboratory glassware or washing equipment	High
Pump primers	Moderate to high
Baptismal founts	Moderate
Access hole flush	High
Agricultural pesticide mixing tanks	High
Irrigation systems	Low to high
Watering troughs	Moderate
Autopsy tables	High

Cross Connection Vocabulary

_____1. Air Gap
_____2. Atmospheric Vacuum Breaker
_____3. Auxiliary Supply
_____4. Backflow
_____5. Back Pressure
_____6. Backsiphonage
_____7. Check Valve
_____8. Cross Connection
_____9. Feed Water
_____10. Hose Bibb
_____11. Overflow Rim
_____12. Pressure Vacuum Breaker
_____13. Reduced Pressure Zone Backflow Preventer
_____14. RPBP

A. A valve designed to open in the direction of normal flow and close with the reversal of flow.
B. A hydraulic condition, caused by a difference in pressures, in which non-potable water or other fluids flow into a potable water system.
C. Reduced pressure backflow preventer.
D. In plumbing, the unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or outlet supplying water to a tank, plumbing fixture or other container, and the overflow rim of that container.
E. A backflow condition in which the pressure in the distribution system is less than atmospheric pressure.
F. A faucet to which a hose may be attached.
G. A mechanical device consisting of two independently operating, spring-loaded check valves with a reduced pressure zone between the check valves.
H. Any water source or system, other than potable water supply, that may be available in the building or premises.
I. Water that is added to a commercial or industrial system and subsequently used by the system, such as water that is fed to a boiler to produce steam.
J. A device designed to prevent backsiphonage, consisting of one or two independently operating spring-loaded check valves and an independently operating spring –loaded air-inlet valve.
K. A backflow condition in which a pump, elevated tank, boiler or other means results in a pressure greater than the supply pressure.
L. Any arrangement of pipes, fittings, fixtures or devices that connects a nonpotable water system.
M. The top edge of an open receptacle over which water will flow.
N. A mechanical device consisting of a float check valve and an air-inlet port designed to prevent backsiphonage.

Cross-Connections Review Questions

1. Define a cross-connection.

2. Explain what is meant by backsiphonage and backpressure.

3. List four situations that can cause negative pressure in a potable water supply.
   -
   -
   -
   -

4. List six waterborne diseases that are known to have occurred as a result of cross-connections.
   -
   -
   -
   -
   -
   -

5. What is the most reliable backflow-prevention method?

6. Is a single check valve position protection against backflow? Why or why not?

7. How often should a reduced-pressure-zone backflow preventer be tested?

8. In what position should an atmospheric vacuum breaker be installed relative to a shutoff valve? Why?

9. How does a vacuum breaker prevent backsiphonage?

10. List seven elements that are essential to implement and operate a cross-connection control program successfully?
    -
    -
    -
    -
    -
    -
    -

Vocabulary Answers:

1. D
2. N
3. H
4. B
5. K
6. E
7. A
8. L
9. I
10. F
11. M
12. J
13. G
14. C

Review Question Answers:

1. A cross-connection is any connection or structural arrangement between a potable water system and a nonpotable system through which backflow can occur.

2. Backsiphonage is a condition in which the pressure in the distribution system is less than atmospheric pressure. In more common terms, there is a partial vacuum on the potable system.
   Backpressure is a condition in which a substance is forced into a water system because that substance is under a higher pressure than system pressure.
3.
   - fire demand
   - a broken water main or exceptionally heavy water use at a lower elevation than the cross-connection
   - a booster pump used on a system
   - undersized piping
4.
   - typhoid fever
   - dysentery and gastroenteritis
   - salmonellosis
   - polio
   - hepatitis
   - brucellosis
5. The most reliable backflow prevention method is an air gap.
6. A single check valve is not considered positive protection against backflow. A check valve can easily be held partially open by debris, corrosion products or scale deposits.
7. Reduced-pressure-zone backflow preventers should be tested at least annually.
8. An atmospheric vacuum breaker must be installed downstream from the last shutoff valve. If it is placed where there will be continuing backpressure, the valve will be forced to remain open, even under backflow conditions.
9. When water stops flowing forward, a check valve drops, closing the water inlet and opening an atmospheric vent. This lets water in the breaker body drain out, breaking the partial vacuum in that part of the system.
10.
    - an adequate cross-connection control ordinance
    - an adequate organization with authority
    - a systematic surveillance program
    - follow-up procedures for compliance
    - provisions for backflow-prevention device approvals, inspection and maintenance
    - public awareness and information programs

Section 13

Safety & Trenching

TDEC - Fleming Training Center

Safety

Distribution Systems

1

TDEC - Fleming Training Center

- An accident is caused by either an unsafe act or an unsafe environment

2

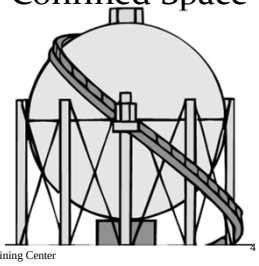
TDEC - Fleming Training Center

General Duty Clause

- FEDERAL - 29 CFR 1903.1
- EMPLOYERS MUST: Furnish a place of employment free of recognized hazards that are causing or are likely to cause death or serious physical harm to employees. Employers must comply with occupational safety and health standards promulgated under the Williams-Steiger Occupational Safety and Health Act of 1970.

3

Confined Space



TDEC - Fleming Training Center

4

TDEC - Fleming Training Center

confined space conditions

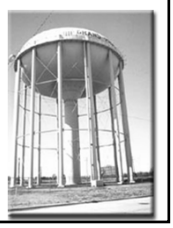
- Defined as any space where BOTH of the following conditions exist at the same time:
  - existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop
  - ready access/egress for the removal of a suddenly disabled employee (operator) is difficult due to the location and/or size of opening(s)
- Large enough and so configured that an employee can bodily enter and perform assigned work
- Limited or restricted means of entry or exit
- Not designed for continuous employee occupancy

5

TDEC - Fleming Training Center

Confined Space Examples

- Vaults
- Silos
- Inside filters
- Basins
- Storage tanks
- Pits
- Hoppers



TDEC - Fleming Training Center

Equipment Needed for Confined Spaces

- Safety harness with lifeline, tripod and winch
- Electrochemical sensors
- Ventilation blower with hose



TDEC - Fleming Training Center

Equipment Needed for Confined Spaces

- PPE
- Ladder
- Rope
- Breathing Apparatus




TDEC - Fleming Training Center

Permit-Required Spaces

- Contains or has potential to contain hazardous atmosphere
- Contains material with potential to engulf an entrant
- Entrant could be trapped or asphyxiated

9

TDEC - Fleming Training Center

Atmospheric Hazards

- Need to have atmosphere monitored!!!
  - Explosive or flammable
  - Toxic
  - Depletion or elimination of breathable oxygen

10

TDEC - Fleming Training Center

Hydrogen Sulfide

- Detected by the smell of rotten eggs
- Loss of ability to detect short exposures
- Not noticeable at high concentrations
- Poisonous, colorless, flammable, explosive and corrosive
- Exposures to .07% to 0.1% will cause acute poisoning and paralyze the respiratory center of the body
- At the above levels, death and/or rapid loss of consciousness occur

11

TDEC - Fleming Training Center

Methane Gas – CH_4

- Product of waste decomposition
- Leaks in natural gas pipelines can saturate the soil
- Explosive at a concentration of 5%
- Spaces may contain concentrations above the Lower Explosive Limits (LEL) and still have oxygen above the 19.5% allowable
- Colorless, odorless, tasteless

12

TDEC - Fleming Training Center

Carbon Monoxide - CO

- Decreases amount oxygen present
- ALWAYS VENTILATE
- 0.15% (1500 ppm) ⇨ DEAD
- Will cause headaches at .02% in two hour period
- Maximum amount that can be tolerated is 0.04% in 60 minute period
- Colorless, odorless, tasteless, flammable and poisonous

13

TDEC - Fleming Training Center

Oxygen – O_2

- ALWAYS ventilate – normal air contains ~ 21%
- Oxygen deficient atmosphere if less than 19.5%
- Oxygen enriched at greater than 23.5%
  - Speeds combustion
- Leave area if oxygen concentrations approach 22%
- At 8%, you will be dead in 6 minutes
- At 6%, coma in 40 seconds and then you die

14

TDEC - Fleming Training Center

Oxygen – O_2

- When O_2 levels drop below 16%, a person experiences
  - Rapid fatigue
  - Inability to think clearly
  - Poor coordination
  - Difficulty breathing
  - Ringing in the ears
  - Also, a false sense of well-being may develop

15

TDEC - Fleming Training Center

Oxygen – O_2

- In a confined space, the amount of oxygen in the atmosphere may be reduced by several factors
  - Oxygen consumption
    - During combustion of flammable substances
    - Welding, heating, cutting or even rust formation
  - Oxygen displacement
    - Carbon dioxide can displace oxygen
  - Bacterial action

16

TDEC - Fleming Training Center

Atmospheric Alarm Units

- Should continuously sample the atmosphere of the area
- Test atmospheres before entering
- Test for oxygen first
- Combustible gases second

17

TDEC - Fleming Training Center

Atmospheric Alarm Units

- Alarms set to read flammable gasses exceeding 10% of the lower explosive limit, H_2S exceeds 10 ppm and/or O_2 percentage drops below 19.5%
- Calibrate unit before using
- Most desirable units: simultaneously sample, analyze and alarm all three atmospheric conditions

18

TDEC - Fleming Training Center

Written Entry System

- Employer shall document entry permits
- Entry supervisor sign permits
- Permit posted
- Shall not exceed time required
- Retain permits for at least 1 year

19

TDEC - Fleming Training Center

Information on Permit Forms

- Space to be entered
- Purpose
- Date and authorized duration
- Attendant ID by name
- Authorized entrants ID by name
- Entry supervisor name and signature
- Hazards of permit space
- Measures to eliminate, isolate, or control the hazards
- Results of tests
- Rescue and emergency services
- Communications

20

TDEC - Fleming Training Center

Information on Equipment

- PPE (personal protective equipment)
- Testing equipment

21

TDEC - Fleming Training Center

Duties Of Entrants

- Know signs, symptoms, and consequence of exposure
- Properly use equipment
- Alert attendant of warning signs, symptoms and other possible hazards
- Exit when ordered to evacuate by supervisor or attendant

22

TDEC - Fleming Training Center

Duties of Confined Space Attendant

- Know signs, symptoms, and consequences of exposure
- Possible behavioral effects of hazards
- Maintain accurate count of entrants
- Remain outside permit space
- Communicate with entrants
- Summon rescue and emergency units

23

TDEC - Fleming Training Center

Duties of Confined Space Attendant

- Warn unauthorized persons to stay away
- Perform non-entry rescue
- Do not perform any duties that may interfere with primary duty: monitoring and protecting entrants

24

TDEC - Fleming Training Center

Duties of Supervisors and Managers

- Knowledge of signs, symptoms, and consequences of exposure
- Verify appropriate entries, procedure, tests and equipment
- Terminate entries and cancel permits if warranted
- Verify means for summoning rescue
- Ensure that acceptable conditions are maintained and operations remain consistent with entry permit

25

TDEC - Fleming Training Center

Required Training

- Employer shall train all employees on hazards, procedures, and skills to perform their jobs safely
- Employees trained before first assigned duty
- Employer shall certify training of employees
- Maintain individual training records of employees

26

TDEC - Fleming Training Center

Record Keeping

- Identification and Evaluation of all Hazardous areas in workplace
- Entrance permits filed
- Training Certification
- Written Confined Space Program

27

TDEC - Fleming Training Center

General Requirements

- Identify, evaluate, and monitor hazards in permit-required confined spaces
- Post signs "Permit Required"
- Prevent unauthorized entries
- Re-evaluate areas
- Inform contractors
- Have a written program available for employees
- Have proper PPE on hand
- Annual Training (TOSHA requirements)

28

TDEC - Fleming Training Center

Confined Space Requirements

- All electrodes removed and machines disconnected from power sources
- Gas supply shut off
- Gas cylinders outside work area
- All employees entering must undergo confined space training
- Ventilation used to keep toxic fumes, gasses, and dusts below max levels

29

TDEC - Fleming Training Center

Lockout / Tagout

TDEC - Fleming Training Center

General Requirements

- Written program
- Utilize tagout system if energy isolating device not capable of being locked out
- Lockout/tagout hardware provided
- Devices used only for intended purposes
- Tagout shall warn **DO NOT START, DO NOT ENERGIZE, DO NOT OPERATE**
- Only trained employees shall perform lockout/tagout

31

TDEC - Fleming Training Center

Requirements When Lockout of Equipment

- Notify employees
- Employees notified after completion of work and equipment re-energized

32

TDEC - Fleming Training Center

Recommend Steps for Lockout/Tagout

- Notify employees that device locked and tagged out
- Turn off machine normally
- De-activate energy
- Use appropriate lockout/tagout equipment
- Release any stored energy
- Try to start machine by normal means

33

TDEC - Fleming Training Center

Steps for Restoring Equipment

- Check area for equipment or tools
- Notify all employees in the area
- Verify controls are in neutral
- Remove lockout/tagout devices and re-energize device
- Notify employees maintenance and/or repairs are complete and equipment is operational

34

TDEC - Fleming Training Center

Training Requirements

- Employer shall train all employees
- All new employees trained
- Recognition of applicable hazardous energy
- Purpose of program
- Procedures
- Consequences
- ANNUAL REQUIREMENT

35

TDEC - Fleming Training Center

Inspections

- Conduct periodic inspection at least annually
- Shall include review between the inspector and each authorized employee
- Recommendation: Frequent walk through of work areas and observation of Maintenance and Operation area

36

TDEC - Fleming Training Center

Required Record Keeping

- Written Lockout/Tagout Program
- Training: Annual and New Employees
- Inspections: Annually; including new equipment, inspection of devices, and procedures

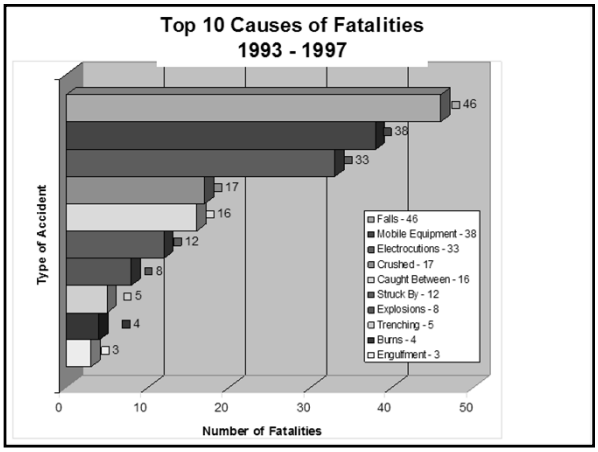
37

TDEC - Fleming Training Center

Most Cited Industry Standards By TOSHA

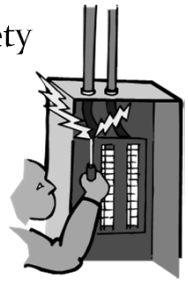
- No written Hazard Communication Program
- Inadequate Hazard Communication Training
- PPE Hazard Assessment not Done
- No Energy Control Program - Lockout/Tagout
- No MSDS on Site
- No one Trained in First Aid
- No Emergency Action Plan
- Metal Parts of Cord and Plug Equipment Not Grounded
- Unlabeled Containers of Hazardous Chemicals

38



TDEC - Fleming Training Center

Electrical Safety



TDEC - Fleming Training Center

OSHA Says

- Any electrical installations shall be done by a professionally trained electrician
- Any employee who is in a work area where there is a danger of electric shock shall be trained
- Employees working on electrical machinery shall be trained in lockout/tagout procedures

41

TDEC - Fleming Training Center

Fire Protection

42

TDEC - Fleming Training Center

Fire Protection Equipment

- Fire extinguishers shall be located where they are readily accessible
- Shall be fully charged and operable at all times
- All fire fighting equipment is to be inspected at least annually

43

TDEC - Fleming Training Center

Fire Protection Equipment

- Portable fire extinguishers inspected at least monthly and records kept
- Hydrostatic testing on each extinguisher every five years
- Fire detection systems tested monthly if battery operated

44

TDEC - Fleming Training Center

Types of Fire Extinguishers

- **Class A**

  - Used on combustible materials such as wood, paper or trash
  - Can be water based
- **Class B**

  - Used in areas where there is a presence of a flammable or combustible liquid
  - Shall not be water based
  - Example is dry chemical extinguisher
  - An existing system can be used but not refilled

45

TDEC - Fleming Training Center

Types of Fire Extinguishers

- **Class C**

  - Use for areas electrical
  - Best is carbon dioxide extinguisher
  - Using water to extinguish a class C fire risks electrical shock
- **Class D**
  - Used in areas with combustible metal hazards
  - Dry powder type
  - Use no other type for this fire

46

TDEC - Fleming Training Center

Types of Fire Extinguishers

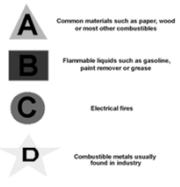
Class	Material	Method
A	Wood, paper	Water
B	Flammable liquids (oil, grease, paint)	Carbon dioxide, foam, dry chemical or Halon
C	Live electricity	Carbon dioxide, dry chemical, Halon
D	Metals	Carbon dioxide

47

TDEC - Fleming Training Center

Types of Fire Extinguishers

- Combination ABC are most common
- Have the types of extinguishers available depending upon analyses performed in each area



48

TDEC - Fleming Training Center

Fire Extinguishers

- To operate a fire extinguisher, remember the word **PASS**
  - **P**ull the pin. Hold the extinguisher with the nozzle pointing away from you.
  - **A**im low. Point the extinguisher at the base of the fire.
  - **S**queeze the lever slowly and evenly.
  - **S**weep the nozzle from side-to-side.

49

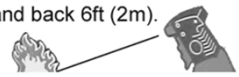
TDEC - Fleming Training Center

Fire Extinguishers

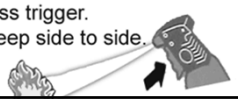
Combo Extinguisher

1. Pull pin.
   Hold unit upright.

2. Aim at base of fire.
   Stand back 6ft (2m).



3. Press trigger.
   Sweep side to side.



TDEC - Fleming Training Center

Traffic Safety

51

TDEC - Fleming Training Center

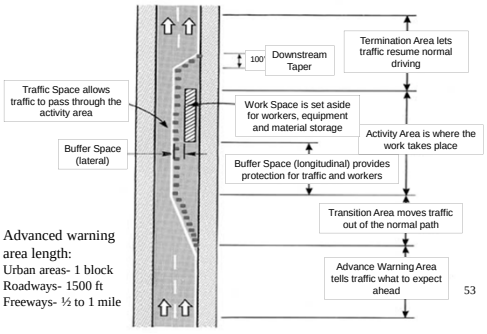
Traffic Control Zones

- Advanced warning area
- Transition area
- Buffer space
- Work area
- Termination area

52

TDEC - Fleming Training Center

Traffic Control Zones



Advanced warning area length:
Urban areas- 1 block
Roadways- 1500 ft
Freeways- ½ to 1 mile

53

TDEC - Fleming Training Center

Advanced Warning Area

- Must be long enough to give motorists adequate time to respond to particular work area conditions
- Typically ½ mile to one mile for highways
- 1500 feet for most other types of roads
- At least one block for urban streets

54

TDEC - Fleming Training Center

Transition Area

- Not required if no lane or shoulder closure is involved
- Use of tapers
  - Channeling devices or pavement markings placed at an angle to direct traffic
- Traffic is channeled around the work area

55

TDEC - Fleming Training Center

Buffer Space

- Provides margin of safety between transition zone and work area

56

TDEC - Fleming Training Center

Work Area

- Ensure closed to traffic
- Shield by barriers
- Post **Road Construction Next ____ Miles** to inform drivers of the length of work area
- Do Not set up sign until work begins

57

TDEC - Fleming Training Center

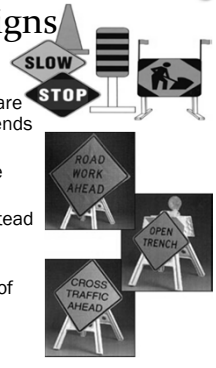
Termination Area

- Provides short distance for traffic to clear work area and return to normal traffic lanes
- Closing tapers are optional

58

TDEC - Fleming Training Center

Traffic Signs



- Always use official signs
- Most permanent warning signs are diamond-shaped with black legends on yellow background
- Temporary signs have an orange background
- Best to use picture direction instead of wording
- Place end of construction signs about 500 feet beyond the end of the work site

TDEC - Fleming Training Center

Channelizing Devices

- Designed to warn and direct traffic away from workers
- Cones are 18-36 inches high and orange in color
- Drums are 2 orange and 2 white stripes

60

TDEC - Fleming Training Center

Channelizing Devices

- Barricades are alternating orange and white strips marked with reflectors sloping downward in the direction traffic must turn

61

TDEC - Fleming Training Center

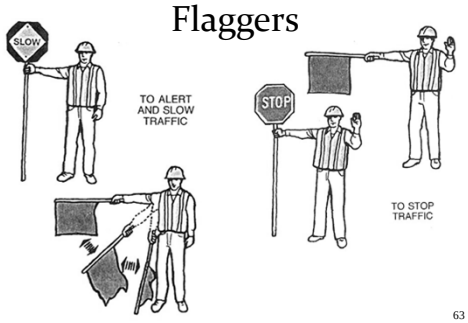
Channelizing Devices

- Flaggers should wear lime green (or orange) and reflectors at night
- Should be positioned at least 100 feet from the work site always facing the oncoming traffic

62

TDEC - Fleming Training Center

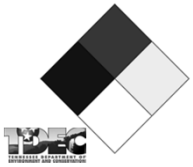
Flaggers



63

TDEC - Fleming Training Center

Chemical Safety



64

TDEC - Fleming Training Center

Personal Protective Equipment

- Gloves
- Coveralls / Overalls
- Face Shield / Goggles
- Respirator / SCBA
- Boots
- Ear Plugs / Muffs

65

TDEC - Fleming Training Center

Material Safety Data Sheets

- Also called MSDS
- Lists:
  - Common and chemical name
  - Manufacturer info
  - Hazardous ingredients
  - Health hazard data
  - Physical data
  - Fire and explosive data
  - Spill or leak procedures
  - PPE
  - Special precautions

66

TDEC - Fleming Training Center

NFPA

- National Fire Protection Association
- Chemical hazard label
  - Color coded
  - Numerical system
    - Health
    - Flammability
    - Reactivity
  - Special precautions
- Labels are required on all chemicals in the lab

67

TDEC - Fleming Training Center

RTK Labels

- "Right to Know"
- In 1983, OSHA instituted Hazard Communication Standard 1910-1200, a rule that gives employees the right to know the hazards of chemicals to which they may be exposed in the workplace.

68

TDEC - Fleming Training Center

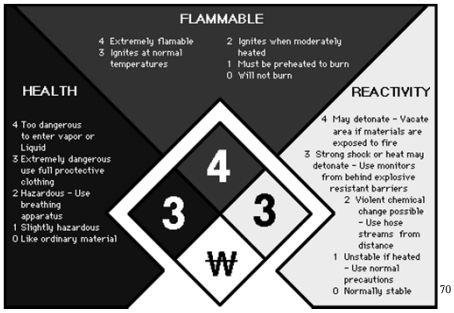
Degrees of Hazard

- Each of the colored areas has a number in it regarding the degree of hazard
  - 4 → extreme
  - 3 → serious
  - 2 → moderate
  - 1 → slight
  - 0 → minimal

69

TDEC - Fleming Training Center

Chemical Label



70

TDEC - Fleming Training Center

Chemical Hazard Label

Health

- 4 (extreme)→highly toxic material
  - Very short exposure can cause death or major residual injury even with prompt medical treatment
  - A known/suspected carcinogen, mutagen, or teratogen
- 3 (serious) → toxic material
  - Short term exposure may cause serious temporary or residual injury even with prompt medical treatment
  - A know/suspected small animal carcinogen, mutagen, or teratogen

71

TDEC - Fleming Training Center

Chemical Hazard Label

Health

- 2 (moderate) → moderately toxic material
  - Intense or continued exposure could cause temporary incapacitation or possible residual injury even with prompt medical treatment
- 1 (slight) → slightly toxic material
  - May cause irritation buy only minor residual injury even without treatment
  - Recognized innocuous material when used with responsible care
- 0 (minimal) → no chemical is without some degree of toxicity

72

TDEC - Fleming Training Center

Chemical Hazard Label

Flammability

- 4 (extreme) → extremely flammable
  - Flashpoint below 73ºF
- 3 (serious) → flammable
  - Vaporizes readily and can be ignited under almost all ambient conditions
  - May form explosive mixtures with or burn rapidly in air
  - May burn rapidly due to self-contained oxygen
  - May ignite spontaneously in air
  - Flash point at or above 73ºF but less than

73

TDEC - Fleming Training Center

Chemical Hazard Label

Flammability

- 2 (moderate) → combustible
  - Must be moderately heated or exposed to relatively high temps for ignition to occur
  - Solids which readily give off flammable vapors
  - Flash point at or above 100ºF but less than 200ºF
- 1 (slight) → slightly combustible
  - Must be preheated for ignition to occur
  - Will burn in air when exposed at 1500ºF for 5 min
  - Flash point at or above 200ºF
- 0 (minimal)
  - Will not burn
  - Will not exhibit a flash point
  - Will not burn in air when exposed at 1500ºF for 5 min

74

TDEC - Fleming Training Center

Chemical Hazard Label

Reactivity

- 4 (extreme)
  - Can explode or decompose violently at normal temperature and pressure
  - Can undergo a violent self-accelerating exothermic reaction with common materials or by itself
  - May be sensitive to mechanical or local thermal shock at normal temperature and pressure

75

TDEC - Fleming Training Center

Chemical Hazard Label

Reactivity

- 3 (serious)
  - Can detonate or explode but requires a strong initiating force or confined heating before initiation
  - readily promotes oxidation with combustible materials and may cause fires
  - Sensitive to thermal or mechanical shock at elevated temp
  - May react explosively with water without requiring heat or confinement

76

TDEC - Fleming Training Center

Chemical Hazard Label

Reactivity

- 2 (moderate)
  - Normally unstable and readily undergoes violent change but does not detonate
  - May undergo chemical change with rapid release of energy at normal temp and pressure
  - May react violently with water
  - Forms potentially explosive mixtures with water
- 1 (slight)
  - Normally stable material which can become unstable at high temperature and pressure
- 0 (minimal)
  - Normally stable material which is not reactive with water

77

TDEC - Fleming Training Center

Safety Data Sheet

- OSHA moving from HCS (Hazard Communication Standard) to GHS (Globally Harmonized System)
- Revised criteria for chemical hazard classification, labeling & new format for Safety Data Sheets (SDS)
- Final rule effective May 25, 2012 but compliance dates are phased in:
  - Complete training on new label formats: 12/1/13
  - Comply with label and SDS requirements: 6/1/15
  - Update Hazcom programs: 6/1/16

78

TDEC - Fleming Training Center

MSDS to SDS

- What is the difference between a MSDS and the new SDS?
- SDSs are in use globally
- The Safety Data Sheets (formerly MSDSs) will now have a specified 16-section format

79

TDEC - Fleming Training Center

MSDS to SDS

- In addition, chemical manufacturers and importers will be required to provide a label that includes a harmonized signal word, pictogram, and hazard statement for each hazard class and category
  - The use of pictograms will enable workers, employers, and chemical users worldwide to understand the most basic chemical information without language barriers

80

TDEC - Fleming Training Center

Minimum Info for SDS

- Product identification
- Hazard Identification
- Composition/info on ingredients
- First-aid measures
- Fire-fighting measures
- Accidental release measures
- Handling and storage
- Exposure controls
- Physical/chemical properties
- Stability & reactivity
- Toxicological information
- Ecological information*
- Disposal considerations*
- Transport information*
- Regulatory information*
- Other information (including date of SDS or last revision)*

* Non mandatory

81

TDEC - Fleming Training Center

OSHA Pictograms

Flammables | Oxidizers | Explosives | Acute toxicity | Corrosives

Gases under pressure | Carcinogens | Environmental toxicity | Irritant

82

TDEC - Fleming Training Center

Terms

- Lower Explosive Level (LEL) – minimum concentration of flammable gas or vapor in air that supports combustion
- Upper Explosive Limit (UEL) – maximum concentration of flammable gas or vapor in air that will support combustion
- Teratogen – causes structural abnormality following fetal exposure during pregnancy
- Mutagen – capable of altering a cell's genetic makeup

83

Trenching Safety

THE GENERAL DUTY CLAUSE

FEDERAL - 29 CFR 1903.1

EMPLOYERS MUST: Furnish a place of employment free of recognized hazards that are causing or are likely to cause death or serious physical harm to employees. Employers must comply with occupational safety and health standards promulgated under the Williams-Steiger Occupational Safety and Health Act of 1970.

OSHA ACT OF 1970

APPLICABLE REGULATIONS

- 29 CFR 1926.650 - General Protection Requirements
- 29 CFR 1926.651 - Specific Excavation Requirements
- 29 CFR 1926.652 - Specific Trenching Requirements
- 29 CFR 1926.653 - Definitions
- Appendix - A - Excavations
- Appendix - B - Sloping and Benching
- Appendix - C - Timber Shoring for Trenches
- Appendix - D - Aluminum Hydraulic Shoring

Cave-ins

- Hundreds of workers killed annually from cave-ins
- Thousand of workers injured annually from cave-ins
- Fatality rate for trenching is twice the level for general construction

Asphyxiation

- Each time a breath is exhaled the weight of the load restricts inhalation of the next breath
- Slow suffocation usually follows unless rescue is immediate

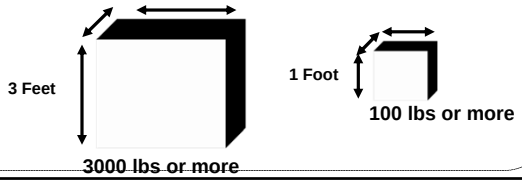
Cave-ins Result From

- Vibrations
- Adjacent structures
- Freezing and thawing
- Weight of the soil itself
- Addition or removal of water
- Reduction in frictional and cohesive capacities of soil

TDEC - Fleming Training Center

Density and Water Content

- One cubic yard weighs - 3000 lbs or more
- One cubic foot weighs- 100 lbs or more



7

TDEC - Fleming Training Center

How do most deaths occur?

- Instantaneously
- Trenches 5 to 15 feet deep
- With absolutely no warning
- In seemingly safe conditions
- With workers in a bent or lying position

8

TDEC - Fleming Training Center

Basic Safety Requirements

- Conduct inspections before each work shift
- Do not travel under elevated loads
- Do not work over unprotected employees
- Wear proper personal protective equipment

9

TDEC - Fleming Training Center

Basic Safety Requirements

- Provide walkways or bridges over trenches
- Provide trench exits within 25 feet of workers in trenches more than four feet deep
  - For every 25 feet of trench there needs to be 1 ladder
- Ensure spoilage is at least 2 feet from trench edges
- Provide protection for trenches 5 feet or deeper
  - Shores needed

10

TDEC - Fleming Training Center

Emergency Procedures

- Immediately call 911, or the Emergency Response Team
- Report:
  - Exact Location
  - Number of Victims
  - Nature of Emergency
  - Trench Measurements
  - Special Hazards

11

TDEC - Fleming Training Center

Emergency Procedures

- Keep all life-support and dewatering systems operating
- Clear workers away from the excavation
- Shut down heavy equipment
- Be prepared to meet and brief rescue personnel

12

TDEC - Fleming Training Center

Emergency Procedures

- What to do:
  - Don't Panic!
  - Control would-be rescuers
  - Don't sacrifice anyone else
  - Never attempt to dig someone out using motorized equipment
- Remember - Your actions could save a life!

13

TDEC - Fleming Training Center

Underground Installations

- Utility lines must be located before excavating begins
- Utility companies or owners must be contacted:

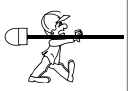
Tennessee One Call 1-800-351-1111

14

TDEC - Fleming Training Center

Trench Safety

- Trenches more than 5 feet:
  - Require shoring
  - Or must have a stabilized slope
- In hazardous soil conditions:
  - Trenches under 5 feet need protection



15

TDEC - Fleming Training Center

Hazards

- Adequate precautions must be taken when working in accumulated water
- Controlling water and water removal must be monitored by a competent person
- Ditches, dikes or comparable means should be used to prevent surface water from entering excavations

16

TDEC - Fleming Training Center

Mother Nature

- Don't underestimate the effects weather can have
- Daily (or hourly) site inspections must be made
- Consider protection from:
  - Lightening
  - Flooding
  - Erosion
  - High winds
  - Hot or cold temperatures

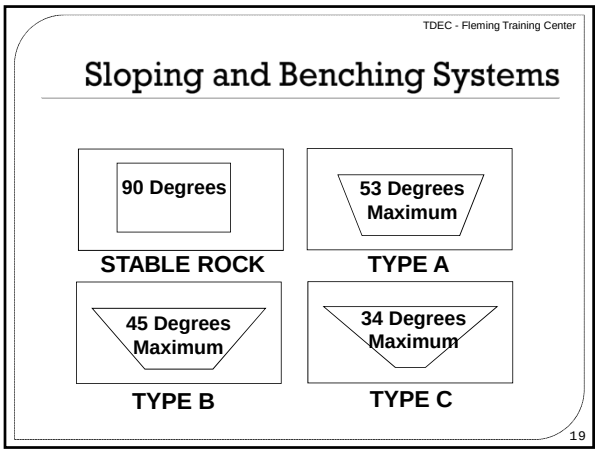
17

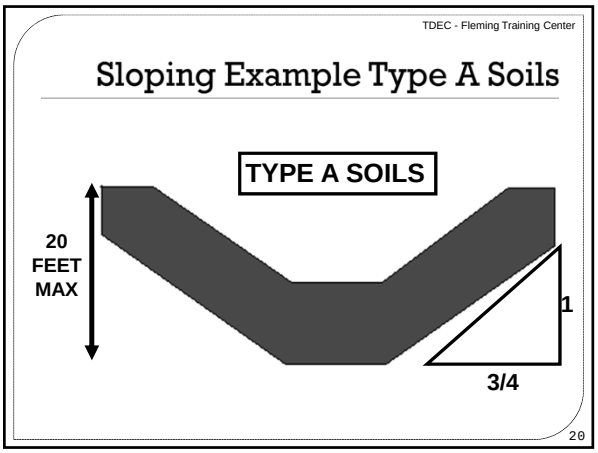
TDEC - Fleming Training Center

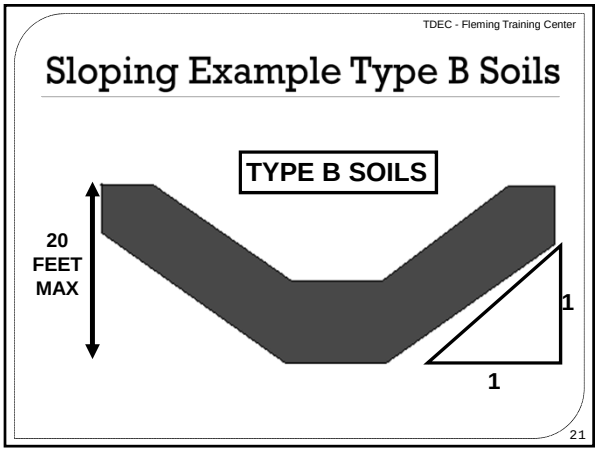
Soil Classification System

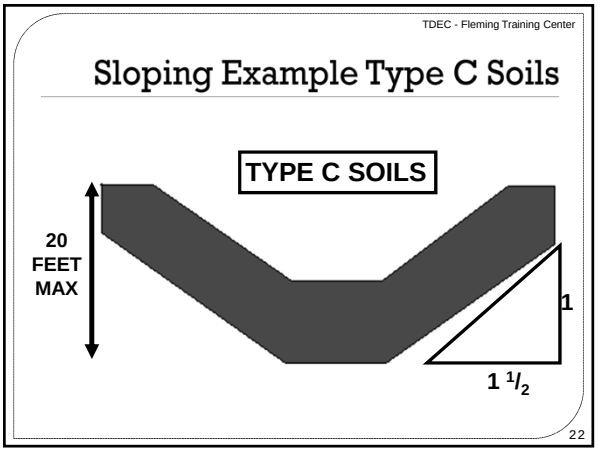
- Type A Soils
  - Clay
  - Silty Clay
  - Sandy Clay
  - Clay Loam
- Type B Soils
  - Granular Cohesionless Soils (Silt Loam)
- Type C Soils
  - Gravel
  - Sand
  - Loamy Sand

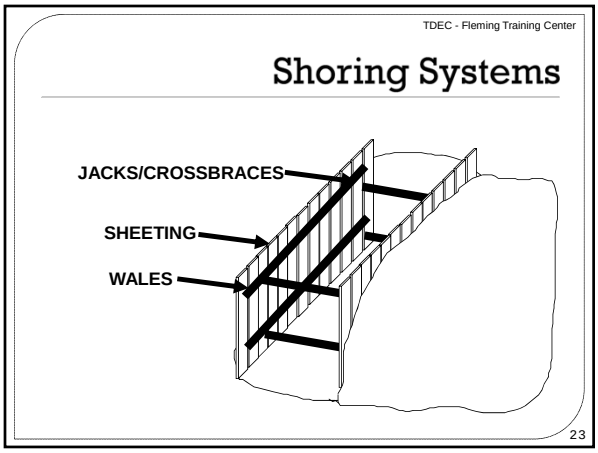
18


TDEC - Fleming Training Center
Sloping and Benching Systems
90 Degrees
STABLE ROCK
53 Degrees Maximum
TYPE A
45 Degrees Maximum
TYPE B
34 Degrees Maximum
TYPE C
19


TDEC - Fleming Training Center
Sloping Example Type A Soils
TYPE A SOILS
20 FEET MAX
1
3/4
20


TDEC - Fleming Training Center
Sloping Example Type B Soils
TYPE B SOILS
20 FEET MAX
1
1
21


TDEC - Fleming Training Center
Sloping Example Type C Soils
TYPE C SOILS
20 FEET MAX
1
1 1/2
22


TDEC - Fleming Training Center
Shoring Systems
JACKS/CROSSBRACES
SHEETING
WALES
23

TOSHA Standards Requiring Annual Training

Class	Regulation	Who should attend?
Medical & Exposure Records	1910.20(g)(1)	All employees (inform-existence, person responsible, location, right of access
Emergency Action	1910.38(a)(5) 1910.38(b)(4)	All employees – based upon other standards and requirements
Noise	1910.95(k)	All employees exposed to an 8 hour TWA or greater of 85dBA
Emergency Response	1910.120(q)	Employees who respond to spills of hazardous chemicals
Personal Protective Equipment	1910.132(f)	Employees who wear PPE
Permit-Required Confined Space	1910.146(g)	Employees who enter, attend or supervise P.R. confined spaces
Lock-Out/Tag-Out	1910.147(c)(7)	Employees who work on machinery
First Aid	1910.151(b)	At least one employee on each shift, annual as required by other standards
Fire Brigade	1910.156(c)	All fire brigade members (quarterly and annually)
Portable Fire Extinguishers	1910.157(g)	All employees expected to use fire extinguishers
Fork Lift Trucks	1910.178(1)	Fork lift truck operators
Mechanical Power Presses	1910.217(f)(2)	Operators
Asbestos	1910.1001(j)(1)	All employees exposures at or above PEL or excursion limit
Lead	1910.1025(1)	Anyone with a potential for exposure at any level – copy of appendix A&B. If exposed at or above action level, must be trained
Bloodborne Pathogens	1910.1030(g)(2)	Employees who render first aid
Hazard Communication	1910.1200(h) TDL 800-1-9-.07	Employees exposed or potentially exposed to any type of chemicals
Hazardous Chemicals in Laboratories	1910.1450(f)(2)	Employees exposed to chemicals

TRENCHSAFETY™ AND SUPPLY, INC.
Memphis, Tennessee ▪ 901/346-5800 ▪ 800/865-5801
North Little Rock, Arkansas ▪ 501/955-3800 ▪ 800/243-6408
www.trenchsafety.com

Trenching & Excavation Safety Checklist

Site Location _____ Date _____ Time _____ a.m. p.m.

GENERAL INSPECTION

1.	Has the "Competent Person" had specific training in—and is knowledgeable about—soil analysis, use of protective systems, and the requirements of 29CFR1926-Subpart P: Excavations and Trenches?	❑ YES	❑ NO	❑ N/A
2.	Does the "Competent Person" have the authority to remove workers from the excavation immediately?	❑ YES	❑ NO	❑ N/A
3.	Are excavations, adjacent areas, and protective systems inspected by a Competent Person: **A.** Daily prior to the start of work, **B.** As needed throughout the shift, and **C.** After every rainstorm or other occurrence that could increase the hazard?	❑ YES	❑ NO	❑ N/A
4.	Are ALL surface encumbrances removed or supported?	❑ YES	❑ NO	❑ N/A
5.	Are ALL employees protected from loose rock or soil that could pose a hazard by falling or rolling into the excavation?	❑ YES	❑ NO	❑ N/A
6.	Are hard hats worn by ALL employees?	❑ YES	❑ NO	❑ N/A
7.	Are spoils, materials, and equipment set back at least 2 feet from the edge of the excavation?	❑ YES	❑ NO	❑ N/A
8.	Are barriers provided at all remotely located excavations, wells, pits, shafts, etc.?	❑ YES	❑ NO	❑ N/A
9.	Are walkways and bridges over excavations 6 feet or more in depth and 30 inches or more in width equipped with standard guard rails and toe boards?	❑ YES	❑ NO	❑ N/A
10.	Are warning vests or other highly visible clothing provided and worn by all employees exposed to vehicular traffic?	❑ YES	❑ NO	❑ N/A
11.	Are employees required to stand away from vehicles being loaded or unloaded?	❑ YES	❑ NO	❑ N/A
12.	Are warning systems established and used when mobile equipment is operating near the edge of an excavation?	❑ YES	❑ NO	❑ N/A
13.	Are employees prohibited from going under suspended loads?	❑ YES	❑ NO	❑ N/A
14.	Are employees prohibited from working on the faces of sloped or benched excavations above other employees?	❑ YES	❑ NO	❑ N/A

UTILITIES

15.	Are utilities companies contacted and/or utilities located as required by local, state, and federal law?	❑ YES	❑ NO	❑ N/A
16.	Are the exact locations clearly marked?	❑ YES	❑ NO	❑ N/A
17.	Are underground installations protected, supported, or removed when an excavation is open?	❑ YES	❑ NO	❑ N/A

ACCESS & EGRESS

18.	Are ladders or other means of access and egress in place in all trenches 4 feet or more deep?	❑ YES	❑ NO	❑ N/A
19.	Are all workers within 25 feet of a means of access and egress?	❑ YES	❑ NO	❑ N/A
20.	Are the ladders that are used in excavations secured and extended 3 feet above edge of the excavation?	❑ YES	❑ NO	❑ N/A
21.	Are ALL structural ramps used by employees designed by a "Competent Person?"	❑ YES	❑ NO	❑ N/A
22.	Are ALL structural ramps used for equipment designed by a Registered Professional Engineer?	❑ YES	❑ NO	❑ N/A
23.	Are ALL ramps constructed of materials of uniform thickness, cleated together, equipped with no-slip surfaces?	❑ YES	❑ NO	❑ N/A
24.	Are employees protected from cave-ins when entering or exiting excavation?	❑ YES	❑ NO	❑ N/A

WET CONDITIONS

25.	Are precautions taken to protect employees from water accumulation?	❑ YES	❑ NO	❑ N/A
26.	Is water removal equipment monitored by "Competent Person?"	❑ YES	❑ NO	❑ N/A
27.	Is surface water or runoff diverted after every rainstorm or other hazard-increasing occurrence?	❑ YES	❑ NO	❑ N/A

continued on back...

HAZARDOUS ATMOSPHERES

28. Is the atmosphere within ALL excavations tested when there is a reasonable possibility of an oxygen-deficient, oxygen-enriched, combustible, toxic, or other harmful contaminant?	❑ YES	❑ NO	❑ N/A
29. Are adequate precautions taken to protect employees from exposure to an atmosphere containing less than 19.5% oxygen and/or other hazardous atmosphere?	❑ YES	❑ NO	❑ N/A
30. Is verification provided to protect employees from an atmosphere containing flammable gas in excess of 10% of the lower explosive limit of the gas?	❑ YES	❑ NO	❑ N/A
31. Is emergency equipment available when hazardous atmospheres could or do exist?	❑ YES	❑ NO	❑ N/A
32. Are employees trained to use personal protective equipment and other rescue equipment?	❑ YES	❑ NO	❑ N/A

SOILS

33. Has the Competent Person classified the soil using one manual test and one visual test, as specified by the standard?	❑ YES	❑ NO	❑ N/A

Visual Test _____ (Type) Manual Test _____ (Type)

Soil Classified as: ❑ Solid Rock ❑ Type A ❑ Type B ❑ Type C

SUPPORT SYSTEMS

3 Primary Options are Available:

Note: *If an excavation is deeper than 5 feet (4 feet in some states), a support system is required by federal law, except for excavations entirely in stable rock (very rare!). If an excavation is less than 5 feet deep (4 feet in some states), a support system is required if there is a potential for a cave-in, as determined by the "Competent Person."*

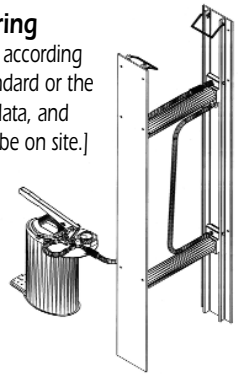
❑ Option #1– Sloping

[For excavations less than 20 feet deep.]

Soil Type	Maximum Allowable Slope (H:V)
Stable Rock	Vertical **or** 90˚
Type A	¾:1 **or** 53˚
Type B	1:1 **or** 45˚
Type C	1½ : 1 **or** 34˚

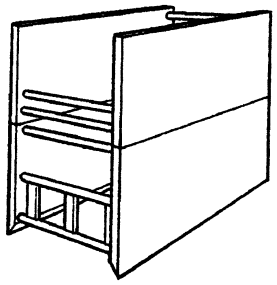
❑ Option #2 – Shoring

[Shoring must be installed according to charts in the OSHA standard or the manufacturer's tabulated data, and these charts or data must be on site.]



❑ Option #3 – Shielding

[Shielding must be installed according to the manufacturer's tabulated data, and this data must be on site.]



Note: **A 4th option always available is a system designed by a Registered Professional Engineer**
[Designs must be in writing, they must meet OSHA's requirement, and must be on site.]

34. Are materials and/or equipment chosen based upon soils analysis, trench depth and expected loads?	❑ YES	❑ NO	❑ N/A
35. Are materials and equipment that are used for protective systems inspected and in good condition?	❑ YES	❑ NO	❑ N/A
36. Are damaged materials and equipment immediately removed from service?	❑ YES	❑ NO	❑ N/A
37. Are damaged materials and equipment inspected by a Registered Professional Engineer after repairs are made and before being placed back in service?	❑ YES	❑ NO	❑ N/A
38. Are protective systems installed without exposing employees to hazards of cave-ins, collapses, or threat of being struck by materials or equipment?	❑ YES	❑ NO	❑ N/A
39. Are ALL members of support systems securely fastened together to prevent failure?	❑ YES	❑ NO	❑ N/A
40. Are support systems provided to insure stability of adjacent structures, buildings, roadways, sidewalks, etc.?	❑ YES	❑ NO	❑ N/A
41. Are excavations below the level of the base or footing supported, and approved by a Registered Professional Engineer?	❑ YES	❑ NO	❑ N/A
42. Does back-filling progress with the removal of the support system?	❑ YES	❑ NO	❑ N/A
43. Is a shield system installed to prevent lateral movement?	❑ YES	❑ NO	❑ N/A
44. Are employees prohibited from remaining in a shield system during vertical movement?	❑ YES	❑ NO	❑ N/A

Job Notes: _____

Inspected by:

Safety Quiz

Lockout / Tagout

True or False

1. The term “lockout” means to block the flow of energy to equipment and keep it blocked by placing a lock to prevent accidental start-up.

   True False

2. The term “tagout” means to place a tag on the power source to identify yourself and the purpose of the lockout, and to warn others not to turn the power back on.

   True False

3. If someone else has already applied a lock and tag to a piece of machinery you need to work on, you should not add another one.

   True False

4. After locking and tagging out the equipment, you should test the equipment to make sure it won’t start.

   True False

5. You don’t need to use the lockout / tagout procedure if a machine has a built-in safety shut-off.

   True False

Confined Spaces

Fill in the blank:

6. A _____ is a form designed to make sure workers can safely enter a confined space by establishing procedures that must be followed.

7. The acceptable range for oxygen level in a confined space is _____ %.

8. List some activities that can reduce the level of oxygen in a confined space:

   _____

9. Entry-level permits should be kept on file for at least _____ year(s).

Multiple Choice:

10. Which of these are examples of confined spaces? (Circle all that apply)
    a. Storage tanks
    b. Automobiles
    c. Meter box
    d. Manholes
    e. Meeting rooms

11. When must the atmosphere of a confined space be tested?
    a. Only before a worker enters
    b. Never, if adequate ventilation exists
    c. Continuously
    d. Only if welding or painting is being performed

12. Some gases in a confined space can be:
    a. Colorless
    b. Odorless
    c. Deadly
    d. All of the above

True or False:

13. If dangerous conditions exist, you do not have to wait for trained rescue personnel to perform a rescue.

    True False

14. Carbon monoxide and hydrogen sulfide are two common dangerous gases found in confined spaces.

    True False

Trenching

Multiple Choice:

15. A trench is generally defined by being less than how many feet wide?
    a. Less than 5 feet wide
    b. Less than 15 feet wide
    c. Less than 20 feet wide
    d. More than 20 feet wide

16. How far from the trench must a spoil be placed?
    a. The toe of the spoil must be at least 1 foot from the edge of the excavation
    b. The toe of the spoil must be at least 2 feet from the edge of the excavation
    c. The toe of the spoil must be at least 3 feet from the edge of the excavation
    d. The toe of the spoil must be at least 4 feet from the edge of the excavation

17. One method of classifying soils has to do with texture. Texture is based on soil particle size, name three soil particle size groupings. (Pick three answers)
    a. Clay
    b. Rock
    c. Loam
    d. Silt
    e. Sand
    f. Gravel

18. When must a ladder be installed in a trench?
    a. Any excavation
    b. Any excavation three feet deep or more
    c. Any excavation four feet deep or more
    d. Any excavation five feet deep or more

19. What is the spacing of ladders in longer trenches?
    a. Ladder must be available every 50 feet
    b. Ladder must be available every 25 feet
    c. Ladder must be available every 15 feet
    d. Ladder must be available every 5 feet

20. Methods of cave-in protection at an excavation work site are:
    a. Sloping
    b. Shoring
    c. Shields
    d. All the above

21. Two hazards immediately associated with water and water accumulations are cave-ins and drownings.
    a. True
    b. False

Calcium Hypochlorite

Multiple Choice

22. Calcium hypochlorite:
    a. Is an oxidizer
    b. May cause a fire if contaminated
    c. Can release hazardous chlorine gas if stored improperly
    d. All of the above

23. Which form of calcium hypochlorite is the safest?
    a. Granular
    b. Tablet
    c. Liquid

24. Calcium hypochlorite should be stored away from:
    a. Acids
    b. Paint
    c. Reducing agents
    d. Oils and greases
    e. All of the above

25. What should be used to extinguish a fire involving calcium hypochlorite?
    a. Water
    b. Carbon dioxide
    c. Chemical smothering agents
    d. All of the above

26. When cleaning up a small spill, you should dispose of the calcium hypochlorite by:
    a. Burying it
    b. Placing it in the trash can
    c. Putting it back in the container
    d. Neutralizing it with acid or ammonia
    e. Dissolving it in a large amount of water

Fill in the blank

27. What personal protective equipment should you wear when handling calcium hypochlorite?

    _____

28. Why should smoking be prohibited in calcium hypochlorite storage areas?

    _____

29. Why must you never dispose of calcium hypochlorite in the trashcan?

_____

Answers:

1. True
2. True
3. False
4. True
5. False
6. Confined space permit
7. 19.5% - 23.5%
8. Poor ventilation, welding, absorption, chemical consumption
9. One
10. A and D
11. C
12. D
13. False
14. True
15. B
16. B
17. A, D and E
18. C
19. B
20. D
21. A
22. D
23. A
24. E
25. B
26. E
27. Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes (rubber gloves and rubber boots)
28. Fire hazard
29. Can react with organic material and cause a flash fire

Section 14

Rules and Regs &

Sanitary Survey

The Design Criteria document can be

found in its entirety at:

http://www.state.tn.us/environment/dws/pdf/design.pdf

The Sanitary Survey document can be

found in its entirety at:

http://www.state.tn.us/environment/dws/pdf/SSManual.pdf

COMMUNITY
PUBLIC WATER SYSTEMS
DESIGN CRITERIA

Division of Water Supply
Tennessee Department of Environment and Conservation
2008

Part 8 - FINISHED WATER STORAGE

8.0 GENERAL - The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Prestressed concrete tanks shall meet applicable AWWA Standards. Other materials of construction are acceptable when properly designed to meet the requirements of this part.

8.0.1 Location

a. The bottom of ground-level reservoirs should be placed at the normal ground surface and above maximum flood level.

b. Where the bottom must be below normal ground surface, it should be placed above the ground water table. Sewers, drains, standing water, and similar sources of contamination must be kept at least 50 feet from the reservoir. Mechanical-joint water pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at lesser separations.

c. The top of a ground-level reservoir should not be less than 2 feet above normal ground surface and any possible flood level. Clearwells constructed under filters may be excepted from this requirement when the total design gives the same protection.

8.0.2 Protection - All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.

8.0.3 Protection from Trespassers - Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

8.0.4 Drains - No drain on a water storage structure may have a direct connection to a sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

8.0.5 Overflow - The overflow pipe of a water storage structure should be brought down near the ground surface and discharged over a drainage inlet structure or a splash plate and flow onto a drainway which is rip-rapped or otherwise protected to minimize erosion. No overflow may be connected directly to a sewer or storm drain.

a. When an internal overflow pipe is used, it shall be located in the access tube.

b. The overflow of a ground-level structure shall be high enough above normal or graded ground surface to prevent the entrance of surface water.

c. The overflow shall be protected with a twenty-four mesh non-corrodible screen and a flap valve.

8.0.6 Access - Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes on scuttles above waterline:

a. shall be framed at least 4 inches, and preferably 6 inches, above the surface of the roof at the opening; on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod;

b. shall be fitted with a solid watertight cover which overlaps the framed opening and extends. down around the frame at least 2 inches;

c. should be hinged at one side;

d. shall have a locking device,

e. shall be a minimum of 20 inches in diameter or equivalent.

8.0.7 Vents - Finished water storage structures shall be vented by special vent structures. Open construction between the side wall and roof is not permissible. These vents:

a. shall prevent the entrance of surface water;

b. shall exclude birds and animals;

c. shall exclude insects and dust, as much as this function can be made compatible with effective venting; for elevated tanks and standpipes, 4-mesh non-corrodible screen may be used;

d. shall, on ground-level structures, terminate in an inverted U construction, the opening of which is 24 to 36 inches above the roof of sod and is covered with 24-mesh non-corrodible screen cloth.

8.0.8 Roof and Sidewall - The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded or properly gasketed in metal tanks, or should be connected to standard wall castings which were poured in place during the forming of a concrete structure; these wall castings should have flanges embedded in the concrete.

b. openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent the access of surface or slop water to the structure.

c. Valves and controls should be located outside the storage structure so that valve stems and similar projections will not pass through the roof or top of the reservoir.

8.0.9 Drainage for Roof or Cover - The roof or cover of the storage structure should be well drained, but downspout pipes shall not enter or pass through the reservoir; parapets, or similar construction which would tend to hold water and snow on the roof will not be approved.

8.0.10 Safety - The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations.

a. Ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

b. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser openings inside the tank.

8.0.11 Freezing - All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, shall be designed to prevent freezing which will interfere with proper functioning.

8.0.12 Grading - The area surrounding a ground-level structure should be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

8.0.13 Silt stop - The discharge pipe of the reservoir shall be located in a manner that will prevent the flow of sediment into the distribution systems. Either a permanent or removable silt stop shall be provided at least 4 inches above the bottom of the storage structure.

8.0.14 Painting and/or Cathodic Protection - Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems consistent with current American Water Works Association standards, or otherwise acceptable to the Department shall be used. All paints must be acceptable to FDA and EPA for contact with potable water.

b. Cathodic protection should be designed and installed by competent technical personnel.

8.0.15 Turnover of water - If the storage reservoir is sized larger than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water in the tank and/or booster chlorination. Internal piping arrangements to prevent water stratification in ground level standpipes are recommended. For large, ground level tanks/reservoirs, piping and/or check valves can be installed to force water in and out of the tank at different locations in order to minimize dead/stagnant water zones.

8.0.16 Sampling - A suitable sampling tap should be provided on all storage structures and be protected from public access.

8.0.17 Disinfection - Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put in service.

8.1 PLANT STORAGE - The applicable design standards of this part shall be followed for plant storage.

8.1.1 Washwater Tanks - If washwater tanks are used, they shall be sized, in conjunction with available pump units and finished water storage, to give the back wash water required by Section 4.2.1.K.

a. Consideration must be given to the possibility of having to wash more than one filter at a time, or several filters in succession.

8.1.2 Clearwell - Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use to meet peak demands, including filter backwash water. Design shall include features to minimize short circuiting.

a. When finished water storage is used to provide proper contact time for chlorine, (see Section 4.4.2), special attention must be given to size and baffling.

b. An overflow shall be provided and must be protected with a screen and flap valve.

8.1.3 Adjacent Compartments - finished water must not be stored or conveyed in a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

8.1.4 Basins and Wet-Wells - Receiving basins and pump wet-wells for finished water shall be designed as finished water storage structures.

8.2 PRESSURE TANKS - Hydropneumatic (pressure) tanks may be acceptable in some circumstances where the number being served is 50 connections or less. When used, they shall meet ASME code requirements or equal which comply with the requirements of state and local laws and regulations for the construction and installation of unfired pressure vessels.

8.2.1 Location - The tank should be located above normal ground surface and be completely housed, or earth-mounted with one end projecting into an operating house, to prevent freezing.

8.2.2 Bypass - tank should have bypass piping to permit operation of the system while the tank is being repaired or painted.

8.2.3 Appurtenances - Each tank should have an access manhole, a drain, a control equipment consisting of pressure gage, water sight glass, automatic or manual air blow-off, mechanical means for adding air, and pressure-operated start-stop controls for the pumps.

8.2.4 Sizing -

a. The capacity of each well and/or pump in a hydropneumatic system should be at least ten times the average daily consumption rate of the community or the maximum peak demand whichever is greater.

b. The gross volume of the hydropneumatic tank, in gallons, should be at least 20 times the capacity of the largest pump, rated in gallons per minute.

8.2.5 Auxiliary power - Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow.

8.3 DISTRIBUTION STORAGE - The applicable design standards of this part shall be followed for distribution storage.

8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage. In the absence of an acceptable engineering study of the amount of water the system needs to meet customer demand and to provide for fire emergencies, the projected 24-hour demand at the end of the planning period will be the minimum requirement for elevated storage. This requirement may be reduced when the source, treatment facilities and pumps have sufficient capacity with standby power capability to supplement peak demands of the system.

8.3.2 Pressure Variation - System pressure variation on account of changes in level of water in storage structures should be minimized. Elevated storage tanks or large diameter ground tanks located on high ground should be the usual choices. Standpipes will not normally be approved and must be completely justified if proposed.

8.3.3 Drainage - Storage structures which float on the distribution system should be designed to drain for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drains should discharge to the ground surface with no direct connection to a sewer or storm drain. (See Section 8.0.4). A nearby fire hydrant may be considered as a drain as long as service is not interrupted and suitable erosion protection is provided.

8.3.4 Level Controls - Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Telemeter equipment should be used when pressure-type controls are employed and any appreciable head loss occurs in the distribution system between the source and the storage structure.

b. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system.

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance on a 24-hour basis.

Part 9 - DISTRIBUTION SYSTEMS

9.0 SYSTEM DESIGN

9.0.1 Minimum Pipe Size

a. The minimum size of pipe for principal water mains and for water mains where fire hydrants are to be attached shall be 6-inch diameter.

b. Size of water mains shall be justified by hydraulic analysis. 2-inch water mains will only be considered for short cul-de-sacs and permanent dead-ends where future growth is not feasible. The length of 2-inch mains shall be restricted to 3000 feet in any one direction.

c. All water mains including those not designed to provide fire protection shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in distribution system under all conditions of flow.

d. Wide variations in pressure above the minimum requirement of 20 psi may be inherent in the design of a distribution system but pressures no greater than 100 psi should be delivered to the customer (unless higher pressures are requested.). Main line pressure reducing valves can be used to reduce pressures below 100 psi where feasible. Where water pressures over 100 psi are necessary to the operation of the distribution system, customers must have individual pressure reducing valves.

e. All assumptions and any flow data used must be clearly documented and submitted with the hydraulic analysis. if actual flow data is not available theoretical calculations shall be based on all storage facilities half-full and the Hazen-Williams friction factor appropriate for type of pipe being used but in no case greater than 130.

f. Water distribution lines should be designed and sized for an instantaneous peak demand of 2 gpm per connection for water lines serving up to 100 residential connections. Peak design demands can be reduced to 1.5 gpm per connection for 150 residential connections, 1.0 gpm per connection for 300 residential connections, 0.75 gpm per connection for 500 residential connections, and 0.5 gpm per connection for 1000 or more residential connections.

9.0.2 Fire Protection

a. The minimum pipe size to which a fire hydrant may be connected is 6-inch.

b. Ordinarily fire hydrants shall not be connected to water mains which are not capable of providing a flow of 500 gpm at 20 psi. When a municipality or county enacts a restrictive use ordinance prohibiting pumper trucks from connecting to restricted fire hydrants which are painted a distinctive color and when a copy of this ordinance in on file at this office, we will permit fire hydrants to be connected to 6-inch mains which do not have the required pressure and flow.

c. When fire protection is to be provided, system design should consider the recommendations of the state Insurance Services Organization.

d. Fire hydrants shall meet current AWWA Standard C502.

9.0.3 Dead Ends

a. Dead ends shall be minimized.

b. Where dead-end mains occur they should be provided with a fire hydrant, when fire flows are available, or blow-off for flushing purposes. The blow-off shall be at least 2 inches in diameter, but should provide flushing velocities of 2 feet per second or greater.

c. No flushing device shall be directly connected to any sewer nor be subject to flooding or plugging.

9.1 INSTALLATION OF MAINS

9.1.1 Adequate support shall be provided for all pipes.

9.1.2 A continuous and uniform bedding shall be provided in the trench for all buried pipe.

9.1.3 Rock Excavation - Stones found in the trench shall be removed for a depth of at least six inches below the bottom of the pipe.

9.1.4 Cover - All distribution mains shall be provided with sufficient earth or other suitable cover to prevent freezing. This shall not be less than 30 inches measured above the top of the pipe.

9.1.5 Hydrostatic Tests

a. Pressure and leakage tests shall be performed in accordance with current AWWA Standard C600 and/or manufacturer's installation procedures.

b. The test pressure of the installed pipe shall be a minimum of 150 psi or 1.5 times the working pressure, whichever is greater.

c. Allowable leakage shall be no greater than as calculated in L = SD /P/133,200 where L is allowable leakage in gallons/hour, S is the length of pipe tested in feet, D is pipe diameter in inches and P is test pressure in psi.

9.1.6 Disinfection of New Water Mains - The specifications shall include detailed procedures for the adequate flushing, disinfection, and (Total Coliform) bacteriological testing of all new water mains. Disinfection as described in current AWWA Standard C651 will be accepted.

9.1.7 Disinfection When Cutting into or Repairing Existing Mains:

a. Shall be performed when mains are wholly or partially dewatered;

b. Shall follow current AWWA C651 procedures including trench treatment, swabbing with hypochlorite solution, flushing and/or slug chlorination as appropriate;

c. Bacteriological testing should be done after repairs are complete but the water main may be returned to service prior to completion of testing to minimize the time customers are out of water;

d. Leaks or breaks that are repaired with clamping devices while mains remain full of water under pressure require no disinfection.

9.1.8 When non-metallic pipe is installed, detection tape or other acceptable means of detection shall be installed.

9.2 SEPARATION OF WATER MAINS AND SEWERS

9.2.1 General - The following factors should be considered in providing adequate separation:

a. materials and type of joints for water and sewer pipes;

b. soil conditions;

c. service and branch connections into the water main and sewer line;

d. compensating variations in the horizontal and vertical separations;

e. space for repair and alterations of water and sewer pipes;

f. off-setting of pipes around manholes;

g. water mains and sanitary or storm sewers shall not be laid in the same trench.

9.2.2 Parallel Installation

a. Normal conditions - Water mains shall be laid at least 10 feet horizontally from any sanitary sewer, storm sewer or sewer manhole, whenever possible; the distance shall be measured edge-to-edge.

b. Unusual conditions - When local conditions prevent a horizontal separation of 10 feet, a water main may be laid closer to a storm or sanitary sewer provided that:

1. the bottom of the water main is at least 18 inches above the top of the sewer;

2. where this vertical separation cannot be obtained, the sewer shall be constructed of materials and with joints that are equivalent to water main standards of construction and shall be pressure tested to assure water-tightness prior to backfilling.

9.2.3 Crossings

a. Normal conditions - Water mains crossing house sewers, storm sewers or sanitary sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water main and the top of the sewer, whenever possible.

b. Unusual conditions - when local conditions prevent a vertical separation as described in Section 9.2.3a, the following construction shall be used:

1. Sewers passing over or under water mains should be constructed of the materials described in Section 9.2.2b2.

2. Water mains passing under sewers shall, in addition, be protected by providing:

i. a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water main;

ii. adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking the water mains;

iii. that the length of water pipe be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.

iv. both the sewer and the water main shall be constructed of water pipe and tested in accordance with Section 9.1.5.

9.2.4 Sewer manholes - No water pipe shall pass through or come into contact with any part of a sewer or sewer manhole.

9.3 SURFACE WATER CROSSINGS - Surface water crossings, both over and under water, present special problems which should be discussed with the Department before final plans are prepared.

9.3.1 Above-water crossings - The pipe shall be:

a. adequately supported;

b. protected from damage and freezing;

c. accessible for repair or replacement.

9.3.2 When crossing water courses which are greater than 15 feet in width:

a. The pipe shall be of special construction, having flexible, watertight joints;

b. Valves shall be provided at both ends of water crossing so that the section can be isolated for test or repair; the valves shall be easily accessible and not subject to flooding;

c. Sampling taps should be available at each end of the crossing;

d. Permanent taps should be made for testing and locating leaks.

9.4 CROSS CONNECTIONS

a. There shall be no physical connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water and other contaminating materials may be discharged or drawn into the system.

b. The approval of the Department shall be obtained for interconnections between potable water supplies.

c. Neither steam condensate nor cooling water from engine jackets or other heat exchange devices shall be returned to the potable water supply.

9.5 WATER SERVICES AND PLUMBING - Water services and plumbing shall conform to relevant local and/or state plumbing codes, or to the Standard Plumbing Code.

9.6 MATERIALS - GENERAL

a. Pipe selected shall have been manufactured in conformity with the latest standards issued by the American Water Works Association, if such standards exist, and be acceptable to the Department.

b. in the absence of such standards, pipe meeting applicable ASTM and ANSI criteria and acceptable to the Department may be selected.

c. Used water mains that meet these standards may be used again, after the pipe has been thoroughly cleaned and restored practically to its original condition.

d. Packing and jointing materials used in the joints of pipe shall meet the standards of the American Water Works Association or the Department.

e. Mechanical joints or slip-on joints with rubber gaskets are preferred.

9.7 PIPE

9.7.1 Ductile iron and cast iron pipe shall meet the latest requirements of ANSI/AWWA - C106 or CIO8 for cast iron pipe and C151 for ductile iron pipe.

9.7.2 Concrete pressure pipe shall meet the latest requirements of AWWA C300 or AWWA C301.

9.7.3 PVC pipe - 2 inch through 12 inch

a. PVC pipe meeting the standards set forth in AWWA C-900 (latest edition) will be accepted for those working pressures as designated by class. (Note that C-900 refers only to 4-inch through 12-inch pipe).

b. SDR 21, Class 200 pressure rated pipe may be used where the working pressure does not exceed 135 psi. The pipe must meet all the requirements set forth in ASTM Standard D 2241 for 2-inch through 12-inch pipe designated SDR 21. The pipe must bear the National Sanitation Foundation Testing Laboratories, Inc. seal of approval for potable water, or an approved equal.

c. Provision must be made for contraction and expansion at each joint with flexible ring gaskets made from rubber or other suitable material. Gasket materials shall meet the requirements established in ASTM F477.

d. Joints for PR 200 (pressure rated) pipe (ASTM D2241) shall be manufactured in accordance with ASTM D3139. Section 5.3.1 of this standard refers to 2000-hour tests. If pipe is manufactured in accordance with that section, the testing must be done by an independent laboratory with the results being furnished to this Department. Note also that a separate test is required for each different type of gasket provided.

e. All fittings such as tees, ells, etc. using welded joints shall be factory welded and shall meet the same specifications as the welded bell section.

f. Lubricants shall be non-toxic and shall not promote biological growth.

g. Solvent cemented joints in the field are not permitted.

h. Forty-foot lengths will be permitted when the engineering specifications contain special conditions for handling such pipe lengths. These conditions shall include provisions for transporting pipe from storage areas to the installation area on specially designed racks to prevent the ends of the pipe from dragging.

i. This policy does not apply to plastic service lines.

9.7.4 Fiberglass Composite Pipe shall be composed of an inner core of PVC overwrapped with fiberglass bonded with epoxy. 350 Pressure Rated shall be in accordance with ASTM D-2992 and D-2996.

9.7.5 Polyethylene pipe for water distribution lines shall meet the requirements of AWWA C906.

9.7.6 Molecular oriented PVC pipe shall meet the requirements of AWWA C909.

9.7.7 Any pipe material which is not specifically covered in this section will be considered on an individual basis.

9.8 VALVE, AIR RELIEF, METER AND BLOW-OFF CHAMBERS

a. Sediment accumulations may be removed through a standard fire hydrant, and compressed air and pumping may be used for dewatering mains through hydrants.

b. At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

c. Chambers of pits containing valves, blow-offs, meters or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer, nor shall blowoffs or air-relief valves be connected directly to any sewer.

d. Such chambers or pits shall be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground.

e. Valves are to be placed at all intersections of water mains but at no time greater than 4000 feet apart.

f. Gate valves shall meet current AWWA standards

(Rule 1200-5-1-.16, continued)

(2) All other siting requirements shall be in accordance with those set forth in "Design Criteria for Public Water Systems" as published by the Department.

Authority: *T.C.A. §§4-5-201 et seq. and 68-221-701 et seq.* ***Administrative History:*** *Original rule filed June 30, 1977; effective August 1, 1977. Amendment filed April 12, 1996; effective June 26, 1996.*

1200-5-1-.17 OPERATION AND MAINTENANCE REQUIREMENTS.

(1) All community water systems which are designated as a surface supply and classified as a filtration system and all iron removal plants which use gravity filters must have an operator in attendance and responsible for the treatment process when the plant is in operation. Gravity iron removal plants which have installed continuous monitoring equipment including equipment for turbidity and chlorine residual with alarms and/or shutdown ability may seek approval from the Department to operate the treatment plant in an automated mode without an operator in attendance. All iron removal plants with pressure filters and using a ground water source from an approved sand and gravel formation will not be required to have an operator in attendance during all periods of operation provided suitable protection, acceptable to the Department, is provided.

Non–community water systems which are classified as a surface supply will be required to have a full time operator in attendance unless certain continuous monitoring equipment is installed.

Pursuant to Tennessee Code Annotated 68–221–904, all operators in direct responsible charge of a water supply system, including the treatment plant and/or distribution system, must be certified by the Department as competent to operate same.

Because the proper operation and maintenance of water systems is critical to a system's ability to provide safe water to the public and to comply with these rules, all water supply systems must comply with the provisions of Rule 1200-5-3. A violation of those rules is a violation of this rule as well.

(2) All community water systems and those non-community water systems classified as a surface source shall compile and maintain accurate daily operating records of the water works system on forms prepared and furnished by the Department. The daily operating records shall be submitted in a timely manner so they are received by the Department no later than ten days after the end of the reporting month. Any special reports, deemed necessary by the Department to assure continuous satisfactory operation of the water system, shall be submitted to the Department.

Water systems which desire to use their own forms to report the daily operating results to the Department must have prior approval of the form from the Department.

(3) All water quality tests, other than those listed in Regulation 1200-5-1-.06 shall be made in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" or alternate methods acceptable to the Department. The schedule of laboratory tests followed in controlling the operation of a waterworks system will vary with the character of the water; therefore, all waterworks systems must have the equipment necessary to perform all laboratory tests pertinent to the control of the plant or system operation, and the equipment shall be maintained in good working order at all times. Laboratory tests pertinent to proper operation shall be prescribed by the Department for each community water system.

(4) Chlorine is the recommended disinfection agent. Other agents will be considered by the Department provided they are effective and testing procedures for their effectiveness are recognized in the latest edition of "Standard Methods for the Examination of Water and Wastewater". All community water systems, using ground water as a raw water source and

(Rule 1200-5-1-.17, continued)

serving more than 50 connections or 150 persons shall continuously chlorinate (unless other disinfection methods are approved) and shall maintain a free chlorine residual in all parts of the distribution system in the amount of not less than 0.2 mg/l. Public Water Systems using surface water shall continuously chlorinate and maintain a free chlorine residual of 0.2 mg/l in all parts of the distribution system. The residual disinfectant concentration specified by this rule shall not be less than 0.2 mg/l in more than 5 percent of the samples each month, for any two consecutive months the system serves water to the public. All public water systems serving 50 or fewer connections that do not disinfect shall install continuous disinfection if the system fails to comply with the maximum contaminant level for coliform, experiences a disease outbreak or is directed to install disinfection by the department. All public water systems serving 50 or fewer connections that do not disinfect shall install continuous disinfection if the system fails to comply with the maximum contaminant level for coliform, experiences a disease outbreak or is directed to install disinfection by the department.

(5) All systems submitting samples for microbiological examination to the State laboratory must submit said sample in the bottle(s) provided by the State and return the samples to the proper State laboratory in the shipping carton provided by the State. The cost of postage for shipping the sample to the proper State laboratory shall be paid by the supplier of water. All samples submitted for microbiological examination must be collected and mailed to arrive at the proper State laboratory not later than Thursday noon of any week. Thirty hours is the limit allowed from the time of collection to the time of examination at the proper State laboratory.

(6) Pursuant to Section 68–221–711(6) the installation, allowing the installation, or maintenance of any cross–connection, auxiliary intake, or bypass is prohibited unless the source and quality of water from the auxiliary supply, the method of connection, and the use and operation of such cross–connection, auxiliary intake, or bypass has been approved by the Department. The arrangement of sewer, soil, or other drain lines or conduits carrying sewage or other wastes in such a manner that the sewage or waste may find its way into any part of the public water system is prohibited.

All community water systems must adopt an ordinance or policy prohibiting all of the above and submit a copy of the executed ordinance or policy to the Department for approval. All community water systems shall develop a written plan for a cross–connection control program to detect and eliminate or protect the system from cross–connections. The written plan must be approved by the Department.

After adoption and approval of the cross–connection ordinance or policy and plan, each community water system must establish an ongoing program for the detection and elimination of hazards associated with cross–connections. Records of the cross–connection control program must be maintained by the water supplier and shall include such items as date of inspection, person contacted, recommendations, follow–up, and testing results.

(a) Public water systems must develop and implement an ongoing cross-connection program. Cross-connection plans and policies shall present all information in conformance with the “Design Criteria for Community Public Water Systems” as published by the Department.

(b) The public water system shall ensure that cross-connections between the distribution system and a consumer’s plumbing are surveyed and/or inspected and determined not to exist or contain a significant risk or are eliminated or controlled by the installation of an approved backflow preventer commensurate with the degree of hazard.

(7) Within one year after the effective date of these regulations all community water system shall prepare an emergency operations plan in order to safeguard the water supply and to alert the public of unsafe drinking water in the event of natural or man-made disasters. Emergency

(Rule 1200-5-1-.17, continued)

operation plans shall be consistent with guidelines established by the State and shall be reviewed and approved by the Department.

(8) (a) General-Public water systems, construction contractors and engineers shall follow and document sanitary practices used in inspecting, constructing or repairing water lines, finished water storage facilities, filters and wells. In lieu of writing their own disinfection standard operating procedures, public water systems, engineers and contractors may chose to follow the latest edition of the AWWA standards C-651, C-652 or equivalent methods provided the method has been approved in writing by the department and is available during the inspection, construction, maintenance or repair activity. The documentation shall include bacteriological sample results, construction logs, standard operating procedures and may include photographs where appropriate. All pipes, tanks, filters, filter media and other materials shall be properly disinfected prior to being placed in service. Any disinfectant used to disinfect shall be NSF approved or plain household bleach and used in a manner that assures sufficient contact time and concentration to inactivate any pathogens present. Bacteriological results including line repair records indicating adequacy of disinfection shall be maintained on file by the water system for five years. All public water systems, contractors, and engineers shall prepare and follow standard disinfection procedures approved by the state when inspecting, maintaining, repairing or constructing lines, tanks, filters and wells. Procedures to ensure that water containing excessive concentrations of disinfectant is not supplied to the customers or discharged in such manner as to harm the environment shall be implemented.

All materials used for new or repaired water lines, storage facilities, filters, filter media, and wells will be inspected prior to use for any evidence of gross contamination. Any contamination observed shall be removed and the materials protected during installation.

(b) Disinfection of New Facilities-Bacteriological samples will be collected and analyzed to verify the effectiveness of the disinfection practices prior to placing new facilities in service. Bacteriological samples shall be collected to determine the effectiveness of the installation process including protecting the pipe material during storage, installation, and disinfection. This can be demonstrated by collecting two sets of microbiological samples 24 hours apart or collecting a single set of microbiological samples 48 hours or longer after flushing the highly chlorinated water from the lines. In either case microbiological samples in each set will be collected at approximately 2,500-foot intervals with samples near the beginning point and at the end point unless alternate sampling frequency and distance between sampling points approval has been obtained from the state. Where sanitary conditions were not maintained before, during or after construction, an additional bacteriological sample shall be collected from a location representing the water from the contaminated area. Unsanitary conditions include failure to document the sanitary handling of materials, to conduct construction inspections and to maintain records, and to document sanitary practices during construction and other hazards such trench flooding during construction. If the constructed facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

(c) Disinfection of Existing Facilities-Drinking water mains, storage facilities and filters that have been partially dewatered during inspection or repair shall, after the repair or inspection is completed, be disinfected, and flushed prior to placing it back in service. Bacteriological samples shall be collected immediately or as soon as possible after the repair is completed and from a location representing the water contained in the repaired line, tank or filter. The repaired facility may be returned to service prior to obtaining bacteriological results. If the repaired facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

(Rule 1200-5-1-.17, continued)

1. If one-half or more of either the original or repeat bacteriological samples collected from the repaired or renovated facility are total coliform positive, the system shall notify the state within 30 days that it has reviewed its disinfection and sampling practices in an attempt to identify why the positive samples occurred and revise its disinfection and sampling plans accordingly.

2. If any public water system collects a fecal coliform positive repeat sample or e-coli positive repeat sample or a total coliform positive repeat sample following an initial positive fecal coliform or e-coli sample collected from the repaired or renovated facility, the system shall notify the state within 24-hours and issue a tier 1 public notice using the language specified in Appendix B of Rule 1200-5-1-.19.

(d) Inspectors, contractors, operators, public water systems or engineers that fail to document and follow adequate disinfection procedures, and fail to collect bacteriological samples during repairs, inspections or maintenance activities that potentially would compromise the microbial quality of the water shall issue a boil water advisory to the customers served by that portion of the public water system prior to returning the facility to service. The boil water advisory shall remain in effect until satisfactory microbial tests results are obtained.

(9) All community water systems shall be operated and maintained to provide minimum positive pressure of twenty (20) psi throughout the distribution system. No person shall install or maintain a water service connection to any premises where a booster pump has been installed unless such booster pump is equipped with a low pressure cut-off mechanism designed to cut off the booster pump when the pressure on the suction side of the pump drops to twenty (20) psi gauge.

(10) All community water systems having more than 50 service connections shall establish and maintain an adequate flushing program. The flushing program established shall help ensure that dead end and low usage mains are flushed periodically, drinking water standards are met, sediment and air removal and the free chlorine residual specified under Rule 1200-5-1.17(4) is maintained. Records of each flushing are to be maintained by the water system. These records shall include date, time, location, persons responsible and length of flushing. In addition to the above information, the free chlorine residual will have to be measured and recorded on the end of dead end mains after being flushed.

(11) All community public water systems serving more than 50 connections and which have their own source of water shall be required to install, operate and maintain duplicate disinfection equipment. Duplicate disinfection equipment means at least two chlorine cylinders connected to at least two chlorinators. Each set of chlorine cylinders consists of one or more cylinders which may be connected together by an automatic switchover valve. The two sets of chlorine cylinders may tee in to a common feed line leading to the chlorinators, but may not be connected together by an automatic switchover valve. The two sets of chlorine cylinders must be weighed independently and operated simultaneously. At least two chlorinators must be operated at all times with each feeding a part of the required dosage. The chlorinators may discharge to a common manifold piping network to allow multiple injection points. Facilities may be exempt from simultaneously operating duplicate disinfection equipment if the facility has a reliable chlorine residual analyzer with an alarm notifying a manned control center capable of immediately shutting down the treatment facility. Facilities, which are staffed during the time water is treated, can use one set of chlorine cylinders with the automatic switchover device provided the free chlorine residual is checked at the facility every two hours. A reliable free chlorine residual analyzer with an alarm system to a manned control center may be used for unmanned facilities that desire to use one set of chlorine cylinders with the automatic switchover device.

(Rule 1200-5-1-.17, continued)

All public water systems which use a hypochlorinator shall be required to have two solution pumps, two tanks for bleach solution and operate both units at the same time.

(12) All public water systems which utilize a filtration system shall use the following bed specifications and not exceed the following rates of filtration.

(a) Rapid Sand Filtration - 2.0 gallons per minute per square foot for turbidity removal, 3.0 gallons per minute per square foot for iron removal.

There must be 30 inches of sand media with an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70

(b) High Rate Filtration - 4.0 gallons per minute per square foot for turbidity removal, 4.0 gallons per minute per square foot for iron removal.

There must be 30 inches of dual media with 10 to 12 inches of sand and 18 to 20 inches of anthracite. The sand shall have an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70. The anthracite shall have an effective size of 0.8 mm to 1.2 mm with a uniformity coefficient not greater than 1.85.

(c) Existing water systems with rapid sand filters and approved for higher rates of filtration by the Department will be allowed to continue at that rate provided the drinking water standards are met. The water supplier must be able to document that the Department approved the system for the higher rate.

(d) All mixed media filter beds will be at least 30 inches in depth and approved by the Department.

(e) Filtration rates above 4.0 gallons per minute per square foot will be considered on an individual basis. The Department will take into account the raw water characteristics, the treatment units, operational history, and operating personnel.

(13) All community water systems serving 50 connections or more shall install duplicate pumps for the raw water, finished water, and distribution pumping stations. A water system will not be required to have duplicate pumps in a distribution pumping station under the following conditions: limited number of service connections, availability of replacement pumps, maintaining adequate flows and pressures without the pumping station, and for emergency use only. All community public water systems using ground water supplies and having more than 50 service connections must have duplicate wells and/or duplicate pumps in a spring supply unless fed by gravity flow.

(14) All community water systems serving 50 connections or more are required to have 24 hours of distribution storage based on the average daily demand for the past twelve months. Distribution storage must be located so that the instantaneous demand can be met in all areas at any time.

(a) Systems which purchase water for resale may utilize the storage of the supplier provided the supplier has adequate distribution storage. Water systems that have large ground storage tanks will be given credit for distribution storage provided auxiliary power is available to pump water to the distribution system.

(b) Systems which have more than three (3) treatment facilities, have more than one source of water, and which have special power arrangements so that it is unlikely that all units would be down at the same time are not required to have distribution storage provided the peak demand can be met.

(Rule 1200-5-1-.17, continued)

(c) Water systems which have an average daily demand of 10 million gallons or more are not required to have 24 hours of distribution storage provided the system has adopted a contingency plan for emergencies that has been approved by the Department. The contingency plan must demonstrate the water system is able to provide residential service to all customers for a 24 hour period during any emergency involving the shut down of the treatment facility.

(d) Public water systems which utilize wells and provide only disinfection, pH adjustment, corrosion inhibitor and/or fluoridation as treatment, may use the capacity of the wells and the plant as part of the distribution storage under the following conditions:

1. The existing distribution storage tank(s) are adequate to meet the peak demands on the system,

2. The well(s), disinfection equipment and other pumping facilities needed to supply water to the distribution storage tank are equipped with an auxiliary power source with automatic controls, and

3. The well field capacity is determined by removing the largest well from consideration.

(e) Public water systems may take into account private distribution storage facilities in the following manner:

1. Private distribution storage may be counted as water system storage provided the private storage tank floats on the water utility's system and the water used serves both the private and utility system demand.

2. The water utility may reduce the amount of needed distribution storage by subtracting the average daily volume of any water user that has its own storage tank. This can be done provided the private storage tank is used on a daily basis.

3. Private distribution storage tanks used strictly for fire protection by the private owner cannot be in the water systems distribution storage capacity.

(15) All community water systems serving 50 or more service connections must have and maintain up-to-date maps of the distribution system. These maps must show the locations of the water mains, sizes of mains, valves, blow-offs or flush hydrants, air-release valves, and fire hydrants. One up-to-date copy of the overall system distribution map(s) is to be submitted to the Division of Water Supply every five years.

(16) All vents on wells, springs, storage tanks, overflows and clearwells shall be properly screened. All overflows on springs and tanks shall be screened and protected.

(17) All buildings and equipment used in and for the production and distribution of water (to include chemical and other storage buildings) must be well maintained and be reliable and fit for the purpose for which they are used. This includes, but is not limited to:

(a) When a water treatment plant is not producing water and an operator is not in attendance, plant entrances must be locked.

(b) Equipment such as chemical feeders, pumps, turbidimeters, pumpage meters, alarm systems, and air tanks shall be maintained and in good working condition. Pumps, tanks, hoses, and other equipment used by system personnel shall be disinfected and dedicated to its use if it comes into contact with water that may be consumed by humans.

(Rule 1200-5-1-.17, continued)

(c) Duplicate or backup equipment shall be available as necessary to maintain the production of water meeting drinking water standards. Backup equipment or alternate treatment means shall be available for feeding all chemicals critical for adequate water treatment.

(18) All community water systems planning to or having installed hydrants must protect the distribution system from contamination. All water mains designed for fire protection must be six inches or larger and be able to provide 500 gallons per minute with 20 pounds per square inch residual pressure. Fire hydrants shall not be installed on water mains less than six inches in diameter or on water mains that cannot produce 500 gpm at 20 psi residual pressure unless -the tops are painted red. Out of service hydrants shall have tops painted black or covered with a black shroud or tape..

Existing Class C hydrants (hydrants unable to deliver a flow of 500 gallons per minute at a residual pressure of 20 pounds per square inch (psi) shall have their tops painted red by January 1, 2008.

The water system must provide notification by certified mail at least once every five years beginning January 1, 2008, to each fire department that may have reason to utilize the hydrants, that fire hydrants with tops painted red (Class C hydrants) cannot be connected directly to a pumper fire truck. Fire Departments may be allowed to fill the booster tanks on any fire apparatus from an available hydrant by using the water system's available pressure only (fire pumps shall not be engaged during refill operations from a Class C hydrant).

(19) Before any new or modified community water treatment facility can be placed in service, it must be inspected and approved in writing by the Department.

(20) Public water systems which adjust the fluoride content of the water supply shall maintain the concentration of fluoride in the finished water between 0.9 mg/l and 1.3 mg/l based on the monthly average. Each water system adjusting the fluoride content to the finished water must monitor for fluoride as required by the system's individual monitoring program established by the Department.

(21) New or modified turbidity removal facilities may not be placed into operation until the facility and the operator have been approved by the Department for the turbidity analysis.

(22) All pipe, solder, or flux which is used in the installation or repair of any public water system shall be lead free. This shall not apply to lead joints necessary for the repair of cast iron pipes. The term "lead free" in this section is defined as follows:

(a) When used with respect to solders and flux shall mean solders and flux containing not more than two-tenths of one percent (0.2%) lead and

(b) When used with respect to pipes and pipe fittings shall mean pipes and pipe fittings containing not more than eight percent (8.0%) lead.

(23) All dead end water mains and all low points in water mains shall be equipped with a blow-off or other suitable flushing mechanism capable of producing velocities adequate to flush the main.

(24) All community water systems must establish and maintain a file for customer complaints. This file shall contain the name of the person with the complaint, date, nature of complaint, date of investigation and results or actions taken to correct any problems.

(Rule 1200-5-1-.17, continued)

(25) The Department may, upon written notice, require confirmation of any sampling results and also may require sampling and analysis for any contaminant when deemed necessary by the Department to protect the public health or welfare.

(26) Those public water systems required to monitor for turbidity and chlorine residual must have the laboratory approved by the Department before the results of these analyses can be accepted for compliance purposes.

(27) By December 30, 1991, or 18 months after the determination that a ground water system is influenced by surface water, all public water systems classified as a ground water system impacted by surface water shall utilize treatment techniques which achieve:

(a) At least 99.9 percent (3 log) removal and/or inactivation of Giardia lamblia cysts between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(b) At least 99.99 percent (4 log) removal and/or inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(28) All public water systems using surface water shall provide disinfection to control the biological quality of the water. Due consideration shall be given to the contact time of the disinfectant in the water with relation to pH, ammonia, taste producing substances, temperature, presence and type of pathogens, and trihalomethane formation potential. All disinfection basins must be designed to prevent water short-circuiting the system. The disinfectant will be applied in the manner needed to provide adequate contact time.

(29) All community water systems using ground water as the raw water source serving water to more than 50 connections or 150 people will apply the disinfectant in the manner needed for adequate contact time. Contact time for ground water systems shall not be less than 15 minutes prior to the first customer.

(30) Any surface supplied public water system or ground water systems under the direct influence of surface water required to filter shall employ filtration in combination with disinfection that will achieve 99.9% (3 log) and 99.99% (4 log) inactivation of Giardia lamblia and viruses respectively between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer. For the purposes of determining removal or inactivation efficiencies for Giardia lamblia and viruses Table 1200-5-1-.17(30)1 and 1200-5-1-.17(30)2 shall apply. The free residual disinfectant concentration in the water entering the distribution system cannot be less than 0.2 mg/l for more than four hours.

TABLE 1200-5-1-.17(30)1

ASSUMED LOG REMOVALS BY FILTRATION METHOD AND REQUIRED LEVELS OF DISINFECTION

Treatment	Assumed Log Removal		Required minimum level of disinfection	
	Giardia	Viruses	Giardia	Viruses
Conventional filtration	2.5	2.0	0.5	2.0
Direct filtration	2.0	1.0	1.0	3.0
Slow Sand filtration	2.0	2.0	1.0	2.0
Diatomaceous Earth				

(Rule 1200-5-1-.17, continued)

filtration	2.0	1.0	1.0	3.0

TABLE 1200-5-1-.17(30)2

CT VALUES FOR ACHIEVING 1-LOG INACTIVATION OF GIARDIA CYSTS[1]

	pH	Temperature			
		0.5°C	5°C	10°C	15°C
Free Chlorine [2,3]	6	55	39	29	19
	7	79	55	41	26
	8	115	81	61	41
	9	167	118	88	59
Ozone		0.97	0.63	0.48	0.32
Chlorine dioxide		1270	735	615	500

1 Values to achieve 0.5 log inactivation are one half those shown in the table.

2 CT values are for 2.0 mg/l free chlorine.

3 CT values for other concentrations of free chlorine may be taken from Appendix E of the guidance manual for Compliance with the "Filtration and Disinfection Requirements For Public Water Systems Using Surface Water Sources," October, 1989, Edition, Science and Technology Branch Criteria and Standards Division, Office of Drinking Water, USEPA, Washington, D.C.

(31) Each public water system must certify annually in writing to the State that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified as follows:

Acrylamide = 0.05% dosed at 1 ppm (or equivalent)
Epichlorohydrin = 0.01% dosed at 20 ppm (or equivalent)

Public water systems can rely on manufacturer's or third parties certification for complying with this requirement.

(32) New service taps on existing mains that must be uncovered to make the tap, shall be flushed and the free chlorine residual measured and recorded prior to connecting the service lines. These records shall be retained until the next sanitary survey or for three years.

(33) All public water systems shall properly maintain their distribution system finished water storage tanks. Each community water system shall establish and maintain a maintenance file on each of its finished water and distribution storage tanks. These maintenance files must be available for inspection by Department personnel. These files must include the dates and results of all routine water storage tank inspections by system personnel, any reports of detailed professional inspections of the water storage tanks by contractor personnel, dates and details of routine tank cleanings and surface flushings, and dates and details of all tank maintenance activities. The tank inspection records shall include dates of the inspections; the sanitary, coating and structural conditions of the tank; and all recommendations for needed maintenance activities. Community Water Systems shall have a professional inspection performed and a written report produced on each of their finished water and distribution storage tanks at least once every five years. Non-community water systems shall have a professional inspection and written report performed on each of their

(Rule 1200-5-1-.17, continued)

atmospheric pressure finished water and distribution storage tanks no less frequently than every five years. Records of these inspections shall be available to the Department personnel for inspection. Persons conducting underwater inspections of finished water storage tanks shall comply with AWWA standard C652-92 or later versions of the standard.

(34) Paints and coatings for the interior of potable water storage facilities must be acceptable to the Department. Paints and coatings accepted by the Environmental Protection Agency (EPA) and/or the National Sanitation Foundation (NSF) for potable water contact are generally acceptable to the Department. Paint systems for steel tanks shall be consistent with AWWA Standard D102-78. Factory coated bolted steel tanks shall be in accordance with AWWA D103-87. Wire-wound circular prestressed concrete tanks shall be in accordance with AWWA D110-86.

(35) By January 1, 1996, public water systems using surface water and ground water systems under the direct influence of surface water that filter shall have rewash capability. Such systems shall perform a rewash cycle, or filter to waste each time a filter is backwashed. The rewash cycle shall be conducted in a way and manner necessary to prevent the introduction of contaminants such as pathogens and turbidity trapped in the filter into the clear well or distribution system.

Existing filter plants may be approved to operate without rewash (filter-to-waste provisions) if existing operational and backwash practices prevent water of unacceptable quality from entering the clearwell or distribution system. To operate without rewash the water system must demonstrate to the Department that filtered water turbidity after backwashing is reliably and consistently below 0.5 NTU immediately after backwashing each filter. Approval to operate without rewash must be approved in writing and approval must be renewed if any modifications are made to the operation or design of the plant. Each filter that operates without rewash must have a continuous recording turbidimeter and retain the records for a period of five years.

(36) By January 1, 1995, all chemicals, additives, coatings or other materials used in the treatment, conditioning and conveyance of drinking water must have been approved by the National Sanitation Foundation (NSF) or American National Standards Institute (ANSI) certified parties as meeting NSF product standard 60 and 61. Until 1995, products used for treatment, conditioning and conveyance of drinking water shall have been listed as approved by the US EPA or NSF.

(37) Any new Community Water System or Non-Transient Non-Community Water System commencing operation after September 30, 1999 shall have a “Capacity Development Plan” and be a “viable water system.”

(38) Public Water Systems identified as not complying or potentially not complying with the requirements of the Safe Drinking Water Act and in accordance with the priorities established in the State’s Capacity Development Strategy shall prepare a “Capacity Development Plan” and demonstrate viability.

(39) Public water systems are not permitted to construct uncovered finished water reservoirs after the effective date of this subparagraph.

(40) Benchtop and continuous turbidimeters used to determine compliance with limits set forth in this rule chapter must be calibrated at least every three months with primary standards and documented. Documentation shall be maintained for a period not less than five years. Primary standards are Formazin, AMCO clear, Stablcal, or alternatives approved in writing by the Division. Dilute Formazin solutions are unstable and must be prepared on the day of calibration. Manufacturers’ recommendations on calibration procedure must be followed.