Water Distribution Level 2 & 3 Certification Course

Presented by
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How to Improve Your Score on the Operator Certification Exam

Test Preparation Strategies for Success on the WTP Exam

1st – Prepare for the Test You are Taking

You won't panic...
if you have a plan and are prepared

- **Target those areas of study on your test**
- **Set priorities**
  - **What are the subjects where I am weak?**
  - **Study most important subjects first !**
  - **Know the Math presented by FRWA !!**
- **Improve Study Habits!**
  - **Set up a Schedule that aligns with your test date**
  - **Use the Taylor Tutorial !!!**
  - **Stick to a Study Schedule !**

2nd – Set a Reasonable Study Schedule

- **Set a Test Date close to the FRWA training**
- Then set a Schedule that is realistic for ***YOU!***
- Study early that aligns with your test date
- Study in short spread-out sessions according to a plan that includes FRWA handouts
- Begin each session with quick review of previous material
  - Use the Study materials provided by FRWA !
  - Something in this Course will help you answer every question !

3rd – Build your Memory

- Long-term memory is a powerful tool
- It is Formed by the process of creating connections, reinforcing the same connections and expanding strength by forming meaningful associations or secondary connections
- In other words,
  - ✓ if a pathways are **FORMED**,
  - ✓ and you **USE them**, and
  - ✓ you **REPEAT them**,
  - ✓ You'll **REMEMBER the information** !

Prepare Physically & Mentally for Exam Day

My To Do List:

1. Get Ready for Test
2. Get Ready for Test
3. Get Ready for Test
4. Repeat #'s 1 - 3

Focus = → **Mental Preparedness** + **Physical Preparedness**

Be Comfortable

- Breakfast is mandatory and includes protein:
  - eggs, bacon, peanut butter, cheese, (Brain Food !)
- Drink plenty of fluids
- Wear comfortable clothes & shoes
- Test Calculator operation
- ***Get Some new Pencils***
- ***Be Early !!!!***



Have a Positive Mental Attitude

- Confidence and positive attitude are very important in test taking as in anything we do that is challenging **.**
- **Confidence is something that can be built by reinforcing fundamentals.**

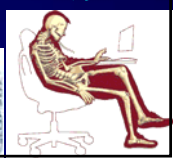
"Ninety Percent of this game is half mental."
Yogi Berra


During the Exam

- **Stay Comfortable and Focused**
- **Stretch during test**
- **Take Deep Breathes**
- **Stop Occasionally to rest**
- **Don't drink lots of coffee if you didn't do so when you were studying**
- **Avoid Sugar**








Approaching Tests Systematically

End

Start

1. Nail What you know.
2. Do the ones where you can eliminate
3. Record the ones you were not so sure on

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Beginning the Test

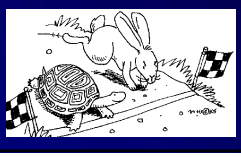
The test is not a race!

You have plenty of time to finish!

No need to Rush !

Use Effective Strategies!

Do not Rush



Before Starting the Test

- ✓ Read ALL directions
- ✓ Scan the questions
  - Get a sense of the nature of questions
  - Think of the questions as several *small* jobs, not one big, overwhelming test
- ✓ Map out your time
  - How much time per question?
  - Keep schedule flexible
- ✓ Use your Scratch Pad
  - Keep track of thoughts and questions
  - Take notes & jot things down

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Plan of Attack

1

FIRST SWEEP

- Read each question in order, answering the ones that you know easily in your first reading,
- Save harder questions for later,
- When you get to the end of the test, pause, relax, stretch, close your eyes and clear your mind for a minute or two; then begin again.

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Read the Questions !

- Read Questions Methodically and Carefully
- Most frequent problem -- question not completely read, misread or misunderstood
- "NOT" is the most commonly misread word.
- Reread the question several times to make sure you are answering the right question

RTQ x2

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Plan of Attack

2

SECOND SWEEP

- Begin your “second sweep”
  - work on the questions that you can answer with a little thought,
- Save the really tough ones for last,
- Reread the questions that you were not able to answer the first time.
- NEVER GUESS ! Answer all questions using something that you know or think you may know about it !

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Plan of Attack

3

THIRD SWEEP

- Answer hardest questions last,
- After you have answered all questions, if you have time, you can skim all the questions and answers one last time.
- Don't change an answer unless you have found additional clues or misread the question the first time
  - Most changed answers are not as good as the original ones

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Plan of Attack

4

FOURTH and FINAL SWEEP

- Re-read Each question and answer!
- After you have answered all questions, use your time to re-read all the questions and answers to identify a few obvious mistakes: 1.) keyed in the wrong letter, 2.) missed a “not” or read a “maximum” as a “minimum”, 3.) did not bother to read all the answers given and there was a better answer and, 4.) found a math error!

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Strategies for Conquering Multiple Choice Questions

18

Multiple Choice Mastery is in the Numbers

- Never Leave Blank !!!
- State the answer then;
  - Find the best match !
- If you can't match then Eliminate Distracters
  i.e., Cross out the Wrong answers
- Use the question clues to find the best answer
- Always favor the one that you remember about subject matter

1 of 4 = 25%
1 of 3 = 33%
1 of 2 > 50%

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Study by Stating the Answer, i.e., as if, it's not Multiple Choice

- Read the question only,
  - covering up the answer choices,
  - see if you already KNOW the answer.
- Always predict the answer first
- Then, read ALL of the answer choices
- Find the best match of the choices

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Using Prediction with Multiple Choice

- If your prediction isn't one of the choices, reread the question
  - you may have misunderstood the question
  - You may have misread the question
- Double check your answer by going back to the question again for clues

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Eliminating Multiple Answers increases your Odds

- ALWAYS ! Cross out those answers that are obviously wrong to get it down to two.
- If more than one choice seems true, then one of them doesn't answer the specific question or is not as complete
- Reread the question to see which answer is best

When you eliminate wrong answers, your chances for success increase dramatically!!

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Opposite Answers Increase Your Odds

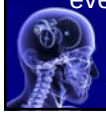
- If two answers are opposites, one is often the correct answer
- Some answers are partially true
  - If any part of the answer is false, eliminate it
- Rephrase the question: "In other words, what I'm looking for is..."

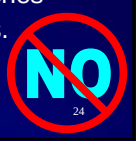
Tests are a perfect time to talk to yourself, but not too loudly.

23

Beware of Negatives

- If a negative such as "**NONE**", "**NOT**", "**NEVER**", or "**NEITHER**" occurs in the question then you're looking for a "catch".
- Read these carefully and be positive you understand the question.
- There will be an answer that matches even if your thinking is backwards.





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Recognize Absolutes

- Words such as "**EVERY**", "**ALL**", "**NONE**", "**ALWAYS**", and "**ONLY**" are superlatives that usually indicate a bad choice.

"If the world were perfect, I wouldn't be here" Yogi Berra

Recognize Qualifiers

- "**USUALLY**", "**OFTEN**", "**GENERALLY**", "**MAY**", and "**SELDOM**" are qualifiers that usually indicate a true statement or a good answer.

Rely on Initial Logic

- Research shows that initial logic is often the best but:
  - ✓ Did you properly read the question?
    And then:
  - ✓ Is the revision **based on new clues?**
- If you cannot figure out the answer by rereading the question and using these strategies within a few minutes
  - ✓ go with the ***initial logic used***

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Solution to Two Possible Answers

- Ask how the two answers differ (just the answers, ignore the question), then look at the question again and ask yourself “How is this difference important for this question?"
- If you really think there's absolutely no difference between the two answers, then look again at the answers you've eliminated,
  maybe one of them is actually a better answer.

House Wins 28

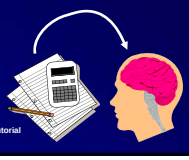
Scratch Paper is your Friend

- Helps you focus and ignore distractions
- Helps to Simplify Difficult concepts
- Helps you remember the questions that were difficult to answer and records their location (#) for your "second sweep".
- Helps to record information that you are sure you will need but might forget in other parts of the test.

SUMMARY

How to Do Well on Exams

- Devise a plan
- Set a study schedule for FRWA materials
- Build long-term memory using repetition
- Be physically well as you can be
- Avoid stress and outside distractions
- Prepare the night before the test
- Have a good breakfast
- Drink plenty of fluids
- Wear comfortable clothes & shoes
- *SHOW UP EARLY*



Taylor Tutorial

SUMMARY
How to Score Higher on Exams

- Be calm, confident and focused
- Have a positive mental attitude
- Bring pencils & calculator
- Scan the test and plan your attack
- First Sweep - answer easy questio
  - ✓ Read questions carefully & twice
  - ✓ Read Twice; Answer Once
- Second Sweep - work on harder questions
- Third Sweep - answer hardest questions last
- Final Sweep – review and find "obvious errors and catches"

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SUMMARY
How to Do Well on Exams

- Last Sweep - after you have answered all questions, if you have time, you can skim all the questions and answers one last time
- Don't change an answer unless you have a good reason to change it!

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SUMMARY
How to Do Well on Exams

- Multiple Choice Questions
  - ✓ Predict the answer
  - ✓ Eliminate distracters to improve odds
  - ✓ Use the question to find the answer
  - ✓ Always Use things you know
- Beware of…
  - ✓ Negatives – "none" "not" "never" or "neither"
  - ✓ Absolutes – "every" "all" "always" and "only"
- Might indicate a true statements…
  - ✓ "usually" "often" "generally" "may" and "seldom"

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Three Rules for Conquering Math

- Always look up the proper formula
- Write it down, then
- Plug in the right units !

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You are Ready

Lets do the FRWA Review

35

DEP Rules for Water System Operators

1

DEP Requirements for Water Distribution System Operators Module Objectives

- Explain the requirements for WD Licensure
- Identify the Reference Materials where the Rules for Distribution Operation and Maintenance are found
- Identify the Major Rules that affect WD Operators
- Identify Specific Monitoring and Sampling Performed by WD Operators
- Identify Proper methods of Sampling
- Identify the requirements for boil water notices

2

Requirements for Water Distribution License

Operator Examination

1. Have a high school diploma or equivalency.
2. Successfully complete a DEP approved training course for the level of the examination to be taken no more than 5 years before the examination.

Operator Licensure

1. One and two above.
2. Verification of actual hours of experience (as required for appropriate certification level sought).
   - Level 1 (highest level) - 10,400 hours of actual experience
   - Level 2 - 6,240 hours of actual experience
   - Level 3 - 2,080 hours of actual experience

3

Water Distribution System Licensing Requirements

Class of WTP	A/B/C	A/B/C	A/B/C	A/B/C	D
Population	≥100,000	≥10,000 <100,000	≥1,000 <10,000	<1,000	NA
Lead/Chief Operator	Level 1 or Class C or higher	Level 2 or Class C or higher	Level 3 or Class C or higher	Level 4 or Class D or higher	Level 4 or Class D or higher
On-site Charge	Level 3	Level 3	Level 3	Level 4	Level 4

4

DEP WTP Classes/Categories

Water Treatment Process	Class A	Class B	Class C	Class D
Category I: Conventional filtration	5.0 MGD and above	1.0 MGD up to 5.0 MGD	0.1 MGD up to 1.0 MGD	Not Applicable
Category II: Micro, Ultra,, Nano, or Reverse Osmosis Filtration	6.5 MGD and above	1.0 MGD up to 6.5 MGD	0.1 MGD up to 1.0 MGD	Not Applicable
Category III: Activated alumina or carbon adsorption with backwashing or on-site regeneration for primary contaminate or DBP removal; DE filtration; Electrodialysis; Ion exchange; Rapid rate or direct filtration; Slow sand filtration	8.0 MGD and above	2.0 MGD up to 8.0 MGD	0.25 MGD up to 2.0 MGD	Not Applicable
Category IV: Activated alumina or carbon adsorption with backwashing or on-site regeneration for only secondary contaminates; chloramination; chlorine dioxide treatment; Oxidation and rapid rate or direct filtration of any secondary contaminant	Not Applicable	10.0 MGD and above	0.1 MGD up to 10.0 MGD	Less than 0.1 MGD
Category V: Activated alumina or carbon adsorption with backwashing or without on-site regeneration; aeration; alkalinity or pH adjustment; chlorination, corrosion control, fluoridation; iron and manganese sequestration; or ultraviolet radiation	Not Applicable	Not Applicable	0.25 and above	Less than 0.25 MGD

5

Requirements for On-Site Supervision of WD Work

1. For systems serving at least 1,000 persons: Must have a WD level 3 or higher or a WTP Class C or higher licensed operator.
2. For systems serving less than 1,000 persons: Must have a WD level 4 or higher or a WTP Class D or higher licensed operator.
3. Must be on-site for all activities that affect water quality or quantity. These include:
   - Swabbing, pigging, scraping or air-purging
   - Tapping, depressurizing/dewatering, or disinfecting water mains
   - Dewatering, cleaning, or disinfecting storage tanks
   - Manually operating pumps, controls or regulating flows or pressures

6

Florida Drinking Water Rules are found in Florida Administrative Code (FAC)

- Updated each Year by DEP in "*Florida Drinking Water Rules.*"
- Also DEP updates each Year "*Book of Forms.*"
- Can be obtained from DEP or at FRWA, annual Focus on Change presentation hosted around the state beginning in March each year.

7

Specific Rules and Regulations for Water Distribution Operators

- Chapter 62-550
  Standards, Monitoring, and Reporting
- Chapter 62-555
  Permitting, Construction and Operation and Maintenance of Public Water Systems
- Chapter 62-560
  Requirements of Public Water Systems that are out of Compliance
- Chapter 62-602
  Operator Certification Rule
- Chapter 62-699 (New 3/6/2013)
  Plant Classification and Staffing Requirements

8

Water Distribution System

- Water distribution system" means those components of a public water system regulated under 62-550, F.A.C., used in conveying water for human consumption from the water treatment plant to the consumer's property, including pipes, tanks, pumps, and other constructed conveyances.

9

Water Distribution Duties

- (a) Cleaning (swabbing, pigging, scraping, or air purging) existing water mains; installing, tapping, repairing/replacing, pressure testing, or disinfecting water mains and appurtenances (including fittings, valves, and hydrants); cleaning or disinfecting finished-water storage tanks; operating or adjusting pumps or control valves as necessary to regulate water distribution system flows or pressures; evaluating and interpreting water quality measurements in water distribution systems and troubleshooting to determine causes of water quality complaints; and estimating and justifying water distribution system operation and maintenance budgets.
- (b) Flushing water mains; installing or repairing/replacing water services lines and appurtenances (including fittings, valves, and meters); establishing or implementing a cross-connection control program (including installing, repairing/replacing, or testing backflow preventers); testing and maintaining water meters; locating and marking water mains or service lines; operating or exercising isolation valves; testing and maintaining fire hydrants; repairing/overhauling water pumps, control valves or meters; performing water quality measurements in water distribution systems; collecting and analyzing water samples; reading or updating water distribution system maps; and preparing water distribution system operation and maintenance records.

10

Water Borne Illnesses and Pathogens of Concern

- Cholera
- Dysentery
- Gastroenteritis
- Giardiasis
- Hepatitis
- Typhoid

Viruses and Bacteria that cause human illnesses are known as "Pathogens"

Water Treatment and Disinfection removes and "inactivates" Pathogens

"Chlorine Residual" is maintained in the Water Distribution System to Prevent possible regrowth

11

Multiple Barrier Approach for Protecting Public Health

- Risk Prevention
- Risk Management
- Monitoring and Compliance
- Individual Action

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Risk Prevention

- When selecting sources, systems should examine:
  - The quality of the raw water (e.g., does it contain pathogens, chemicals, radionuclides, nitrates, or high turbidity?).
  - The risk of contamination (e.g., will development encroach on the water source?).
  - The ability of the supply to meet current and future needs.
- Existing systems can and should take steps to protect their water sources, including:
  - Identifying sources of contamination in watersheds and recharge areas.
  - Identifying the conditions under which the risks increase.
  - Developing and implementing source water protection strategies.

13

Risk Management

- Water treatment:
  - Removes and inactivates contaminants present in source water.
  - Leads to improved finished water quality.
- To provide adequate protection of public health, a water system:
  - Must meet its state's minimum design and construction standards.
  - Should develop asset management plans that help provide sound infrastructure.
  - Must meet federal and state drinking water standards.

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Monitoring and Compliance

- They accomplish this by collecting information about:
  - The presence of contaminants.
  - The effectiveness of current treatment processes.
  - Any deterioration in the quality of source or treated water.
- In particular, the contamination of treated water can result from:
  - Line breaks.
  - Inadequate water pressure.
  - Deficiencies in storage tanks.
  - Inadequate separation of water supply lines and sewers.
- Monitoring programs should:
  - Be developed around the needs and characteristics of individual water systems
  - Be developed to comply with all regulatory requirements
  - Help a system maintain the physical integrity of its components and make adjustments as necessary to provide a consistent, safe supply of water.

15

Individual Action

- Consumer Confidence Reports (Annual Water Quality Reports) that discuss:
  - The condition of the system's source water.
  - The level of contaminants in the system's drinking water.
- Public notification makes sure that:
  - Consumers are informed of any health risks in a timely manner.
  - Water systems build trust with consumers by sharing information.
- Beyond information sharing, systems can benefit greatly from involving the public in a variety of activities. For example:
  - Systems can further their source water protection efforts by helping the public form watershed associations.
  - Systems can encourage the public to notice and report activities that could represent contamination or sabotage threats to the water system.

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Review of Florida Primary and Secondary Drinking Water Standards and Other Regulated Parameters affecting Water Distribution Operators

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Allowable Chlorine Residuals in a Water Distribution System

Contaminant	MRDL (mg/l)
Chlorine	4.0 (as Cl_2)
Chloramines	4.0 (as Cl_2)
Chlorine Dioxide	0.80 (as ClO_2)

Note: Chapter 62-550: For chlorine and chloramines, a PWS is in compliance when the running annual average of monthly averages of samples taken in the distribution system, computed quarterly, is less than or equal to the MRDL. For chlorine dioxide, a PWS is in compliance when daily samples are taken at the entrance to the distribution system and no two consecutive daily samples exceed the MRDL.

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Basics of Disinfection By-Products Formation Using Cl_2

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Disinfection Byproducts Formation

- Disinfection Byproducts (DBP) are produced by the reaction of free chlorine with natural organic material (NOM) found in source waters.
- The amount of organic materials (NOM) can be approximated by the amount of Total Organic Carbon (TOC) present.
- The portion of the NOM that forms the DBP's is generally the dissolved portion

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Maximum Contaminant Levels allowed for Disinfection Byproducts

Contaminant	MCL (mg/l)
Total Trihalomethanes	0.08
Haloacetic Acids (Five)	0.06
Bromate	0.010
Chlorite	1.0

Sometimes expressed in PPB as
TTHM <80 PPB and HAA_5 < 60 PPB

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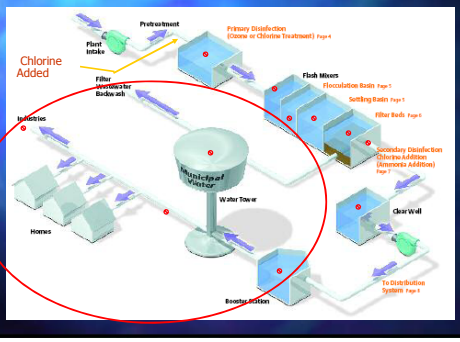
Approaches to Controlling DBPs

- Source water selection
- Remove DBP precursors
- Reduce the amount of disinfectant and/or change the point of application
- Switch from chlorine to alternative primary and/or secondary disinfectants
- Minimize reaction time

22

Formation of DBP in a Typical Water Treatment and Distribution System



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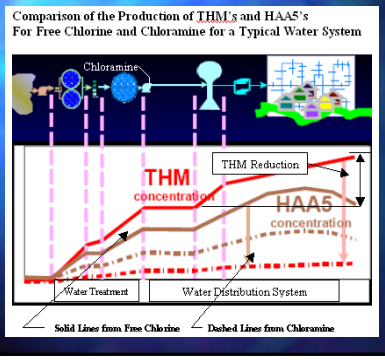
Disinfectant and DBP Production in a Typical Water System



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Monitoring, Sampling and Reporting

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Approved DEP Sampling Procedures

- Found in DEP Standard Procedures at www.dep.state.fl.us/water/sas/sop/sops.htm (from 2008)
- Changes are being finalized. Draft SOPs can be found at www.dep.state.fl.us/water/sas/qa/62-160-drafts.htm
- All parties producing data for use by DEP are required to use applicable DEP SOPs per the DEP Quality Assurance Rule, 62-160.
- Any water distribution operator that performs these tasks should download a copy of the procedures, read them, understand them and place them in a protected place inside the work vehicle.

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Initial and Routine Monitoring for Water Distribution Systems

PARAMETER	Type System (GW / Sub-part H)	Population	Frequency (Routine)	# of Samples
Asbestos	GW/Subpart H	NA	Every 9 Years	1
Nitrate/Nitrite	GW	NA	Annually	1
	Subpart H	NA	Quarterly	1
Microbiological	GW/Subpart H	NA	Monthly	Multiple by Population
Chlorine /Chloramines	GW/Subpart H	NA	Monthly	At Coliform Location
THMs/HAA5s	GW/Subpart H	≥ 10,000	Quarterly	1 / 4
	GW	≥ 500 < 10,000	Annually	1 - Month of warmest water
	Subpart H	≥ 500 < 10,000	Quarterly	1
	GW/Subpart H	< 500	Annually	1 - Month of warmest water

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Bacteriological Monitoring
Four Principle DEP Requirements

1. All PWS Systems must test for coliform bacteria to determine compliance.
2. All PWS Systems must provide a raw sample from each source or each well monthly.
3. **The number of distribution samples is dependent on the population served.** See CH 62-550.518.
4. Provide bacteriological and chemical analysis results to FDEP postmarked by the 10th of following month.

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The Coliform Group as Indicator Organisms

The **Coliform Group are** :

What is the term that describes an atmosphere with no or lack of oxygen?
Anaerobic

"All aerobic and facultative anaerobic, gram-negative, non-spore-forming, rod shaped bacteria that ferment lactose with gas and acid formation within 48 hours at 35°C."

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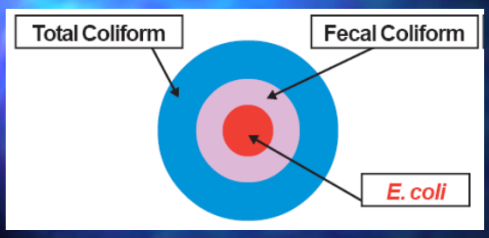
Identifying Source of Contaminants



30

Coliform Use as Pathogen Indicators in Water Treatment

Total Coliform	Ferment Lactose @ 35ºC
Include Species of Genera	Citrobacter Enterobacter Klebsiella E. Coli
Fecal Coliform	Grow at 44ºC Produce Enzyme
E. Coli	More Specific Indicator of Contamination
HPC	< 500 colonies/ml

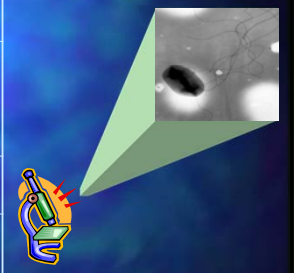


Photo: CDC. *E. coli* 0157:H7
11 of 140 cause gastrointestinal disease

31

Gastroenteritis from Fecal Contamination of Water

- Symptoms are nausea, vomiting and diarrhea; typically not reported
- Can be caused by viral or bacterial contamination
- Viruses are the smallest and simplest life form
  - Over 100 types of human intestinal viruses have been identified in wastewater; there are 1000's of bacteria
  - 10 to 100 times smaller than bacteria
  - Viruses must have a living host to multiply – plant or animal bacteria can grow anywhere
  - There are some useful bacteria but all viruses are harmful
  - Antibotics can kill bacteria but not viruses
- Viruses survive longer than indicator organisms in the presence of disinfectant

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Water Borne Diseases found in Virally all Contaminated Water

Viral Group	Disease
Enterovirus	Meningitis, GB Spinal Syn., Respiratory, Hepatitis
Adenovirus	Respiratory, Conjunctivitis, Appendicitis
Hepatitis	Infectious Hepatitis, Downs Syndrome

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The Sanitary Survey

- A comprehensive examination of a water system to identify potential sources of contamination
- Covers all ground and surface water systems
- Frequency :
  - CWS every 3 years
  - CWS DEP option every 5 years if 4–Log Viral Inactivation
  - NCWS every 5 years

Sanitary Survey

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The Eight Requirements of the Sanitary Survey per GWR

1. Source water
2. Treatment
3. Distribution system
4. Finished water storage
5. Pumps, pump facilities, and controls
6. Monitoring, reporting, and data verification
7. System management and operation
8. Operator compliance with State requirements

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Coliform Rule

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Total Coliform Rule of 1989

- All Public Systems must monitor
- Promulgated to decrease the risk of waterborne illness
- Corrective measures based on detection
- Required public notice based only on the presence of total coliforms

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Revised Total Coliform Rule RTCR)

- Revision effective 2/13/13
- 1989 TCR remains effective until 3/31/16
- PWSs must comply beginning 4/1/16
- Eliminates MCLG and MCL for total coliforms, replacing it with a treatment technique for coliforms that requires assessment and corrective action
- Establishes an MCLG and MCL of 0 for E. coli
- Under the RTCR there is no longer a monthly MCL violation for multiple total coliform detections

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Revised Total Coliform Rule - cont

- Under the new treatment technique for coliforms, total coliforms serve as an indicator of a potential pathway of contamination into the distribution system.
- A PWS that exceeds a specified frequency of total coliform occurrence must conduct an assessment to determine if any sanitary defects exist and, if found, correct them.
- Under the new treatment technique requirements, a PWS that incurs an E. coli MCL violation must conduct an assessment and correct any sanitary defects found.

39

Objectives of the RTCR

- Maintains objectives of the 1989 TCR, to:
  - Evaluate effectiveness of treatment
  - Determine integrity of the distribution system
  - Signal possible presence of fecal contamination
- Reduce potential pathways of contamination into the distribution system
- Using total coliform as an indicator of system operation rather than immediate public health concern and using E. coli as a fecal indicator
- More stringent standards for reduced monitoring
- Vulnerable systems required to monitor more often

40

Sampling/Siting Plan Narrative and Description of Facilities

- Water system name, contact persons, telephone numbers, and addresses.
- Water system PWSID #.
- Water source name(s).
- Storage volume.
- Treatment facility description (process used, source[s] treated, location, etc.).
- Total population served.
- Number of service connections.

41

Considerations in the Development of a Representative Sample Siting Plan

- The location and type of water sources, treatment facilities, storage tanks, pressure stations, and service connections
- The location of dead-end pipes, loops, and other areas of the piping system configurations.
- Cross connection hazards and shared connections.
- Areas of low water pressure and slow water movement.
- Varying population densities.

42

Ensuring Suitable Sampling Locations

Some examples of **unsuitable sample sites** are:

- Swivel-type faucets that have a single valve for hot and cold water.
- Faucets that have leaky packing material around the stem.
- Faucets that supply areas, such as janitorial or commercial sinks, where bacterial contamination is likely.
- Faucets close to or below ground level.
- Faucets that point upward.
- Faucets that have threads on the inside of their spouts.
- Faucets that have aerators. (If such faucets are to be used, the aerators must be removed before a sample is collected.)

Samples should be taken at sites that are representative of water throughout the distribution system and in accordance with a written sampling plan.

43

Sample Collection Procedures

- Accidental Contamination – Remove Obstruction (aerators, hoses, etc. that harbor bacteria
- Sample Containers – Use Appropriate Type of Container (Sample Bottles or Whirl-Pac)
- Preservation- Use Specified Method; if refrigeration required use $\leq 4^{o}$ C
- Label – Sample Container and Time
- Chain of Custody – Tracing and Handling

44

Preparing for Field Sampling

- **Cooler for shipping and storage of your sample while in transit between collection point and lab**
- **Ice in baggies for shipping cooler**
- **PVC or unsupported Neoprene gloves to keep sample from possible contamination**
- **125mL sample bottle with sodium thiosulfate for chlorinated water systems**
- **Lab slips, labels, and markers for sample container identification**
- **Paper towel for drying off the outside of sample**

45

Taking a Distribution Sample

When filling a sample bottle, for field sampling, how full do you fill the bottle?

To the Line

- Turn on the cold water and run the water to flush the tap.
- This typically takes 1-3 minutes.
- Then reduce the flow so that the stream is no greater than 1/8 inch in diameter, or the width of a pencil.
- Use a chemical test kit to check a separate sample for residual chlorine. If residual chlorine is present, collect the sample in the appropriate sample container(s) using the required preservatives.
- Fill the sample bottle to the line.

For Bacteriological samples, Sodium Thiosulfate present in sample bottles to neutralize chlorine

46

Preparing Sample for Storage and Shipping

- The sample container should be tightly capped.
- Blot the sample container with a paper towel to dry it off.
- Ice for shipping should be bagged separately or frozen in containers to prevent contamination.
- Make sure sample is nestled and that any melted ice water does not raise above the sample containers.

47

Laboratory Requirements

- The samples must reach the laboratory and the analysis must begin within 30 hours of collection and 8 hours from receipt. All samples must be cooled to 4 degrees Celsius (39 degrees Fahrenheit).
- If the laboratory is nearby, refrigerate the sample with ice packs, and deliver it directly.
- If not, send the samples overnight by US mail or by an overnight courier.
- Tape the chest prior to shipping. Be sure to tape any additional forms or sample documentation either inside or on the outside of the lid.

48

Bacteriological Monitoring Failure to Meet Standards

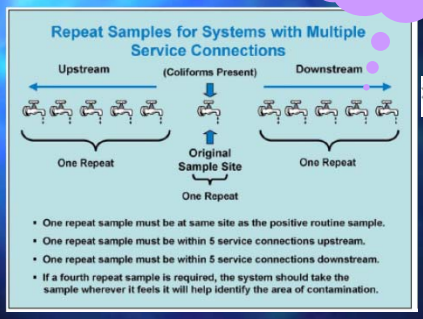
- Under the RTCR, systems have the flexibility to propose repeat sample locations that best verify and determine the extent of potential contamination.
- In lieu of proposing new sample locations, systems may use a default of taking repeat samples at site of failure and at locations within 5 service connections upstream and downstream.
- Repeat samples must be taken within 24 hours of learning any routine sample is total coliform positive.
- Systems collecting fewer than five samples a month that has one or more total coliform-positive samples shall collect at least five routine samples the next month.
- If fecal coliform is detected DEP must be notified by the end of the day that the system is notified of the test result.

49

Default Repeat Samples

For a bacteriological sample positive test, what would be the next step?

Repeat Samples



50

Chemical Constituents Nitrate/Nitrite Testing

- Transient Non-Community Water Systems (TNCWS) must test for Nitrate/Nitrite yearly, along with quarterly bacteriological samples.
- All PWS's must test for Nitrate/Nitrite yearly, with Community (CWS) and Non-Transient Non-Community (NTNCWS) monitoring for bacteriological samples monthly.
- Nitrate MCL - 10 mg/l
- Nitrite MCL - 1 mg/l
- Combination – 10 mg/l

51

Lead and Copper Rule

52

Lead and Copper Rule Basic Requirements

- Provide optimal corrosion treatment
- Determine tap water lead and copper levels
- Rule out Source Water as the problem
- When levels are exceeded notify the public of the dangers and perform corrective actions

53

Lead and Copper Sampling Requirements

- Must collect in 1 Liter Bottles
- Water must have set motionless for at least 6 Hours 
- Must be collected from Cold Water Kitchen or Bathroom taps 
- Samples may be held up to 14 days with acidification using Nitric Acid

54

Chemical Constituents Lead and Copper Action Levels

Chemical Constituent	Action Level	MCL (mg/l)
Lead	>0.015 mg/l	0.015
Copper	>1.3 mg/l	1.0

- All CWS and NTNCWS are covered
- Compliance is based on the 90th percentile
- Action levels are exceeded if 10% of the samples exceed the above.
- Samples are based on population served

55

Lead and Copper Monitoring

Number of samples required for Lead and Copper is based on the population served by the water system		
System Size	Initial Monitoring	Reduced Monitoring
>100,000	100	50
10,001 to 100,000	60	30
3,301 to 10,000	40	20
501 to 3,300	20	10
101 to 500	10	5
≤100	5	5

Reduced Monitoring is Yearly for Large Systems and Every Three Years for Small Systems

56

Determining Action Levels

Ref: 40 CFR Part 141 (Sections 80 through 91)

Based on Population

1 Lowest
•
•
36 – 90th Percentile
•
40 Highest

The 90th percentile is the number of samples required times 0.9. If 40 are required then 90th percentile is 36.

Population <100

1 Lowest
2
3
4 Second Highest
5 Highest

5 samples required. 90th percentile computed by taking the average of the highest and second highest concentration

57

Lead Toxicity

- Interference with Red Blood Cell Chemistry
- Delays in Physical and Mental Development
- Learning Disabilities
- Kidney Disease, Stroke and Cancer

Lead Problems originate from Corrosion of fittings and solder in Dist. System especially when copper fittings were installed before 1982.

58

Minimum Reporting Requirements for CWS

- MORs postmarked by the 10th of the month following the reporting period;
- Submit chemical analysis results for Pesticides & PCBs, Volatile Organics, Radionuclides, Primary Inorganics, TTHMs, Asbestos, Nitrate and Nitrite, Secondary Contaminants.

59

Procedures for Exceedance of Lead Action Level (>0.015)

- Contact DEP immediately
- Additional Water Quality Testing Required
- Install Treatment to Reduce Corrosivity
- Inform Public

Note: Lead service line replacement is required when your 90th percentile level exceeds the lead action level in any monitoring period conducted after you install corrosion control treatment.

60

Other Water System Requirements

61

Water System Record Keeping Requirements

- Copies of written reports, cross connection control programs, sanitary surveys, shall be kept at least 10 years.
- Chemical analyses shall be kept for 10 years. Water plant operation reports (MORS) shall kept for not less than 10 years.
- Records concerning a variance or exemption granted shall be kept for at least 5 years.
- Records of bacteriological analyses shall be kept for not less than 5 years.
- Records of action to correct a violation shall be kept for 3 years.

62

Water Distribution System Requirements

What is the rule of thumb for the number of turns required to close a gate or butterfly valve?

3 times the diameter

- Maintain 20 psi in distribution system at service connection except for break or extraordinary conditions to prevent backflow
- Document program for exercising all system valves
- Must have quarterly dead-end system flushing program and as necessary from complaints
- > 350 people or 150 connections, must map locations of valves, fire hydrants and facilities
- > 350 people or 150 connections must have Emergency Preparedness Plan for system

63

Exceptions to Getting a Construction Permit

A construction permit is generally required for construction or alterations of any public water system component, however, rule 62-555.520 F.A.C. provides for exceptions to getting a permit. Generally, requires only DEP notification and in some cases written approval. See the rule for a complete list.

- Discontinuing use of treatment, pumping or storage
- Changes in chemical treatment (i.e., to protect public health in emergencies; eliminate excess ammonia; oxidize nitrite)
- Replacement of existing water pumping, storage, or treatment facilities meeting same design and capacity
- Replacement of existing water main (up to 2 sizes larger)
- Relocations for other utilities provided < 100 ft away
- Alteration of structures that do not treat, store or handle DW

64

Approved Work that Requires only Public Notification

- Temporarily converting to free chlorine from chloramines for public health
- Any maintenance and repair work
- Any electrical work that does not affect compliance
- Installation or alteration of valve, flow meter, FH or backflow preventer
- Installation of water service to single building or a fire protection line

65

DOH Guidelines for Precautionary Boil Water (PBWN) Notice

66

Florida Health Dept. Requirements for Water Main Contamination

1	Microbiological Contamination	Boil Water Notice
2	Zero or Neg. Pressure	Boil Water Notice
3	Low Water Pressure (Drop Below 20 psi)	Boil Water w/ aggravating factors
4	Water Main Breaks/ Interruptions	Boil Water if Imminent Threat
5	Flooding of Wells	Boil Water Notice if surface water inundation occurs

Precautionary Boil Water Notice Requires Notification of DOH, DEP and the Public!

Confirmed Microbiological Problems

- Confirmation samples indicate the presence of fecal or E coli or other pathogens;
- Boil water notices must be issued ASAP but no later than 24 hours after results;
- DEP/Local County Health Department shall be notified ASAP but NLT 24 hours after the occurrence;
- To lift notice repeat samples must be clear of Total Coliform, Fecal Coliform and E. Coli and residual must be >0.20 mg/l Cl.

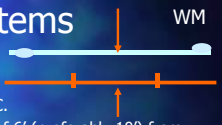
68

Rescission of Boil Water Notices

- Responsibility of entity issuing the PBWN to rescind it.
- Always requires two satisfactory days of sample results.
- Analysis of samples should conducted by DOH or a lab certified by DOH.
- PBWN may be lifted after one day when supplemented by appropriate disinfection residual levels and other water quality parameters showing water is safe. STILL REQUIRES SECOND DAY OF SAMPLES.
- May be returned to operation without DEP approval.
- Report all repairs for mains out of service and report the results of the bacteriological evaluation on next MOR.

69

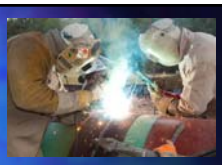
Water Pipeline Additions to Distribution Systems



- A general DEP permit is granted under Chapter 62-555.405 F.A.C.
- Must provide min horizontal separation of 6′ (preferably 10′) from sanitary sewer, wastewater forcemain or unregulated reclaimed water and 3′ from storm sewers or forcemains or reclaimed water.
- Must maintain min 6″ and preferably 12″ vertical separation between sanitary or storm sewer
- Must maintain min 12″ vertical separation between pressure sewers, force main, or reclaimed pipelines.
- Utility crossings must maintain full length of pipe centered on other pipeline to ensure joints will be farthest away from intrusion points. Alternatively, water pipe shall be 3′ for storm water and reclaimed water lines and 6′ for sanitary sewers

70

Exceptions to the Minimum Distance Requirements



- Use of pressure rated pipe
- Use of welded, fused, or otherwise restrained joints
- Use of watertight casing pipe or concrete encasement at least 4″ thick

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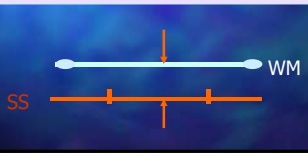
Pipeline Separation Related to New or Relocated Fire Hydrants with Underground Drains

Type pipeline	Horizontal Separation
Storm sewer or force main or reclaimed water	3′
Vacuum type sewer	3′ preferably 10′
Gravity or pressure sewer or force main or unregulated reclaimed water	6′ preferably 10′
On-site sewage	10′
Where not possible - use a watertight casing pipe or concrete encasement at least 4″ thick.	



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Minimum Disinfection Requirements

Maintaining a chlorine residual of 0.2 mg/l in the distribution system will?
Prevent Possible Regrowth

- Maintain a free chlorine residual of 0.2 or combined chlorine residual of 0.6 mg/l throughout the distribution system.
- Samples are run using approved DPD "free chlorine" test kit
- Must measure each day at point of max. residence time if >3,300 or 2/wk if < 3,300 people.

73

DEP Flushing Requirements

Flushing Program	Suggested Actions/DEP Rule	Benefits to Treatment System
Written Flushing Procedures	Submit a Written Water Main Flushing Program. DEP Rule 62-555.350	Sampling is during normal operating conditions, and is not valid if you ONLY flush the day you are collecting samples
Treatment Components in Contact With Water	Clean & remove biogrowths, calcium or iron / manganese deposits, & sludge (Yearly) DEP Rule 62-555.350(2)	Improves water quality, reduces chlorine demand & regrowth in the water system.
Reservoirs and Storage Tanks	Clean & remove biogrowths, mineral deposits, & sludge from storage tanks (5 yrs). DEP Rule 62-555.350(2) FAC	Improves water quality, reduces chlorine demand & biological regrowth in the water system.
Water Distribution Mains	Begin systematic flushing of water system from treatment plant to system extremities.	Improves water quality, reduces chlorine demand & biological regrowth in the water system.
Dead-End Water Mains	Flushing or Automatic Flushing. (complaints) DEP Rule 62-555.350(2) (Quarterly / IAW plan)	Improves water quality,& reduces biological regrowth.

74

Water Treatment System Facility Maintenance Requirements

- Storage tanks with access must be inspected every 5 years by a registered professional engineer to:
  - Ensure structural stability
  - Ensure that the metal or concrete is sound and free of corrosion or rust
- Must rehabilitate tanks as needed using approved coatings
- Must exercise isolation valves at water storage tanks and in-plant facility

75

Mathematics for Water Distribution Operators

Revision 12/2010

1

Water Distribution Mathematics Module Objectives

- Understand the Basic Concepts of Converting between Volume and Weight
- Calculating Water Levels in Tanks
- Converting between Percent of Chemical and PPM
- Computing volumes and weights of liquids for various geometric shapes
- Calculating Flows and Detention Times
- Calculating Disinfectant Dosing Rates and Use of Chemical Dosing Wheel

2

Remember the Three Rules for Conquering Math

- Always look up the proper formula
  - This means disregarding all the numbers and recognizing the type of problem.
- Write it down
  - Always use the same equation; don't try to remember multiple versions of the same equation.
- Plug in the right units !
  - Many times the units given in the problem are not those required in the equation
  - Conversion of terms is essential.

3

Movement of Terms

- In solving equations, terms must be moved from one side of the equation to the other.
- How the terms (numbers) are moved depends on the type of problem and how the numbers are related. For example, does the problem only involve multiplication and division or terms, or is addition or subtraction also indicated.
- Mathematical rules of movement and order operation must be followed to obtain the correct answer to a calculation.

4

Order of Operations - How do I remember what to do first?

PEMDAS

P - Parenthesis first

E – Exponents (i.e. powers and sq roots)

MD – Multiplication/Division (left to right)

AS – Addition/Subtraction (left to right)

You can remember by saying "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally".

5

Equations

- These are the formulas that operators deal with every day.
- Every part of the formula has a numerator (top) and a denominator (bottom)
- When no denominators are shown, a one is assumed to be the denominator of the fraction

6

Multiplication and Division Problems

- Move terms diagonally from one side of the equation to the other.

- Only one type of movement is permisssible: Diagonal
- Example: Solve Q = VA for A

7

Addition and Subtraction

- What you do to one side of an equation you have to do to the other.
- Applies to terms or numbers

Example: A = B, add C to each side

A+C = B+C

Example: 3 = 4–1, add 2 to each side

3+2 = 4-1+2

5 = 5

8

Example

- What would you do to rearrange the disinfection formula to solve for demand?

Dose = Demand + Residual

- Subtract Residual from each side

Dose – Residual = Demand + ~~Residual~~ - ~~Residual~~

Dose – Residual = Demand

9

Some Basics

- Multiplying either side of an equation by 1 doesn't change the sides being equal it only changes the units.
- All of the conversions shown on the formula sheets are equal to 1!

Length =12 inches

Length = 12 ~~in~~ x $\frac{1\ ft}{12\ ~~in~~}$ = 1 ft

10

Some Basics

What is meant by the following?

- ft^2 or ft^3
- Pi or π
- fps or cfs
- acre-ft
- diameter
- radius
- circumference

11

Conversions - Box Method

- Many times people get confused on whether to multiply or divide
- The box method is an aid in making that decision. To use it first set up the boxes, with the smaller box on the left.

- Because multiplication is associated with increasing a number, we use multiplication when moving from the smaller box to the larger box
- When moving from the larger box to the smaller box, division is indicated (number gets smaller)

12

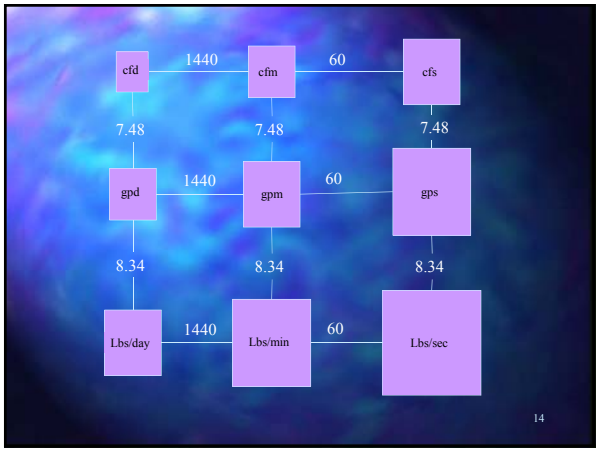
Example

To see how this works, convert a 36 inch pipe to feet.

Going from right to left, do you multiply or divide?

We are going from the larger box to the smaller box, so using the association that the number is getting smaller, we divide.

13



14

Fraction/Percentage/Decimal

- How do we change a fraction into a decimal?
  - Do the division.
- How do we convert a decimal to a percent?
  - Simply move the decimal two places to the right and add a % sign
- How do we convert from a percent to a decimal?
  - Simple remove the % sign and move the decimal two places to the left.
- How do we convert from a percent to a fraction?
  - Write the percent as a common fraction and then reduce the fraction to its lowest terms.

15

Fraction/Percentage/Decimal

Fraction	Decimal	Percent
3/4		
	.34	
		25%
1/2		
	.125	
		100%
2/3		

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Some Basics – Pipe Size Equivalents

Diameter in Inches	Diameter in Feet	Radius in Inches	Radius in Feet
24	2	12	1
12	1	6	.5
10	.83	5	.42
8	.67	4	.33
6	.5	3	.25
4	.33	2	.167
2	.167	1	.083

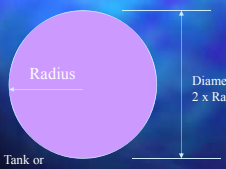
17

Calculating the Area of the top of a Tank or end of a Pipe

- Area or Surface Area of a Round Shape

Area may be expressed as ft^2 or as sq.ft.
These terms are synonymous.

Area of a Circle



Storage Tank or Pipeline Shape

Make sure that all units are expressed in feet!

$$\text{Area} = \pi \times R^2$$
$$= \pi \times R \times R$$
$$= 3.14 \times R\ (ft) \times R\ (ft)$$

18

Example: Determine the Area of the Top of a Circular Tank or the end of a Pipeline

Calculate the area of the end of a pipe in square feet, given a pipe diameter of 8 inches.

- Area = π x R^2
- What is our radius?
- Radius is 4 inches.
- What units do I need for formula?
- Area = (3.14) x (4/12)ft x (4/12)ft
- Area = .35 sq.ft. or ft^2
- How would it look using conversion factor?
- Area = 3.14 x 4in x 4in x $\frac{1ft^2}{144in^2}$ = $.35ft^2$

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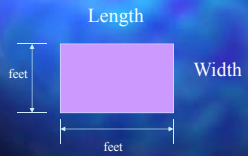
Determine the Area of a Rectangular Tank or Basin

Calculate the Area of the Rectangle. Remember the units for area are ft^2 or in^2.

Make sure that all units are expressed in feet!



Area = Length x Width

= Length (ft) x Width (ft)

20

Example: Calculate the Surface Area of a Rectangular Tank

Calculate the Surface Area of a Rectangle.

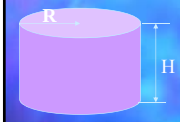
Area = Length x Width

Area = 20 ft x 10 ft

Area = 200 sq.ft. or ft^2

21

Calculate the surface area of the side of a tank



What would be the shape of the side of the tank if we split the tank up the side and rolled it out flat?

A RECTANGLE

A = 3.14 x 30 x 15
= 1,413 ft²

W

L

- Area = length x width
- In this case, what are length and width equal to?
- Length is equal to the circumference
- Width is equal to the height
- Example: If the height is 15ft and radius is 15ft, what is the area of the side of the tank?

22

How many gallons of paint need to be purchased to paint the top and outside of a 40 ft diameter and 20 ft tall tank? One gallon of paint will cover 400 ft².

- Area of top = .785 x 40 x 40 = 1256 ft²
- Area of side = 3.14 x 40 x 20 = 2512 ft²
- Total area = 3768 ft²
- Paint needed = 3768 ft² / (400 ft²/gal)
  = 9.42 gals or 10 gals

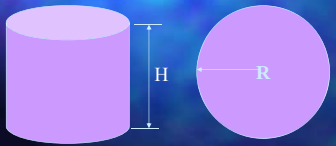
23

Calculating the Volume of a Circular Tank or Pipeline

Step 1: Choose the right formula! Volume = π x R^2 x H

Step 2: Calculate the Area of the Circular Shape, ft²

Step 3: Multiply the Area times the Height of the water tank or length of the pipeline, ft³



Area Calculation:

Area = π x R^2

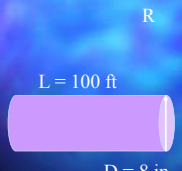
= π x R x R

Volume = π x R^2 x H

24

Example: Calculate the Volume of a Circular Tank or in a length of Pipeline

What is the volume of water in 100 feet of 8 inch pipe?



Step 1: Volume = π x R^2 x L

Step 2 : Area of end = π x R^2

Area = 3.14 x .33ft x .33ft = .34ft^2

Step 3: Volume = Area x 100 ft.

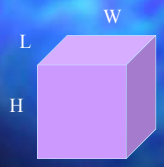
Volume = .34 ft^2 x 100 ft

Volume = 34 ft^3

25

Determining the Volume of a Rectangular Tank

- Volume of a Rectangular Shape



Make sure that all units are expressed in feet!

Volume = Length x Width x Height

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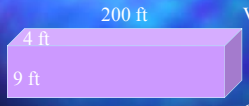
Calculation of the Volume of Soil Removed from a Trench

A trench 4 ft wide, 9 ft deep and 200 ft long has no place for storing the soil. How many cubic yards of soil must be hauled away?



Volume = Length x Width x Height

= 200 ft. x4 ft. x 9 ft.

= 7200 c.ft. or ft^3

Convert to cubic yards

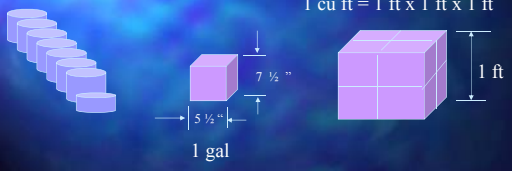
= 7200 ft^3 x 1 cu yd /27 ft^3

= 267 cu yds

27

Volume can also be expressed in Gallons

- What conversion factor do we use?
- VOLUME: 7.48 gal = 1 ft^3

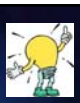


1 gal

1 cu ft = 1 ft x 1 ft x 1 ft

28

Convert Cubic Feet to Gallons:



How much water is in a basin that measures 10 foot deep, 30 foot wide and 60 foot long?

Determine cubic feet in basin:

Volume is = 10' x 30' x 60' = 18,000 ft^3

Convert to Gallons using 7.48 gal/ft^3

$$18{,}000\ ft^3 \times \frac{7.48\ gal}{ft^3} = \text{Gallons of Water}$$

= 134,640 Gallons

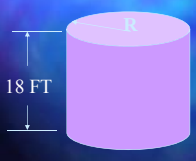
29

Examples Converting Cubic Feet to Gallons

When the Volume of a tank has been computed in cubic feet, it is often necessary to convert it to gallons. This is easily performed by multiplying the volume or cubic feet by 7.48.

Volume = π x R^2 x H

Gallons = Volume, ft^3 x 7.48 gal/ft^3



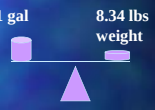
R = 20 ft
= 3.14 x 20 x 20 x 18
= 22,608 ft^3
= 22, 608 x 7.48
= 169,108 gal

R =30 ft
= 3.14 x 30 x 30 x 18
= 50,868 ft^3
= 50,868 x 7.48
= 380,493 gal

30

Volume can be Converted to Weight

- What conversion factors do we use?
- Weight: 62.4 lbs = 1 ft^3
- or 8.34 lbs = 1 gal



- What is the relationship between the two?
- 1 ft^3 = 7.48 ~~gals~~ x $\frac{8.34 \text{ lbs}}{\sim\!\!\text{gals}}$
- 1 ft^3 = 62.4 lbs

31

Gallons to Pounds Example

8.34 LBS / GAL or 62.4 LBS / ft^3

Determine Pounds of Water in a 78,500 ft^3 Tank

ft^3 of Water x 62.4 lbs/ft^3 = Pounds of Water

78,500 ft^3 x 62.4 lbs/ft^3 = Pounds of Water

= 4,898,400 Pounds or

= 4.9 Million Pounds of Water

Determine Pounds of Water in 587,000 Gallon Tank

Gallons of Water x 8.34 lbs/gal = Pounds of Water

587,000 gal x 8.34 lbs/gal= Pounds of Water

= 4,895,580 Pounds or

= 4.9 Million Pounds of Water

32

Math Question 3: determine dose in ppm or mg/l

Concentration of Chemicals

- Chemical Doses are expressed as PPM or as mg/l. These units are exactly the same

PPM = 1 Pound of Chemical Added to 1 M lbs of Water

Example:

10 Pounds of chemical are added to 4,897,081 pounds of water. What is Concentration in PPM and mg/l?

Note: Divide lbs of Water by 1,000,000 to get Million Pounds

$\frac{10 \text{ lbs chemical}}{4.9 \text{ M lbs}}$ or 2 PPM

33

Determining Height of Water in Tank with Pressure Gauge

1 psi = 2.31 feet

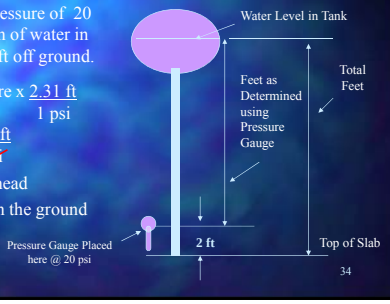
Given a gauge pressure of 20 psi, find elevation of water in tank. Gauge is 2 ft off ground.

Elev = gauge pressure x $\frac{2.31 \text{ ft}}{1 \text{ psi}}$

= 20 ~~psi~~ x $\frac{2.31 \text{ ft}}{1 \text{ ~~psi~~}}$

= 46.2 feet of head

And about 48 ft from the ground



34

A storage tank is 165 ft above the centerline of the water main and the pressure gage is placed 10 ft above the centerline of a main. What would the gage read in pounds per square inch? Assume the tank is full.

- Pressure, psi = height x 1 psi/2.31 ft
- Therefore:

  Pressure, psi = (165 ft – 10 ft) x 1 psi/2.31 ft

  Pressure, psi = 67 psi

35

Converting Percent to mg/l

- Chemical Concentration

The Concentration of a chemical can be described as a percentage by weight or in parts per million.

1 ppm = 1 mg/l

1% = 10,000 ppm = 10,000 mg/l

Given: 1.4% Solution

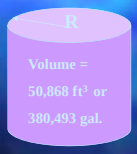
What is the Chemical Concentration in PPM?

1.4 X 10,000 = 14,000 PPM

36

Example Converting Gallons to Pounds

Calculate the pounds of water in a cylindrical tank when the gallons of water in the tank is known. In this example we have ~ 380,000 gal.



380,493 gal.

= 380,493 x 8.34

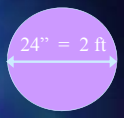
= 3,173,311 lbs

= 3.17 Million Pounds

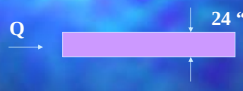
37

Example Pipe Flow Problems

Given a pipeline with a velocity of 2 fps and a diameter of 24", find the flow rate in cfs.



Q (cfs) = Velocity (fps) x Pipe Area (ft^2)



Q (cfs) = Vel (fps) x Area (ft^2) = $\pi \times R^2$

Q = (2 ft/s) x (3.14 x 1 ft x 1 ft)

Q = 6.28 ft^3/ sec

Given:

V = 2 fps

Pipe D = 24" = 2 ft

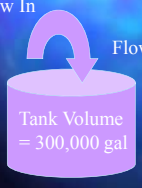
Radius = 1 ft

38

Determining Filling Time or Detention Time based on Flow into a Tank

DETENTION TIME = TANK CAP. (GAL.)
RATE **OR FLOW (GAL/TIME)**

Flow In



Flow Rate = 100,000 gal/hr.

39

Example: Filling or Emptying a Tank Calculations

FILLING TIME = TANK CAP. (GAL.)
RATE OR FLOW In (GAL/TIME)

DETENTION TIME = TANK CAP. (GAL.)
RATE OR FLOW Out (GAL/TIME)

FLOW = 100,000 GAL/HR in or out

300,000 GAL.
100,000 GAL / HR

= 3 HOURS
= 0.125 Days
= 180 Minutes

40

Using Direct Conversion for GPD to GPM Flow

Convert 100 gpm to gph, gpd and MGD

100 gpm = 100 gpm x 60 min/hr = 6,000 gph
= 6,000 gph x 24 hr/day = 144,000 gpd
= 144,000 gpd / 1,000,000 = 0.14 MGD

Useful Conversion Factor 1440 gpd = 1 gpm

Example: Convert 144,000 gpd to gpm

144,000 gpd = 144,000 / 1440 = 100 gpm

A flow meter indicates a flow rate of 4.5 gpm. How much water will flow in 2.5 days?

4.5 gpm x 1440 min/day x 2.5 days = 16,200 gals

41

Determining Chemical Concentrations using the Pound Method

PARTS PER MILLION or PPM is the Pounds of Chemical added to One Million Pounds of Water.

A PPM is also exactly equal to a mg/l. This convention allows us to directly convert from English to Metric units.

PPM = mg/l = Pounds of Chemical
(8.34 x Million gal. of water)

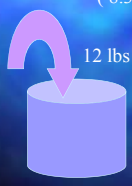
42

Chemical Dose Calculation Example

Determine the chemical dose in mg/l (or PPM) for 12 lbs of chlorine added to a 750,000 gallon tank.

MG/L = Pounds of Chemical Added

(8.34 lbs/ gal x Millions of gallons of water)



12 lbs Chlorine

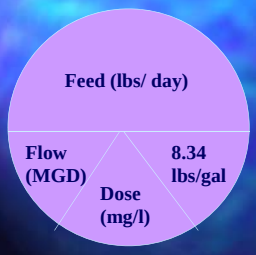
$$\frac{12 \text{ LBS}}{8.34 * 0.750} = 1.9 \text{ MG/L}$$

$$\frac{750{,}000}{1{,}000{,}000} = .750 \text{ MG}$$

43

Chemical Dose Wheel

Feed = Flow x Dose x 8.34



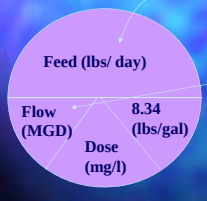
Use of Wheel

1. Identify the two variables that are given eg. Feed, Dose or Flow
2. Cover variables that is needed.
3. Divide the what is below the line into the variable that is on top of the line.
4. If all are below the line then multiply the three triangles together.

44

Example Chemical Dosing Wheel

Feed = Flow x Dose x 8.34



Chlorine is being added at 10 lbs per day. The average daily demand in the water system is 0.5 MGD. What is the dose rate in mg/l ?

Divide top "Feed" by bottom "Flow" and "8.34" to find the Dose (mg/l)

$$\text{Dose (mg/l)} = \frac{\text{Feed (10 lbs//day)}}{\text{Flow (0.5 MGD) x 8.34 lbs /gal}}$$

Dose (mg/l) = 2.4 mg/l

Divide Top by #'s Below to get Answer

45

How much water (in gals) must be disinfected in a new 24-inch diameter water main 5,280 feet long?

Pipe volume, gal = area x length x 7.48 gal/ft^3

Pipe volume, gal = .785 x 2' x 2' x 5280' x 7.48

Pipe volume, gal = 124,012 gal

46

Using the answer on the previous slide how many pounds of chlorine gas is needed for a 2.0mg/l solution?

Using dose wheel calculate feed in lbs of chlorine needed:

Feed, lbs = .124 M gal x 2.0 mg/l x 8.34 lbs/gal

Feed, lbs = 2.1 lbs

47

A basin holds 103,403 gallons of water, how much HTH (65% chlorine) must be added to reach a 1.5 mg/l solution?

Using the dose wheel formula:

Feed = (Flow, mgd x dose, mg/l x 8.34 lbs/gal)/purity

Feed = (.1 x 1.5 x 8.34)/.65

Feed = 1.92 lbs

48

Percentages

A percentage is a fraction of two numbers multiplied by a hundred. To calculate the percentage, divide the smaller number by the bigger one and multiply by one hundred.

- A water plant produces 875,000 gallons of water per day and has unaccounted water loss of 200,000 gallons. What is the percentage of water loss?
- Percentage = 200,000 / 875,000 = .229 or 22.9%

49

Normal Water Use per Person with and without Irrigation

Average use (no irrigation)	100 gpd
Average use (with irrigation)	150 gpd
Peak use	250 gpd
Average people per household	3.2

50

Computer Based Examinations

1

Overview

Drinking Water and domestic Wastewater Treatment Plant Operator Examinations

- Composed of four levels – Class A, B, C, and D
- Class A, B, and C
  - Time allocated is three hours
  - 100 multiple choice questions
- Class D
  - Time allocated is two hours
  - 50 multiple choice questions

Water Distribution System Operator Examinations

- Composed of four levels – Class 1, 2, 3, and 4
  - Time allocated is two hours
  - 50 multiple choice questions

2

Examination Process

- Submit application to DEP for review and approval
- Notified of approval in writing and given a unique ID number
- Contact AMP via internet or phone to schedule
- Administered at AMP Assessment Centers
  - Typically at H&R Block offices
  - Administered Monday through Saturday

3

What to Bring and what not to Bring to the Examination Site

- What to Bring
  - Two forms of identification
  - Only keys and wallets are allowed
- What not to Bring
  - Cameras, recorders or cell phones
  - No personal items
  - No pencils or scratch paper (to be provided)

4

The Exam

- Exam is 50 questions
- Two hours to complete
- Candidates will receive an on-site score report
- Minimum passing score is 70%
- Candidates that fail to achieve a passing score must wait at least 60 calendar days before they will be permitted to retake their exam

5

Good Luck!

6

Water Distribution Facilities

Florida Rural Water Association 1

Water Distribution System Module Objectives

- Explain the purpose of WDS
- Understand Basic Hydraulics of WDS
- Explain the Purpose of Dist. Storage and Pumping
- Identify Pipe and Material Standards
- Recognize Proper Pipe Installation Procedures
- Identify the Major Components of Water Loss
- Identify and Test Water Meters

Florida Rural Water Association 2

Purpose of Water Distribution System

- Deliver Adequate Quality and Quantities of Water
- At Sufficient Pressure
- At all Times
- Under Changing Conditions

* These are accomplished by proper System Design and Maintenance

Florida Rural Water Association 3

Operational Components of a Water Supply System

- Wells properly designed to meet Design Average Daily Demand (with largest well out of operation) and preferably the Design Maximum-day Water Demand
- Constructed of Approved Materials
- Provides Storage to meet Peak Demands
- Identify where Water is Consumed using Meters
- Provide Water for Fire Protection (in some instances)
- Maintains Adequate Disinfection Residual (at least 0.2 mg/l free or 0.6 mg/l combined)
- Maintains Adequate Pressure (at least 20 psi at all points)
- Record the Locations of Valves and Hydrants
- Flush Sediments and Bacteriological Growths from System

Florida Rural Water Association 4

Water System Hydraulics

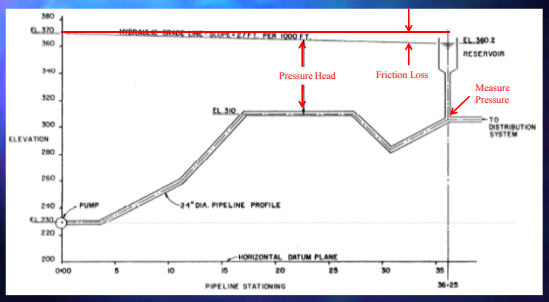
Florida Rural Water Association 5

Distribution System Hydraulics

- The major hydraulic concerns are:
  - Whether water will flow, and
  - In what direction will the water flow
- Available pressures are also of concern:
  - Normal working pressure in the distribution system should be ~ 60 to 80 psi
  - The desired minimum working pressure is 35 psi while 20 psi at the delivery point is minimum
  - Excessive pressure, >100 psi, could damage customer facilities and fixtures

Florida Rural Water Association 6

Significance of Water Storage and Hydraulic Grade Line



Basic Hydraulic Formulas

- Pressure or the energy available is equal to the elevation difference from the ground to the water in the tank.

  Pressure (psi) = Elevation Diff (ft) \ 2.31

- The flow in a pipeline at any point in the system is equal to the velocity of the flow times the cross sectional area of the pipe.

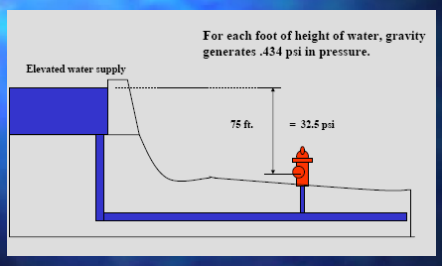
  Q (cfs) = V (fps) x A (sft)

- Total Dynamic Head (TDH) is the energy needed to pump water through the system (to overcome elevation and friction).

  $TDH = H_S + H_D + H_F + V^2/2g$, where
  H_S = suction lift
  H_D = discharge head
  H_F = friction head
  $V^2/2g$ = velocity head

8

Pressure Measurement in a Water Distribution System



Florida Rural Water Association 9

Overcoming Friction

- Pipe Friction will vary with the square of the velocity; valves, fittings and bends also cause friction
- To minimize friction losses
  - We use looped water systems
  - We also place water storage tanks at center of demand centers
  - Dead end lines should be avoided because friction losses will be maximum
  - Use larger pipelines for appropriate

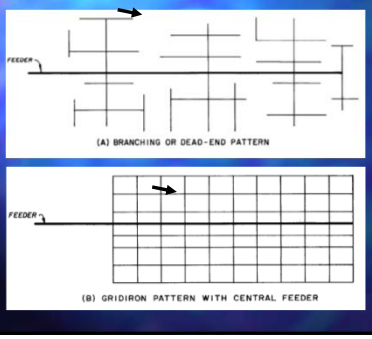
Florida Rural Water Association 10

Pipeline Categories

Water Pipes
There are three major components of a water piping system:
1. Primary feeders (transmission mains) – water mains that are usually owned by a utility. Sizes vary from 12" to 60" in diameter
2. Secondary feeders – network of intermediate size pipes that interlace a grid system, Sizes no smaller than 12" in diameter.
3. Distributors – pipes that serve consumer blocks and feed individual hydrants. Sizes should be no less than 8" and 12" on principal streets.

11

Types of Water Distribution Hydraulic Configurations – Dead-end and Looped



- Dead-end
  - flow in one direction
  - Higher friction
- Looped
  - Flow from multiple directions
  - Lower water velocities means less friction
  - More efficient flow

12

Computing Friction Loss in Pipelines

$$V = 0.55\ C\ D^{0.63}\ S^{0.54}$$

$$Q = 0.433\ C\ D^{2.63}\ S^{0.54}$$

$$S = \frac{2.32Q}{C\ D^{2.63}}^{1.85}$$

$$V = 1.318\ C\ R^{0.63}\ S^{0.54}$$

where:

- V = velocity of flow in feet per second
- C = coefficient of roughness
- D = diameter of pipe in feet
- S = head loss in feet per foot of length
- Q = flow in cubic feet per second
- R = hydraulic radius in feet

Pipe Material	C
Concrete (regardless of age)	130
Cast iron:	
New	130
5 years old	120
20 years old	100
Welded steel, new	120
Wood stave (regardless of age)	120
Asbestos-cement	130
Plastic (PVC, Fiberglass)	130

Charts are Typically Used to Determine Friction Loss

Pipe Friction Greatly Influences Carrying Capacity

GPM (8" Pipe)	Velocity (fps)	Loss / 100 ft Feet	= PSI
400	2.55	0.30	0.1
600	3.83	0.66	0.2
800	5.11	1.14	0.5
1000	6.38	1.76	0.8
1200	7.66	2.53	1.0
1400	8.93	3.40	1.5

Generally, pipeline is designed to carry water at between 2.5 and 5 feet per second.

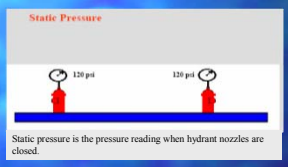
Valves and Fittings Friction in Equivalent Pipe (expressed in feet of pipeline)

Fittings or Appurtenances	Length of Pipe Diameters (d)
Gate Valve	
¾ Closed	900
½ Closed	160
¼ Closed	35
Full Open	13
Angle Valve Open	170
Globe Valve Open	340
Swing Check Valve	80
Elbows	
90° Standard	30
90° Long Radius	20
45° Standard	16

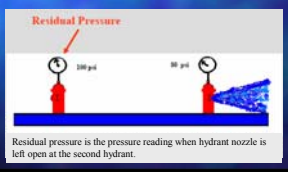
Fittings or Appurtenances	Length of Pipe Diameters (d)
Tee Flow Through Run	20
Standard Tee Take-off	75
Run of Tee Reduce one-Half	32
Sudden Contraction	75
d/D – 0.25	15
d/D – 0.5	12
d/D – 0.75	7
Sudden Enlargement	
d/D – 0.25	32
d/D – 0.5	20
d/D – 0.75	19
Entrance to Basin	75

For an 8 inch, ½ closed gate valve: 160 x (8/12) = 107 feet of equivalent pipe

Pressure/Friction Relationships in a Water Distribution System



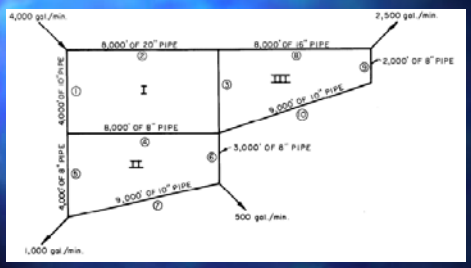
Static pressure is the pressure reading when hydrant nozzles are closed.



Residual pressure is the pressure reading when hydrant nozzle is left open at the second hydrant.

16

Water Distribution System Modeling



Florida Rural Water Association 17

Equivalent Pipes

Pipe Req / EQ Sz.	4”	6”	8”	10”
6”	2	1		
8”	6	2	1	
12”	18	6	2	2
16”	39	13	6	3

Note: Smaller diameter pipe increases velocity that increases friction

Florida Rural Water Association 18

Materials Standards and Construction of Water Distribution Systems

Florida Rural Water Association 19

Pipeline Systems

- Must Comply with the *Recommended Standards for Water Works* known as the "Ten State Standards"
- Pipelines and materials must meet AWWA Standards
- Pipelines are designed to carry a maximum velocity of 5 fps
- Pipelines must be restrained at changes in direction
- Pipelines require proper bedding and bedding material

Florida Rural Water Association 20

Additional Pipeline Requirements for Ten State Standards

- Water systems shall be designed to maintain a minimum pressure of 20 psi.
- Normal working pressure in water distribution system should be 60 to 80 psi and minimum of 35 psi
- Minimum diameter to supply a Fire Hydrant (FH) for fire protection = 6"
- Minimum size water main where fire protection is not provided = 3"
- Dead end mains shall be provided with means of flushing
- Valves should be located no greater than 500 ft in commercial and not more than one block in residential
- FH spacing ranges from 350 to 600 ft. depending on the area being served.

Florida Rural Water Association 21

Standards for Materials Used in Water Pipelines

- AWWA and ANSI/NSF Standards
- Cast Grey Iron Pipe or spun iron since 1920 (prior to 1948, no mortar lining)
- Ductile Iron Pipe (mortar lined, CI not used since 1960)
- Steel Pipe (welded joints)
- Reinforced Concrete Pressure Pipe
- Asbestos Cement Pipe
- Plastic Pipe (after 1970)

Florida Rural Water Association 22

Standards for Pipe, Fittings, Valves, Hydrants and other WD Appurtenances

Standards for Pipe, Valves and Fittings are found in AWWA C100 thru C900 Series

Most common pipe in use today

AWWA Amount of Pipe in the Ground	
CI Unlined	19%
CI Lined	17%
DI Lined	22%
Asb. Cement	15%
PVC	15%
Steel	5%

Florida Rural Water Association 23

Comparison of Plastic (PVC) and Ductile Iron (DI) Pipe

PVC Pipe C-900 & 909 (CL 200 and 150 DR 18)

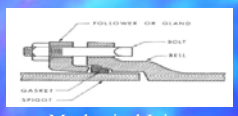
- Used in 4" – 12" installations
- PVC is lighter thus easier to install
- Low friction head
- Not subject to corrosion
- Less costly

DI Pipe C-151 (CI-50)

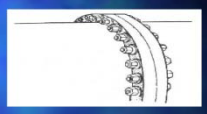
- Used in 4 to 36" installation
- Can withstand heavy external loads
- Provides extra surge allowances
- Used under roads and crossings of water courses

Florida Rural Water Association 24

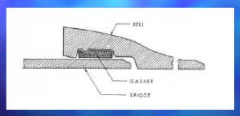
Joining Methods for Water Pipelines



Mechanical Joint



Flanged Joint



Slip Joint (elastomeric seal)

Bells placed in direction of work and Up when going downhill.

Note: Inspect pipe for debris and cleanliness before placing in trench

25

Repairing Small Leaks

- Bell joint clamp
  - Repairs leaks in cast-iron bell and spigot caulked or rubber ring joints
- Pipe clamp
  - Repairs pinholes, cracks, bruises, fractures, holes, and other damage in any type of pipe

Florida Rural Water Association 26

Pressure Testing of New Water Mains

(AWWA Standards for each type of pipe material)

Pipe Material	Pipe Length/ Section (ft)	Test Pressure (psi)[a]	Leakage (GPD/mi-in)[b]
Asb. Cement	13	150	30
Ductile Iron	18	150	23.3
PVC (6" and 8")	-	150	1.45[c]/1.88[d]

[a] Test Pressure > Operating Pressure + 50% or 150 psi whichever is higher
[b] Allowable leakage in gallons per day per mile of pipe per inch of diameter
[c] Allowable leakage is 1.45 gph for each 100 joints for six-inch pipe
[d] Allowable leakage is 1.88 gph for each 100 joints for eight-inch pipe

Water Pressure to be maintained at 150 psi for 4 hrs and Volume of Water to Refill Pipe is Recorded.

27

Procedures for Testing Newly Installed Watermains

- Typically tested after trench is partially backfilled
- Pipeline valved sections are filled with water
- Air is released through corporation stops or FHs and all air must be removed
- Pipes should be filled at < one foot of pipe length per second (eg. 0.785 D^2 x 1 fps)
- Sit for 24 hours filled with water
- Test is conducted for 4 hours at min. 50% > operating pressure or 150 psi whichever is greater
- Amount of leakage to refill the pipe is measured with meter and compared with AWWA allowance

Florida Rural Water Association 28

Actual Leakage Calculation

- Leak tests for asbestos-cement and ductile-iron pipe report results in gallons of water leaked per day per mile of pipe length per inch of pipe diameter

$$\text{Actual leakage (GPD/mi-in)} = \frac{\text{Leak Rate, GPD}}{(\text{length, mi})(\text{Diamter, in})}$$

- Leak tests for plastic pipe report results in gallons per hour for each 100 joints of pipe

$$\text{Actual leakage (GPH/100 Joints)} = \frac{\text{Leak Rate, GPH}}{\text{Number of Joints/100 Joints}}$$

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A two-mile section of 12-inch diameter water main is being filled with water for a leakage test. If the pipe is filled at a flow rate of one foot of pipe length per second, what should be the maximum flowmeter reading in gallons per minute for filling the pipe?

- First determine the maximum allowable flow in cfs
- Q = VA = 1 fps x .785 x $(1\text{ ft})^2$ = .785 cfs
- Next determine the maximum flowmeter reading in gpm
- Q = .785 ft^3/sec x 7.48 gals/ft^3 x 60 sec/min
- Q = 352 GPM

Florida Rural Water Association 30

The normal operating test pressure is 110 psi. At what pressure should the pipe be tested if the test pressure is 50% higher than the normal expected operating pressure or 150 psi, whichever is larger?

- Test pressure, psi = Normal + 50% or 150psi
- Normal pressure = 110 psi
- Normal plus 50% = 110 psi + 55 psi = 165psi
- Use a test pressure of 165 psi because it is greater than the 150 psi

31

A 12-hour leak test is performed on 1,000 feet of 12-inch ductile iron pipe with a test pressure of 150 psi. The pipes are 18 feet long. According to the table on slide 25, the allowable leakage is 23.3 gallons per day per mile of pipe per inch of diameter. During the 12-hour test period, 30 gallons of water were added to maintain the 150 psi pressure. Did the pipe pass the leak test?

Calculate leakage rate = Volume, gals/Time, days
Leakage rate = 30 gals/0.5 days = 60 gpd

Convert pipe length from feet to miles
Pipe length, mi = 1,000 ft/5,280 ft/mi = 0.189 mi

Determine the actual leakage gpd/mi-in = leak rate, gpd/(length, mi)(diameter, in)
Actual leakage = 60 gpd/(0.189 mi)(12 in) = 26.45 gpd/mi-in

Does the pipe pass the leak test?
No. Since the actual leakage rate was 26.45 gpd/mi-in which is more than the allowable leakage rate of 23.3 gpd/mi-in, the pipe did not pass the test.

32

Pipes Used for Service Lines

	Pipeline Type	Pipe Considerations
1	Galvanized Steel Pipe	Susceptible to Corrosion & Tuberculation
2	PVC (schedule 40; thick wall, glued joints)	Susceptible to affects external Organic Solvents
3	Polybutylene (compression or banded Joints)	Susceptible to affects of Chlorine
4	Copper (Type K; soft and Type L; hard)	Susceptible to Internal and External Corrosion

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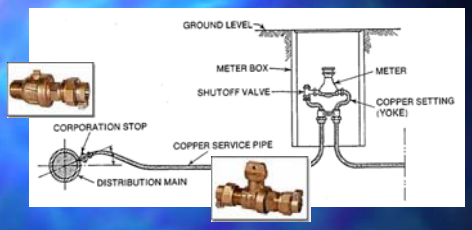
Installation of Service Lines



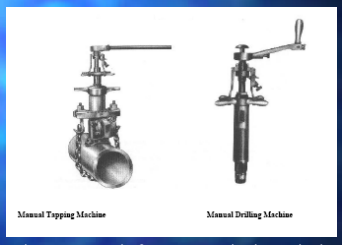
Service Installation : 1) Corporation Stop and 2) Curb Stop or a Meter with a Shutoff Valve

Corporation Stop – A water service shutoff valve located at a street water main. This valve cannot be operated from the ground surface because it is buried and there is no valve box.

34

Tapping Water Mains

Typical Tapping Saddle



Note: Tapping a water main for a new service is required to be recorded in the distribution O&M log book.

35

Steps to insert a tap into a main under pressure

- Excavate down to an around the main (install shoring if necessary)
- Clean the main
- Install saddle and tapping equipment
- Combined drill and tap used to drill the hole
- Insert the tap
- Corporation stop installed
- Service line connected

Florida Rural Water Association 36

Pipe Plug Assembly Coupons

- A steel specimen inserted into water to measure the corrosiveness of water
- Can be periodically removed, examined, weighed, and photographed
- Can be used to determine the rate of corrosion

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Installation of Water Main

Florida Rural Water Association 38

Separation Distances for Water Mains from Other Facilities

Type of Pipeline	Horizontal or Vertical Separation Req'd
	Horizontal
Storm sewer, stormwater force main, or regulated reclaimed water	3'
Vacuum sanitary sewer	Minimum 3' Preferred 10'
Gravity or pressure sanitary sewer, wastewater force main, unregulated reclaimed water	Minimum 6' Preferred 10'
On-site sewage treatment and disposal system	10'
	Vertical
Gravity or vacuum sanitary sewer or storm sewer	Minimum 6" above, preferred 12" above or at least12" below the outside of the other pipe. Preferred above

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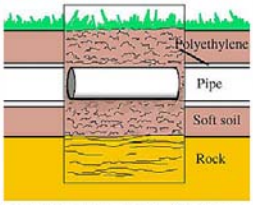
Pipeline Installation



DI Manf's specify that all DI pipe be wrapped in PE to inhibit corrosion

Pipe bedding is designed to cushion the pipe. Soft soil surrounds the pipe to prevent rocks and other hard objects from causing leaks.

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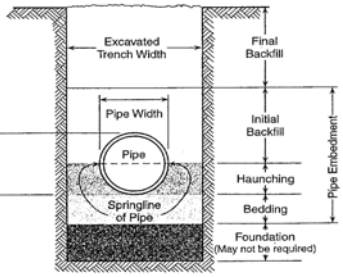
Standard Pipe Bedding for Water Mains

Note:

Rocks or Clay in backfill can result in damage



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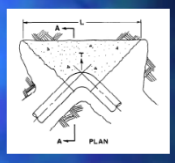
Thrust Blocks for Watermains

At bends: $T = 2\pi r^2 p$; min $\Delta/2$

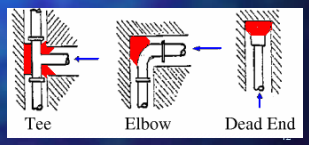
At deadends or branch: $T = \pi r^2 p$

Where:

T = thrust in pounds
R = radius of pipe joints in inches
P = water pressure in psi
Δ = bead deflection angle



Thrust Blocks are needed at every bend and transition to keep pipe from separating and are sized by the pressure and type of soil. They must extend to the undisturbed soil.



Mechanical Joint Restraints an Alternative to Thrust blocks

- Eliminates the need for thrust blocking
- Easy to install
- Flexible
- Saves time and money

Florida Rural Water Association 43

Placing New Watermains into Operation

Requirements for new watermain only

- Must have permitted capacity
- Must not be in petroleum or organic solvent contaminated areas
- No portion may remain dry
- Must be permitted, designed by PE
- Must disinfect, obtain approval from DEP, and document as-built record

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Water Distribution Work that does not require DEP Permit

- Replacing watermain with ≤ 2 sizes at same location
- Relocation to accommodate utilities
- Work on structures or alarm system
- Maintenance or repair work on watermains
- Maintenance work on FHs or System Valves
- Installation or alteration of valves, FHs or BFPs

Florida Rural Water Association 45

Water Meters

Metered Water System

One in which meters are used at all strategic points in the system.

- Main supply lines
- Pumping stations
- Reservoir outlets
- Connections to other utilities
- Each customer's service

Metering Benefits

- Bill customer for exact amount used
- Amount of water produced can be determined
- Losses can be detected
- Prevents waste through excessive use
- Provide accurate blending of water
- Show how efficiently system operating

Meter Selection Criteria

- Ability to measure and register your anticipated flow levels
- Ability to meet required capacity with minimum head loss
- Durability
- Ruggedness
- Precision of workmanship
- Ease of repair
- Availability of spare parts
- Free of irritating noise
- Reasonable price
- Manufacturer with a good reputation

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Meter Types

- Displacement Meters (Small flow)
  - Nutating-disc
  - Piston
- Velocity Meters (Large flow)
  - Multi-jet
  - Propeller
  - Turbine
  - Venturi
  - Orifice plate - Insertion Meters
  - Electronic Meters
- Compound Meters (Combination)

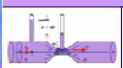
50

Types of Water Meters

Positive Displacement (Oscillating piston and nutating disc)	Most commonly used meter in residential and small commercial applications. Accurate at low flows.
Multi-jet	Are very dependable meters and have a relatively low loss of head.
Propeller	Not designed for low flows or stop-and-go operation. Useful in measuring continuously high flows and has low friction loss.
Turbine	Used in industrial and commercial applications as well as for raw water supply. Best applied where flow is fairly constant. Useful in measuring continuously high flows and has low friction loss.

51

Types of Water Meters

	Venturi	Doesn't interfere with flow of water if meter fails. Accurate over a large flow range and causes little friction loss.
	Orifice plate	Less expensive than venturi meters, occupy less space, but have more severe pressure losses and less reliable.
	Electronic	Highly accurate and no head loss. However, they are affected by anything that distorts flow like elbows, valves, and pumps. Allow at least 10 pipe diameters between obstruction and flowmeter
	Compound	Composed of two meters (turbine and displacement. Used in commercial and industrial applications. Advantageous when flow fluctuates widely. Large, cumbersome and expensive.

A displacement meter (nutating-disc) is installed on a residential service line. What is the head loss in feet through the meter if the pressure loss is 1.3 psi?

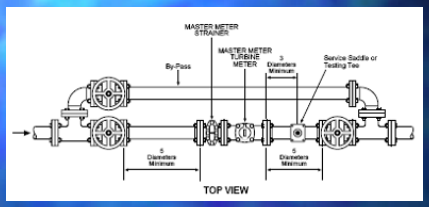
- Convert the pressure loss from 1.3 psi to feet
- Head loss, ft = (Head loss, psi)(2.31 ft/psi)
  = (1.3 psi)(2.31 ft/psi)
  = 3 ft

Florida Rural Water Association 53

Water System Meter Applications

Type of Meter	Type Application	Sizes	Flow Type	Flow Range GPM	Accuracy All Ranges
Displacement Meters	Residential and Small Commercial	5/8" ¾" 1" 1½" 2"	Intermittent Flow	1-20 2-30 3-50 5-100 8-160	Continuous flow at max. rate is 50% of rated value
Multi-jet Meters	Residential and Commercial Irrigation	5/8" ¾" 1" 1½" 2"	Intermittent Flow	1-20 2-30 3-50 5-100 8-160	
Propeller	Raw (dirty) Water Measurement	3" to 36"	10:1 Flow Range	Varies	+/- 2%
Turbine Meter	Commercial and Industrial	1½" 2" 3"	100:1 Flow Range	4-120 4-160 5- 350	+/- 1.5% (Intermittent flows at 25% above max.)
Compound	Wholesale Customers	Varies	1000:1 Flow Range	Varies	+/- 1.5%

Turbine Meters



Turbine Meters must be provided with 5 pipe diameters laying length from valves or Tees.

If no Strainer is used 7 – 10 pipe diameters upstream recommended and 5 downstream.

55

Domestic Meter Testing AWWA C700

5/8	Flow Range	Flow Rate GPM	Accuracy Range	
			Low	High
1.	Max. Rate	15 GPM	98%	101.5 %
2.	Int. Rate	2 GPM	98%	101.5 %
3.	Low Rate	1/4 GPM	95%	101.0 %

Note: Because of their range of water use, domestic and compound meters should be tested in the low, intermediate and high flow ranges to arrive at a cumulative accuracy.

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Meter Service Life

5/8" Meter Normal Use 7 – 15 years
5/8" Meter High Use 5 - 7 years
> 5/8" Meter Normal Use 7 - 10 years

* **Meters should be tested on both life span and registered consumption**

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Testing Water Meters

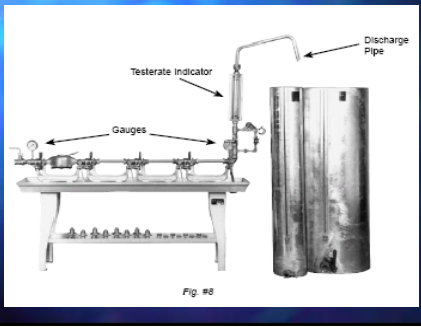

Fig. #8

58

Leaks in Water Mains

- Lost Revenue (typical $5.00/1,000 gallons of water and $10-$15/1000 sewer)
- Chemical and Electrical Costs at Water Plant (typical 66% of cost)
- Capital Cost for System Upgrades (from $3M to $5M per MGD)

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Leaks in Water Systems (Water Loss @ 60 psi)

Leak Size	Gallons/Day	Gallons/Month
1/8 "	300	11,160
1/4 "	3,096	95,976
3/8 "	8,424	261,144
1/2 "	14,952	463,512

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Water Loss and Unaccounted for Water

- **Typical Water System < 10% loss is acceptable** (remember there is acceptable leakage proportional to psi)
- Meter Comparison Used to Calculate Efficiencies
- Unaccounted by Authorized Losses are Estimated
- > 10% loss indicates problem

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A pump produces 750,000 gallons a day and 125,000 gallons are unaccounted for. What is the percentage of water loss?

Percentage is equal to water loss divided by the water produced.

Percentage = 125,000/750,000 = 16.7%

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Estimating Water Losses

Fire Fighting	Errors; Record Keeping
WM Flushing	Water Credits
Landscape/Street	FH Testing
Construction Uses	WM Breaks
Storage Tank Cleaning	Service Line Breaks
Flushing Valves	

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Non-Authorized Water Losses

- Inaccurate Water Meters
- Water Main Leaks
- Open Flushing Valves
- Water Theft

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Identifying Leaks in Water Mains

- Customer Complaints
- Physical Inspections
- Standing Water in Dry Periods
- Continuous Flow in Storm Sewers
- Ponding in Low Areas
- Use of Leak Detection Equipment

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GPR Pipe Locator

Can Locate both geographic location (newer models equipped with GPS) and Depth

Can distinguish between types of pipelines

Units have difficulty in saturated soils

Very good accuracy in 5 – 12 ft. depth range

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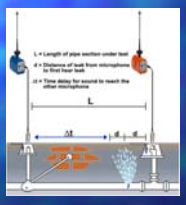
Use of Leak Detection Equipment



- Leak Detectors use sound waves to detect the leak
- Best in areas with low traffic
- Correlation units are used in tandem to and measure travel time of sound waves.
- Correlators can pinpoint leaks with an accuracy of several inches.

Florida Rural Water Association 67

Water Storage Systems

1

Water Storage Module Objectives

- Identify the basic Principles of Well Pump Operation
- Identify the Types of Water Storage Facilities
- Identify Water Storage Inspection Techniques
- Identify the Requirements for Storage Startup
- Operate and Maintain a Water Storage Tank
- Identify Proper Corrosion Protection
- Sample Storage Facilities
- Disinfect a Storage Tank
- Understand Proper Storage Tank Maintenance Procedures

2

Brief Review of Well Systems for Water Distribution System Operators

3

Types and Uses of Well Pumps

Turbine Pumps
Most Commonly Used
Single Stage < 28′
Multi-Stage 50 – 300′

Submersible
moderate head & flow
(smaller water systems)

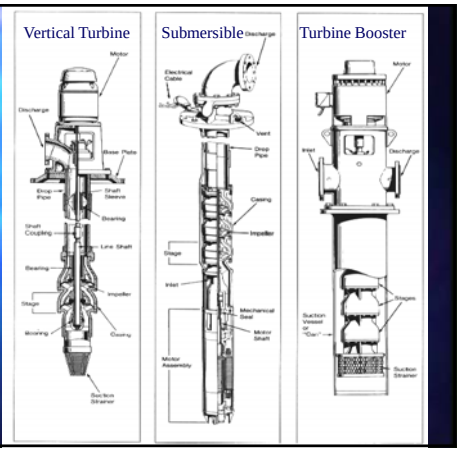
Vertical Turbine
high head and high flow
(larger water systems)

Positive Displacement
Shallow ~ 25′
Deep ~ 600′
Limited to ~25 GPM

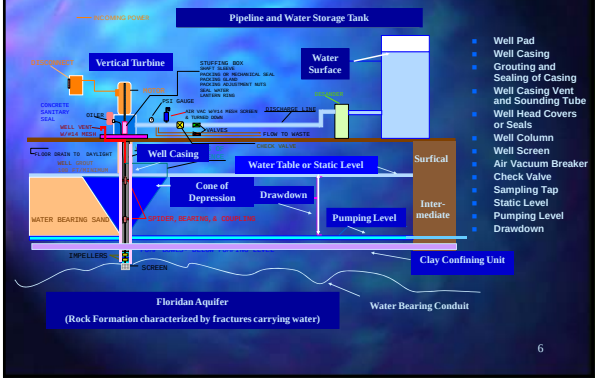
Jet Pumps
Shallow ~ 20′
Deep 50 - 200′
Generally limited to small capacities < 50 GPM

4

Turbine Well Pumps



Component Parts and Operation of a Well



- Well Pad
- Well Casing
- Grouting and Sealing of Casing
- Well Casing Vent and Sounding Tube
- Well Head Covers or Seals
- Well Column
- Well Screen
- Air Vacuum Breaker
- Check Valve
- Sampling Tap
- Static Level
- Pumping Level
- Drawdown

6

DEP Well Site Protection and Security Requirements

- Area around well must be fenced, clean, and free of debris
- No hazardous materials can be stored on-site
- Minimum Setbacks from a sanitary hazard such as a sanitary sewer or residential septic tank must be at least 100' (sewage flow ≤2000 gpd)
- Unauthorized entry, sabotage, or suspicious incident shall be reported to the State Warning Point immediately (within 2 hours) of discovery.
- Shall be reported to DEP in the MOR.

7

Water System Well Capacity Requirements

- Total well capacity connected to a water system using only ground water shall equal at least the system's design maximum water demand (including design fire-flow if fire protection is provided)
- CWS serving or design to serve 350 persons or 150 connections the total well capacity with the largest well of operation shall equal at least the design average daily water demand and preferably the design maximum-day water demand
- A minimum of two wells must be provided.

8

Water System Auxiliary Power Requirements

- Community systems with 350 or more people, or 150 or more connections shall provide auxiliary power for the operation of the source and treatment at a rate at least equal to the average daily demand.
- Auxiliary power shall be equipped with automatic startup unless 24 hr., 7 days per week supervision is provided.
- Auxiliary power shall be operated at least once per month.
- Requires an audio-visual alarm system.

9

Distribution System Capacity Summary

- All Wells can be used to supply peak demand (occurs on highest demand day of the year)
- Wells must meet average demand with largest out of service
- Typically this assurance will require an engineering hydraulic network analysis
- The water system must provide 20 psi minimum pressure under all conditions
- In Small Water Systems pressure is supplied by wells connected to a hydro-tank
- In larger Water Systems Distribution Storage is often necessary

10

Water Storage for Water System Operators

11

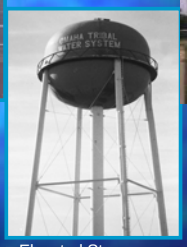
Water Storage Tank Types, Applications and Operational Controls

- Gravity or Elevated Tanks are located near center of demand with the maximum tank level controlled by an altitude valve.
- Ground Storage Tanks are often located near point of water production and level controlled by level sensor to a pump.
- Hydropneumatic Tanks are supplied at smaller water systems and controlled by pressure sensors.

12

Water Storage Tanks

Ground Storage
Very high volumes of water at low head



Elevated Storage
Moderate Volumes at High head

Hydropneumatic
Low volumes of water at high head.

13

Purpose of Water Storage

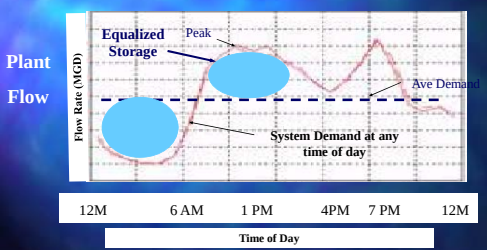
In selecting and evaluating a tank, storage capacity must be matched to the _____ of the system?

Peak Demand

- Storage is provided to meet the peak demand placed on a water system
- Moderate the extreme changes in Water Demands that occurs in a Water System
- Storage tanks also provide surge protection to water distribution systems

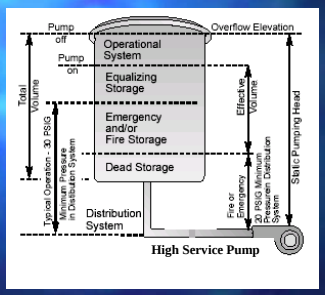
14

Diurnal Flow Pattern



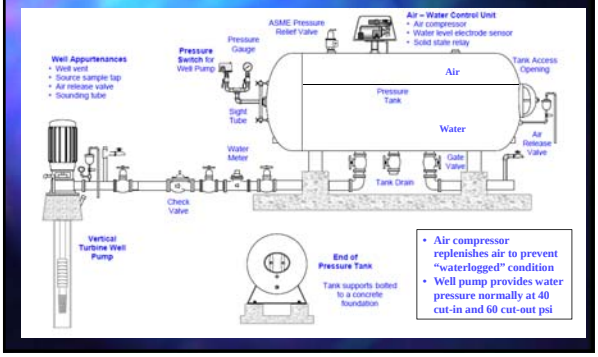
15

Schematic Illustrating the Benefits of a Storage Tank



16

Conventional Hydropneumatic Tank



Hydropneumatic Tank (cont.)

A hydropneumatic tank serves three main functions:

- Delivers water within a selected pressure range.
- Prevents a pump from starting up every time there is a minor call for water.
- Minimizes pressure surges (water hammer).

If a pressure tank becomes waterlogged (tank filled with water), the motor cycles on and off too frequently (more than six times an hour). This leads to:

- Higher energy costs.
- Inefficiency.
- Equipment failure.

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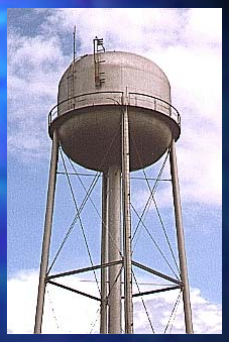
Benefits of Elevated Tanks

- Provides water to meet peak demands.
- Stabilizes distribution system pressures.
- Keeps pumps from cycling and operating in efficient ranges.

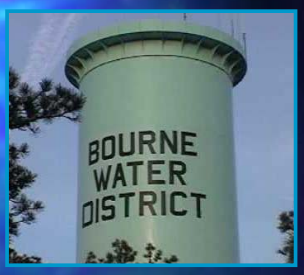


19

Standpipe

Used for Surge protection in water systems

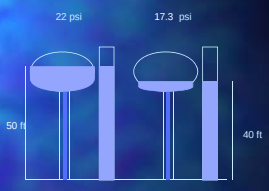
Some are fitted with pumps to allow water to be used for fire protection



20

Elevated Tank and Standpipe Comparison

- Used to provide pressure head to the distribution system.
- Large storage capacity
- Shallow tanks with large diameter are preferred over deep one with small diameters.



Pressure = Water Elevation (ft) * Water Density (lb/ft) * (1 ft2/ 144 in2)

Where:
Water Density = 62.4 lb/ft^3

21

How to Use Head Pressure to Calculate Tank Height

This calculation can be used to compute the height of water in a tower without climbing it.

- Water head pressure is static pressure caused by the weight of water solely due to its height above the measuring point.
- The pressure at the bottom of a 40-foot lake or a 40-foot high thin tube would be identical, since only height is involved.

Density of Water $= \frac{62.4\ lb}{ft^3} = \frac{62.4\ lb}{ft^3} * \frac{1\ ft^2}{144\ in^2} = \frac{0.433\ lb}{in^2 - ft}$ or $\frac{0.433\ psi}{ft}$

Therefore:
1 ft of water = 0.433 psi
2.31 ft of water = 1 psi

Given a pressure of 17.3 psi what is the water elevation?

Water Elevation (ft) = Pressure $* \frac{2.31\ ft}{psi} = 17.3\ psi * \frac{2.31\ ft}{psi} = 40\ ft$

22

Summary of the Advantages Offered by Elevated Tanks

1. Less variation in pressure
2. Available water for fire fighting
3. Storage to meet peak demands
4. Allows use of lower capacity wells
5. Cycling of well pumps is reduced
6. Wells can be better matched to average water demand
7. High service pumps and the treatment plant can operate more efficiently

23

Troubleshooting Water Quality Problems in Elevated Storage Tanks

24

Tastes and Odors

- Probable Cause – high/low chlorine residual or bacterial growth
  - Low velocity or stagnant water allows suspended matter to settle and eat up Cl residual, allowing bacteria to grow
  - Bacteria convert inorganic and organic substances found in the water to more bacteria
- Likely Solution – flush tank and lower/raise CL dose

25

Turbidity

- Turbidity – the cloudy appearance of water caused by the presence of suspended and colloidal matter
- Probable Cause – colloidal matter, calcium carbonate or precipitated iron/sulfide
  - Pipeline repairs
  - Treatment plant upset (filter breakthrough)
  - Water tank problems
- Likely Solution – flush tank, flush mains or adjust treatment

26

Color

Probable Cause – Vegetative decay or bacteria

- Dissolved Organic material entering the system
- Inadequate treatment

Likely Solution – flush tank, flush mains or adjust treatment

27

Coliform

Probable Cause – contaminated water distribution system

- Contaminants in the distribution system
- Faulty seals
- Leakage points
- Unprotected vents
- Backsiphonage

Likely Solution – backflow prevention, raise Cl dose and flushing

28

Troubleshooting Water Quality Problems in Elevated Storage Tanks

Problem	Probable Cause	Likely Solution
Tastes and Odors	- High/Low Cl residual - Algal or Bacterial Growth	- Lower/Raise Cl Dose - Flush Tank
Turbidity	- Colloidal Matter - Calcium Carbonate - Precipitated Iron/Sulfide	- Flush Mains - Adjust Treatment - Flush Tank
Color	- Vegetative Decay Bacteria	- Increase Cl dose
Coliform	- Contaminated WD System	- BFP, raise Cl dose, & Flushing

29

Maintenance Considerations for Elevated Water Storage Tanks

- Check for intrusion of Water
- Secure tank site from unauthorized access
- Clean Tank yearly recommended (DEP 5-yr. required by P.E.!) to prevent bacterial growth and nitrification
- Ensure that overflow structures are working, secure and properly drained
- Inspect Structures for Stability, Blockages and Surface and Internal Corrosion.

30

Ground Storage

- Used for storing large amounts of water.
- New Tanks must be Covered!
- Not under pressure uses transfer pumps to pressurize or pump to elevated tank.
- Aerators are often used for source waters to remove hydrogen sulfide prior to chlorination.

31

Troubleshooting Ground Storage Tank Problems

Problem	Likely Cause	Solution
Tastes & Odors	- Low/High Chlorine - Biological Growth - Sedimentation - Suspended Material	- Raise/Lower CL - Increase Chlorine - Flush - Flush/Adjust treat.
Turbidity 	- Calcium Carbonate - Precipitant Iron - Microorganisms - Floc Carryover - Air entrainment	- Adjust Treatment - Adjust Treatment - Increase Chlorine - Adjust Treatment - False turbidity
Color	- Vegetative Decay	- Increase Chlorine
Bacteria/coliform	- Cross Connection - Broken Main	- Eliminate - Flush and Disinfect

32

Factors for Microbial Colonization in Storage Tanks and Pipelines

- Source of Nutrients (found in sediments in dead-end lines, fire hydrants and water storage reservoirs)
- Protective Habitat (sediments and tuberculation)
- Favorable Water Temperature (warm temperature)
- Lack of Proper Disinfection Levels

33

Nitrification Cycle in a Water Storage Tank

- 1. Sediment and Deposits
- 2. High Temperature
- 3. Long Detention Time
- 4. Low Chloramine Residual
- 5. High Nitrite Levels (5 : 1 Ratio)
- 6. High Bacterial Counts (HPC> 500/ml)
- 7. Coliform Regrowth

34

Exterior Water Tank Inspection

- Check foundations for cracking, spalling (flaking), exposed reinforcing metal or settling
- Keep vegetation away from foundations
- Trim limbs that may scratch surfaces
- Look for rust stains that may indicate leaks
- Inspect vent and overflow screens for holes or debris
- Check for signs of overflow
- Check for signs of unauthorized entry
- Look for loose bolts/nuts
- Check for paint flaking
- Look for rotation of columns or tower

35

Interior Water Tank Inspection

1. Interior roof condition
2. Corrosion
3. Leaks
4. Silt depth
5. Cathodic protection system

36

Interior Tank Inspection Methods Employed

Dry Inspection

- The tank must be taken out of service
- The interior of the tank can (and should) be cleaned
- A lot of water is wasted
- The method has the greatest potential for tank worker injury
- It is the most expensive method
- Once drained, the tank must be disinfected before returning it to service

Wet Inspection

- The tank must be taken out of service
- There is no opportunity to clean the tank
- There is no wasted water
- There is less potential for personal injury to tank workers
- It is not as thorough method of inspection as dry method
- It is less expensive than dry method
- There are some sanitary concerns or
- Remotely Operated Vehicle.

37

AWWA Approved Methods for Disinfecting a Water Storage Tank

Method 1

- Fill tank with potable water that has been treated to provide a Chlorine residual of at least 10 mg/l after a contact time of :
  - For bleach and Tablets 24 hours
  - For Gas 6 hours

Method 2

- Spray or brush interior with 200 mg/l chlorine and let sit 30 min.
- California State Univ. also requires - Fill tank with potable water that has been treated to provide a Chlorine residual of 3 mg/l. Let stand for 3 to 6 hours.

Method 3

- Add enough chlorine to produce 50 mg/l of available chlorine with tank ~ 5% full. Let stand for not less than 6 hours.
- Fill tank and allow to sit for not less than 24 hours.

Note: all methods must pass bacteriological tests and chlorine residual must be reduced to acceptable limits, but not less than 2 mg/l, to enter distribution system.

38

DEP Requirements for Placing New or Existing Tank in Service

- Total Cl Residual must be conducted per DEP SOP 001/01
- Must be conducted by a certified lab
- Sampling Procedure
  - Reduce Total Chlorine Residual to < 4mg/l
  - 2 samples, separate days, 6 hours apart
  - Analyze sample for Total Res. CL & TC
  - If > 4 mg/l Total Res. CL or TC+, repeat
- For new construction, must notify appropriate DEP/ACHD office; for existing tanks report on next MOR
- If activities may lead to TC+, issue PBWN

39

The Eight Requirements of the Sanitary Survey per GWR

1. Source water
2. Treatment
3. Distribution system
4. Finished water storage
5. Pumps, pump facilities, and controls
6. Monitoring, reporting, and data verification
7. System management and operation
8. Operator compliance with State requirements

40

Finished Water Storage System Evaluation

EPA Priority Criteria that Affects Public Health

- Capacity of Storage Tanks
- Design of Storage Tanks
- Cleaning and Maintenance of Storage Tanks
- Site Security

41

Finished Water Storage Evaluation

Significant Deficiencies: inadequate internal cleaning, maintenance, improper screening of overflow pipes, drains and vents, failure to make necessary repairs to structure.

- Review Finished Water Storage Components
- Review Storage Operational Records
- Review Integrity of Storage Structure(s)
- Review potential sanitary risks
- Ensure that maintenance checks have been made

42

DEP Water Storage Deficiency Index

- Types of Storage including improper use of Hydropneumatic Tank for Fire Storage
- Location and Inadequate Capacity of Storage
- Improper Design of Vents and Overflow
- Corrosion resulting from paint deterioration
- Cleaning, Inspection and Maintenance
- Site Security

43

Review Finished Water Storage Components

- **Roof Sloped to prevent standing water**
- **No leaks in roof**
- **Lockable access hatch with raised curbs**
- **Vent on roof facing downward with screen**
- **Water measurement device**
- **Overflow at ground with flapper**
- **Piping that ensures circulation of water**
- **Drain to remove accumulated sediment**
- **Access ladder**
- **Inlet/outlet isolation valves**
- **Control and monitoring water level system**
- **Low and high water alarms**

44

Inspection of Hydropneumatic Tank Components

- Tank is located above ground
- Tank meets ASME standards with nameplate attached
- Access port for periodic inspection
- Pressure relief device with pressure gauge
- Control system for proper air/water ratio
- Site glass to determine water level
- Slow closing valves and time delay pump to prevent water hammer

45

Review of Finished Storage Operational Records

- Ensure periodic flushing of tank
- Perform periodic sanitary checks
- Ensure that tank is protected from corrosion
- Performance of storage tank Cl residual monitoring
- Ensure adequate storage disinfection provided
- Ensure that water is circulating and turnover is adequate
- Ensure that operating personnel are trained

46

Integrity Review of Water Storage Structures

- Check for Intrusion of Water
- Ensure that overflow structures are working, secure and properly drained
- Inspect Structures for Stability, Blockages and Surface and Internal Corrosion.

47

Sanitary Hazards Review of Water Storage Structures

1. Ensure that tank drain is plugged with flapper valve at outlet end
2. Ensure that vents are screened and that birds are not entering tank
3. Ensure that areas around access are secure from water intrusion
4. Ensure that hatches are secure and locked

48

Maintenance Checks for Finished Water Storage

- Does the tank appear structurally sound?
- Is inspection and cleaning performed at minimum every 5 years
- Is inspection performed by qualified PE?
- Is the paint coating inside and outside in good condition?
- Is the tank properly disinfected after maintenance is performed?

49

Storage Tank Security

- Is tank properly fenced and gated with lock?
- Is there evidence of intrusion under fence?
- Does the system make periodic security checks?

50

Pumps, Facilities and Controls Evaluation

EPA Priority Criteria that Affects Public Health

- Capacity of Pumps
- Condition of Pumps
- Pump Location
- Pump Security

51

Pumps, Facilities and Controls Evaluation

Significant Deficiencies: inadequate pump capacity, inadequate maintenance, and inadequate or inoperable control system.

- Ensure proper application of pumps and that they are in working order
- Ensure that pumps are in reliable condition from maintenance records and/or pumping records
- Ensure that monitoring and controls are properly functioning

52

Proper Application and Condition of Pumps

- What is average and peak system demand and are the well pumps and high service pump capacities able to meet the anticipated demand conditions per state requirements?
- Is information recorded for manufacturer, model, and serial number of pumps?
- Are all pumps operational?
- Is there excessive noise or vibration?
- Is there a preventative maintenance program in place?

53

Valves and Fire Hydrants for Water Distribution Operators

1

Water Distribution Valve & Fire Hydrants Module Objectives

- Identify the various Types of Valves and FH's used in WD
- Identify the applications of the various types of valves
- Review Maintenance problems that occur with valves
- Identify the Various types of Flushing Regimes used in Water Distribution
- Review proper procedures for setting up flow tests using Fire Hydrants
- Discuss Pigging in Water Systems

2

Types of Valves and Applications in Water Distribution

3

Each Type of Valve is Used for a Specific Application

Gate Valve

Globe Valve

Butterfly Valve

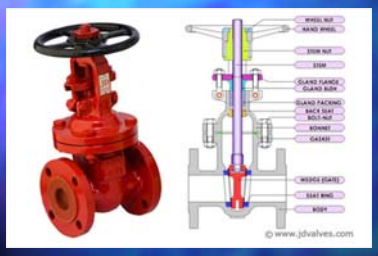
4

Valves and their Applications

Type	Application	Size	AWWA Standard
Butterfly (rotary)	Isolation and throttling. Water mains typically larger than 8". Have movable disc.	3" and up	C504 Rubber Seated Butterfly Valves
Ball (rotary)	Isolation. Used in water service lines to provide an on or off position.	6" and below	C507 6" – 48" and for pressures to 300 psi
Plug (rotary)	Isolation. Water service lines.	6" and below	
Globe (linear stroke)	Throttling. Efficient in either flow or pressure regulation	6" and below	
Gate (linear stroke)	Isolation. Most common valve in Dist. System. Should never be used for throttling.	3" and up	C500 3" – 48"

5

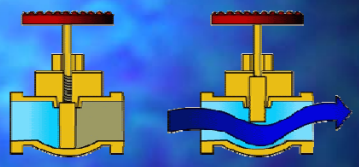
Gate Valves



- The most common valve used in Water Distribution.
- It must be left either open or closed.
- Its only use is for isolation.
- Cost effective in sizes from 3" to 12"
- Valve with lowest friction loss

6

Standard Rules of Thumb for Gate Valves



Valve Closed Valve Open

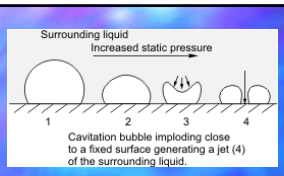
• To determine the number of turns to open or close a gate or butterfly valve multiply it's size by 3.

7

Butterfly Valves

- Butterfly Valves are generally used on 16" and larger mains.
- **An advantage is that they may be used for throttling as well as for isolation.**
- More economical than gate valves in larger sizes.
- Can be fitted with motorized operators

8



Cavitation Caused by Valve Closure

- Cavitation is caused when valve is left partially closed and inlet pressure drops rapidly across the valve causing gases to come out of solution.
- When the cavitation bubbles collapse, they emit shock waves
- Localized collapses can erode metals
- This situation causes the loss of pressure in the water distribution line.
- When cavitation occurs immediate action must be taken to prevent the valve from being damaged

9

Water Hammer Caused by Valve Closer

- Water hammer is caused by the rise and fall of pressure caused by the rapid change of a valve position.
- Pressure waves can be 4 to 5 times higher than static pressure (60 psi x 5 = 300 psi)
- Water hammer can cause pipes to rupture and damage equipment.
- This condition can be corrected by slowly opening and closing valves.
- In Water Distribution FH's closed rapidly are often a cause of water hammer leading to ruptures of distribution lines.

10

Use of Portable Hydraulic Valve Opener

Hydraulic Openers are often used for larger valves and valve exercise programs

Use of Hydraulic Openers

Large water distribution valves can require many turns to open and close requiring much labor.

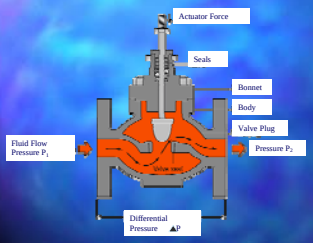
Additionally valves can be damaged by application of too much torque that can result in broken stems.

Hydraulic openers are often used in the field for operating larger valves.

11

Florida Rural Water Association

Globe Valve



- Globe Valves are designed for throttling or reducing flow.
- Globe Valves are typically found in use for pressure reduction in customer residences or in altitude valves for pressure regulation.
- High friction losses
- Expensive in large sizes

12

Check Valves

- Ensures water flows in a single direction.
- Automatic
- **Used on discharge side of pumps to prevent backflow**
- Requires little attention

13

Types of Check Valves

There are three basic designs of the check valve:

- the swing check valve,
- the horizontal and vertical lift check valve,
- and the ball check valve.

14

Swing Check Valve

- Most popular
- Little resistance to flow when open
- Not recommended for frequent flow reversal, causes valve chatter
- Can cause “Water Hammer” if not properly adjusted

15

Horizontal/Vertical Lift Check Valve

Horizontal Lift Check Valves

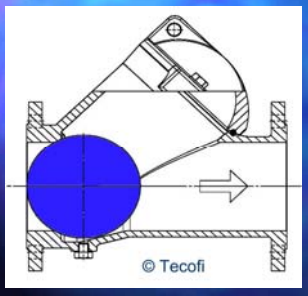
- installed in a horizontal position
- Often used with smaller piping
- Used in frequent flow reversal applications

Vertical Lift Check Valves

- similar to horizontal lift check valves
- designed for vertical pipe installation

16

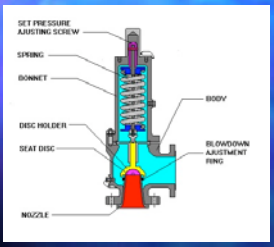
Ball Check Valves



- Not the same as a ball valve
- Designed to handle viscous fluids
- Made in vertical, horizontal, and angle designs
- Recommended for rapidly fluctuating lines
- Quiet operation
- Low friction losses
- **Used for curb and corporation stops**

17

Pressure Relief or Pressure Sustaining Valve



Pilot operated valves are used to control pressure such as in a altitude valve application that prevents storage tanks from overfilling.

18

Altitude Valves

- Special type of pressure sustaining valve
- Uses a pilot valve to control opening/closing
- Two types – one way and two way
- Controls water level
- Prevents tank overflow

19

Maintenance of Altitude Valves

- Altitude valves require minimal maintenance.
- The most important thing to do is to be sure that the valve and its connecting pipes are free of debris when installed.
- **When gauges or altitude valves exhibit erratic behavior, check the snubbers which can be clogged.**
- Snubbers are the small fittings that restrict flows, preventing rapid pressure changes. Snubbers help prevent "water hammer" damage.

20

Fire Hydrants

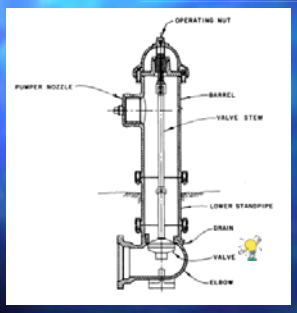
21

Spacing of Fire Hydrants

- Generally Spaced at 350 to 600 feet apart (amount of hose on fire truck)
- Provided at each Intersection
- May be placed closer in commercial areas

22

Typical Dry Barrel FH use in Water Distribution System



Fire Hydrants are fitted with two 2 1/2" and one 4" nozzle.

23

Fire Hydrant Flow Identification (Optional)

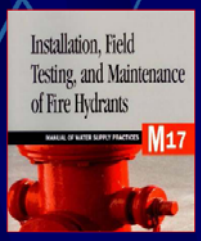
BLUE	1500 GPM or more	Very good flows
GREEN	1000-1499 GPM	Good for residential areas
ORANGE	500-999 GPM	Marginally adequate
RED	Below 500 GPM	Inadequate

- Minimum fire flow in a residential area is 500 gpm for 2 hours
- Colors should be highly visible, day or night
- Marking consistent with the National Fire Protection Association

24

Fire Hydrant Testing

- Provides figures and procedures as well as useful tables for measuring flow from hydrants
- Explains use of pitot gauge



Pitot Gauge Placed in Flow Stream

25

Primary Concern in Fire Flow Testing

- Ability to maintain sufficient residual pressure to prevent developing a negative pressure at any point in the system
  - Could result in collapse of mains or other components
  - Could cause back-siphonage of polluted water from some other interconnected source

26

Use of Fire Flow Formula

$$Q_r = Q_f X \frac{h_r^{0.54}}{h_f^{0.54}}$$

Fire flow formula found in M17

- Q_r = flow available at the desired residual pressure
- Q_f = the observed flow in gpm
- H_r = the difference between the normal pressure and the desired pressure
- H_f = the actual drop in pressure observed

For accurate test results, the pressure drop (H_f) between the static and the residual pressures should be at least 10 psi

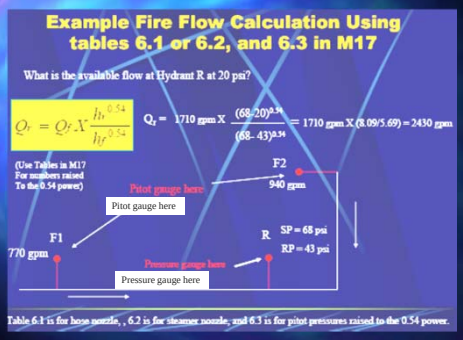
27

Controlling Pressure Drop

- **A minimum of two hydrants are needed to conduct a fire flow test.**
- If mains are small and the system weak, only one or two hydrants need be flowed
- If mains are large and system strong, it may be necessary to flow as many as seven or eight hydrants
- In the example that follows it is not necessary to reduce the pressure to 20 psi to determine the flows at that hydrant

28

Fire Flow Calculations Using M17



29

Water Distribution System Maintenance

1

Water Distribution System Maintenance Module Objectives

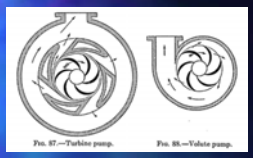
- Identify the various Types of Pumps Used in a Water Distribution System
- Identify the applications of the various types of pumps
- Review the Use of a Pump Curve
- Identify Common Pumping Problems in Water Distribution Systems
- Identify Flushing Techniques and Proper methods of Flushing
- Discuss Effective Preventative Maintenance and Work Management Systems

2

Pumps and Pump Maintenance

3

Centrifugal Pumps for Water Distribution



Impeller (volute) - Used for Low Head Conditions to move high volumes of water

Turbine – Used in High Discharge Head Conditions such as wells and are often stacked in series to provide higher lift

4

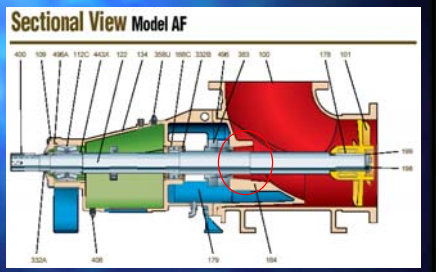
Centrifugal Pump Components

- The shaft is the part of the pump that turns the impeller.
- The impeller is a device that creates a vacuum by spinning and impelling liquid outward between the blades by centrifugal force. A worn impeller will result in loss of delivered flow.
- Seals on the shaft prevent intrusion of air into the pump case or volute and/or the loss of water when pumping. Leaking seal could cause cavitation and/or loss of water.
- Bearings allow smooth rotation of the pump shaft.
- The coupling connects the motor with the pump.
- Stuffing boxes are used to keep air leakage out of a pump. It consists of a casing, rings of packing (or mechanical seal) and a gland at the outside end.

5

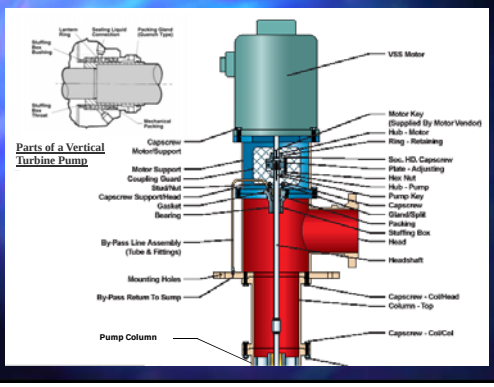
Axial Flow Raw Water Pump

101 Impeller
109 Thrust Bearing
112C Out Brg.
168C In Brg.
184 Stuffing Box Cover
332A In Seal
332B Out Seal
383 Mech Seal
496 Stuffing Box Cover



Courtesy of Goulds Pumps 6

Vertical Turbine Well Pump

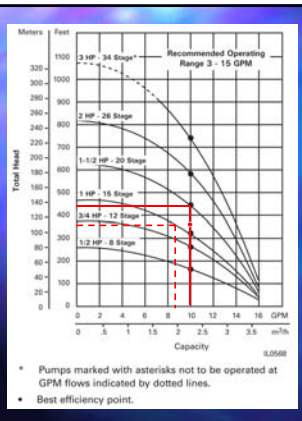


7

Centrifugal Pump Operation

- Every pump has certain characteristics under which it will operate efficiently.
- These conditions can be illustrated with characteristic curves.
- The chart in which they are printed shows the head capacity curve, the capacity, and the best efficiency point.
- Operating a pump outside these ranges will cause damage to the pump

8



Typical Pump Curve

- A pump curve is a graphical relationship between flow rate and the total dynamic head on the pump. Discharge will increase as head decreases.
- If the head is marginally too high for the pump the flow rate will be reduced.
- If the pump runs to the right/above of the curve, the pump is less efficient and damage to the pump could occur

9

Pumps Applications in Water Systems

Application	Function
Low service (transfer pump)	To lift water from the source to treatment processes or from storage to filter backwashing system.
High service	To discharge water under pressure to distribution system
Booster	To increase pressure in the distribution system or to supply elevated storage tanks
Well	To lift water from shallow or deep wells and discharge it to the treatment plant, storage facility, or distribution system
Chemical feed	To add chemical solutions at desired dosages for treatment processes
Sampling	To pump water from sampling points to the laboratory
Sludge	To pump sludge from sedimentation facilities to further treatment or disposal

10

Effective Pump Maintenance

- Keep O&M Manuals On-Hand
- Lubricate in accordance with Manf. Suggestions
- Use proper packing and do not over tighten
- Keep equip aligned
- Exercise Isolation Valves
- Keep Spare Parts on-hand
- Perform preventative maintenance
- Maintain comprehensive Equipment Records.

11

Problems With Defective Mechanical Seals or Packing

- Loss of suction due to air leak.
- Shaft or sleeve damage from wear
- Water contamination of bearings.
- Attractant for carriers of pathogens
- Large Amounts of Unaccounted for water loss
- Flooding of building or pumping facility

12

Lubrication Considerations

- Too much grease in antifriction type bearings (ball or roller) will promote friction and heat.
- The main job of grease in anti-friction bearings is to protect steel elements against corrosion, not friction.
- Lubricant should be changed in accordance with the manufacture's recommendations or before it's too worn or becomes too dirty.
- Some utilities analyze oil to identify the amount of metal wear to optimize lubrication and lubrication scheduling.

13

Troubleshooting Centrifugal Pumps

Problem	Likely Cause
Reduced Capacity	❑ TDH higher than pump rating ❑ Lift is too high (over 15 ft.) ❑ Excessive Air in Water ❑ Direction of Rotation reversed
Loses Water after Starting	❑ Air Leak in Inlet Pipe ❑ Lift is too high (over 15 ft.) ❑ Excessive Air in Water
Motor Overloaded	❑ Speed of pump is too high ❑ TDH is too high or low for pump rating ❑ Mechanical Defects
Excessive Vibration	❑ Misalignment ❑ Foundation is not rigid ❑ Foreign Materials in impeller ❑ Mechanical Defect (ie bent shaft)

14

Common Problems with Centrifugal Pumps

- ❑ Packing gland should have small amount of water leakage for lubrication
- ❑ Pump should be checked for excessive vibration, it may be misaligned (alignment should be performed using a laser)
- ❑ Foundation deterioration or settlement
- ❑ Foreign materials
- ❑ Mechanical defects
- ❑ Worn Impeller wear caused by sand or corrosion such as H_2S causing loss in delivered flow

15

Common Pumping Problems

- Blockage
- Air Lock
- Vibration
- Water Hammer
- Cavitation

16

Air Locks

- An accumulation of air that impedes the flow of water.
- Air locking is caused by air being trapped in the volute of the pump.
- These gasses collect becoming compressed creating an artificial head pressure within the pump housing.
- This artificial head will continue to build as more air is sucked into the pump until the maximum discharge head pressure (shut off head) is reached completely restricting the flow of water.
- Air locking is most often caused by leaks in the suction line

17

Excessive Vibration

- Pumps should run smoothly. Excessive vibration causes expedited and excessive wear especially on bearings.
- Vibration is typically caused by misalignment or base problems
- Vibration can be measured with specialized equipment

18

Water Hammer

- Water hammer is caused by the rise and fall of pressure caused by the rapid change of a valve position.
- Water hammer sends shock waves that are at 4 to 5 times higher pressures through the water system
- Water hammer can cause pipes to rupture and damage equipment
- Rapidly closing (check) valves are notorious for this problem and should be corrected by adjusting the speed of closure

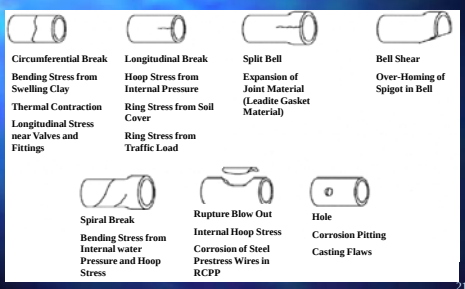
19

Cavitation

- Cavitation - usually caused when pump inlet pressure drops below the design inlet pressure as a result of a closed valve or a blockage. Causes low flow rate through the pump either on the suction side or discharge side. Impeller could also be restricted.
- Cavitation occurs when the pump starts discharging water at a rate faster than it can be drawn into the pump.
- When cavitation occurs, immediate action must be taken to prevent the impeller from being damaged.

20

Water Distribution Pipeline Break Signatures



21

Common Reasons for Pipeline Breaks

1. Water Hammer
2. Soil Movement including settlements/tide
3. Improper Backfill
4. Improper Restraining
5. Traffic Impact (H-20 Loadings)
6. Corrosion (internal and external)
7. Construction Accidents (Florida Sunshine 24 hr. notification system; call 811 for ticket or 1-800-432-4770. Two full days notification necessary for regular tickets!
8. High Systems Pressures (> 100 psi)

23

Field Preparation for Main Repair

- Notify Residents 24 – 48 hours in advance
- Identify Valves to be Used for shut down (use OSHA Lock Out Procedures)
- Identify Buried Lines Using One Number Alert
- Make sure that proper tools, repair clamps or coupling are on-site
- Use proper equipment for trenching and earth moving
- Remove Debris from inside and swab with Chlorine Solution, gaskets to be clean and dry

24

Repair of Broken Water Mains

- Maintain Positive Pressure at all times when possible!
- Notify Customers not to use taps
- Have repair materials and equipment at job site
- Excavate adequate distance below broken pipe
- Remove water to below pipe to prevent contamination
- Chlorinate pipe and swab repair materials
- Allow Disinfection Time inside pipe
- Flush Chlorine and potential sand out of system
- Turn Line back on slowly
- Check for chlorine residual and coliform in main
- Notify Customers when to use water

25

Water Pipeline Physical Location Requirements

- Must adhere to DEP location requirements
- Must provide min a horizontal 6' and preferably separation of 10' from sanitary sewer pipe and 3' minimum and 6' from storm sewer
- Must maintain min 6" and preferably 12" vertical separation between sanitary, storm and reclaimed pipelines
- Must maintain full length centered from water pipe to ensure joints for san. & 3' from storm. Joints to be farthest away from intrusion points.

26

Valve Maintenance and Flushing for Water Systems

27

Valve Inspection

- Location of Valve from Permanent Reference Point. Best to use 3 triangulation points!
- Exercise the valves (open and close) and record the…
  - Type and Size of the Valve
  - Number of Turns to Open the Valve
  - Last Date the Valve was Operated. (AWWA suggests every 2 years as minimum!)
  - Last Date that Valve was Repacked or Repaired
  - Condition of the Valve
  - Other Unusual Circumstances or Conditions

28

Eliminating the Most Common Water Distribution System Problems

1. Disinfectant Residual – increase residual by turning over the water in the distribution system's pipelines.
2. Sediment - ensure that sediment in dead-end lines does not accumulate and is removed
3. Water Storage Tank Chlorine Residual – ensure residual is maintained and DBP are minimized by managing the water levels and detention times

All of these tasks are accomplished by Flushing !

29

Air and Vacuum Problems

How can you release air from a newly installed or repaired water main?
Through a corporation stop or fire hydrant

- Air can cause serious problems pipeline problems.
- Air may get into water through pumps, packing glands, leaky joints or may already be in the water.
- Air collects at high points in the lines.
  - Increase resistance to flow by 10 to 15 percent.
  - Create possible air lock condition and stop flow.
- Vacuum condition can cause pipe collapse.

30

Water Distribution System Bacteriological Hot Spots

Location in Water System	Relative # Coliform*
Low Flow, Dead End	High
Low Flow, Internal	Medium
Extended Flushing	Low
High Flow	Lowest

Coliform Measurements Performed in July and August

* Smith, et al, New Haven Connecticut Study, 1989

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Water Detention Time in a Water Distribution System Can Be Very High

Typical Distribution System Water Age (Days)

Population	Miles of WM	Water Age Range
> 750,000	> 1,000	1 – 7 days
< 100,000	< 400	> 16 days
< 25,000	< 100	12 – 24 days

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Purpose of Conventional Flushing

- Reducing Water Age
- Increasing Disinfectant Residual
- Removing Coloration

33

Problems Minimized by Water System Flushing

- Water that stands still, moves slowly, or does not circulate in water mains eventually loses disinfection residuals.
- With inadequate disinfectant residuals bacterial growth increases in the water distribution system.
- Excessive bacterial growth leads to color and taste and odor complaints from customers.
- Bacterial growth results in corrosion problems
- Coliform bacteria and water borne pathogens survive longer and the public's health is compromised when stagnant water loses its disinfectant residual.
- Suspended matter that contains organic material settles in the main further compromising the ability to maintain disinfectant residual
- Water with a long detention time results in higher concentrations of regulated disinfection by-products

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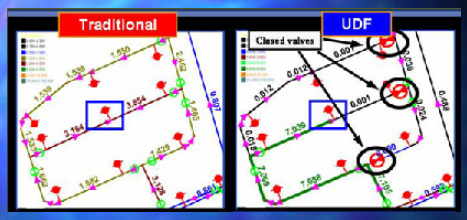
Methods of Flushing



Conventional Flushing

- Water from all directions
- Low flow velocities
- Less scouring
- Don't control flushing direction

Unidirectional Flushing

- Water channeled
- Higher flow velocities
- More scouring/better cleaning
- Systematic valve operation

35

Determining the Correct Amount of Water to Flush

Automated Flushing Valve Installation

Methods for Flushing Fire Hydrants for Maintaining Chlorine or Chloramine Residuals

1. Flush ~ 3 pipe volumes or until the disinfectant residual is restored.
2. Flush until color and turbidity are restored to normal levels.
3. Flush at a rate that keeps the main pressure above 35 psi.
4. To minimize water loss, flush for the least amount of time needed.

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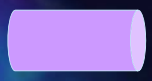
How do we determine 3 pipe volumes?



If given a 24" pipe, what is the volume in gallons for 1ft of pipe?

What is the shape that we need to calculate the volume for? Cylinder
What is the formula? Its the area for the end of the pipe times its length
Area = πr^2 = $(3.14)(1ft)^2$ = 3.14 ft^2

Volume = Area x Length = (3.14 ft^2)(1ft) = 3.14 ft^3

Convert to gallons; How many gallons are in 1 ft^3? 7.48 gals/ft^3
Gallons = (3.14 ft^3)(7.48 gal/ft^3) = 23.5 gals

What is the volume in gallons for an 8" pipeline that is 1,000 ft long?
Volume = $\pi r^2 L$ = $(3.14)(4/12\ ft)^2(1{,}000\ ft)$ = 349 ft^3
Gallons = (349 ft^3)(7.48 gal/ft^3) = 2,611 gals

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Determining Gallons per Foot of Pipe

Pipe Volume per foot

Pipe Diameter (inches)	Volume (gallons per foot)
2	0.16
3	0.37
4	0.65
6	1.47
8	2.61
12	5.88
16	10.44
20	16.3
24	23.5

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Gallons to Flush to Achieve Three (3) Volumes of Pipeline

Main Size dia"	Feet of Pipeline				
	100	200	300	400	500
2	50	100	150	200	250
3	110	220	330	440	550
4	200	400	600	800	1000
6	440	880	1320	1600	2200
8	800	1600	2400	3200	4000

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How Often to Flush

- Dead-end mains at least monthly
- Other flushing points at least twice annually (DEP requires quarterly flushing)
- At intervals necessary to maintain consistent water quality throughout the distribution system
- Often enough to maintain adequate disinfection residuals throughout the distribution system
- Whenever Customer complaints of bad taste, odor, clarity or turbidity are received (DEP requirement)

40

Flow (gpm) to Achieve Sediment Removal Velocity of 3 to 5 feet per second

- In flushing we want the flows high enough to flush any sediment. Therefore, we want velocities greater than 2.5 fps. To make sure our velocities are high enough we can measure the flow. The flow is going to vary depending on the size of the pipe.
- What is the relationship between velocity and flow? $Q = VA$

Question: If we want to have a minimum velocity of 3 fps in our pipeline, what flow in gpm would I need to have in a 12" pipeline?

Using $Q = VA$ calculate the flow required. We know V, find A to get Q

For a pipe with a diameter of 12" what is the area?

$A = \pi r^2 = 3.14 \times (6/12)^2 = .785\ ft^2$

We were given that V = 3fps

Therefore, $Q = (3\ fps)(.785\ ft^2) = 2.36\ ft^3/sec$

To convert to gpm what needs to change? ft^3 to gals and sec to min

$Q = (2.36\ ft^3/sec)\ (7.48\ gal/ft^3)\ (60sec/min) = 1059\ gpm$

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Flow (gpm) to Achieve Sediment Removal Velocity of 3 to 5 feet per second

	Velocity in Pipeline	
Size of Main dia"	3 fps	5 fps
2	29	52
4	118	200
6	264	450
8	470	775
12	1,060	1,760
16	7,500	12,500

42

Approximating Conventional Flushing Velocities for a 2" Blow Off

This condition represents a velocity of 2 feet per second. Approximately Correct!

This condition represents a velocity of 15 feet per second. Wasteful and likely to stir sediment

43

Measuring Fire Hydrant Flow for Flushing Purposes

- Pitot Meter
- Pitot Gauge and Flow Calculation
- Pitot Gauge and Chart
- Yardstick

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Measuring Fire Hydrant Flow for Flushing Purposes

A Fire Hydrant Flow Calculator can be found at: http://www.firehydrant.org/info/hycalc.html

Pitot Gauge and Diffuser Pollard Water Co.

45

Approximate Flow Rates (gpm) from 2½" Fire Hydrant for Pitot Readings (psi)

Pressure at Pitot	Approx. FH Flow	Pressure at Pitot	Approx. FH Flow
1	170	11	555
2	240	12	580
3	290	13	605
4	340	14	630
5	380	15	650
6	410	16	670
7	440	17	690
8	480	18	710
9	500	19	730
10	530	20	750

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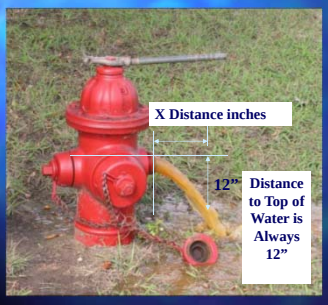
Approximate Flow (gpm) from Hydrant Using Level and Tape



X	Flow
6	30
8	40
10	50
12	60
14	70
16	80
18	90
20	100
30	150

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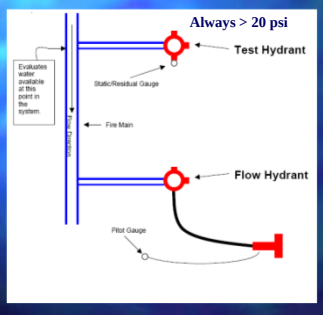
Proper Method for Flushing or Flow Testing Fire Hydrants



High Flows can cause significant reductions in pressure resulting in customer complaints and rusty water.

48

Results of Flushing too Fast More is not Better!

- Excessive Water Loss
- Low Water System Pressures
- Customer Complaints

An acceptable Flushing Program includes measuring the flow rate and flush time, then calculating and recording the total gallons used.

49

Approximate Time To Flush in a Flushing Program

	Length of Pipeline and Time for Three (3) pipe volumes				
Flushing Velocity	100 feet	200 feet	300 feet	400 feet	500 feet
3 fps	1:40	3:20	5:00	6:40	8:20
4 fps	1:15	2:30	3:45	5:00	6:15
5 fps	1:00	2:00	3:00	4:00	5:00

Conventional

Unidirectional

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Informing the Customer with the Flushing Schedule

- Purpose of Flushing and Water Quality Objectives i.e. improving taste, color and eliminating odor
- Duration of Flushing Program
- Dates, Times and Street Addresses Targeted
- Customer notification methods i.e. universal and personal methods to be used
- Customer Requirements for using water during flushing period

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Flushing Benefits Summarized

- Restores disinfectant residual
- Maintains or improves water quality
  a. Reduces bacterial growth
  b. Reduces customer complaints
- Restores flow and pressure in the distribution system
  a. Reduces sediment
  b. Reduces corrosion and tuberculation in mains
- Reduces DBP problems and lowers disinfection costs
- Reduces pipeline maintenance costs
- Increases life expectancy of the distribution system
- Typically results in a fire hydrant maintenance program

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Suggested Customer Information to be Included in a Flushing Program

- Avoid using water each day during flushing period regardless of where water main flushing is being performed.
- Turn off and by-pass any water softening system before 8:00 a.m. on the days flushing will be performed. Do not return your softener to service until after you have flushed your water lead (see number 4).
- DO YOUR LAUNDRY ON ANOTHER DAY TO PREVENT STAINING..
- Turn off any automatic water systems, such as time-delayed dishwashers or timed lawn sprinkling systems.
- After 4:00 p.m. on the days flushing is performed, or when a notice is posted on your front door, and prior to using water in your home, open the faucet closest to the point where the water enters your home. Allow the water to run into the nearest drain until it runs clear. If appropriate, return you water softener and/or automatic systems to service.
- If you use water while we flush the main waterlines it is possible that some of the rust that collects in the supply lines could enter your household pipes and water softener.
- Problems: Call Phone # --- -----

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Pigging Pipelines with Tuberculation or Excessive Sedimentation

Various Configurations of Pigs used in water system maintenance.

Heavily Tuberculated Water Main where pigging must be used to remove deposits

54

Preventative Maintenance and Work Management

55

Maintaining Records in a Water Distribution System

- Laboratory Records
- Financial Records
- Valve and Fire Hydrant Records
- Flushing Records
- Maintenance Logs
- Work Orders
- System maps
- As-Built Drawings
- Shop Drawings
- Equipment Manuals
- Customer Complaints
- Cross Connection Records

56

Types of Maintenance

- Predictive Maintenance: is proactive; characterized by
  - Having established baseline performance data
  - Establishing monitoring performance criteria over a period of time
  - Observing changes in performance
- Preventative Maintenance ; is proactive; characterized by
  - Maintenance performed on regular schedule
  - Work backlog can be identified
  - Resources that can be budgeted
  - CIP items that can be identified and budgeted for
  - Effective use of human and material resources
- Corrective Maintenance: is not scheduled and is reactive;
  - Inability to plan and schedule work
  - Inability to budget adequately
  - Poor use of resources
  - A high incidence of equipment and system failure

57

Development of an Effective Work Management Monitoring System

- Work is categorized
- Work Standards that include time and quality are developed
- Work is Assigned based on Standards to Individuals or Crews
- Work is Completed, Data Recorded (and Inspected)
- Work Data is compared to acceptable standards
- Deviations of Acceptable Performance is identified
- Problems that inhibit performance are eliminated
- Maintenance Equipment Histories are often an outcome of a successful work management program

58

Water Distribution System Disinfection

1

Water Distribution System Disinfection Module Objectives

- Understand Basics of Disinfection with Chlorine
- Understand the Chemical Relationships that govern the reactions
- Understand handling and Safety Concerns
- Understand the Properties of Chlorine
- Understand how to Disinfect Wells, Pipelines and Storage Tanks
- Understand how to neutralize and dispose of chlorinated water

2

Purpose of Disinfection and Sterilization in Water Distribution

- **Disinfection protects the public from disease-causing pathogens**
- **Disinfection "inactivates" pathogens to ensure that they are reduced to non-harmful levels**
- **When Boiling is used, Sterilization results which is the destruction of all bacteria.**

3

Reasons for the Selection of Chlorine as a Disinfectant

- Readily available and economical
- Low cost compared to other substances
- Proven effectiveness in relatively low dosages
- Simple feed and control procedures
- Requires safe storage and handling

4

Disadvantages in the Use of Chlorine

- Highly toxic
- Regulatory agencies placing tightening restrictions on storage and use
- Produces Disinfection Byproducts

5

Other Uses of Chlorine in a Water Distribution System

- Control Aquatic Life
- Remove iron, manganese, sulfide, tastes and odors
- Maintain a Microbial Residual in Water Distribution System
- Prevent Algal Growth in Storage Basins
- Prevent Bacterial Regrowth in a Water Distribution System

Chlorine used to Provide Residual in a Water Distribution System is called “Secondary Disinfection”

6

Properties of Chlorine

7

Forms of Chlorine

- Gas Chlorine (Cl_2) - pressurized containers that keep the chlorine in a liquid state that is converted to gas (100% available as chlorine)
- Liquid Chlorine or Bleach (NaOCL) - Sodium hypochlorite is a pale yellow liquid (concentrations are 5 to 15%)
- Solid Chlorine [$Ca(OCL)_2$] - Calcium hypochlorite is a white solid (contains 65% to 75% available chlorine)

8

Methods of Using the Forms of Chlorine in Water Treatment

- Gas chlorination from liquid
- Hypochlorination liquid dosing from bleach
- Hypochlorination liquid dosing after mixing a solid with water

9

All Forms of Chlorine are Hazardous

- All forms of chlorine are extremely hazardous substances
- Chlorine in contact with moisture, even under very low concentrations, becomes extremely corrosive
- Disinfection agents kill living organisms and tissue

10

Factors Affecting Chlorination Effectiveness

- Chlorine concentration and form
- Effluent pH (lower increases effectiveness)
- Effluent temperature (higher increases effectiveness)
- Contact time (generally, longer increases effectiveness)
- Effluent suspended solids (turbidity reduces effectiveness)

11

What is Turbidity?

- Turbidity is the amount of cloudiness in the water.
  - Can shield organisms and present a chlorine demand
  - Lower disinfection efficiency
  - A temporary cloudiness is caused by air entrainment
- Turbidity is caused by:
  - Silt, sand and mud
  - Bacteria and other germs
  - Chemical precipitates
- Measured using a turbidity meter in Nephelometric Turbidity Units (NTU's). DEP secondary standard is 15 NTU's.

12

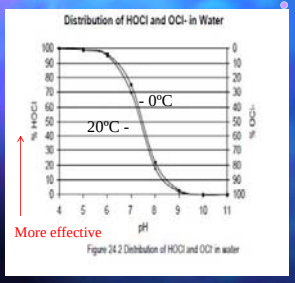
Chlorine Residual Requirements in Distribution System

- A free chlorine (HOCl or OCL^-) residual of 0.20 mg/l or a combined chlorine (NH_2Cl) residual of 0.60 mg/l or an equivalent chlorine dioxide residual, must be maintained in the water distribution system at all times.
- Chlorine residual is measured in the field using a DPD test kit.

13

Reactions with Water (HOCl, OCl^- and pH)

HOCL is 40 to 80 times greater in effectiveness than OCL



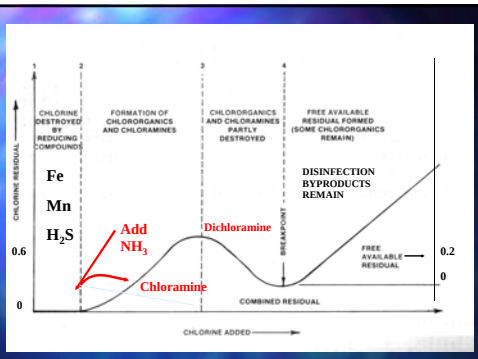
- Chlorine reacts with water producing hypochlorous acid (HOCl) and the hypochlorite ion (OCl^-)
- Both provide the disinfection ability of chlorine
- Chlorine gas tends to lower pH
- Hypochlorite compounds tend to raise the pH
  - $Ca(OCl)_2$ ~ pH 7-8
  - NaOCl ~ pH 13

14

Reactions of Chlorine with Water Constituents

- Reducing Compound (inorganics)
- Production of Chloramines
- Production Chlororganics
- Combined Chlorine
- Breakpoint Chlorination
- Free Chlorine Residual

15



Breakpoint Chlorination Curve

16

Some Useful Definitions Free and Combined Chlorine

- Chlorine existing in forms of hypochlorous acid and the hypochlorite ion is called "free available chlorine"
- Chlorine that has reacted with ammonia is called "combined chlorine"
- Free chlorine is more reactive than combined chlorine
- Many substances and compounds react with free chlorine and combined chlorine and this is known as "chlorine demand"
- Most water systems use free chlorine.
- Combined chlorine is produced by the addition of ammonia and reduces DBP production potential. Sometimes used as a secondary disinfectant to prevent the formation of DBP.

17

Substances that Cause Chlorine Demand

- Hydrogen Sulfide (H_2S) (8:1 ratio)
- Inorganic metals - Fe and Mn (3:1 ratio)
- Nitrite (5:1 ratio, 3:1 ratio with NH_3)
- Organic materials (TOC and NOM)
- All react with chlorine and reduce it to the chloride ion
- No chlorine residual is provided by this reacted chlorine

18

Reactions of Hypochlorous Acid and Ammonia to Produce Chloramines

$NH_3 + HOCl > NH_2Cl$ (monochloramine) + H_20 (@ pH > 7)

$NH_2Cl + HOCl > NHCl_2$ (dichloramine) + H_20 (@ pH 3 - 7)

$NHCl_2 + HOCl > NCl_3$ (nitrogen trichloramine) + H_20 (@ pH < 4)

Forms controlled by pH

- Monochloramine, none below a pH of 6.5
- Dichloramine is not desirable , imparts taste and odors to the water
- Trichloramine has no disinfection power

19

Chlorine Relationships

Chlorine Residual = CL Dose - CL Demand

CL Dose = Chlorine Residual + CL Demand

CL Demand = CL Dose - Chlorine Residual

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Chlorine Residual

- Free Chlorine - aqueous chlorine, hypochlorite ion and hypochlorous acid
- Combined Chlorine Residual - compounds formed by reactions of hypochlorous acid and ammonia (chloramines)
- Total Chlorine Residual is the sum of free and combined chlorine remaining in the water

21

Minimum Chlorine Residual

- DEP requirements are 0.20 PPM Free Chlorine Residual or 0.60 PPM Chloramine Residual at all points in Distribution System
- Plants generally use 0.50 PPM Free Residual for 15 minutes as safe minimum

22

Considerations for Hypochlorination Systems (Water Operators)

23

Difference between Gas and Hypochlorination

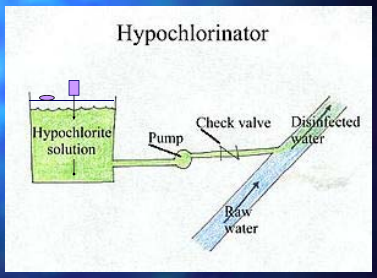
- Gas chlorine lowers the pH (increases the hydrogen concentration) favoring the formation of Hypochlorous acid (more effective)
- Hypochlorination (both Sodium and Calcium) raises the pH favoring the formation of the Hypochlorite ion. (less effective)

24

Parts of a Hypochlorinator for Calcium Hypochlorite Dosing

Parts:

- Mixing Tank
- Metering Pump
- Check Valve
- Well Pump



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Chemical Feed Pumps

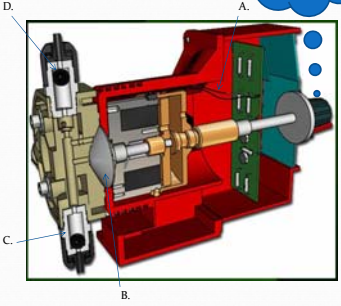
2 Basic Types

- Peristaltic (tube or hose)
- Diaphragm (solenoid, Motor or Hydraulic)

Diaphragm Metering Pump

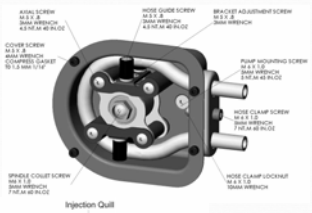
Change stroke length only when running

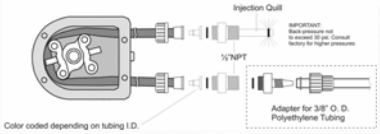
A. The coil is energized via electrical charge on the board
B. The solenoid shaft pushes the diaphragm into the pump head cavity
C. The suction ball valve seats (via gravity)
D. Liquid in the pump head is forced out through the discharge valve as the ball is forced to raise in the guide



Peristaltic Metering Pump

- A motor drives a shaft that is connected to rollers
- The rollers push the tubing flat against the collet which drives the liquid through the tube





Hypochlorination System Maintenance Considerations

- Pumps, feed lines, and injection points should be regularly inspected and cleaned
- Clean using mild acid solution
- Pump should be properly lubricated and free of corrosion
- Adjust feed rate only when running
- Do not store chemical for long periods

  @ Date of Manf. 12.5% after 30 days 11.5%
- Heat and Sunlight destroy chlorine and PVC materials such as pipe and storage vessels

29

Considerations for Hypochlorite Storage

Chlorine is not corrosive until you add?

Moisture

- Protect skin, eyes, and respiratory tract
- Wear protective gloves. Hypochlorite will burn skin
- Cover all containers
- Keep chemical dry, covered and stored away from direct sunlight.
- Add water to container before the hypochlorite powder is added.
- Flush all spills with large amounts of water
- Keep the chlorine room well ventilated.
- Store Calcium hypochlorite away from contact with organic matter to prevent fire.

30

Considerations for Gas Chlorination Systems

31

Physical and Chemical Properties of Chlorine as a Gas

- Pressurized liquid expands 450 times in atmosphere
- Under normal atmospheric pressure at room temperature, chlorine is a yellow-green gas

- 2.5 times heavier than air
- 1.5 times heavier than water

32

Maximum Draw-Off Rates

150 lb cylinders - approximately 40 lbs/day

1-ton containers - approximately 400 lbs/day

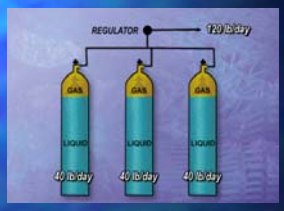
Computed as 8 pounds / ºF drop

- Temperature of remaining chlorine decreases as the rate of withdrawal increases
- When temperature of chlorine is low enough it will not evaporate

33

Preventing Chlorine Icing

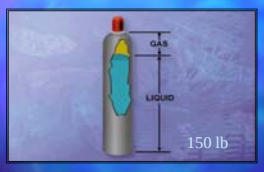
- When attempting to feed more than the allowable amount from any container, manifolding is required



Computed as 8 pounds / °F drop

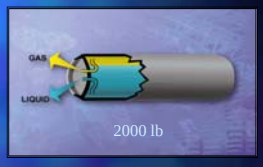
34

Dosing Configurations of Chlorine Cylinders



150 lbs Cl - 92 lbs Tare

Total Weight ~ 242 lbs



2000 lbs Cl – 1550 lbs Tare

Total Weight ~ 3,600 lbs

35

Storage of Chlorine Cylinders

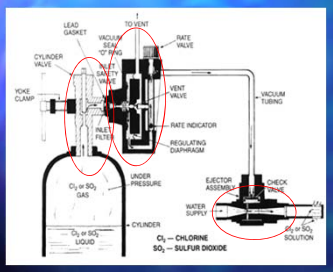
- Keep away from heat or direct sunlight
- Provide separate room with ventilation.
- Maintain >50° F Temperature
- Protect from Fire
- Chlorine tanks are provided with fusible plugs that melt between 158 to 165 degrees F.
- Ton cylinders will have 6 of these plugs, 3 on each end; 150 lb, one.

36

Safe Handling of 1-Ton Cylinder

37

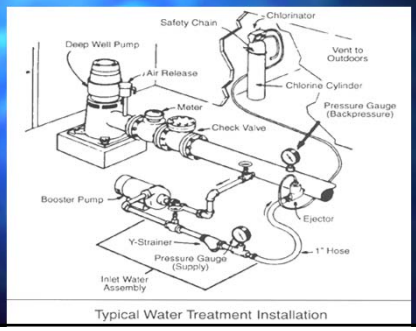
Principles of Gas Chlorination



- Ejector Assembly
- Venturi
- Vacuum Regulator
- Rate Valve
- Rotameter
- Check Valve
- Ejector

38

Gas Chlorination Components and Operation



Typical Water Treatment Installation

39

Chlorinator Start Up

- Use Self Contained Breathing Apparatus, Protective Clothing and work in pairs
- Inspect cylinder before connecting
- Check fittings
- Use new lead gasket
- Connect yoke with ¾ turn
- Open cylinder valve one turn
- Check for leaks with ammonia (rag preferable)
- Have emergency repair equipment on-hand (A-kit 150, B-kit 2000, C-kit tank car)

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Emergency Eyewash Shower at Treatment Plant using Cl

Required for
All forms of Chlorine

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Effects of Chlorine on Humans

Chlorine Concentration	Effect
.3-3.5 mg/L	detectable by smell
30 mg/L	causes coughing
40-60 mg/L	damage to tissue
> 60 mg/L	can kill

OSHA – Permissible Exposure Limit (PEL) is 1.0 ppm

NIOSH – Recommended Exposure Limit (REL) is 0.5 ppm in 15 minutes

CDC – Immediately Dangerous to Life or Health (IDLH) is 10 ppm

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AWWA Standards for Disinfection Water Distribution Facilities

- **AWWA A100: AWWA Standard for Water Wells.**
- **AWWA B300: AWWA Standard for Hypochlorites.**
- **AWWA B301: AWWA Standard for Liquid Chlorine.**
- **AWWA C651: AWWA Standard for Disinfecting Water Mains.**
- **AWWA C652: AWWA Standard for Disinfection of Water-Storage Facilities.**
- **AWWA C654: AWWA Standard for Disinfection of Wells**

45

Methods for Disinfecting Wells

- Protect all parts and swab with 50 mg/l solution before installation
- Inject Chlorine through the column pipe not the vent pipe!
- 50 mg/l is needed for 24 hours
- Pump well until no chlorine residual is observed
- Test for Coliform

46

Bacteriological Well Testing

- A total of at least 20 samples – each taken on a separate but consecutive workday
- Taken at least six hours apart from other samples
- Taken after first pumping to waste to remove all chlorine residual and then pumping to waste at a rate approximately equal to that of the permanent well pump for 15 minutes before each sample is collected.
- Analyze samples for total residual chlorine, total coliform and E. coli.

47

Disinfecting New Pipeline Construction

- Prevent of Contamination in handling and storage
- Swab with 50 ppm min. chlorine solution in areas that may have been contaminated and may touch the water
- Install new Pipe making sure to remove water from trench and below pipeline
- After installation, flush pipe to remove any air and sand
- Fill pipe slowly with water and dose using DEP approved methods
- Wait 24 hours and observe minimum residual
- Flush Chlorine to 4 ppm with water
- Test new water main for Coliform contamination
- Receive Clearance from DEP for putting line into service (two consecutive samples taken 24 hrs.. apart.)

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Methods for Disinfecting Water Mains

Method	Hrs. Contact	Min. Dose	Min. Res.
Continuous	24 hours	25 mg/l	10 mg/l
Slug	3 hours	300 mg/l	50 mg/l
Tablet *	24 hours	25 mg/l	10 mg/l

Reduce Chlorine to <4 mg/l and test for Coliform and HPC (24 hrs apart)

* Notes:
- Do not use for PVC pipe!
- Tablets are placed at inside top of pipe and any joints as it is laid
- keep velocity < 1 fps when filling

AWWA Standard C651-92

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AWWA Standards for Disinfecting Storage Tanks

- Method 1 – Fill Tank Using Calcium or Sodium Hypochlorite to 10 ppm and allow to sit for 24 hours > 2 mg/l
- Method 2 – Brush Surfaces with 200 ppm Chlorine solution allow tank to sit 3 to 6 hours
- Method 3 – Fill to ~ 5% of storage volume with 50 mg/l hold for 6 hours then fill to top and hold for 24 hours.
- Test for Coliform (2 days with no hits)

50

Disposal of Chlorine Solutions

- After the 24 hour retention period, flush the chlorinated water from facilities until chlorine measurements show the concentration in the water leaving the main is no higher than typical residual.
- Legally dispose of disinfecting water and ensure no chlorine buildup or damage to the environment.
- Failing to flush the line may require replacement of gaskets in pipelines and can damage other equipment.

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Chemicals Needed for Chlorine Neutralization

1 mg/l chlorine:

0.8 mg/l Sulfur Dioxide (SO_2)
1.2 mg/l Sodium Bisulfite ($NaHSO_3$)
1.4 mg/l Sodium Sulfite (Na_2SO_3)
1.2 mg/l Sodium Thiosulfate ($Na_2S_2O_2$)

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Water Quality for Water Distribution System Operators

1

Water Quality for Water Distribution Systems Module Objectives

- Understand and Identify the Basic Water Quality Concerns in Drinking Water
- Understand the Differences between Corrosion and Scaling
- Identify the Factors that Cause Corrosion problems
- Understand Galvanic Action and how it Affects the Corrosion Process
- Identify Basic Corrosion Activity in Water Distribution Pipelines
- Recognize How to Adjust Water Corrosive Properties
- Identify Corrosion Indexes and how they are Used for Prediction
- Identify Corrosion Problems and Solutions by Corrosion Signatures

2

Basic Water Quality for Water Distribution Operators

3

Water Hardness

- Hardness in water causes scaling, causes fibers in clothes to become brittle and increases the amount of soap that must be used for washing
- Hardness in water is caused by the water's Calcium and Magnesium Content
- Water is considered hard when it has a hardness concentration of > 100 mg/l expressed as calcium carbonate equivalent
- Water with hardness < 100 mg/l expressed as CaCO3 is considered soft
- Hardness can either be removed by water treatment or sequestered using phosphates

4

Iron Problems

- Iron is an essential element in biological systems
- Present in two forms: soluble ferrous iron and insoluble ferric iron
- Iron can cause staining of plumbing fixtures and laundry and impart taste and odor problems in concentrations > 0.3 mg/l
- Iron often enters the water system in the soluble or clear form
  - when it contacts oxygen falls out as a precipitate that pass through to customers
  - used by iron bacteria that can colonize in a water distribution system and impart foul odors and tastes to the water
- Iron is removed in the water by oxidation using aerators or chlorine that changes the soluble iron to a precipitate that must be filtered

5

Hydrogen Sulfide Problems

- Hydrogen Sulfide is often present in ground water and is distinguished by its noticeable rotten egg odor slightly detectable at concentrations as low as 0.1 mg/l in the water.
- Hydrogen sulfide causes corrosion of iron pipelines and a characteristic dark black stains around fixtures
- Hydrogen sulfide can also form in hot water tanks from sulfate in the water
- Hydrogen sulfide is removed in water treatment by degasification or oxidation with chlorine

6

Fluoride in Water

- Fluoride is a naturally occurring element found in small concentrations in most ground waters
- Fluoride is regulated and must not exceed concentrations above 2 mg/l
- In high concentrations fluoride causes tooth mottling (a yellow discoloration of teeth)
- Fluoride is often supplemented to concentrations from 0.8 mg/l to 1.2 mg/l to provide protection from tooth carries (cavities)

7

Nitrate Problems

- Nitrate is regulated by DEP and must be under 10 mg/l
- Nitrate occurs from the breakdown of waste products from animals and humans
- At higher concentrations nitrate causes methemoglobinemia (blue baby syndrome)

8

Water Stabilization

- Potable water should be stable, neither corrosive or scale forming.
- Stabilization consists of adjusting the water content so it is not corrosive or scale forming
- Control by adjusting alkalinity and pH to make it slightly scale forming.

9

Corrosive Water

- Weakens pipes and equipment, including residential plumbing.
- Dissolves toxic metals such as lead and copper from the distribution system or house plumbing into the drinking water.
- Causes color, taste, and odor problems when metals such as iron and copper are dissolved into the water.

10

Scale Forming Water

- Causes excessive buildup in pipes causing decreased flow and pressure problems.
- Causes buildup on hot water heater elements causing them to fail.

11

Corrosion and Chemical Activity

Most all forms of corrosion are chemical reactions (erosion is the exception) that require three things:

1. A carrier such as Water that allows the movement of positively charged ions (from Anode+ to Cathode-)
2. A condition (water metal contact) that allows metals to disassociate (ionize) and allows electrons to flow
3. An imbalance that favors the transport of metals or ions to achieve a chemical balance in a water solution.

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Types of Corrosion in Water Systems

- Galvanic — Dissimilar metals in contact in water. Frequently occurs in service lines.
- Pitting — Caused by scratches or imperfections in metal pipe. Can result holes in pipe.
- Tuberculation — Caused by metal ion transfer and development of electrolytic cell formation inside pipe. Can result in large deposits.
- Crevice — Occurs at joints where there is little water movement.
- Biological — Reactions of pipe materials and bacteria. Cause of most taste and odor problems.
- Dealloying — Preferential removal of one alloy from a metal also called Graphitization from anaerobic soils.

13

Galvanic Series for Common Metals

Material	Activity
Magnesium	Most active, Anodic (+)
Zinc	
Aluminum	
Steel or iron	
Cast iron	Direction
Brasses	Of flow
Copper	
Bronzes	
Stainless steel	
Silver	
Gold	Least Active, Cathodic (-)

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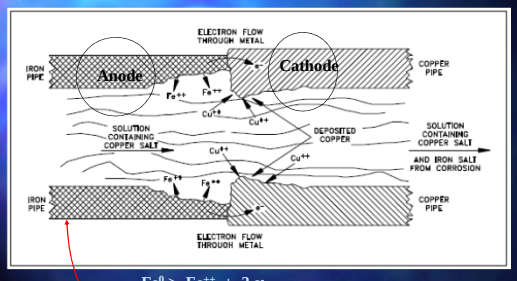
Galvanic Corrosion with Two Different Metals in Contact



$Fe^0 > Fe^{++} + 2e^-$

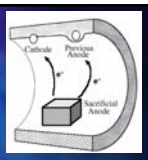
15

Tuberculation in a Cast Iron Pipeline

- Tuberculation is an electro – chemical action that is caused by oxygen present in the water
- Metals in contact with the water ionize into solution, leaving an excess of electrons on the metal that acts as an anode.
- The electrons flow to a cathode formed by hydrogen ions on the metal surface or with ions dissolved in the water
- These are deposited as insoluble precipitates such as rust on the metal surface called tuberculation that restricts the flow.

16

Corrosion Prevention Applications

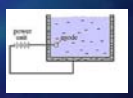


- Passivation (sacrificial anode) - use of light coat of material such as metal oxide to create a shell against corrosion.
- Cathodic Protection – uses a sacrificial anode or uses an external electric current on the iron to act as a cathode and has no anodic areas.
- Removing Corrosive Agents - Treating the water by softening and demineralization removing the dissolved solids and reducing the conductivity of the water.
- Chemical additions that alter the chemical reaction or tie up a particular in solution or at a metal surface.

17

Use of Cathodic Protection Systems for Storage Tanks

- Used to protect metal surfaces in contact with water
- Typically used to protect water tanks and pipelines in saturated corrosive soils
- Two methods: sacrificial (magnesium) anode or inert powered electrode



18

Other Methods Used to Stabilize Water

- pH adjustment
- Using scale forming tendencies to provide a barrier
- Providing protective coatings at surface of the metal
- Using Chemical Binding or the processes of Sequestering metal ions at the surface

19

Physical Factors Influencing Corrosion

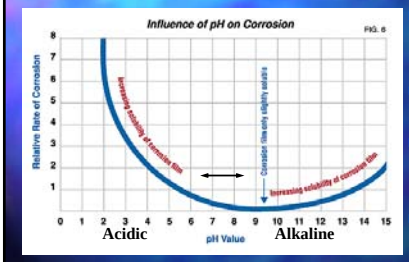
- Type and arrangement of materials
- System pressure
- Soil moisture
- Presence of stray electric currents
- Temperature
- Water flow velocity

20

Chemical Factors Influencing Corrosion

Cause	Effect
pH	pH below 7 causes water to be acidic
Alkalinity	Buffering capacity to resist change in pH.
Gases	Oxygen reacts with iron to form rust; carbon dioxide lowers pH
Solid Content	Increases electrical conductivity which increase potential for corrosion
Minerals Present	Water with little hardness tends to be more aggressive; no protective coating

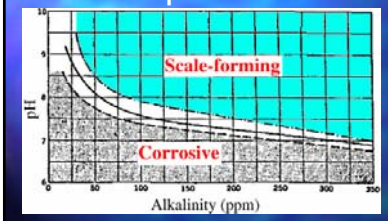
Effects of pH on the Rate of Corrosion of Metals in Water



- DEP requires water to have a pH 6.5 to 8.5
- At low pH water is corrosive
- At slightly alkaline pH water is stable
- At very high pH water will become corrosive

22

Relationships between Alkalinity, pH



This graph is known as the Baylis Curve. It shows the relationship between pH, alkalinity, and water stability. Water above the lines is scale-forming while water below the lines is corrosive. Stable water is found in the white area between the lines.

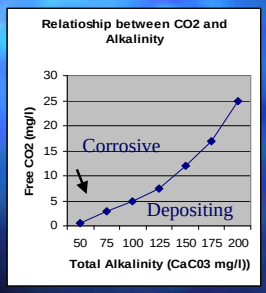
23

Corrosion Control by Adjusting pH or Alkalinity

- Adjustment of water chemistry
  - pH
  - Alkalinity
- Thin scale coating is provide to protect water mains and plumbing

24

Carbon Dioxide Content in Water Greatly Affects it's Corrosivity



- A Water with a High Concentration of CO2 will be very Corrosive.
- CO2 is often removed to it's ambient air concentration of 3.5 – 4 PPM by Aeration.

25

Chemical Stabilization Recap

- For high pH waters, lower the pH by adding sulfuric acid or carbon dioxide
- For low pH waters, lime, soda ash, sodium bicarbonate, or caustic soda can be added to raise pH
- Sequestering agents such as phosphates or silicates can be added that chemically tie up the scale forming ions

26

Concepts of Alkalinity and Chemical Adjustment

- When an alkali is added to water alkalinity?
  - increases
  - decreases
- Carbon dioxide is produced in water when alkalinity is?
  - added
  - consumed
- Carbon dioxide is destroyed when an alkali is?
  - added
  - consumed
- When carbon dioxide is formed the pH of a water will?
  - increase
  - decrease
- When carbon dioxide is destroyed the pH will?
  - increase
  - decrease

27

Chemicals Used in Water Treatment that change Alkalinity and pH

Lower	Raise
Gas Chlorine	Sodium Hydroxide
Sulfuric Acid (Muriatic)	Calcium Hydroxide (Lime)
Carbon dioxide	Sodium bicarbonate (Soda)
Alum	Sodium Carbonate (Soda Ash)
Ferric Chloride	Calcium Hypochlorite
Hydrofusolisic Acid	

28

Determining $CaCO_3$ Saturation Using the Marble Test

$CaCO_3$

Acid

Sample Compares	Water Stability	Saturation $CaCO_3$
pH and Alkalinity Increase	Water is Corrosive	Water is Under Saturated
pH and Alkalinity Decrease	Water is Scale Forming	Water is Supersaturated
pH and Alkalinity the same	Water is Stable	Water is Saturated

29

Langelier Saturation Index for Determining Water Stability

- Every water has a particular pH value where the water will neither deposit scale nor cause corrosion.
- A stable condition is termed saturation.
- Saturation (pHs), varies depending on calcium hardness, alkalinity, TDS, and temperature.
- The Langlier Index = pH – pHs
  Corrosive, 0 > LSI > 0, Scale Forming

30

Recommended Treatment for Corrosive and Scaling Water based on LSI

Saturation Index	Description	General Recommendation
- 5	Severe Corrosion	Treatment Recommended
- 4	Severe Corrosion	Treatment Recommended
- 3	Moderate Corrosion	Treatment Recommended
- 2	Moderate Corrosion	Treatment May Be Needed
-1	Mild Corrosion	Treatment May Be Needed
-0.5	None- Mild Corrosion	Probably No Treatment
0	Near Balanced	No Treatment
0.5	Some Faint Coating	Probably No Treatment
1	Mild Scale Coating	Treatment May Be Needed
2	Mild to Moderate Coatings	Treatment May Be Needed
3	Moderate Scale Forming	Treatment Advisable
4	Severe Scale Forming	Treatment Advisable

31

Use of Phosphates for Sequestering Dissolved Metals

32

Sequestering of Iron and Manganese in Drinking Water by Sequestering

What does sequester mean?

- To set aside; to separate and reject; to eliminate
- In Chemistry as in sequester metal; remove it from solution or combine it with something else to prevent it from coming out of solution

33

Sequestering Action of Poly and Ortho Phosphates

- Phosphates are used to solve water quality problems from inorganics (iron, manganese, and calcium) and maintain water quality by inhibiting and reducing:
  - Corrosion
  - Scale
  - Biofilm
  - Lead and copper levels
- Two general types are ortho and poly phosphate
- Orthophosphate is a corrosion inhibitor; forms a thin coating
- Polyphosphate sequesters (binds-up) the metals to maintain their solubility

34

Use of Corrosion Inhibitors (Polyphosphates, Orthophosphates and Silicates)

- Inorganic Phosphates (Polyphosphates,, glassy phosphates and bimetallic phosphates) and Sodium Silicates for dissolved metals in source water
- Orthophosphates for corrosive water to prevent leaching (iron ionization)
- Sodium Silicate for higher levels of Dissolved Iron (allowed by DEP rules for Iron between 1 PPM to 2 PPM)
- Corrosion inhibitors are most effective where water has low alkalinity and pH below 8.4.
- Apply 2 to 3 times dosage initially to build protective base
- Maintain consistent dose (2 to 12 mg/l) per manufacturer thereafter

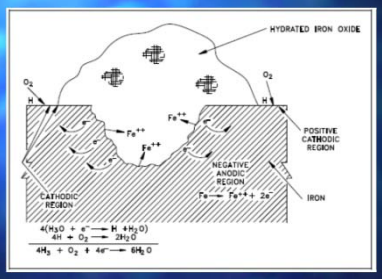
35

Polyphosphate Sequestering Agents for Dissolved Iron and Manganese

- 1 PPM < Fe and/or 0.3 PPM Mn can sequestered per DEP rules
- Polyphosphate is typically used and must be added before oxygen contact (in well)
- Sometimes be added after sedimentation also to capture bleed through or in combination with orthophosphate
- Large doses (>5 mg/l) will soften rust deposits in pipelines
- Proper dose is to keep iron and/or manganese tied up for 4 days

36

Problems with Sequestering Iron With Stagnant Water



37

Use of Orthophasphate and Orthophosphate Blends

- Used when Iron problems are result of pipeline corrosion
- Typical application is about 2 PPM with base dose required
- Too high of an application will dissolve iron deposits and carry them into customer residences

38

Troubleshooting Customer Complaints caused by Corrosion

Water Characteristic	Likely Cause
Red/reddish-brown Water	Distribution Pipe Corrosion
Blueish Stains on fixtures	Copper Line Corrosion
Black Water	Sulfide Corrosion of Iron
Foul Tastes and Odors	By-Products of Bacteria
Loss of Pressure	Tuberculation
Lack of Hot Water	Scaling
Reduced Life of Plumbing	Pitting from Corrosion

39

Backflow Prevention for Water Distribution System Operators

1

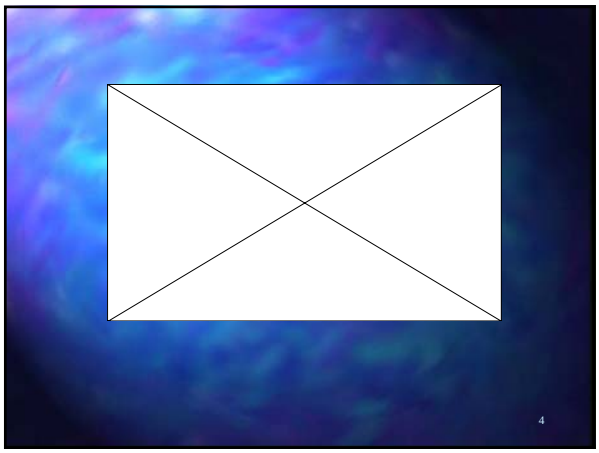
Backflow and Cross Connection Control Module Objectives

- Identify Backflow and CCC Requirements
- Understand how Backflow problems occur
- Identify DEP Requirements for Backflow and Cross Connection Control in Water Distribution Systems
- Identify the Various Hazards in a Water Distribution System
- Identify the types and applications of backflow prevention devices
- Identify Rules for Auxiliary Water Systems

2

Backflow & Cross Connection Requirements

3



4

Cross-Connections

- A cross connection is a improper connection between a contaminated water source and the public water system
- Plumbing cross-connections are a dynamic problem because piping systems are continually being installed, altered or extended

5

Reducing the Probability for Cross-Connections

- Education is essential even for those experienced in piping installations
- The biggest hazard in a backflow problem is the failure to recognize the cross-connections and its potential dangers
- Control of plumbing cross-connections is possible through thorough knowledge and vigilance

6

Examples of Cross Connections

- One of the most notorious incidents of cross connection was the "Holy Cross Episode," when many members of the Holy Cross football team developed infectious hepatitis as a result of contact with contaminated water pooled around a sprinkler head. The water supply became contaminated when a partial vacuum in the water distribution system was created due to a nearby fire which drew contaminated water back into the potable water supply.
- Another backflow contamination case occurred in Minnesota in 1978 after an herbicide was backsiphoned from a farmer's tank truck into a city's water system. The farmer filled his water tank from a hose by the city's water plant. The water pressure suddenly dropped and the pesticide in the truck was siphoned into the city's water system. Fortunately, no illness from the contamination occurred, but the city had to limit its water use until the entire system could be flushed and refilled with clean water.

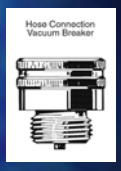
7

Most Frequent Causes of Cross Connections

- Plumbing is frequently installed by persons unaware of the inherent dangers of cross connections
- Connections are made a matter of convenience without regard to the dangerous situation that might occur
- Connections are made with reliance on inadequate protection such as a single valve or other mechanical device that does not provide the needed protection from backflow

8

Example of a Cross Connection with Possible Backflow



Device to prevent backflow from hose.

9

Most Frequent Types of Cross-Connection Problems Encountered in the Field

- Fire protection sprinkler systems
- Lawn irrigation systems
- Hose bibs

10

State Mandated Cross - Connection Programs

- Community water systems and all public water supply systems that have service areas also served by reclaimed water are required to have cross-connection control programs.
- All public water systems and private water supply systems should also be familiar with the dangers of cross-connections and should exercise careful surveillance of their systems

11

Methods of Contamination through Cross-Connections

- Cross-connections are the links through which it is possible for contaminating materials to enter a potable water supply
- Contaminants enter the potable water system when the pressure of the polluted source exceeds the pressure of the potable source
- Backflow results from either:
  - **backsiphonage**
  - **back pressure**

12

Back Pressure

- Reversed flow due to backpressure other than siphon action
- Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other as a result of the pressure differential
- Flow occurs from the zone of higher pressure to the zone of lower pressure

13

Backsiphonage

- Occurs when there is a pressure drop in the water system
- Higher elevations in the system cause the water to reverse gradient and flow into areas of lower gradients
- Water flows from the zone of higher pressure to the zone of lower pressure
- This is why DEP requires 20 psi at the service connection

14

Degree of Hazard (def.)

- a determination on whether the substance in the non-potable system is toxic (health hazard) or non-toxic (non-health hazard).

15

Health Hazard Facilities

Type of Facility	Potential Hazard
Hospitals, clinics, laboratories, mortuaries	Bacterial cultures, laboratory solutions, blood & tissue, toxic materials
Sewage & industrial wastewater treatment fac.	Sewage industrial wastewater, contaminated water, toxic chemicals
Paper manufacturing, dye plants, petroleum processing, tanneries	Toxic chemicals, water conditioning compounds (acids, solvents, mercury, chromium
Canneries, breweries, food processing, meat packers	Process wastewater, steam, detergents, acids, caustics
Commercial greenhouses, spraying & irrigation systems using herbicides and pesticides	Toxic chemicals (phosphates, arsenite, lindane, malathion
Metal-plating, photo processing, car washes, dry cleaning	Toxic chemicals, concentrated cleaning agents, solvents (cyanides, copper, chromium, caustic & acid solutions

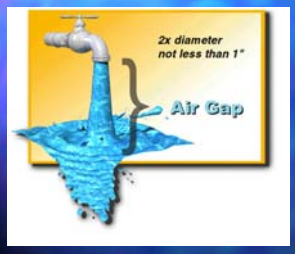
16

Types of Backflow Prevention Devices

- Air Gap
- Reduced Pressure Principle Devices
- Atmospheric Vacuum Breaker
- Pressure Vacuum Breaker
- Double Check Valve Assembly
- Residential Dual Check

17

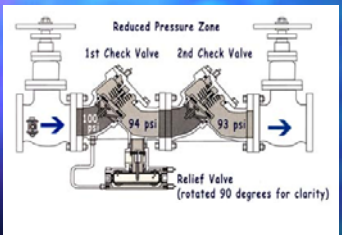
Air Gap



- **Physical Separation**
- **Gap must be 2x Diameter but not less than 1”**
- **Provides Maximum Protection**

18

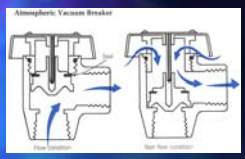
Reduced Pressure Principle Assembly

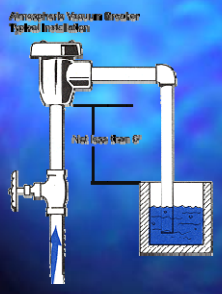


- **Prevents both Back Siphonage and Backpressure**
- **Independent operated dual check valves and automatically operated pressure differential relief valve that will open and release water**
- **Must be installed above grade**

19

Atmospheric Vacuum Breaker





- Prevents backsiphonage only
- Should be used only in non-health situations
- Must be installed at least 6" above any downstream piping
- Uses gravity to stop flow - installed vertically
- Absolutely no shutoff on the discharge side of the vacuum breaker

20

Pressure Vacuum Breaker

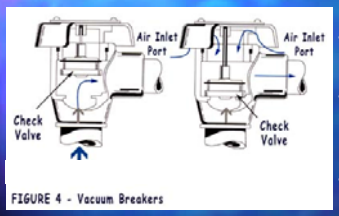
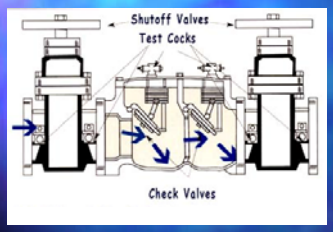


FIGURE 4 - Vacuum Breakers

- Used in both health and non-health applications
- Prevents backsiphonage only not backpressure.
- Air vent opens system to atmospheric pressure when flow stops.
- Minimum of 12" above highest outlet
- May have two valves and two test cocks

21

Double Check Valve Assembly

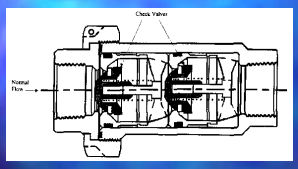


- Two single operating check valves and four test cocks located between two tightly closing shutoff valves.
- Will isolate backflow and backsiphonage but used only in non-health hazards
- Place valve 12" or more above high water level of surrounding ground.

Check Valves May Be Tested In-Place

22

Residential Dual Check Valve



- Protects against both backsiphonage and backpressure in low hazard situations
- May be used under continuous pressure
- Low initial installation cost
- May be used in areas served by reclaimed water
- No external indication of failure

23

Responsibility for Cross-Connections

- Purveyor, supplier, or the water utility;
  - Under the provisions of the SDWA of 1974 and subsequent Amendments, the water purveyor is held responsible for providing water that meets all applicable National Primary DW Stds
  - Upon discovery of a cross-connection the public water system shall eliminate the cross-connection by installing an appropriate backflow device or discontinue service.
- Water users
- Plumbing officials
- Health agencies

24

Acceptable DEP Cross Connection and Backflow Program

Must be developed using AWWA Manual 14

1. Establishment of authority and policy
2. Establishment policy requirements and appropriate use of BFP devices for health hazards encountered.
3. Establish installation and service standards
4. Establish policy for testing and maintenance
5. Establish procedures for new and existing service connections
6. Establish procedures for maintaining CCC records
7. Establish standards for customer notification and education

25

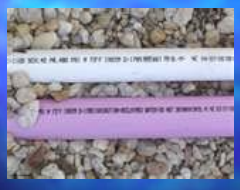
Identification of Backflow Problems

If customers complain of odor, discoloration and taste problems what may be the cause?

- Watermain breaks where pressure <20 psi
- Rapid Drops in Disinfection Residual
- Meters Running in Reverse
- Persistent Bacterial contamination

26

Color Identification for Reclaimed Water Pipe



27

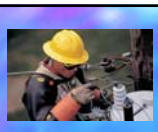
Water Distribution Safety

1

Water Distribution Safety Module Objectives

- Identify Basic Trench Safety Requirements
- Identify Peripheral Hazards in Water Distribution Work such as Falling Debris, Trench Ingress and Egress, Confined Space Requirements and Traffic Control
- Identify the Requirements for Shoring
- Understand the Requirements for a Lock-out/Tag-out Program
- Understand "Right to Know" and SDS Program

2



Hard Hat Area

- The shell and suspension inside of the hat work to absorb energy and protect the worker from a blow to the head.
- Effectiveness impacted by:
  - Ultraviolet light
  - Tears or cracks in the suspension
  - If hard hat is involved in an impact accident or dropped from any elevation it needs to be replaced.
  - Solvents can affect integrity of the shell
- Recommend to replace every five years or sooner if conditions warrant.

3

Trench Safety

4

Underground Utilities

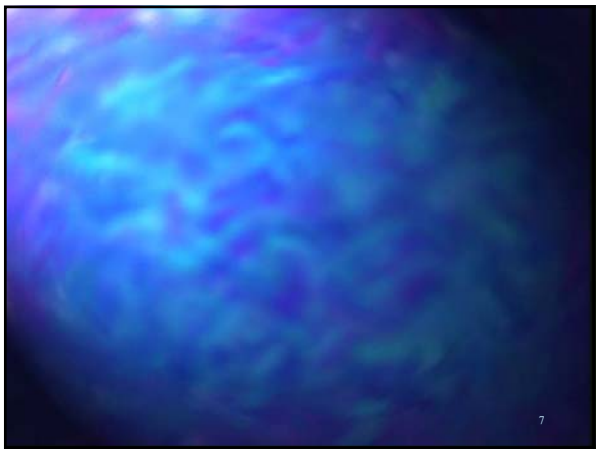
- "Call Before You Dig" - locate before you dig all buried water, sewer, gas, power, telephone, cable TV, and storm drains
- Sunshine 811 is Florida's one-call center charged with helping prevent damages to underground utilities
- Underground utility owners and operators are required by law to be members of Sunshine 811
- Failure to call may result in fines or criminal charges

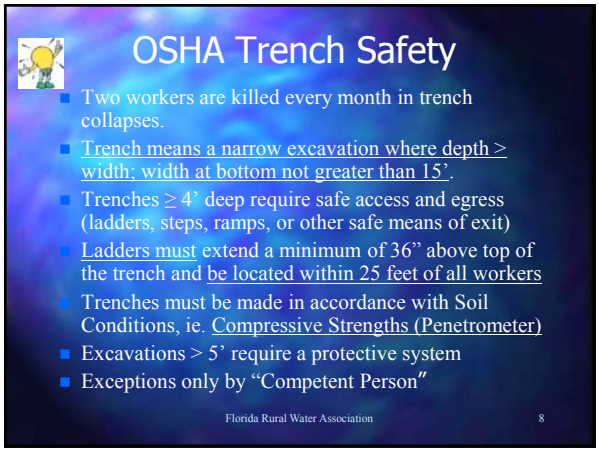
5

APWA Uniform Color Codes for Underground Utilities Marking

Color Code	Type Utility
White	Proposed excavation
Pink	Temporary Survey Markings
Red	Electric Power Lines, Cables, Conduit, and Lighting Cables
Yellow	Gas, Oil, Steam, Petroleum, or Gaseous Materials
Orange	Communication, Alarm or Signal Lines, Cables, or Conduit
Blue	Potable Water
Purple	Reclaimed Water, Irrigation, and Slurry Lines
Green	Sewers and Drain Lines

6


7


OSHA Trench Safety
Two workers are killed every month in trench collapses.
Trench means a narrow excavation where depth > width; width at bottom not greater than 15'.
Trenches ≥ 4' deep require safe access and egress (ladders, steps, ramps, or other safe means of exit)
Ladders must extend a minimum of 36" above top of the trench and be located within 25 feet of all workers
Trenches must be made in accordance with Soil Conditions, ie. Compressive Strengths (Penetrometer)
Excavations > 5' require a protective system
Exceptions only by "Competent Person"
Florida Rural Water Association
8


Competent Person
Competent Person in- "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them."
OSHA Trench Safety Training is required for all employees:
The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.
The Competent Person must have the actual authority to stop work until the unsafe situation is resolved.
9

Trench Inspection Requirements

- Daily and before the start of each shift;
- As dictated by the work being done in the trench;
- After every rainstorm;
- After other events that could increase hazards, e.g. snowstorm, windstorm, thaw, earthquake, etc.;
- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom, or other similar conditions occur;
- When there is a change in the size, location, or placement of the spoil pile; and
- When there is any indication of change or movement in adjacent structures.

10

Allowable Trench Slopes

Soil Type (no water)	Run to Rise	Slope Angle
Stable Rock	Vertical	90º
Type A > 1.5 tsf (cohesive sandy clay)	3/4 to 1	53º
Type A (short term)	1/2 to 1	63º
Type B > 0.5 tsf (cohesive silt w/ grvl)	1 to 1	45º
Type C < 0.5 tsf (granular & sand)	1½ to 1	34º
Maximum Depth < 8 feet		

11

Common Causes of Cave-ins

- Improper shoring for soil type and conditions
- Shoring installed and removed improperly - correct procedure is to install braces from top to bottom and removed from bottom to top
- Spoil bank too close and too heavy
- Eight (8) feet is the max spacing for uprights with a max depth of 10 ft. For unconsolidated soils or depth > 10' solid sheeting may be required.
- External vibration increases risk of failure.

12

There is a trench that is 4 ft wide, 6 ft deep and 100 ft long and there is no safe for storing the soil. How many cubic yards of soil must be hauled away and how many ladders are needed?

Volume = L x W x H

Volume = 100 x 4 x 6 = 2400 ft^3

Convert to cubic yards

Volume = 2400 ft^3 x $\frac{1 \text{ cu yd}}{27 \text{ ft}^3}$ = 88.9 cu yd

Number of ladders: 2

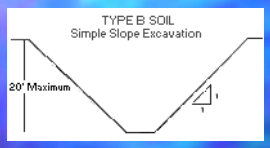
13

Protective Systems

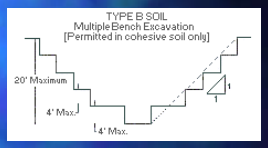
- **Benching** means a method of protecting workers from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps. *Benching cannot be done in Type C soil.*
- **Sloping** involves cutting back the trench wall at an angle inclined away from the excavation.
- **Shoring** requires installing aluminum hydraulic or other types of supports to prevent soil movement and cave-ins.
- **Shielding** protects workers by using trench boxes or other types of supports to prevent soil cave-ins.

Florida Rural Water Association 14

Sloping and Benching



Standard Trench Construction

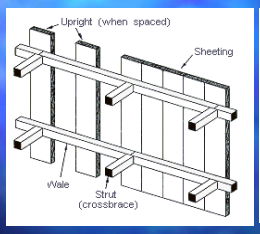


Benching to achieve greater safety

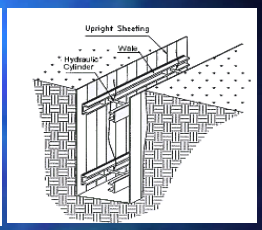
- Maximum depth is 20’
- Slope varies depending on the type of soil
- Trench width is not greater than 15’ (at bottom)
- Safe access and egress required for trenches ≥ 4’ deep

Refer to OSHA Technical Manual for other configurations 15

Shoring in Unstable Soils



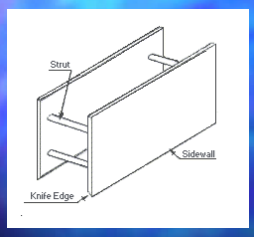
Timber Shoring

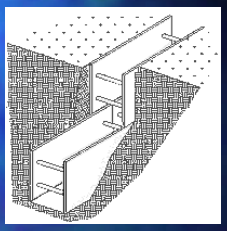


Hydraulic Shoring – allows for increased axial compressive load, thus increased safety

16

Shielding: Use of a Trench Box





Pre-engineered Trench Boxes provide additional safety over shoring and sheeting methods

17

Excavations
Other Considerations

- Traffic Control
- Falling Loads
- Spoil or Backfill >4′ from edge (> 2′ from trench OSHA)
- Removal of Water from Trench
- Stability of Adjacent Structures
- Hazardous Atmosphere
- Underground Utilities - Electrical Cables

18

Working in Areas with Vehicular Traffic

- Workers must wear vests with reflective markers
- Require a dedicated flag person
- Proper signals, signage and barricades must be used

19

Surface Crossing of Trenches

- Vehicle Crossing must be designed by PE
- Walkways must be provided for foot traffic
- Have a minimum width of 20" and be fitted with handrails
- Must extend 24" from end of trench

20

Requirements to Prevent Vehicles from Falling into Trenches

- Barricades must be installed
- Hand or Mechanical Signals must be used
- Stop Logs must be installed whenever there is a danger of falling vehicles
- Soil must be graded away from trench

21

Requirements for Exposure to Falling Loads

- Workers can't be under raised loads
- Must stand away from equipment being loaded or unloaded
- Drivers may stay in vehicle while being loaded provided the vehicle is fitted with a cab shield or appropriate canopy

22

Standing Water Accumulations

- Use of special support or shield systems approved by a registered professional engineer.
- Water removal equipment, i.e. well pointing, used and monitored by a competent person.
- Safety harnesses and lifelines used in conformance with 29 CFR 1926.104.
- Surface water diverted away from the trench.
- Employees removed from the trench during rainstorms.
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

23

Hazardous Atmospheres and Confined Spaces

- Workers may not enter spaces with < 19.5% or > 23.5% Oxygen
- The range of explosive or flammable gas mixtures is defined by the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL).
- The objective of gas detection equipment is to warn us when we are within 10% of the LEL.
- Workers may not enter spaces with Threshold Limit Values of Airborne Contaminants established by American Conference of Governmental Industrial Hygienists

24

Common Gases Encountered

Chemical	Physiological Effects
Oxygen	Respiratory problems
Carbon Dioxide	.2 to .25% causes unconsciousness in 30 minutes
Hydrogen Sulfide	Death in a few minutes at 0.2%
Methane	Deprives tissues of oxygen; does not support life
Nitrogen	Deprives tissues of oxygen; does not support life

25

Testing of Atmospheric Conditions in a Trench

- Testing must be conducted before employees enter a trench
- Oxygen must be not less than 19.5%
- Frequency of testing must be increased if equipment is operated in the trench
- Testing frequency must be increased if welding, cutting or burning is occurring in the trench

26

Confined Space Entry

- Fitted Respirators must be used in Hazardous Atmospheres
  - Employees must be trained in their use and a program established
- Attended (at all times) lifelines must be provided when employees enter bell-bottom pier holes, deep confined spaces, or other similar hazards.
- Employees who enter confined spaces must be trained.

27

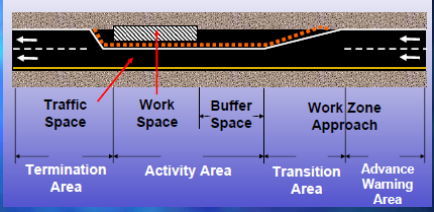
Work Zone Safety

The Florida Department of Transportation establishes policy

- Adopted the "Manual on Uniform Traffic Control Devices" (MUTCD)
- Index No. 600 provides Department policy and standards
- Mandatory to use the MUTCD on State Maintained Highways for construction, maintenance operations or utility work
- All work shall have a traffic control plan

28

Elements of a Traffic Control Plan

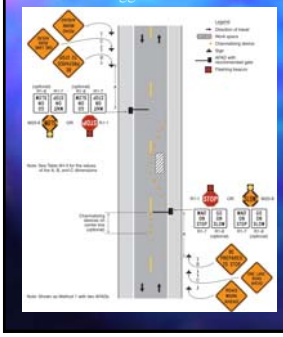


Warning Signs should be placed at a distance calculated as 4 to 8 times (in feet) the speed limit (in MPH)-use a higher multiplier for higher speed areas

29

Spacing for Safety Signage

Automated Flagger Assistance Device



Road Type	Approximate Distance between signs		
	A	B	C
Urban (low speed*)	100	100	100
Urban (high speed*)	350	350	350
Rural	500	500	500
Expressway/ Freeway	1,000	1,500	2,600

Traffic Channelizing Devices

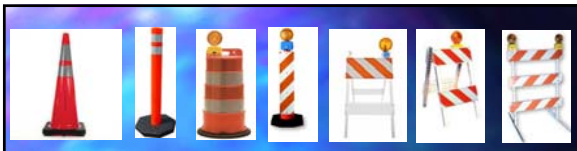
- Cones
- Tubular Markers
- Drums
- Vertical Panel
- Type I Barricade
- Type II Barricade
- Direction Indicator Barricade
- Type III Barricade
- Longitudinal Channelizing Device

31

Function of Channeling Devices

- Warn and alert drivers of hazards created by work zone activities
- Provide for smooth and gradual vehicular traffic flow from one lane to another, onto a bypass or detour, or into a narrower traveled way
- Channelize vehicular traffic away from the work space, pavement drop-offs, pedestrian or shared-use paths, or opposing direction of vehicular traffic

32



CONES | TUBULAR MARKER | PLASTIC DRUMS | VERTICAL PANEL | TYPE I | TYPE II BARRICADES | TYPE III

- Minimum height is 36 inches, except the type III barricade which is 5 feet minimum and 6 feet wide
- At night, all drums, vertical panels, and barricades shall have warning lights
- Ballast shall not be on top rails or more than 13 inches above driving surface
- Cones shall be used only in active work zones where workers are present
- Cones shall be predominantly orange, fluorescent red-orange, orange, or fluorescent yellow and shall be made of a material that can be struck without damaging vehicles on impact.

33

Use of Construction Flagging

- Construction equipment or vehicles are in uncontrolled traffic lanes
- Two way traffic can pass in only one direction
- Pathway through traffic is confusing to motorists
- In emergency situations

34

Electrical Safety

35

Employer's Energy Control Program (Lockout/Tagout)

- Required for all Stored Potential Energy (Water, Electricity and Air Pressure)
- Procedures for Lockout/Tagout Devices
- Training for all Employees which includes safe application, use and removal of Lockout/Tagout Devices
- Inspect Procedures at Minimum Annually

36

Preventing Accidents from Unexpected Startup

Basic Elements of a Proper Lockout/Tagout Procedure

- Notify affected employees
- Shut down operating equipment using normal procedures.
- Isolate equipment from its energy source
- Lock out and tag the energy isolating device
- Ensure no personnel are exposed and start machine to ensure the equipment will not operate
- The equipment is now locked and tagged out. Work may begin.
- After work complete, tools removed, guards installed and employees clear remove lockout and tagout devices
- Notify employees that devices have been removed

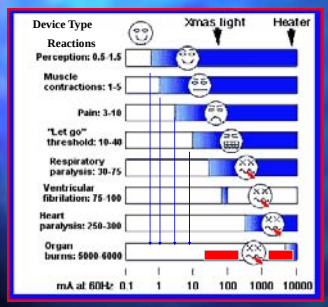
37

Electrical Shock and Human Body

- Two Live Wires of Electric Circuit
- One Wire of an Energized Circuit and the Ground
- A Metal Part that is Accidentally Energized due to Loss of Insulation
- Another Live Conductor

38

Dangers of Electricity Hand to Foot for 1 Second



milli-amps	Reaction
1	Tingle
5	Shock
6	Pain
7	Freezing
50	Severe
1000	Heart
10000	Death

39

Damaging Effects of Electrical Shock

- Amount of Current Flowing through the Body (milliamps)
- The Currents path through the Body
- Length of Time the Body remains in the Circuit
- The Current's Frequency

40

Factor Present in Every Electrical Accident

1. Established safe work procedures were either not implemented or not followed
2. Adequate or required personal protective equipment was not provided or worn
3. Lockout/Tagout procedures were either not implemented or not followed;
4. Compliance with existing OSHA, NEC, and NESC regulations were not implemented;
5. Worker and supervisor training in electrical safety was not adequate.

41

Preventing Electrical Accidents

- Develop and implement a comprehensive safety program
- Ensure compliance with existing OSHA regulations Subpart S of 29 CFR 1910.302 through 1910.399
- Ensure compliance Subpart K of 29 CFR 1926.402 through 1926.408 of the OSHA Construction Safety
- Provide all workers with adequate training in the identification and control of the hazards
- Provide additional specialized electrical safety training to those workers working with or around exposed components of electric circuits
- Include lockout and tagout procedures and ensure that workers follow these procedures.
- Provide those workers who work directly with electrical energy with testing or detection equipment
- Actively encourage all workers to participate in workplace safety.

42

Basics of Current Flow

- Must have a complete path
- Current will flow through humans and other conductors (metal, earth and concrete)
- Current causes injuries to internal organs
- Insulators resist the flow of current
- Voltage has potential at all times

43

Insulators and Conductors

- Material which permits the flow of electric current, like copper, is called a conductor
  - Insulation on conductors is often color coded
  - Insulated equipment grounding conductors usually are either solid green or green with yellow stripes
  - Ungrounded conductors, or "hot wires," are black or red and in three phase motor installation are black, red and white with the green ground.
- Material which will not permit the flow of electricity is called an insulator
  - Glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current
  - When wrapped or cast around a wire it is called insulation; used to prevent loss of electrical flow by two conductors coming into contact with each other

44

Importance of Guarding and Labeling Electrical Equipment

- Guarding involves locating or enclosing electric equipment to make sure people don't accidentally come into contact with its live parts
- Guarding requires equipment with exposed parts operating at 50 volts or more to be placed where it is accessible only to authorized people qualified to work with it
- Conspicuous signs must be posted at the entrances to electrical rooms

45

Volt/Ohm Meter uses

- Check to determine if circuit is live
- Check voltage at each leg
- Check electrical components for activation
- Check continuity of a circuit or a device such as a fuse

46

Some uses of an Ammeter in Testing Pumps and Motors

Problem	Indication
Pump clogged with rags or other obstructions	Amp Readings that exceed FLA or normal signature
Pump shaft broke or impellor loose	Amp Readings that are significantly under FLA or normal signature
Problem with motor or electrical feed	Motor legs have amp imbalance

47

The Purpose of Grounding Electrical Equipment

- "Grounding" a tool or electrical system means intentionally creating a low-resistance path that connects to the earth
- Grounding prevents the buildup of voltages that could cause an electrical accident
- Grounding substantially reduces the risk especially when used in combination with other electrical safety measures

48

Ever Present Dangers of Working near Overhead Power Lines

- Always Assume that any overhead power lines are energized
- You are required to Stay at least 10 feet from overhead lines by OSHA.
- Employees standing on the ground should avoid contact with the motorized equipment unless it is located outside of the 10 ft danger zone or the equipment's maximum reach
- Guarding power lines with barriers (safety cones) is the best way in preventing accidental contact.
- Never jump off equipment that has been energized by a powerline!

49

Hazards Communication Plan (Hazcom)

- Identify Hazardous Materials
- Obtain Chemical Information and Define Hazardous Conditions
- Properly Label Hazards
- Train Operators

50

Worker Right to Know

- Employee "Right to Know" legislation requires employers to
  - Inform employees of the possible health effects resulting from contact with hazardous substances
  - Train operators to work safely with hazardous substances under normal and emergency conditions
- As an operator you have the right to:
  - Know information on the hazardous substances
  - Be trained to work safely with the hazardous substances
  - To ask your employer if you are working with any hazardous substances

51

Materials Safety Data Sheet (MSDS)

1. Chemical identification information and also an emergency phone number
2. Hazardous ingredients and exposure limits
3. Physical data such as boiling point, vapor pressure, solubility, appearance and odor
4. Fire and explosion data including flammability and extinguishing media
5. Reactivity data lists the conditions and materials with which it may react
6. Health hazards such as symptoms of over exposure and first aid procedures should exposure occur
7. Precautions for safe handling and use including what to do to clean up an accidental spill or leak
8. Control measures list any personal protective equipment or special work practices required when handling this chemical

52

Chemical Labeling

- All chemical containers must be labeled, tagged or marked with the identity of hazardous chemical and must show hazard warnings appropriate for employee protection
- The hazard warning can be any type of message, words, pictures or symbols that provides information regarding the hazards of the chemical in the container, generally ANSI standards will be used
- Labels must be legible, in English and all other necessary languages appropriate to the facility
- Exemption to requirement would be for
  - Portable containers in which hazardous chemicals are transferred from labeled containers and that are intended only for the immediate use of the employee who makes the transfer

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OSHA and American National Standards Institute (ANSI) for Chemical Labeling

- signal words - DANGER, WARNING, CAUTION
- highly toxic materials shall be marked POISON
- precautionary measures useful in preventing physical harm to the individual
- instructions in case of exposure
- notes to physician for emergency treatment
- instructions in case of fire or chemical spill
- instructions for chemical handling and storage

OSHA Requirements

Identification

Name of Supplier

Hazard Precautions

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Detection and Protection for Hazardous Chemicals

Detection Training

- During training provide samples of hazardous chemicals to observe for odor, color and viscosity
- Prior to observation, review each MSDS for hazardous chemical and review
- Go over exposure and symptoms
- Review the standard precaution of any unmarked, unidentifiable chemical. Dispose of as a hazardous chemical.

Protective Measures

- For all hazardous chemicals in your facility you must include in your training employee's PPE. It is important to provide this training at the same time as MSDS training

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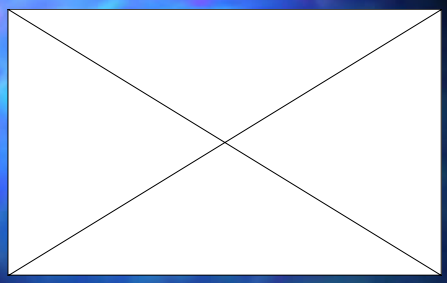

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NEW! Globally Harmonized System (GHS)

- What is GHS?
  - Stands for the Globally Harmonized System of classification and labeling of chemicals
  - Same criteria throughout the world
  - Standardizes Warning Labels and Safety Data Sheets
- Who will be Affected? Manufacturer, supplier and user
- When will GHS start? It has already begun.

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What must be done to comply with GHS?

- Classification of chemicals to GHS criteria
- Prepare GHS format "Safety Data Sheets" (SDS)
- Prepare labels with GHS elements
- Train Employees on New Label Elements and SDS Format (complete by 12/1/13)

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Elements of a Container Label

(OSHA adopted "GHS" labeling requirements)

- Identity of product or chemical
- "Signal" word
  - Danger or
  - Warning
- Hazard Statement(s)
  - Standardized
  - Based on hazard classification & category

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Elements of a Container Label (cont)

- Precautionary Statements
  - Standardized in GHS
  - How to prevent exposure
  - Storage requirements
  - First aid procedures
  - Spill response
  - Disposal of chemical

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Elements of a Container Label (cont)

- Supplier Information
  - Name of manufacturer or distributor
  - Address
  - Telephone number
- Supplemental Information
  - Directions for use
  - Expiration date
- Pictograms

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Pictograms

- Appear on container labels and Safety Data Sheet's
- 9 different labels

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SULFURIC ACID

DANGER!

HAZARD STATEMENT:
Keep locked up. Keep container dry. Do not breathe gas/fumes/vapor/spray. Never add water to this product. Keep away from incompatibles such as oxidizing agents, reducing agents, combustible materials, organic materials, metals, acids, moisture. May corrode metallic surfaces. Store in metallic or coated fiberboard drum using a strong polyethylene inner package.
Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas. Reacts with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.

PRECAUTIONARY STATEMENT:
AVOID CONTACT WITH SKIN AND EYES. Very hazardous in case of skin contact, of eye contact, of ingestion, of inhalation. Liquid or spray mist may produce tissue damage particularly on mucous membranes. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract. Severe over-exposure can result in death.
The substance may be toxic to kidneys, lungs, heart, cardiovascular system, upper respiratory tract, eyes, teeth,. Repeated or prolonged exposure to the substance may produce general deterioration of health in one or many human organs.

FIRST AID INFORMATION:
In the event of any personal contact, seek medical attention immediately. Flush with water. If inhaled, remove to fresh air. If digested, do not induce vomiting.

COMPANY NAME _____
STREET ADDRESS _____
CITY _____ **STATE** _____
ZIP CODE _____ **COUNTRY** _____
EMERGENCY PHONE NUMBER _____

SUPPLEMENTAL INFORMATION:
Other information may be included on the label as needed. Example: See Safety Data Sheet for further details regarding the safe use of this product.

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Deadlines

- Revised Haz-Com standard published March 24, 2012
- GHS-compliant labels by June 1, 2015
- Employers provide training on new labeling system by December 1, 2013
- Update written Haz-Com program by June 1, 2016

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