Collection System Operation & Maintenance

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Wastewater Collection Operation & Maintenance

MCET
ENVIRONMENTAL, HEALTH, AND SAFETY TRAINING

Maryland Center for Environmental Training
College of Southern Maryland
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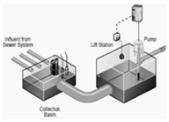
Wastewater Collection and Treatment

- Wastewater moves primarily by gravity flow
- Pumping stations lift wastewater from low lying areas to higher elevations
- During wet weather events, wastewater flows increase due to I/I:
  - **I**nflow of rainwater
  - **I**nfiltration of groundwater



Wastewater Collection and Treatment

- ***Velocity*** plays a key role in solids and grit travel through a collection system
- Average rates range between 2 to 3.5 ft/sec (fps); peak rates can exceed 10 ft/sec
- Solids stay mixed while grit concentrations travel like a moving bed along the bottom of the sewer pipe
- At higher velocities, flow becomes turbulent dispersing the grit with the solids; at velocities below 2 fps, grit will begin to settle out

Sanitary Sewer Overflow (SSO)

An incident where any measurable or observable quantity of wastewater exits the sanitary sewer system.

4

This is an SSO if a discharge to the environment occurs during pump-out

Wastewater Collection 5

Most collection system problems fall into one of three categories:

- *Design Problems*
- *Maintenance Problems*
- *I&I Problems*

Give some examples of each?

Wastewater Collection 6

Goals of the Maintenance Program

- Prevent Overflows
- Maximize the system's reliability
- Maximize the system's life

Objectives of Sewer Cleaning and Maintenance Programs

- Minimize the number of stoppages per mile of sewer
- Minimize the number of odor complaints
- Minimize the number of sanitary sewer overflows

What are the characteristics of good maintenance programs?

- Uses planned and scheduled maintenance to prevent problems
  - Preventive maintenance
- Responds quickly and effectively to problems
  - Corrective maintenance
- Uses long-range planning to schedule repairs and replacements
  - Predictive maintenance

Corrective Maintenance

- Unplanned, emergency maintenance.
- Reactive, not planned.
- Undesirable, but unavoidable.
- Minimizing = Program goal
- Establish the means to minimize response time.
- Have operating procedures to quickly resolve problem.

Preventive Maintenance

- Proactive maintenance
- Programmed, systematic approach
- Planned and scheduled maintenance.
- Maintenance frequencies determined by system condition.
- Indicates problem areas for further attention.

Predictive Maintenance

- CMOM identifies components at the end of their useful life
- These components are either replaced, rehabilitated or upsized
- By using CMOM techniques, rehabilitation/replacement can be scheduled based on need

Collection Systems

Inspection and Testing

Common Collection System Inspecting and Testing Techniques

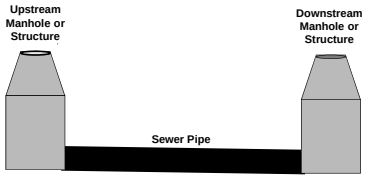
- Manhole Inspections
- Trunk-Line Walking
- Closed-Circuit Television Inspection
- Smoke Testing
- Dye Testing

Reasons for Inspection & Testing

- Identify existing or potential problems in the collection system
- Evaluate the seriousness of the detected problems
- Locate the position of the problems
- Provide clear, concise and meaningful reports

The Line Segment

The basic location reference for all collection system components



Manhole Numbers

- Designed to give each manhole a unique identifier based on its location in the City.
- Manhole numbers use the City's Sanitary Sewer Map Key to reference it's location
- By interpreting the number you can determine where in the city the manhole is located

Manhole Inspections

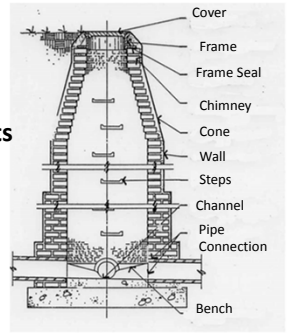
Why Inspect Manholes?

- Our main view into the collection system's interior
- They tell us a lot about the condition of the system
- Problems in manholes can result in problems in the mains
- They can be a source of I/I

Objectives of Manhole Inspections

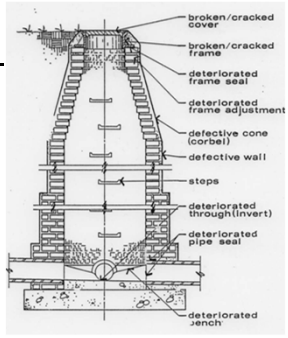
- Determine if manhole is accessible
- Determine proper elevation or grade around lid
- Observe its structural integrity
- Observe any debris buildup in the main
- Observe evidence of surcharging
- Look for sources of I/I
- Observe incoming and outgoing pipes

Manhole Components



Manhole Inspection Procedure

1. Observe lid location and condition
2. Check frame for damage
3. Observe interior conditions
4. Lamp incoming and outgoing lines
5. Replace manhole lid securely



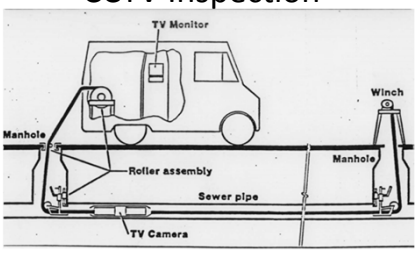
Inspection Recording Guidelines

- Wall - Material, Diameter, Height, Condition
- Bench - Material, Condition
- Channel - Type, condition
- Steps - Type, spacing, condition
- Observe pipe connections and lamp pipe interior
- Location - Address, cross street, manhole number
- Cover
  - Type, size, material, condition
  - Subject to ponding
  - Distance above/below grade
  - Cover – frame fit
- Frame - Height, size, condition, offset
- Chimney - Type, Height , Condition
- Cone - Material, Height, Condition

CCTV Inspection

- Uses a CCTV camera to observe and record the conditions within the pipe interior
  - Identifies existing or potential line problems
  - Allows for evaluation of the causes and sources of I/I in the line
  - Determines the appropriate methods for repair
  - Provides a method to check new installations or recent repairs of the line

CCTV Inspection



- TV Inspection is normally conducted from upstream to downstream
- Keep TV truck a minimum of 8 feet from the working manhole.
  - Cable reel should be aligned with center of manhole opening
- Install proper tractor or skids so camera will be in the center of the pipeline
- Connect and secure cable

TV Inspection Procedure

- Place camera in channel. Slowly pan the interior of manhole
- All distances should be measured from the manhole wall
  - Set footage meter accurately
    - Use a reference point on the cable to set the meter
    - Once a month you should reel out 100 feet of cable and measure it with a tape to check against footage meter
- Move camera into line
- Pipe should be clean so entire pipe can be seen
- Travel speed should not exceed 30 feet per minute
- Use clock positioning for object location
- Record service connection location & street address
- Temporarily stop camera at each service connection, defect and other features
- Make every effort to televise the entire line from US to DS manhole
- Record all observations using accurate codes

Pipeline Assessment and Certification Program (PACP)

- A standardization of TV observation codes that will provide consistent assessment information throughout the industry.
- Users are certified through the National Association of Sewer Service Contractors (NASSCO)
- All information is recorded on a CCTV inspection form
- Allows all recorded observations to be placed in a database
- Allows those observations to be consistent among operators
- Allows us to determine changes in the pipe over time without video review
- Allows for the establishment of a condition rating for each line
- Document all header information
  - Header is the top part of the CCTV Inspection form
- A separate inspection form will be started for each line segment
- If a new manhole is discovered, a new form will be created
- A separate inspection form is used for reverse setups

PACP Codes give information about

- Continuous Defects
- Structural Defects
- Operational and Maintenance Conditions
- Construction Features
- Miscellaneous Features

Operational and Maintenance Defects

Defects can be either **Point** or **Continuous**

- **Point defects** are at a distinct location
- **Continuous defects** occurs over a length of sewer.
- This family of defects describe foreign objects found in sewers. Comprise 5 groups:
  1. Deposits
  2. Roots
  3. Infiltration
  4. Obstacles/obstructions
  5. Vermin

DEPOSITS (D)

- Can be either
  - Attached (DA): material attached to the wall
  - Settled (DS): material on the pipe invert
  - Ingress (DN): material that has washed into the pipe from surrounding ground
- Modifiers will be used to further describe the material such as grease (G), Rags (R), Encrustation (E), etc

ROOTS (R)

- These codes describe the entry of roots through the pipe barrel, connections and laterals
- They can be either fine (RF), tap roots over ½ inch thick (RT), a medium mass less that 50% of the pipe area (RM) or a root ball greater than 50% of the pipe area (RB)
- The code also indicates the origin as the pipe barrel (B), inside the lateral (L) or between the service pipe and main connection (C)

Infiltration

- Infiltration is recorded based on its severity
  - Weeper (IW) refers to moisture but no dripping
  - Dripper (ID) refers to dripping water through the wall or defect
  - Runner (IR) refers to water continuously running
  - Gusher (IG) refers to water entering the pipe under pressure

Obstacles/Obstructions (OB)

- A group of codes used to record the presence of large and medium sized obstacles that can cause a obstruction in flow and pipe capacity
- Smaller obstacles, such as sand and gravel are handled under DEPOSIT codes

Construction features

Four groups:

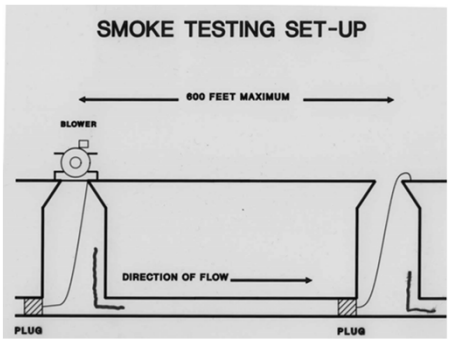
- Tap (T)
- Intruding Sealing Material (IS)
- Line (L)
- Access points (A)

Smoke Testing…

- Detects sources of surface water entry
- Verifies building connections
- Locates illegal connections
- May locate broken sewers
- Best performed during low groundwater conditions

Smoke Testing Precautions

- Warn public in advance - Always use good public relations.
- Notify local fire and police departments
- Establish procedures for dealing with public's concerns about smoke testing
- Respect property and privacy of residents
- Inspect area before testing
- Investigate all buildings where smoke does not issue from roof vents.
- Basement sump pump connections are usually not detected through smoke tests.
- Smoke in building can come from unused floor drains, bathrooms, plumbing rough-ins, etc.

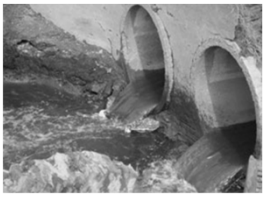


Look for smoke from…

- …Roof vents
- …Building foundations
- …Front and back yards
- …Rain gutters
- …Building interiors

Dyed Water Flooding

- Consists of using a brightly colored dye to confirm
  - Whether building plumbing is connected to the sewer
  - Potential sources of I/I
  - Sources of sewer exfiltration
- Dye can also be used to determine the average flow velocity in a sewer
  - Dye can be purchased in powdered or tablet form
  - Typically red or green



Estimating Velocity using Dye Test

- Assume a dye that is dumped into a manhole first appears 2 minutes later in a manhole 375 feet away then disappears altogether 4 minutes after being dumped. Estimate the flow velocity.

  Avg. time = (2 + 4)/2 = 3 mins x 60 secs/min
  = 180 secs

  Avg. Velocity = 375 ft/180 secs = 2.1 fps

Dye Flooding Operation

- Notify the public before conducting dye testing.
- Get the water running and add the dye directly to the drain
- Estimate the velocity of the flow to determine how long the dye will take to appear. It usually takes longer than expected.
- When multiple dye tests are performed, start downstream and work upstream
- Powdered dye is messy, especially on windy days. Buy powdered in bulk and mix it with water beforehand.
- The transfer of dye always seems to take longer than you expect. Be patient.
- Have various color dyes. Green is the most visible but red works well also.

Using Dye to Determine Exfiltration

- This consists of adding dye to the sewer and looking for its transfer into a stream, storm drain or other suspected source.
- Dye should be added constantly over a period of time. Put dye powder in a cloth bag and submerge it in the flow.
- Tracer dyes are fluorescent and the use of a black light may help verify transfer

Dealing with Blockages

STOPPAGEs

Partial or complete blockage of flow as a result of an obstruction in the sewer.

Identifying Causes of Stoppages

- Does line have a history of previous stoppages?
- Are trees growing near the line?
- Have new building sewers or laterals been installed recently?
- Have repairs been made to the street or nearby utilities recently?
- Is there any ground settlement nearby?

Causes of Stoppages

- Roots
- Grease
- Debris
- Broken Pipes
- Joint Failure
- Pipe barrel obstruction

Sewer Cleaning Methods

- Hydraulic
  - Flushing
  - Balling
  - High-velocity cleaning
- Mechanical
  - Rodding
  - Bucket machines
- Chemical

Sewer Cleaning Methods

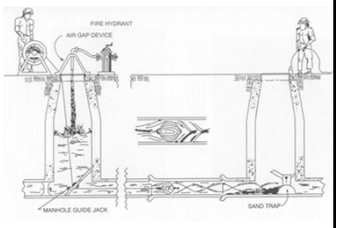
- **Flushing**
  - Adding a surge of water from fire hydrant or tank truck to move light, floatable debris downstream in slow moving sewers
  - Temporarily moves debris from one point to another
  - Does not remedy cause of the problem
- Must use caution near basements and air-gap devices must be used when obtaining water from hydrants

Sewer Cleaning Methods

- **Balling**
  - Hydraulic action of spinning ball and velocity of water flowing around it dislodges debris from pipe walls and moves it downstream.
  - Effective in removing heavy accumulations of sand, grit, rock and debris from sewers
- Dangerous to use in areas with basements and steep grades.

HYDRAULIC CLEANERS

- Controlled obstruction
  - Sewer Ball, Scooter, Kite
- Scouring action created by water moving past the tool
- Go with the flow
- May flood residence



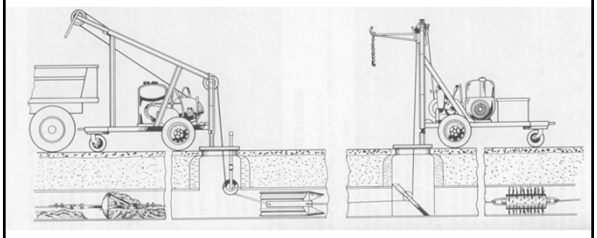
Sewer Cleaning Methods

- **High-Velocity Cleaner**
  - Very effective method for removing grease, sand, grit, gravel and debris from sewers and manholes.
  - Can be used to break stoppages
  - Can remove roots when using hydraulic root attachments
- Operator must be well trained or water can back up into residences or pipe can be damaged by high-pressure water

Sewer Cleaning Methods

- **Bucket machine**
  - Best suited for removing large amounts of sand and debris from large diameter sewers
  - Smaller bucket rigs can be maneuvered into areas inaccessible to larger equipment
  - Cannot be used to break stoppages
- Setup can be time-consuming, and can damage pipe if used incorrectly

Bucket Machine Setup



High Velocity Cleaning

- Use high pressure water to
  - Open stoppages
  - Remove grease
  - Clean lines of silt, sand, sludge and other light debris
  - Wash manholes and wet wells
- When combined with vacuum equipment they can remove the dislodged materials

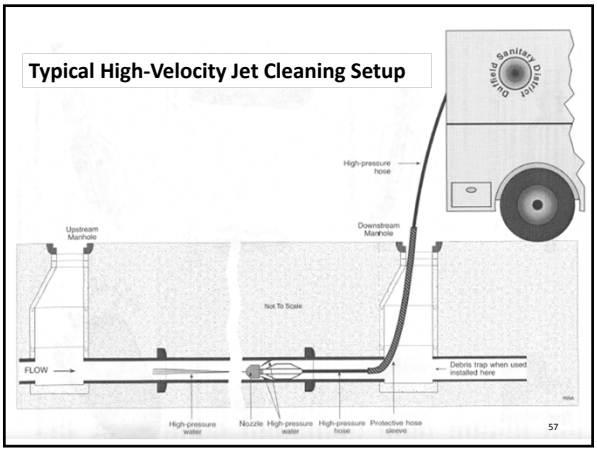
Main Components

- Water supply tank
- High-pressure water pump
- Pump power source
- Hose reel with 500 feet or more of hose
- Nozzle to direct water into jets to clean pipe

Operating Characteristics

- Effectively clean pipes ranging from 4 inch to 20 inch in diameter
- Trailer mounted systems use ¾ inch hose and deliver 1,500 to 2,000 psi at 25 to 40 GPM.
- Truck mounted systems use 1 inch hose and deliver 1,500 to 2,500 psi at 55 to 80 GPM
- Specialized systems can deliver even more flow and pressure
- Various cleaning nozzles are attached to the end of the hose for different sewer conditions

Typical High-Velocity Jet Cleaning Setup



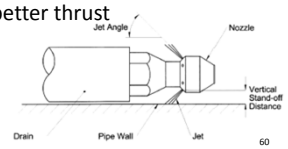
Filling the Water Tank

- Water tank is usually filled from a fire hydrant
  - Use a hydrant wrench to open the hydrant
  - Open the hydrant fully and control flow with a separate gate valve attached to hydrant
  - Open gate valve slowly and flush hydrant until water is clear. Slowly close valve.
  - Attach fill hose (use air gap) and start flow
  - When tank is full, slowly close hydrant and disconnect hose

The Air Gap

Cleaning Nozzles

- Nozzles come in various shapes and sizes with various angles of discharge
  - Discharge of water through the nozzle is given in degrees
  - Higher angles provide better pipe wall cleaning
    - Larger pipes
  - Lower angles provide better thrust
    - Long or steep runs
    - Hard blockages



Common Nozzle Angles

- 15° Nozzles
  - Provides 50% more forward motion than 30° Nozzles. This is better in high grade, long lines and when penetrating blockages
- 30° Nozzles
  - Provide thrust and radial impact forces against the wall of the pipe to loosen debris.
  - This nozzle does a better job of cleaning than the 15°, due to the jets hitting the wall directly

Categories of Nozzles

- Preventive maintenance
- Stoppage relief
- Crown Obstruction
- Invert Obstruction
- Specialty usage
- Root Cutter Tools

Preventive Maintenance Nozzle

- Used when there are no known pipe problems and quick cleaning is required
- Normally 15 to 30 degree orifice angles
- Can have multiple orifice angles

Stoppage Relief Nozzle

- Usually have a lower spray angle to provide higher thrust
- May have a large front orifice designed to open a hole in the stoppage

Crown Cleaning Nozzles

- Designed to remove grease, oils and detergents from top and sides of pipe
- Usually have high angles to provide a sharp cutting spray

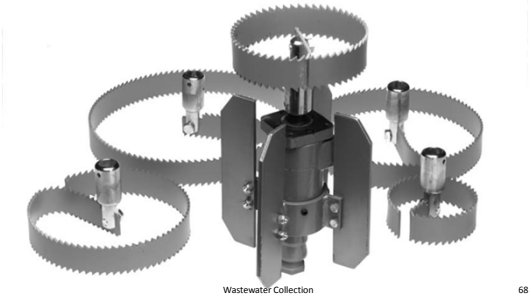
Invert Cleaning Nozzles

- Designed to remove sand, grit and gravel and sediment from the bottom of the pipe.
- It's low angle and high volume uses a lot of water to move materials

Specialty Nozzles & Attachments

Root Cutter Tools

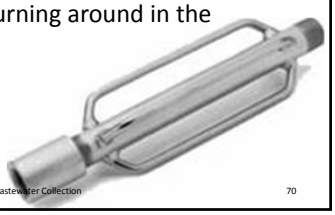
- Hydraulic motors designed to cut roots



Chain Cutter Tool

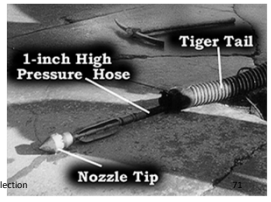
Nozzle Guide

- Attaches the nozzle to the hose
- It keeps the nozzle from running on the pipe and wearing
- It prevents the nozzle from turning up into laterals or turning around in the pipe



Tiger Tail

- Shields the pressure hose from the rough edges of the pipe opening
- Allows for smoother movement of the hose into and out of the pipe

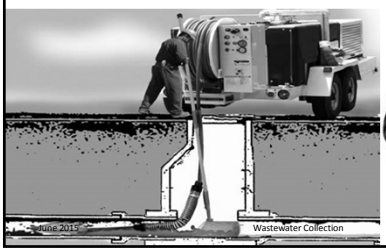


Leader Hose

- The first 10 to 20 feet of high pressure hose just behind the nozzle will be the first to wear with the impact with the materials being removed.
- A braided, steel reinforced leader hose should be used in this area.
- The leader coupling also lets you know how far the nozzle is from the manhole

Grit Catcher

- Device placed in manhole to prevent removed material from moving downstream



Cleaning Operation

- Cleaning is normally performed from the downstream manhole
- Position truck so that the jetting hose will drop straight into the manhole
- Lay nozzle in channel facing upstream with a little sag in the hose
- Start nozzle moving up pipe and set counter to zero
- Set grit catcher in manhole

Cleaning Operation (cont'd)

- Use the "Step" method for cleaning lines
  - Move nozzle 25 - 50 feet up the line
  - Pull back nozzle observing material entering manhole
  - The amount of material brought back will determine how many "steps" will be needed to clean the line
  - Clean grit catcher if needed
- The Step method prevents leaving piles of material in the line or flooding houses
- Keep nozzle moving and pump operating when in the line
- Always know where the nozzle is in the line

Breaking Stoppages

- Select the appropriate penetrating nozzle
- Set up in normal way but be prepared to catch and remove solids
- Upon contact with the stoppage
  - If nozzle does not penetrate, pull the hose back a few feet by hand and let go
  - Nozzle will shoot forward quickly to pound the stoppage – continue until stoppage is broken
- Remove solids when they get to the manhole
  - Large solids could cause another stoppage in manhole or downstream

Unusual Conditions

- If fresh soil or pipe are washed into the manhole, stop the operation. Continued high pressure can cause sinkhole to develop
  - Determine location and try to pull the nozzle back "dead" (without pressure)
  - If this doesn't work, move nozzle to upstream manhole**, remove nozzle and guide and pull hose back
- This method can also be used if the hose cannot be pulled back due to debris buildup

Unusual Conditions (cont'd)

- Often bends or offsets will prevent you from pulling the line back under full pressure
  - Higher the pressure, the stiffer the line
- Reduce pressure or even turn it off until you get past the bend
- Avoid setting up at surcharged manholes to break the stoppage. THIS IS DANGEROUS!!
  - You can't tell if the nozzle is in the line and can blow out of the manhole and hit you

Blown Toilets

- Result from a combination of pressure, nozzle angle and system conditions
  - A nozzle moving up a pipe will pull air from upstream
  - If the pipe is restricted, air will be pulled through building plumbing
  - When the nozzle is moved downstream it can push air and water into these same pipes with dramatic results
- This can often happen in shallow mains or sewers where there are belly's

Preventing Blown Toilets

- Use a steeply angled nozzle
  - A 35 degree nozzle will pull less air from upstream than a 15 degree nozzle
- Use reduced pressure
  - 1,000 to 1,200 psi
- If problem continues CCTV line to see if there is a condition that restricts air flow in the main

Using Hydraulic Root Cutters

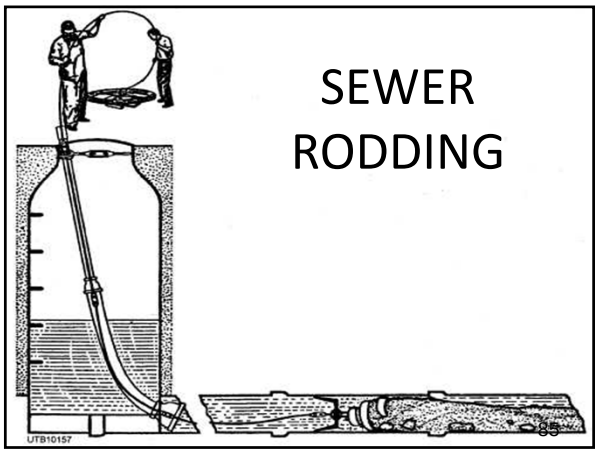
- These can be used to correct minor root and grease problems
- When attached to the hose, water pressure and volume propel the tool up the pipe and rotate the blade to cut the roots
- Work well for light roots but not heavy root masses
- Can get stuck in the main when used by inexperienced operators

Questions?

Power Rodder Usage

Sewer Cleaning Methods

- **Rodders (Hand and Powered)**
  - May be used to cut roots, loosen hardened grease and dislodge certain types of materials.
  - Very effective in breaking root-related stoppages
- Cannot remove grease or debris (must be used with hydraulic cleaners) and is only effective in smaller (up to 15”) pipes.



SEWER RODDING

Rodding Machine Usage

- Perform tasks that hydraulic cleaning methods have difficulty in performing, such as
  - Heavy root removal
  - Heavy grease and grit loosening
  - Stoppage relief
- After pipe is cleared by rodder, hydraulic cleaning should be used to clean line

Rod Machine Types

- Truck or trailer mounted
  - Most common use sectional rods either 5/16 or 3/8 inch in diameter

  - Usually used in mains 12 inch and smaller
- Cable tool machines
  - Used for small diameter pipe cleaning

Rodding Machine Tools

- Designed to be rotated clockwise in pipe, most commonly used are
  - SQUARE BAR CORKSCREW
  - AUGER
  - ROOT SAW
  - FINISHING TOOL
  - PICK-UP TOOL

Square Bar Corkscrew

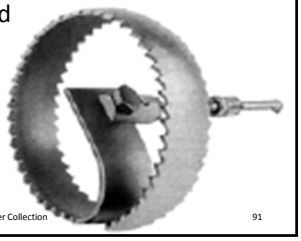
- Primarily used to relieve stoppages in pipes over 6 inch in diameter
- Effective due to the open structure of the blade that allows materials to pass through and grip the tool

Auger

- Used to pilot a hole through roots, grease and other solids
- Primarily used to open a path in the line so that another tool can be used to finish cleaning

Root Saw

- Used to cut through root masses in the pipe after the auger has piloted a hole in the line
- Available in various configurations
- Work best when pulled



Finishing Tool

- Normally a spring blade cutter is used to scour the pipe wall to remove remaining material left behind.
- Always pulled back from the far manhole slowly at high (50 – 60) rpm

Pick-up Tool

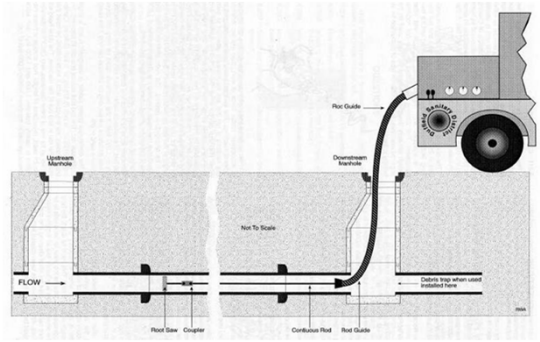
- Used to retrieve sectional rods that have broken in a sewer line
- Tool slowly turns and locks on the rod coupling, allowing rods to be removed

Rodding Accesories

- Rod Guide Hose
  - Protect the rods from machine to bottom of manhole

- Lower Manhole Brace
  - Prevents end of guide hose from pushing back out of pipe when obstruction is encountered
- Assembly wrench
  - Used on couplings to install tools and rods

Rod Machine Setup



Rod Machine Setup

- Check couplings for tightness
- Set forward pressure to no more than about 350 pounds
- Set footage meter to zero
- Push tool into line and start slow rotation
- When tool engages material, the tool may stop but the machine will continue to turn
  - Back tool away from obstruction to relieve torque

Overtorque

- Overtorque can result in twisted and broken rods. Monitor torque by:
  - Watching rod and pressure gauge carefully and pulling tool back to relieve pressure
  - Observe guide hose and listen to engine
  - Move reel lever to neutral and see if reel stops quickly or spins in reverse

Breaking Stoppages

- Use square bar corkscrew from downstream manhole
  - Insert catcher in manhole to prevent solids from continuing downstream
- Using slow revolution (25 rpm) work corkscrew into obstruction until stoppage is relieved
- Bring back tool to see what material caused stoppage

Clearing Roots

- Start with an auger at least on pipe size less than the pipe diameter (8” pipe = 6” auger)
- Work auger at slow speed through the stoppage and up to the next manhole
- Change to a root saw at far manhole
- Pull saw slowly back at high speed (35 -50 rpm)
- Can move cutter to far manhole and change to a finishing tool

Clearing Hardened Grease

- Rods will loosen the grease to allow jet truck to remove it
  - Install grit catcher in working manhole
- Use auger smaller than pipe size and work to far manhole
- Change to an auger the same size as the pipe and pull back to the machine

Bent Rods

- Most bent rods are cause by excessive pushing of the tool into the obstruction
  - Keep forward pressure low
- Use a small tool to work past the problem area and install a larger tool at the far manhole and pull it back to complete cleaning
  - This keeps the rods straight in the line and puts greater pressure on the obstruction

Basic Maintenance

- Keep couplings tight and replace bent rods
- Remove rags and debris from rods before they get to the reel
- Keep drive head chain tight
- Look for “stacking” of the rods on the reel when bringing the rods back

Basic Rules of Power Rodding

- Do not jam tool into an obstruction
- Do not rotate rod in one position for extended period of time
- When torque builds up, retract tool to relieve it
- When changing tools make sure torque is out of the rod
- Adjust forward pressure to low level to avoid bending or breaking the rod
- Do not allow a bend or "S" curves to develop in the guide hose
- Observe rod couplings to determine tightness

Small Diameter Power Rodding

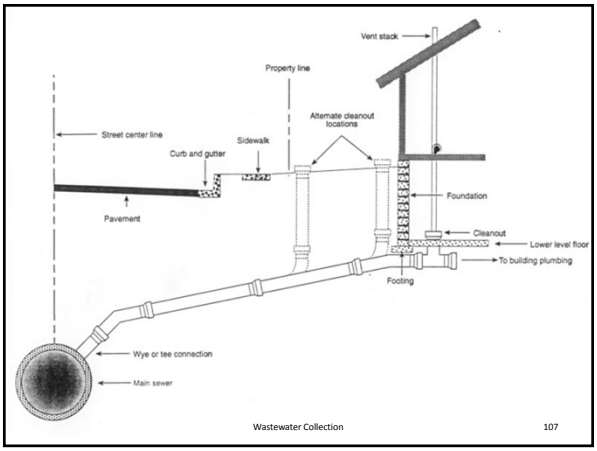
Sewer Cleanouts

Clearing Small Diameter Laterals

- Determine where the customer's service lateral attaches to the main line.
- Check manholes upstream and downstream of the connection for surcharging.
  - If surcharged, problem is most likely a main line blockage.
- Open cleanout and look for surcharging.
  - If cleanout riser is dry, problem may be in the customer's sewer.
- Use appropriate tools to relieve the blockage.
- ***Record upstream and downstream manhole numbers and material removed on work order.***

Breaking a House Connection Blockage

- If main line is flowing properly, work from cleanout with drain cleaning machine or hand rods.
- Operate machine according to manufacturer's recommendations. Wear appropriate PPE.
- Use a small cutter first. After relieving blockage, increase size to thoroughly clean the line all the way to the main line.
- When encountering blockage, do not force tool into obstruction; move back and forth until blockage is clear.
  - If blockage cannot be cleared, estimate the approximate location of the blockage.
- After blockage is cleared, flush line with water.
- Check manholes after blockage is cleared to ensure free flow in main line.



Tips for using Drain Cleaning Machines

- Never let tension build up in cable. This will happen if the cutting tool hits a snag and stops turning. ***TORQUE BUILD-UP IN A ROTATING CABLE OR ROD IS DANGEROUS!***
- Always know where you are going and where the cutting tool is. Over-running cables into the main line or building sewer can cause cable damage and retrieval problems

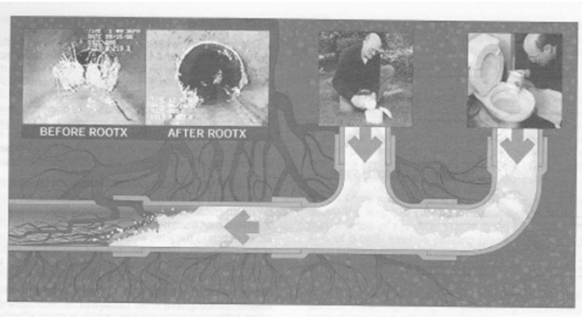
Chemical Cleaning

- Chemicals are used for the control of roots and grease
- Because root control chemicals require certified applicators, this work is normally performed by contractors
- Grease accumulation in the lines is controlled through the use of chemicals injected during jet cleaning.

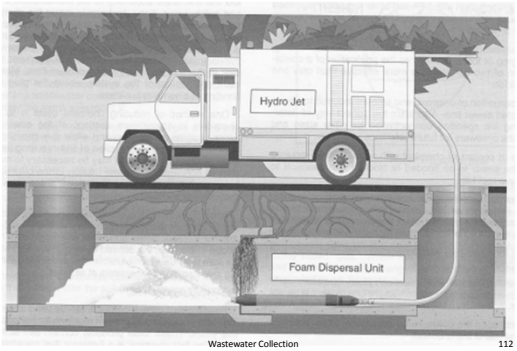
Chemical Root Removal

- Root control chemicals are used to destroy existing roots and prevent re-growth for 3 to 5 years
- These chemicals are normally applied through the use of foaming or powder application
- Two active chemicals are normally used
  - A **fumigant** that penetrates the root cells and starts root decay
  - A **growth inhibitor** that attaches itself to the roots

Dry Chemical Addition



Foaming Chemical Addition



Grease Removal from Pipeline

- A chemical degreaser designed to liquefy the grease is applied using a jet truck
- This chemical remains in contact with the grease for several minutes
- The line is jet cleaned and the liquified grease is moved downstream
  - The chemical breaks down the grease and prevents it from coagulating

Jet Truck Degreaser Attachments

Chemical Tank

Injector Valve

Degreasing fluid

Liquefied Grease

FOG

- FOG stands for:
  - Fats
  - Oils
  - Grease
- Along with roots, grit and debris, these are the materials that accumulate in sewers and lead to SSOs.
- FOG is best controlled from the source.
  - Utility needs the authority to regulate and monitor grease traps and other prevention methods.
- Degreasers can be used, but they are expensive.
- Routine cleaning is necessary

Causes of Sewer Deterioration

- Structural Fatigue
- Corrosive Gases
- Microbial Induced Corrosion (MIC)
- Old Age

Causes of Deterioration

Structural Fatigue

- Caused by:
  - Traffic Loading
  - Freeze/Thaw Cycling
  - Soil Movement
  - Erosion or Cavitation

Causes of Deterioration

Corrosive Gases

- Hydrogen Sulfide: H_2S
  - Corrosive to metal and concrete
  - Reduces the pH level
  - Converts to sulfuric acid when it comes in contact with Sulfur Reducing Bacteria (SRB's)
- Carbon Dioxide: CO_2
  - Slow deterioration of the substrate
  - Naturally occurring
  - Acts to reduce pH of the substrate
  - Carbonated concrete

Stopping Inflow & Infiltration

- Purpose:
  - Lower the cost of wastewater being treated at the plant.
  - Lower the cost of equipment maintenance associated with abrasive soils in the waste stream.
  - Protect the environment for Sanitary Sewer Overflows (SSO's) and Combined Sewer Overflows (CSO's)

Stopping Inflow & Infiltration

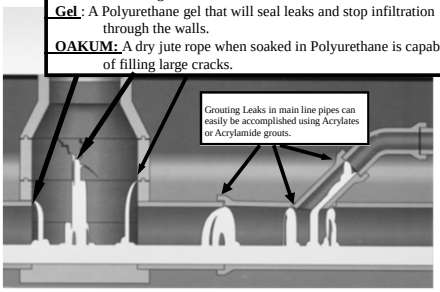
- Grouting is a Non Structural repair, if the manhole/pipe is in good sound condition, grouting is all that is needed to seal leaks, fill voids, extend the structures life, lower repair costs.
- Grouting, in many cases, may be needed to stop infiltration prior to the application of coatings and linings.

Repair, Rehab, and Replace Options

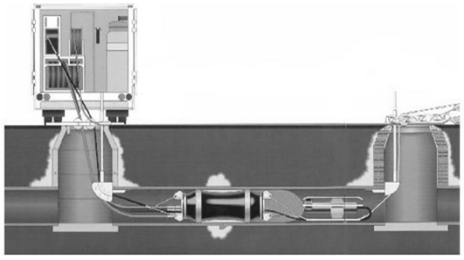
- Pipe Rehabilitation
  - Point Repair
  - Replacement
  - Joint Grouting
  - Pipe Sealing
  - Pipe Lining
  - Lateral Sealing
- Manhole Rehabilitation
  - Upper Structure Rehab
    - Seal Frame and Cover
    - Replace Frame & Cover
    - Replace and Seal Frame Adjustment
  - Wall & Base Rehab
    - Wall Sealing
    - Wall Coating
    - Structural Relining
    - Step replacement

Typical Problems and Fixes

Polyurethane foam A flexible Polyurethane for cracks and pipe penetration.
Hydrophobic: A Polyurethane capable of shutting off gushing leaks and filling voids.
Gel: A Polyurethane gel that will seal leaks and stop infiltration through the walls.
OAKUM: A dry jute rope when soaked in Polyurethane is capable of filling large cracks.



Grouting Small Size Sewer Pipe



Stopping Inflow & Infiltration

- Chemical Grouts are broken down into 4 basic categories.
  1. Acrylamide
  2. Acrylate
  3. Acrylic
  4. Polyurethane

Acrylamide and Acrylate grouts are the primary chemical grouts used for sewer grouting

Stopping Inflow & Infiltration

- Possible Applications
  - Leak Repairs
    - Manholes, Storm Sewers, Treatment Plant Tanks,Tunnels, Box Culverts, Dams, Seawalls & Pipe joints.
  - Stabilization
    - Manholes, Roadways, Seawalls , Pipe lines &Tank Slabs.

Stopping Inflow & Infiltration

- Why use polyurethane grouts?
  - Lowest cost permanent repair procedure.
  - Little disruption to the community.
  - Grouting seals leaks and fills voids.
  - Can be performed in house or contracted out.

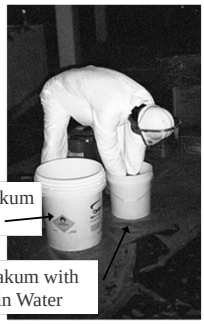
Stopping Inflow & Infiltration

Polyurethane Chemical Grouts are broken in to two categories:

Hydrophilic Resins
- **Absorbs Water**
- Flexible
- Resin only
- Great Bond
- Medium to High Shrinkage
- Medium Expansion
- Foam or Gel

Hydrophobic Resins
- **Repeals Water**
- Rigid and Flexible
- Resin + Catalyst
- Good Bond
- Low Shrinkage
- High Expansion
- Adjustable Set Times
- Foam

Using Oakum



Chemical Resistant Coatings & Linings

- Protect the surrounding environment
- Provide a longer life cycle for the substrate they are protecting
- Provide an excellent infiltration barrier
- Available chemistries include:
  - Epoxy
  - Polyurethane
  - Polyurea

Epoxy Coatings & Linings

Pros

- Moisture tolerance
- High film builds
- High strength
- Low/No Odor
- Chemical Resistance
- Variable formulations
  - Epoxy Resins
    - "Hot Pot" Spray
    - Plural Component Spray
  - Epoxy Mortars
    - Hand trowel
    - "Hot Pot" Spray

Cons

- Rigid films
- Subject to Blush
- Exothermic Reaction could cause microfracturing

Polyurethane Coatings & Linings

Pros

- Flexibility of formulation
  - Flexible
  - Rigid
  - Hand Applied Repair Grades
- Improved elongation
- Fast cure times
- Abrasion Resistance
- High film builds

Cons

- Do not tolerate moisture well during application or initial cure
- Plural Component Spray
- May require a primer

Polyurea/Hybrid Polyurea Coatings & Linings

Pros

- Fast dry times
- High film builds
- Used for linings and chimney seals
- Physical Toughness
  - Excellent Abrasion resistance
  - Elongation

Cons

- Do not tolerate moisture well during application or initial cure
- Plural Component direct impingement application
- Chemical resistance
- High tensile strength
- Primer may be required

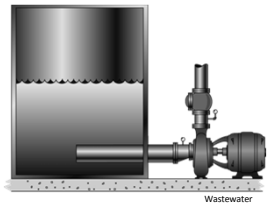
Purpose of Lift Stations

- Raise the wastewater to a higher level to restart its gravity flow
- If the station has a long force main or discharges to a pressurized system, it is considered a ***pumping*** station

The pump can either be in a. . .

. . .Suction lift condition

. . .Suction head condition

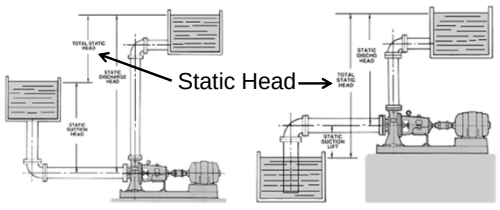


Wastewater Collection

A Pump Exists in Two Conditions:

- Static (When the pump is shut off)
  - Static Head is the distance between the suction and discharge water levels with the pump off.
- Dynamic (When the pump is running)
  - Dynamic head is the distance between the suction and discharge water levels when the pump is running.

Total Static Head

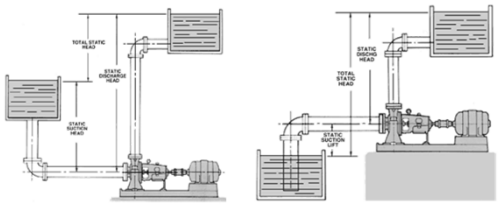


- Vertical distance between the free levels of supply source and discharge liquid

Head Loss

The head, pressure or energy lost by water flowing in a pipe or channel as a result of the turbulence of the flowing water and the roughness of the pipe, channel walls or restrictions caused by fittings.

Total Dynamic Head (TDH)



- TDH = Static Head + friction losses
- Friction losses due to piping and velocity

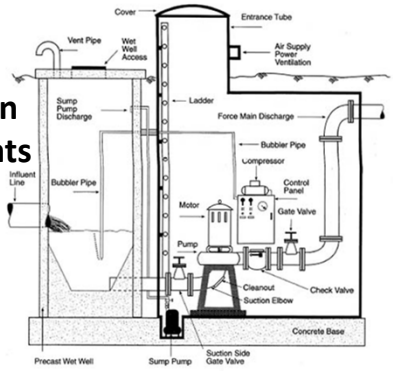
Common Lift Station Types

- Wet Well (Submersible)
  - Pumps are submerged in the wastewater
- Wet well/Dry well
  - Pumps are in a dry chamber
- Above Ground
  - Pumps are above the wastewater
- Pneumatic Ejector
  - Uses compressed air to eject wastewater

Lift Stations May Also Have Odor Control Systems

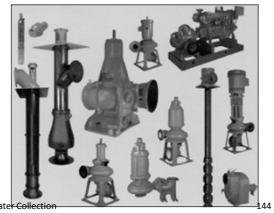
- **Chemical feed systems containing**
  - Storage Tanks
  - Metering pumps
  - Diffusers
- **Soil Compost Filters**
  - Circulate air through a soil compost
- **Wet well blowers/bubblers**

Lift Station Components



Types of Pumps

- Positive Displacement (PD)
  - Piston / Diaphragm – Reciprocating
  - Hose / Peristaltic
  - Gear / Lobe - Rotating
  - Progressing Cavity (like a screw) - Rotating
- Centrifugal
  - Single Stage
  - Multi-stage
  - Very high speed



Centrifugal Force

Centrifugal force tends to push water

How Do Centrifugal Pumps Work?

- Atmospheric pressure pushes water into the pump
- Water is directed to an *"impeller"* which "slings" water outward at high velocity
- The pump housing or *"volute"* directs this water to the discharge
- The greater the TDH, the lower the flow

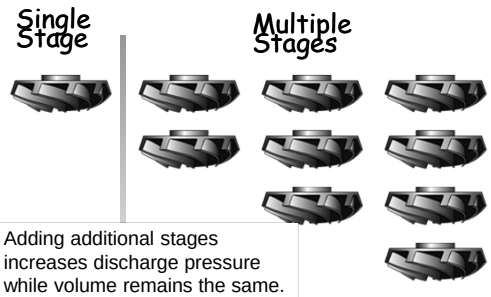
IMPELLER TYPES

Closed
Two
Shrouds

Semi-Open
One Shroud

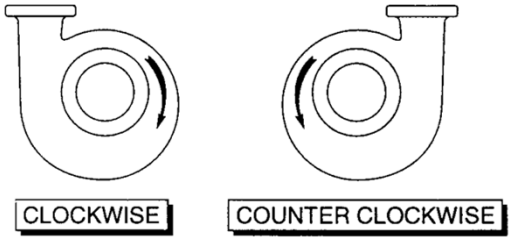
Open
No Shroud

Multi-stage Pumps

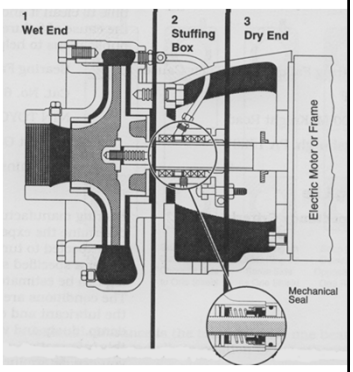


Adding additional stages increases discharge pressure while volume remains the same.

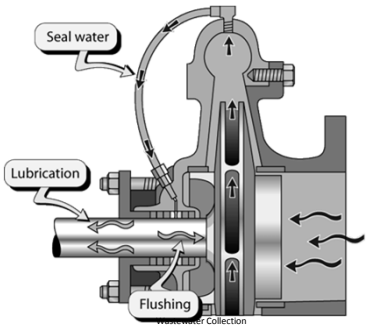
VOLUTE



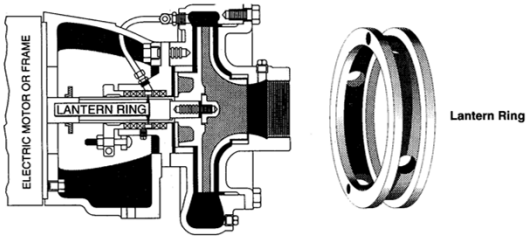
The Impeller is connected to the motor by a shaft. Leakage around the shaft is controlled by either packing or a seal



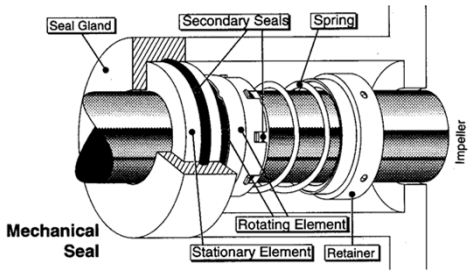
Controlled leakage is required to lubricate and flush the packing



Lantern Ring

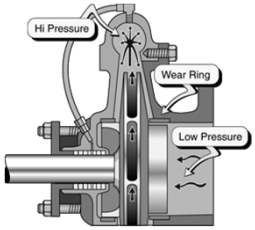


Mechanical Seal



WEAR RINGS

Installed inside the volute to separate the high pressure, or discharge, side of the pump from the low pressure, or suction side.

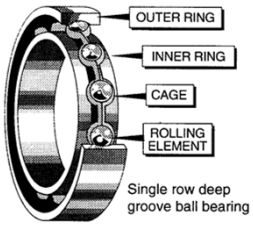


Pump Shaft & Bearings

The shaft is used to transfer energy from the motor to the impeller.

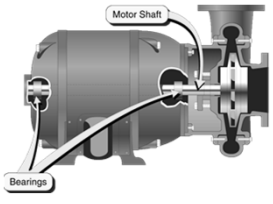
It is usually made of high carbon or stainless steel.

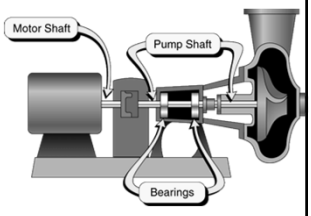
The shaft is supported by bearings.



Single row deep groove ball bearing

Pump-Motor Configurations





The pump and motor can either share a shaft or have independent shafts connected by a coupling

Motor-Pump Couplings

Motor and Pump are connected by a shaft and coupling.

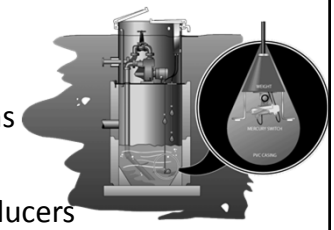
The coupling efficiently transfers energy and compensates for any misalignment

Coupling Condition Monitoring

- Coupling:
  - Transfer rotary motion
  - Allow end movement of shaft
  - Dampen vibration
- Alignment
  - The better the alignment, the longer the coupling life
- Misalignment
  - Parrallel
  - Angular
  - Combined angular and parallel
  - Eventually, will damage bearings and seals
- Causes:
  - Foundation not rigid
  - Thermal expansion

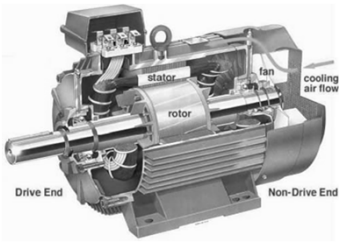
Control System Level Sensors

- Floats
- Bubbler systems
- Ultrasonic
- Pressure transducers
- Electronic probes



Pump is Operated by an AC Electrical Motor

- Most common is a “Squirrel Cage” induction motor.
- *Single phasing*

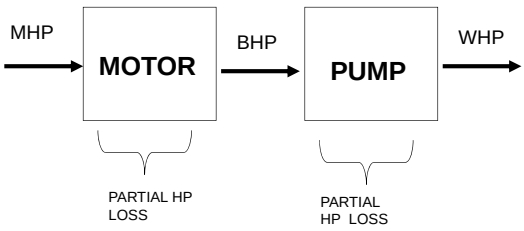


Motor Condition Monitoring

- Cleanliness
  - Air intake
- Noise
  - Bearings
  - Alignment
  - Loose bolts
- Temperature
  - Compare with insulation class
  - Cooling fan
  - Motor overload
- Insulation
  - Clean, dry, cool
  - Resistance checked with a meggar
  - 1 megaohm for each 1000 volts of operating voltage

ELECTRICAL POWER

1 HP = 746 WATTS (OR .746 KW)



WHP = FLOW (GPM) X HEAD (FT)

3960

BHP = FLOW (GPM) X HEAD (FT)

3960 X PUMP EFF.

MHP = FLOW (GPM) X HEAD (FT)

3960 X MOTOR EFF. X PUMP EFF.

Questions?