We know that these criteria are important when considering protective coatings for your project or facility. This course will look at some of the conditions specific to Wastewater facilities; and will provide you with guidance to determine the best coating technology for your project.

**Todays Agenda**

- Manhole Rehabilitation
  - Why it Matters
  - Manhole Problems
  - Microbial Induced Corrosion
  - Inspection Techniques
  - Repair Materials
  - Repair Techniques
  - Alternative Lining Systems
  - Testing
  - RFP Qualifications
Why It Matters

Every day in the United States, millions of people pass over manholes, either on foot or in vehicles, without noticing them

- It wasn’t until about 20 years ago that those in the water/wastewater industry paid much attention either
- “Out of sight, Out of mind” mentality
- Manholes are an important part of the infrastructure and their failure could ultimately lead to big problems throughout the collection system
Why It Matters

- During rainy weather, an average manhole contributes from 3,000 to 12,000 gallons of rainwater per day to sewage collection systems.

- In 2009, a North Carolina city discharged nearly 15.9 million gallons of sewage into local waterways because a 50-year-old brick and mortar manhole collapsed.
  - The city faced an environmental disaster, state and federal fines and lawsuits.
Manhole Problems: Leaking Rings and Covers

Leaking Manhole Rings and Covers:

- A damaged seal between the manhole cover and the frame will be a source of inflow into the collection system.
- Covers over time become loose in fitting due to improper design, and the inspector must take note of whether the manhole cover fits the frame properly.
- Loose-fitting covers may be due to deterioration of the cover itself, as these components of the manhole are subject to cracking, braking, and corrosion.
Manhole Problems: Inflow

- Inflow is stormwater that enters into sanitary sewer systems at points of direct connection to the systems
- Various sources contribute to the inflow, including roof drains, downspouts, drains from driveways, groundwater and even streams
Manhole Problems: Infiltration

- Infiltration is groundwater that enters sanitary sewer systems through cracks and/or leaks in the sanitary sewer pipes.
- Cracks or leaks in sanitary sewer pipes or manholes may be caused by age related deterioration, loose joints, poor design, installation or maintenance errors, damage or root intrusion.
- In brick manholes, any spot where the mortar has deteriorated or individual bricks have given way can be a prime spot for infiltration.
- On concrete manholes, the joints connecting segments of the cone and barrel are susceptible to infiltration, particularly if the structure has shifted and the joints have offset.
- Any connection from a pipe into the manhole.
Manhole Problems: Traffic Loads

Traffic Loads:

- Manholes on busy streets, particularly those frequently traversed by heavy commercial vehicles, are particularly prone to defects stemming from bearing traffic loads.
- The primary areas affected are the frame and cover section and the manhole chimney.
- This can affect how the cover sits on the frame and can create avenues for inflow from storm water runoff.
Microbial Induced Corrosion (Four Phases)

Corrosive Gases
- Hydrogen Sulfide - H₂S
  - Corrosive to metal and concrete
  - Reduces the pH level
  - Gets converted to sulfuric acid
- Carbon Dioxide - CO₂
  - Slow deterioration of the substrate
  - Naturally occurring
  - Acts to reduce pH of the substrate
  - Carbonated concrete
Microbial Induced Corrosion
(Four Phases)

Phase 1

- Sulfur reducing bacteria (SRB) break down sulfates in the waste stream and produce hydrogen sulfide ($H_2 S$) and carbon dioxide $CO_2$
Phase 2

- The gases $\text{H}_2\text{S}$ and $\text{CO}_2$ act to reduce the pH of concrete from approximately 12 to as low as 9.
- Sulfur oxidizing bacteria (SOB’s) attach to the surface as sulfates are produced.
Phase 3
- The SOB’s are known as Thiobacillus Thioxidans. They consume $\text{H}_2\text{S}$ and discharge sulfuric acid $\text{H}_2\text{SO}_4$.
- The PH continues to drop and microbial growth accelerates creating more $\text{H}_2\text{SO}_4$. 
Microbial Induced Corrosion (Four Phases)

Phase 4 - Final Phase
- Acid attack of the concrete creates a layer of gypsum (calcium sulfate). As organisms reproduce additional acid is produced.
- Eventual structural failure
Microbial Induced Corrosion
Manhole Inspection

Common Issues

- Cracks and breaks
- Infiltration/inflow
- Joint security
- Misalignments
- Grease accumulation
- Root intrusion
- Debris
- Corrosion
Manhole Inspection: Methods

Visual, Above Ground Surveys:

- Fastest and least expensive way to determine the general condition of a manhole and to pinpoint its exact location with GPS coordinates.
- Involves opening the cover and looking down while recording information on a report, shining a light as far down as possible, and taking photographs or video of the manhole from the street.
Manhole Inspection: Methods

Manned Entry:
- One of the most popular methods for a detailed inspection of a manhole.
  - Involves setting up a tri-pod on the street above the manhole and lowering a operator equipped with either a breathing apparatus or air-monitoring tools down into the manhole for an up-close look

Two advantages to this method:
- Allows for an up-close examination of the surface of the manhole
- Allows for materials in the manhole to be sampled.
Manhole Inspection: Methods

Pole Cameras:

- These devices are becoming more and more popular for manhole inspection as well as for viewing limited distances into the mainline sewers.
- The advantage is two-fold: eliminating the hazards of manhole entry by conducting a remote visual inspection, and by offering a recordable video of the condition of the manhole from up-close.
Manhole Inspection: Pole Camera
Manhole Inspection: Crawler Cameras

The scanning technology works by utilizing two high resolution “fish-eye” cameras with 185° fields of view, facing opposite directions mounted on a wheeled crawler

- As the cameras move through the pipe, digital snap-shots are taken from each camera
- The images are transmitted back to the inspection vehicle instantly using a fiber optic cable
Manhole Inspection: Crawler Cameras
Manhole Rehabilitation Materials

Active Leaks / Infiltration
- Hydraulic Cement
- Hydroactive Grouts
Manhole Rehabilitation Materials

Portland Cement

- This is the most commonly used cement during the precasting and/or cast-in-place production of today’s wastewater components.
  - Relatively Inexpensive
  - Readily available
  - Susceptible to MIC
  - Long cure times before topcoating
Manhole Rehabilitation Materials

Microsilica Repair Mortars

- Microsilica repair mortars utilize Portland cement to create the cement paste but also contain a fumed silica admixture to create a more dense substrate.
- Chemical Resistant / Lower Permeability
- Can be used as a stand alone liner in a mild H₂S environments.
- Faster cure times for topcoating
- Susceptible to MIC
- Lower cost than Calcium Aluminate Mortars
Manhole Rehabilitation Materials

Microsilica effects concrete in two ways:

- **Physical**
  - 1/100th the size of average concrete particle
  - Micro-packing

- **Chemical**
  - Pozzolan
  - Calcium Silicate Hydrate (CSH)
Manhole Rehabilitation Materials

Calcium Aluminate Mortars

- Maintain a higher pH that prevents the colonization of Thiobacillus bacteria
- Offer an improved life cycle over other repair mortars
- Fastest cure time for topcoating
- Susceptible to MIC but a reduced rate
- Can be used as a stand alone liner in moderate H₂S environments
Manhole Rehabilitation Materials: Chemical Resistant Linings

- Protection from the surrounding environment
- Provide a longer life cycle for the substrate they are protecting
- Provide an excellent infiltration barrier

Available chemistries include:
- Epoxy
- Polyurethane
Manhole Rehabilitation Materials: Epoxy Liners

**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
Manhole Rehabilitation Materials: Polyurethane Liners

**Pros**

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

**Cons**

- Does not tolerate moisture during application or initial cure
- Plural Component Spray
- Requires a primer on cementitious substrates
Manhole Rehabilitation Materials: Polyurethane Liners
Manhole Rehabilitation Materials: Chimney Seal

- Polyurethane
- Polysulfide Caulk
- Polyurea
QA / QC
Testing Methods

- Vacuum Testing
- Adhesion Testing
- Film Thickness
- Cube Testing
- Holiday Testing
RFP Qualifications

- Contractor Experience—1,000 manholes completed
- Licensed (G.C. and Public Utilities) and Insured
- Bonding
- Project References
Manhole Rehabilitation: Case Study Wilmington, NC

- Profile: 4’Dia. × 5’VF Manhole Demo for Cape Fear Public Utilities Authority, City of Wilmington, NC

○ Surface Preparation and Coating Application
  ○ Pressure wash with 5000 psi Pressure washer to remove any loose and or contaminated Concrete
  ○ Apply CemTec Rapid Cure Mortar at a thickness of 1 to 2 inches to the walls and Bench
  ○ Apply Dura-Plate 235 Multi- Purpose Epoxy Primer (4-6 mls DFT)
  ○ Apply Sherflex Elastomeric Polyurethane Lining (100-125 mls DFT)

○ Special items to note:
  • The Manhole was in very poor condition with the presence of a high concentration of H2S gas that had caused the concrete block/mortar to deteriorate to the point where ground water infiltration and wastewater exfiltration through the walls was possible.
Manhole Rehabilitation: Case Study Wilmington, NC

The manhole before the rehabilitation was started.
Manhole Rehabilitation: Case Study Wilmington, NC

With the installation of an invert screen, all the loose concrete was removed from the walls and bench.
Manhole Rehabilitation: Case Study Wilmington, NC

The manhole after being pressure washed with 5000 PSI pressure washer.
Mixing of the mortar to be applied to the manhole and layout out of work area showing all permits and products used.
Manhole Rehabilitation: Case Study Wilmington, NC

Applying the Cementitious Lining with “hole watch” monitoring above.
Manhole Rehabilitation: Case Study Wilmington, NC

The Manhole after the cementitious lining was complete.
Manhole Rehabilitation: Case Study Wilmington, NC

Applying the Dura-Plate 235 Epoxy primer - hand applied in this instance, normally spray applied when multiple manholes are coated.
Cut termination joints at the trough to terminate the coating at invert and Hydra Cat Spray Rig setup.
The Manhole after the application of the Sherflex Elastomeric Polyurethane Lining was applied.
Brian Huffman
(336) 467-5480
Brian.K.Huffman@Sherwin.com