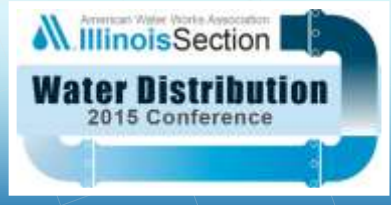
Selecting Watermain Materials for Replacement Projects



April 28, 2015

Presenter:
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Senior Project Engineer

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- Village of Oak Lawn
- Fellow CDM Smith Engineers:
  - Dave Tanzi, P.E.
  - Neill Hampton, P.E.
  - Amrou Atassi, P.E.
  - Brandon Celaya, P.E.

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Agenda

- Design Criteria
- Typical distribution pipe materials (i.e. DIP, HDPE, PVC)
- Typical Installation Methods
- Evaluation Matrix
- Questions

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ESTABLISH KEY DESIGN CRITERIA FOR PROPER SELECTION OF PIPELINE MATERIAL

Design Criteria

- Application/service – Potable finished water (chlorine residual)
- Working and Surge Pressures
- Water Temperature – for plastic pipes
- Burial depth
- Pipe diameter
- Pipe Location

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PIPELINE MATERIALS

Typical Material Selection for Distribution System Pipe

- Ductile Iron
  - Cement Mortar Lined (standard)
  - Specialty Linings (ceramic epoxy, fusion bonded epoxy, glass lining)
  - Restrained Joint
  - Bell and Spigot Joint
- Polyvinyl Chloride (PVC)
  - Bell and Spigot
  - Certa-Lok
  - Fusible
- High Density Polyethelene (HDPE)
  - Fusible
- Larger Diameter Pipe Not Covered
  - i.e. Carbon Steel, PCCP, and Fiberglass

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Ductile Iron Pipe (DIP)

- DIP
  - AWWA C150/151
  - 4" through 64"
  - Bell and Spigot Joints
  - Restrained Joints
  - Several Manufacturers
  - Great Competition

48" DIP (Wilmington)

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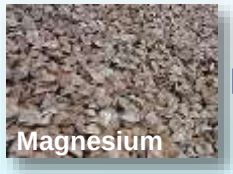
DIP Manufacturing (Continued)

- Manufactured from shredded cars, scrap and pig iron
- Key Ingredient: Magnesium

+



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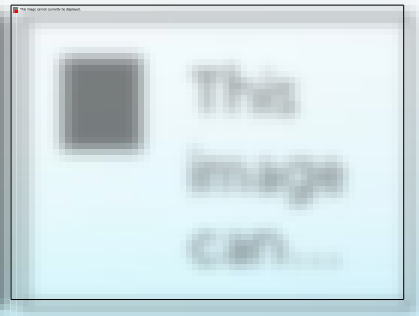
DIP – Manufacturing Defects

COMMON MANUFACTURING DEFECTS



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DIP – Manufacturing QA/QC

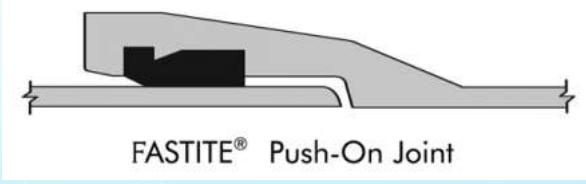
HYDROSTATIC TESTING

DIP – Manufacturing QA/QC (Continued)

DIMENSIONAL INSPECTION AND ADJUSTMENT OF BELLS

SPIGOT GAUGING & ADJUSTMENT

DIP – Joints



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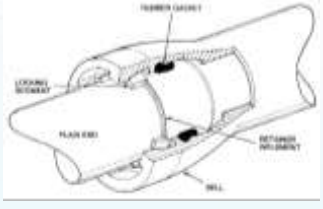
DIP

Joints (Continued)



4-36", US Pipe TR Flex

42-64", US Pipe TR Flex

4-12", American Flex-Ring

14-48", American Flex-Ring

54-64", American Flex-Ring

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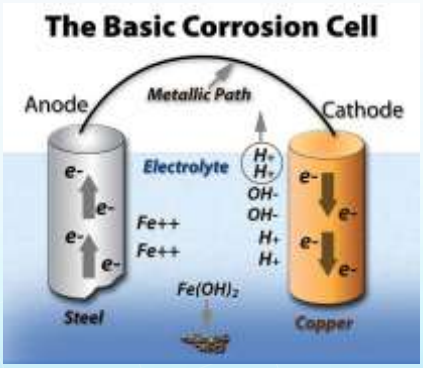
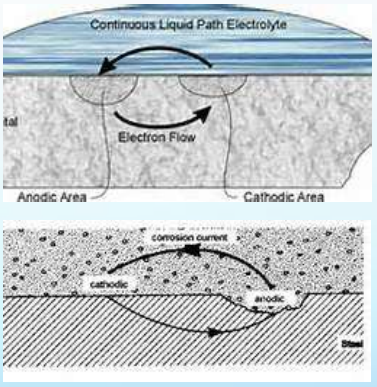
DIP – Pipeline Corrosion

BASIC PIPELINE CORROSION





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DIP – Coatings

- Asphalt Varnish (Standard)
- Asphalt Varnish with Polyethylene Encasement (Garbage Bags)
- Moisture-Cured Urethane Primer Ferro-Clad® with Epoxy Intermediate and Top Coat
- Thermal-Sprayed Zinc Base-Coat with Asphalt Varnish Top-Coat (Europeans)
- Metalized Zinc-Aluminum Base-Coat with Epoxy Top-Coat (Europeans)
- Fusion Bonded Epoxy Coatings (US Pipe)

MOST COMMON DIP COATINGS:

Material	Pros	Cons
Asphaltic Varnish	Aesthetics	No considerable corrosion control
Polyethylene Encasement	• Low Cost • Betterment for moderately corrosive soils	• Can trap moisture to create underfilm corrosion • Shield CP
Moisture-Cured Urethane	Immersion resistance	Higher cost than PE encasement

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Polyvinyl Chloride (PVC) Pipe

- Polyvinyl Chloride (PVC) AWWA C900/905
  - HDB of 4,000psi
  - 4" through 12" C900
  - 14" through 48" C905 (up to 36" in Fusible)
  - Good Competition
- Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe:
  - HDB of 7,100psi
  - 4" through 24" AWWA C909
  - Installation of both in accordance with AWWA C605


Photo Curtesy of JM Eagle

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PVC – Joints for Trenchless

Fusible PVC



Pros	Cons
• Restrained Joint 0-gpm leakage PVC • Pipe meets AWWA Standards • HDD, pipe bursting, and sliplining	• Pipe by one vendor • Fusion over 12" by one vendor • Fusion of 12" and below by certified contractors

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PVC – Joints for Trenchless (Continued)

Certa-Lok (RJ and RJIB)

Photos Curtesy of Certa-Lok

Pros	Cons
• Minimal training required to install • Pipe meets AWWA Standards • HDD, pipe bursting, and sliplining	• Lower pulling force than fPVC (i.e. shorter pull lengths) • Joint which can still leak • RJIB has metallic component providing restraint

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PVC Quality Control

- PVC quality control divided into three categories: qualification testing, quality control testing, and assurance:

1. **Qualification testing** is of the materials used to manufacture the pipe. These testing include PVC extrusion compound cell classification testing, gasketed joint design testing, toxicological testing, etc.
2. **Quality control testing** include workmanship, markings, dimension measurement, quick burst test, flattening test, etc.
3. **Assurance testing** is of the finished PVC pipe product. This test includes the sustained pressure test, and hydrostatic proof test. The hydrostatic proof test is performed on every piece of PVC pipe and machined fitting is tested to a minimum dwell time of 5 seconds. AWWA C900 requires a hydrostatic proof test at four times the pressure class (i.e. 4*160psi = 600 psi for DR 18 pipe). AWWA C905 requires a hydrostatic proof test to be conducted at 2 times the pressure rating of the pipe (i.e. 2*235 psi = 470psi for DR18 pipe).

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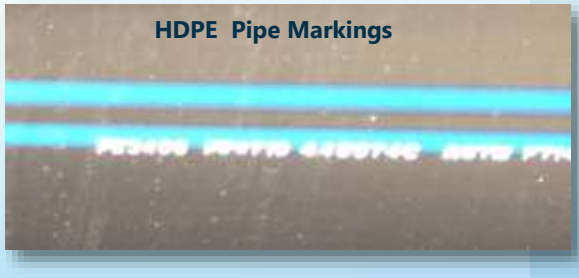
High Density Polyethylene Pipe (HDPE)

- ASTM D3350
- 3" through 48" IPS (160 psi) – up to 63" (63 psi)
- 3" through 36" DIPS (160 psi) – up to 48 " (63 psi)
- AWWA C906



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HDPE Quality Control

- HDPE quality control divided into three categories: qualification testing, quality control testing, and assurance:

1. **Qualification Testing** – Health affects evaluation, long term hydrostatic strength and material cell classification
2. **HDPE Quality Control** – Dimensions, workmanship, pressure test to failure of samples, and bend back test
3. **HDPE Quality Assurance** – Performed on a statistical basis of completed pipe samples at completion of manufacture for the following parameters: sustained pressure test, elevated pressure sustained-pressure test, and thermal stability test.

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Pipe Materials – Comparison of Properties

Material	Internal Pressure Design	Hydrostatic Design Basis (HDB) or Minimum Yield Strength (SMYS)(psi)	Modulus of Elasticity (psi)	Thermal Expansion and Contraction Coefficient (in/in/oF)	Common Failure Mode	Permeation
DIP	Cannot exceed 21,000psi (42,000psi/Safety Factor of 2)*	SMYS=42,000	24,000,000	5.8x10-6	Corrosion	Potential at gaskets, but can use a nitrile or fluorocarbon gasket to minimize permeation
PVC	Cannot exceed 2,000psi (HDB/2)*	HDB=4,000	400,000	3.0x10-5	Longitudinal cracks	Potential along pipe material. Known pathway for water quality degradation**
HDPE	Cannot exceed 625psi (HDB/2)*	HDB=1250	100,000	1.2x10-4	Oxidative degradation resulting in stress corrosion cracking	Potential along pipe material. Known pathway for water quality degradation**

References:
* Stress due to working pressure plus surge pressure cannot exceed these values assuming a safety factor of 2.
** Office of Water of the Environmental Protection Agency (EPA)."Permeation and Leaching." August 15, 2002.

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Pros & Cons of DIP

Pros	Cons
• Great Competition • All Contractors have installed • Repair/Tapping experience • Parts inventory • Easy to locate • More resilient to tapping • Higher pressure rating	• Susceptible to corrosion

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Pros & Cons of PVC

Pros	Cons
• Good Competition • All Contractors have installed • Corrosion resistant • Chlorine tolerant • Can be installed by HDD • Can connect to DI fittings and valves	• Susceptible to rapid crack propagation • Less resilient to tapping • Requires warning tape/tracer wire to locate • Lower pressure rating than DIP

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Pros & Cons of HDPE

Pros	Cons
• Good Competition • Most Contractors have installed • Corrosion resistant • Can be installed by HDD	• Susceptible to chlorine degradation • Must use electrofusion taps or saddles • Requires warning tape/tracer wire to locate • Requires transition fittings/adapters for DI valves and fittings • Lower pressure rating than DIP

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PIPELINE INSTALLATION METHODS

Installation Methods Common to Distribution Systems

Open Cut

Horizontal Auger Boring or Jack and Bore

Horizontal Directional Drilling

Pipe Bursting

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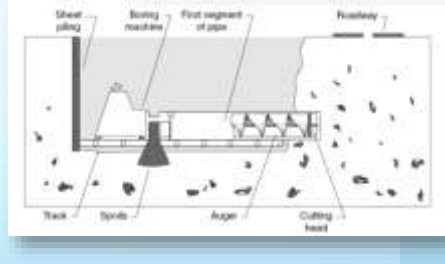
Open Cut

- Disturbances to immediate work zone
- Social and economic impacts to the public



Trenchless – Horizontal Auger Boring/Jack and Bore

- Open excavation to place boring machine, auger, appurtenances, and pipe. Small work area for receiving side
- Additional work area to facilitate work

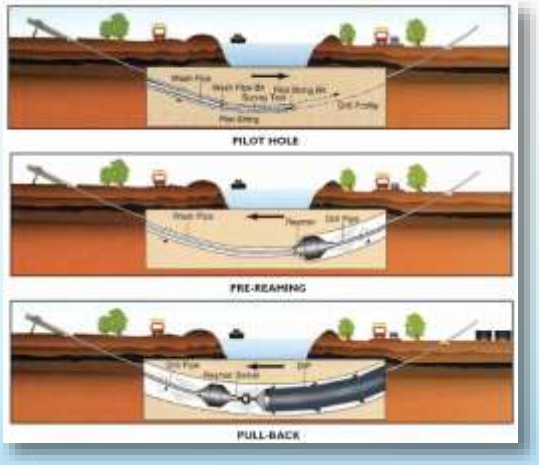



Trenchless – Horizontal Directional Drilling (HDD)

Drill pilot hole along proposed alignment

Back ream to desired bore hole diameter

Pull back final product pipe

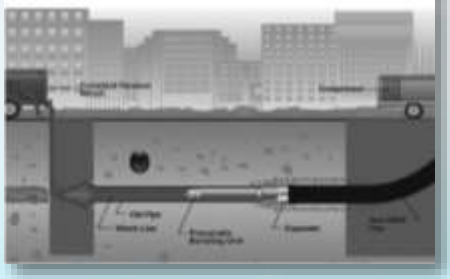


Trenchless – HDD (Continued)

Pipe Bursting

TWO TYPES OF PIPE BURSTING METHODS:

Pneumatic



Static

Photos Curtesy of AWWA Manual M28

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EVALUATION MATRIX WORKSHOP

Participants

- Prior to the evaluation matrix session workshop, identify your participants.
- Participants should be a broad spectrum to determine the best pipe material for your utility. Participants can include:
  - Public works management
  - Operations
  - Engineering
  - Other municipalities that cost share with your utility
  - May consider board members

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Establish Goals for Evaluation Matrix

Participants Should Assist in Developing the goals such as:

- Service Life
- Water Quality
- Reliability
- O&M
- Leakage
- Corrosion
- Ability to withstand field changes
- History of performance
- Maintain a common pipeline material in distribution system

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Evaluation Matrix Workshop

- Establish Purpose of Workshop
- Agree on/Discuss Goals for Evaluation Matrix
- Weighting Criteria:
  - Determine if any pipe material goals are any more or less critical to your system then others.
  - If the importance of the goals differs, establish weighting criteria.
- Scoring:
  - Establish the scoring methodology
  - Participants should clearly understand the scoring for the matrix to be effective.

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Evaluation Matrix

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QUESTIONS?

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