



## Buried High Density Polyethylene Pipe for Safety-Related Applications

George Antaki, PE  
Becht Nuclear Services, Aiken, SC

gantaki@becht.com  
www.bechtns.com

U.S. NRC Regulatory Information Conference  
March 11, 2010

Buried HDPE Pipe

1

---

---

---

---

---

---

---

---

### Summary

- Buried metallic pipes corrode
  - Water-side
  - Soil-side
- HDPE is a reliable and cost effective alternative, if
  - Correctly designed
  - Correctly manufactured
  - Correctly installed
- ASME III and XI Code Case N-755

Buried HDPE Pipe

2

---

---

---

---

---

---

---

---

### Interest in Buried HDPE Piping

- Buried metallic pipes corrode
  - Soil-side
  - Water-side



Buried HDPE Pipe

3

---

---

---

---

---

---

---

---

### HDPE - Industrial Experience

- Waterworks (AWWA)
- Gas distribution (GTI, DOT, ASME B31.8)
- Intake and outfall process plants (ASME B31.3)
- Petrochemical (ASME B31.3)
- Paper mills (ASME B31.3)
- Fossil power plants (ASME B31.1)
- Slurries and mining (ASME B31.11)
- Plastic Pipe Institute (PPI)
- ISO standards

⇒ ASME III and XI Code Case N-755

Buried HDPE Pipe

4

---

---

---

---

---

---

---

---

### HDPE - Ductility



Buried HDPE Pipe

5

---

---

---

---

---

---

---

---

### Kobe Earthquake

- *"We have also been strengthening the pipeline networks to make them earthquake-resistant by using earthquake-resistant joints and employing polyethylene pipes which have enough flexibility to accommodate large deformation"*

Ref. "Damage of Gas Facilities by the Great Hanshin Earthquake and Restoration Process", S. Oka, Osaka Gas [Kobe earthquake, January 1995, 6.8 MM]

Buried HDPE Pipe

6

---

---

---

---

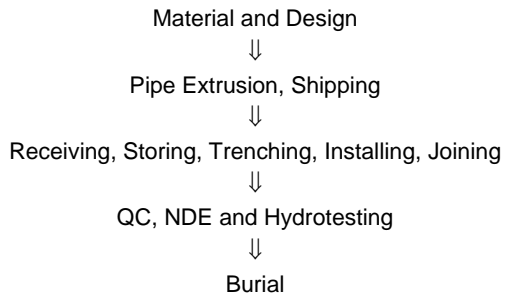
---

---

---

---

### Engineering Considerations



Buried HDPE Pipe

7

---

---

---

---

---

---

---

---

### 1 Material

Buried HDPE Pipe

8

---

---

---

---

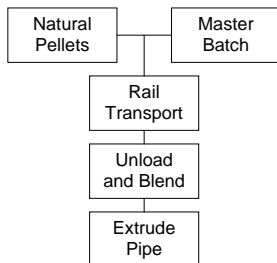
---

---

---

---

### Material Quality Control



Buried HDPE Pipe

9

---

---

---

---

---

---

---

---

### Natural HDPE Pellets and Carbon Black



(source: Chevron Phillips Chemical Company)

Buried HDPE Pipe

10

---

---

---

---

---

---

---

---

### Challenges

- Nearly 20 ASTM Specifications
  - Tensile strength
  - Melt flow rate
  - Density
  - Carbon black content
  - Short-term failure
  - Slow-crack growth
  - Thermal stability
  - etc.



Buried HDPE Pipe

11

---

---

---

---

---

---

---

---

### ASTM D 3350 Cell Classification

- |                                    |   |
|------------------------------------|---|
| • Density                          | 4 |
| • Melt index                       | 4 |
| • Flexural modulus                 | 5 |
| • Tensile strength at yield        | 5 |
| • Slow crack growth resistance     | 7 |
| • Hydrostatic design basis at 23°C | 4 |
| • Color and UV stabilizer          | C |

445574C

Buried HDPE Pipe

12

---

---

---

---

---

---

---

---

### Common Designation

- Bimodal high density resin 4
- SCG PENT test over 500 hrs 7
- HDS in water at 1000 psi DF = 0.63 10

PE 4710

Buried HDPE Pipe

13

---

---

---

---

---

---

---

---

### Pipe Extrusion Lines



(source: WL Plastics)

Buried HDPE Pipe

14

---

---

---

---

---

---

---

---

### Pipe Shipment



(source: Performance Pipe Company)

Buried HDPE Pipe

15

---

---

---

---

---

---

---

---

**Material Control: Critical**

- Resin mix
- Extruded pipe
- Shipment
- Receiving
- Storage
- Protection against dents, gouges, scratches

Buried HDPE Pipe

16

---

---

---

---

---

---

---

---

**2  
Design**

Buried HDPE Pipe

17

---

---

---

---

---

---

---

---

**Design Loads**

- Soil
- Surface
- Pressure
- Temperature
- External pressure (water table)
- Frost heave
- Constrained expansion-contraction
- Thick-wall temperature gradient
- Ground settlement
- Seismic
- Surface defect (SCG)

Buried HDPE Pipe

18

---

---

---

---

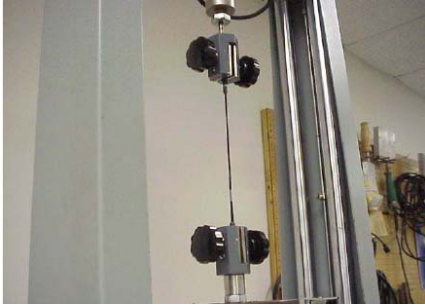
---

---

---

---

**Elongation at Rupture ~ 700%**



Buried HDPE Pipe

19

---

---

---

---

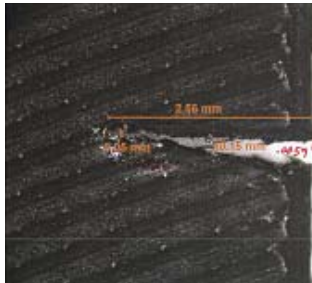
---

---

---

---

**Slow Crack Growth (SCG) PE 3408 ⇨ PE 4710**



(source: EPRI)

Buried HDPE Pipe

20

---

---

---

---

---

---

---

---

**Slow Crack Growth (SCG)**



(source: EPRI)

Buried HDPE Pipe

21

---

---

---

---

---

---

---

---

### 3 Fabrication

Buried HDPE Pipe

22

---

---

---

---

---

---

---

---

### Excavation Challenges



(source: Duke Energy)

Buried HDPE Pipe

23

---

---

---

---

---

---

---

---

### Joints and Fittings

- Butt Fused Joint
- Miter Bend
- Flanged Joint

Buried HDPE Pipe

24

---

---

---

---

---

---

---

---



**Fusion Machine**



(source: McElroy Manufacturing)

Buried HDPE Pipe

25

---

---

---

---

---

---

---

---

**Butt Fused Joint**



(source: Duke Energy)

Buried HDPE Pipe

26

---

---

---

---

---

---

---

---

**Butt Fused Joint**



(source: Chevron Phillips Chemical Company)

Buried HDPE Pipe

27

---

---

---

---

---

---

---

---

### Butt Fused Joint: Essential Variables

- Must be complete, quantitative and cover a range
  - HDPE material
  - Diameter and thickness
  - Alignment
  - Heating surface temperature
  - Heater removal time
  - Fusion pressure
  - Heat soak time
  - Cool time
  - Environment temperature
  - other ...

Buried HDPE Pipe

28

---

---

---

---

---

---

---

---

### Butt Fused Joint: Qualifications

- Fusing procedure specification (FPS)
- Fusing procedure qualification record (PQR)
- Fusion machine operator qualification
  - Training
  - Knowledge test
  - Performance test

Buried HDPE Pipe

29

---

---

---

---

---

---

---

---

### Quality of Butt Fused Joint



(source: Pacific Northwest National Laboratory)

Buried HDPE Pipe

30

---

---

---

---

---

---

---

---

**Quality of Butt Fused Joint**



(source: Pacific Northwest National Laboratory)

Buried HDPE Pipe

31

---

---

---

---

---

---

---

---

**Fittings: Miter Bend**



(source: Isco Industries)

Buried HDPE Pipe

32

---

---

---

---

---

---

---

---

**Examination of Butt Fused Joints**

- Data acquisition record
- Visual
- Volumetric
- Destructive

Buried HDPE Pipe

33

---

---

---

---

---

---

---

---

**Volumetric NDE of Butt Fused Joints**



(source: Pacific Northwest National Laboratory)

Buried HDPE Pipe

34

---

---

---

---

---

---

---

---

**NDE Acceptance Criteria**

- Workmanship standard
  - Experience based
- Fitness-for-service standard
  - Flaw-tolerance based

Buried HDPE Pipe

35

---

---

---

---

---

---

---

---

**Destructive Test of Butt Fused Joint**



Buried HDPE Pipe

36

---

---

---

---

---

---

---

---

### Flange Adapter and Back-Up Ring



(source: Isco Industries)

Buried HDPE Pipe

37

---

---

---

---

---

---

---

---

### Flange Capacity Tests



(source: EPRI)

Buried HDPE Pipe

38

---

---

---

---

---

---

---

---

### Hydrotest

- Test pressure
  - 1.5 times the design pressure
  - 4 hours pressurized
  - Joint inspection
  - 1 more hour pressure hold within 5%

Buried HDPE Pipe

39

---

---

---

---

---

---

---

---

**Burial and Compaction**



Buried HDPE Pipe

40

---

---

---

---

---

---

---

---

**4  
In-Service Integrity**

Buried HDPE Pipe

41

---

---

---

---

---

---

---

---

**4. In-Service Integrity**

- Leak prevention
- Leak detection
- Repairs

Buried HDPE Pipe

42

---

---

---

---

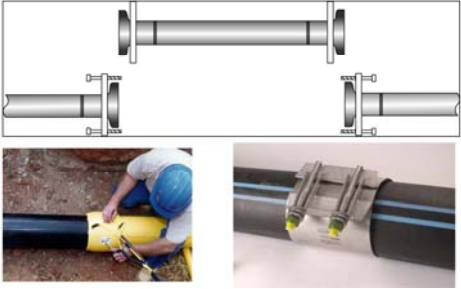
---

---

---

---

### Repair Options



Buried HDPE Pipe

43

---

---

---

---

---

---

---

---

### Summary

- Buried metallic pipes corrode
  - Water-side
  - Soil-side
- HDPE is a reliable and cost effective alternative, if
  - Correctly designed
  - Correctly manufactured
  - Correctly installed
- ASME III and XI Code Case N-755

Buried HDPE Pipe

44

---

---

---

---

---

---

---

---