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Selecting & Specifying HDPE Conduit for Power and Communications Applications

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Course Description

This course will provide guidance to designers and specifiers of **nonmetallic raceway** (polymer conduit) for power and communications projects when selecting and specifying high density polyethylene (HDPE) conduit products.

The course discusses product capabilities and benefits, lists common applications, describes typical installation techniques, and introduces the latest industry standards. It will also provide access to a **Model Specification** available from the conduit industry.

In addition, the course describes how to use PPI publications such as **PPI TN-50** *Guide to Specifying HDPE Conduit* and **PPI MS-5** *Model Specification for HDPE Solid Wall Conduit for Power and Communications Applications*.

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Course Outline

By the end of this course, you will be able to:

1. Discuss **HDPE* material** and its benefits in conduit applications
2. List the common **applications** of HDPE conduit
3. Describe typical **installation techniques** and the benefits of each
4. Introduce the latest **industry standards** for HDPE conduit
5. Explain how to access a **model specification** for HDPE conduit

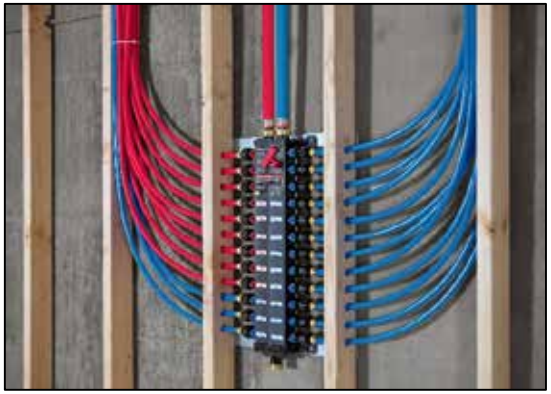
**High Density Polyethylene*

Bonus: Refer to PPI resources available at www.plasticpipe.org

Introduction to the Plastics Pipe Institute

PPI was formed in 1950 to develop test methods for plastic pressure pipes

- PPI's five divisions focus on solutions for multiple applications:
  - Building & Construction Division
  - Corrugated Plastic Pipe Association
  - Energy Piping Systems Division
  - Municipal & Industrial Division
  - **Power & Communications Division (PCD)**



BCD: PEX tubing for plumbing

EPSD: Gas distribution piping

MID: HDPE water mains

Introduction to the Plastics Pipe Institute

PPI's Power & Communications Division (PCD) Mission Statement:
"To expand the knowledge of the uses and benefits of HDPE conduit for power and communications applications."

PCD collaborates with standards development organizations (SDOs) that set standards for manufacturing practices, quality control, product-testing and installation methods. PCD also educates designers, installers, users and government officials about HDPE conduit; establishes a forum for problem solving and new ideas; and maintains liaison with industry, educational and government agencies.

1. HDPE Material for Conduit Applications

Introduction to High Density Polyethylene (HDPE)

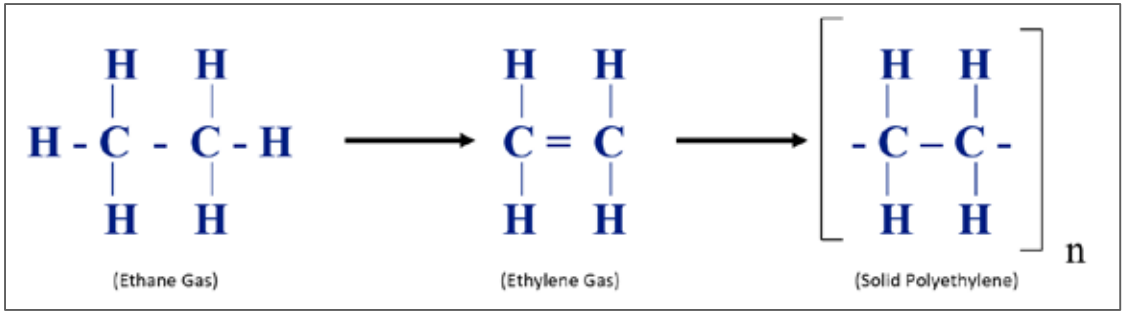
HDPE is a thermoplastic polymer with a very broad range of applications

- Pipe for many applications
  - Water and sewer
  - Gas distribution
  - Oil and gas production
  - Industrial
  - Drainage
  - Conduit
- Sheet
- Bottles
- Fuel Tanks
- Cable insulation

HDPE Material for Conduit Applications

What is PE?

- **Polyethylene** (PE): A thermoplastic produced from polymerization of ethylene
- **Ethylene** is a derivative of ethane, a constituent within natural gas or derived from oil



- **Ethane** is a very clean molecule, energy efficient in production
- PE is non-polar, making it slippery (low surface polarity)
- Saturated bonds resist most chemical attack
- PE is environmentally-friendly

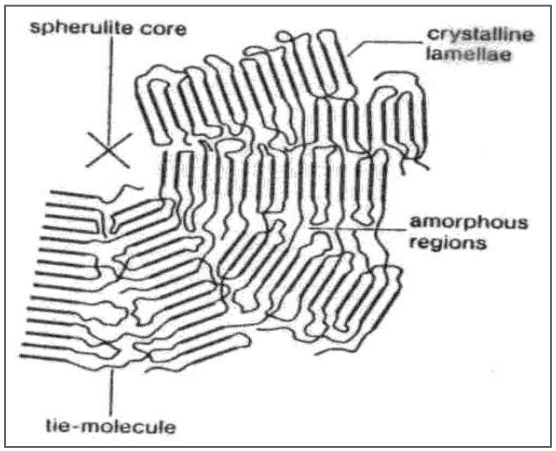
HDPE Material for Conduit Applications

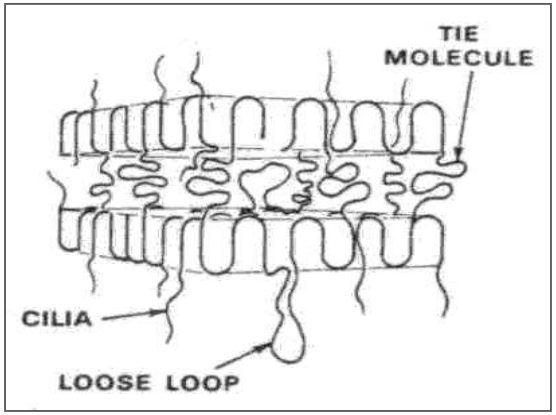
What is HDPE?

- **High Density** Polyethylene (PE) is a grade of PE

- **Crystalline structures** consist of folded chains, providing stiffness and tensile strength

- **Amorphous phase** consists of tie molecules, providing flexibility, impact resistance, stress crack resistance and abrasion resistance





HDPE Material for Conduit Applications

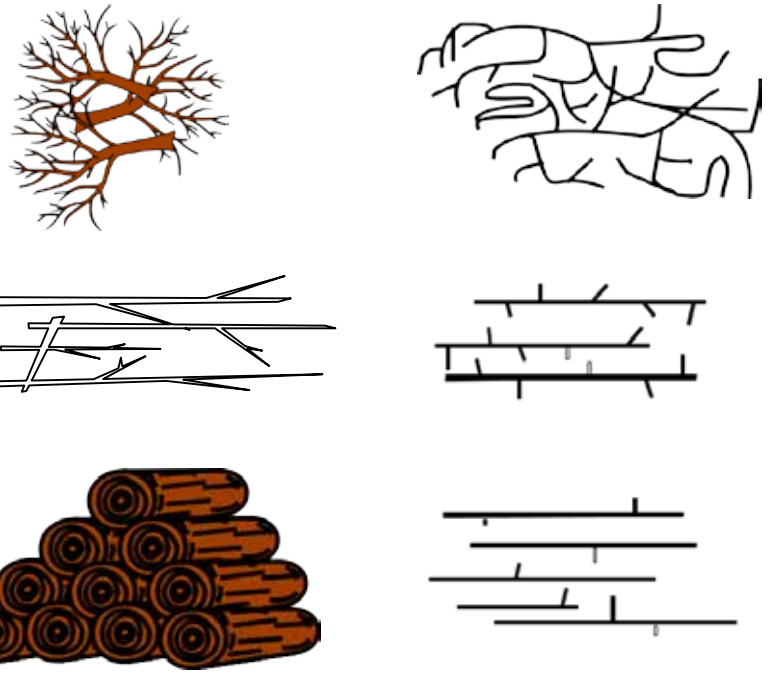
What is HDPE?

- **The effects of "Branching"**

- With **Low Crystallinity**, large numbers of branches interfere with the ability of molecules to fit close together

- With **Medium Crystallinity**, there are numerous short Branches

- With **High Crystallinity**, there are no branches, and molecules can pack tightly together



HDPE Material for Conduit Applications

What is HDPE?

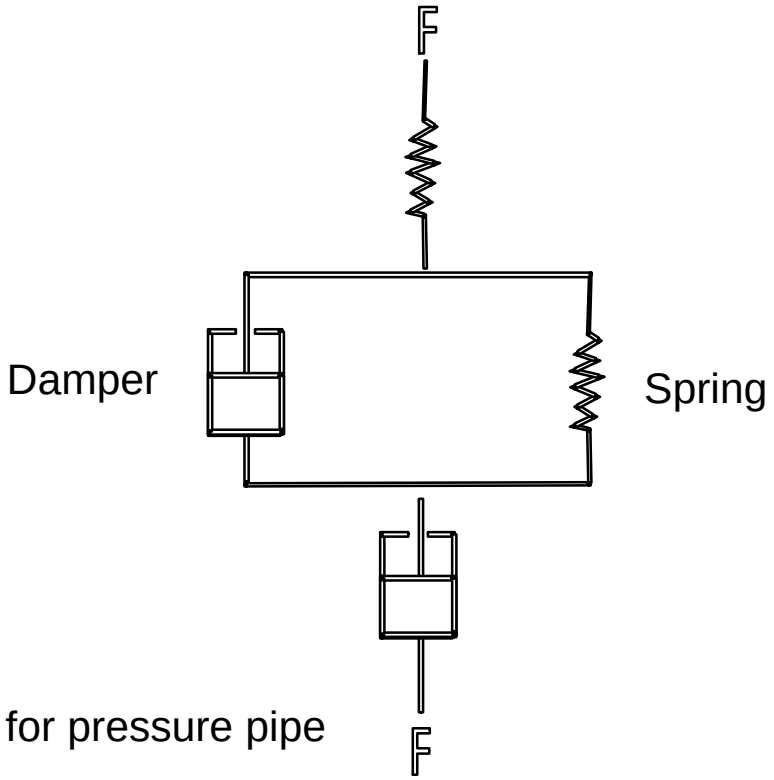
- This unique polymeric structure of HDPE yields a **Visco-Elastic** material

- **Viscous:** Requires time to deform and to recover deformation

- **Elastic**: Immediate recoverable deformation

- HDPE materials are blended or “tuned” for ideal combinations of material properties

- Typical Max. Operating Temp. is 140°F (60°C) for pressure pipe



HDPE Material for Conduit Applications

HDPE Properties – Cell Classification According to ASTM D3350

- Cell classifications define if a material is low-, medium-, or high-density

- ASTM D3350: "Standard Specification for Polyethylene Plastics Pipe and Fitting Materials"

D3350 – 14

TABLE 1 Primary Properties[A] —Cell Classification Limits

Property	Test Method	0	1	2	3	4	5	6	7	8
1. Density, g/cm[3]	D1505	Unspecified	0.925 or lower	>0.925-0.940	>0.940-0.947	>0.947-0.955	>0.955	...	Specify Value	
2. Melt index	D1238	Unspecified	>1.0	1.0 to 0.4	<0.4 to 0.15	<0.15[B]	C		Specify Value	
3. Flexural modulus, MPa (psi)	D790	Unspecified	<138 (<20 000)	138-<276 (20 000 to <40 000)	276-<552 (40 000 to 80 000)	552-<758 (80 000 to 110 000)	758-<1103 (110 000 to <160 000)	>1103 (>160 000)	Specify Value	
4. Tensile strength at yield, MPa (psi)	D638	Unspecified	<15 (<2200)	15-<18 (2200-<2600)	18-<21 (2600-<3000)	21-<24 (3000-<3500)	24-<28 (3500-<4000)	>28 (>4000)	Specify Value	
5. Slow Crack Growth Resistance										
I. ESCR	D1693	Unspecified								
a. Test condition (100% Igepal.)[C]			A	B	C	C	...	...	...	Specify Value
b. Test duration, h			48	24	192	600				
c. Failure, max, %		Unspecified	50	50	20	20				
II. PENT (hours)	F1473									
Molded plaque, 80°C, 2.4 MPa		Unspecified	...	...	...	10	30	100	500	Specify Value
Notch depth, F1473, Table 1		Unspecified								
6. Hydrostatic Strength Classification										
I. Hydrostatic design basis, MPa (psi), (23°C)	D2837	NPR[E]	5.52 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)	...	...		
II. Minimum required strength, MPa (psi), (20°C)	ISO 12162	...	...	...	...	...	8 (1160)	10 (1450)		

HDPE Material for Conduit Applications

HDPE Properties – Cell Classification According to ASTM D3350

- Minimum Cell Classification for HDPE conduit is **PE334480C** or **PE334480E**
- This is what that means:

Property	Value/Range	Test Method
Density = **3**	> 0.94 g/cm^3	ASTM D1505
Melt Index = **3**	< 0.4 g/10 min.	ASTM D1238
Flexural Modulus = **4**	≥ 80,000 psi (≥ 552 MPa)	ASTM D790
Tensile Strength, Yield = **4**	≥ 3,000 psi (≥ 21 MPa)	ASTM D638
Slow Crack Growth Resistance = **8**	F10 ≥ 96 hours (10% Igepal)	ASTM D1693
Hydrostatic Strength Classification = **0**	N/A	ASTM D2837

C = Black using Carbon Black, whereas **E** = Colored with UV Stabilizer

HDPE Material for Conduit Applications

Other HDPE Properties – Typical Conduit Grade

Property	Value/Range	Test Method
- Tensile Elongation to Break	> 400%	ASTM D638
- Brittleness Temperature	< -139°F (-95°C)	ASTM D746A
- Melt Temperature	~ 250°F (121°C)	ASTM D746A
- Auto-Ignition	> 650°F (340°C)	
- Dielectric Strength	500-600 Volts/mil (19 – 23 kV/mm)	
- Coefficient of Friction	0.29	

HDPE Material for Conduit Applications

HDPE Properties – Conduit Materials According to ASTM F2160

- Product standards such as **ASTM F2160** define Materials requirements

- Excerpt from ASTM F2160-16
- "Standard Specification for Solid Wall HDPE Conduit…"

4. Materials

4.1 PE compound shall meet Specification D3350 requirements and be classified in accordance with Specification D3350 with a minimum cell classification of PE334480C or PE334480E. Higher classification values for the first four cells and the sixth cell shall be acceptable. The classification value for the fifth cell shall be 8 in accordance with 4.2.

4.2 *Slow Crack Growth*—The minimum specified ESCR cell class 8 requirement is F10 > 96 h per Test Method D1693, condition B, 10 % Igepal. Alternatively, slow crack growth cell classification per Specification D3350 of 4 or higher is acceptable in meeting this requirement

4.4 *Aerial Applications*—PE material for black conduit in long-term above ground applications, such as aerial suspension, shall be stabilized with a minimum of 2–4 % by weight carbon black having an average particle size less than or equal to 20 nanometers.

HDPE Material for Conduit Applications

HDPE Properties – Conduit Performance According to ASTM F2160

- Product standards such as **ASTM F2160** define Performance requirements

- Excerpt from ASTM F2160-16
- "Standard Specification for Solid Wall HDPE Conduit…"

5.3.1 *Elongation at Break*—When tested in accordance with 6.2, the minimum elongation at break shall be 400 %.

5.3.2 *Impact*—The conduit shall not fail when three specimen are tested at the low-temperature condition of -4°F (-20°C), in accordance with 6.3 – 6.3.2 or if one out of three specimen fails, then a retest of three additional specimen shall result in no failures.

5.5 *Pipe Stiffness, Compression and Recovery*—Specimens shall achieve the minimum loads given in Table 5, Table 6, and Table 7 at 5% deflection when tested in accordance with 6.5. In addition, during compression and recovery testing specimens shall not split or crack, when tested in accordance with 6.6.

NOTE 4—The minimum values for Pipe Stiffness (PS) are calculated using the minimum allowable flexural modulus specified of 80,000 psi. The calculated values are derived as outlined in Appendix X2 of Test Method D2412. The minimum values shown for (LbsF) force are calculated based on the test requirements of 5% deflection of the average ID at a deflection rate of 0.5 in/minute on a sample six inches long from the minimum PS values.

HDPE Material for Conduit Applications

HDPE Properties – Conduit Materials According to NEMA TC 7

- Product standards such as **NEMA TC 7** define Materials requirements
- Excerpt from NEMA TC 7-16

> **3.1 Materials**
>
> **3.1.1 Electrical Conduit**
>
> Electrical Polyethylene Conduit (EPEC) shall be made from non-pressure rated (NPR) high-density polyethylene classified in accordance with ASTM D 3350 and Table 1.
>
> Reworked clean polyethylene compound from the manufacturer's own production, and approved reprocessed material, may be re-extruded into conduit, either alone or blended with virgin compound. Conduit containing rework and/or reprocessed materials shall meet all the material and product requirements of this standard.

HDPE Material for Conduit Applications

HDPE Properties – Conduit Performance According to NEMA TC 7

- Product standards such as **NEMA TC 7** define Performance requirements
- Excerpt from NEMA TC 7-16

5.3 Pipe Stiffness

Three specimens that are 6 ±1/8 in. (150 ±3 mm) in length shall be cut from lengths from the EPEC conduit to be tested. The inside diameter of each specimen shall be calculated using the following formula:

ID = OD − 2t
Where: ID = Calculated Inside Diameter, in. (mm)
OD = Measured Outside Diameter, in. (mm)
t = Average Wall Thickness, in. (mm)

After the specimens are prepared, each one shall be tested as defined in ASTM D 2412 by being placed between a pair of rigid flat steel plates that are of equal or greater length than the specimen length. The plates shall be parallel and in contact with the specimen OD. One plate shall be moved toward the other at the rate of 0.50 ±0.020 in. (12.5 ±0.5 mm) per minute until the distance between the parallel plates has been decreased by 5% of the original calculated inside diameter of the specimen. The highest load shall be recorded and noted and shall be greater than the value provided in Table 4-1 for the trade size and respective type being tested.

HDPE Material for Conduit Applications

HDPE Conduit Introduction

- High density polyethylene (HDPE) conduit is the preferred material to house and protect electrical power and telecommunications cables
- HDPE offers unmatched corrosion and chemical resistance, is flexible and durable, and is available in long reel lengths to reduce joints and installation time
- HDPE conduit is available in a variety of sizes, colors, dimensions and lengths

HDPE Material for Conduit Applications

HDPE Conduit Benefits

- Not susceptible to corrosion
- Moisture-proof and watertight
- Can be installed around underground obstacles
- Resists brittleness due to aging or cold weather
- Eliminates maintenance common to aerial networks
- Easy installation due to long lengths and high pull strength
- Low coefficient of friction allows easier long-distance cable pulls
- Accommodates gradual changes in direction and elevation
- Bends and flexes without breakage, even with ground heaves or shifts, over a wide range of temperatures
- High ductility resists damage during transportation, handling, and installation and retains impact resistance

HDPE Material for Conduit Applications

HDPE Conduit Types

Outside Plant (OSP) Types:

i. Smoothwall, Ribbed and Corrugated walls
ii. Pull lines factory-installed for pulling cables
iii. CIC has cable factory-installed
iv. Microducts and microfiber cables
v. Innerduct

OSP Applications:

- Innerduct
- Direct burial
- Aerial
- Cable-in-Conduit (CIC)

HDPE Material for Conduit Applications

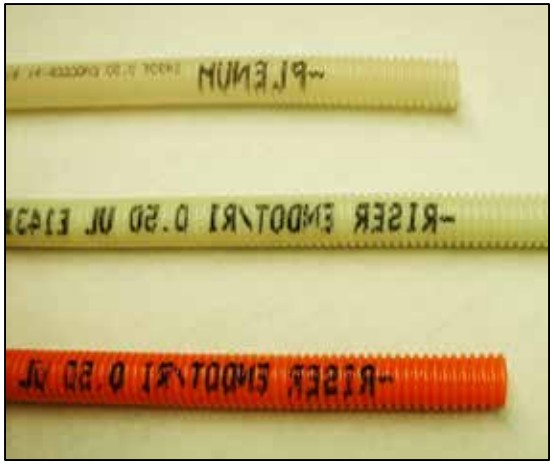
HDPE Conduit Types

Inside Plant (ISP) Types:

i. Riser-rated

ii. Plenum-rated

iii. LSZH-rated



Courtesy Blue Diamond

HDPE Material for Conduit Applications

HDPE Conduit Types and Colors

- Example: Three-in-One HDPE conduit with innerduct
- Example: Multi-color reel of 2 inch IPS conduit

HDPE Material for Conduit Applications

HDPE Conduit Types and Colors

- Various solid colors and stripe combinations are available

HDPE Material for Conduit Applications

HDPE Conduit OD/ID and Wall Options

- OD sizing systems include IPS wall types SDR9, SDR11, SDR 13.5, DR 15.5, Schedule 40, and Schedule 80

- ID sizing systems include "True Sized" and SIDR

- Wall thickness is described by the **Dimension Ratio** (DR)* which typically ranges from SDR 9 to SDR 17 for diameters up to 12-inch

- Standards such as **ASTM F2160, NEMA TC 7, UL 651A** specify exact dimensions

**Ratio of outside diameter to wall thickness. The lower the DR number, the thicker the wall, relative to other dimension ratios. Some dimension ratios are numerically "standard" and referred to as "SDR"*

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HDPE Material for Conduit Applications

HDPE Conduit OD/ID and Wall Options

- Excerpt from **ASTM F2160-16** shows wide range of wall types

TABLE 4 Minimum Wall Thickness and Tolerance for IPS SDR 9, SDR 11, SDR 13.5, DR 15.5, Schedule 40 and Schedule 80 PE Conduit

Nominal Size	DR 15.5		SDR 13.5		SDR 11		SDR 9		Schedule 40		Schedule 80	
	Min. in. (mm)	Tol. in. (mm)	Min. in. (mm)	Tol. in. (mm)	Min. in. (mm)	Tol. in. (mm)	Min. in. (mm)	Tol. in. (mm)	Min. in. (mm)	Tol. in. (mm)	Min. in. (mm)	Tol. in. (mm)
½	0.062 (13.00)	+0.020 +(0.51)	0.062 (1.57)	+0.020 +(0.51)	0.076 (1.93)	+0.020 +(0.51)	0.093 (2.36)	+0.020 +(0.51)	0.109 (2.77)	+0.020 +(0.51)	0.147 (3.73)	+0.020 +(0.51)
¾	0.068 (1.73)	+0.020 +(0.51)	0.078 (1.98)	+0.020 +(0.51)	0.095 (2.41)	+0.020 +(0.51)	0.117 (2.97)	+0.020 +(0.51)	0.113 (2.87)	+0.020 +(0.51)	0.154 (3.91)	+0.020 +(0.51)
1	0.084 (2.13)	+0.020 +(0.51)	0.097 (2.46)	+0.020 +(0.51)	0.120 (3.05)	+0.020 +(0.51)	0.146 (3.71)	+0.020 +(0.51)	0.133 (3.38)	+0.020 +(0.51)	0.179 (4.55)	+0.021 +(0.53)
1¼	0.107 (2.72)	+0.020 +(0.51)	0.123 (3.12)	+0.020 +(0.51)	0.151 (3.84)	+0.020 +(0.51)	0.184 (4.67)	+0.022 +(0.56)	0.140 (3.56)	+0.020 +(0.51)	0.191 (4.85)	+0.023 +(0.58)
1½	0.123 (3.12)	+0.020 +(0.51)	0.141 (3.58)	+0.020 +(0.51)	0.173 (4.39)	+0.021 +(0.53)	0.211 (5.36)	+0.025 +(0.64)	0.145 (3.68)	+0.020 +(0.51)	0.200 (5.08)	+0.024 +(0.61)
2	0.153 (3.89)	+0.020 +(0.51)	0.176 (4.47)	+0.020 +(0.51)	0.216 (5.49)	+0.026 +(0.66)	0.264 (6.71)	+0.032 +(0.81)	0.154 (3.91)	+0.020 +(0.51)	0.218 (5.54)	+0.026 +(0.66)
2½	0.185 (4.70)	+0.022 +(0.56)	0.213 (5.41)	+0.020 +(0.51)	0.261 (6.64)	+0.031 +(0.80)	0.319 (8.11)	+0.038 +(0.97)	0.203 (5.16)	+0.024 +(0.61)	0.276 (7.01)	+0.033 +(0.84)
3	0.226 (5.74)	+0.027 +(0.69)	0.259 (6.58)	+0.031 +(0.79)	0.318 (8.08)	+0.038 +(0.97)	0.389 (9.88)	+0.047 +(1.19)	0.216 (5.49)	+0.026 +(0.66)	0.300 (7.62)	+0.036 +(0.91)

HDPE Material for Conduit Applications

Summary

- HDPE's physical properties make it ideally-suited for a wide range of installation applications protecting both power and communications cables
- HDPE Conduit is available in a variety of diameters, wall types, colors, configurations
- HDPE Conduit can be supplied with special features including color & stripes, added UV protection for aerial, pull tapes, lubrication and/or cables which are factory-installed

Suitability for Power Applications:

- HDPE Conduit is resistant to typical heat experienced in power applications
- Capable of protecting 90°C-rated power cables

2. Common Applications for HDPE Conduit

Applications addressed by HDPE Conduit

Common applications include:

- Power:
  - Low-voltage and medium-voltage
  - Site Lighting
  - Signal and Control
- Fiber Optic and Communications
- Renewable Energy
- ITS (Intelligent Transportation Systems)
- SCADA (Supervisory Control and Data Acquisition)
- Sensing, IOT (internet of things), Security, Healthcare
- 5G wireless

Common Applications for HDPE Conduit

Power

- HDPE conduit is used to protect underground power lines
  - Low voltage: **600 V**
  - Medium voltage: **15kV** to **35kV**
- Underground installation of power distribution cables using HDPE conduit is a reliable, sustainable and economical solution
- Buried power lines are not as susceptible to storm damage and other events as compared to aerial cables
- Underground cables require less maintenance than aerial cables (e.g. tree trimming)
- The resiliency and reliability of utilities is typically improved when buried underground


Courtesy Southwire

Common Applications for HDPE Conduit

Power: Cable-in-Conduit (CIC)

- CIC is HDPE conduit extruded over cable in the controlled environment of the manufacturing facility
- Reduces installation time, improves productivity
- CIC is less susceptible to damage than installing power cables in the field

Common Applications for HDPE Conduit

Fiber Optic and Communications

- HDPE conduit is used to protect fiber optic installations serving neighborhoods, schools, industry and government with high-speed data

Common Applications for HDPE Conduit

Fiber Optic and Communications

- HDPE conduit is used to protect fiber optic installations connecting data centers to neighborhoods, schools, industry, and government with high-speed data
- Protecting the Information Superhighway

Common Applications for HDPE Conduit

Fiber Optic and Communications

- When new roads are constructed or rebuilt, HDPE conduit is one of the first utilities to be installed, often for future fiber optic cable ("**Dig once**")

Common Applications for HDPE Conduit

Renewable Energy

- Solar and wind power projects utilize HDPE conduit for command & control

Common Applications for HDPE Conduit

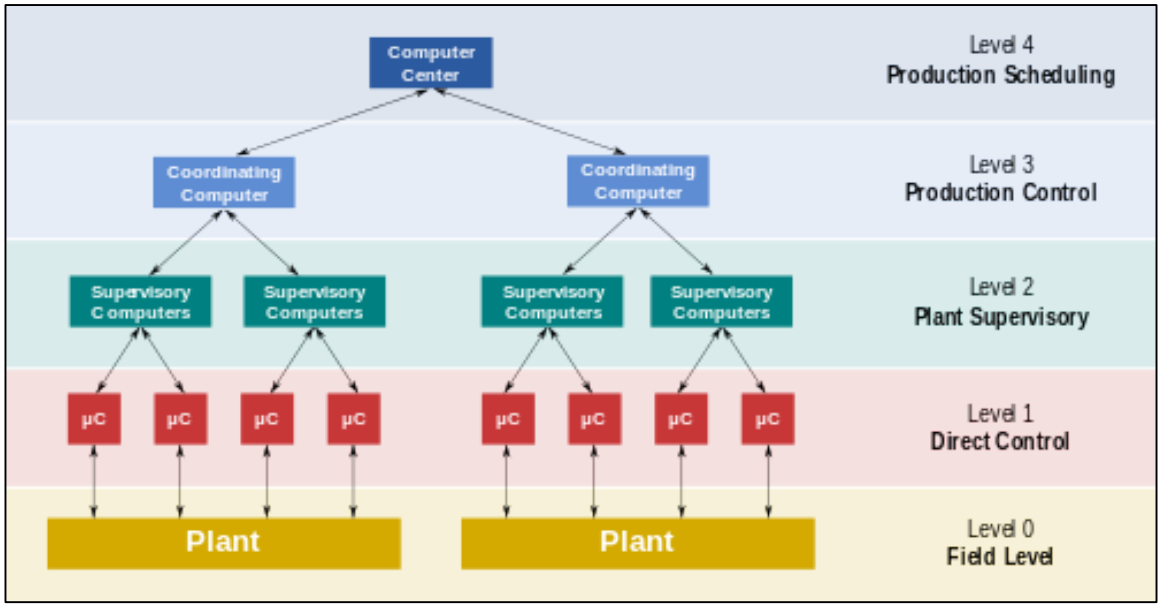
ITS - Intelligent Transportation Systems

- HDPE conduit protects fiber optic & copper communication cables and power cables

Common Applications for HDPE Conduit

SCADA - Supervisory Control and Data Acquisition

- Examples are command/control systems for water treatment plants, oil and gas pipelines, factories, control of solar farm panels, control of wind power propellers, etc.



Common Applications for HDPE Conduit

Summary

Common applications include:

- Power
  - Low-voltage and medium-voltage
  - Site Lighting
  - Signal and Control
- Fiber Optic and Communications
- Renewable Energy
- ITS (Intelligent Transportation Systems)
- SCADA (Supervisory Control and Data Acquisition)
- Sensing, IOT (internet of things), Security, Healthcare
- 5G wireless

3. HDPE Conduit Installation Techniques

Installation Types

HDPE conduit is installed via three primary methods

1. Trenching
2. Plowing
3. HDD

- Several design and installation “tools” available

HDPE Conduit Installation Techniques

Installation Types

1. Open Cut
   - Trenching
   - Backhoe

HDPE Conduit Installation Techniques

Installation Types

2. Plowing
   - Chute plow
   - Pull plow

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HDPE Conduit Installation Techniques

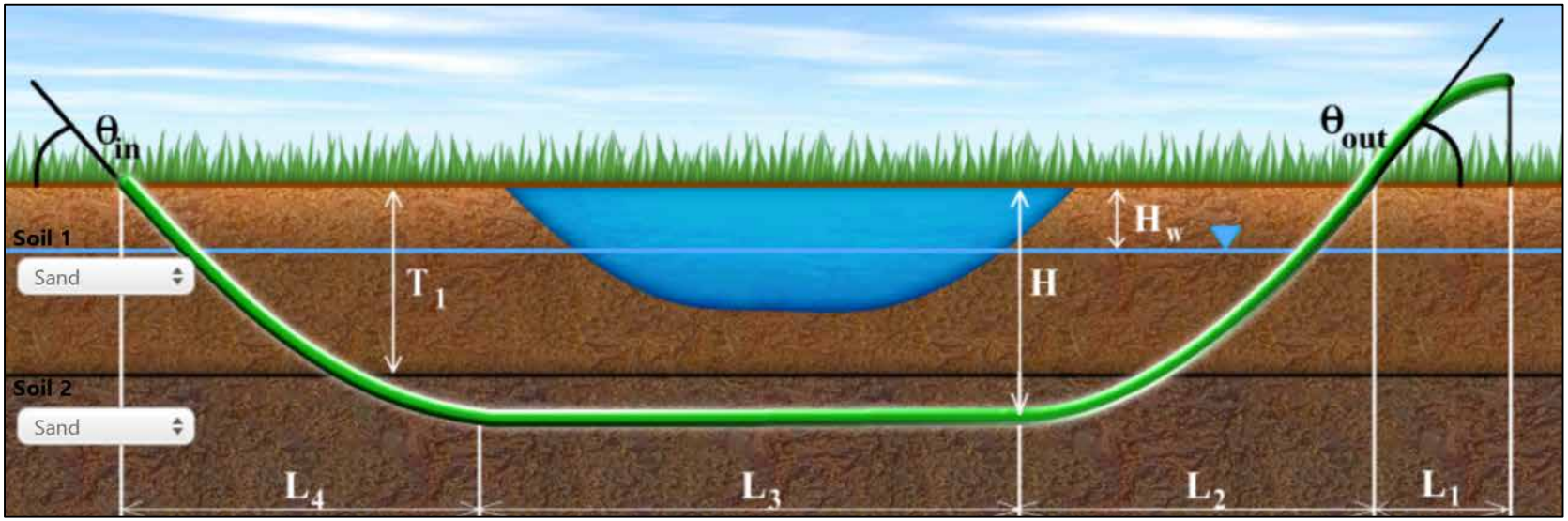
Installation Types

2. Plowing
   - Continuous lengths 1000+ ft

HDPE Conduit Installation Techniques

Installation Types

3. Horizontal Directional Drilling (HDD)
   - Boring under roadways or waterways and pulling the conduit underground
   - Can also be done as Slip Lining or Pipe Bursting



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HDPE Conduit Installation Techniques

Installation Types

3. Horizontal Directional Drilling (HDD)
   - Boring under roadways or waterways and pulling the conduit underground
   - Can also be done as Slip Lining or Pipe Bursting

HDPE Conduit Installation Techniques

Installation Types

3. Horizontal Directional Drilling (HDD)
   - Example: Twenty 2” ducts installed under a field, a river and a golf course – 800 ft

HDPE Conduit Installation Techniques

Installation Types

3. Horizontal Directional Drilling (HDD)
   - Example: Twenty 2” ducts installed under a field, a river and a golf course – 800 ft

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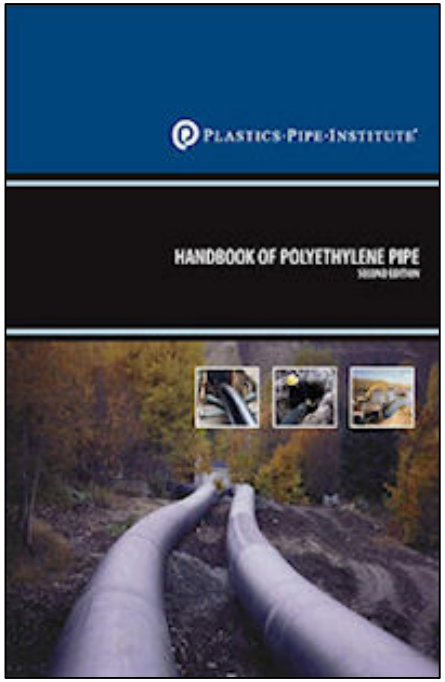
HDPE Conduit Installation Techniques

Design & Installation Tools

- Examples from PPI: “Handbook of Polyethylene Pipe 2nd Edition” (Ch. 14)



Chapter 14

Duct and Conduit

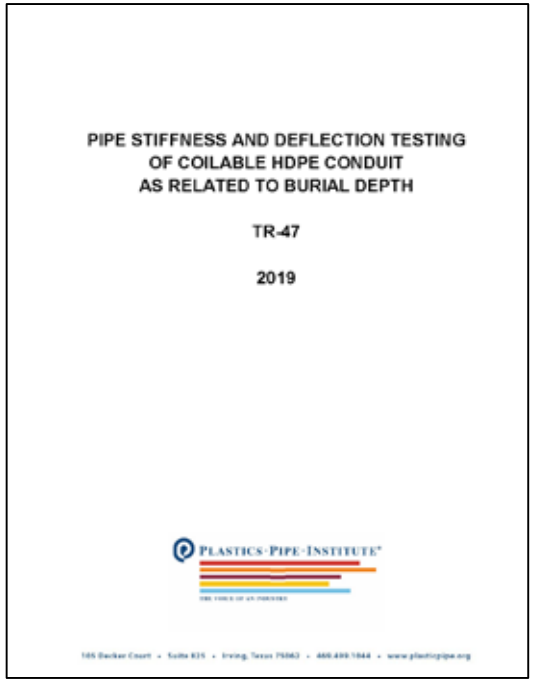
Introduction

Conduit Specifications

HDPE Conduit Installation Techniques

Design & Installation Tools

- Examples: PPI Technical Report **TR-47**



PIPE STIFFNESS AND DEFLECTION TESTING
OF COILABLE HDPE CONDUIT
AS RELATED TO BURIAL DEPTH

TR-47

2019

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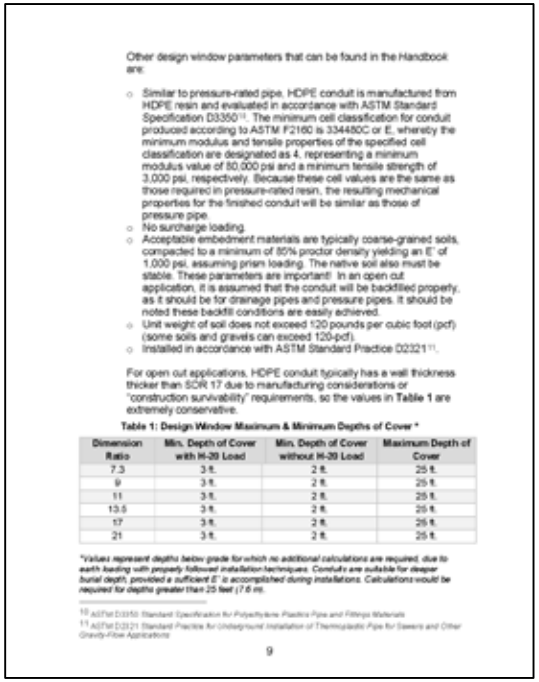

Other design window parameters that can be found in the Handbook are:

- Similar to pressure-rated pipe, HDPE conduit is manufactured from HDPE resin and evaluated in accordance with ASTM Standard Specification D3350[10]. The minimum cell classification for conduit produced according to ASTM F2160 is 334480C or E, whereby the minimum modulus and tensile properties of the specified cell classification are designated as 4, representing a minimum modulus value of 80,000 psi and a minimum tensile strength of 3,000 psi, respectively. Because these cell values are the same as those required in pressure-rated resin, the resulting mechanical properties for the finished conduit will be similar as those of pressure pipe.
- No surcharge loading.
- Acceptable embedment materials are typically coarse-grained soils, compacted to a minimum of 85% proctor density yielding an E' of 1,000 psi, assuming prism loading. The native soil also must be stable. These parameters are important! In an open cut application, it is assumed that the conduit will be backfilled properly, as it should be for drainage pipes and pressure pipes. It should be noted these backfill conditions are easily achieved.
- Unit weight of soil does not exceed 120 pounds per cubic foot (pcf) (some soils and gravels can exceed 120-pcf).
- Installed in accordance with ASTM Standard Practice D2321[11].

For open cut applications, HDPE conduit typically has a wall thickness thicker than SDR 17 due to manufacturing considerations or "construction survivability" requirements, so the values in **Table 1** are extremely conservative.

Table 1: Design Window Maximum & Minimum Depths of Cover *

Dimension Ratio	Min. Depth of Cover with H-20 Load	Min. Depth of Cover without H-20 Load	Maximum Depth of Cover
7.3	3 ft.	2 ft.	25 ft.
9	3 ft.	2 ft.	25 ft.
11	3 ft.	2 ft.	25 ft.
13.5	3 ft.	2 ft.	25 ft.
17	3 ft.	2 ft.	25 ft.
21	3 ft.	2 ft.	25 ft.

**Values represent depths below grade for which no additional calculations are required, due to earth loading with properly followed installation techniques. Conduits are suitable for deeper burial depth, provided a sufficient E' is accomplished during installations. Calculations would be required for depths greater than 25 feet (7.6 m).*

[10] ASTM D3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
[11] ASTM D2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

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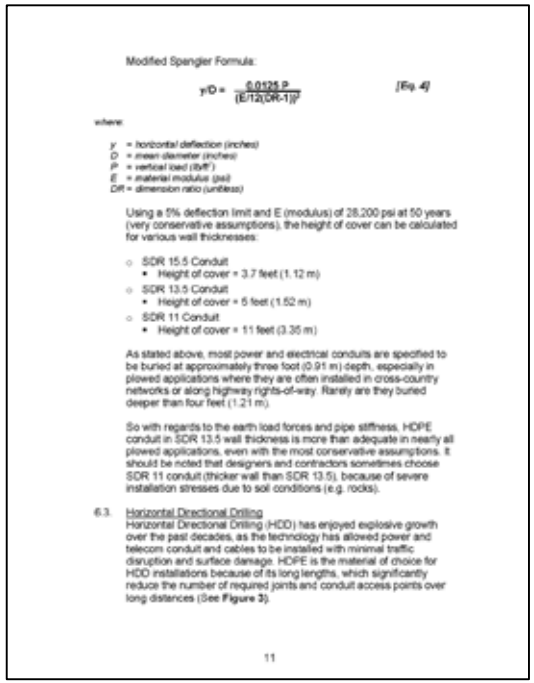

Modified Spangler Formula:

$$y/D = \frac{0.0125\ P}{(E/12)(DR-1)^3} \qquad [Eq.\ 4]$$

where:

y = horizontal deflection (inches)
D = mean diameter (inches)
P = vertical load (lbf/ft')
E = material modulus (psi)
DR = dimension ratio (unitless)

Using a 5% deflection limit and E (modulus) of 28,200 psi at 50 years (very conservative assumptions), the height of cover can be calculated for various wall thicknesses:

- SDR 15.5 Conduit
  - Height of cover = 3.7 feet (1.12 m)
- SDR 13.5 Conduit
  - Height of cover = 5 feet (1.52 m)
- SDR 11 Conduit
  - Height of cover = 11 feet (3.35 m)

As stated above, most power and electrical conduits are specified to be buried at approximately three foot (0.91 m) depth, especially in plowed applications where they are often installed in cross-country networks or along highway rights-of-way. Rarely are they buried deeper than four feet (1.21 m).

So with regards to the earth load forces and pipe stiffness, HDPE conduit in SDR 13.5 wall thickness is more than adequate in nearly all plowed applications, even with the most conservative assumptions. It should be noted that designers and contractors sometimes choose SDR 11 conduit (thicker wall than SDR 13.5), because of severe installation stresses due to soil conditions (e.g. rocks).

6.3. Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) has enjoyed explosive growth over the past decades, as the technology has allowed power and telecom conduit and cables to be installed with minimal traffic disruption and surface damage. HDPE is the material of choice for HDD installations because of its long lengths, which significantly reduce the number of required joints and conduit access points over long distances (See **Figure 3**).

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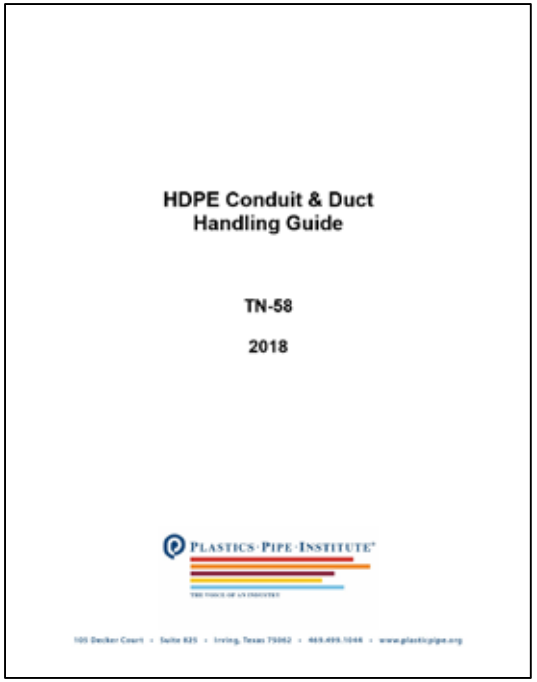
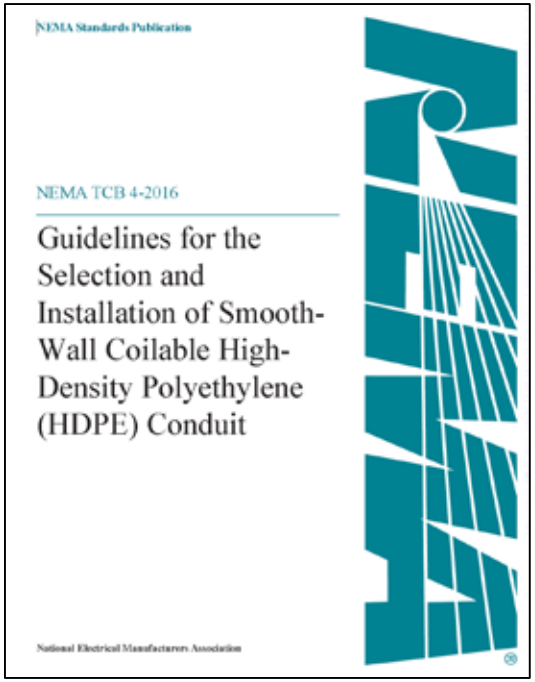
HDPE Conduit Installation Techniques

Design & Installation Tools

- Examples: PPI Technical Note **TN-58**, NEMA **TCB4-2016**

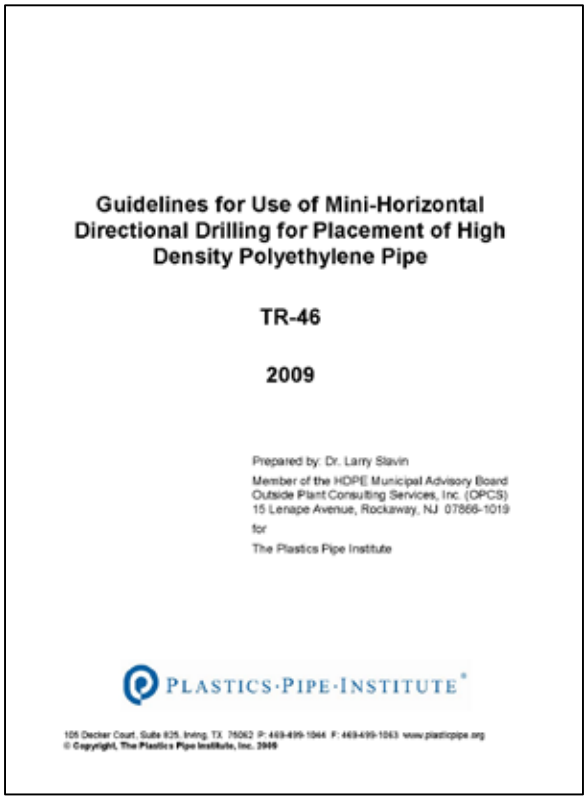




HDPE Conduit Installation Techniques

Design & Installation Tools

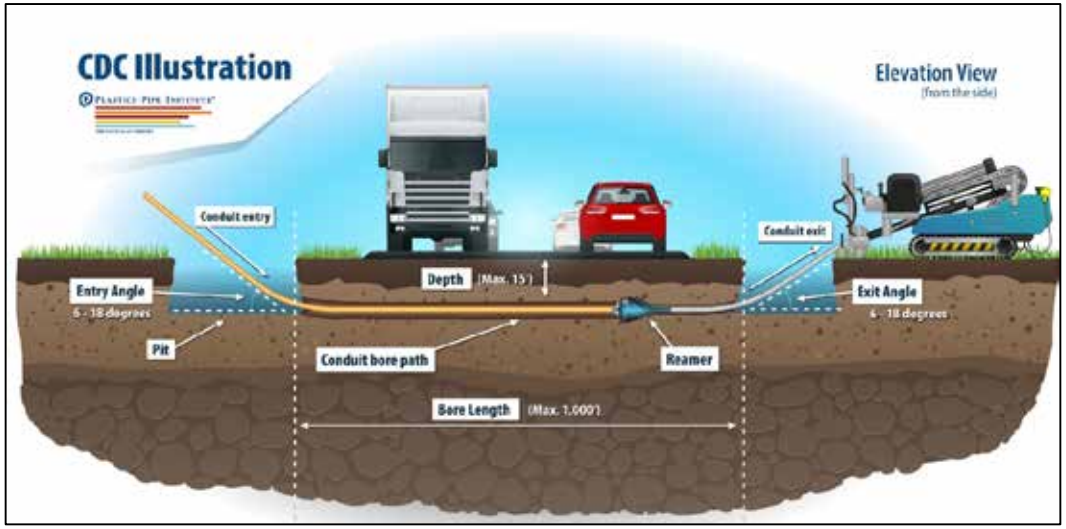
- Example: **PPI TR-46 "Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe"**
- "These guidelines describes the design, selection considerations, and installation procedures for the placement of polyethylene (PE) pipe or conduit below ground using mini-horizontal directional drilling (HDD) equipment."
- **Mini-HDD** is typically employed for boring segments less than 600 feet in length, at depths up to 15 feet, and placing pipes up to 12 inches diameter



HDPE Conduit Installation Techniques

Design & Installation Tools

- Example: **PPI Conduit Design Calculator**
- Aids in determining the most appropriate wall thickness to be installed via Horizontal Directional Drilling (HDD)
- www.conduitcalc.com



HDPE Conduit Installation Techniques

Design & Installation Tools

- Example: **PPI Conduit Design Calculator**
- Aids in determining the most appropriate wall thickness to be installed via Horizontal Directional Drilling (HDD)
- www.conduitcalc.com

User Input Summary	
Conduit Diameter:	2.0" IPS SDR 11
Selected Material:	Industry Standard HDPE Conduit
Maximum Depth (feet):	12
Bore Length (feet):	780
Drill Rod Diameter:	2
Total Curvature (Degrees):	160

HDPE Conduit Installation Techniques

Design & Installation Tools

- Example: **PPI Conduit Design Calculator**
- Aids in determining the most appropriate wall thickness to be installed via Horizontal Directional Drilling (HDD)
- www.conduitcalc.com

Results					
Conduit Wall Type for selected Diameter Type and Diameter	**Safe Pull Strength (lbs)**	**Calculated Tensile Load (lbs)**	**Safety Factor (if <1.0, do not use)**	**Status Pass / Fail**	**Message**
Schedule 40	1367	1400	0.98	Fail	Use a Thicker Wall
Schedule 80	1867	1298	1.44	Pass	This Wall Type is OK
SDR 9	2211	1229	1.80	Pass	This Wall Type is OK
SDR 11	1852	1301	1.42	Pass	This Wall Type is OK
SDR 13.5	1535	1366	1.12	Pass	This Wall Type is OK
DR 15.5	1359	1401	0.97	Fail	Use a Thicker Wall
SDR 17	1258	1422	0.88	Fail	Use a Thicker Wall

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HDPE Conduit Installation Techniques

Design & Installation Tools

- Example: **ASTM F1962** "Standard Guide for Use of **Maxi-Horizontal Directional Drilling** for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings"

- "This guide describes the design, selection considerations, and installation procedures for the placement of polyethylene pipe or conduit below ground using maxi-horizontal directional drilling equipment."

Designation: F1962 – 11

Standard Guide for
Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings[1]

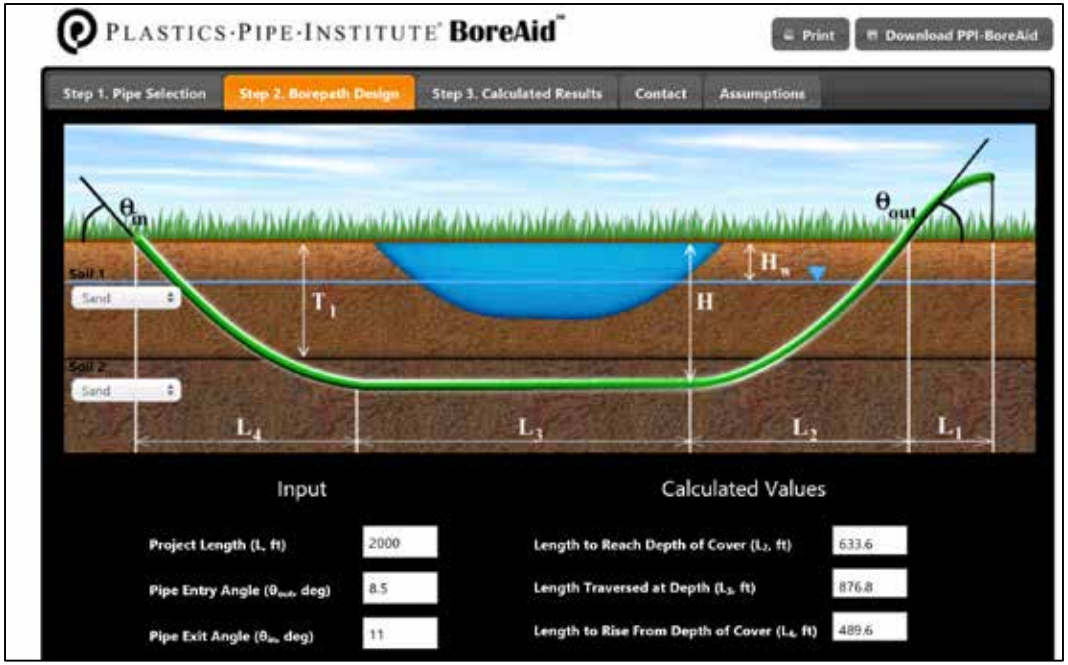
1. Scope*

2. Referenced Documents

HDPE Conduit Installation Techniques

Design & Installation Tools

- **PPI BoreAid™** software is used for Maxi-HDD calculations, per ASTM F1962
- Calculates safe pull strength per various SDR options



HDPE Conduit Installation Techniques

Summary

- HDPE conduit is installed via three primary methods
  1. Trenching
  2. Plowing
  3. HDD
- Several design and installation “tools” available

4. Industry Standards for HDPE Conduit

Current HDPE Conduit Standards

- The first ASTM standard specification written and approved for HDPE conduit was **ASTM F2160** “Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)”

- F2160 was originally approved in 2001, then revised in 2008, and again in 2010

- In 2016, a significant revision of F2160 expanded the Scope, consolidated 11 dimensional tables into four, clarified test procedures, added pipe stiffness requirements, and revised requirements, such as resistance to slow crack growth

- Revision was published as **F2160-16** in December 2016 www.astm.org

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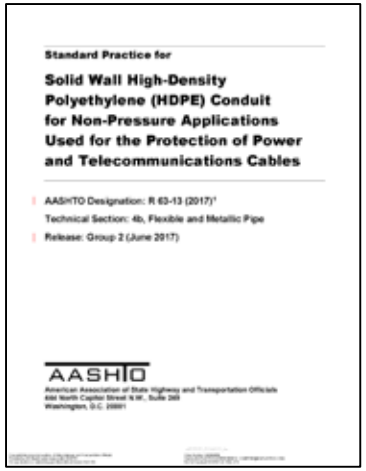
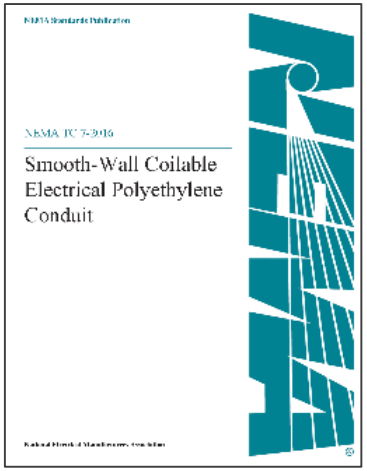
Industry Standards for HDPE Conduit

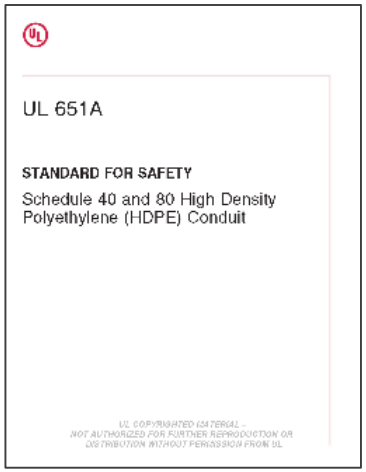
Current HDPE Conduit Standards

- Today, there are **seven (7) recognized standard specifications** for HDPE conduit and cable in conduit for various applications
- HDPE conduit standards specify material properties, dimensions, performance requirements and test methods for evaluating HDPE conduit


Standard Practice for
Solid Wall High-Density Polyethylene (HDPE) Conduit for Non-Pressure Applications Used for the Protection of Power and Telecommunications Cables
AASHTO Designation: R 63-13 (2017)
Technical Section: 4b, Flexible and Metallic Pipe
Release: Group 2 (June 2017)
AASHTO


Standard Specification for Coilable High Density Polyethylene (HDPE) Cable in Conduit (CIC)


NEMA Standards Publication
NEMA TC 7-2016
Smooth-Wall Coilable Electrical Polyethylene Conduit


UL 651A
STANDARD FOR SAFETY
Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit
UL COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM UL

Industry Standards for HDPE Conduit

AASHTO R63-2013 (2017): Standard Practice for Solid Wall High-Density Polyethylene (HDPE) Conduit for Non-Pressure Applications Used for the Protection of Power and Telecommunications Cables

"This standard practice provides guidance to engineers in the specification of HDPE conduit used in buried applications for the protection of power cables for use in highways, airport lighting, traffic control, and fiber optic data and command and control applications in State Transportation Projects."

"This standard practice does not include guidelines for installation of HDPE conduit. Typical installation methods include trenching, plowing, and Horizontal Directional Drilling (HDD). Consult the PPI (Plastics Pipe Institute) Handbook of Polyethylene Pipe and TN (Technical Notes) on the PPI website, http://plasticpipe.org, for further information and guidance on installation methods."

Industry Standards for HDPE Conduit

ASTM F2160-16: Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

"This specification covers material, dimensional, workmanship and performance requirements for polyethylene conduit, duct and innerduct manufactured for use in non-pressure applications for the protection of fiber optic and power cables. Applications include telecom, SCADA command and control, highway lighting, ITS (Intelligent Transportation Systems) and Underground Utilities with PE conduit installed using methods such as Horizontal Directional Drilling (HDD),plowing and open trench."

- Includes trade sizes from ½ to 12
- Originally approved 2001
- Current edition approved in **2016**

Industry Standards for HDPE Conduit

ASTM D3485-15: Standard Specification for Coilable High Density Polyethylene (HDPE) Cable In Conduit

"This specification covers cable in conduit (CIC), which is a smooth-walled, coilable, high-density polyethylene (HDPE) conduit (duct) that contains preassembled wires and cables. The outside diameter of the conduit is controlled and the wire or cable encased within may be comprised of single or multiple configurations consisting of electrical/ power wires or cables, fiber optic, traditional copper communication, coaxial cable, or any combination thereof."

- Includes trade sizes from ½ to 3
- Originally approved 1976
- Current edition approved in **2015**

Industry Standards for HDPE Conduit

CSA C22.2 No. 327: HDPE Conduit, Conductors in Conduit, and Fittings

"This Standard applies to high density polyethylene (HDPE) conduit, HDPE conduit with conductors, and fittings, intended for use at a continuous operating temperature of 75°C or 90°C, for installation in accordance with the Rules of the Canadian Electrical Code, Part I, for direct burial or encasement in concrete or masonry in ordinary (non-hazardous) locations.."

- Includes trade sizes from ½ to 8
- Originally published in **2016**

Industry Standards for HDPE Conduit

NEMA TC 7-16: Smooth Wall Coilable Electrical Polyethylene Conduit

"This standard covers several wall types of high-density polyethylene (HDPE) conduit for use in providing a protective raceway for electrical cables or communication cables buried underground or concrete encased."
"Note: Typical applications for HDPE conduit include power distribution, site lighting, signal and control, and Supervisory Control and Data Acquisition (SCADA)."

Includes wall types EPEC-40, EPEC-80, EPEC-11, EPEC-13.5, EPEC-15.5, EPEC 17

- Includes trade sizes from ½ to 8
- Originally published in 1983
- Current edition approved in **2016**

Industry Standards for HDPE Conduit

UL 651A: Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit

"These requirements cover straight conduit and coilable, smooth-wall, continuous length conduit with a circular cross section:

a) Extruded straight rigid Schedule 40 high density PE (polyethylene) electrical conduit and the following fittings for use with this conduit type:

1) Elbows, and

2) Rigid high density PE couplings;

b) Schedule 40, Schedule 80, EPEC-A (DR 15.5), and EPEC-B (SDR 13.5) coilable, smooth-wall continuous length high density PE electrical conduit."

- Includes trade sizes from ½ to 6
- Originally published in 1981
- Current edition shows as "Fifth Edition – Oct. 26, 2011" but includes **2016** updates

Industry Standards for HDPE Conduit

UL 1990: Standard for Nonmetallic Underground Conduit with Conductors

"These requirements cover nonmetallic underground conduit with conductors. These products consist of a factory assembly of conductors or cables inside a coilable, smooth-wall, continuous length conduit with a circular cross section. The conduit is Schedule-40, Schedule-80, EPEC-A or EPEC-B High Density Polyethylene (HDPE) in trade sizes 1/2 (16) - 4 (103). This product is intended for installation in accordance with the National Electrical Code, NFPA 70."

- Includes trade sizes from ½ to 4
- Originally published in 1998
- Current edition shows as "Third Edition – Nov. 22, 2013" but includes **2017** updates

Industry Standards for HDPE Conduit

NEMA TCB 4-16: Guidelines for the Selection and Installation of Smooth-Wall Coilable High-Density Polyethylene (HDPE) Conduit

"NEMA TCB 4-2016 Guidelines for the Selection and Installation of Smooth-Wall Coilable High-Density Polyethylene (HDPE) Conduit provides recommendations for the selection, handling, and installation of underground HDPE conduit or raceway for power, lighting, signaling, and communications applications. It applies to both direct burial and encased burial installations, and covers topics such as handling, joining methods, separation and mandrelling."

- Originally published in **2016**
- A Guideline for selection and installation of HDPE conduit, not a product standard

Industry Standards for HDPE Conduit

To learn more about Conduit Standards

See PPI TN-50: Guide to Specifying HDPE Conduit

- *"The purpose of this technical note is to provide general information about the history of the development of high-density polyethylene (HDPE) conduit and the various standards which apply to these products. The technical note may also be used as a guide for selecting appropriate standard specifications for users and specifiers."*
- Maintained annually by industry through PPI
- First published in 2016, revised in **2019**
- Visit www.plasticpipe.org

Industry Standards for HDPE Conduit

To learn more about Conduit Standards

See PPI TN-50: Guide to Specifying HDPE Conduit

- Table 1: HDPE Conduit Diameters Available per Wall Type and Standard Specification

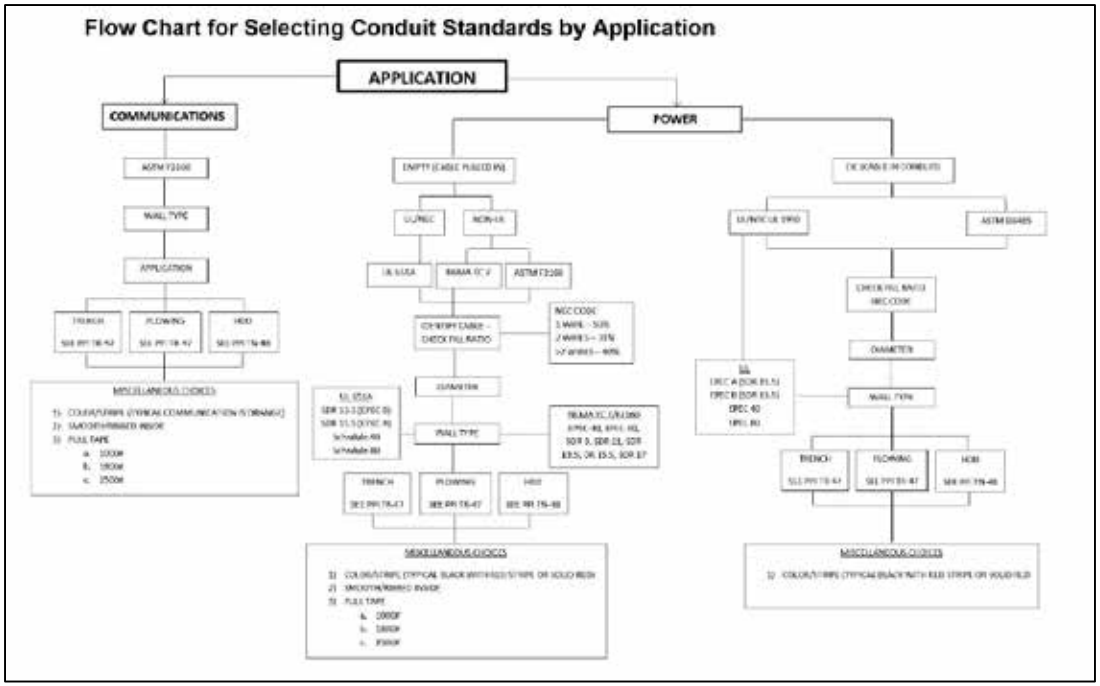
Wall Type	HDPE Conduit Standards with Available Diameters				
	ASTM D3485	ASTM F2160	NEMA TC 7	UL 651A	UL 1990
Schedule 40	1/2" to 3"	1/2" to 12"	1/2" to 8"	1/2" to 6"	1/2" to 6"
Schedule 80	1/2" to 3"	1/2" to 6"	1/2" to 6"	1/2" to 6"	1/2" to 6"
SDR 17	N/A	N/A	1/2" to 2"	1/2" to 6"	1/2" to 6"
DR 15.5	1/2" to 3"	1/2" to 12"	1/2" to 6"	N/A	N/A
SDR 13.5	1/2" to 3"	1/2" to 12"	1/2" to 8"	1/2" to 6"	1/2" to 6"
SDR 11	1/2" to 3"	1/2" to 12"	1/2" to 8"	N/A	N/A
SDR 9	N/A	1/2" to 12"	N/A	N/A	N/A
SIDR	N/A	1" to 5"	N/A	N/A	N/A
True-size 9	N/A	13 mm to 2"	N/A	N/A	N/A
True-size 11	N/A	13 mm to 2"	N/A	N/A	N/A

Industry Standards for HDPE Conduit

To learn more about Conduit Standards

See PPI TN-50: Guide to Specifying HDPE Conduit

- Flow Chart for Selecting Conduit Standards by Application



Industry Standards for HDPE Conduit

Summary

- **PPI TN-50 Guide to Specifying HDPE Conduit**
- A helpful resource to learn the details about each of the industry standards

- Intended for specifiers, end-users, installers and inspectors

- Includes the Flow Chart for Selecting Conduit Standards by Application

- Compliments of PPI and our Members

5. PPI Model Specification MS-5

Introduction to PPI MS-5

- Over the decades, PPI has published several model specifications related to the use of plastic pipes for various industries

- **Model Specification-5** is the fifth in this series

- Originally published in 2008, revised in **2018**

- Compliments of PPI and our Members

PPI Model Specification MS-5

Introduction to PPI MS-5

- **PPI MS-5** provides specifiers with a starting point in developing final specifications for a particular project's needs

- It includes reference to various product specifications by SDOs such as ASTM, CSA, NEMA, and UL, and describes when and how to utilize these industry documents

PPI Model Specification MS-5

Risk of Using "Customized" Specifications for Conduit

- Project specifications that combine inappropriate or incompatible requirements, sometimes pulled from various sources with the best intentions, can create the need for products that don't exist!

- Sometimes referred to as "**Frankenstein specs**" – "a bit of this, a bit of that"

- This causes confusion with manufacturers, the supply chain, and installers, and can result in the incorrect product being installed

Is this really what was intended?

PPI Model Specification MS-5

Important Notes

NOTICE: This publication is intended for use as a guide to support the designer of HDPE conduit systems, but it should not be used in lieu of the advice of a professional engineer. The Plastics Pipe Institute (PPI) has made every reasonable effort to ensure the accuracy of this publication, but it may not provide all necessary information, particularly with respect to special or unusual applications. This publication may be changed from time to time without notice. Visit https://www.plasticpipe.org for the most current edition.

PPI Model Specification MS-5

Important Notes

Note 1: The user may choose to adopt part or all of this Model Specification. However, users should ensure that all parts which are used are appropriate for the intended purpose. See Notice above.

Note 2: Users should review PPI TN-50 “Guide to Specifying HDPE Conduit” for more information about conduit products and the standards listed within this Model Specification, as well as other information, such as HDPE conduit guidelines. TN-50 also includes an easy-to-follow flow chart to help guide users in selecting the most appropriate specification for various applications.

PPI Model Specification MS-5

General Terms & Conditions

1.0 GENERAL TERMS AND CONDITIONS

1.1. Scope:

This specification covers requirements for coilable solid wall high-density polyethylene (HDPE) conduit, innerduct, and duct ("conduit") for power and communications applications. Applications include telecom, SCADA command and control, highway lighting, Intelligent Transportation Systems (ITS), and underground utilities. Installation types include plowing, trenching, and horizontal directional drilling (HDD).

1.1.1. Configurations:

This specification applies to solid wall high-density polyethylene (HDPE) conduit delivered in coils or straight lengths.

PPI Model Specification MS-5

Qualification of Manufacturers

2.0 HIGH DENSITY POLYETHYLENE SOLID-WALL CONDUIT

2.1. Qualification of Manufacturers:

The conduit manufacturer shall be capable of producing and assuring the quality of the conduit required by the appropriate industry standard specifications listed in section 2.3.

The conduit manufacturer shall have a documented quality management system that defines product specifications, manufacturing procedures, and quality assurance procedures that assure conformance with customer and applicable regulatory requirements.

PPI Model Specification MS-5

Approved Manufacturers

- Specifier can include own list of firms
- Use PPI PCD list of members as a guide
- https://plasticpipe.org/power-comm/pcd-members.php

2.2. Approved Manufacturers:

Manufacturers that are qualified and approved by the Project Engineer are listed below. At the discretion of the Project Engineer, products from unapproved manufacturers may be submitted for approval.

(Insert Company Name and Address of approved suppliers.)

PPI Model Specification MS-5

Materials

- Specifier can list the appropriate product standard(s) here (not all)

2.3. Materials:

Compounds used for the manufacture of polyethylene conduit shall be high-density polyethylene of minimum cell class 334480C or E, as per ASTM D3350, in accordance with the appropriate industry standard specification listed below (*see Section 5.0 for details on reference standards and specifications*)

2.3.1. ASTM F2160
2.3.2. ASTM D3485*
2.3.3. CSA C22.2 No. 327
2.3.4. NEMA TC 7
2.3.5. UL 651A
2.3.6. UL 1990*

* Standard Specifications for Cable in Conduit

PPI Model Specification MS-5

Materials

- Specifier would list the intended size and wall type here
- E.g. “Trade size 2 IPS SDR11, Orange, manufactured in accordance with ASTM…”

2.4. Size and Dimensions:

HDPE conduit shall be manufactured to the dimensions and requirements of the applicable product standard, such as those listed in section 2.3.

2.4.1. Other sizes and requirements shall be acceptable by advance mutual agreement between the customer (Owner, Purchaser, or Project Engineer as appropriate) and the manufacturer.

Note 4: Specifier and Purchaser shall select the correct product trade size, wall type (e.g. SDR, SIDR, true-size), color (e.g. stripes, full wall, coextruded), maximum reel size, and length.

PPI Model Specification MS-5

Colors

- Requirements for how color is applied

2.6. Colors:

For buried (below–ground) use, solid wall colors or a permanent color identification shall be available either as stripes or as a coextruded skin. The color layer of the stripes or coextruded skin shall be permanently bonded to the main body and exhibit the same chemical and mechanical properties as the underlying material. Colored conduit shall maintain its color for a period of one (1) year when stored outside, or as otherwise agreed to by the specifier and producer.

Striped conduit shall have a minimum of three (3) equally spaced stripes of sufficient width and color intensity to be easily distinguished from a distance of 10 feet (3 m) and from any angle.

PPI Model Specification MS-5

Friction Reduction

- Optional
- Current language used by the conduit industry is provided

2.7. Friction Reduction:

Friction reduction, if required, shall be available in the form of lubrication or interior ribbing, or both, as specified by the customer. Ribbing shall not be sharp or severe.

Factory pre-lubrication shall be performed with materials or agents that provide a stable treatment and result in a dynamic coefficient of friction less than or equal to (≤) 0.20, when tested in accordance with Telcordia (Bellcore) GR-356-CORE, section 4.2.5. Lubricants shall be chemically compatible with both conduit and cable jacket materials.

PPI Model Specification MS-5

Pull Media

- Optional
- Current language used by the conduit industry is provided

2.8. Pull Media:

Pull media, if required, shall be available pre-installed into the conduit. Media shall consist of high tensile fiber tapes or rope. Tapes shall be pre-lubricated and shall include sequential length marks. Sufficient slack shall be available in the tapes to prevent binding when unwinding the conduit from the coil.

Note 5: Pull media (tape or rope) is available in numerous tensile strength ratings. Specifiers should indicate the tensile strength that is required, in units of pounds of tensile strength.

PPI Model Specification MS-5

Joining

- Section lists various joining techniques; Specifier may allow all, or select only one

3.0 JOINING

3.1. Methods:

HDPE conduit shall be joined by the methods listed within this section. Couplers shall be selected in consideration of installation requirements, such as tensile loads encountered during horizontal directional drilling (see 4.3). The coupling manufacturer's recommendations shall be observed when making mechanical connections.

Note 6: Numerous styles of couplers are available with varying levels of performance related to tensile strength, internal pressure capability, and external pressure capability (water-tightness). Specifiers should indicate the performance that is required to ensure satisfactory performance.

PPI Model Specification MS-5

Construction and Installation

- Provides specific language for various installation types (details not shown here)

4.0 CONSTRUCTION AND INSTALLATION

4.1. General:

Conduit sizing and placement shall be consistent with the recommendations provided by the *PPI Handbook of Polyethylene Pipe*, Chapter 14 "Polyethylene Duct and Conduit" and with NEMA TCB 4 *Guidelines for the Selection and Installation of Smooth-Wall Coilable High-Density Polyethylene (HDPE) Conduit*.

4.2. Underground Installation:

4.3. Horizontal Directional Drilling (HDD):

PPI Model Specification MS-5

Standards and Specifications

- More than 15 industry Standards/Specifications with sources (abridged list shown)

5.0 STANDARDS AND SPECIFICATIONS

ASTM D3485 *Standard Specification for Coilable High Density Polyethylene (HDPE) Cable in Conduit (CIC)*

CSA C22.2 No. 327 *HDPE conduit, conductors-in-conduit, and fittings* www.shop.csa.ca

NEMA TC 7 *Smooth-Wall Coilable Electrical Polyethylene Conduit* www.nema.org

UL 651A *Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit* www.UL.com

PPI TR-46 *Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High-Density Polyethylene Pipe* www.plasticpipe.org

PPI Model Specification MS-5

Summary

- **PPI MS-5** is a current and accurate Model Specification
- Specifiers are welcome to use all or portions of it
- Use of MS-5 helps to prevent “Frankenstein” specs to which no product can comply
- PPI MS-5 is available at our website www.plasticpipe.org

Course Summary

At this time, participants should be able to:

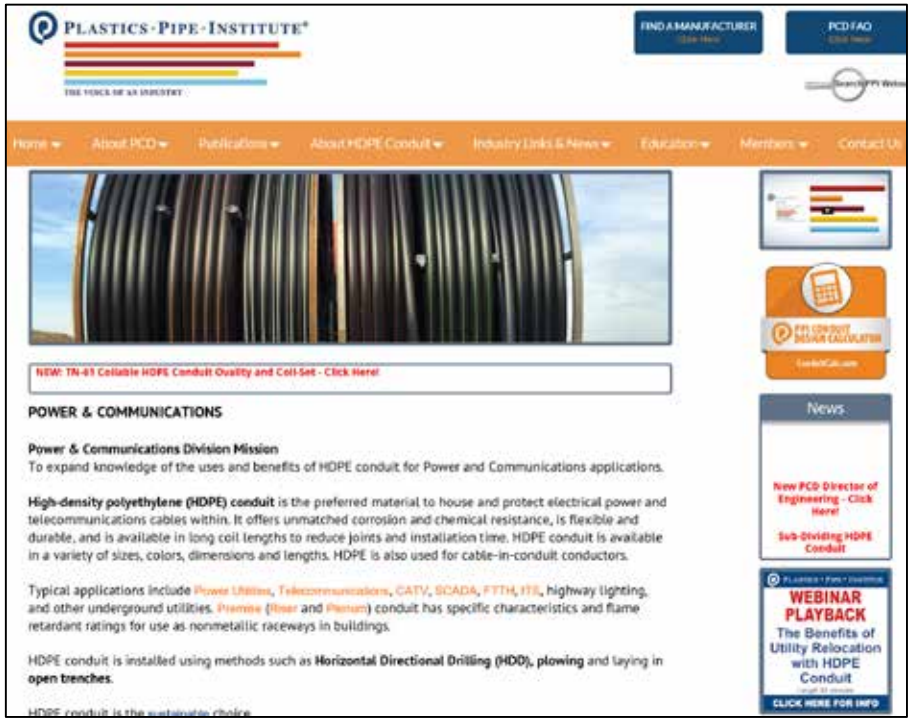
1. Discuss **HDPE material** and its benefits in conduit applications
2. List the common **applications** of HDPE conduit
3. Describe typical **installation techniques** and the benefits of each
4. Introduce the latest **industry standards** for HDPE conduit
5. Explain how to access a **model specification** for HDPE conduit

Bonus: Refer to PPI resources available at www.plasticpipe.org

Bonus: PPI Publications

Please visit our website for:

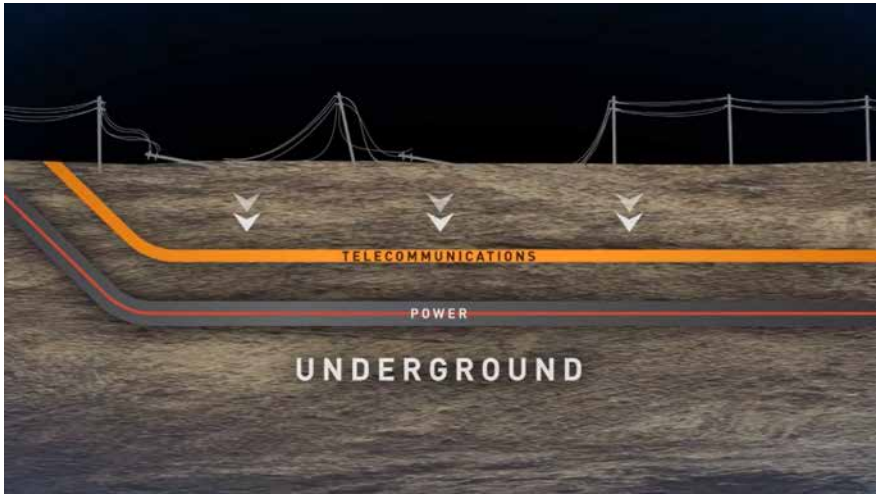
- Product information
- Technical Reports
- Technical Notes
- Case studies
- Position Papers
- Design information
- Presentations
- Educational videos
- Finding a Manufacturer
- Frequently Asked Questions
- www.plasticpipe.org/power-comm

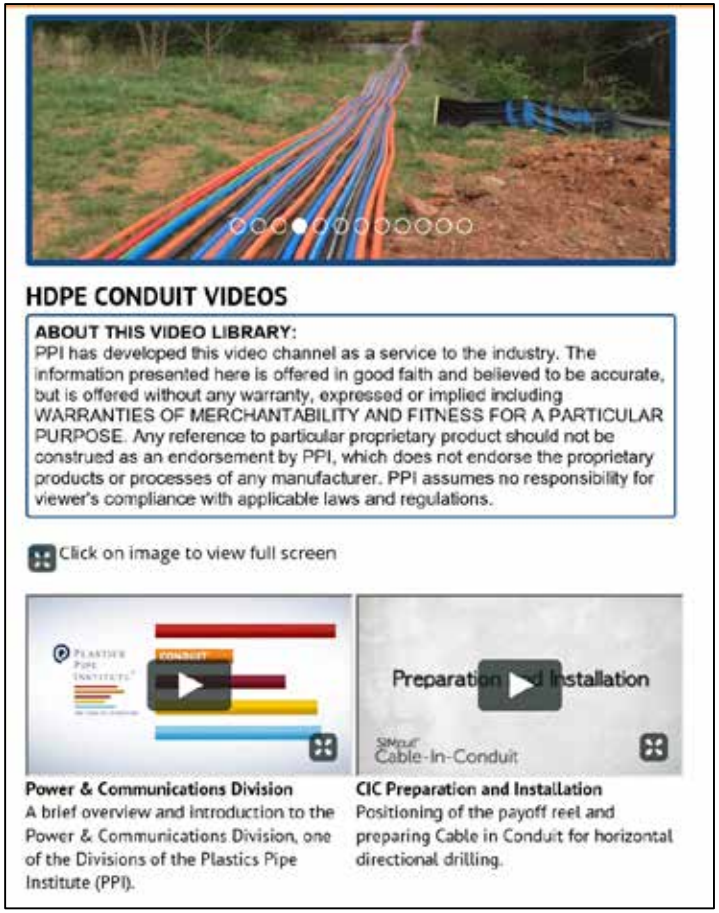


Bonus: PPI Publications

Educational Videos

- PCD Division video introduces HDPE Conduit
- Instructional videos explain how to work with HDPE conduit for buried applications





Path Forward

Contact PPI's Power & Communications Division at:

Website: www.plasticpipe.org and http://plasticpipe.org/power-comm

Thank you!

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Selecting & Specifying HDPE Conduit for Power and Communications Applications