GUIDE TO SPECIFYING HDPE CONDUIT

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Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

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.

PPI has prepared this technical note as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered "as is" without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

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

1.0 HISTORY OF HDPE CONDUIT STANDARDS

The early driver behind the use of conduit produced from high-density polyethylene (HDPE) was for deploying and protecting fiber optic (FO) cables placed underground for the telecommunications industry. Tremendous growth occurred for the installation of fiber optic cables during the early to mid-1980s for linking major metropolitan areas.

This era saw massive projects where FO cables were being deployed in both aerial and underground installations. These fiber optic cables were typically made and installed in very long lengths up to 30,000 feet (9,145 m), with the goal of using as few splice locations as possible to minimize signal attenuation or decibel (dB) losses in a complete system.

Fiber optic cable and the equipment used to send and receive light waves were in the early stages of becoming the technology of choice for streaming huge amounts of voice, video and data over fibers not much thicker than a human hair. However, FO cable needed more protection and different handling procedures as compared to traditional jacketed metallic cables.

For buried installations, there was an immediate need for a conduit system that would offer improved installation efficiencies and cable protection. In metropolitan areas, the smaller diameter FO cables were replacing very large diameter copper cables that filled banks of conduits made up of individual lengths of 3 ½ inch to 6 inch diameter conduits. As these large copper cables were being removed, telephone companies began installing small conduits ranging from 1 to 1 ¼ inch, using HDPE water pipe as the conduit. Multiple 1 or 1 ¼ inch HDPE water pipes, commonly termed “innerducts”, would be pulled into the vacated larger diameter conduit left behind after the copper cables had been removed.

The newly installed HDPE innerducts created multiple pathways that could be used for initial and future fiber optic cable placement, or to use as spares for rapid FO cable deployment in case the initial FO cable got damaged. Multiple 1 inch through 4 inch HDPE innerducts were also being installed in the more rural parts of the network. Much of this work was completed by using new trenchless methods like rail plowing and horizontal directional drilling (HDD), also known as directional boring. This new technique was employed to install pipes, conduits or cables below ground using a surface-mounted drill rig that launches and places a drill string at a shallow angle to the surface, and has tracking and steering capabilities. These procedures are intended to minimize above and below ground surface damage, restoration requirements, and disruption to traffic, with little or no interruption of existing services.

2.0 HISTORICAL STANDARDS OVERVIEW

By the mid-1980s, Fiber Optic cable deployment was booming, and multiple manufacturers of HDPE conduit were busy keeping up with demand. However, there were no third-party product standards in place specifically for HDPE conduit, so the industry adopted existing ASTM standards for HDPE pressure pipes, such as those listed below. Many end-user specifications were developed using these HDPE pressure pipe standards.

Examples of typical HDPE pressure pipe standards with title and scope:

ASTM D3035: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

"All pipes produced under this specification are intended for use as the distribution and transmission of potable and non-potable water, grey water, reclaimed water, wastewater, force main and gravity municipal sewage, etc. The user should consult the manufacturer to determine whether the material being transported is compatible with polyethylene pipe and will not affect the service life beyond limits acceptable to the user."

ASTM D2239: Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

"This specification covers polyethylene (PE) pipe made in standard inside dimension ratios (SIDR) and pressure rated for water. Included are requirements for PE compounds and requirements and test methods for workmanship, dimensions, elevated temperature sustained pressure, burst pressure, and marking."

ASTM D2447: Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter (Withdrawn 2010)

"This specification covers polyethylene (PE) pipe that is outside diameter controlled, made in Schedule 40 and 80 sizes for use with socket-type fittings and butt fittings joined by heat fusion, and pressure-rated for water."

ASTM F714: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

"This specification covers polyethylene (PE) pipe made in dimensions based on outside diameters of 90 mm (3.500 in.) and larger. The piping is intended for new construction and insertion renewal of old piping systems used for the transport of water, municipal sewage, domestic sewage, industrial process liquids, effluents, slurries, etc., in both pressure and non-pressure systems."

See Section 5.0 for the current versions of ASTM standards for HDPE conduit.

2.1. Other Polymer Raceway Standards - Historical

Beginning in 1965, Underwriters Laboratories (UL) has published a series of standards for polymer raceway products, including rigid PVC conduit as well as high-density polyethylene conduit. In older versions of these standards, PVC and HDPE conduit were combined.

Examples of previous UL conduit standards:

UL 651, Standard for Rigid Nonmetallic Conduit
First Edition – Published September, 1965 (included HDPE for first 3 editions)

UL 651, Standard for Schedule 40 and 80 Rigid PVC Conduit
Fourth Edition – Published May 1981

UL 651A, Standard for Type EB and A Rigid PVC Conduit and HDPE Conduit
First Edition – Published May, 1981

UL 651B, Standard for Continuous Length HDPE Conduit
First Edition – Published February 12, 1999

UL 651B, Standard for Continuous Length HDPE Conduit
Second Edition – WITHDRAWN – October 27, 2011

See Section 5.0 for the current versions of UL standards for HDPE conduit.

3.0 FORMATION of the PPI POWER & COMMUNICATIONS DIVISION (PCD)

By the late 1980's, HDPE conduit was gaining wider acceptance for use in protecting power, electrical, fiber optic and coaxial cables placed underground. The Conduit Division was added to the Plastics Pipe Institute during this period. In 2016, the division was renamed the Power & Communications Division (PCD) to better reflect the focus on solutions for the markets served by HDPE conduit.
The Power & Communications Division's mission is to expand the knowledge of the uses and benefits of HDPE Conduit. The PCD collaborates with standards development organizations (SDOs) to keep product standards up-to-date with the latest product developments. PCD also helps educate engineers, designers, installers, and users about HDPE conduit, and maintains outreach with industry and government agencies.

4.0 DEVELOPMENT of STANDARDS for HDPE CONDUIT

One of the first objectives of PPI's Power & Communications Division was to develop an ASTM standard specification for HDPE conduit.

In 1996, the American Society of Testing and Materials (now ASTM International) published test method **ASTM D6070**, "Standard Test Methods for Physical Properties of Smooth-Wall, Coilable, Polyethylene (PE) Conduit (Duct) for Preassembled Wire and Cable". This was not a product standard, but rather a test method to address "environmental performance properties of smooth-wall, coilable, medium-density and high-density polyethylene (MDPE and HDPE) conduit (duct) for preassembled wire and cable." In the meantime, this standard was not updated, as other standards took its place. In 2016, PPI balloted for the withdrawal of this obsolete standard. The ballot was successful, and therefore, ASTM D6070 is no longer published.

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)", originally approved in 2001, then revised in 2008 and 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 other requirements, such as resistance to slow crack growth.

To coincide with the advancing technology, a HDPE conduit specification was also developed by NEMA (National Electrical Manufacturers Association). That specification is known as **NEMA TC 7** "Smooth-Wall Coilable Electrical Polyethylene Conduit", which was first published in 2000 and is updated regularly with input from PPI and its members. The latest revision was released in March 2017, and includes a new wall type, new UV stabilization requirements, and clarification of marking requirements.

However, these were not the first HDPE conduit specifications. Integral Corporation was the first manufacturer of cable-in-conduit (CIC), whereby a cable or cables are factory-installed within the conduit as it is extruded. Related to this product, **ASTM D3485** "Standard Specification for Coilable High Density Polyethylene (HDPE) Cable In Conduit" was originally published in 1976.

5.0 CURRENT STANDARDS for HDPE CONDUIT

Today, several state-of-the-art conduit standards exist for various applications and industries.

The following is a list of five (5) current standard specifications for HDPE conduit, with the latest year of issue shown:

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. CIC configurations are preassembled into the conduit during the extrusion process and in industry-specific designs for use in commercial, industrial, transportation, government, and utility applications."

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.

"HDPE conduit meeting the requirements of this standard shall be made as OD or ID controlled solid wall, with or without internal or external ribs in IPS types SDR 9, SDR 11, SDR 13.5, DR 15.5, Schedule 40, Schedule 80 and "True-sized" and SIDR dimensions. The internal or external surface may contain a coextruded layer provided the finished conduit meets the product requirements of this specification."

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)."

Extracted, with permission, from NEMA TC 7. Originally approved in 2000. Available from NEMA (National Electrical Manufacturers Association) at www.nema.org

UL 651A-11 (03/17): 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: Extruded straight rigid Schedule 40 high density PE (polyethylene) electrical conduit and the following fittings for use with this conduit type: Elbows, and Rigid high density PE couplings; Schedule 40, Schedule 80, EPEC-A, and EPEC-B coilable, smooth-wall continuous length high density PE electrical conduit. The conduit and fittings mentioned in Section 1.1 of the specification are intended for use at 50°C (122°F) and lower ambient temperatures. Extruded straight rigid and continuous length conduit, where directly buried or encased in concrete in trenches outside of buildings, may be used with 90°C (194°F) wiring. The conduit and fittings covered in these requirements are intended for use as rigid nonmetallic raceway for wires and cables in accordance with the National Electrical Code, NFPA 70. Extruded straight rigid Schedule 40, Schedule 40, Schedule 80, EPEC-A, and EPEC-B coilable conduit is for aboveground use where encased in not less than 2 inches (50 mm) of concrete and for underground use by direct burial or encasement in concrete."

Note 1: A revised version of UL 651A was announced on June 24, 2016 containing several revisions requested by PPI. A minor revision was published on March 10, 2017. However, UL no longer updates the "Effective Date" for new and revised requirements within existing standards. Therefore, the latest edition of UL 651A still shows as "Fifth Edition - October 26, 2011" even though it contains these new revisions.

Available from UL (Underwriters Laboratories) at www.ul.com

UL 1990-13 (01/17): 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. The values in parentheses are metric trade designators of conduit. The designations Schedule-40, Schedule-80, EPEC-A and EPEC-B refer to conduit having specific outside diameters and wall thicknesses. This product is for aboveground use where encased in not less than 2 inches (51 mm) of concrete and for underground use by direct burial or encasement in concrete."

Available from UL (Underwriters Laboratories) at www.ul.com

Note 2: A revised version of UL 1990 was announced on January 20, 2017 containing several revisions requested by PPI. However, UL no longer updates the "Effective Date" for new and revised requirements within existing standards. Therefore, the latest edition of UL 1990 still shows as "Third Edition - November 22, 2013" even though it contains these new revisions.

6.0 INDUSTRY PRACTICES and GUIDELINES

Industry organizations AASHTO and NEMA have published additional documents related to the use of HDPE conduit. These are AASHTO R63 and NEMA TCB-4:

AASHTO R63-13 (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 (cables for use in) data and command and control applications in State Transportation Projects."

"This standard practice covers conduit used in the following manner:

- HDPE pipe used as a casing for the protection of smaller individual conduits, innerducts, in road crossings;
- HDPE conduit in coils, on steel reels, or in straight sticks; and
- CIC (cable in conduit), when power cable (conductors), CATV (coaxial), or fiber optic cable is installed in the conduit at the conduit manufacturing facility.
- HDPE pipe is commonly installed in standalone duct installations for the protection of power cable (conductors), CATV (coaxial cable), or fiber optic cable.

- HDPE pipe is commonly installed in standalone duct applications for road crossings when the bury depth is sufficient to avoid degradation effects to the road.
- HDPE pipe is commonly installed in standalone duct applications parallel to the roadway."

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

"This guideline covers recommendations for the selection, handling, and installation of underground High-Density Polyethylene (HDPE) conduit or raceway for power, lighting, signaling, and communications applications."

7.0 SELECTING APPROPRIATE STANDARD/s BASED on CONDUIT SIZE, WALL TYPE

To help clarify the HDPE conduit products available in the current conduit standards, **Table 1** lists the wall types and range of diameters found within each of these standards.

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

Note 3: Wall types Schedule 40, Schedule 80, SDR 17 and DR 15.5 in diameters 4" and greater are typically available only in stick lengths, with limited availability in coils. Diameters greater than 6" are available in stick lengths only.

Note 4: Consult the HDPE conduit manufacturer for their complete list of qualified conduit types made to the listed standards which have been certified or listed by a recognized third-party certification agency or a Nationally Recognized Testing Laboratory (NRTL).

DR Dimension Ratio, the average specified outside diameter of a pipe or tubing divided by the minimum specified wall thickness.

SDR Standard Dimension Ratio, the ratio of the average specified outside diameter divided by the minimum specified wall thickness, the value of which is derived by adding one to the pertinent number selected from the ANSI Preferred Number Series 10. While all SDRs are DRs, not all DRs are SDRs.

N/A Not applicable or not available.

8.0 SUMMARY

Initially, water pipe specifications were used to establish minimum standards covering the dimensions, materials and test requirements for conduit made from high-density polyethylene. This was out of necessity, because HDPE conduit specifications had not yet been developed.

Over the past 25 years, multiple product standards have been published for specific types and applications of HDPE conduit. Unfortunately, many end users and specifiers utilize specifications that cite inappropriate pressure pipe standards, and have not revised them to list the appropriate conduit standards, whether for power, telecommunications or other applications.

It is important that end users, engineers and specifiers update project specifications to reference the correct HDPE conduit product standard. Accordingly, references to pressure pipe standards should be removed from product or project specifications for HDPE conduit. In other words, pressure pipe standards should be replaced with the most appropriate of the HDPE conduit standards listed above by selecting the single HDPE conduit standard that is the closest match for the application. It is recommended that if a product or project specification currently lists multiple HDPE conduit standards, then it should be revised to select the one standard that is the best fit for the application.

Why update product or project specifications? HDPE conduit manufacturers, such as PPI Power & Communications Division members, design and produce their conduit products to ensure compliance with the latest, relevant HDPE conduit standards. While HDPE pressure pipe and conduit standards may appear similar, there are technical differences that are critical to the performance of the products in specific applications. Specifying a water pipe for a conduit application may even violate requirements of relevant electrical codes while potentially increasing costs, with no value for the customer.

In addition, conduit standards are continuously reviewed, maintained and revised by manufacturers through participation in organizations like PPI, which facilitates interface between manufacturers, users, and standards development organizations such as AASHTO, ASTM, NEMA, UL, TIA and others. This continuous connection ensures that HDPE conduit standards meet the various code and regulatory requirements for the intended uses.

To assist end users, engineers and specifiers, the attached flow chart can help guide selection of the correct HDPE conduit specification to fit the application. Additionally, the flow chart helps identify other technical information such as color, pull tape selection options and other unique wall options that can be added.

The PPI Power & Communications Division and member companies may be reached through our website, www.plasticpipe.org and https://plasticpipe.org/power-comm/.

Flow Chart for Selecting Conduit Standards by Application