

Pipe Stiffness and Flattening Tests in Coilable HDPE Conduit; and Its Relationship to Burial Depth in Conduit Applications TR-47/2011

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FOREWORD

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The purpose of this technical report is to provide important information available to PPI on design factors and design coefficients recommended for thermoplastic pressure piping applications. These recommendations are based on discussions with several internationally recognized technical experts in the plastic pipe industry. More detailed information on its purpose and use is provided in the document itself.

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The Plastics Pipe Institute, Inc.

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Introduction

Continuous length, coilable HDPE conduit has enjoyed tremendous growth not only as a protection for electrical cable, but in large part due to the huge expansion of the telecommunications industry in the US and abroad to protect fiber optic cable. Its availability in long lengths combined with HDPE's ductility, strength and durability make it ideally suitable for the "long haul" and trenchless installation technologies such as HDD (horizontal directional drilling) installations in the power and telecom industries. Buried cables installed in conduit provide long term and improved protection from damage caused by storms and vandalism when compared to aerial cables. Conduit also extends the life and reliability of underground cables by providing added protection from ground movement or poor soil conditions. These permanent raceways allow for easier and less costly future cable replacements.

HDPE conduit has been used for decades with great success due to its low coefficient of friction, resistance to corrosion, excellent chemical resistance and ability to remain ductile (flexible) even at low temperatures. Because the properties of HDPE result in a wide range of flexibility, HDPE conduit can be provided on coils or on steel reels in long lengths specifically for trenchless or plowing technologies (i.e. a reel of 1 ¼" diameter HDPE conduit could hold as much as an 8,500 ft continuous length). Larger diameter HDPE conduit such as 8" or greater is available in sticks up to 50-ft. An alternative plastic used in the conduit industry is PVC where typical lengths are limited to 20-ft.

When HDPE conduit is considered for underground installations, there have been cases where PS (pipe stiffness) and the term "Crush Strength" are used to determine strength relative to other materials regardless of their property differences. (In reality, "Crush Strength" is a term misapplied to thermoplastic,

flexible pipes (i.e. HDPE and PVC). Crush Strength implies a brittle failure, where flexible pipes can deflect in excess of 20% with no signs of wall buckling, cracking or splitting. Flattening is the correct and more appropriate engineering term to measure how much deflection a flexible pipe can take without damage.) When HDPE is compared to PVC at similar diameters and wall thicknesses, PVC will inherently have a higher PS attributed to the modulus being more than twice that of standard HDPE conduit materials¹. However, this in no way indicates how HDPE will ultimately perform compared to PVC conduit.

PS has applicability in calculations of burial depth but it should not be used to compare dissimilar materials. Also, too often, engineers consider “Crush Strength” or Flattening to determine allowable burial depth. Flattening does not relate to burial depth and should be considered a quality control test. Finally, the national specifications calculate PS inconsistently. This technical note provides the reader with detailed information showing that HDPE conduit’s PS is more than adequate at typical burial depths. Furthermore, because of the inconsistencies in the national specifications, PS and Flattening should be considered only as quality control tests.

Specifications

The inconsistencies of existing national specifications referencing stiffness and flattening have created confusion even for comparable materials. PS in ASTM D-2412 titled, “Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading”, is defined as the force per unit length of the test specimen, loaded at a prescribed loading rate, at a prescribed percentage deflection (0.5” per minute, typically 5% deflection). The test measures the conduit’s resistance to ring deflection as it is being compressed between two steel plates. This parallel plate test empirically determines PS where as an alternative “calculated” method uses the materials modulus and SDR (dimension ratio). This shows the usefulness of PS as a Quality Control Test. Requirements referenced in several applicable national specifications are as

follows where PS and Flattening are both used as quality assurance tests. Note: “Crush Strength” does not have a defined formula in the ASTM standards.

1. HDPE conduit for power and telecom applications is manufactured in accordance with standard ASTM F-2160, a standard written specifically for solid wall conduit based on controlled outside diameter. ASTM F-2160 specifies the material, dimensional, manufacturing, and quality assurance testing requirements for HDPE Conduit.
2. ASTM F-512 is the Standard Specification for PVC Conduit for Underground Installation. It uses PS as a quality control test at 5% deflection with a modulus of 500,000 psi (the minimum allowed by the material specifications).
3. ASTM D-1785 is the Standard Specification for PVC pipe in Schedule 40, 80 and 120. This is a pressure pipe specification. The test method only includes a flattening test with no load requirement. The requirement is a pass/fail on visual inspection.
4. NEMA (National Electrical Manufacturers Association) are specifications for conduit used in electrical applications. The following are pipe stiffness requirements for HDPE and PVC:
 - NEMA TC 7 for HDPE Electrical Conduit (Various Types)
 - Minimum load at 5% deflection
 - Compression and recovery test to 50% with 85% diameter recovery
 - NEMA TC 6 & 8 for PVC Plastic Utilities Duct (Type EB/DB Ducts)
 - Minimum load at 5% deflection
 - NEMA TC 2 for PVC Electrical Conduit (Type Schedule 40/80)
 - Minimum load required (no deflection limit indicated)
 - Flattening test to 40% with no visible cracking
5. Underwriters Laboratory UL 651 is a specification used for both PVC and HDPE conduits housing electrical cables in accordance with the NEC (National Electric Code published by NFPA):