

SAFE PULL STRENGTH CALCULATIONS FOR CONDUIT: INCLUDING DERATING FACTORS

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Foreword

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This technical note has been prepared to provide guidance, to those responsible for the selection and installation of HDPE conduit, on the appropriate selection of conduit based on installation considerations. This document was not intended to provide system design information. The reader is referred to the PPI website at www.plasticpipe.org for system design documents.

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SAFE PULL STRENGTH CALCULATIONS FOR CONDUIT: INCLUDING DERATING FACTORS

1.0 OVERVIEW

One of the most commonly used methods for installation of high-density polyethylene (HDPE) conduit is to pull it into place. Examples where HDPE conduit is pulled into place would be when it is installed as an innerduct or into an open trench or directly into the ground using a trenchless method such as either the pull plow method or by Horizontal Directional Drilling (HDD). When pulling HDPE conduit into place, an increasing axial tensile load will be exerted on the conduit.

The purpose of this technical note is to provide designers and end users criteria for determining the “Safe Pull Strength” (SPS). SPS is the calculated maximum tensile load that should be placed on a conduit, of a given diameter and wall type, as it is being pulled into place.

The following sections are provided in the document:

- **SPS Calculation** showing the calculation method and calculation results
- **Physical Behavior of Conduit Under Load** explaining the physical basis of the calculation
- **Conduit Installation Considerations**
- **Other Resources**
- **Appendix A** providing temperature compensations factors
- **Appendix B** providing metric conversions for all tables

2.0 SPS CALCULATION

As a short-term pulling stress is placed on HDPE conduit it will stretch slightly but will fully recover provided the tensile load is limited to 40% of the materials rated tensile yield strength. The 40% tensile load limit is incorporated into the SPS calculation as F_Y . The SPS should not be exceeded to assure that the conduit is not damaged during installation.

The SPS can be calculated as shown using Equation 1:

$$SPS = \pi \cdot D^2 \cdot F_Y \cdot F_t \cdot F_T \cdot \left[\frac{1}{DR} - \frac{1}{DR^2} \right] \quad \text{Equation 1}$$

Where

SPS	=	Safe pull strength, lbs.
π	=	3.1415 (i.e., the value Pi)
D	=	Conduit outside diameter, in.
F_Y	=	Tensile yield design stress (psi), see Table 1
F_t	=	Time under tension design factor, see Table 2
F_T	=	Conduit temperature compensation factor (see Appendix A) (at approximately 73 °F, $F_T = 1.00$)
DR	=	Conduit standard dimension ratio (DR or SDR), where DR is equal to the nominal conduit OD divided by the minimum wall thickness.

Two types of HDPE compound are typically used for extruding conduit: they are standard industry strength PE conduit compound or higher strength PE conduit compound (see Note 1). The SPS can be derived from the minimum tensile yield strength for each compound type. Table 1 provides minimum Tensile Yield Design Stress (F_Y) values at 73 °F (23 °C).

The SPS may require further downrating for the time under tension and for the conduit temperature while under tension. Factors F_t and F_T in Equation 1 address each of these concerns, respectively.

- Table 2 provides the Time Under Tension Design Factor, F_t .
- The Conduit Temperature Compensation Factor, F_T , is 1.0 or greater, at temperatures lower than 80 °F. **Appendix A** provides the factors, F_T , for conduit installation at other temperatures, from -20 to 140 °F.

Table 1: Tensile Yield Design Stress, F_Y

Temperature	Compensating Multiplier (F_T)	Standard Strength HDPE Conduit	Higher Strength HDPE Conduit
73 °F (23 °C)	1.00	1200 psi	1400 psi

Table 2: Time Under Tension Design Factor, F_t

Time Under Tension (Hours)	Design Factor (F_t)
≤1	1
>1 to 12	0.95
>12 to 24	0.91

Note 1: Industry standards for HDPE conduit, such as ASTM F2160, NEMA TC 7, and UL 651A, require a standard minimum PE compound cell classification of PE334480C or PE334480E, as defined by specification ASTM D3350. The fourth digit of the cell class corresponds to the specified minimum yield strength, specifying a minimum yield strength of 3,000 psi (21 MPa) for standard strength conduit compound. Occasionally a higher strength grade may be specified or needed for the installation. If using a higher strength grade, the fourth digit of the cell class will be greater than 4, typically 5 corresponding to a minimum yield strength of 3,500 psi (24 MPa). The conduit print line is not required to include the PE cell class (only the general term HDPE is included); if needed (e.g., for tensile calculations), contact the conduit manufacturer for the conduit compound strength.

Using the values for each conduit type from Table 1, calculations can be made for SPS for the commonly used conduit diameters and wall types. Those values for each diameter and wall type are provided below in Tables 3 through 8. **All of these calculations have been done based on the conduit temperature of 73 °F (23 °C) and with a 1-hour or less time under tension design factor (i.e., both F_T and F_t equal to 1.00). For deviations from these conditions, apply the appropriate factors for F_T and F_t per Equation 1.** Metric conversions of all tables are provided in **Appendix B**.