

Guide to Differences in Pressure Rating PE Water Pipe using the ASTM/PPI and ISO Methods TN-28/2014



Foreword

This technical note was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc.). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical note is to provide important information available to PPI on describing the differences in the calculated design pressure for water piping applications using the ASTM/PPI and ISO pressure-rating methods. These descriptions 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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GUIDE TO DIFFERENCES IN PRESSURE RATING PE WATER PIPE BETWEEN THE ASTM/PPI AND ISO METHODS

1.0 Scope and Purpose

This technical note illustrates differences between the North American ASTM/PPI and ISO methods for pressure rating polyethylene (PE) water distribution pipe. This note focuses specifically on pressure rating of PE water pipe because different recommended operating pressures are obtained for the same polyethylene pipe depending on which method is utilized.

This technical note provides general information, background and guidance for comparing ASTM/PPI and ISO-based pressure-rating methods for polyethylene water pipe. It is not an in depth technical comparison of ASTM/PPI and ISO long term stress rating methods. Other documents such as PPI Technical Note 7 (TN-7) and Technical Report 9 (TR-9) and various published technical papers serve this purpose. This note focuses specifically on how the long-term stress ratings determined under the ASTM/PPI and the ISO systems are applied to determine pressure ratings for a polyethylene pressure pipe using these two widely recognized industry protocols.

2.0 Introduction

The North American thermoplastic pipe compound rating methodology uses ASTM standards and PPI policies and procedures to provide design stress ratings that are used to determine polyethylene pipe pressure ratings for various end use applications such as water distribution and transmission. A similar but different rating method, based on ISO standards, is used in other parts of the world.

Potential for confusion exists within the engineering community when these two rating methods are compared because the same polyethylene pipe can appear to have different pressure ratings by one method or the other. Intuitively, the same pipe installed in the same way, operated under the same conditions, would be expected to have the same pressure rating and, hence, the same service lifetime regardless of the rating method used.

In the case of PE water pipe, the pressure rating associated with a specific size and DR can appear to be quite different depending on which standards system is used to rate it. This technical note helps to explain the perceived and real differences between these two rating methods.

3.0 Background

The ASTM/PPI and ISO methods for pressure rating polyethylene water piping developed separately in North America and Europe over nearly half a century. Both methods are technically correct, but when viewed on the surface appear to produce different pressure ratings for the same pipe.

Around 1980, higher strength high density polyethylene materials were introduced in North America and Europe. Under the ASTM/PPI system, these HDPE materials were characterized as PE 3408, and under the ISO system these materials were first characterized as PE 80 and later in 1988 as PE 100 as a result of further improvements in these materials. These nomenclatures for HDPE compounds are similar, but reflect differences in the measurement systems (inch-pound vs. metric) and the stress rating methodologies.

In both nomenclatures, PE is the abbreviation for polyethylene. In PE 3408, the 34 indicates cell classification values for density and slow crack growth in accordance with ASTM D3350, which is a standard for identifying PE piping compounds in North America. The 08 is the material's hydrostatic design stress, HDS, for water at 73°F in hundreds of psi with tens and units dropped; that is 08 = 800 psi. HDS is the material's hydrostatic design basis, HDB, per ASTM D2837 and PPI TR-3 at 73°F multiplied by a design factor, DF for water at 73°F. The HDB is the categorized intercept of the average long term hydrostatic strength at 100,000 hours (11 years). For PE 3408, the ASTM D2837 HDB is 1600 psi and the PPI TR-3 DF is 0.50, which yields a HDS of 800 psi for water at 73°F.

For PE 100, the 100 represents a 10 MPa or 100 bar minimum required strength, MRS, at 20°C in accordance with ISO 9080. MRS is the categorized intercept of the lower predictive limit (LPL) of the material's long term hydrostatic strength at 438,300 hours (50 years) at 20°C (68°F) per ISO 12161.

HDB per ASTM D2837 and MRS per ISO 9080/ISO 12162 are both predicted long- term strength ratings for the PE compound, but are different points at different temperatures and different extrapolated times. The matter is somewhat further complicated as requirements and properties for pressure rated PE compounds may overlap and may be the same or different under the two systems. For example, currently, some PE 4710 compounds can be rated as PE 100 or PE 80 under the ISO protocol, and some PE 100 compounds can be rated as either PE 4710 or PE 3408 when evaluated within the context of the ASTM/PPI protocol. Listings of recommended long-term hydrostatic strengths for PE materials that are rated under the ASTM/PPI and ISO systems are published in PPI TR-4, which is available from www.plasticpipe.org.¹

¹ Note - As of this writing, commercial factors have resulted in the replacement of PE 3408 compounds by designated as PE 3608 or PE 4710. PE 3408 is used in this discussion because updates to some North American water standards have not yet been completed. Although not reflected in ISO standards, the PE 100 Association identifies PE 100+ as PE 100 with enhanced performance properties.

4.0 The ASTM/PPI Method

The ASTM/PPI pressure rating method was the first of its kind and was initially published in 1962. It uses a categorized long-term hydrostatic strength value, the Hydrostatic Design Basis (HDB), that is reduced by a design factor (DF) to determine an allowable stress (hydrostatic design stress, HDS) for water pipe pressure rating. The HDB is developed by extensive hydrostatic testing of PE pipe samples and mathematical analysis of the stress-rupture data in accordance with ASTM D2837 and the policies of PPI TR-3. The Hydrostatic Stress Board (HSB), an independent assembly of plastics experts within the Plastics Pipe Institute (PPI), reviews data submitted by manufacturers, and then recommends HDB, DF and HDS values for the material to the manufacturer. PPI publishes recommended HDB and HDS values in PPI TR-4, which is available at www.plasticpipe.org. The categorization of HDB values in accordance with ASTM D2837 is replicated here as **Table 1** for ease of reference.

Table 1: Hydrostatic Design Basis Categories per ASTM D2837

Range of Calculated LTHS Values		Hydrostatic Design Basis (HDB)	
psi	(MPa)	psi	(MPa)
190 < 240	(1.31 < 1.65)	200	(1.38)
240 < 300	(1.65 < 2.07)	250	(1.72)
300 < 380	(2.07 < 2.62)	315	(2.17)
380 < 480	(2.62 < 3.31)	400	(2.76)
480 < 600	(3.31 < 4.14)	500	(3.45)
600 < 760	(4.14 < 5.24)	630	(4.34)
760 < 960	(5.24 < 6.62)	800	(5.52)
960 < 1200	(6.62 < 8.27)	1000	(6.89)
1200 < 1530	(8.27 < 10.55)	1250	(8.62)
1530 < 1920	(10.55 < 13.24)	1600	(11.03)
1920 < 2400	(13.24 < 16.55)	2000	(13.79)
2400 < 3020	(16.55 < 20.82)	2500	(17.24)
3020 < 3830	(20.82 < 26.41)	3150	(21.72)
3830 < 4800	(26.41 < 33.09)	4000	(27.58)
4800 < 6040	(33.09 < 41.62)	5000	(34.47)
6040 < 6810	(41.62 < 46.92)	6300	(43.41)
6810 < 7920	(49.62 < 54.62)	7100	(48.92)

Note: The LTHS is determined to the nearest 10 psi. Rounding procedures in Practice E29 should be followed.

HSB recommended design factors for water service are based on an engineering risk assessment for two groups of variables; testing quality and application requirements. The first HSB design factor, 0.50, was developed in the early 1960's as part of the ASTM/PPI rating method and has historically been uniformly applied to all thermoplastic pipe materials covered in PPI TR-3. It is generally accepted that the HSB recommended 0.5 design factor takes into consideration the following:

- Resin variation
- Test data accuracy
- Pipe extrusion and processing variables