Guide to Differences in Pressure Rating PE Water Pipe between the ASTM and ISO Methods

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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 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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I. Scope and Purpose

This technical note provides general information, background and guidance for comparing the pressure rating methods for polyethylene water pipe using the ASTM and ISO methods. Its purpose is not only to compare the two different rating methods but also to explain these differences.

This technical note is not an in depth technical discussion of the two methods. There are other documents and papers that serve this purpose (see PPI TN 7 and TR-9).

II. Introduction

The ASTM rating method is used in North America to provide a pressure rating methodology for the use and installation of polyethylene (PE) pressure piping in various end use applications such as water and fuel gas piping. A parallel but different rating method, based on ISO standards, is used in other parts of the world.

A problem occurs for the engineering community when these two rating methods collide, since the same identical polyethylene pipe can seem to have different pressure ratings when rated by these two different methods. This is confusing since the same pipe in the same application would be expected to have the same calculated design pressure rating. Obviously, the same pipe installed in the same way, operated under the same conditions, will have the same lifetime regardless of the rating method used.

This technical note helps to explain the perceived and real differences between these two rating methods.

III. Background

The ASTM and ISO methods for pressure rating polyethylene water piping have both evolved over the past 40 to 50 years as two parallel, but different, methods. Both methods are technically correct, but when viewed on the surface appear to produce different pressure ratings for the same pipe. For example, an ISO rated PE 100 material rates 2” SDR 11 pipe at 230 psig for water service piping, while the same pipe rated as a PE 3408 by the ASTM method is pressure rated for the same service at 160 psig. This is a 44% difference in pressure rating from these two methods for the same pipe.

Because of the introduction of newer European PE pressure piping materials into North America in recent years, with enhanced sustained pressure, slow crack growth (SCG)

and rapid crack propagation (RCP) properties that are not fully recognized by ASTM standards, there is considerable interest in the ISO rating method.

This interest in these ISO rated PE's has spurred considerable activity in the codes and standards areas trying to harmonize these two different rating methods. This harmonization activity continues.

IV. The ASTM Method

The ASTM pressure rating method uses a long-term strength value called the HDB (Hydrostatic Design Basis) when calculating the pipe's pressure rating. The HDB is developed by extensive hydrostatic testing of PE pipe samples in accordance with ASTM method D 2837. The data from this testing are submitted to the Hydrostatic Stress Board (HSB), an independent arm of the Plastics Pipe Institute (PPI), who reviews the data and then awards the HDB value to the manufacturer. These HDB values, if not private listings, are published in PPI TR-4, which is available as a free download at www.plasticpipe.org.

The engineer then uses the pressure rating formula below to calculate the pressure rating of the PE pipe, for water service, with a given HDB.

$$P = [2 \times HDB / (SDR - 1)] \times D.F.$$

Where: D.F. (design factor) = 0.5 for water applications.

An example calculation for an SDR 11 PE 3408 with an HDB of 1600 psi is:

$$P = [2 \times 1600 / (11-1)] \times 0.5 = 160 \text{ psig.}$$

This is the maximum pressure rating for buried PE water piping using the PPI recommended design factor (D.F.) of 0.5. This PPI recommended design factor has shown by successful use throughout the diverse installation and use conditions across North America for over 40 years to be an excellent, conservative, design factor for potable water applications. It's generally accepted that this 0.5 design factor used within North America takes into consideration the following:

- Resin variation
- Extrusion and processing variables during the production of the PE pipe
- Handling during storage, shipping and installation.
- Application temperatures of up to 80°F.
- Joining and Bending (within recommended practice)
- Various soil conditions (subject to manufacturer's recommendations)
- Typical installation methods
- Dynamic loading, surges and water hammer

V. ISO Method

The ISO pressure rating method uses a long-term strength value called the MRS (Minimum Required Strength) when calculating the pipe's pressure rating. The MRS is developed by extensive hydrostatic testing of PE pipe samples in accordance with ISO 9080. The data from this testing may also be submitted to the Hydrostatic Stress Board (HSB), an independent arm of the Plastics Pipe Institute (PPI), who reviews the data and then awards the MRS value to the manufacturer. These MRS values are published in PPI TR-4, which is available for free download at www.plasticpipe.org.

The engineer then uses the pressure rating formula below to calculate the pressure rating of the PE pipe, for water service, with a given MRS.

Note: The ISO method divides the design pressure by a **design coefficient** (≥ 1) to derate the pipe as opposed to multiplying the design pressure by a **design factor** (≤ 1) as is done in the ASTM method. The net effect is the same, to derate the design pressure of the pipe. The ISO method's application specifications may apply higher design coefficients to further reduce the design pressure based on other application specific variables.

$$P = [2 \times MRS / (SDR - 1)] / C$$

Where C (design coefficient) = 1.25 for water applications.

An example calculation for a PE 100 rated material with an MRS of 1450 psi (10 MPa) is:

$$P = [2 \times 1450 / (11-1)] / 1.25 = 230 \text{ psig.}$$

This is the maximum pressure rating for buried PE water piping using the ISO recommended design coefficient (C) of 1.25. *The significant difference is that this ISO recommended design coefficient only takes into consideration the variations due to extrusion and processing and static water pressure.*

ISO codes of practice require that additional design coefficients be considered for:

- Application temperatures above 68°F (20°C)
- Joining
- Bending
- Handling during storage and shipping
- Unusual burial or soil conditions
- Installation methods
- Dynamic loading, surges and water hammer

Thus, when using the ISO method, it is the responsibility of the design engineer or governing code authority to determine the actual application conditions and apply the additional design coefficients, if any, as required by the specific application.

VI. Conclusions

The above examples point out the apparent differences between the ASTM method and the ISO method. By simply using the two rating methods, developed parallel but independently over the past 40 to 50 years, the ASTM method rates SDR 11 PE water pipes at 160 psig while the ISO method rates PE pipe made from the same PE material at 230 psig. This example assumes that the PE resin used is dual rated under both ASTM D 2837 and ISO 9080. Thus the PE has both a 1600 psi HDB and a 10 MPa MRS.

Why the differences? As pointed out, the ASTM method uses a design factor to derate the design pressure for water applications of 0.5, which correlates to a design coefficient (ISO) of 2, while the ISO method uses a design coefficient of 1.25, which correlates to a design factor (ASTM) of 0.8. Using only these safety factors the ISO method calculates a service design pressure 1.44 times greater than the ASTM method.

This 44% difference is, in part, attributable to the ASTM method using a design factor which provides for all normally anticipated processing, handling and installation factors in North America, while the ISO method's design coefficient accounts for only the normally anticipated processing factors. Thus, in the ISO method the design engineer is responsible for ascertaining additional handling and installation factors and the application of additional safety factors which are additive to the 1.25 design coefficient. ISO 12162 provides some guidance.

The 44% difference is also attributable to the fact that the ASTM rating method is based on extrapolation of the data at 23°C to 11 years; whereas, the ISO rating method is based on extrapolation of the data at 20°C to 50 years. Another difference is that the ASTM rating method is based on the mean extrapolated value; whereas, the ISO rating method is based on the 97.5% lower confidence level, which takes into account scatter of the data. These two factors account for part of the 44% difference.

In practice in Europe, the ISO method is used as a model and additional pressure reduction factors , in addition to the 1.25, are sometimes nationally mandated or recommended. In North America there are no such national guidelines for using the ISO method. Thus, the difference is that in North America when using the ISO method it is the design engineer who has the responsibility to determine what, if any, pressure reduction factors, in addition to the 1.25 design coefficient, must be applied. For example, the ISO 12162 suggests using an appropriate temperature design factor for use temperatures above 68°F (20°C).

Example Temperature Derating for PE Water Pipe Under the ISO Method
For example, if PE pipe is expected to be used for water piping at service temperatures of up to 86°F (30°C), *ISO 4427 Polyethylene (PE) pipes for water supply – Specifications* requires a pressure reduction factor of 0.87 for Type A PE and 0.81 for Type B PE's. Thus the 230 psig pressure rating in the above example is reduced for temperature considerations to 200 psig and possibly as low as 186 psig.

In conclusion this document provides some guidance in comparing the two rating methods. Furthermore, there are significant activities within the North America technical community seeking better answers in integrating the two rating methods that will result in furthering the safe, efficient, cost effective use of polyethylene pipe in water piping applications.