

PPI Adopts International Pressure Rating Method for Plastic Piping Materials

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ABSTRACT

In addition to the HDB (Hydrostatic Design Basis) pressure rating obtained using ASTM D 2837, PPI (Plastics Pipe Institute Inc.) now also lists the MRS (Minimum Required Strength) pressure rating obtained with ISO 9080 in PPI's publication TR-4, "Hydrostatic Design Bases (HDB), Pressure Design Bases (PDB), Strength Design Bases (SDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe". This paper also summarizes other recent revisions to TR-4, which include the PDB (Pressure Design Basis) using ASTM D 2837 and the SDB (Strength Design Basis) using ASTM F 2018. Finally, we also discuss the latest addition, which will be to list PEX pipe chlorine resistance in accordance with ASTM F 2023.

HYDROSTATIC DESIGN BASIS (HDB)

For many years, PPI has published the Hydrostatic Design Basis (HDB) of plastic piping materials in TR-4. This has provided a great service to the plastic piping industry. Some ASTM pipe standards require that the material have a pressure rating, such as the HDB that is listed in PPI's TR-4. Also, NSF requires that any material it lists for potable water applications must have an HDB listed by PPI. The HDB published in TR-4 assures the industry that an independent party (PPI) has analyzed the material's stress rupture data and the material meets the minimum requirement for the published HDB. Currently, PPI lists the HDB for eight plastic piping materials in TR-4. They are:

- CPVC 4120 (chlorinated PVC),
- PA 32312 (polyamide),
- PB 2110 (polybutylene),
- PE 1404, PE 2406 and PE 3408 (polyethylene),
- PEX 0006 (crosslinked PE),
- POM 21110 (poly oxymethylene),
- PVC 1120 and PVC 2116 (poly vinyl chloride) and
- PVDF 2016, PVDF 2020 and PVDF 2025 (poly vinylidene difluoride).

The listings of HDB's at 73°F (23.0°C) have been subgrouped in accordance with the pipe material designation code. In this designation system, which is widely used by major national product standards, the plastic is identified by its standard abbreviated terminology in accordance with ASTM D1600, "Standard Terminology Relating to Abbreviations, Acronyms, and Codes for Terms Relating to Plastics", followed by a four or five digit number. The first two or three digits, as the case may be, code the material's ASTM classification (short-term properties) in accordance with the appropriate ASTM standard specification for that material. The last two digits of this number represent the PPI recommended Hydrostatic Design Stress (HDS), which is the HDB times a 0.5 design factor, at 73°F (23.0°C) divided by one hundred. Three examples of this pipe material designation code are as follows:

- CPVC 4120 is a chlorinated polyvinyl chloride (the CPVC abbreviation is in accordance with ASTM D1600) classified as Type 4, Grade 1 (in accordance with ASTM D1784), which has a 2,000 psi maximum recommended HDS at 73°F (23.0°C).
- POM 21110 is a polyoxymethylene (the POM abbreviation is in accordance with ASTM D1600) classified as Group 2, Class 1, Grade 1 (in accordance with ASTM D4181), which has a 1,000 psi maximum recommended HDS at 73°F (23.0°C).
- PE 3408 is a polyethylene (the PE abbreviation is in accordance with ASTM D1600) classified as a grade PE 34 with a density cell class of 3 and a slow crack growth cell class of 4 (in accordance with ASTM D3350). It has an 800-psi maximum recommended HDS at 73°F (23.0°C).

Companies from 12 different countries list these plastic piping materials in TR-4:

- Belgium
- Canada
- France
- Germany
- Ireland
- Italy
- Japan
- Korea
- Sweden
- Thailand
- United Kingdom
- USA

In addition to the HDB listing at 73°F, several materials are also listed at higher temperatures. Examples of these are ([Table 1](#)):

Two grades of recommended hydrostatic design basis (HDB) are issued by PPI:

1. The Standard Grade recommendation is for a five-year period for those materials that comply with the full data requirements of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, and all the pertinent additional data requirements which are detailed in TR-4.
2. The Experimental Grade recommendation is for a limited duration. It is for those materials covered by data that do not yet comply with the full requirements of the

Table 1

Temperature (°F)	Pipe Material Designation Code
140	PA 32312
	PE 2406
	PE 3408
	PVDF 2016
180	CPVC
	PA 32312
	PB 2110
	PE 2406
	PEX 0006
200	PEX 0006
	PVDF 2016
	PVDF 2020
248	PVDF 2016
	PVDF 2025
284	PVDF 2025

Standard Grade, but satisfy the applicable minimum preliminary data requirements which are detailed in TR-4. An Experimental Grade recommendation must be periodically advanced through certain specified data levels until the full data requirements of the Standard Grade are satisfied. Failure to make a required advance of an Experimental Grade recommendation will cause the recommendation to expire. This Experimental Grade system offered by PPI allows a manufacturer to market his product after only 2000 hours of stress rupture data (3 months) while the full Standard Grade data are being generated.

A PPI listing for a recommended HDB, independent listing, may be used to establish a separate listing for the same formulation but under another owner’s designation, dependent listing. The value of the HDB for the dependent listing is the same as that for the independent listing. PPI established this dependent listing program so that a pipe manufacturer could have a pressure rating for his pipe product without having to submit stress rupture data to PPI. The pipe manufacturer simply requests a transfer of the HDB pressure rating owned by the resin manufacturer. In this program, the pipe manufacturer

is dependent on the resin manufacturer. The PPI TR-4 listing of this dependent pipe product is an indication to the industry that the pipe is made from a pressure rated resin. Both standard grade and experimental grade listings may be transferred from the resin supplier to the pipe supplier. When the resin supplier advances the expiration date for an experimental listing, the dependant listing of the pipe supplier is also automatically advanced.

MINIMUM REQUIRED STRENGTH (MRS)

In January 2000 PPI began to list the Minimum Required Strength (MRS) of plastic piping materials in TR-4. This came about at the request of several European and Asian companies who saw the benefit of listing the HDB in TR-4. They wanted to have their material's MRS listed in TR-4 also. The same advantages of having an HDB listed by PPI in TR-4 apply to the MRS listed in TR-4. The MRS is the categorized value of the long-term hydrostatic strength determined in accordance with ISO 9080 like the HDB is the categorized value of the long-term hydrostatic strength determined in accordance with ASTM D 2837. Key differences between the HDB and MRS are that the MRS is based on extrapolation to 50 years; whereas, the HDB is based on extrapolation to 11 years. Also, the MRS uses the three-coefficient equation or four-coefficient equation and may be determined at any desired temperature. The HDB uses a two-coefficient equation and is used only at the temperature at which the data are generated.

The MRS Standard Grade recommendation is for a five-year period for those materials that comply with the full data requirements of ISO 9080 "Determination of Long-Term Hydrostatic Strength of Thermoplastic Materials in Pipe form by Extrapolation." These MRS ratings are now listed in PPI TR-4. PPI currently publishes the MRS for PE 80, PE 100 and PE 112 materials in TR-4.

Only the Standard Grade recommendation is granted for the Minimum Required Strength (MRS) at this time. The experimental grade may also become available through a special case hearing of the Hydrostatic Stress Board.

At this time changes to the composition of a material with an MRS listing are not allowed, except through a special case hearing of the Hydrostatic Stress Board. As PPI gains more experience with this rating method, substitutions that are permitted for various ingredients as outlined in the different parts of TR-3 for HDB listings may also be allowed for MRS listings.

As was the case with the HDB listing, the MRS listing may also be transferred from the resin supplier (independent listing) to the pipe supplier (dependant listing). This program can be a significant advantage to the pipe supplier who wants to market a product without having to do the ISO 9080 testing.

ISO TC 138/SC 4 has also developed a new design equation in which the MRS may be determined at the desired end use temperature and the desired lifetime. This MRS (T,t) is used for design purposes to calculate the MAOP (maximum allowable operating

pressure) at the end use conditions. The material is still classified per the MRS obtained at 20°C and 50 years. As an example, if a gas engineer wants to design a system that will operate at 35°C for 100 years, he would use the calculated MRS (35,100). This MRS is the categorized value of the ISO 9080 long-term hydrostatic strength (lower confidence limit at 35°C and 100 years). Once the ISO 9080 coefficients have been determined, an MRS (T,t) may be obtained for any end use conditions of temperature and time. PPI will also publish MRS (T,t) values in TR-4.

PRESSURE DESIGN BASIS (PDB)

TR-4 also lists recommendations for the Pressure Design Basis (PDB) for pipes of multi-layered construction consisting essentially of two layers of thermoplastic material that sandwich a thin layer of metallic aluminum reinforcement. The same advantages of having an HDB listed by PPI in TR-4 apply to the PDB listed in TR-4.

The PDB is developed using the same PPI TR-3 protocol as is used for establishing the HDB's that are listed in TR-4. The use of ASTM method D 2837 was deemed appropriate for each of the listed multi-layer pipe constructions because their pressure versus time-to-rupture behavior exhibits the same kind of regression with duration of loading as is exhibited by thermoplastic pipes of homogenous wall construction. The Hydrostatic Stress Board excludes wall constructions that cannot be evaluated and analyzed in accordance with ASTM D2837 from consideration.

Because the longer-term strength of pipes of such construction is determined not only by the properties of each of the materials used but also by the specific combination of materials and layer thicknesses, the PDB differs from the HDB in two important respects:

1. The long-term strength recommendations are presented in terms of a *pressure design basis* (PDB) which represents the categorized value of the pipe's estimated long-term *pressure* strength determined by ASTM D 2837; and
2. Each PDB recommendation is specific to the particular wall construction and pipe diameter that are represented by the data upon which the PDB recommendation was established.

PPI currently lists PDB's for PE/AL/PE (polyethylene/aluminum/polyethylene) and PEX/AL/PEX in TR-4. PPI will also list a multi-layer pipe's MRP (Minimum Required Pressure) that is measured in accordance with ISO 9080. The MRP uses pressure vs. time rather than stress vs. time for the long-term pressure calculation.

STRENGTH DESIGN BASIS (SDB)

The Strength Design Basis (SDB) is a method of obtaining a long-term strength rating for thermoplastic materials intended for molding applications. This method is not applicable for fiber-filled thermoset materials that are used in some molded fittings.

The Standard Grade recommendation is for a five-year period for those materials that comply with the full data requirements of ASTM F 2018 “Standard Test Method for Time-to-Failure of Plastics Using Plane Strain Tensile Specimens”. These SDB ratings are listed in PPI TR-4.

Only the Standard Grade recommendation is granted for the Strength Design Basis (SDB) at this time. The experimental grade may also become available through a special case hearing of the Hydrostatic Stress Board.

At this time, changes to the composition of a material with an SDB listing are not allowed, except through a special case hearing of the Hydrostatic Stress Board. As PPI gains more experience with this rating method, substitutions that are permitted for various ingredients as outlined in the different parts of TR-3 for HDB listings may also be allowed for SDB listings.

The SDB rating for a molding material may not be used to determine the pressure rating of a fitting. This rating is for the material only and is intended to satisfy industry requirements for a molding material to have an established long-term strength rating. Of course, if the material already has an HDB or MRS listing it would meet this requirement. The main advantage of the SDB is for those materials that do not have an HDB or MRS, a long-term strength rating may be obtained without having to extrude pipe samples.

The SDB rating also may not be used for a pipe pressure rating. The only way to get a pipe pressure rating is to test extruded pipe and obtain an HDB or MRS. Since the SDB is obtained on molded plaques, it may only be used for materials intended for molding applications.

CHLORINE RESISTANCE

ASTM D 2023 is the new ASTM test method to determine the projected performance of PEX pipe in the presence of chlorine. The tests may be conducted at a range of pH values and a range of chlorine levels. ASTM F 2023 also defines performance criteria at three different end use conditions.

PPI will publish in TR-4 the categorized value of the PEX pipe projected performance at the selected pH and chlorine level for the three ASTM F 2023 end use conditions.

A PPI task group is currently developing the categorized values of PEX projected performance, which will then be added to ASTM F 876, the PEX pipe standard. These categorized values will also become the first two digits in the PEX pipe material designation code, which is currently PEX 0006.

SUMMARY

PPI’s TR-4 has long served the plastic piping industry in North America by listing the pressure rating (HDB as determined by ASTM D 2837) of various plastic piping materials

at various temperatures. TR-4 has now become international by listing the MRS of plastic piping materials as determined by ISO 9080. As with HDB's, these MRS listings may be transferred from the resin supplier (independent listing) to the pipe supplier (dependent listing). TR-4 also lists the pressure rating of multi-layer pipe; the PDB as measured by ASTM D 2837 or the MRP as measured by ISO 9080. In addition to materials for pipe applications, TR-4 also lists the SDB for molding materials obtained on molded plaques using ASTM F 2018. Finally, TR-4 will soon list the PEX pipe projected performance category when measured in accordance with ASTM F 2023 at a defined chlorine level and pH.