

**Recommended Design
Factors and Design
Coefficients for
Thermoplastic Pressure Pipe**

TR-9

2025



Foreword

RECOMMENDED DESIGN FACTORS AND DESIGN COEFFICIENTS FOR THERMOPLASTIC PRESSURE PIPE

This report was developed and published with the technical help of the members of the Hydrostatic Stress Board (HSB) and PPI (Plastics Pipe Institute, Inc.) members. 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 technical reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

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

This report has been prepared by PPI as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this technical report within five years or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions for improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting plasticpipe.org. The Plastics Pipe Institute, Inc.

Click here to ensure that you are viewing the latest version of this document:
plasticpipe.org/TR-9

This Technical Report, PPI TR-9, was first issued in October 1968. The document was revised and published in August 1973, February 1992, April 2000, October 2002 and October 2025.

© 2025 PLASTICS PIPE INSTITUTE

Table of Contents

1.0 INTRODUCTION	3
2.0 REFERENCES	4
2.1 PPI Documents	4
2.2 ASTM Standards	4
2.3 ANSI Standards	4
2.4 ISO Standards	5
3.0 TERMINOLOGY	6
3.1 Hydrostatic Design Basis (HDB) Method	6
3.2 HDB Method: Factors	8
3.3 Minimum Required Strength (MRS) and Categorized Required Strength (CRS) Methods	9
3.4 MRS Methods: Coefficients and Factors	10
4.0 SIGNIFICANCE OF DESIGN FACTOR (DF) AND DESIGN COEFFICIENT (C)	11
5.0 THE HYDROSTATIC DESIGN BASIS (HDB) APPROACH	12
5.1 HDB and HDS	12
5.2 Recommended Hydrostatic Design Basis Factors (DF_{HDB})	13
5.3 Service Design Factor (F_s)	14
5.4 Service Temperature Factor (F_T)	14
5.4.1 Using recommended HDB established at an elevated temperature	14
5.4.2 Using the Interpolation Equation based on HDB	15
5.4.3 Using the Interpolation Equation based on LTHS	16
5.5 Service Chemical Factors (F_c)	17
5.6 Pressure Rating (PR)	18
5.7 Pressure Design Basis (PDB)	19
6.0 THE MINIMUM REQUIRED STRENGTH (MRS) AND THE CATEGORIZED REQUIRED STRENGTH (CRS) APPROACH	19
6.1 Minimum Required Strength (MRS)	19
6.2 Categorized Required Strength ($CRS_{\theta,t}$)	20
6.3 Design Coefficient (C)	20
6.4 Nominal Pressure (PN) and Pressure Rating (p_{PMS})	22
6.4.1 Nominal Pressure (PN)	22
6.4.2 Maximum Allowable Operating Pressure Rating (p_{PMS})	22
6.5 Addressing Pressures and/or Temperatures that are not constant	23
7.0 EVALUATIONS USING ASTM AND ISO METHODOLOGIES	23
8.0 CONCLUSION	23

RECOMMENDED DESIGN FACTORS AND DESIGN COEFFICIENTS FOR THERMOPLASTIC PRESSURE PIPE

1.0 INTRODUCTION

This Technical Report provides a summary of recommended design factors used with the Hydrostatic Design Basis (HDB) determined in accordance with ASTM D2837 and PPI TR-3, recommended design coefficients (C) used with the Minimum Required Strength (MRS) determined in accordance with ISO 9080 and ISO 12162, and calculated design stress values for pipes produced from HDB and MRS stress rated thermoplastic compounds.

A design factor applied to an HDB and a design coefficient applied to an MRS differ due to the conventions and assumptions by which the HDB and the MRS values are determined. Therefore, design factors applied to HDB rated compounds and design coefficients applied to MRS rated compounds, are used only with the respective rating system and cannot be interchanged. However, it is the position of PPI that when pipes are made from the same compound for the same application and with the same installation practices operated at the same stress levels and same temperatures, the pipes will perform the same regardless of the stress-rating method, e.g., ASTM (HDB) or ISO (MRS), used to evaluate the strength of the material for that application.

Other PPI Technical Reports that are concerned with pressure applications of thermoplastic pipe compounds are *PPI TR-2 PPI PVC Range Composition Listing of Qualified Ingredients*, PPI TR-3, "*Policies and Procedures for Developing HDB, PDB, SDB and MRS Ratings for Thermoplastic Piping Materials or Pipe*", and PPI TR-4, "*PPI Listing of HDB, SDB, PDB, MRS Ratings for Thermoplastic Piping Materials or Pipe*" and *HSB-R01 - The Nature of the 0.63 Design Factor (DF) for Qualified Polyethylene Pipe Compounds*.

These recommended design factors and design coefficients have been developed on the basis of decades of North American and international field experience, engineering tests, investigations, and safety considerations. Experience to date indicates that the recommended design factors in this report are conservative within the limits for which they are recommended. However, guarantee or warranty is not assumed regarding their application and use. Under some conditions, other than which the hydrostatic testing was conducted, such as cyclic pressure applications, chemically aggressive fluids, and the like, or applications where the consequences of failure are heightened, additional design factors and design coefficients must be considered by the design engineer (see Sections 5.3, 5.4, 5.5 and 6.3).

2.0 REFERENCES

All references are specific to the most recent version available, unless otherwise indicated.

2.1 PPI Documents

TR-2 PPI PVC Range Composition Listing of Qualified Ingredients

TR-3 HDB/HDS/PDB/SDB/MRS Policies – Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe

TR-4 HDB/HDS/SDB/PDB/MRS Listed Materials – PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe

HSB-R01 - The Nature of the 0.63 Design Factor (DF) for Qualified Polyethylene Pipe Compounds

2.2 ASTM Standards

ASTM D1598 Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

ASTM D2837 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

ASTM F412 Standard Terminology Relating to Plastic Piping Systems

2.3 ANSI Standards

ANSI-Z17.1 Numbers, Preferred

2.4 ISO Standards

ISO 3 Preferred numbers – Series of preferred numbers¹

ISO 161-1:1996 Thermoplastic pipes for the conveyance of fluids – Nominal outside diameters and nominal pressures

ISO 497 Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers²

ISO 3213 Polypropylene (PP) pipes — Effect of time and temperature on the expected strength

ISO 4437 Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE)

ISO 9080 Plastics piping and ducting systems -- Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation

ISO 10508 Plastics piping systems for hot and cold water installations — Guidance for classification and design

ISO/TS 10839 Polyethylene pipes and fittings for the supply of gaseous fuels — Code of practice for design, handling and installation

ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications -
- Classification, designation and design coefficient

ISO 13760 Plastics pipes for the conveyance of fluids under pressure — Miner's rule — Calculation method for cumulative damage

ISO 15494 Plastics piping systems for industrial applications — Polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PERT), crosslinked polyethylene (PE-X), polypropylene (PP) — Metric series for specifications for components and the system

ISO 16422 Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure — Specifications

ISO 16486 Plastics piping systems for the supply of gaseous fuels - Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing

¹ R10 series of preferred numbers

² R20 series of preferred numbers

3.0 TERMINOLOGY

Similar terminology is used in the HDB and the MRS based methodologies. To avoid confusion, the reader is cautioned to review the terminology presented in the specific context of use with each methodology. Further, the equations shown in this terminology section are explained later in the document.

3.1 Hydrostatic Design Basis (HDB) Method

Related terms are grouped to assist understanding of the differences between the definitions.

Dimension Ratio (DR) – the average outside diameter of the pipe divided by the minimum wall thickness. The DR values are rounded to the nearest 0.5 unless otherwise specified [ref: ASTM F412]. When the DR conforms to the R10 preferred number series plus one, the term Standard Dimension Ratio (SDR) is applied [ASTM F412].

Standard Dimension Ratio (SDR) – a specific ratio of the average specified outside diameter to the minimum specified wall thickness (D_o/t) for outside diameter-controlled plastic pipe, the value of which is derived by adding one to the pertinent number selected from the ANSI Preferred Number Series 10 [ASTM F412].

Standard Inside Dimension Ratio (SIDR) – a specific ratio of the average specified inside diameter to the minimum specified wall thickness (D_i/t) for inside diameter controlled plastic pipe, the value of which is derived by subtracting one from the pertinent number selected from the ANSI Preferred Number Series 10 [ref: ASTM F412].

Hydrostatic Design Basis (HDB) psi – one of a series of established stress values specified in the long-term strength-based methodology D2837 and is obtained by categorizing the LTHS determined in accordance with D2837 for a plastic pipe compound at a specified temperature [ref: ASTM F412].

Note 1: The Hydrostatic Stress Board (HSB) recommended HDB values at 73°F and elevated temperatures for sustained water pressures are listed in PPI TR-4.

Note 2: LTHS increments up to 1250 psi HDB are based on the R10 series. For LTHS values above 1250 psi HDB, the increments are based on the R20 series [ref: ASTM D2837; ANSI Standard Z17.1 for Preferred Number].

Hydrostatic Design Stress (HDS), psi – the estimated maximum tensile stress (psi) in the wall of the pipe in the circumferential orientation due to internal hydrostatic pressure that can be continuously applied with a high degree of certainty that failure of the pipe will not occur [ref: ASTM F412].

Note 3: The HSB recommended HDS values for sustained water pressures at 73°F are listed in PPI TR-4.

$$\mathbf{HDS = HDB \times DF_{HDB}} \quad \text{Eq (1)}$$

where:

HDS = hydrostatic design stress, psi

HDB = hydrostatic design basis as per ASTM D2837, psi

DF_{HDB} = design factor for sustained water pressure at 73°F.

Reference: DF_{HDB} is defined in Section 3.2 HDB Method: Factor

Long-Term Hydrostatic Strength (LTHS), psi – an estimated tensile stress in the wall of the pipe in the circumferential orientation that when applied continuously, will cause failure of the pipe at 100,000-hours. This is the intercept of the stress regression line with the 100,000-hours coordinate [ref: ASTM D2837].

Long-Term Hydrostatic Pressure Strength (LTHS_p), psi – the estimated internal pressure that when applied continuously will cause failure of the pipe at 100,000-hours. This is the intercept of the pressure regression line with the 100,000-hours intercept [ref: ASTM D2837].

Pressure Design Basis (PDB), psig – one of a series of established pressure values for a plastic piping component (multilayer pipe, fitting, valve) obtained by categorizing the long-term hydrostatic pressure strength (LTHS_p) determined in accordance with an industry test method that uses linear regression analysis [ref: ASTM F412].

Pressure Rating (PR), psi – the estimated maximum pressure (psig) that the fluid in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur [ref: ASTM D2837].

$$\mathbf{PR = \frac{2 \times (HDB \times DF_{HDB})}{(DR - 1)} = \frac{2 \times HDS}{(DR - 1)}} \quad \text{Eq (2)}$$

Note 4: When needed, include in the numerator service factors (e.g., environmental, chemical or temperature) to calculate the pressure rating.