TR-3/2010
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

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105 Decker Court, Suite 825, Irving, TX 75063 469-499-1044 www.plasticpipe.org

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POLICIES AND PROCEDURES FOR DEVELOPING HYDROSTATIC DESIGN BASIS (HDB), PRESSURE DESIGN BASIS (PDB), STRENGTH DESIGN BASIS (SDB) and MINIMUM REQUIRED STRENGTH (MRS) RATINGS FOR THERMOPLASTIC PIPING MATERIALS OR PIPE

FOREWORD

This report presents the policies and procedures used by the HSB (Hydrostatic Stress Board) of PPI (Plastics Pipe Institute, Inc.) to develop recommendations of long-term strength ratings for commercial thermoplastic piping materials or pipe. Recommendations are published in PPI TR-4, "PPI Listing of Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB) and Minimum Required Strength MRS) Ratings for Thermoplastic Piping Materials or Pipe", a regularly updated document.

PPI is a trade association dedicated to promoting the effective use of plastics piping systems. Since the early 1960s, HSB has worked as a volunteer group under PPI's auspices to issue listings and continually evaluate and update procedures for long-term strength forecasting.

Listings are developed from stress rupture data submitted to the HSB by the manufacturer. The general method used to evaluate the data is given in ASTM D2837, "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials," for HDB, SDB and PDB listings, or in ISO 9080 for MRS listings, with additional requirements delineated in this report. Many important national and international thermoplastic piping standards, including those issued by ASTM, ISO (International Standards Organization), NSF International, AWWA (American Water Works Association), ANSI (American National Standards Institute), ASME (American Society of Mechanical Engineers) and the API (American Petroleum Institute), reference these HSB/PPI listed long-term strength recommended ratings.

This report was 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 without any warranty, expressed or implied. 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.

Questions, comments, and problems of interpretation should be referred to the Chairman of the HSB, Plastics Pipe Institute, 105 Decker Court, Suite 825, Irving, TX 75062. Copies of this report, as well as other publications, are available from the PPI website: www.plasticpipe.org.

This report was updated February 2010.

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NOTES TO THE READER

SOME RULES AND CONDITIONS

1. **Processing Techniques**: It is stressed that these policies and procedures are for development of recommended ratings for thermoplastics piping compounds or pipe based on test data from good quality pipes (extruded or molded) made by specific processing techniques. These recommended ratings may or may not be valid for products made by differing processing techniques.

2. **Definitions and Acronyms:** Definitions and Acronyms are shown in the next section. The terminology of this report is in accordance with the definitions given in ASTM Standards D883, "Standard Definition of Terms Relating to Plastics," and F412, "Standard Terminology Relating to Plastic Piping Systems.

3. **Adjusting Recommended Ratings for Application-Specific Environments:** HDB/PDB/MRS/SDB recommended ratings issued by PPI are for conditions equivalent to those under which the test data were obtained, e.g., constant pressure, temperature and specific test environment. Various industry standards or regulations provide appropriate design factors or design coefficients to calculate the corresponding maximum allowable operating pressure for the piping system used in the desired application. Under some conditions, such as pressure cycling, higher temperature, more aggressive environment, or handling and installation quality, all of which may significantly reduce pipe durability, a more conservative design factor or design coefficient should be chosen.

4. The term maximum HDS (Hydrostatic Design Stress) refers to the maximum allowable working circumferential or hoop stress for a given set of end use conditions, from which is computed the maximum sustained working pressure of a plastic pipe. The HDS is determined by reducing the HDB by a design factor (DF), a multiplier less than 1.0, that takes into consideration variables and degrees of safety involved in thermoplastics piping installation.

   HDS recommendations issued by PPI are maximum recommended values for conditions equivalent to those under which the test data were obtained, e.g., constant pressure, temperature and specific test environment. Maximum HDS values are arrived at in this report by multiplying the HDB by a design factor of 0.50 ***unless otherwise stated in this report***. Under some conditions, such as pressure cycling, higher temperature, or more aggressive environment, all of which may significantly reduce pipe durability, a more conservative (i.e., smaller) design factor should be chosen. More information on design factors is given in PPI TR-9, "Recommended Design Factors for Pressure Applications of Thermoplastic Pipe Materials". The HDB and HDS recommendations in this document are made for the 73ºF (23ºC) listings only. At higher temperatures, only the HDB is listed. Prior to calculating the HDS at temperatures above 120ºF (50ºC), the thermal and oxidative stability of these materials must be independently determined. This stability should be considered in selection of an appropriate DF. ***Sustained pressure testing at elevated temperatures in accordance with ASTM D1598 and evaluated per ASTM D 2837 may not be sufficient to fully evaluate either the thermal or oxidative stability performance of plastic materials.***

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It is the opinion of the HSB that our current policy is to provide listings of HDB's and HDS's at 73°F and elevated temperature HDB's for water for thermoplastic piping compounds. The application of any design factor to elevated termperature HDB's is an issue that is best addressed in the product standards and/or codes. However, we do not see any reason to not utilize the application of a given design factor to an elevated temperature HDB provided that other relevant design considerations such as, but not limited to, thermal stability, live and dead loads, notch sensitivity of the buried pie, etc., are thoroughly considered.

5. **Product Standards:** An HDB/HDS/PDB/SDB/MRS recommended rating has been shown, through both scientific procedures and historical experience, to be a useful indicator of the relative long-term strength of a thermoplastic material when tested under the conditions set out in test method ASTM D2837 or ISO 9080. The performance of a material (or a piping product made with that material) under actual conditions of installation and use is dependent upon a number of other factors and conditions, which are not addressed in this report. These other factors and conditions are properly governed by the relevant product standard. The usefulness and adequacy of an HDB/PDB/SDB/MRS as an indicator of the strength of a material or pipe for use in any particular application is reflected in its incorporation in the applicable product standard, along with other appropriate performance parameters for the product and its component material. The appropriateness of an HDB/PDB/SDB/MRS for a specific application is also determined by the decision of a private or governmental entity to adopt such a standard as part of its own requirements for the product. The term "50-year strength value," as used in ASTM D2837, is a mathematical extrapolation that is useful in the context of developing an HDB. It does not necessarily constitute a representation that any material with such a value will perform under actual use conditions for that period of time.

6. **Sunlight (UV) Exposure:** These policies do not take into consideration the adequacy of a plastic composition's protection against sunlight exposure. Manufacturers may include in plastic pipe compositions suitable ingredients for the protection of properties against possible degradation by sunlight radiation during normal storage and use. The user should insure that sufficient protection has been incorporated into the selected piping composition should the application involve extended sunlight exposure during storage and/or use.

7. **Recommended Ratings are Formulation Specific:** Each HDB/HDS/PDB/SDB/MRS issued by PPI is specific to that particular thermoplastic piping material formulation, including the procedure for mixing, which is represented by the data submitted to the HSB. Any changes in the mixing procedure, in the formulation, or in its ingredients, outside those permitted in TR-3 are considered to result in a new composition, which may have different long-term strength properties. The listed HDB/PDB/SDB/MRS does not apply to this new composition, unless the changes have been made, or validated, in accordance with one or more of the policies presented in this report; or have been ruled upon by the HSB as acceptable based on information provided to the HSB.

8. **Resin Changes:** An inherent assumption in the development of these policies and procedures is that the commercial pipe resin will be of equivalent chemical and molecular composition, insofar as these parameters influence long-term strength and durability, to the resin used in the composition on which the original long-term data supplied to PPI were obtained. Any modification of the resin composition is considered to result in a different material from the one

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on which the original HDB and HDS listings were based. The Chairman of the HSB should be notified of such modifications and the applicable policy followed to maintain the listing. In the case of a change in manufacturing location of the resin used in a listed compound, the Chairman of the HSB should be notified and any applicable policy followed to maintain the listing. Also, in the case of any deviation or circumstance not covered by a specific policy, a disposition will have to be made by the HSB in consultation with the manufacturer.

9. **Disclaimer:** While every effort has been made by the Plastics Pipe Institute to assure that these policies are sound, reasonable and prudent, PPI expressly disclaims any guarantee or warranty regarding their application. Each manufacturer who lists compositions in accordance with the procedures in TR-3 does so voluntarily and with the express agreement that PPI assumes no liability in regard to the listed compositions, and that the manufacturer will hold PPI harmless from any claims or liability arising in connection with its listed pipe compositions.

10. **Manufacturer's Responsibility:** The manufacturer is responsible to insure that his product is continually manufactured in such a manner as to maintain the long-term strength and durability consistent with the long-term data supplied to the HSB. In the case of a deviation or circumstance not covered by a specific policy, a disposition will have to be made by the HSB in consultation with the manufacturer.

11. **Adoption of Policies and Procedures**: These policies and procedures have been adopted using standard letter ballot methods.

12. **Interpretations:** Questions pertaining to the interpretation of any policies in this report should be referred to the Chairman of the HSB, Plastics Pipe Institute, 1825 Connecticut Ave N.W., Suite 680, Washington, DC 20009.

13. **Maximum Temperature for Listings:** The maximum temperature for which PPI will list an HDB/PDB/SDB/MRS for a material in accordance with the policies and procedures in TR-3 is 200°F (93°C). PPI listing for temperatures above 200°F may be requested as a "Special Case" (see note 13) for consideration by the HSB.

14. **Special Case Listings:** The policies and procedures in TR-3 are intended to cover HDB/HDS/PDB/SDB/MRS listings for most thermoplastic piping materials. PPI recognizes there may be unusual cases, issues or circumstances that are not covered in TR-3, and that may justify an exception to the standard policies. To allow manufacturers an opportunity to have their material(s) listed by PPI when this occurs, the HSB has provided a "Special Case" system. The manufacturer may present its "Case" to the HSB at one of their two annual meetings, usually in February and August, using the approved "**Checklist for HSB Submissions**" form in TR-3 Appendix X.1. All information provided to HSB in these special cases will be made available for review only by HSB members and PPI staff, and will be held by them in strict confidence, in accordance with PPI's written confidentiality procedures (available from the HSB Chairman). There is a PPI fee for each special case. You must contact the HSB Chairman well in advance of each meeting to arrange for your special case. A completed HSB submission form **must** be received at least two (2) weeks prior to the HSB meeting to permit HSB consideration at that meeting.

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Acronyms and Definitions

ANSI	American National Standards Institute 1430 Broadway New York, NY 10018
API	American Petroleum Institute 211 North Ervay Suite 1700 Dallas, TX 75201
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, PA 19428
AWWA	American Water Works Association 6666 West Quincy Avenue Denver, CO 80235
CSA	CSA, International 178Rexdale Boulevard Etobicoke, Ontario CANADA M9W 1R3
NSF	NSF International 789 Dixboro Road Ann Arbor, MI 48113-0140
PPI	Plastics Pipe Institute, Inc. 1825 Connecticut Ave. NW Suite 680 Washington, DC 20009
HSB	Hydrostatic Stress Board c/o Plastics Pipe Institute, Inc. 105 Decker Court, Suite 825 Irving, TX 75062
ISO	International Standards Organization Secretariat: Nederlands Normalisatie-instituut (NNI) P. O. Box 5059 2600 GB Delft, Netherlands USA Contact: American National Standards Institute 1430 Broadway New York, NY 10018
TR	Technical Report

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Brittle	A failure mode which exhibits no visible (to the naked eye) material deformation (stretching, elongation, or necking down) in the area of the break.
Composite pipe	Pipe consisting of two or more different materials arranged with specific functional purpose to serve as pipe.
CRS $_{\theta,t}$	The Categorized Required Strength, CRS $_{\theta,t}$, is the categorized lower prediction limit (LPL) of the long-term hydrostatic strength at a temperature (θ) and a time (t) as determined in accordance with ISO 9080 and ISO 12162. CRS $_{\theta,t}$ **,** at 20°C and 50 years equals MRS.
(C)	Design Coefficient - a number greater than 1.00 that takes into consideration the variables and degree of safety involved in a properly installed thermoplastic pressure piping installation. For purposes of this document, a service design coefficient recommended for use with an MRS category is designated $\mathbf{C_S}$**.**
(DF)	Design Factor - a number less than 1.00 that takes into consideration the variables and degree of safety involved in a properly installed thermoplastic pressure piping installation. For purposes of this document, a service design factor recommended for use with an HDB category is designated $\mathbf{DF_S}$**.**
Dependent Listing	A separate listing of a formulation that has previously been established as an independent listing under another owner's designation. Refer to Part D.3 of TR-3.
Ductile	A failure mode which exhibits material deformation (stretching, elongation, or necking down) in the area of the break.
E-X	The data level of an experimental grade listing where 'X' is the number of the grade level. e.g.: E-2 covers data out to at least 2,000 hours, E-8 covers data out to at least 8,000 hours, etc.
Experimental Grade (E)	A PPI HSB recommended rating that is valid for a limited duration, given to those materials covered by data that do not yet comply with the full requirements of the Standard Grade, but satisfy the applicable minimum preliminary data requirements that are detailed in TR-3. **The owner of an experimental listing must understand there is a potential risk in commercial sale of an experimental product in case it does not meet all the TR-3 requirements for a standard grade.**
HDB	The term HDB (Hydrostatic Design Basis) refers to the categorized long-term hydrostatic strength (LTHS) in the circumferential or hoop direction, for a given set of end use conditions, as established by

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	ASTM Test Method D 2837, "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials." Hydrostatic Design Basis (HDB) – one of a series of established stress values (specified in Test Method D 2837) for a plastic compound obtained by categorizing the long-term hydrostatic strength determined in accordance with ASTM Method D 2837.
HDS	Hydrostatic Design Stress – the recommended maximum hoop stress that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.
Independent listing	A listing that has been established by a formulation owner under the provisions of Part A of TR-3.
LCL Ratio	The ratio of $\frac{LCL}{LTHS}$ expressed as a percentage. This ratio is a measure of the amount of scatter in the data and must be at least 85%.
LCL	Lower Confidence Limit - The lowest value of the LTHS, based on a statistical analysis of the regression data that can be expected at 100,000 hours.
LTHS	Long-term hydrostatic strength - the 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-h coordinate.
MRP	Minimum Required Pressure – one of a series of established pressure values for a plastic piping component (multilayer pipe, fitting, valve, etc.) obtained by categorizing the long-term hydrostatic pressure strength in accordance with ISO 9080.
MRS	The Minimum Required Strength (MRS) is the categorized lower prediction limit (LPL) of the long-term hydrostatic strength at 20°C determined in accordance with ISO 9080 and ISO 12162.
Multilayer pipe	Multilayer pipe – a pipe constructed of multiple layers that are bonded to each other and in which at least 60% of the wall thickness consists of polymeric materials (s). TYPE 1 multilayer pipe: A pressure rated pipe which at least 60% of the wall thickness is comprised of polymeric material that has an established HDB (Hydrostatic Design Basis) or MRS (Minimum Required Strength), from which the pressure rating of the pipe is determined.

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DISCUSSION: An example of this type is co-extruded plastic pipe with an outer layer for barrier or color purposes. If this outer layer has the same HDB as the bulk wall, the entire wall thickness is used for pressure calculations; if not, only the bulk wall that has an HDB/MRS rating is used for pressure calculations.

TYPE 2 multilayer pipe: A pressure rated pipe in which at least 60% of the wall thickness is comprised polymeric material, and for which the pipe pressure rating is determined for each pipe size and pipe wall construction, based on the pipe's experimentally established PDB (Pressure Design Basis) or MRP (Minimum Required Pressure).

DISCUSSION: An example of this is PEX/AL/PEX pipe.

TYPE 3: non-pressure rated pipe comprising more than one layer in which at least 60% of the wall thickness is polymeric material.

NOTE: the different layer(s) of multilayer pipe may provide color, barrier, stiffness or other properties according to the intended application.

PDB

The term PDB (Pressure Design Basis) refers to the categorized long-term pressure strength for multilayer pipes or other complex piping components, as established by ASTM Test Method D 2837, "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials." Pressure Design Basis – one of a series of established pressure values for a plastic piping component (multilayer pipe, fitting, valve, etc.) obtained by categorizing the long-term hydrostatic pressure strength determined in accordance with an industry test method that uses linear regression analysis. Although ASTM D 2837 does not use "pressure values", the PPI Hydrostatic Stress Board uses the principles of ASTM D2837 in plotting log pressure vs. log timeto determine a "long-term hydrostatic pressure strength" and the resulting "Pressure Design Basis" for multilayer pipe that is listed in PPI TR-4.

PHR

Parts by weight of a specified ingredient per hundred parts by weight of the base resin. (See Appendix X. 3)PR Pressure Rating – the estimated maximum pressure that the medium in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur.

PR = 2 (HDB) x (design factor) / (SDR-1),

SDR = Standard Dimension Ratio

= Average outside diameter / minimum wall thickness

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Or

PR = (PDB) (design factor)

Private Listing	Manufacturer's listing that is held privately within PPI and is not published in PPI TR-4.
SDB	Strength Design Basis – one of a series of established stress values (specified in Test Method D 2837) for a plastic molding compound obtained by categorizing the long-term strength determined in accordance with ASTM Test Method F 2018. The term SDB (Strength Design Basis) refers to the categorized long-term strength for a plastic molding compound obtained by ASTM F 2018, "Standard Test Method for Time-to - Failure of Plastics Using Plane Strain Tensile Specimens." NOTE: The SDB is used only for a material intended for molding applications. The SDB shall not be used for pipe applications.
Standard Grade (S)	A PPI HSB recommended rating that is valid for a five year period, given to those materials that comply with the full data requirements of TR-3.
Substantiation	A requirement of ASTM D 2513 for PE materials to show that extrapolation of the 73°F stress regression curve is linear to the 438,000-hour intercept.
Thermoplastic	A plastic that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and that in the softened state can be shaped by flow into articles by molding or extrusion.
TR	Technical Report
TR-X	A PPI Technical Report where 'X' is the number of the report. e.g.: TR-3/2002 is the 2002 edition of TR-3, *"Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB) and Minimum Required Strengths (MRS) Ratings for Thermoplastic Piping Materials or Pipe"*.
UCL	Upper Confidence Limit - The highest value of the LTHS, based on a statistical analysis of the regression data that can be expected at 100,000 h.
UV	Ultra-Violet radiation from solar exposure.
Validation	The process of ensuring that, for those materials that exhibit a transition from ductile to brittle failure mode, this transition occurs after 100,000 h at the rated temperature.

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Common Material Abbreviations

CPVC	Chlorinated Poly (vinyl chloride)
PA	Polyamide (aka nylon)
PB	Polybutylene
PE	Polyethylene
PEX	Crosslinked polyethylene
PFA	Perfluoro (alkoxy alkane)
POM	Polyoxymethylene (aka polyacetal)
PP	Polypropylene
PVC	Poly (vinyl chloride)
PVDF	Poly (vinylidene difluoride)

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PART A. GRADES OF RECOMMENDATIONS AND DATA REQUIREMENTS FOR HDB and PDB

A.1 GRADES OF RECOMMENDATION

A.1.1 Three grades of recommended hydrostatic design basis (HDB), hydrostatic design stress (HDS) and pressure design basis (PDB) are issued by PPI. These recommended grades are either publicly listed in PPI TR-4 or privately listed within PPI:

A.1.1.1 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 Sections that follow.

A.1.1.2 The Experimental Grade recommendation is for a limited duration and is for those materials covered by data that do not yet comply with the full requirements of the Standard Grade, but satisfy the applicable minimum preliminary data requirements that are detailed in the Sections that follow. **The owner of an experimental grade listing must understand there is a potential risk in commercial sale of an experimental product in case it does not meet all theTR-3 requirements for a standard grade. The 85% LCL requirements, and all other requirements in D 2837 applies to experimental grades except as noted in TR-3.**

A.1.2 Duration and Renewal of Recommendations

A.1.2.1 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.** The recommendation level and temperature determine the data requirements. The experimental point distribution requirements for each test lot vary according to the test data level as follows:

			MINIMUM DISTRIBUTION OF DATA POINTS					
Experi-mental Data Level	**Covers Data for at Least (hrs)**	**Total Min. number of test points**	**Less than 1000 (hrs)**	**Over 2000 (hrs)**	**Over 4000 (hrs)**	**1000-6000 (hrs)**	**Over 6000 (hrs)**	**Over 8000 (hrs)**
E-2	**2,000**	**10**	**6**	**1**	**---**	**---**	**---**	**---**
E-4	**4,000**	**10**	**6**	**1**	**1**	**---**	**---**	**---**
E-6	**6,000**	**12**	**6**	**---**	**---**	**3**	**1**	**---**
E-8	**8,000**	**15**	**6**	**---**	**---**	**3**	**1**	**1**
E-10	**10,000**	**18**	**(Consult latest issue of ASTM D 2837 for data distribution requirements)**					

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A.1.2.2 The Standard Grade recommendation is for a five-year period. The owner of such recommendations may request a continuation for another five-year period within 4 1/2 and 5 years after the initial listing. This renewal procedure may be repeated.

A.2 REQUIREMENTS FOR GRADES AT 73°F (23°C):

A.2.1 The Experimental Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except that the submitted test data need only meet the requirements given in the following table:

Level of Recommendation	Time of Data Submission	Minimum Data Required	
		Lots	At Level
E-2	**Initial**	**One**	**E-2**
E-4	**Initial or, Within 6 months after level 2**	**One**	**E-4**
E-6	**Initial or, Within 6 months after level 4**	**One**	**E-6**
E-8	**Initial or, Within 6 months after level 6**	**One**	**E-8**

An additional requirement for the Experimental Grade for polyethylene (PE) pipe compositions is successful validation of at least one test lot in accordance with Part F.4 of this document.

A.2.2 The requirements of the Standard Grade shall be met within six months after those of E-8 Level Experimental Grade are met.

A.2.3 The Standard Grade shall meet the requirements of the latest revision of "Standard Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, for at least one lot and the minimum requirements of the E-2 level of the Experimental Grade for each of at least two additional lots. At least one of these three lots of pipe shall be made by a pipe producer on commercial production equipment.

An additional requirement for the Standard Grade for PE compositions is successful validation, in accordance with Part F.4 of this document, which is to be established on each of two lots of pipe, one of which is to be the same as that tested through at least 10,000 hours for the purpose of determining the LTHS. A pipe producer shall make one of the two tested lots on commercial equipment.

A.2.4 The Standard Grade recommendation listing will expire five years after the initial listing date. The owner of the listing may request a continuation within 4 1/2 and five years after the initial listing date for another five years. This renewal procedure may be repeated.

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A.3 REQUIREMENTS FOR GRADES AT 140°F (60°C):

A.3.1 The Experimental Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except for the following requirements:

A.3.1.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the E-2 level or higher.

A.3.1.2 Not less than the following test data shall be available at 140°F (60°C):

Level of Recommendation	Time of Data Submission	Lots	At Level
E-6	**Initial**	**One**	**E-6**
E-8	**Initial or, Within 6 months after level 6**	**One**	**E-8**

A.3.2 An additional requirement for the Experimental Grade for Polyethylene (PE) pipe compositions is successful validation of at least one test lot in accordance with Part F.4 of this document.

The requirements of the Standard Grade shall be met within six months after those for the E-8 level are met.

A.3.2.1 PPI will grant an E-2 Experimental Grade at 140°F (60°C) based on presentation to the HSB Chairman of acceptable E-2 stress rupture data at both 140°F (60°C) and 176°F (80°C). The owner of this E-2 listing shall submit E-6 stress rupture data at 140°F (60°C) to PPI within six months to retain this special listing.

A.3.3 The Standard Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis of Thermoplastic Pipe Materials," ASTM D 2837, except for the following requirements:

A.3.3.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the Standard Grade.

A.3.3.2 Test data shall be available at 140°F (60°C) for at least one lot, meeting the requirements of the test method (10,000 hours minimum).

A.3.3.3 Test data shall be available at 140°F (60°C) on at least two additional lots of pipe meeting the E-6 level.

A.3.3.4 At least one of the lots in items 3.3.2 or 3.3.3 shall be made by a pipe producer on commercial production equipment.

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A.3.4 The Standard Grade recommendation listing will expire five years after the initial listing date. The owner of the listing may request a continuation within 4 1/2 and five years after the initial listing date for another five years. This renewal procedure may be repeated.

An additional requirement for the Standard Grade for PE compositions is successful validation, in accordance with Part F.4 of this document, which is to be established on each of two lots of pipe, one of which is to be the same as that tested through at least 10,000 hours for the purpose of determining the LTHS. A pipe producer shall make one of the two tested lots on commercial equipment.

A.4 REQUIREMENTS FOR GRADES AT 180°F (82°C):

A.4.1 The Experimental Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except for the following requirements:

A.4.1.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the E-2 level or higher.

A.4.1.2 Test data shall be available at 180°F (82°C) as follows:

Level of Recommendation	Time of Data Submission	Lots	At Level
E-6	**Initial**	**One**	**E-6**
E-8	**Initial or, Within 6 months after level 6**	**One**	**E-8**
E-10	**Initial or, Within 6 months after level 8**	**One two**	**E-10 and E-6**

A.4.1.3 PPI will grant an E-2 Experimental Grade at 180°F (82°C) based on presentation to the HSB Chairman of acceptable E-2 stress rupture data at both 180°F (82°C) and 200°F (93°C). The owner of this E-2 listing shall submit E-6 stress rupture data at 180°F (82°C) to PPI within six months to retain this special listing.

A.4.2 The requirements of the Standard Grade shall be met within 18 months after those for the E-10 level.

A.4.3 The Standard Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except for the following requirements:

A.4.3.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the Standard Grade.

A.4.3.2 a. Test data shall be available at 180°F (82°C) for at least one lot for not less than 16,000 hours, or:

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b. Test data shall be available (1) at 180°F (82°C) for at least one lot for not less than 10,000 hours, and (2) at 200°F (93°C) for at least one lot for not less than 4,000 hours.

A.4.3.3 Test data shall be available at 180°F (82°C) on at least two additional lots which meet the full requirements of test method ASTM D 2837.

A.4.4 The Standard Grade recommendation listing will expire five years after the initial listing date. The owner of the listing may request a continuation for another five-year period within 4 1/2 and 5 years after the initial listing date.

A.5 REQUIREMENTS FOR GRADES AT 200°F (93°C):

A.5.1 The Experimental Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except for the following requirements:

A.5.1.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the E-2 level or higher.

A.5.1.2 Test data shall be available at 200°F (93°C) as follows:

Level of Recommendation	Time of Data Submission	Lots	At Level
E-6	**Initial**	**One**	**E-6**
E-8	**Initial or, Within 6 months after level 6**	**One**	**E-8**
E-10	**Initial or, Within 6 months after level 8**	**One two**	**E-10 and E-6**

A.5.2 The requirements of the Standard Grade shall be met within 18 months after those for the E-10 level.

A.5.3 The Standard Grade shall meet the requirements of the latest revision of "Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials", ASTM D 2837, except for the following requirements:

A.5.3.1 The pipe material shall have a PPI recommended hydrostatic design stress at 73°F (23°C) at the Standard Grade.

A.5.3.2 a Test data shall be available at 200°F (93°C) for at least one lot for not less than 16,000 hours, or:

b Test data shall be available at 200°F (93°C) on at least two additional lots of pipe meeting the full requirements of the test method ASTM D 2837, i.e. E10.

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A.5.3.3 Test data shall be available at 200°F (93°C) on at least two additional lots of pipe meeting the full requirements of the test method ASTM D 2837, i.e. E10.

A.5.4 The Standard Grade recommendation listing will expire five years after the initial listing date. The owner of the listing may request a continuation for another five years within $4^1/_2$ and 5 years after the initial listing date. This renewal procedure may be repeated.

A.6 RECOMMENDED HDB FOR NEW MATERIALS:

A.6.1 The following are the requirements for the development of recommended hydrostatic design basis for new plastic pipe materials which, for this purpose, are those for which there is no standard pipe material designation included in the latest edition of ASTM specifications that cover plastic pressure pipe (for example, PVC 1120 is not a new material, but PVC 1125 would be a new material):

A.6.1.1 Material Classification: The base material or compound shall be identified by classification in an ASTM material specification or in a proposed ASTM specification that has been submitted to at least an ASTM Committee letter ballot.

A.6.1.2 Time-Strength-Creep Characteristics

A.6.1.2.a. Experimental Grade: Satisfactory hydrostatic E-6, or higher level test data for at least one lot, and E-2, or higher level, test data for each of two or more additional lots shall be supplied. This recommendation shall be limited to one year, after which period the requirements for the Standard Grade shall be met to continue the recommendation.

A.6.1.2.b. Provisional Standard Grade: Satisfactory hydrostatic E-10 or higher level for at least one lot, and E-2 or higher level test data for each of two or more additional lots shall be supplied. At least one of these lots of pipe shall have been made by a commercial pipe extruder. This provisional Standard Grade recommendation shall be limited to one year after which the recommendation will be reviewed in depth by the HSB in conjunction with a representative of the manufacturer. After this review the Board will take one of the following actions:

- extend for another year the Provisional Standard Grade recommendation;
- change the recommendation to the regular five-year Standard Grade; or,
- withdraw the recommendation.

A.6.2 Additional information: Data and information on the aging characteristics and on any unusual properties that may be helpful in evaluating the time-stress behavior of the material in pipe form in service shall be submitted to the Board for study before the Standard Grade recommendation is made.

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A.7 RECOMMENDED PDB RATINGS FOR COMPOSITE PIPES

A.7.1 General

TR-4 Section II lists recommendations for the Pressure Design Basis (PDB) for Composite pipe as defined in TR-3.

For *Composite* pipe the analysis of the regression data by D2837 must show a negative slope. Because the long-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, these PDB ratings differs from HDB ratings in two important respects:

- The long-term strength recommendations are presented in terms of a *pressure design basis* (PDB) which represents the pipe's estimated long-term hydrostatic *pressure* strength; and
- 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.

A.7.1.1 Exception: When *Multilayer Type I* pipes incorporate one or more discrete layers of non-stress-rated material, dissimilar to the stress-rated polymer, they may be considered non-composite pipes comprised of a single stress-rated material with a single Hydrostatic Design Basis at each listed temperature, provided all of the following are met:

- The total thickness of the non-stress-rated layers is the same for all pipe sizes;
- The stress-rated polymer is separately listed with a PPI HDB, based on data generated from samples comprised of the stress-rated polymer only;

The HDB calculated from data generated on samples including the layer(s) of non-stress-rated material shall be the same as that of the listed stress-rated polymer (material stress to be calculated from the full sample dimensions with no correction for the non-stress-rated layer).

The HDB so obtained may not be applied to pipe with thinner walls than that tested per the provision above.

A.7.2 Pressure Design Basis - The PDB is the categorized estimated long-term hydrostatic pressure strength of a pipe. The procedures for the estimating of the long-term hydrostatic pressure strength, and for its categorization into preferred values, are the same as those used for the establishing of a material's hydrostatic design basis (HDB).

The *maximum* pipe pressure ratings (PR's) are obtained by multiplying the PDB by a 0.5 design factor. The design factor is intended to take into consideration all the variables and degree of safety involved on a particular application. The 0.5 value is without consideration to conditions such as aggressive environments, cyclic stressing, localized stress concentrations, and temperature fluctuations which were not present in the testing

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of the pipes but which could significantly affect long-term durability. Smaller design factors (effectively, larger safety factors) should be considered to compensate for conditions not adequately represented by the test protocol upon which the PDB's have been established. The pipe manufacturer, appropriate pipe standards and codes, and relevant technical information should be consulted for guidance.

The PDB's listed in TR-4 Section II have been developed under the same PPI TR-3 protocol as is used for the establishing of the HDB's that are listed in Section I of TR-4. The use of this protocol, including the use of ASTM method D2837, Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products was deemed as appropriate for each of the listed 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.

For a Standard grade rating, the PPI Hydrostatic Stress Board requires three pipe lots for the "worst case" pipe size at the highest listed temperature and at the lowest listed temperature. The "worst case" pipe size is that size with the highest strain energy in the pipe wall. Rationale must be presented with the listing request to support the "worst case" analysis.

Table A.7.1 shows the requirements for Provisional and Standard Grade listings of a composite pipe.

For piping constructions that have been previously evaluated and listed, and that are constructed only with thermoplastic materials that have a Standard Grade HDB in TR-4, and for which an ASTM product standard is published, the reduced requirements in Table A.7.2 may be followed in order to establish a Provisional and Standard Grade listing for the composite pipe. At this time, these reduced requirements are limited to the PE/AL/PE, PE-RT/AL/PE-RT, and PEX/AL/PEX multi-layer type composite piping products. Other products will be considered for evaluation with these reduced requirements on a Special Case basis.

Provisional listings will expire after one year unless additional data is provided to move the listing to the Standard Grade.

There are indications that the long-term strength of a pipe of multilayer construction could be expressed as some function of the tensile strength properties and relative thickness of each of the separate material layers (Reference #1 and #2). Should this be confirmed for any of the listed material combinations, then the recommended strength for each such combination will be reported in terms of a material strength (i.e., and HDB), rather than a pipe strength (a PDB). This design methodology and rationale must presented to the HSB as a special case for consideration.

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Reference #1 – Frank Furno, A New Concept in Plastics Piping, Proceedings of the Eleventh Plastic Fuel Gas Pipe Symposium (October 1989, San Francisco, CA), American Gas Association.

Reference #2 – Jeremy Bowman, The Influence of Time and Temperature on the Strength of Multilayered Pressure Pipe, Plastics Pipe VII Proceedings (September, 1992, Koningshof, The Netherlands) The Plastics and Rubber Institute.

Table A.7.1
Requirements for Listing Composite Pipes

Grade	Temperature	Worst Case Size	Other Sizes
Provisional	23 °C	1 x E2	1 x E2
	Intermediate	1 x E6 and 1 x E2 @ 23 °C	1 x E6 and 1 x E2 @ 23 °C
	Highest	1 x E6 and 1 x E2 @ 23 °C	1 x E6 and 1 x E2 @ 23 °C
Standard	23 °C	1 x E10 2 x E2	1 x E10
	Intermediate	1 x E10	1 x E6
	Highest	1 x E16 2 x E10	1 x E16

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Table A.7.2

Requirements for Listing Composite Pipes Constructed using only thermoplastic material(s) with a Standard Grade HDB in TR-4

Grade	Temperature	Worst Case Size	Other Sizes
Provisional	23 °C	1 x E2	1 x E2
	Intermediate	1 x E6, and 1 x E2 @ 23 °C	1 x E6 and 1 x E2@23 °C
	Highest	1 x E6 and 1 x E2 @ 23 °C	1 x E6, and 1 x E2@23 °C
Standard	23 °C	1 x E10	1 x E2
	Intermediate	1 x E10	1 x E6
	Highest	1 x E16	1 x E6

A.8 PRESSURE RATING OF THERMOPLASTIC PIPES WITH BARRIER LAYERS

Polymeric (oxygen) barrier layers composed of non-stress related polymers are often used in thermoplastic piping intended for hydronic heating and other related applications. If the barrier layer is either on the OD or ID see TN-23 section 4. If the barrier layer is contained within the pipe wall, an equivalency rating is required to affirm the HDB of the parent thermoplastic material is not negatively affected by the presence of the subject barrier material. In order to establish an equivalency to the original material listing, the following shall apply:

A.8.1 The parent thermoplastic material must have a Standard Grade listing.

A.8.2 The specific construction of the product shall be supplied with the listing request.

A.8.3 An equivalent listing for a thermoplastic barrier pipe may be granted upon submission of stress rupture data of E-2 at 73°F, and E-6 at the highest listed temperature and the thinnest wall manufactured (i.e. the pipe which has the barrier layer at the highest percentage of the overall wall thickness). The total thickness of the barrier layer shall be

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the same, ± 10 %, for all pipe sizes to be manufactured under this listing. Data must result in the same HDB as the original thermoplastic stress rupture data.

A.9 SUBSTITUTION OF INGREDIENTS IN POLYOLEFIN/ALUMINUM/POLYOLEFIN COMPOSITE PIPE CONSTRUCTIONS.

A.9.1 General – Section A.9 details the requirements for substituting ingredients in Polyolefin/Aluminum/Polyolefin *Composite* Pipe Constructions. Pipe of this type of construction typically consists of ingredient layers of polyolefin compound, adhesive, aluminum, adhesive and polyolefin compound.

A.9.2 A manufacturer who has Polyolefin/Aluminum/Polyolefin *Composite* Pipe with a PPI Standard Grade recommended PDB for 73 °F (23 °C) may substitute a like ingredient provided that:

A.9.2.1 the construction is the same as those sizes that have the PPI Standard Grade recommended PDB;

A.9.2.2 test data are provided as stipulated in Table A.9;

A.9.2.3 the 100,000-hour hydrostatic pressure strength is not less than required to give the same pressure design basis as that recommended for the Standard Grade construction;

A.9.2.4 the 50-year pressure strength value ($LTHP_{50}$) is not less than 85% of the 100,000-hour hydrostatic pressure;

A.9.2.5 the 50-year pressure value is not less than 85 percent of the 50-year pressure value of the Standard Grade construction (to assure that the slope for the substituted construction is approximately the same as that for the Standard Grade construction)

A.9.3 Test data requirements at temperatures other than 73°F (23°C) shall be as stipulated in Table A.9

A.9.4 The manufacturer shall make available to the Chairman of the HSB, on a confidential basis, justification for a particular size being considered the "Worst Case Size" and the results of the evaluation studies undertaken to show apparent material identity.

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Table A.9

Requirements for Substitutions in Listed Composite Pipes

Grade	Substituted Ingredient	Temperature	Worst Case Construction Size	Other Sizes
Provisional	Polyolefin Compound	23 °C	1 x E2	1 x E2
		Highest	1 x E6 and 1 x E2 @ 23 °C	1 x E4 and 1 x E2 @ 23 °C
	Aluminum or Adhesive	23 °C	1 x E2	on one additional size: 1 x E2
		Highest	1 x E6, and 1 x E2 @ 23 °C	on one additional size: 1 x E6, and 1 x E2 @ 23 °C
Standard	Polyolefin Compound	23 °C	1 x E10	1 x E2
		Highest	1 x E16	1 x E6
	Aluminum or Adhesive	23 °C	1 x E6	on one additional size: 1 x E6
		Highest	1 x E10, and 1 x E6 @ 23 °C	on one additional size: 1 x E10, and 1 x E6 @ 23 °C

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