# TR-3/2016
# HDB/HDS/PDB/
# SDB/MRS/CRS
# Policies

## Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or Pipe

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# TABLE OF CONTENTS

**Foreword**

**Notes to the Reader**

**Acronyms and Definitions**

**Summary of Changes**

**Part A - Grades of Recommendations and Data requirements for HDB and PDB**

- A.1 Grades of Recommendation
- A.2 Requirements for Grades at 73ºF (23ºC)
- A.3 Requirements for Grades at 140ºF (60ºC)
- A.4 Requirements for Grades at 180ºF (82ºC)
- A.5 Requirements for Grades at 200ºF (93ºC)
- A.6 Recommended HDB for New Materials
- A.7 Recommended PDB Ratings for Multilayer and Composite Pipes
- A.8 Pressure Rating of Thermoplastic Pipes with Barrier Layers
- A.9 Substitution of Ingredients in Polyolefin/Aluminum/Polyolefin Composite Pipe Constructions
- A.10 Recommended HDB and PDB Rating Using ASTM D2992

**Part B - Grades of Recommendations and Data Requirements for MRS and $CRS_{\Theta,t}$**

- B.1 Grades of Recommendation
- B.2 Protocol for Determination of MRS and $CRS_{\Theta,t}$

**Part C - Grades of Recommendations and Data Requirements for SDB**

- C.1 Grades of Recommendation
- C.2 Changes to Formulations
- C.3 Guidance to Use of SDB

**Part D - General Policies, Practices, and Procedures**

- D.1 Policy on Colorant Changes for HDB
- D.2 Policy for Determining Long-Term Strength (LTHS) by Temperature Interpolation
- D.3 Policy on Dependent Listings
- D.4 Changes Between Two Percentages of a Compounding Ingredient
- D.5 Measurement Variability
- D.6 Requirements for Molding Materials
- D.7 Establishing the Hydrostatic Design Stress for a Material

**Part E - PVC Specific Policies, Practices and Procedures**

E.1 Standard Industry Practice of High Intensity Mixing of PVC Pipe Compounds
E.2 Policy on Substitution of an Apparently Identical Ingredient in a PVC Composition
E.3 Fulfilling Certain PPI TR-3 Requirements by Utilizing an Alternate Method of Analyzing Stress-Rupture Data for PVC
E.4 Substitution of Resin in Poly (vinyl chloride) PVC Plastic Pipe Formulations
E.5 Allowable Formulation Variability for PVC Pipe and Fittings Compositions
E.6 Substitution of Thermal Stabilizers in PVC Pipe Compositions

**Part F - Polyethylene Specific Policies, Practices and Procedures**

F.1 Substitution of Thermal Stabilizers in PE Plastics Pipe Compounds
F.2 Variation in Amount of Stabilizer in PE Plastics Pipe Compounds
F.3 Substitution of Ultraviolet Light Stabilizers in Non-Black PE Plastics Pipe Compounds
F.4 Determination and Validation of the Hydrostatic Design Basis (HDB) for Polyethylene Piping Materials
F.5 Hydrostatic Design Basis Substantiation for PE Materials
F.6 Policy on Establishing Equivalence of Modified PE Pipe Compositions
F.7 Requirements for Polyethylene (PE) Materials to Qualify for a Higher Design Factor

**Part G - PEX Specific Policies, Practices and Procedures**

G.1 Protocol for PPI Listing of PEX Pipe in PPI TR-4
G.2 Policy on Formulation Modifications for PEX HDB Listings
G.3 Policy on Establishing Equivalence of Modified PEX Pipe Compositions

**Part H - Chlorinated Poly (Vinyl Chloride) (CPVC) Specific Policies, Practices and Procedures**

H.1 Policy for Obtaining a Hydrostatic Design Basis (HDB) for a new CPVC Compound
H.2 Policy on Substitution of an Apparently Identical Ingredient in a CPVC Composition
H.3 Fulfilling Certain PPI TR-3 Requirements by Utilizing an Alternate Method of Analyzing Stress-Rupture Data for CPVC
H.4 Substitution of Resin in Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Formulations

H.5 Allowable Formulation Variability for CPVC Pipe and Fittings Compounds
H.6 Substitution of Thermal Stabilizers in CPVC Pipe Compositions

**Appendices**

**X.1 Test Data Report Requirements**
X.1.1 Checklist for HSB Submissions
X.1.2 Additional Information
X.1.3 Release of Recommendations
X.1.4 Appeals of Hydrostatic Stress Board Actions
X.1.5 Confidentiality

**X.2 Suggested Letters for Transmitting the Information Required by Various Parts of this Report**
X.2.1 Letters from Owner of Independent Listing (For Part D.1.2)
X.2.2 Letter from Intended Receiver of Independent Listing (For Part D.1.2)
X.2.3 For Part E.4: Resin Substitution in PVC Compositions
X.2.4 For TR-2/TR-4: PVC Generic Range Formulation

**X.3 Calculation Example to Convert PVC Compound Formulations from PHR to Weight Percent**

**X.4 Plastics Pipe Institute Membership**

# FOREWORD

**TR-3/2016**
**HDB/HDS/PDB/SDB/MRS/CRS**
**Policies**

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 "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.

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 March 2016.

# 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/CRS/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 D2837 may not be sufficient to fully evaluate either the thermal or oxidative stability performance of plastic materials.***

   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 temperature 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 pipe, etc., are thoroughly considered.

5. **Product Standards:** An HDB/HDS/PDB/SDB/MRS/CRS 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/CRS 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/CRS 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/CRS 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/CRS 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 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, 105 Decker Court, Suite 825, Irving, TX 75062.

13. **Maximum Temperature for Listings:** The maximum temperature for which PPI will list an HDB/PDB/SDB/MRS/CRS for a material in accordance with the policies and procedures in TR-3 is 200ºF (93ºC). PPI listing for temperatures above 200ºF may be requested as a "Special Case" (See Note 14) 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/CRS 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.

# Acronyms and Definitions

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

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| TR | Technical Report |
| 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 ($\theta$) 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 design coefficient recommended for use with an MRS category is designated **C.** |
| (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 design factor recommended for use with an HDB category is designated **DF.** |
| 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.** |

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| 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 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 D2837) for a plastic compound obtained by categorizing the long-term hydrostatic strength determined in accordance with ASTM Method D2837. |
| 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. |

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| 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).<br><br>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.<br><br>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/CRS rating is used for pressure calculations.<br><br>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).<br><br>DISCUSSION: An example of this is PEX/AL/PEX pipe.<br><br>TYPE 3: non-pressure rated pipe comprising more than one layer in which at least 60% of the wall thickness is polymeric material.<br><br>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 time to 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. |
| Pressure Rating | PR = 2 (HDB) x (design factor) / (SDR-1), |

SDR = Standard Dimension Ratio

= Average outside diameter / minimum wall thickness

Or

PR = (PDB) (design factor)

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| 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 D2837) 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 F2018, "Standard Test Method for Time-to - Failure of Plastics Using Plane Strain Tensile Specimens."<br><br>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 D2513 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 |

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| TR-X | A PPI Technical Report where 'X' is the number of the report. **e.g.: TR-3/2011 is the 2011 edition of TR-3, *"Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) 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. |

**Common Material Abbreviations**

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| 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) |

## Summary of Changes

**From TR-3 2010 to TR-3 2012**

Title – **Added** "CRS"

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

**Addition of**

A.10 RECOMMENDED HDB AND PDB RATINGS USING ASTM D2992

**PART B.** GRADES OF RECOMMENDATIONS AND DATA REQUIREMENTS FOR MRS AND $CRS_{\theta,t}$

**Removed** B.2; renumbered section

**PART D.** GENERAL POLICIES, PRACTICES AND PROCEDURES

**Edits to clarify TR-3 language** related to Colorant Ranges

D.1. POLICY ON COLORANT CHANGES

D.1.1.2
- D.1.1.2.1
- D.1.1.2.2
- D.1.1.2.3

**PART E.** PVC SPECIFIC POLICIES, PRACTICES AND PROCEDURES

E.2 POLICY ON SUBSTITUTION OF AN APPARENTLY IDENTICAL INGREDIENT IN A PVC COMPOSITION

**Addition of** E.2.1

**PART F.** POLYETHYLENE SPECIFIC POLICES, PRACTICES AND PROCEDURES

**Edits to**

F.6 POLICY ON ESTABLISHING EQUIVALENCE OF MODIFIED PE PIPE COMPOSITIONS

**Addition of**

F.6.1 HDB Equivalence

F.6.2 MRS Equivalence

Part G. **PEX Specific Policies, Practices and Procedures**

G.1 Protocol for PPI Listing of PEX Pipe in PPI TR-4

G.2 Policy on Formulation Modifications for PEX HDB Listings

G.3 Policy on Establishing Equivalence of Modified PEX Pipe Compositions

**PART H.** POLICY ON SUBSTITUTION OF AN APPARENTLY IDENTICAL INGREDIENT IN A CPVC COMPOSITION

**Addition of** H.2.1

**PART F POLICY ON ESTABLISHING EQUIVALENCE OF MODIFIED PE PIPE COMPOUNDS**

**Language clarified in Part F.6**

**APPENDIX X.1**

**Language clarified in X.1.1**

# 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)** | | | | | |

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:

| | | Minimum Data Required | |
|---|---|---|---|
| **Level of Recommendation** | **Time of Data Submission** | **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.

## 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 73ºF (23ºC) at the E-2 level or higher.

A.3.1.2 Not less than the following test data shall be available at 140ºF (60ºC):

| 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 73ºF (23ºC) at the Standard Grade.

A.3.3.2 Test data shall be available at 140ºF (60ºC) 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.

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 73ºF (23ºC) at the E-2 level or higher.

A.4.1.2 Test data shall be available at 180ºF (82ºC) 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 73ºF (23ºC) at the Standard Grade.

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

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

A.4.3.3 Test data shall be available at 180oF (82ºC) 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 73ºF (23ºC) at the E-2 level or higher.

A.5.1.2 Test data shall be available at 200ºF (93ºC) 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 73ºF (23ºC) at the Standard Grade.

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

A.5.3.2.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.

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 41/2 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.

## 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 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.

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<br>and<br>1 x E2 @ 23 °C | 1 x E6<br>and<br>1 x E2 @ 23 °C |
| | Highest | 1 x E6<br>and<br>1 x E2 @ 23 °C | 1 x E6<br>and<br>1 x E2 @ 23 °C |
| Standard | 23 °C | 1 x E10<br>2 x E2 | 1 x E10 |
| | Intermediate | 1 x E10 | 1 x E6 |
| | Highest | 1 x E16<br>2 x E10 | 1 x E16 |

**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,<br>and<br>1 x E2 @ 23 °C | 1 x E6<br>and<br>1 x E2@23 °C |
| | Highest | 1 x E6<br>and<br>1 x E2 @ 23 °C | 1 x E6,<br>and<br>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 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 (LTHP50) 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 73ºF (23ºC) 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.

**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<br>1 x E2 @ 23 °C | 1 x E4 and<br>1 x E2 @ 23 °C |
| | Aluminum or Adhesive | 23 °C | 1 x E2 | on one additional size:<br>1 x E2 |
| | | Highest | 1 x E6, and<br>1 x E2 @ 23 °C | on one additional size:<br>1 x E6, and<br>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:<br>1 x E6 |
| | | Highest | 1 x E10, and<br>1 x E6 @ 23 °C | on one additional size:<br>1 x E10, and<br>1 x E6 @ 23 °C |

### A.10 Recommended HDB AND PDB Ratings USING ASTM D2992

In those cases where it is determined to be appropriate, the HSB may grant an HDB or PDB based on ASTM D2992 analysis on a special case basis.

A.10.1 Analysis of the regression data of fiber-reinforced thermosetting and thermoplastic-resin for composite pipe constructions by ASTM D2992, Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings, Procedure B (static) is permitted under the following conditions:

- All the requirements of Article A.7 must be complied with, except that the analysis of the regression data is performed per ASTM D2992, Procedure B instead of ASTM D2837. Other exceptions may be proposed on a Special Case basis.
- Any granting of an HDB or PDB listing of pipe analysed under this Section is on a SpecialCase request basis. As more experience and precedent is established based on this methodology, additional policy will be developed.

## PART B. GRADES OF RECOMMENDATIONS AND DATA REQUIREMENTS FOR MRS AND $CRS_{\theta,t}$

### B.1 GRADES OF RECOMMENDATION

B.1.1 Only the Standard Grade is recommended for the MRS and $CRS_{\Theta,t}$ at this time.

B.1.2 The 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."* It is preferable that the test data is generated from one lot of material. If more than one lot of material is used to develop the required data, the data from each lot must be evenly distributed over all temperatures and time ranges tested. All data points from each lot included in the analysis must be reported. Any data excluded from use in the analysis must include an explanation and justification for its exclusion.

B.1.2.1 For polyolefin materials, and other thermoplastic materials that exhibit a knee, test data must be submitted for at least three temperatures meeting the data requirements of ISO 9080 for one lot of material with the pipes tested being the same dimensions and made from the same batch of material and come from the same production run. One test temperature must be either 20°C or 23°C. One test temperature must be 80°C, or higher. The other temperature must be between 40°C and 70°C, inclusive.

NOTE: If 23°C is used as a test temperature the MRS forecast will be at 20°C.

B.1.2.2 The report must state the method of manufacture of the pipe specimens tested - such as whether the pipe specimens were produced on commercial or laboratory production equipment, and whether the material was a pre-compounded resin or a resin blend (i.e. natural compound and color masterbatch) at the extruder. Data points are to be identified by material lot.

### B.2 PROTOCOL FOR DETERMINATION OF MRS AND $CRS_{\Theta,t}$

B.2.1 The data and submission report must meet all the requirements of ISO 9080 and TR-3, Part B.1.2.

B.2.2 The SEM (standard extrapolation method) software is available from Becetel and Pipeson for determination of the long-term hydrostatic strength and 97.5% lower prediction limit (LPL) in accordance with ISO 9080.

B.2.3 Determine the LPL at 50 years and the standard listing temperature (20, 60, 80, 82°C, or 93°C) from the SEM calculation. The LPL must meet the extrapolation time limits which are based on the $k_e$ extrapolation factors table in ISO 9080.

Other temperatures and times will be considered on a Special Case Basis for listing in TR-4 if a current published consensus based product standard requires an alternate $CRS_{\Theta,t.}$ be established.

B.2.4 The calculated LPL of the long-term strength shall be categorized according to ISO 12162. If the temperature forecast is 20°C, the categorized value is called the Minimum Required Strength, or MRS. For other temperatures, the categorized value of the LPL is called the Categorized Required Strength, or $CRS_{\Theta,t.}$

## PART C. GRADES OF RECOMMENDATIONS AND DATA REQUIREMENTS FOR SDB

### C.1 GRADES OF RECOMMENDATION

C.1.1 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.

C.1.2 Only the Standard Grade is recommended 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.

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.

**C.2** 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.

**C.3** 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.

## PART D. GENERAL POLICIES, PRACTICES AND PROCEDURES

### D.1 POLICY ON COLORANT CHANGES

D.1.1 Permitted Colorant Changes Without Need for Additional Testing

D.1.1.1 Compounds With a Recommended HDB Which Has Been Established Based on a Specified Colorant Content

D.1.1.1.1 The amount of colorant in a plastic pipe compound with a PPI recommended HDB may be changed from the amount specified for the base composition by as much as 0.5 PHR without the need to submit additional hydrostatic strength data, provided the colorant is neither a liquid nor includes a liquid component at ambient temperature conditions.

D.1.1.1.2 Any type inorganic colorant that is used in the base composition may be substituted in part or in whole, by any other inorganic colorant provided the substituted colorant is limited to a maximum of 0.5 PHR. Organic colorants that are used in the base composition may be substituted in part or in whole, by any other organic colorant provided the substituted colorant is limited to a maximum of 0.5 PHR. provided that the substituted organic colorant is equivalent to the original organic colorant. Colorants for compounds are considered equivalent only if they are of the same chemical nature, same particle size classification, exhibit the same distribution or mixing properties, exhibit the same non-reactive properties with the base resin, remain solid over the intended application range and the petitioner for the organic colorant change has established that detrimental effects will not result due to the substitution.

D.1.1.1.3 The compound with a colorant change does not become a new base compound to which additional formulation changes can be made.

D.1.1.2 Compounds With a Recommended HDB or PDB That Have Been Established Based on a Specified Range of Colorant Content

D.1.1.2.1 A listing holder may establish a colorant range for a compound upon having established an equivalent HDB or PDB for two compounds that differ in the level of colorant and may obtain additional HDB or PDB listings for any colorant level within the range without further hydrostatic testing. For PE compounds, one of the range limits may be qualified by conducting hydrostatic testing in accordance with the requirements of Part F.6 of this report.

Note: The colorant level of zero (natural resin data set) can be considered as one end point in the colorant range.

D.1.1.2.2 Any type colorant that is used in the colorant range may be substituted in part or in whole by any other colorant provided the total content of colorant remains within the minimum/maximum limits specified in the colorant range and provided that the substituted colorant is equivalent to the original colorant. See D.1.1.1.2 for definition of colorant equivalency.

D.1.1.2.3 The compound with a colorant change does not become a new base compound to which additional composition changes can be made.

D.1.2 Colorant Changes Which Require Additional Testing

D.1.2.1 For all colorant changes not permitted under Section D.1.1.1above, or that fall outside the range limits established under Section D.1.1.2 above, satisfactory test data developed in accordance with Part F6 (for PE pipe compositions) or in accordance with Part E5 (for PVC pipe composition) are required.

D.1.2.2 General – Acceptance of colorant changes that do not meet the above criteria may sometimes be obtained by making a petition to the HSB. Sufficient data are +required to provide adequate assurance that the contemplated change will not compromise the HDB (or HDB's if they have been issued for more than one temperature) of the original formulation. The HSB may be consulted in advance to establish an acceptable test protocol.

NOTE 1: The manufacturer should make adequate tests to assure users that the colorant changes do not adversely affect performance properties other than long-term hydrostatic strength, such as aging and weather resistance.

## D.2 POLICY FOR DETERMINING LONG-TERM STRENGTH (LTHS) BY TEMPERATURE INTERPOLATION

D.2.1 The HDB (Hydrostatic Design Basis) for a PPI standard listing temperature (73, 100, 120, 140, 160, 180, or 200°F) may be established on the basis of an LTHS that has been interpolated from LTHS values obtained for one higher and one lower temperature. The data used for this interpolation method must be in compliance with the applicable Parts of PPI TR-3. Strength prediction above highest listed temperature is not allowed. The following additional policies shall also apply in such cases:

D.2.1.1 The Grade of the HDB recommendation established from the interpolated LTHS shall be based on the minimum Grade for which the higher or lower temperature data would qualify.

D.2.1.2 The higher temperature data shall also be sufficient to qualify the subject material for at least the minimum Experimental Grade at that temperature. If this higher test temperature is not one of the PPI standard listing temperatures, then the minimum data requirements of the higher PPI standard listing temperature shall apply.

D.2.1.3 Data sets used in determining an interpolated LTHS do not need to be from the same lot. However, these lots used to determine an interpolated LTHS may not be used again for subsequent lots required by PPI TR-3.

Use the following equation to determine a temperature interpolated LTHS:

$$S_T = S_L - \frac{(S_L - S_H)\left(\frac{1}{T_L} - \frac{1}{T_T}\right)}{\left(\frac{1}{T_L} - \frac{1}{T_H}\right)}$$

Where: $S_T$ = LTHS at interpolation temperature (psi)
$S_L$ = LTHS at the lower temperature (psi)
$S_H$ = LTHS at the higher temperature (psi)
$T_T$ = interpolation temperature (K)
$T_L$ = lower temperature (K)
$T_H$ = higher temperature (K)

## D.3 POLICY ON DEPENDENT LISTINGS

D.3.1 Establishing Dependent Listings:

A PPI listing for a recommended HDB or MRS that has been established under the provisions of Part A and Part B (henceforth known as the independent listing) may be used to establish a separate listing for the same formulation but under another owner's designation (hence known as the dependent listing). The value of the HDB or MRS for the dependent listing is, but for the exception given in this Part, the same as that for the independent listing. A dependent listing may be established when the following requirements are satisfied **(See Appendix X.2 for suggested information transmittal letters)**:

D.3.1.1 By the owner of the Independent Listing: The owner of an independent listing wishing to establish thereupon a dependent listing shall provide the Chairman of the HSB with the following information in writing:

D.3.1.1.1 The identification of the compound with the independent listing and the identification by which the formulation is to be listed as a dependent compound;

D.3.1.1.2 Identification of the organization receiving the formulation and the HDB or MRS dependent listing;

D.3.1.1.3 An assertion that the organization receiving the formulation has been provided with the names of suppliers of the ingredients, and all pertinent information and know-how required to produce, mix, and process the dependent formulation as an equivalent to the independent formulation, or, for cases in which there may be some reason to question complete equivalence (see Note 1) the recommended reduction, if any, of the level of the HDB or MRS for the dependent listing from that assigned to the independent listing.

NOTE 1: It is generally recognized that the equipment and conditions employed in the mixing and processing of a thermoplastic pipe composition will influence the composition's long-term strength characteristics. For example, the same pipe formulation that in one case is premixed prior to pipe extrusion, but in another depends entirely on the extrusion process for proper dispersion of its ingredients, may not yield the same long-term strength under both conditions. Accordingly, it is considered prudent for those cases in which there might be some reason to question complete equivalence to limit the duration and the level of the HDB or MRS recommendations until more definitive data have been obtained on pipe made under the different sets of processing conditions. It is the responsibility of those presenting requests for establishing dependent listings to ensure, as best as possible, the equivalence of the processing conditions under the independent and dependent listings.

D.3.1.1.4 That permission has been given to the recipient of the formulation to reference the test data supplied on behalf of the independent listing.

D.3.1.2 By the intended owner of the Dependent Listing: The intended owner of the dependent listing shall provide the Chairman of the HSB with the following information in writing:

D.3.1.2.1 The identification by which the independent formulation is listed;

D.3.1.2.2 The identification by which the resultant dependent formulation is to be listed;

D.3.1.2.3 Confirmation that the owner of the independent formulation has made available the names of the ingredient suppliers, and all pertinent information and know-how required to prepare, mix and process the dependent compound as an equivalent to the independent formulation; or, if this is not the case, in accordance with the recipe established by the owner of the independent formulation;

D.3.1.2.4 A statement that it is intended to prepare, mix and process the dependent compound in accordance with the above;

D.3.1.2.5 That permission has been received from the owner of the independent listing to use test data supplied on behalf of the independent formulation;

D.3.1.2.6 That any limitation on the HDB or MRS that may have been recommended by the owner of the independent listing is an acceptable condition for obtaining the dependent listing.

D.3.2 Duration and Level of Recommendation for Dependent Listings:

D.3.2.1. Unless otherwise requested by the owner of the independent listing and except when the listing is covered by the provision in 2.C of this Part, a recommendation for a dependent listing will be for the same level as that of the referenced independent listing.

D.3.2.2. But for the exception presented in 2.C of this Part, a recommendation for a dependent listing will have the same expiration date as that of the referenced independent listing.

D.3.2.3. In the case of dependent pipe formulations that are to be mixed and converted into pipe by different processing than that represented by the pipe on which the independent listing was obtained (e.g., as when the dependent formulation essentially relies on the extrusion process for homogenization of ingredients whereas the independent formulation was pre-compounded prior to pipe extrusion), or with any processing conditions by which the quality of homogenization may be suspect (See Note 1 on previous page), the recommended HDB or MRS shall be set in accordance with the recommendation of the holder of the independent listing and be in effect for only six months unless one of the following occurs prior to the end of the six-month period:

D.3.2.3.1 Test data obtained in accordance with Part A and B shall be presented on at least one lot of pipe that has been made in the commercial production equipment of the owner of the dependent listing. The data that are developed in accordance with Part A shall cover not less than the E-2 data level and shall support the recommended HDB or MRS assigned the dependent formulation. Continuance of the recommendation requires that it be advanced through the progressive steps outlined in Part A until a Standard Grade recommendation is established.

D.3.2.3.2 The holder of the dependent listing advises the Chairman of the HSB that he accepts a permanent recommended HDB or MRS of 80 percent of the value established for the referenced independent formulation.

D.3.3 Substitutions in Dependent Listings:

A formulation change accepted for the independent listing is also acceptable for the dependent listing. This may be explained by a general example as follows:

EXAMPLE: Company A has a compound listed and gives the formulation, the suppliers of the ingredients, and the mixing and handling know-how to Company B along with permission for Company B to use the test data submitted by Company A. Company B agrees to follow strictly the information supplied by Company A to mix the equivalent that they designate under another name. When Company A has a formulation change accepted for this listing, then this formulation change is also acceptable for the equivalent compound under the Company B listing

## D.4 CHANGES BETWEEN TWO PERCENTAGES OF A COMPOUNDING INGREDIENT

The percent of a specific compounding ingredient may be varied without further testing over the range between the percentages given in two listings that differ only in the percent of this ingredient so long as both listings are maintained. In the case of stabilizers, both referenced listings shall be at the Standard Grade level. If it is desired that a compound with an intermediate percentage be listed, it will be at the grade level of the lower of the two listings.

## D.5 MEASUREMENT VARIABILITY

Because of the differing precisions of measuring devices and the normal variations inherent even in good handling techniques and processing equipment, the small variations in the amount of an ingredient in a compound are not considered to be changes in the formulation provided (a) the norm is set at the percentage given in the formulation and (b) variations over a reasonable number of batches are small and about equal on the average on the plus and minus side of the norm.

## D.6 REQUIREMENTS FOR MOLDING MATERIALS

D.6.1 Materials intended for molding only must be evaluated in accordance with this part. Materials intended for both extrusion and molding may be evaluated in accordance with this Part or Part A.

D.6.2 The test specimens shall be injection-molded tubes with knit lines that result from either a side gate or an end gate. The tube wall of each specimen should be as uniform in thickness as is technically possible.

NOTE 1: For some materials this molding process can have an effect on the long-term hydrostatic strength. The molding conditions used to mold these pipe specimens should be consistent with molding conditions used for that material in actual end use applications.

D.6.3 These specimens shall be tested in the same manner as extruded pipe specimens. The exposed length of the specimen between end enclosures shall be at least five times the specimen outside diameter.

D.6.4 The policies and procedures shall be the same as those used for developing recommended hydrostatic design stresses for thermoplastic pipe materials except that the report shall include complete information about the specimen configuration.

D.6.5 The resultant HDB recommendations for molding materials shall identify whether the data were obtained on extruded or molded specimens and, if molded, the gating design.

## D.7 Establishing the Hydrostatic Design Stress for a Material

D.7.1 The hydrostatic design stress (HDS) at 73°F (23°C) is derived by multiplying the HDB of the material by a design factor (DF). The Hydrostatic Stress Board will recommend a design factor for each material which has a HDB listed in TR-4.

D.7.2 The recommended design factor shall not exceed 0.50, unless material-specific policies and requirements are developed and are included in the appropriate Part(s) of TR-3. The HDS calculated using this design factor will be used in establishing the thermoplastic pipe material designation code.

D.7.3 Policies and requirements specific to polyethylene are listed under Part F.7 of TR-3.

D.7.4 Policies and requirements specific to other materials will be added to TR-3 as they are considered and developed by the HSB.

# PART E. PVC SPECIFIC POLICIES, PRACTICES AND PROCEDURES

## E.1 STANDARD INDUSTRY PRACTICE OF HIGH INTENSITY MIXING OF PVC PIPE COMPOUNDS

E.1.1. Equipment

High Intensity Mixers: Characterized by a closed bowl or vessel containing motor driven plows or blades. The blades typically run between 500 and 800 rpm, with a tip speed of 30 to 40 meters per second. These blades are designed to homogenize the resin and other ingredients through intensive mixing and frictional heat that they develop.

Low Intensity Coolers: Characterized by a closed bowl or vessel containing motor driven plows or blades. The blades typically run between 50 and 100 rpm with a tip speed around 6 meters per second. These blades are designed to assist in the cooling of the compound though aeration and the action of throwing the compound against the walls of the cooler. Coolers can be water-jacketed and/or air injected.

E.1.2 Single Batching

Resin is dumped into the mixer with the blades turning. The other ingredients are added to the resin at the same ratio as specified by the formulation. The material is mixed until an approximate temperature between 190°F and 245°F is reached. The blended compound is dumped into the cooler and cooled. The material is transferred to storage.

E.1.3 Double Batching

Resin is dumped into the mixer with the blades turning. The other ingredients are added to the resin at a higher ratio than specified by the formulation. This ratio does not exceed 2:1. The material is mixed until an approximate temperature between 190°F and 245°F is reached. The blended concentrate is dumped into the cooler and resin is added to make a blended compound with proportioned ingredients at the ratios specified by the formulation. The blended compound is cooled and then transferred to storage.

NOTE: Words like "typical" and "approximately" were chosen intentionally, as this procedure does not pretend to be perfectly precise, but only describes common industry practice.

It should also be noted that the description is as concise as possible and limited to variables that are likely to have the potential to impact HDB results. For example, a cooler dump temperature range was intentionally omitted because this temperature is more of a material-conveying question than a HDB question.

It is recognized that the method of mixing affects dispersion of ingredients in compounds and potentially the quality of pipe. Therefore when qualifying new chemically equivalent ingredients to the current PPI Range Formula the method of mixing is to be described.

It is recognized that the method of mixing affects dispersion of ingredients in compounds and potentially the quality of pipe. Therefore when qualifying new ingredients that are not chemically equivalent to currently listed ingredients or extending a range in the PPI Range formulation the first data set submitted for qualification must be derived from pipe made from compound that was doubled batched at a 2:1 ratio per the Standard Industry Practice of High Intensity Mixing of PVC pipe Compounds.

## E.2 POLICY ON SUBSTITUTION OF AN APPARENTLY IDENTICAL INGREDIENT IN A PVC COMPOSITION

E.2.1 A manufacturer having a PVC compound with a PPI Independent Standard Grade recommended HDB at 73 °F (23 °C) may substitute ingredients complying with properties and use levels of PPI TR-2 Parts A.2 – A.6 without the need to submit any additional hydrostatic data providing the substituent is within the range limitations of TR-2.

PVC Resin made in new plant:

E.2.1.1 For equivalent PVC resin listed in TR-2 that is made in a new plant, grant a provisional listing based on manufacturer's data supporting equality of resin.

E.2.1.2 E-2 data required for standard grade listing.

E.2.2 A manufacturer who has a PVC pipe compound with a PPI Standard Grade recommended HDB for 73ºF (23ºC) may substitute an apparently identical ingredient from a different supplier with no change in amount for an ingredient that is present in no more than 5 parts per hundred parts (by weight) of resin provided the least squares regression line for the substituted compound obtained with E2 test data produces: (1) a 100,000-hour hydrostatic strength that is not less than required to give the same hydrostatic design basis as that recommended for the base compound and, (2) a 50-year strength value that is not less than 85 percent of the 50-year strength value of the base compound (to assure that the slope for the substituted compound is approximately the same as that for the base compound). In this case the substituted formulation will be considered to be identical to the original formulation in regard to the hydrostatic design stress. The manufacturer shall make available to the Chairman of the HSB, on a confidential basis, the results of the evaluation studies undertaken to show apparent material identity.

E.2.3 The HSB shall be consulted for minimum data requirements for other formulation modifications and stress recommendations at temperatures other than 73ºF (23ºC).

NOTE 1: Consult Part E.3 for an alternate method for analyzing stress-rupture data for PVC.

## E.3 FULFILLING CERTAIN PPI TR-3 REQUIREMENTS BY UTILIZING AN ALTERNATE METHOD OF ANALYZING STRESS - RUPTURE DATA FOR PVC

The use of this method is optional and its inclusion here does not in any way preclude the use of the procedures that are published elsewhere in TR-3.

E.3.1 Applicability:

E.3.1.1 This procedure may be applied in the evaluation of stress-rupture data developed for PVC compounds.

E.3.1.2 This procedure may be used in evaluating the stress-rupture data for:

E.3.1.2.1. Second and third lots of pipe required in Part A to obtain a Standard Grade rating.

E.3.1.2.2. Lots of pipe used to demonstrate the effects of substitution of "apparently identical ingredients" as described in Part E.2.

E.3.1.2.3. Lots of pipe used to show the effects of changes in the level of compounding ingredients (excluding stabilizers) up to ± 50 percent from the levels contained in a compound with an established recommended hydrostatic design stress.

E.3.2 Alternate Method:

As soon as five or more stress-rupture data points are developed, compute the long-term hydrostatic strength (LTHS), the 95 percent upper (UCL) and lower (LCL) confidence levels, and the lower confidence level ratio (RLCL = LCL/LTHS) (Note 1). Check these results against the following requirements:

E.3.2.1. If the RLCL is 0.85 or greater, evaluate data in accordance with 2.2, 2.3, or 2.4 below. If RLCL is less than 0.85, incorporate additional data points as they become available and re-compute until RLCL ≥ 0.85.

E.3.2.2. If the 100,000-hour LCL stress value is greater than 4,000 psi, this lot will always exceed the present 3,830-psi long-term hydrostatic strength requirements (NOTE 2). This test work can be stopped and the data can be submitted to fulfill the requirements listed in Part E.2 above.

E.3.2.3. If the 100,000-hour UCL stress value is less than 3,830 psi, this lot will not attain the required long-term hydrostatic strength (Note 2). The tests should be stopped.

E.3.2.4. If the 100,000 hours UCL stress value is more than 3,830 psi, and the 100,000 hour LCL stress value is less than 3,830 psi, the test should be continued to obtain more data points (Note 2). As additional data points are developed, re-compute and re-examine data to see whether it meets the requirements. Continue testing until the lot qualifies or fails either under this method or another part of PPI TR-3.

NOTE 1. Calculate the lower confidence level (LCL), and the lower confidence level ratio (RLCL) in accordance with ASTM D 2837 (see Section 5.2.3.3 of the 1990 edition). Consult any standard treatment on analysis of regression equations for the calculation of the upper confidence level (UCL).

NOTE 2. The 3,830-psi value is the minimum long-term hydrostatic strength that qualifies for a 4,000 psi HDB category. Minimum required long-term hydrostatic strengths for other HDB categories are given in ASTM D 2837.

NOTE 3. As an approximation, the UCL may be estimated from the LCL by the following equation:

Log UCL = log LTHS + (log LTHS - log LCL)

**E.4 SUBSTITUTION OF RESIN IN POLY (VINYL CHLORIDE) PVC PLASTIC PIPE FORMULATIONS**

Consent of the Chairman of the HSB is required to substitute an alternate resin (resin B) in a PVC pipe formulation for the original resin (resin A). Such consent shall be awarded when the following conditions are satisfied:

E.4.1 The listing for the subject formulation is for the Standard Grade (per 1.2 of Part A) at 73ºF (23ºC).

E.4.2 The Chairman of the HSB shall be advised in writing (see Note 1) by the owner of the "independent" listing (per D.3) that the proposed resin substitution has been determined to be an acceptable formulation variation on the basis of established requirements that the owner has set for that formulation and upon demonstrated compliance to the following:

E.4.2.1 Resin B is an originally specified resin in at least one PVC compound formulation that carries a Standard Grade hydrostatic design stress recommendation at 73ºF (23ºC) of the same value as that of the subject compound (see Note 2.)

E.4.2.2 Resin B satisfies all of the property requirements established by its manufacturer for the use of the resin in pressure rated PVC pipe compounds;

E.4.2.3 The cell classification, when determined in accordance with ASTM D 1784, "Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds", or D 3915, "Standard Specification for Poly(Vinyl Chloride) (PVC) and Related Plastic Pipe and Fitting Compounds for Pressure Applications", of the compound made from the subject formulation, is the same with resin B as when using resin A; and,

E.4.2.4 Both resin A and resin B satisfy the following property requirements:

| PROPERTY | TEST METHOD | REQUIREMENT |
|---|---|---|
| **Type of Material** | **------** | **PVC Homopolymer** |
| **Inherent Viscosity** | **ASTM D1243** | **0.88 - 0.96** |
| **Heat Loss (water); % by weight** | **1 Hr @ 221ºF (105ºC)** | **0.5 max** |
| **Apparent Bulk Density, gm/cc** | **ASTM D1895** | **0.46 - 0.62** |
| **Compacted Bulk Density, gm/cc** | **------** | **0.54 - 0.72** |
| **RVCM** | **------** | **10 ppm max** |

E.4.3 Results of hydrostatic rupture tests at 73ºF (23ºC) shall be submitted to the Chairman of the HSB which demonstrate, when evaluated in accordance with ASTM D 2837 but with the exceptions herein given, that the long-term hydrostatic strength, the lower confidence limit, and the 50-year intercept of pipe made on commercial equipment from the formulation using the substitute resin (resin B) continue to satisfy the D 2837 requirements established on pipe made from the original formulation. The exceptions to D 2837 are that circumferential expansion tests need not be made and minimum data point and test requirements are relaxed to the following:

E.4.3.1 For initial approval (experimental grade )for the use of the substitute resin (resin B), the test data shall consist of not less than nine data points, representing one or more extrusion lots, which shall cover a range of failure times, in hours, spanning at least three log cycles (i.e., from 0.05 to 50 hours, or from 1 to 1,000 hours).

E.4.3.2 For final approval (standard grade) for the use of the substitute resin (resin B), additional test data shall be provided within six months of the granting of the initial approval consisting of at least six additional data points representing not less than three different extrusion lots. The failure time for these points shall be not less than 10 hours with at least two points over 2,000 hours. These additional data may be evaluated either in combination with, or separately from, those supplied for the initial approval (see Note 3).

This policy is intended only to cover the alternative use in PVC formulations of PVC resins that are judged by the criteria herein presented as sufficiently similar in nature to produce pressure pipes that are essentially the same in performance. The requirements given are not to be considered as specifications or standards that describe the requirements for all the PVC resins suitable for PVC pressure pipes. Proposed substitution of PVC resins not meeting the requirements of this policy may be evaluated in accordance with other policies and procedures in TR-3.

NOTE 1. The Appendix includes a suggested letterform that may be used to transmit to the Chairman of the HSB the information required in Part E.4.

NOTE 2. PPI TR-2, Table 1 PVC Resins demonstrate compliance with this section.

NOTE 3. The intention of the Board is to eventually drop this requirement and change initial and final approval, after it has been demonstrated, as expected, that the longer time data per this requirement confirm the 'initial' approval results.

## E.5 ALLOWABLE FORMULATION VARIABILITY FOR PVC PIPE AND FITTINGS COMPOUNDS

The content of one or more ingredients of PVC pipe and fittings compositions may be varied without changes in the recommended HDB for 73ºF (23ºC) provided the formulation variations and the procedures for establishing the recommendation comply to provisions given herein:

E.5.1 Allowable formulation variation for a fixed composition formulation:

E.5.1.1 The formulation shall have a Standard Grade recommended design stress at 73ºF (23ºC) per section 1.2 of Part A.

E.5.1.2 The originally specified content of any number of the following components may be adjusted within the given limits provided each adjusted component meets the indicated property requirements and the resultant formulation can be processed into pipe of acceptable quality:

| COMPONENT | MAXIMUM COMPONENT VARIATION FROM ORIGINAL SPECIFIED CONTENT * |
|---|---|
| **Titanium dioxide** | **± 20%** |
| **Calcium stearate** | **± 10%** |
| **Calcium Carbonate** | **± 20%, but not to exceed 5.0 phr, or the original specified amount if greater than 5.0 phr.** |
| **Paraffin Wax** | **± 10%** |
| **Polyethylene Wax** | **± 20%, but not to exceed 0.30 phr, or the original specified amount if greater than 0.30 phr.** |
| **Colorant** | **± 20%** |
| **Process Aid** | **± 20%** |
| **Stabilizer** | **± 20%, but the resultant change not to exceed ± 0.2 phr** |

* Original specified content is that which was contained in the formulation upon which the LTHS was established.

E.5.2 To establish a range with greater component variability:

Select the maximum and minimum levels for one or more ingredients, and proceed as follows:

E.5.2.1 Test data shall be provided as required by Part A of PPI TR-3 for both the compound when prepared with all additives (all ingredients except resin) at the specified maximum level (maximum range formula) and when prepared with all additives at their minimum level (minimum range formula). To assist in the processing of the data, the maximum and minimum range formulas shall be treated as separate entities until the requirements given in b, c and d below are fulfilled. As long as both the maximum and minimum formulas carry a recommendation of the HSB for the same design stress, and other requirements herein stipulated are satisfied, any formula of that compound which lies within the maximum/minimum range also enjoys that recommendation. For range formulas, the provisions for formulation variation for "fixed" composition formulas do not apply; component content beyond that indicated by the maximum/minimum range is not permitted.

E.5.2.2 Stress-rupture data obtained on pipe made from the maximum range formula shall be provided for at least one lot in accordance with the schedule given in Part A of PPI TR-3 until the full requirements of ASTM D 2837 are satisfied.

E.5.2.3 Stress-rupture data obtained on pipe made from the minimum range formula shall be provided for at least one lot for the E-2 level of Part A.

E.5.2.4 To advance the recommendation for the range formula combination to the Standard Grade, in addition to the above, E-2 level data shall be provided for one other lot of pipe extruded on commercial production equipment that is made from any formula lying within the maximum/minimum range. The Standard Grade recommendation for the range formula shall be granted upon each of all the submitted data lots qualifying for the same hydrostatic design basis per ASTM D 2837.

Formulation changes outside these guidelines, including those for recommended HDB at temperatures beyond 73ºF (23ºC), may be evaluated in accordance with other policies and procedures in TR-3.

## E.6 SUBSTITUTION OF THERMAL STABILIZERS IN PVC PIPE COMPOSITIONS

This policy presents conditions under which stress-rupture data at the E-2 level per Part A are acceptable in demonstrating that the recommended HDB that has been assigned to a PVC pipe composition are not compromised by the use in that composition of a new, or modified, stabilizer (stabilizer B) as a substitute for the original stabilizer (stabilizer A). Under this policy, consent from the Chairman of the HSB is required before the so-modified composition can be accepted under the recommended values assigned the original, or base, composition. Such consent shall be available provided the following conditions are met:

E.6.1 The composition under consideration is either an independent listing, or is dependent upon an independent listing that carries a Standard Grade recommended value for the temperature in question.

E.6.2 If the composition is a dependent listing, then the owner of the independent listing shall advise the Chairman of the HSB in writing that the proposed stabilizer substitution is an acceptable formulation variation.

E.6.3 Both the original stabilizer (stabilizer A) and the substitute stabilizer (stabilizer B) shall be identified along with the use levels of each. (This information shall be kept administratively confidential by the Chairman of the HSB.).

E.6.4 The substitute stabilizer (stabilizer B) shall be an originally specified stabilizer in at least one PVC compound that carries a Standard Grade hydrostatic design stress recommendation.

E.6.5 The cell classification, when determined in accordance with ASTM D 1784 or D 3915, shall be the same for the composition when made with stabilizer B as was established when made with stabilizer A.

E.6.6 The stabilizer level in the compound must be within the range from 0.3 to 1.0 parts per hundred parts of resin and the amount cannot be varied more than allowed by PPI formulation variability policy (See Part E.5). In the case of a range formulation, only the highest usage level of stabilizer must be tested.

E.6.7 Pipe manufactured under commercial production conditions from a compound made with stabilizer B shall, when subjected to hydrostatic testing per ASTM D 1598, yield stress rupture data that when evaluated in accordance with ASTM D 2837, with the exceptions given herein, produces calculated values of the long-term hydrostatic strength, the lower confidence limit and the 50-year intercept that satisfy the ASTM D 2837 requirements for the hydrostatic design basis assigned the compound when formulated with stabilizer A. The exceptions to ASTM D 2837 are that circumferential expansion tests need not be made and the test data only need satisfy the E-2 level requirements of Part A. These tests are to be carried out for each temperature for which recommended HDB equivalence is being established.

Proposed substitutions outside these guidelines may be evaluated in accordance with other policies and procedures in TR-3.

## PART F. POLYETHYLENE SPECIFIC POLICES, PRACTICES AND PROCEDURES

### F.1 SUBSTITUTION OF THERMAL STABILIZERS IN PE PLASTICS PIPE COMPOUNDS

Thermal stabilizers designed for use in polyethylene (PE) compounds may be used interchangeably in a PE plastic pipe formulation that has a recommended HDB without having to submit additional long-term strength test data provided:

F.1.1 Thermal stability requirements in ASTM Standard D 3350, "Standard Specification for Polyethylene Plastics Pipe and Fittings Materials", are met;

F.1.2 The total content of the stabilizer package in the formulation is less than 0.5 parts per 100 parts of resin;

F.1.3 The quantity of the substituted stabilizer is within ±50 percent of the level of the stabilizer in the original formulation.

F.1.4 The quantity of the substituted thermal stabilizer does not exceed 0.25 parts per 100 parts of resin.

The compound with the stabilizer change does not become a new base compound to which additional changes can be made.

Proposed substitutions outside these guidelines may be evaluated in accordance with other policies and procedures in PPI TR-3.

### F.2. VARIATION IN AMOUNT OF STABILIZER IN POLYETHYLENE PLASTICS PIPE COMPOUNDS

In the case of a polyethylene (PE) pipe compound with a recommendation at the E-6 Grade or higher, the amount of stabilizer may be changed up to ± 50 percent from the specified amount for the base composition without the need to submit additional hydrostatic strength data, provided the so altered composition satisfies the thermal stability requirements in ASTM Standard D 3350, "Standard Specification for Polyethylene Plastics Pipe and Fitting Materials".

The compound with the stabilizer change does not become a new base compound to which additional formulation changes can be made.

## F.3 SUBSTITUTION OF ULTRAVIOLET LIGHT STABILIZERS IN NON-BLACK POLYETHYLENE PLASTICS PIPE COMPOUNDS

Ultraviolet (UV) light stabilizers designed for use in non-black polyethylene (PE) compounds may be used interchangeably in a polyethylene plastic pipe formulation that has a recommended HDB without the submission of additional long-term strength test data provided:

1. The total content of the UV stabilizer package in the formulation is less than 0.75 parts per 100 parts of resin;
2. The quantity of the substituted stabilizer does not exceed 0.75 parts per hundred.

The compound with the stabilizer changes does not become a new base compound to which additional changes can be made.

Proposed substitutions outside these guidelines may be evaluated with other policies and procedures in PPI TR-3. No consideration is given to the effectiveness in UV light protection in that this characteristic of the compound is not considered by PPI nor ASTM pipe standards and is between the purchaser and seller.

## F.4 DETERMINATION AND VALIDATION OF THE HYDROSTATIC DESIGN BASIS (HDB) FOR POLYETHYLENE PIPING MATERIALS

Part F.4 offers several methods to validate that the stress regression curve extrapolation will continue in a linear manner to at least 100,000 hours. A recommended HDB at 73°F will not be given to a material that does not validate the ductile stress regression extrapolation.

For a 73°F HDB it is most common to use the Part F.4.1, Table F.4.1.1 for validation. For an elevated temperature HDB at 140°F, any of the methods may be appropriate – Table F.4.1.2, Part F.4.2, or Part F.4.3 – depending on the material and the chosen test conditions. If brittle failures occur at the temperature for which an HDB is desired before 10,000 hours, then Part F.4.4 shall be used to determine the elevated temperature HDB.

### F.4.1 Standard Method - Validation of HDB

Develop data in accordance with Part A for the temperature at which an HDB is desired. **If a brittle failure occurs before 10,000 hours, this standard method is not applicable and Part F.4.4 must be used to establish the elevated temperature LTHS and HDB.**

F.4.1.1 Analyze the data to determine the linear regression equation. Extrapolate this equation to 100,000 hours to determine the LTHS. If the 97.5% LCL at 100,000 hours is less than 90% of this LTHS, consider the data unsuitable for use by this method. If all conditions are satisfied, use Table 1 of ASTM D 2837 to determine the HDB category at this temperature.

F.4.1.2 When the HDB category has been determined by section F.4.1.1, use tables F.4.1.1 or F.4.1.2 to define the time and stress requirements needed to validate this HDB.

Test at least six specimens at the stress level determined by the tables. These specimens must have a minimum log average time exceeding the value shown in the table to validate the HDB. For example, to validate an HDB of 1000 psi at 140ºF, this required time is 3800 hours at 193ºF (90ºC)/690 psi or 11,300 hours at 176ºF (80ºC)/775 psi.

If a temperature/stress condition in the table results in a premature ductile failure for a particular PE material, the stress at that temperature may be lowered by 15%. The corresponding required time for this lowered stress is then six times the value in the table. For example, when validating an HDB of 1600 psi at 73°F, if testing at 80°C/825 psi results in ductile failures, lower the stress to 700 psi and retest. The required time to validate using this condition is now 1200 hours. If ductile failures still occur, the stress may be lowered to 595 psi and the corresponding time is increased to 7200 hours.

If a temperature/stress condition in the table results in a premature ductile failure for a particular PE material, the stress at that temperature may also be lowered by less than 15%. In this case, consult with the HSB Chairman to determine the appropriate required time at the selected stress level.

**Table F.4.1.1**

Validation of 73°F (23°C) HDB

| HDB to be Validated (psi) | 193°F (90°C) | | 176°F (80°C) | |
|---|---|---|---|---|
| | Stress (psi) | Time (hrs.) | Stress (psi) | Time (hrs.) |
| 1600 | 735 | 70 | 825 | 200 |
| 1250 | 575 | 70 | 645 | 200 |
| 1000 | 460 | 70 | 515 | 200 |
| 800 | 365 | 70 | 415 | 200 |
| 630 | 290 | 70 | 325 | 200 |
| 500 | 230 | 70 | 260 | 200 |

**Table F.4.1.2**

Validation of 140°F (60°C) HDB

| HDB to be Validated (psi) | 193°F (90°C) | | 176°F (80°C) | |
|---|---|---|---|---|
| | Stress (psi) | Time (hrs.) | Stress (psi) | Time (hrs.) |
| 1250 | 860 | 3800 | 970 | 11300 |
| 1000 | 690 | 3800 | 775 | 11300 |
| 800 | 550 | 3800 | 620 | 11300 |
| 630 | 435 | 3800 | 490 | 11300 |
| 500 | 345 | 3800 | 390 | 11300 |
| 400 | 275 | 3800 | 310 | 11300 |

Note: When an elevated temperature HDB is validated by this standard method, all lower temperature HDB's are considered validated for that material.

F.4.2 Rate Process Method (RPM) Validation of the HDB

Develop data in accordance with Part A for the temperature at which an HDB is desired. **If a brittle failure occurs before 10,000 hours, or if the HDB does not validate using this RPM protocol, then the HDB may be determined using Part F.4.4.**

1. Select an elevated temperature to test the PE pipe specimens. The maximum temperature chosen should not be greater than 203°F (95°C).

2. Select a stress at this temperature at which all failures occur in the slit mode (a crack through the pipe wall with no visible evidence of material deformation). Test at least six pipe specimens at this Condition I until failure. Ideally, the selected stress should result in failure times of about 100 to 500 hours.

3. At the same temperature, select another stress about 75 to 150 psi lower than for Condition I. Test at least six specimens at this Condition II until failure. Ideally, the selected stress for Condition II should result in failure times of about 1,000 to 5,000 hours.

4. Select a temperature 18ºF (10.0ºC) to 36ºF (20.0ºC) lower than Condition I and use a stress approximately the same stress as for Condition I. Initiate testing for six specimens at this Condition III. Ideally, the selected temperature for Condition III should result in specimens that are on test for at least 1,000 to 5,000 hours.

5. To validate the ASTM D 2837 long-term hydrostatic strength (LTHS) on a given material lot at a desired temperature, use the 12 data points from Conditions I and II, and the value of the LTHS at 100,000 hours determined at the desired temperature as determined from method D 2837. Using all these points, calculate the A, B, and C coefficients for the following three-coefficient rate process method equation:

$$Log\, t = A + \frac{B}{T} + \frac{C \, Log\, S}{T}$$

where: t = time, hours
T = absolute temperature, °K (°K = °C + 273)
S = hoop stress, psi
A,B,C = constants

6. Using this model, calculate the mean estimated failure time for Condition III. When the log average time on test for the six specimens tested at Condition III have reached this time, the ASTM D 2837 extrapolation to 100,000 hours to obtain the LTHS at the desired temperature has been validated.

F.4.3 ISO 9080 Based Method for Validation of 140°F (60°C) HDB

F.4.3.1 Develop data in accordance with Part A for the temperature at which an HDB is desired. Analyze the data to determine the linear regression equation as per ASTM D 2837. Extrapolate this equation to 100,000 hours to determine the LTHS. If the 97.5% LCL at 100,000 hours is less than 90 % of this LTHS, consider the data unsuitable for use by this method.

**If a brittle failure occurs before 10,000 hours, this method is not applicable and Part F.4.4 shall be used to establish the elevated temperature HDB.**

F.4.3.2 Develop a regression based on ductile stress-rupture data at either 80° or 90°C. Use Table F.4.3.2 to determine the appropriate data level for the temperature to be validated. The regression data must satisfy the following requirements:

F.4.3.2.1 The 97.5% LCL ratio for these data must be greater than 90%.

F.4.3.2.2 Non-failed specimens at the longest running times may be included in the regression, provided their inclusion does not decrease the LTHS (See ASTM D2837, section 5.2.2).

F.4.3.2.3 The log average of the five highest times (used in the regression) must exceed the minimum time tmax indicated in Table F.4.3.2.

**Table F.4.3.2**

| Temperature to be Validated (°F) | 193°F (90°C) Regression | | 176°F (80°C) Regression | |
|---|---|---|---|---|
| | Data Level[1] | Min. $t_{max}$[2] | Data Level[1] | Min. $t_{max}$[2] |
| 140 (60°C) | E-6 | 5500 | E-10+ | 17,000 |

[1] Per data interval requirements
[2] $t_{max}$ = log average of 5 longest times (included in regression)

See example below.

**EXAMPLE**:

140°F (60°C) regression data are determined in accordance with Part A and support an HDB of 1000 psi. No brittle failures are obtained within 10,000 hours.

According to Table F.4.3.2, minimum data requirements for a 193°F (90°C) regression are an "E-6" data level (Part A) and a $t_{max}$ of 5,500 hours. The following data are obtained:

| Stress | Failure Time | Failure Mode |
|---|---|---|
| 760 | 71 | Ductile |
| 755 | 102 | Ductile |
| 745 | 514 | Ductile |
| 740 | 693 | Ductile |
| 740 | 717 | Ductile |
| 735 | 908 | Ductile |
| 730 | 1478 | Ductile |
| 730 | 1726 | Ductile |
| 725 | 2155 | Ductile |
| 720 | 2943 | Ductile |
| 720 | 4087 | Ductile |
| 715 | 4382 | Ductile |
| 710 | 5207 | Ductile |
| 705 | 5928 | Ductile |
| 700 | 6174 | Ductile |
| 700 | 7000 | Non-Failure |

LCL Ratio = 98.4% (> 90%)

Longest 5 times:

| | |
|---|---|
| | 4382 |
| | 5207 |
| | 5928 |
| | 6174 |
| | 7000 |
| **Log Avg.** | **5667** |

[5,667 > 5,500]

***HDB is validated.***

F.4.4 Determination of Elevated Temperature HDB When Brittle Failures Occur Before 10,000 hours.

If the previous methods to validate an elevated temperature (i.e. above 73°F) HDB are not appropriate for the material and test data, then use this alternate method to determine the elevated temperature HDB.

F.4.4.1 Develop data in accordance with Part A for the temperature at which an HDB is desired.

Using only the ductile failures, determine the linear regression equation. The failure point data must be spread over at least two log decades and meet the LCL requirements of section 1.1. The stress intercept at 100,000 hours using this equation is the "ductile" LTHS.

F.4.4.2 To determine the brittle failure performance, solve for the three coefficients of the rate process equation using steps 1-4 Part F.4.2, or another recognized rate process method protocol. All failures must be in the brittle mode. Data developed under ASTM D 2837 to validate a 73°F HDB can be used to solve for the three-coefficient equation as long as all specimens at the three conditions were tested to failure and resulted in brittle type failures. Use the failure points at the three conditions to solve for the three unknown coefficients.

Using this brittle failure model, calculate the stress intercept value at 100,000 hours for the temperature at which an HDB is desired. This resulting stress intercept is the "brittle" LTHS.

F.4.4.3 The LTHS used to determine the HDB category as per Table 1 in ASTM D 2837, shall be the lower value of the ductile failure LTHS from section 2.1 or this brittle failure LTHS.

Rate Process Equation:

$$\mathit{Log}\ t = A + \frac{B}{T} + \frac{C \operatorname{Log} S}{T}$$

where: t = time, hours

T = absolute temperature, °K (°K = °C + 273)

S = hoop stress, psi
A,B,C = constants

Note: The ISO 9080 four-coefficient model may be used if it has a better statistical fit to the data, subject to review of the HSB Chairman.

### F.5 Hydrostatic Design Basis Substantiation for PE Materials

When it is desired to show that a PE material has additional ductile performance capacity than is required by validation of the 73°F (23°C) time/stress curve to 100,000 hours, one of the following three procedures may be used to further substantiate that the stress regression curve is linear to the 50 year (438,000 hour) intercept.

F.5.1 If the 140°F HDB has been validated by Part F.4.1 or F.4.3, then the 73°F extrapolation is considered to be substantiated linear to 50 years (438,000 hours).

F.5.2 Use the twelve data points from Condition I and II obtained from Alternate Method of ASTM D 2837 (rate process method), along with the 50 year (438,000 hour) intercept, to solve for the three-coefficient rate process extrapolation equation. Then using this new model, calculate the mean estimated failure time for Condition III. When the log average time for six specimens tested at Condition III has reached this time, linear extrapolation of the 73°F (23°C) stress regression curve to 50 years (438,000 hours) is substantiated.

F.5.3 When the Standard Method of ASTM D 2837 (TR-3, Part F.4.1 or F.4.3) is used to validate the 73°F (23°C) HDB, linear extrapolation of the stress regression curve to 50 years (438,000 hours) is substantiated when the log average failure time of six test specimens at 176°F (80°C) surpasses 6000 hours, or at 193°F (90°C) surpasses 2400 hours at a stress of no more than 100 psi below where all failures are ductile. A ductile failure reference stress shall be established by 3 specimens all failing in the ductile mode at the same temperature.

NOTE 1 The Long-Term Hydrostatic Strength (LTHS) at 50 years is not to be used for pressure rating calculations. The maximum stress is still calculated using the HDB (with the appropriate design service factors) obtained from the LTHS at 100,000 hours.

PE materials meeting this additional substantiation of the 73°F (23°C) extrapolation shall be denoted by an asterisk (*) in PPI TR-4.

### F.6 POLICY ON ESTABLISHING EQUIVALENCE OF MODIFIED PE PIPE COMPOSITIONS

The Independent listing holder of a polyethylene pipe compound with a Standard Grade recommended HDB or MRS may modify that compound provided that either 1) the changes are minor (per F.6.1), or 2) the listing holder submits test data (per F.6.3) to confirm that the modified compound has an equivalent HDB or MRS to the original compound at each listed temperature.

F.6.1 Minor modification(s) in PE compounds that require no testing and reporting to the HSB are covered in the following sections of TR-3:

| | |
|---|---|
| Colorant changes | Part D.1 |
| Thermal Stabilizer Substitution | Part F.1 |
| Stabilizer Variations | Part F.2 |
| UV Stabilizer Substitution | Part F.3 |

F.6.2 Other modifications to the composition of a piping compound could significantly affect its long term service life and will require hydrostatic test data to confirm the modified compound's HDB or MRS is unchanged, per F.6.3. Examples of such compositional modifications include:

Changes in color concentrate, which may include:

A change in pigment level or type not permitted in Part D, and/or A change in the concentrate carrier resin. The concentrate carrier resin is not considered to have changed if the following characteristics are the same as that of the carrier resin used in the original composition:

- nominal melt index and density,
- polymer manufacturing process technology and catalyst system
- comonomer

Changes in PE resin manufacturing process or specifications.

Changes in the PE pipe compound manufacturing process.

It is recognized that a change in PE resin manufacturing process conditions will generally, but not always, result in no adverse change in long-term strength characteristics, provided the resin and compound are made to the same manufacturer's product specifications. The determination of which process change could affect long-term strength has to be determined by the listing company using the best judgment. Past experience can be a guide. Whenever there is reasonable suspicion, testing (per F.6.3) should be conducted to confirm that the compound's long-term strength characteristics have remained unchanged. Some examples of process changes that should be considered during the decision making process include:

1. Changes in the type of manufacturing process.
2. The start-up of new reactors at existing or new plant sites.
3. Changes in the type of compounding equipment used in the pelletization process.

F.6.3 Test requirements to establish equivalence

For compound modifications determined to require test data, stress-rupture testing shall be developed on one (1) lot of the modified compound to confirm that all HDBs and MRSs assigned to the original compound are maintained, as detailed below.

F.6.3.1 HDB Equivalence

The minimum levels of data required are:

- E-2 per Part A at 73°F
- E-2 per Part A at the highest other listed temperature, if any
- Validation at the highest listed temperature
- If applicable, 50-year substantiation according to Part F.5

F.6.3.2 MRS Equivalence

An abbreviated data set (less than the full ISO 9080 data requirement) is acceptable to establish equivalence of a modified compound with MRS listing, provided the following conditions are satisfied (*Note: Modified compounds not meeting these criteria must be tested to the full requirements of ISO9080 to establish equivalence or a Special Case can be requested to present an alternate qualification requirement*):

- The original compound has a Standard Grade recommended HDB listing at 73°F.
- The modified compound meets Part F.6.1 requirements for HDB equivalence.
- The ISO 9080 data set used to establish the original compound's MRS listing consists of:
  - Data from only one lot
  - At least three temperatures (per B.1.2.1).
  - The 20°C /50-year LPL is based on *Type A* (ductile) failure mode

For compounds meeting the above criteria, test data on the modified compound shall be developed per ISO9080 and Part B.1.2, with the following exceptions:

- All observations must be generated from a single lot and on the same nominal pipe size used to generate the original data set.
- Minimum data levels (per Part A):
  - E-2 at 20º or 23ºC
  - E-2 at a temperature between 40 ºC and 70ºC (inclusive)
  - E-6 at 80ºC or above. Also, the log average of the 5 longest times (failure or non-failure) included in the LPL determination, shall exceed 5000 hours
- The ISO 9080 LPL (20°C, 50-years) of this abbreviated data set, must be based on "Type A" (ductile) mode and support the same MRS (per ISO 12162) as that of the original full data set.

Modifications that are not within the scope of those defined in this Part are considered to result in a new compound subject to the full testing requirements of Part A, and Part F.4. However, the HSB will review, on a Special Case basis, a request to consider different testing requirements upon review of the proposed modification.

### F.7 REQUIREMENTS FOR POLYETHYLENE (PE) MATERIALS TO QUALIFY FOR A HIGHER DESIGN FACTOR

A PE material that meets the following requirements qualifies for a recommended design factor of 0.63. PE materials not meeting these requirements will have their HDS established as per Part D.7.

1. 50 year substantiation according to Part F.5.
2. Minimum slow crack growth performance by ASTM F 1473 of 500 hours as required by ASTM D 3350.
3. LCL/LTHS ratio of at least 90% as per ASTM D 2837.

These requirements apply to the PE material – meaning that all compounding ingredients and colorants are included matching the material formulation to be listed. The HDS calculated with this design factor will be used to establish the pipe material designation code to be listed in TR-4.

## PART G. PEX SPECIFIC POLICES, PRACTICES AND PROCEDURES

### G.1 PROTOCOL FOR PPI LISTING OF PEX PIPE IN PPI TR-4

Policy Revision pending

### G.2 POLICY ON FORMULATION MODIFICATIONS FOR PEX HDB LISTINGS

The following formulation modifications to cross-linked polyethylene (PEX) compounds may be made without having to submit additional long-term strength test data provided the formulation changes fit within the guidelines below and the required additional supporting data detailed below is provided.

G.2.1 The Gel content of the new compound as determined according to ASTM D2765, "Standard Test Methods for Determination of Gel Content and Swell Ratio of Cross-linked Ethylene Plastics" is not lower than that for the original compound for which the recommended HDB was obtained.

G.2.2 Colorant Changes:

Colorant changes as detailed in Part D.1 of PPI TR-3.

G.2.3 Thermal Stabilizers:

G.2.3.1 Thermal Stabilizer Substitution:

Thermal Stabilizers for use in PEX compounds may be used interchangeably in a PEX plastic pipe formulation provided:

G.2.3.1.1 The requirements for Stabilizer Validation in Section 6.8 of ASTM Standard F876, "Standard Specification for Cross-linked Polyethylene (PEX) Tubing", are met;

G.2.3.1.2 The total content of the stabilizer package in the formulation is less than 0.75 parts per 100 parts of resin;

G.2.3.1.3 The quantity of substituted stabilizer is within ± 50 percent of the level of the stabilizer in the original formulation;

G.2.3.1.4 The quantity of the substituted thermal stabilizer does not exceed 0.75 parts per 100 parts of resin.

G.2.3.2 Change in Amount of Thermal Stabilizer:

The amount of thermal stabilizer may be changed up to ± 50 percent from the specified amount for the base composition. An increase in thermal stabilizer does not require testing. If the level of thermal stabilizer is decreased the new compound must satisfy requirements for Stabilizer Validation in Section 6.8 of ASTM Standard F876, "Standard Specification for Cross-linked Polyethylene (PEX) Tubing"

G.2.4 Addition of UV Light Stabilizers:

Ultraviolet (UV) light stabilizers designed for use in cross-linked polyethylene (PEX) compounds may be used interchangeably in a PEX plastic pipe formulation provided:

G.2.4.1 The total content of the UV stabilizer package in the formulation is less than 0.75 parts per 100 parts of resin;

G.2.4.2 The quantity of the substituted stabilizer does not exceed 0.75 parts per hundred of resin.

No consideration is given to the effectiveness in the UV light protection in that this characteristic of the compound is not considered by PPI or ASTM standards and is between the purchaser and seller.

G.2.5 Catalyst Changes:

For PEX pipe manufacturing processes that utilize a catalyst to accelerate the cross-linking process, the level of this catalyst may be changed up to ± 50 percent from the specified amount for the base composition.

The type of catalyst may also be changed provided the same carrier fluid or resin is utilized. Also, the level of the substituted catalyst must be within ± 50 percent of the original catalyst level.

G.2.6 Carrier Resin Changes:

Carrier resins for the addition of additives to the PEX formulation may be used interchangeably provided:

G.2.6.1 The substituted Carrier Resin has the same Cell Classification according to ASTM D3350, "Specification for Polyethylene Plastics Pipe and Fittings Materials";

G.2.6.2 The addition level of the Carrier Resin including additives is below 6% of the total formulation.

G.2.6.3 The level of substituted resin is the same as for the original base formulation.

NOTE 1: Due to the chemical nature of the PEX manufacturing process changes to formulations may result in an interference with the cross-linking process or the cross-linking process may interfere with the functioning of the additive. The manufacturer should make adequate tests to assure users that the formulation changes do not adversely affect the performance properties other than long-term hydrostatic strength.

NOTE 2: The compound to which any one of the above mentioned formulation change is made does not become a new base compound to which additional changes can be made.

Proposed substitutions outside these guidelines may be evaluated with other policies and procedures in PPI TR-3.

## G.3 POLICY ON ESTABLISHING EQUIVALENCE OF MODIFIED PEX PIPE COMPOSITIONS

A manufacturer who has a cross-linked polyethylene (PEX) compound with a PPI Standard Grade recommended HDB may modify that compound provided that the changes are minor, as herein defined, or adequate testing is performed to confirm that the new material has an equivalent HDB to the original PPI listed material at each of the temperatures for which the material is listed. Minor modification(s) in PEX compounds that require no testing and reporting to the HSB are covered in TR-3 Part G.2.

Other modification to the composition of a piping compound could significantly affect its long-term service life. Accordingly such changes will require certain hydrostatic pressure testing to confirm the modified compound has the same HDB as the original listed compound. Examples of possible compound modifications include:

For PE Base resin (prior to cross-linking):

- Changes in the manufacturing specifications for the PE resin
- The start-up of new reactors at existing or new plant sites for PE base resin manufacture
- Changes in PE base resin manufacturing process

Changes such as those outlined above will require certain minimum confirmatory stress-rupture testing and validation in accordance with Part A of this report. Test data on one (1) lot of the modified compound shall be developed to confirm the same HDB as the original compound. The levels of data required are:

| **Listing Temperature** | **Minimum Data Requirement for Listed Temperature** |
|---|---|
| 73 °F (23 °C) | E-2 per Part A |
| Highest Rated Temperature | E-6 at highest rated temperature |

In addition to the above stress-rupture testing, data shall be supplied to confirm that the Gel content of the modified PEX composition as determined according to ASTM D2765, "Standard Test Methods for Determination of Gel Content and Swell Ratio of Cross-linked Ethylene Plastics", is not lower than that for the original compound for which the recommended HDB was obtained.

Modifications that are not within the scope of those defined in this Part are considered to result in new materials subject to the full testing requirements of
Part A. However, the HSB has the authority, on a case-by-case basis, to recommend different testing requirements upon review of the proposed modification.

# PART H. CHLORINATED POLY (Vinyl Chloride) (CPVC) SPECIFIC POLICIES, PRACTICES AND PROCEDURES

## H.1 POLICY FOR OBTAINING A HYDROSTATIC DESIGN BASIS (HDB) FOR A NEW CPVC COMPOUND

H.1.1 Equipment
Clause E1.1 applies

H.1.2 Single Batching
Clause E1.2 applies

H.1.3 Double Batching
Double batching of CPVC compounds is not allowed at this time.

## H.2 POLICY ON SUBSTITUTION OF AN APPARENTLY IDENTICAL INGREDIENT IN A CPVC COMPOSITION

H.2.1 A manufacturer having a CPVC compound with a PPI Standard Grade recommended HDB at 73 °F (23 °C) and 180°F (82°C) may substitute ingredients complying with properties and use levels of PPI TR-2 Parts A.2 – A.6 without the need to submit any additional hydrostatic data providing the substituent is within the range limitations of TR-2.

H.2.2 A manufacturer having a CPVC pipe compound with a PPI Standard Grade recommended HDB at 73°F (23°C) and at 180°F (82°C) may substitute an apparently identical ingredient from a different supplier with no change in amount for an ingredient that is present in no more than 5 parts per hundred parts (by weight) of resin provided the least squares regression lines for the substituted compound obtained with E-2 test data at 73°F (23°C) and E-6 test data at 180°F (82°C) produces: (1) a 100,000-hour hydrostatic strength that is not less than required to give the same hydrostatic design basis as that recommended for the base compound and, (2) a 50-year strength value that is not less than 85 percent of the 50-year strength value of the base compound (to assure that the slope for the substituted compound is approximately the same as that for the base compound). In this case the substituted formulation will be considered to be identical to the original formulation in regard to the hydrostatic design stress. The manufacturer shall make available to the Chairman of the HSB, on a confidential basis, the results of the evaluation studies undertaken to show apparent material identity.

H.2.3 PPI will grant an experimental acceptance of the substituted ingredient at 180ºF (82ºC) based on presentation to the HSB Chairman of acceptable E-2 stress rupture data at both 180ºF (82ºC) and 200ºF (93ºC). The owner of this experimental acceptance shall submit E-6 stress rupture data at 180ºF (82ºC) to PPI within six months to retain acceptance of the substituted ingredient.

H.2.4 The HSB shall be consulted for minimum data requirements for other formulation modifications and stress recommendations at temperatures other than 73ºF (23ºC) and 180ºF (82ºC).

NOTE 1: Consult Part H.3 (for an alternate method for analyzing stress-rupture data for CPVC.

## H.3 FULFILLING CERTAIN PPI TR-3 REQUIREMENTS BY UTILIZING AN ALTERNATE METHOD OF ANALYZING STRESS - RUPTURE DATA FOR CPVC

The use of this method is optional and its inclusion here does not in any way preclude the use of the procedures that are published elsewhere in TR-3.

H.3.1 Applicability:

H.3.1.1 This procedure may be applied in the evaluation of stress-rupture data developed for CPVC compounds.

H.3.1.2 This procedure may be used in evaluating the stress-rupture data for:

H.3.1.2.1 Second and third lots of pipe required in Part A to obtain a Standard Grade rating.

H.3.1.2.2 Lots of pipe used to demonstrate the effects of substitution of "apparently identical ingredients" as described in Part H.2.

H.3.1.2.3 Lots of pipe used to show the effects of changes in the level of compounding ingredients (excluding stabilizers) up to ± 50 percent from the levels contained in a compound with an established recommended hydrostatic design stress.

H.3.2 Alternate Method:

As soon as five or more stress-rupture data points are developed, compute the long-term hydrostatic strength (LTHS), the 95 percent upper (UCL) and lower (LCL) confidence levels, and the lower confidence level ratio ($R_{LCL}$ = LCL/LTHS) (Note 1). Check these results against the following requirements:

H.3.2.1 If the RLCL is 0.85 or greater, evaluate data in accordance with 2.2, 2.3, or 2.4 below. If RLCL is less than 0.85, incorporate additional data points as they become available and recompute until RLCL ≥ 0.85.

H.3.2.2 If the 100,000-hour LCL stress value is greater than 4,000 psi at 73ºF (23ºC) and 1,000 psi at 180ºF (82ºC), this lot will always exceed the long-term hydrostatic strength requirements (Note 2). This test work can be stopped and the data can be submitted to fulfill the requirements listed in H.2 above.

H.3.2.3 If the 100,000-hour UCL stress value is less than 3,830 psi at 73ºF (23ºC) and 960 psi at 180ºF (82ºC), this lot will not attain the required long-term hydrostatic strength (Note 2). The tests should be stopped.

H.3.2.4 If the 100,000 hours UCL stress value is more than 3,830 psi at 73ºF (23ºC) and 960 psi at 180ºF (82ºC), and the 100,000 hour LCL stress value is less than 3,830 psi at 73ºF (23ºC) and 960 psi at 180ºF (82ºC), the test should be continued to obtain more data points
(Note 2). As additional data points are developed, re-compute and re-examine data to see whether it meets the requirements. Continue testing until the lot qualifies or fails either under this method or another part of PPI TR-3.

NOTE 1: Calculate the lower confidence level (LCL), and the lower confidence level ratio (RLCL) in accordance with ASTM D 2837 (see Appendix X3 of the 2004 edition). Consult any standard treatment on analysis of regression equations for the calculation of the upper confidence level (UCL).

NOTE 2: The 3,830 psi value is the minimum long-term hydrostatic strength that qualifies for a 4,000 psi HDB category at 73 °F (23 °C ); the 960 psi value is the minimum long-term hydrostatic strength that qualifies for a 1,000 psi HDB category at 180 °F (82 °C ). Minimum required long-term hydrostatic strengths for other HDB categories are given in ASTM D 2837.

NOTE 3: As an approximation, the UCL may be estimated from the LCL by the following equation:

$$\text{Log UCL} = \log \text{LTHS} + (\log \text{LTHS} - \log \text{LCL})$$

## H.4 SUBSTITUTION OF RESIN IN CHLORINATED POLY(VINYL CHLORIDE) (CPVC) PLASTIC PIPE FORMULATIONS

Consent of the Chairman of the HSB is required to substitute an alternate resin (resin B) in a CPVC pipe formulation for the original resin (resin A). Such consent shall be awarded when the following conditions are satisfied:

H.4.1 The listing for the subject formulation is for the Standard Grade at 73ºF (23ºC) and 180ºF (82ºC).

H.4.2 The Chairman of the HSB shall be advised in writing (See Note 1) by the owner of the "independent" listing (per D.3) that the proposed resin substitution has been determined to be an acceptable formulation variation on the basis of established requirements that the owner has set for that formulation and upon demonstrated compliance to the following:

H.4.2.1 Resin B is either:

H.4.2.1.1 Derived by chlorination of a PVC resin designated an originally specified resin in at least one PVC compound formulation that carries a Standard Grade hydrostatic design stress recommendation at 73ºF (23ºC) (either a private listing with PPI or a listing in Table 1 of TR2) of the same value as that of the subject compound;

or

H.4.2.1.2 an originally specified resin in at least one CPVC compound formulation that carries Standard Grade hydrostatic design stress recommendations at 73ºF (23ºC) and 180ºF (82ºC) of the same value as that of the subject compound;

H.4.2.2 Resin B satisfies all of the property requirements established by its manufacturer for the use of the resin in pressure rated CPVC pipe compounds;

H.4.2.3 The cell classification, when determined in accordance with ASTM D 1784, "Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds", or D 3915, "Standard Specification for Poly(Vinyl Chloride) (PVC) and Related Plastic Pipe and Fitting Compounds for Pressure Applications", of the compound made from the subject formulation, is the same with resin B as when using resin A; and,

H.4.2.4 Both resin A and resin B satisfy the following property requirements:

| PROPERTY | TEST METHOD | REQUIREMENT |
|---|---|---|
| **Type of Material** | | **CPVC Homopolymer** |
| **Percent Chlorine** | | **66.5 % Min.** |
| **Inherent Viscosity** | **ASTM D1243** | **0.88 - 0.96** |
| **Heat Loss (water); % by weight** | **1 Hr @ 221ºF (105ºC)** | **0.5 max** |
| **Apparent Bulk Density, gm/cc** | **ASTM D1895** | **0.46 - 0.66** |
| **Compacted Bulk Density, gm/cc** | **------** | **0.54 - 0.76** |
| **RVCM** | **------** | **10 ppm max** |

H.4.3. Results of long term hydrostatic stress rupture tests at 180ºF (82ºC) shall be submitted to the Chairman of the HSB which demonstrate, when evaluated in accordance with ASTM D 2837 but with the exceptions herein given, that the long-term hydrostatic strength, the lower confidence limit, and the 50-year intercept of pipe made on commercial equipment from the formulation using the substitute resin (resin B) continue to satisfy the D 2837 requirements established on pipe made from the original formulation. The exceptions to D 2837 are that circumferential expansion tests need not be made and minimum data point and test requirements are relaxed to the following:

H.4.3.1 For initial approval (experimental grade) for the use of the substitute resin (resin B), The following data shall be provided:

- E6 at 180ºF (82ºC).

or

- E2 at 180ºF (82ºC) and E2 at 200ºF (93ºC)

H.4.3.2 For final approval (standard grade) for the use of the substitute resin (resin B), E10 data at 180ºF (82ºC) shall be provided.

Unless it can be demonstrated that they are part of the same regression line, do not use failure points for stresses or pressures that have failure times less than 100 h. Include failure points excluded from the calculation by this operation in the report, and identify them as being in this category.

This policy is intended only to cover the alternative use in CPVC formulations of CPVC resins that are judged by the criteria herein presented as sufficiently similar in nature to produce pressure pipes that are essentially the same in performance. The requirements given are not to be considered as specifications or standards that describe the requirements for all the CPVC resins suitable for CPVC pressure pipes. Proposed substitution of CPVC resins not meeting the requirements of this policy may be evaluated in accordance with other policies and procedures in TR-3.

NOTE 1: The Appendix includes a suggested letter form that may be used to transmit to the Chairman of the HSB the information required in Part H.4.

NOTE 2: The intention of the Board is to eventually drop this requirement and change initial and final approval, after it has been demonstrated, as expected, that the longer time data per this requirement confirm the 'initial' approval results.

## H.5 ALLOWABLE FORMULATION VARIABILITY FOR CPVC PIPE AND FITTINGS COMPOUNDS

The content of one or more ingredients of CPVC pipe and fittings compositions may be varied without changes in the recommended HDB for 73ºF (23ºC) and 180°F (82°C) provided the formulation variations and the procedures for establishing the recommendation comply to provisions given herein:

H.5.1 Allowable formulation variation for a fixed composition formulation:

H.5.1.1 The formulation shall have a Standard Grade recommended design stress at 73ºF (23ºC) and at 180ºF (82ºC) per section 1.2 of Part A.

H.5.1.2 The originally specified content of any number of the following components may be adjusted within the given limits provided each adjusted component meets the indicated property requirements and the resultant formulation can be processed into pipe of acceptable quality:

| **COMPONENT** | **MAXIMUM COMPONENT VARIATION FROM ORIGINAL SPECIFIED CONTENT *** |
|---|---|
| **Titanium dioxide** | **± 20%** |
| **Calcium stearate** | **± 10%** |
| **Calcium Carbonate** | **± 20%, but not to exceed 5.0 phr, or the original specified amount if greater than 5.0 phr.** |
| **Paraffin Wax** | **± 10%** |
| **Polyethylene Wax** | **± 20%, but not to exceed 0.30 phr, or the original specified amount if greater than 0.30 phr.** |
| **Colorant** | **± 20%** |
| **Process Aid** | **± 20%** |
| **Stabilizer** | **± 20%, but the resultant change not to exceed ± 0.2 phr** |

* Original specified content is that which was contained in the formulation upon which the LTHS was established.

H.5.2 To establish a range with greater component variability:

Select the maximum and minimum levels for one or more ingredients, and proceed as follows:

H.5.2.1 Test data shall be provided as required by Part A of PPI TR-3 for both the compound when prepared with all additives (all ingredients except resin) at the specified maximum level (maximum range formula) and when prepared with all additives at their minimum level (minimum range formula). To assist in the processing of the data, the maximum and minimum range formulas shall be treated as separate entities until the requirements given in b, c and d below are fulfilled. As long as both the maximum and minimum formulas carry a recommendation of the HSB for the same design stress, and other requirements herein stipulated are satisfied, any formula of that compound which lies within the maximum/minimum range also enjoys that recommendation. For range formulas, the provisions for formulation variation for "fixed" composition formulas do not apply; component content beyond that indicated by the maximum/minimum range is not permitted.

H.5.2.2 Stress-rupture data obtained on pipe made from the maximum range formula shall be provided for at least one lot at the maximum temperature for which recommended HDB equivalence is being established in accordance with the schedule given in Part A of PPI TR-3 until the full requirements of ASTM D 2837 are satisfied.

H.5.2.3 Stress-rupture data obtained on pipe made from the minimum range formula shall be provided for at least one lot for the E-2 level of Part A at 180ºF (82ºC) for initial approval. The following data shall be provided for final approval:

- E-6 at 180ºF (82ºC).
  or
- E-2 at 180ºF (82ºC) and E2 at 200ºF (93ºC)

H.5.2.4 To advance the recommendation for the range formula combination to the Standard Grade, in addition to the above, E-2 level data shall be provided for one other lot of pipe extruded on commercial production equipment that is made from any formula lying within the maximum/minimum range. The Standard Grade recommendation for the range formula shall be granted upon each of all the submitted data lots qualifying for the same hydrostatic design basis per ASTM D 2837.

Formulation changes outside these guidelines, including those for recommended HDB at temperatures beyond 180ºF (82ºC), may be evaluated in accordance with other policies and procedures in TR-3.

## H.6 SUBSTITUTION OF THERMAL STABILIZERS IN CPVC PIPE COMPOSITIONS

This policy presents conditions under which stress-rupture data at the E-2 level per Part A are acceptable in demonstrating that the recommended HDB that has been assigned to a CPVC pipe composition are not compromised by the use in that composition of a new, or modified, stabilizer (stabilizer B) as a substitute for the original stabilizer (stabilizer A). Under this policy, consent from the Chairman of the HSB is required before the so-modified composition can be accepted under the recommended values assigned the original, or base, composition. Such consent shall be available provided the following conditions are met:

H.6.1 The composition under consideration is either an independent listing, or is dependent upon an independent listing that carries a Standard Grade recommended value for the temperature in question.

H.6.2 If the composition is a dependent listing, then the owner of the independent listing shall advise the Chairman of the HSB in writing that the proposed stabilizer substitution is an acceptable formulation variation.

H.6.3 Both the original stabilizer (stabilizer A) and the substitute stabilizer (stabilizer B) shall be identified along with the use levels of each. (This information shall be kept administratively confidential by the Chairman of the HSB).

H.6.4 The substitute stabilizer (stabilizer B) shall be an originally specified stabilizer in at least one CPVC compound that carries a Standard Grade hydrostatic design stress recommendation.

H.6.5 The cell classification, when determined in accordance with ASTM D 1784 or D 3915, shall be the same for the composition when made with stabilizer B as was established when made with stabilizer A.

H.6.6 The stabilizer level in the compound must be within the original range and the amount cannot be varied more than allowed by PPI formulation variability policy (See Part H.5). In the case of a range formulation, only the highest usage level of stabilizer must be tested.

H.6.7 Pipe manufactured under commercial production conditions from a compound made with stabilizer B shall, when subjected to hydrostatic testing per ASTM D 1598, yield stress rupture data that when evaluated in accordance with ASTM D 2837, with the exceptions given herein, produces calculated values of the long-term hydrostatic strength, the lower confidence limit and the 50-year intercept that satisfy the ASTM D 2837 requirements for the hydrostatic design basis assigned the compound when formulated with stabilizer A. The exceptions to ASTM D 2837 are that circumferential expansion tests need not be made and the test data only need satisfy the E-2 level requirements of Part A. These tests are to be carried out at the maximum temperature for which recommended HDB equivalence is being established.

Proposed substitutions outside these guidelines may be evaluated in accordance with other policies and procedures in TR-3.

# APPENDICES

# APPENDIX X.1 TEST DATA REPORT REQUIREMENTS

## X.1.1 Checklist for HSB Submissions

The minimum information required by PPI's HSB to develop recommendations of HDB/PBD/SDB/MRS for specific thermoplastic pipe and fitting materials is summarized in the following two submission checklists (one for non-PVC compounds and one for PVC and CPVC compounds). The HSB may require additional information for certain cases.

Complete all sections, then send to the HSB Chairman, along with the signed certification below:

CERTIFICATION TO ACCOMPANY SUBMISSIONS TO THE HSB

I do hereby certify that the data and other information included with this submission are truthful and accurate; that the data are derived from testing actually performed on the samples identified in the submission by (INSERT NAME OF COMPANY OF OUTSIDE LABORATORY THAT CONDUCTED THE TESTING ______________________________________); that the data do not, in any way, misrepresent the performance or other characteristics of the material covered by the submission; and that this submission does not omit any data or information known to my company (including that derived from any testing summarized in this submission) which would be material to an HSB decision on the action requested.

Signed: __________________________________________________

Authorized Representative

Print Name: _______________________________________________

Title: _____________________________________________________

Company: _________________________________________________

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# CHECK LIST FOR HSB SUBMISSIONS

## NON - PVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**1 - Owner of Proposed PPI Listing**

Manufacturer: ______________________________

Address: ______________________________

______________________________

______________________________

Phone: ( ) ______________ Fax: ( ) ______________

Contact: ______________________________

**2 - Data Submission:**

Compound Designation: ______________________________

Compound is Intended for
- ☐ Extrusion Only
- ☐ Molding Only
- ☐ Either Extrusion or Molding

Data Submission is for a:
- ☐ New Formulation
- ☐ Modified Formulation

Base, (or Parent), Formulation is: ______________

______________________________

**Description of Modification**

**3 - Type of Request:**

☐ Routine Request: The data and other information herewith presented are in full compliance with PPI TR-3 requirements for the requested level, (E2, E4, E6, etc.) of PPI listing.

☐ Special Case: Some of the information, as follows, is not in full compliance with the TR-3 requirements:

______________________________

______________________________

______________________________

______________________________

______________________________

Notwithstanding this, it is believed that the data presented are sufficient for granting the request listing based on the following reasons:

______________________________

______________________________

______________________________

______________________________

(**Note**: Special Cases are referred to the HSB for adjudication)

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# CHECK LIST FOR HSB SUBMISSIONS
## NON - PVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**4 - Requested Action:**

Based on this data submission the following action is requested:

☐ A listing of the subject formulation (see Note) for the listing level, (Standard, E2, E4, E6, etc.) of ____________________ ,
for a recommended HDB/PDB/SDB/MRS of ____________ psi,
for a temperature of ____________ $^0$F (or $^0$C, specify), and
external environment of ____________ .

☐ Acceptance of the subject formulation as equivalent to the base formulation. It is requested that this equivalent formulation be listed under:

☐ Its own identification, which is: , ____________________

or

☐ The Base formulation.

**(Note:** Consult PPI TR-3, Parts A & B for listing grades, conditions and requirements)

**5 - Other Data or Listings:**

Does this material have a PPI listing at other temperatures or conditions?

☐ No

☐ Yes (Provide the details)

____________________

____________________

____________________

Are there stress-rupture data available for other temperatures?

☐ No

☐ Yes - Have been previously submitted
(List the temperatures in $^0$C or $^0$F)

____________________

____________________

____________________

; - Are now being submitted via separate data submissions
(List the temperatures in $^0$C or $^0$F)

____________________

____________________

____________________

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# CHECK LIST FOR HSB SUBMISSIONS
## NON - PVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**6 - Pipe or Fitting Material Designation and Classification:**

**ASTM Standard:** ______________________

**Cell Classification or Material Identification** (all cell class values must be listed). ______________________

**Actual Values (indicate the units):**

| Physical Property | Test Method | Average Value, or Range |
|---|---|---|
| Density, g/cc | ASTM D 1505 | |
| Melt Index, g/10 min. | ASTM D 1238 | |
| Tensile strength, psi or MPa | ASTM D638 | |
| Flexural Modulus, psi or MPa | ASTM D790 | |
| Stress Crack Resistance, hrs. | ASTM F 1473 | |

[

**Others:**

| | | |
|---|---|---|
| | | |
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**7 - Compound Mixing:**

Material is: ☐ Pre-Compounded or ☐ Blended In-Plant

**8 - Hydrostatic Stress/Time Data:**

- Use the form in Section 10 to provide the stress, time and failure mode for each lot of pipe that was tested (make copies if necessary). All data points must be reported even though they may not be considered appropriate for the calculation. The reason for the latter is to be given.

- Indicate the Mode of Failure in Section 10, using the following codes:

N - Non-failure point
S – Shatter
D – Ductile
B - Brittle
? - Other, Specify

# CHECK LIST FOR HSB SUBMISSIONS

## NON - PVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**8 - Hydrostatic Stress/Time Data (cont'd):**

- Is Creep the controlling factor?

(See Paragraph 5.3, "Circumferential Expansion", of ASTM D2837 for details on data requirements for evaluating creep as a potential limiting factor. Based on historical data, PPI's HSB recognizes the following materials as having long term strengths which are not limited by the ASTM D2837 creep criterion: PVC, medium and high density PE, CPVC, PA & PB.)

☐ **No** Present the basis for this conclusion if the material is other than those listed above.

☐ **Yes** Present the circumferential expansion data summary and resultant calculations on a separate data sheet.

- Calculate the 100,000-h LTHS, 50-year intercept, LCL and LCL Ratio and show these results in Section 10.

- Computer printouts of the data and calculations are acceptable if they provide the information requested in Section 10 in an easy to read format.

- Polyethylene materials, which are to be listed with an HDB at 73°F and at higher temperatures, must also undergo supplemental validation of the long-term hydrostatic strength in accordance with Clause 5.6 of ASTM D2837, or Part F.4 of TR-3.

Remember to submit these validation data on a separate data sheet.

- For crosslinked polyethylene (PEX) pipe data, what is the measured level of cross-linking for specimens tested?

____________________

What is the measurement method? ______________________________________________

**The listed HDB/MRS for this PEX pipe will be based on this minimum crosslink level.**

**9 - Hydrostatic Stress Summary** (indicate the units)

HDB/PDB/SDB/MRS requested: ☐ psi or MPa

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# CHECK LIST FOR HSB SUBMISSIONS

## NON - PVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**10 - Data Submission for Lot #_________:**

10.1 - Actual Stress/Time Data

Average Outside diameter, in: ____________
(approximate values)
Minimum Wall Thickness, in: ____________

| Stress psi | Time h | Failure Mode (see 8.2) |
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10.2 - Fabrication Process

10.2.1 - Extrusion: ☐

Extrusion was done on:
☐ Laboratory Equipment and Conditions
or
☐ Production Equipment and Conditions

10.2.2 - Molding: ☐

Type of Mold:

☐ Side Gated
or
☐ End Gated

(indicate the units)
Outside Diameter: ____________ Average

Wall Thickness; ____________ / ____________ Minimum Average

Length: ____________ Average

10.3 - Hydrostatic Properties

100,000 h LTHS: ____________ psi or MPa

50 year intercept: ____________ psi or MPa

LCL: ____________ psi or MPa

LCL Ratio: ____________ %

Temperature: ____________ ⁰C or ⁰F

Environment:

Inside Pipe: ____________

Outside Pipe:

E Level: ☐ 2 ☐ 4 ☐ 6 ☐ 8 ☐ 10 ☐ ____

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# CHECK LIST FOR HSB SUBMISSIONS PVC and CPVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**1 - Owner of Proposed PPI Listing**

Manufacturer: ____________________

Address: ____________________

____________________

____________________

Phone: ( ) ____________________ Fax: ( ) ____________________

Contact: ____________________

**2 - Data Submission:**

Compound Designation: ____________________

Submission is a:

☐ New PVC Formulation (see 6.1.1)

☐ New Compound (See 6.1.3), for:

(check one of the following:)

☐ PVC Resin (6.1.2)

☐ Process Aid

☐ Heat Stabilizer

Commercial Designation of the new Component: ____________________

(Attach Physical Property Data Sheet)

☐ PPI Range Formulation

☐ Private Formulation

☐ Other component not complying to the guidelines of PPI TR-3: ____________________

Specify

☐ Special Case (Attached an explanation of why it should be considered)

**3 - Compound Mixing:**

Equipment:

☐ High Intensity Mixer or ☐ ____________________ Describe Other

☐ Low Intensity Cooler or ☐ ____________________ Describe Other

Procedure:

☐ Double Batching or ☐ Single Batching

Description:
(Describe the procedure followed in preparing the compound. See Note 7 of TR-3)

____________________

____________________

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____________________

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# CHECK LIST FOR HSB SUBMISSIONS PVC and CPVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**4 - Fabrication Process:**

4.1 - Extrusion: ☐

Extrusion was done on: ☐ Laboratory Equipment and Conditions or ☐ Production Equipment and Conditions

4.1 - Molding: ☐ Type of Mold ☐ Side Gate or ☐ End Gate

Specimen Dimensions, in or mm (Indicate Units):

Outside Diameter: ________ Average

Wall Thickness: ________ / ________ Minimum / Average

Length: ________ Average

**5 - Resin and/or Compound Properties:**

5.1 - Resin Properties:

| (Only required if **PVC Resin** box was checked in Section 2) | | **Lot 1** | **Lot 2** | **Lot 3** | |
|---|---|---|---|---|---|
| | | — (if required) — | | | |
| Inherent Viscosity | ASTM D1243 | ______ | ______ | ______ | (0.88 - 0.96) |
| Heat Loss (water) % by wt. | 1 hr @ 221$^0$F (105$^0$C) | ______ | ______ | ______ | (0.5 max.) |
| Apparent Bulk Density, g/cc | ASTM D1895 | ______ | ______ | ______ | (0.46 - 0.62) |
| Compacted Bulk density, g/cc | ASTM D1895 (Method C) | ______ | ______ | ______ | (0.54 - 0.72) |
| RVCM | ASTM D3749 | ______ | ______ | ______ | (10 ppm max.) |

5.1 - Compound Properties:

Cell Classification per ASTM D1784: ________________

Actual Values (indicate units):

| | | |
|---|---|---|
| Base Resin | | PVC |
| Izod Impact Strength, ft-lb/in or J/m | ASTM D256 Method A | ______ |
| Tensile strength, psi or MPa | ASTM D638 | ______ |
| Modulus of elasticity, psi or MPa | ASTM D638 | ______ |
| Deflection temperature under load, $^0$F or $^0$C [264 psi (1.82 MPa) load] | ASTM D648 | ______ |

# CHECK LIST FOR HSB SUBMISSIONS PVC and CPVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

## 6 - Hydrostatic Stress/Time Requirements

6.1 - Data Required:

| | Provisional Listing | Standard Listing |
|---|---|---|
| 6.1.1 - New PVC Formulation: | ☐ Provisional Listing: ≥ E2 followed by ≥ E4, E6, etc. every 6 months. | ☐ Standard Listing: E10 on one lot plus ≥ E2 on two additional lots. |
| 6.1.2 - New PVC Resin:: (stabilizer and calcium carbonate must be at the maximum of range). | ☐ Provisional Listing: ≥ E6 followed by ≥ E8, etc. every 6 months. | ☐ Standard Listing: E10 on one lot plus ≥ E2 on two additional lots. |
| 6.1.3 - New Component: (subject component must be at the maximum of range). | ☐ Provisional Listing: ≥ E6 followed by ≥ E8, etc. every 6 months. | ☐ Standard Listing: E10 on one lot plus ≥ E2 on two additional lots. |

6.1.4 - Special Case:
(what protocol is proposed?) ____________________

6.2 - Stress/Time Data:

- Use the forms in Section 8 to provide the stress, time and failure mode for each lot of pipe that was tested. All data points must be reported even though they may not be considered appropriate for the calculation. The reason for the latter is to be given.
- Indicate the mode of failure using the following codes:

| | |
|---|---|
| N - Non-failure point | B - Brittle |
| S - Shatter | ? - Other, Specify |
| D - Ductile | |

- Calculate the 100,000-h LTHS, 50-year intercept, LCL and LCL Ratio and show these results in Section 8.
- Computer printouts of the data and calculations are acceptable if they provide all the information requested in Section 8 in an easy to read format.

## 7 - Hydrostatic Stress Summary: (Indicate the units)

HDB/PDB/SDB/MRS requested ☐ psi or MPa

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# CHECK LIST FOR HSB SUBMISSIONS PVC and CPVC COMPOUNDS

Consult PPI TR-3 for Definitions, etc. Date:

**8 - Actual Stress/Time Data:**

**Lot #** ______________

Size, In: ______________

SDR # or SCH #: ______________

| Stress psi | Time h | Failure Mode (see 6.2.2) |
|---|---|---|
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100,000 h LTHS: ______________ psi or MPa

50 Year intercept: ______________ psi or MPa

LCL: ______________ psi or MPa

LCL Ratio: ______________ %

Temperature: ______________ $^0$C or $^0$F

Environment:

Inside Pipe: ______________

Outside Pipe: ______________

E Level: 2 ☐ 4 ☐ 6 ☐ 8 ☐ 10 ☐

**Lot #** ______________

Size, In: ______________

SDR # or SCH #: ______________

| Stress psi | Time h | Failure Mode (see 6.2.2) |
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100,000 h LTHS: ______________ psi or MPa

50 Year intercept: ______________ psi or MPa

LCL: ______________ psi or MPa

LCL Ratio: ______________ %

Temperature: ______________ $^0$C or $^0$F

Environment:

Inside Pipe: ______________

Outside Pipe: ______________

E Level: 2 ☐ 4 ☐ 6 ☐ 8 ☐ 10 ☐

### X.1.2 Additional Information

Supplemental information useful in the development of new or improved policies and in enhancing the quality of correlation, interpretation and extrapolation of stress-rupture data is welcomed by the HSB. For example, data obtained on poor quality pipe (i.e., pipe that does not meet the latest standards and/or specifications), will be helpful and will be used to study the method and other auxiliary procedures used to develop recommended HDB/PDB/SDB/MRS values and in preparing effective product specifications. The sources of such data and the detailed data itself will be kept confidential if those submitting such data so request. For this purpose, the material identification may be omitted from the report. Data in this category will not be used as a basis for developing recommendations for hydrostatic design stresses for plastic pipe materials. It should be noted that design stresses cannot be recommended for pipe materials that do not meet current standards and specifications.

The submission of results of research and development studies on the stress rupture behavior of thermoplastic pipe and field experiences on the effect of changes in formulations are also requested. Such data are helpful in determining whether or not changes in or additions to these policies and procedures should be made, thereby improving plastic pipe engineering.

### X.1.3 Release of Recommendations

The HSB will not issue any recommendations for HDB/PDB/SDB/MRS values for specific commercial materials without the written approval of the manufacturers of the materials.

Data and other information should be sent to:

Stephen Boros, Chairman
Hydrostatic Stress Board
Plastics Pipe Institute, Inc.
105 Decker Court, Suite 825
Irving, TX 75062
sboros@plasticpipe.org

### X.1.4 Appeals of HSB Actions

It is PPI's hope that a thorough understanding of the policies and procedures for developing recommended HDB/PDB/SDB/MRS values for thermoplastic piping materials will minimize any disputes or disagreements regarding HSB actions on requests for recommendations. However, if a manufacturer disagrees with an action taken by the HSB in regard to his product, he may request that the HSB review its initial determination. The action on any request for review will be subject to approval by PPI's President and Counsel.

A request by a manufacturer for review of a disagreement with the HSB must be in writing and contain a complete description of the manufacturer's original proposal and sufficient information to accurately explain the nature of the disagreement and the decision or action sought by the manufacturer. Upon receipt by the HSB, the Board will consider the matter and reply in writing to the manufacturer within thirty (30) days. The manufacturer may, if he so chooses, request a conference call with, or appear before the

Board to discuss the issue. If necessary, the HSB may request any additional information needed to reach a decision.

### X.1.5 Confidentiality

Neither PPI staff, PPI members, nor any member of the HSB will make any public comment on the status of a particular manufacturer's products or test results, except to note whether the product is publicly listed in PPI's TR-4.

# APPENDIX X.2

# SUGGESTED LETTERS FOR TRANSMITTING THE INFORMATION REQUIRED BY VARIOUS PARTS OF THIS REPORT

**FOR PART D.3 - ESTABLISHING DEPENDENT LISTINGS:**

**X.2.1 Letters from owner of independent listing:**

A. Covering condition of complete equivalence of mixing and processing of the independent and dependent formulation. (For example, when premixing and extrusion of dependent formulation uses basically the same equipment and conditions as used for independent formulation.)

Dear ________________________________________

(Chairman of HSB):

Our (give independent formula designation) is presently listed by PPI as a (give PPI material designation, e.g., PVC 1120). The following recommended hydrostatic design basis (HDB) or Minimum Required Strength (MRS) has been established by PPI on the basis of the data we provided: (list the HDB/MRS for each temperature for which an HDB/MRS recommendation has been granted).

We have supplied (give name and address of the intended receiver of this formulation) the formulation for this composition, and the specification requirements and source of supply for all required ingredients. In addition we have furnished them with all pertinent information, including equipment description and mixing and processing details, such that their processing of this composition can be equivalent, and yield a product that is equivalent, to that represented by the data we supplied on behalf of (give name of independent formula designation).

Therefore, we request, and grant permission, for the test data developed for (give independent formula designation) to be used for the transfer of the above HDB/MRS recommendations to the (give name of company receiving transfer) who will be preparing this composition, and listing it, under their designation (give dependent formula designation).

*_________________ agrees to hold the Plastics Pipe Institute (PPI) harmless and indemnify PPI for any and all liability, loss, damage, cost and expense which PPI may suffer, incur, or be put to by reason of any claim, suit or proceeding for personal injury, property damage or economic loss on account of the failure or alleged failure of the compound listed (or pipe produced from the compound) to conform to specifications on which the listing is based, or based on the HDB or MRS assigned to the compound, and *_________ further agrees to defend PPI at *________________'s expense, against any and all suits, claims or proceedings.

Yours very truly,
*Give company name

B. Covering condition where complete equivalence mixing and processing cannot be assured (see 1.1.3 of D.3). (For example, when a melt homogenized compound was used to prepare pipe under the independent listing but the dependent listing will depend solely on the extrusion process to effect proper mixing.)

Dear (Chairman of HSB):

Our (give independent formula designation) is presently listed by PPI as a (give PPI material designation, e.g., PVC 1120). The following recommended HDB or MRS has been established by PPI on the basis of the data we provided: (list the HDB/MRS for each temperature for which an HDB/MRS recommendation has been granted).

We have supplied (give name and address of the intended receiver of this formulation) the formulation for this composition and the specification and source of supply for all required ingredients. In addition we have furnished them with all pertinent information, including equipment description and mixing and processing details, such that their processing of this composition can be equivalent, and yield a product that is equivalent, to that represented by the data we supplied on behalf of (give name of independent formula designation).

However, because of certain apparent differences between the processes by which (give name of independent formula designation) was prepared and that by which it will be prepared by (name of intended receiver), we cannot establish with reasonable certainty complete equivalence between the two processes.

Accordingly, we request that in accordance with D.3 of TR-3 the test data we developed on behalf of (give independent formula designation) be used for the transfer, for a maximum period of six months, of the HDB/MRS recommendations referenced in the first paragraph. Prior to the end of this period confirmatory data shall be supplied by us (or by intended receiver).

{An alternate to this last paragraph is the following.}

Therefore, we request that in accordance with D.3 of TR-3 the test data we developed on behalf of (give independent formula designation) be used for the transfer of the HDB/MRS recommendations referenced in the first paragraph, after they are first reduced by a factor of 0.80.

*___________ agrees to hold the Plastics Pipe Institute (PPI) for any and all liability, loss, damage, cost and expense which PPI may suffer, incur, or be put to by reason of any claim, suit or proceeding for personal injury, property damage or economic loss on account of the failure or alleged failure of the compound listed (or pipe produced from the compound) to conform to specifications on which the listing is based, or based on the HDB or MRS assigned to the compound, and *__________ further agrees to defend PPI at *____________'s expense, against any and all suits, claims or proceedings.

Yours very truly,
*Provide Company Name

**X.2.2 Letter from intended receiver of dependent listing:**

Dear ________________________________________

(Chairman of HSB)

We have received from (give name and address of owner of independent listing) the formulation, and the specification requirements and the source of all required ingredients, for their (give PPI material designation, e.g., PVC 1120) composition (give independent formula designation). In addition we have been furnished with all pertinent information, including equipment description and mixing and processing details, to allow us to process this composition as an equivalent to that represented by the data that was supplied by the HSB (give name of owner of independent formula) on behalf of this composition. It is our intention to exactly reproduce this composition, which we will designate as (give dependent composition designation), and to process it in accordance with this information. Please publish (or do not publish) this new listing in the next update to PPI's TR-4, and notify NSF International of your acceptance of this listing.

Accordingly, we request that the data supplied on behalf of (give name of independent formulation) be used for the transfer of the HDB or MRS recommendation for the composition to (give dependent composition designation). We accept any time limitation and data requirements or stress reduction established by (give name of owner of independent formulation) for this transfer.

*_____________ agrees to hold the Plastics Pipe Institute (PPI) harmless and indemnify PPI for any and all liability, loss, damage, cost and expense which PPI may suffer, incur, or be put to by reason of any claim, suit or proceeding for personal injury, property damage or economic loss on account of the failure or alleged failure of the compound listed (or pipe produced from the compound) to conform to specifications on which the listing is based, or based on the HDB or MRS assigned to the compound, and *__________ further agrees to defend PPI at *_____________'s expense, against any and all suits, claims or proceedings.

Sincerely,

*Provide Company Name

### X.2.3 FOR PART E.4: RESIN SUBSTITUTION IN PVC COMPOSITIONS

Dear ________________________________________
(Chairman of HSB):
Presently, our PVC pipe formulation (give formula designation) carries a HSB recommended hydrostatic design basis (HDB) or Minimum Required Strength (MRS) of {give value(s) and temperature(s)}. We request the consent of the HSB for the use of alternate PVC resin (description of alternate resin) in addition to the originally specified PVC resin (designation of originally specified resin). The proposed alternate resin has been determined by us to be an acceptable substitute for the original resin on the basis of our requirements for this compound as well as the following criteria proposed by the HSB:

- (in case this is a dependent formulation) the owner of this formulation has established that this proposed resin substitution is acceptable and communications in this regard has been sent to you by him.
- the alternate resin is an originally specified material in at least one other PVC pipe formulation carrying a Standard Grade recommendation from the HSB.
- the use of the alternate resin has been determined not to result in any change of the ASTM material cell classification of the originally formulated compound. Supporting data are included with this letter.
- both the alternate and the original resins satisfy the following property requirements:

| PROPERTY | TEST METHOD | REQUIREMENT |
|---|---|---|
| **Type of Material** | **-------** | **PVC Homopolymer** |
| **Inherent Viscosity** | **ASTM D 1243** | **0.88 - 0.95** |
| **Heat Loss (water); by wt.** | **1 Hr. @ 221$^0$F (105$^0$C)** | **0.5 max.** |
| **Apparently Bulk Density gm/cc** | **ASTM D 1895** | **0.46 - 0.62** |
| **Compacted Bulk Density, gm/cc** | **-------** | **0.54 - 0.72** |
| **RVCM** | **-------** | **10 ppm max.** |

Stress rupture data demonstrating that the long-term strength category of the formulation is unaffected by the use of the alternate resin are enclosed. These data support an initial approval from the HSB for this proposed formulation modification and we request that such approval be granted.

*_________ agrees to hold the Plastics Pipe Institute (PPI) harmless and indemnify PPI for any and all liability, loss, damage, cost and expense which PPI may suffer, incur, or be put to by reason of any claim, suit or proceeding for personal injury, property damage or economic loss on account of the failure or alleged failure of the compound listed (or pipe produced from the compound) to conform to specifications on which the listing is based, or based on the HDB or MRS assigned to the compound, and *________ further agrees to defend PPI at *_____________'s expense, against any and all suits, claims or proceedings.

Sincerely,

(*Provide Company Name)

## X.2.4 FOR TR-2/TR-4: PPI PVC GENERIC RANGE FORMULATION:

Dear ________________________________________
(Chairman of HSB):

We wish to list with PPI, under our commercial designation _________________, the pre-qualified PVC range compound as defined in PPI TR-2. We would also like to have this listing published in PPI TR-4, and NSF International notified of your acceptance of this listing. We understand and agree that this listing is given subject to the policies and procedures set forth in PPI TR-2 and TR-3.

We understand that this PVC compound is pre-qualified for a 4,000 psi hydrostatic design basis, and a maximum hydrostatic design stress of 2,000 psi, for water at 73ºF (23ºC), provided that only the specified materials are used, the blend of these materials is suitably homogenized prior to extrusion, and the extrusion into pipe is so conducted as to satisfy all the requirements of the applicable and current ASTM, AWWA, API, or other product standards.

We also understand that we shall be periodically advised, by the issuance of the update to PPI TR-2 and TR-3, of any approved changes in composition and approved components of this compound to which we shall comply.

In addition, we reserve the right to modify this composition for public, or our own private use, in accordance with the stipulations given in PPI TR-3.

*______________________ agrees to hold the Plastics Pipe Institute (PPI) harmless and indemnify PPI for any and all liability, loss, damage, cost and expense which PPI may suffer, incur, or be put to by reason of any claim, suit or proceeding for personal injury, property damage or economic loss on account of the failure or alleged failure of the compound listed (or pipe produced from the compound) to conform to specifications on which the listing is based, or based on the HDB or MRS assigned to the compound, and *__________________ further agrees to defend PPI at *_______________'s expense, against any and all such suits, claims or proceedings.

Sincerely,

(*Provide Company Name)

# APPENDIX X.3

# CALCULATION EXAMPLE TO CONVERT PVC COMPOUND FORMULATIONS FROM PHR TO WEIGHT PERCENT

**GIVEN:** A typical PVC pressure pipe compound formulation is expressed in PHR, or parts of a specific ingredient per 100 parts resin used. This makes batching caluclations easier. PHR is not the same as weight percent, but the conversion from one basis to the other is fairly straight forward.

An example of such a formulation is given in the Table below.

| Ingredient Type | PHR | Weight Percent (%) |
|---|---|---|
| Resin | 100.00 | 92.57 |
| Heat Stabilizer | 0.70 | 0.65 |
| Paraffin | 1.20 | 1.11 |
| PE Wax | 0.15 | 0.14 |
| Calcium Carbonate | 5.00 | 4.63 |
| Titanium Dioxide | 0.50 | 0.46 |
| Pigment | 0.03 | 0.03 |
| Calcium Stearate | 0.45 | 0.42 |
| TOTAL | **108.03** | **100.00** |

**DETERMINE: What is the weight percent for each individual ingredient?**

1. Write down the PVC compound ingredients expressed as parts by weight for every ingedient in the formulation.(see column headed "PHR")
2. Add the PHR column of individual ingredients to obtain a total number of parts utilized (i.e. - pounds / one hundred lbs. of PVC resin) (e.g. 100+0.7+ 1.2+0.15+5.0+0.5+0.03+0.45 = 108.03
3. To calculate the corresponding weight percent for each ingredient, divide the PHR for each ingredient by the total number of parts utilized. Then multiply by 100 (e.g. (1.20 / 108.03) x 100 = 1.11%).
4. Record these results in the column labeled "weight percent".
5. Check - If the calculation was performed correctly, the total weight percent must equal 100 percent.

# APPENDIX X.4

## PPI Membership

PLASTICS·PIPE·INSTITUTE®

# 8 Reasons to Join the Plastics Pipe Institute

1. **Learn from the Experts – Your Industry Peers!**
PPI offers unmatched opportunities to learn more about the plastics pipe industry from the experts in your industry – your peers. Learn about best practices, market opportunities, standardization issues, ongoing research and many other areas critical to your company's success.

2. **Input into Industry Positions**
PPI is recognized as the industry voice before North American and international standards setting organizations, code writing bodies, municipalities and other regulatory agencies. And we regularly provide industry positions to these groups. Help us develop positions that will benefit your interests.

3. **Networking**
Membership allows you participation in all PPI forums and meetings. At these events, you will meet and learn from your peers in the industry. Our membership includes material and additive suppliers, pipe manufacturers, equipment manufacturers and distributors, giving you access to the complete supply chain. PPI's Spring and Fall meetings are recognized throughout the industry as "must-attends" and are open to members only.

4. **Technical Credibility of PPI and the Use of the PPI Logo**
PPI is recognized around the world as the technical expert on plastic piping issues. The use of our logos is available to members only, and provides unmatched credibility. Use the logo(s) on your literature, product packaging, website and business cards to show that you are part of the worldwide leader on plastic pipe issues.

5. **Links to Your Company from PPI's Website**
We provide links to all of our members through our website www.plasticpipe.org. PPI has thousands of visitors monthly, all looking for suppliers of piping products, or information about products. We provide a link for them to quickly get to you.

6. **Services of PPI's Staff**
Our technical, engineering and marketing staff are ready to answer your questions and help you grow your business. This knowledge base is available to members everyday, and is a benefit we encourage you to use. Call us today!

7. **Discounts on PPI Services & Products**
PPI members get significant discounts on PPI's products and services, including literature, certification program fees and product listing fees. These products and services will help your business succeed – and at a discount!

8. **50 + Years of Experience**
PPI was founded in 1950, and through responsible and credible leadership, has established itself as the technical and marketing leader of the industry before a wide variety of stakeholders. Today, PPI is the voice of the plastics piping industry.

***Working to make plastics the material of choice for all piping applications.***