

Book 1: Chapter 4 - Polyethylene Material Standards

Cell Classification Number

Polyethylene pipe and fitting materials (resins) are characterized according to ASTM D 3350. This standard identifies polyethylene piping resins according to a cell classification system that sequentially identifies seven physical properties. Cell numbers and letters are used to identify physical property cell value ranges for the physical properties. A “cell classification number” thus identifies seven physical properties, and value ranges for those properties.¹

Table 4-1 identifies in order, the physical properties specified in ASTM D 3350, and the value ranges for those properties.

An ASTM D 3350 cell classification identifies specific physical properties and value ranges for these physical properties.

- *ASTM D 3350 does not specify manufacturing tolerances for resin physical properties.*
- *ASTM D 3350 does not provide specific engineering data for design purposes.*

The cell classification for a resin is based on the resin manufacturer’s typical (average, nominal, etc.) physical property values for numerous production lots of a material. However, the manufacturer’s material production tolerances can allow a production lot or a single test specimen to be outside of ASTM D 3350 cell classification range values. This does not indicate an out of specification material. For this reason, it is not appropriate to use ASTM D 3350 cell value ranges as a basis for determining whether a material sample meets a manufacturer’s specifications.

For example, a medium density PE material has a typical density value of 0.940 g/cm³ and a resin manufacturing tolerance for density of ±0.005 g/cm³. Under ASTM D 3350, the material is correctly classified as a density cell 2 (0.926-0.940 g/cm³) material. Within the manufacturer’s tolerance, the acceptable density range for this example material is from 0.935 g/cm³ to 0.945 g/cm³; therefore, any single specimen or individual lot having a density between 0.940 g/cm³ and 0.945 g/cm³ is correctly classified as a Density Cell 2 material, and is not an out-of-specification material.

Long Term Strength

Most of the material properties discussed thus far are evaluations of short-term performance. However, durable goods such as pipe must handle the application for the long-term.

Traditional metal and concrete pipes usually deteriorate over time from galvanic or chemical corrosion. Thus, long-term corrosion resistance is a critical design consideration for these materials.

Polyethylene is immune to galvanic corrosion, and resistant to a wide range of chemicals that corrode traditional piping materials. Polyethylene piping must be engineered for resistance to cracking from long-term application-applied stresses. Applied stresses may be tensile or compressive or both; however, long-term performance is normally associated with resistance to cracking from tensile stresses.

¹ ASTM D 1248 is no longer applicable to piping materials. In 1998, PE piping materials were deleted from D 1248.

Table 4-1 ASTM D 3350 Properties and Cell Classification Limits

Property	Test Method	0	1	2	3	4	5	6	7
Density, gm/cm ³	D 1505	(a)	0.910-0.925	0.926-0.941	0.941-0.955	>0.955	–	–	(b)
Melt Index, gm/10 min	D 1238	(a)	>1.0	1.0 - 0.4	<0.4 – 0.15	<0.15	(c)	(d)	(b)
Flexural Modulus, MPa, (1000 psi)	D 790	(a)	<138 (<20)	138 - <276 (20 - <40)	276 - <552 (40 - <80)	552 - <758 (980 - <110)	758 - <1103 (110 - <160)	>1103 (>160)	(b)
Tensile Strength, MPa (1000 psi)	D 638	(a)	<15 (<2.2)	15 - <18 (2.2 - <2.6)	18 - <21 (2.6 - <3.0)	21 - <24 (3.0 - <3.5)	24 - <28 (3.5 - <4.0)	>28 (>4.0)	(b)
Slow Crack Growth Resistance (e)									
1. ESCR a. Test Condition b. Test Duration c. Failure, max, %	D 1698	(a)	A 48 50	B 24 50	C 192 20	C 600 20	–	–	(b)
2. PENT (hours) Molded plaque; 80°C; 2.4 MPa; Notch depth per Table 1 F 1473	F 1473	(a)	0.1	1	3	10	30	100	(b)
Hydrostatic Design Basis, MPa (psi)	D 2837	NPR (f)	5.22 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)			
Cell Classification Letter (g)		A	B	C	D	E			
Color & UV Stabilizer	D 3350	Natural	Color	Black; 2% min. carbon black	Natural with UV stabilizer	Color with UV stabilizer			
<p>(a) Unspecified.</p> <p>(b) Specify value.</p> <p>(c) Classify materials having a melt index <0.15 as Cell 5 only if they have a flow rate not greater than 4.0 g/10 min when tested in accordance with Test Method D 1238, Condition 190/21.6.</p> <p>(d) Classify materials having a melt index <0.15 as Cell 6 only if they have a flow rate not greater than 0.30 g/10 min when tested in accordance with Test Method D 1238, Condition 310/21.5.</p> <p>(e) Slow Crack Growth Resistance is classified using either ESCR per D 1693 or PENT using F 1473, but not both. Where there are cell values for ESCR per D 1693 and PENT per F 1473, equivalency of material performance between D 1693 and F 1473 is not implied.</p> <p>(f) NPR = not pressure rated.</p> <p>(g) The letter denoting the classification for color and UV stabilizer is added at the end of the cell classification number.</p>									

Externally applied tensile and compressive stresses may result from earthloads, or thermal expansion or contraction. Internal (hoop) tensile stresses are applied when there is pressure inside the pipe. In general, higher stress, higher temperature, higher concentrations of aggressive chemicals, and cyclically applied stresses act to reduce lifetime.

Polyethylene pipe materials are evaluated for long-term stress by conducting long-term sustained pressure tests per ASTM D 1598. Data from these tests are evaluated in accordance with ASTM D 2837.

Based on the data, the temperature and the media inside the pipe, a long-term hydrostatic stress (LTHS) is determined. The LTHS is compared to hydrostatic design basis (HDB) categories to determine the HDB - the material's long-term tensile stress rating at a temperature and for a given fluid media. The HDB is used for pressure rating, and in engineering calculations that involve long-term tensile strength. Pressure rated polyethylene materials must also undergo testing and analysis to validate that a ductile to brittle transition will not occur during the projected service period.

Lastly, the long-term performance of polyethylene piping in an application is highly dependent upon installation. When the piping and the installation are properly designed for the application and the pipe is properly installed in accordance with the installation design, application and installation related stresses are minimized, and long-term performance is maximized.

Application, design, and installation information is available in the *Performance Pipe Engineering Manual, Books 1, 2, and 3*, information and standards from AGA, ASTM, AWWA, PPI, and others, and regulatory and codifying agencies.

Material Designation Code

Polyethylene materials for pressure piping are commonly identified by an ASTM Material Designation Code (PE 2406 or PE 3408). ASTM defines the Code as the letter abbreviation for the thermoplastic (PE for polyethylene), followed by two numbers that identify ASTM D 3350 cell values for density and slow crack growth resistance, followed by two numbers that identify the material's Hydrostatic Design Stress, HDS², in hundreds of psi with any tens and units dropped.

ASTM Material Designation Codes for Performance Pipe pressure piping materials are:

Medium density - PE 2406

PE = polyethylene

2 = density cell 2

4 = SCG cell 4 or higher³

06 = 630 psi HDS⁴

High density - PE 3408

PE = polyethylene

3 = density cell 3

4 = SCG cell 4 or higher³

08 = 800 psi HDS

² The Hydrostatic Design Stress, HDS = HDB X f_E , an environmental design factor.

³ PE 2406 and PE 3408 materials used for ASTM D 2513 for gas distribution applications must have a SCG cell 6.

⁴ Unless otherwise specified, the HDS is for water at 73°F (23°C), that is, HDS = HDB x 0.50.

Performance Pipe Materials

Performance Pipe pressure-piping products are manufactured from either medium density or high-density polyethylene materials that have been engineered to provide the balance of properties required for the intended application. Medium density is usually produced in a yellow color, and used in gas distribution service. High-density materials are provided in black and various colors. Different pigments are used for co-extruded striped or color shell pipe; however, the base resin is the same for pipe, shell and stripe.

- Performance Pipe medium density polyethylene materials are listed by the Plastics Pipe Institute in PPI TR-4 with minimum standard grade hydrostatic design basis ratings of 1250 psi (8.62 MPa) at 73° F (23° C) and 1000 psi (6.89 MPa) at 140° F (60° C) and meeting or exceeding an ASTM D 3350 cell classification of 234363E.
- Performance Pipe high density polyethylene materials are listed by the Plastics Pipe Institute in PPI TR-4 with minimum standard grade hydrostatic design basis ratings of 1600 psi (11.03 MPa) at 73° F (23° C) and 800 psi (5.52 MPa) at 140° F (60° C) and meeting or exceeding an ASTM D 3350 cell classification of 345464C for black.
- DriscoPlex™ 2000 SPIROLITE® high density polyethylene pipe material meets or exceeds ASTM D 3350 type and grade specification PE33, with a minimum ASTM D 3350 cell classification of 335444C
- Performance Pipe HDPE conduit is manufactured from utility-grade HDPE material that is engineered for the requirements of conduit applications including pull strength, stiffness, ESCR, density, melt index, chemical resistance and toughness.