



1.0 Introduction

Effective August 2007, Hawkeye Industries Inc. will no longer publish pressure rating information on manufactured polyethylene fittings. The Polyethylene material designation and standard dimensional ratio will still be applied to all fittings leaving the manufacturing facility, and will continue to be included on any quotation, packing slip and invoices. It is the responsibility of the end-user to ensure that the material and SDR specified is appropriate for their application and jurisdiction. This document is intended as a guideline to establish the pressure rating of a polyethylene fitting based on material, application and temperature.

2.0 Codes and Standards

Polyethylene material used for pipe and fittings falls under the jurisdiction of some, or all of these documents, based on application.

ASTM D3350-06

Standard Specification for Polyethylene Pipe and Fittings Materials

CSA Z662-07

Oil and Gas Pipeline Systems

ERCB Directive 077¹

Pipelines – Requirements and Tools

PPI TR-4/07a

HDP/PDB/SDB/MRS Listed Materials

PPI TR-9/92

Recommended Design Factors and Design Coefficients for Thermoplastic Pipe

3.0 Full Pressure Rating and ID Control

Unless specified otherwise, all polyethylene fittings manufactured by Hawkeye Industries are fully pressure rated. There is no reduction in pressure rating as a result of the fitting construction.

As per **ASTM F2206-02**, fittings with mitered butt-fusion joints must have 25% greater wall thickness in the region of the fusion, achieved by decreasing to the next nominal SDR. However, to simultaneously maintain ID-Control and full pressure rating, Hawkeye Industries increases fitting OD in the region of the fusion(s). This ensures a constant inside-diameter free of obstruction, while still maintaining the minimum 25% wall thickness increase.

4.0 Pressure Rating

4.1 Polyethylene Nomenclature

Polyethylene material can be expressed as a cell classification, as described in **ASTM D3350-06**, or in a PPI-derived short-hand. The designation follows the form:

PE

a	b	c	d
---	---	---	---

Starting with the abbreviation “PE” for “polyethylene,” the following 4 places are filled with:

a: the value from the cell classification for density (1st cell)

b: the value from the cell classification for slow crack growth resistance (5th cell)

c & d: the hydrostatic design stress, in psi, with the tens and ones columns dropped, and a leading zero if the HDS is less than 1000 psi.

For example, a PE material with cell classification 345474C and HDS of 800 psi would be designated PE3708. Similarly, a material with cell classification 446574C with HDS of 1000 psi would be designated PE4710.

4.2 Determining pipe and fittings pressure rating via CSA Z662-07

CSA Z662-07 uses the following formula to calculate pressure rating:

$$P = \frac{2S}{R-1} \times F \times T \quad \text{Eq. 4.1}$$

Where:

P = Pressure Rating [MPa]

S = Hydrostatic Design Stress [MPa]

R = Dimensional Ratio

F = Service Fluid Factor

T = Design Temperature Factor

Table 13.2 provides the hydrostatic design stress value for both cell classifications and polyethylene designation. A summary is tabulated below:

ASTM D3350 Cell Classification*							PPI Designation
3	4	5	4	6 7	4	C	PE3608 PE3708
S = 5.5 MPa (11 MPa HDB x 0.50 Design Factor)							
3	4	5	4	7	4	C	PE3710
4		6	5				PE4710
S = 6.9 MPa (11 MPa HDB x 0.63 Design Factor)							

Table 4.1 Summary of Table CSA Z662-07 Table 13.2

¹ Rescinds and Replaces EUB Directive 022

*Refer page 296 in CSA Z662-07 for information and important usage notices.

Table 13.3 provides the service fluid factor. This is a design factor based on the service fluid in the pipeline system:

Service	F
Dry Gas Gathering**	1
Wet Gas Gathering	0.5
Multiphase	0.5
LVP Liquid Hydrocarbons	0.5
Oilfield Water (>=2% Liquid Hydrocarbon)	1
Oilfield Water (<2% Liquid Hydrocarbon)	0.5

Table 4.2 Summary of Table CSA Z662-07 Table 13.3

** Refer page 297 in CSA Z662-07 for information and important usage notices.

Table 13.4 provides the design temperature factor.

Design Temperature, °C	T	
	PE3608 PE3708	PE3710 PE4710
< 23	1	1
23 - 27	0.95	0.96
28 - 32	0.88	0.91
33 - 38	0.8	0.85
39 - 44	0.72	0.79
45 - 49	0.65	0.74
50 - 55	0.57	0.68
56 - 60	0.5	0.63

Table 4.3 Summary of Table CSA Z662-07 Table 13.4

Using values for Polyethylene Pipe in Dry Gas Gathering below 23 °C, the following pressure ratings result:

SDR	Pressure rating, P [MPa]	
	PE3608 PE3708	PE3710 PE4710
21	0.55	0.69
17	0.69	0.86
11	1.10	1.38
9	1.38	1.73
7.3	1.75	2.19
6.3	2.08	2.60

Table 4.4 Sample CSA Z662-07 Pressure Ratings

Values calculated below 23 °C for Dry Gas Gathering using design factors from CSA Z662-07 and equation 4.1.

4.3 Determining pipe and fittings pressure rating via PPI TR-4 and TR-9

The Plastic Pipe Institute document TR-9 suggests the following formula to determine pressure rating:

$$PR = \frac{2(HDB)(DF)(DF_T)}{SDR - 1} \quad \text{Eq. 4.2}$$

Where:

- PR = Pressure Rating [psi]
- HDB = Hydrostatic Design Basis [psi]
- SDR = Dimensional Ratio
- DF = Design Factor

DF_T = Temperature Factor (DF_T = 1.0 @ 73 °F)

The Hydrostatic Design Basis values for polyethylene are listed in PPI document TR-4. The product of HDB and DF is known as the Hydrostatic Design Stress (HDS). Substituting HDS into equation 4.2:

$$PR = \frac{2(HDS)(DF_T)}{SDR - 1} \quad \text{Eq. 4.3}$$

HDS values for polyethylene materials are provided alongside HDB in PPI TR-4.

PPI Designation	Max HDS @ 73 °F (psi)	HDB @ 73 °F (psi)
PE1404	400	800
PE2406	630	1250
PE2708	800	1250
PE3408	800	1600
PE3608	800	1600
PE3708	800	1600
PE3710	1000	1600
PE4608	800	1600
PE4708	800	1600
PE4710	1000	1600

Table 4.5 Polyethylene HDS and HDB at 73 °F from PPI TR-4

Refer to document TR-4 for specific information regarding resins and pipe manufacturers.

DF_T values are provided in PPI TR-9 for operating temperatures above 73 °F.

Service Temperature (°F)	DF _T
80	0.95
90	0.9
100	0.8
110	0.75
120	0.7
130	0.5
140	0.4

Table 4.6 Temperature design factors from PPI TR-9

For intermediate temperatures, use linear interpolation to determine DF_T.

Using HDS for PE3708 and PE4710 respectively, at temperatures below 73 °F, the following pressure ratings result:

SDR	Pressure rating, PR [psi]	
	PE3708	PE4710
21	80	100
17	100	125
11	160	200
9	200	250
7.3	254	317
6.3	302	377

Table 4.7 Sample PPI TR-4 & TR-9 Pressure Ratings

Calculated below 73 °F using eq. 4.3 and HDS values from PPI TR-4/07a, pg 14.

4.4 Determining pipe and fittings pressure rating for ISO designed pipe systems via ERCB Directive 077

ERCB Directive 077 replaces and rescinds EUB Directive 022, effective 15-Jun 2010.

Directive 077 provides the following formula, based on ISO 12162, to determine the pressure rating of a fitting manufactured from PE 80 or PE 100 material:

Note, this does not apply to PE3608 or PE4710 type materials.

$$P = \frac{2 \cdot MRS}{SDR - 1} \cdot \left(\frac{1}{C_a \times C_m \times C_t} \right) \quad \text{Eq. 4.4}$$

Where:

- P = Pressure Rating [MPa]
- MRS = Minimum Required Strength [MPa]
- SDR = Dimensional Ratio
- C_a = Application Coefficient
- C_m = Material Coefficient (C_m = 1.25, as per ISO)
- C_t = Temperature Coefficient

The minimum required strength (MRS) is determined experimentally via ISO 9080, and values are listed in PPI TR-4. PE 80 has MRS of 8.0 MPa, and PE 100 has MRS of 10.0 MPa.

The application coefficient is based on polyethylene pipe service, and is determined from the following table:

Service	C _a
Oil & Gas Field Water	1.00
Dry Gas Gathering	1.12 (ERCB Req.)
Dry Gas Distribution	1.6 (ERCB Req.)
LVP Fluids	2 (ERCB Req.)
Hydrocarbon Wet Gas Gathering	2 (ERCB Req.)

Table 4.8 Application Coefficients from ERCB Directive 077

Values for C_t, for service conditions above 20°C are listed in the following table:

Design Temperature	C _t
Up to, and including 20°C	1
Over 20°C up to and including 30°C	1.1
Over 30°C up to and including 40°C	1.3

Table 4.9 Temperature Coefficients from ERCB Directive 077

Using MRS values listed in ERCB Directive 077 for PE 80 and 100 respectively, for polyethylene pipe in dry gas gathering service, at or below 20°C, the following pressure ratings result:

SDR	Pressure rating, PR [MPa]	
	PE 80	PE 100
21	0.57	0.71
17	0.71	0.89
11	1.14	1.43
9	1.43	1.79
7.3	1.81	2.27
6.3	2.16	2.70

Table 4.10 Sample ERCB Directive 077 Pressure Ratings
Calculated for dry gas gathering service, at or below 20°C.

4.5 Pressure Rating Summary

The following tables compile the sample pressure ratings from tables 4.4, 4.7 and 4.10 and converting to consistent units. The lowest common temperature was used in the calculations (20°C [68°F]) and for Dry Gas Gathering.

SDR	Calculated Pressure Rating [MPa]					
	Z662		PPI TR-9 *		ERCB D077	
	3608	3710	3708	4710	PE 80	PE 100
21	0.55	0.69	0.55	0.69	0.57	0.71
17	0.69	0.86	0.69	0.86	0.71	0.89
11	1.10	1.38	1.10	1.38	1.14	1.43
9	1.38	1.73	1.38	1.72	1.43	1.79
7.3	1.75	2.19	1.75	2.19	1.81	2.27
6.3	2.08	2.60	2.08	2.60	2.16	2.70

Table 4.11 Summary of sample pressure ratings [MPa]
All pressure ratings are calculated at 20°C [68°F] for Dry gas gathering applications. Z662 calculated from eq. 4.1; PPI calculated from eq. 4.3; ERCB calculated from eq. 4.4. * Note PPI pressure ratings are converted from their native units (psi).

SDR	Calculated Pressure Rating [psi]					
	Z662 *		PPI TR-9		ERCB D077 *	
	3608	3710	3708	4710	PE 80	PE 100
21	80	100	80	100	83	104
17	100	125	100	125	104	129
11	160	200	160	200	166	207
9	199	250	200	250	207	259
7.3	253	318	254	317	263	329
6.3	301	378	302	377	313	391

Table 4.12 Summary of sample pressure ratings [psi]
All pressure ratings are calculated at 20°C [68°F] for Dry gas gathering applications. Z662 calculated from eq. 4.1; PPI calculated from eq. 4.3; ERCB calculated from eq. 4.4. * Note Z662 and ERCB pressure ratings are converted from their native units (MPa).

5.0 Note on PE 100 and PE4710

To date, the resin used in the manufacture of all PE 100 fittings by Hawkeye Industries is also designated as PE4710.