ID-Controlled Polyethylene to Steel Transition Fittings

Material and Design Specifications

1.0 Introduction

Polyethylene to steel non-inside diameter obstructed transition fittings are becoming the *de facto* standard for connecting steel to polyethylene pipe in gas applications. This document intends to define and explain the design specifications for Hawkeye Industries' line of transition fittings, including polyethylene and steel material options.

2.0 Design Specifications

2.1 Codes and Standards

Hawkeye Transition Fittings are designed and manufactured in consideration of the applicable sections of following codes and standards:

CSA B137.4-05
Polyethylene Piping Systems for Gas Service

ASTM F1973-05
Standard Specification for Factory-Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide (PA11) Fuel Gas Distribution Systems

ASME B31.8-2003
Gas Transmission and Distribution Piping Systems

CSA Z662-07[1]
Oil and Gas Pipeline Systems

The transition fitting components also are also influenced by the following documents:

ASTM D2513-05
Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings

ASTM D2837-04
Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Bases of Thermoplastic Products

ASTM D3035-03
Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Base on Controlled Outside Diameter

ASTM D3350-05
Standard Specification for Polyethylene Pipe and Fittings Materials

ASTM F714-05
Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F1588-02
Standard Test Method for Constant Tensile Load Joint Test (CTLJT)

CSA B137.0-05
Definitions, General Requirements, and Methods of Testing Thermoplastic Pressure Piping

[1] This document supersedes CSA Z662-03

ERCB Directive 077[2]
Pipelines – Requirements and Reference Tools

ISO 9080:2003
Plastics Piping and Ducting Systems – Determination of the long-term hydrostatic strength of thermoplastic materials in pipe form by extrapolation

ISO 12162:1995
Thermoplastics Materials for pipes and fittings for pressure applications: Classification and designation – Overall service (design) coefficient

PPI TR-3
HDB/PDB/SDB/MRS Policies

PPI TR-4/07a
HDP/PDB/SDB/MRS Listed Materials

PPI TR-9/92
Recommended Design Factors and Design Coefficients for Thermoplastic Pipe

PPI TR-21
Thermal Expansion and Contraction in Plastic Piping Systems

2.2 Inside Diameter Control

Transition fittings designed and manufactured by Hawkeye Industries are referred to as "ID Controlled" Fittings. Specifically, there is no load-bearing component reducing the inside diameter of the fitting. Some designs require use of a steel tube, known as an *insert stiffener* on the inside diameter of the fitting. The purpose of the stiffener is to support the polyethylene pipe against radial stress imparted by the compression component of the fitting.

Hawkeye Industries' transition fittings use the steel pipe itself in the insert stiffener capacity. This ensures that the fitting has an ID no smaller than the smallest of the polyethylene or steel pipe inside diameters.

The term indicates that the inside diameters of the steel and polyethylene pipe are as near to equal with no pigging obstruction. The amount the inside diamters differ, known as the margin, depends solely on the size and Standard Dimension Ratio (SDR) of the polyethylene pipe and the size and wall thickness of the steel pipe

[2] Rescinds and Replaces EUB Directive 022

For example, if connecting *10 NPS SDR 11* polyethylene (*ID = 8.795 in*.) to *10 NPS SCH 40* Steel pipe (*ID = 10.020 in.*), there will be a inside diameter margin of *1.225 in*.

Hawkeye Industries fittings with an ID margin feature have a smooth ID transition between the two diameters. This will allow a reasonably soft pig to still pass through the fitting unhindered.

2.3 Pullout Strength

Defined as the minimum axial force that will separate the polyethylene and steel components, Pullout Strength is a standard-specified design requirement to ensure the mechanical joint maintains pressure containment while under longitudinal load. **ASTM F1973** and **CSA B137.4** each specify minimum pullout strengths.

ASTM categorizes fittings solely on size. For sizes 4 *NPS* and smaller, the fitting must, while pressurized, remain in-tact and bubble-tight before tensile loading, during tensile loading (*0.2 in / min* up to *25% elongation*), and immediately following tensile loading. For sizes larger than *4 NPS*, fittings must either meet the above criteria, or remain bubble-tight while under a tensile load equal to or greater than that as a result of a *100°F [38°C]* temperature change.

Table 7 of **CSA B137.4** lists minimum pullout values for a narrow range of PE sizes and SDRs (sizes up to *12 NPS*, and *SDRs 21, 13.5, 11* and *8.8* only). Table 2.1 lists these values, (converted to *lbf*) and interpolated for *5 NPS*, as well as *SDR's 17, 9, 7.3* and *6.3*. An examination of the values provided in the CSA table reveals that there is a linear correlation between the specified pullout strength, and the tensile strength of the pipe. The pullout strength of the fitting is approximately 1/2 the tensile strength of the pipe.

CSA Pullout (lbf) (regressed from Table 7 of CSA B137.4-05)								
	SDR							
Size	21	*17*	13.5	11	*9*	8.8	*7.3*	*6.3*
2	1076	*1343*	1577	1900	*2284*	2322	*2610*	*2803*
2.5	1528	*1945*	2311	2782	*3345*	3401	*3824*	*4105*
3	2267	*2888*	3431	4135	*4956*	5038	*5653*	*6064*
4	3741	*4769*	5669	6829	*8189*	8325	*9345*	*10025*
5	*5937*	*7559*	*8979*	*10814*	*12973*	*13189*	*14808*	*15888*
6	8132	*10350*	12290	14799	*17757*	18053	*20272*	*21751*
8	13785	*17543*	20832	25084	*30098*	30600	*34361*	*36868*
10	20361	*25971*	30880	37208	*44566*	45301	*50819*	*54498*
12	28742	*36583*	43444	52401	*62760*	63796	*71566*	*76746*

Table 2.1 Pullout Data from CSA B137.4-05
Values interpolated for *SDR 17, 9* and *5 NPS* sizes. Data extrapolated for *SDR 7.3* and *6.3*

Hawkeye Industries, in an effort to make the most robust fitting as possible, designs transition fittings with pullout strengths equal or greater than the tensile strength of the lowest common SDR polyethylene pipe, based on a tensile strength of *3500 psi* for polyethylene. The resulting pullout strength values (as tested by independent labs) far exceed either the ASTM or CSA pullout strengths. In any given application using Hawkeye Industries' transition fittings, the weakest link of the polyethylene / steel pipeline will be the polyethylene pipe, not the transition fitting.

Table 2.2 lists the design pullout strength for Hawkeye Industries transition fittings.

Hawkeye Design Pullout (lbf)					
	SDR				
Size	17	11	9	7.3	6.3
2	7332				
2.5	10745				
3	15924				
4	26323				
5	40228				
6	57054				
8	96701				
10	150221				
12	211316				
14	254782				
16	332777				

Table 2.2 Hawkeye Industries Transition Pullout Strengths
Pullout values based on tensile strength of smallest common SDR pipe in each size, thus all fittings of a particular pipe size will have the same pullout strength, regardless of SDR.

3.0 Polyethylene Specifications

3.1 PE 100(ISO) vs. PE 3X08[3] (ASTM / PPI)

Updated June 2010.

With specifications and special dispensation procedures listed in **EUB Directive 022**, bimodal polyethylene materials are gaining more and more acceptance for use in polyethylene pipelines. The most common bimodal resin in use is the ISO-defined *PE 100*. Bimodal polyethylene materials, like *PE 100*, allow pipeline to operate at higher pressures than an equivalent *PE 3X08 pipe*. This increased operating pressure is not only as a result of the increased performance capabilities of *PE 100* vs *PE 3X08*, but also as a result of the more rigorous testing, intensive interpretation of test data and a high level of confidence in long term characteristics as required by the ISO standard versus the ASTM / PPI method used for *PE 3X08* materials.

The higher operating pressure of a *PE 100* fitting has two benefits. Most obviously, the pipeline can accommodate higher pressure processes; but, a higher

[3] 3X08 was changed from 3408, where the X is a place holder for the value of the Slow Crack Growth resistance cell. This is to include materials with similar hydrostatic performance and density, but with increased slow-crack growth resistance (i.e. 3608, 3708) as listed in CSA Z662-07.

pressure rating can result in using less material for a similar *PE 3X08* application. A *PE 100* fitting does not require as thick a wall as similarly sized *PE 3X08* pipe to achieve the same pressure rating. This smaller wall thickness means less material used, which reduces overall material cost.

CSA Z662-07 does not mention the use of PE 100 material, as was anticipated. Instead, bimodal materials following the ASTM / PPI method are listed (i.e PE4610, PE4710).

As of 15-June, 2010 ERCB Directive 077 rescinded and replaced EUB Directive 022, allowing routine use of PE4710 in pipeline systems, which brings into agreement with CSA Z662-07. The Nonroutine application process of ERCB Directive 056 is still required for pipelines using ISO-based design (i.e. using PE80 or PE100 instead of PE3608 or PE4710).

All high performance polyethylene parts supplied by Hawkeye Industries are manufactured from resin dually classified as PE4710 and PE100.

3.2 Pressure Rating

The pressure rating of polyethylene pipe made from a particular resin is based on pipe SDR, application type, application temperature, and design strength value (hydrostatic design basis, HDB, for ASTM / PPI materials; minimum required strength, MRS, for ISO materials).

Table 3.1 lists pressure ratings for both *PE 3X08* and *PE 100* in common SDR's.

Operating Pressure (psi)		
Material	PE 3408	PE 100
SDR	*see note 1*	*see note 2*
21	80	105
17	100	130
13.5	130	165
11	160	205
9	200	260
7.3	255	330
6.3	300	390

Table 3.1: Pressure ratings for PE Pipe
Notes:
1.) Determined using PPI method for Dry Natural Gas at or below 73°F [23°C]
2.) Determined using EUB Directive 022 method for Dry Gas Gathering at or below 68°F [20°C]

The above values are for reference only. Please refer to technical bulletin TB-0807-TF for more information regarding the pressure rating of Hawkeye Industries Polyethylene Fittings.

3.3 Traceability

Standard P.O. / MTR document control is used to track steel and other metallic fitting components.

Raw polyethylene used to manufacture the Hawkeye Industries transition fitting is identified immediately upon receipt with the following information:

- Resin type (*PE 3408*, *PE 100*, etc)
- Manufacturer of the Raw Material
- Size and SDR of the raw material
- Our purchase order number

Following each manufacturing operation, information is reapplied to the part if, as a result of the handling and machining, the information is removed. At no time is a polyethylene part is staged, assembled or stored without individual identifying information.

Material is traceable from end-user purchase order number, through Hawkeye Industries internal work order number, to raw material supplier to resin manufacturer.

4.0 Design Summary

Regardless of size or materials used, the Hawkeye Industries' transition fitting has five major components. The steel nipple connects to the steel pipe system, the plastic adapter connects to the polyethylene pipe system and the compression sleeve which forms and reinforces the mechanical joint. Additionally, elastomeric seals between the steel nipple and plastic adapter guarantee a leak-free joint, and a corrosion-protecting wrap eliminates deterioration of the compression sleeve and bare mechanical joint surfaces.

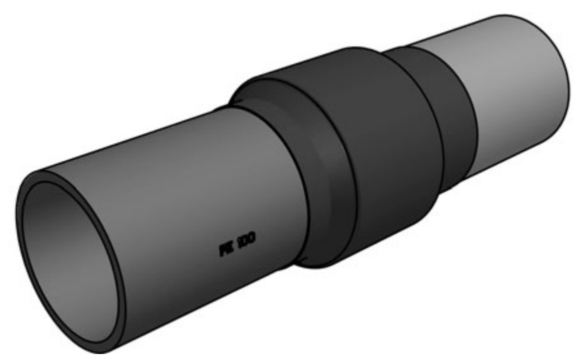

Figure 4.1 Transition Fitting Assembly
Typical transition fitting assembly, with shrink wrap installed. Not-shown: Pipe caps.

4.1 Steel Nipple

Manufactured from steel pipe, the steel nipple sports the indentation system which provides the pullout strength of the mechanical joint (figure 4.2). Additionally, the steel nipple contains the elastomeric seals. The steel nipple can be manufactured from any grade of steel pipe, with ASME SA-106B being the most common.

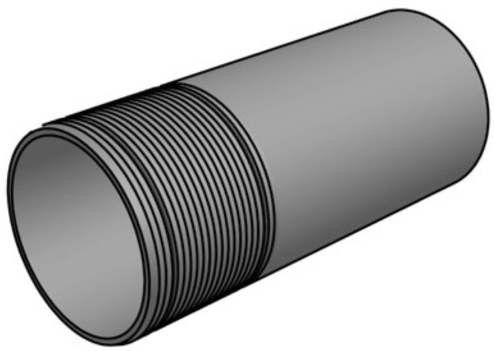

Figure 4.2 Steel Nipple
The indented end fits inside of the bell of the plastic adapter, forming one-third of the mechanical joint. It also contains the glands for the elastomeric seals.

4.2 Plastic Adapter

A precision machined component, the plastic adapter connects to the polyethylene pipe system, and forms the mechanical joint along with the steel nipple and compression sleeve (figure 4.3). The adapter features a bell/socket feature to accept the steel nipple without deforming the polyethylene, eliminating long-term embrittlement which reduces the life of the fitting. The compression sleeve fits, with significant interference, over the bell locking the joint into place. The free-end of the plastic adapter is fusion-ready, meeting the dimensional specifications listed in ASTM D2513.

Figure 4.3 Plastic Adapter
The upset end, known as the bell, accepts the steel nipple in a precision machined socket. The free end connects to the polyethylene pipe system via standard fusion methods.

4.3 Compression Sleeve

The third and final part of the mechanical joint, the compression sleeve imparts radial pressure onto the plastic adapter, forcing material into the steel nipple indentation system (figure 4.4). The compression sleeve is pressed onto the bell of the plastic adapter, displacing material radially into the indentations. As there is significant interfacial pressure between the inside diameter of the compression sleeve and the outside diameter of the plastic adapter, the compression sleeve is designed and manufactured such that it will resist creep, and impart even pressure circumferentially. This even circumferential pressure ensures that the indentations on the steel nipple are filled evenly with material from the plastic adapter, resulting a strong, bubble-tight joint.

Figure 4.4 Compression Sleeve
The compression sleeve is pressed over the bell of the plastic adapter. Significant interference between the sleeve and the adapter ensure a tight, even pressure and complete joint integrity.

4.4 Seals

Elastomeric seals are used as a fail-safe pressure-retaining feature of the mechanical joint. Placed in the interfacial space between the outside diameter of the steel nipple, and the inside diameter of the plastic adapter socket, the elastomeric seals provide a bubble-tight barrier in the event the mechanical joint itself can no longer retain pressure.

4.5 Corrosion Protection

Covering the compression sleeve, a the portion of the steel nipple adjacent to the plastic adapter bell, as well as a portion of the free-end of the plastic adapter, corrosion protection seals the ferrous materials from the elements (figure 4.5). It is factory-applied in a controlled and monitored environment, ensuring that the mechanical joint is free of any sources corrosion.

Figure 4.5 Corrosion Protection Sleeve
Factory applied in a controlled environment. The sleeve protects and seals metallic components against corrosion.