



PE Fabricated Fittings for Pressure Applications: Derating Requirements

This publication serves as a guide to the pressure de-rating of Polyethylene (PE) fabricated fittings, for use with polyethylene pipe made to AS/NZS 4130.

The previous version of POP006 (V5.01) provided default performance and manufacturing derating factors that could be applied to a range of common fittings - these have carried over into this document as the default position. There was also an option for manufacturers to use alternative values if suitable performance and test data was provided. The type of test data required was previously not specified. This version of POP006 (V6.0) provides guidance in terms of the test requirements that need to be satisfied to establish alternative derating values by formally referencing ISO 4427-3.

Also, since the preparation of V5.01 in 2003 other fittings such as "pull out tees" have come into common use. These fittings have no established default derating factors and have in most cases relied on manufacturer's declarations to establish this factor.

Pressure de-ratings are taken from ISO 4427-3 and are considered to be conservative. It is considered necessary to use this conservative approach, as the consequential costs involved with a fitting failure can be high and should be avoided.

It is appreciated that testing to ISO 4427-3 will take some time to complete. Where pre-existing alternate derating factors have been agreed between the purchaser and manufacturer, consideration may be given to retaining these factors based on historical performance, until testing is completed. Validation of the ISO 4427-3 values by testing is required to be completed by 1 December 2015. This is also relevant for fittings such as pull-out tees that were not specifically covered previously. The option to continue to utilise pre-existing agreements is a short-term option to facilitate the transition to the ISO 4427-3 requirements.

Note: Butt welded straight, or coiled pipe lengths are not derated – they operate at the rated pressure of the pipe. Similarly, Electrofusion joints and fittings and injection moulded fittings have design pressure ratings marked on them and operate at their stated pressure rating. No derating is applied to these components.

SCOPE

These guidelines cover pressure rated PE fabricated fittings manufactured from Polyethylene, not covered by AS/NZS 4129 or an equivalent International Standard, intended for use with polyethylene pipes made to AS/NZS 4130.

If in the case of segmented fabricated fittings where welding techniques other than butt fusion to ISO 21307 have been used (e.g., extrusion welding), additional de-rating factors will need to be considered.

Note: PE fittings manufactured via injection moulding should be marked with a PN number and are not subject to de-rating factors.

This guideline specifies the pressure de-rating factors of PE fabricated fittings operated at temperatures up to 20°C. Where the operating temperature is above 20°C, additional -temperature de-rating factors are required. Refer to PIPA POP013 for further information.

COMPOSITION

POLYETHYLENE PIPES

PE Pipes used for the manufacture of PE fabricated fittings shall comply with AS/NZS 4130.

DESIGN

GENERAL

The design and pressure de-rating of PE Fabricated fittings shall be in accordance to ISO 4427-3.

The pressure derating shall be in accordance with ISO 4427-3 unless the manufacturer specifies an alternative derating factor. An alternative derating factor must be supported by objective evidence of compliance with the minimum performance requirements of ISO 4427-3 Table B1 or as stated above existing agreements between purchaser and manufacturer may be used until 1 December 2015.

The design and Nominal Pressure (PN) rating, stated at 20°C, as well as the applicable Derating Factor (f), shall be evidenced and recorded in the manufacturer's technical file.

DIMENSIONS

The dimensions of PE fabricated fittings shall be in accordance with ISO 4427-3 Table B.2.

In the case of pull-out tees, the most widely referenced document with respect to dimensions is DIN 16963-2. As this standard has been withdrawn it is recommended the dimensions in DIN 16963-2 be used as a reference but does not exclude alternative dimensions agreed between purchaser and manufacturer.

Measurement of Dimensions

The dimensions of fittings shall be measured in accordance with ISO 3126. Production measurements may be taken at ambient temperature, provided those dimensions are subsequently adjusted to their equivalent dimensions at 20°C.

Note: the coefficient of thermal expansion for PE may be taken for reference purposes as $2 \times 10^{-4}/^{\circ}\text{C}$.

PRESSURE RATING OF A PIPELINE SYSTEM

The maximum allowable operating pressure of a pipeline system (i.e., pipe and fittings) shall be limited to the lowest pressure rated component in the system.

APPEARANCE OF FABRICATED FITTINGS

Special requirements concerning the appearance of fabricated fittings e. g. Bead removal shall be agreed between the manufacturer and customer.

FITTINGS GEOMETRY

SEGMENTED BENDS

PE Segmented bends are manufactured by butt fusion welding PE pipe segments together to specified geometric angles i.e., 90° , 45° , 30° , and shall comply with the dimensional requirements of ISO 4427-3 Section B.3. For a full set of fitting dimensions refer to the fitting manufacturer.

For Segmented bends fabricated out of pipe segments cut from pipe complying with AS/NZS4130, the following de-rating calculation of the PN shall apply:

$$PN = f_B \times PN \text{ Pipe}$$

Where:

f_B = The derating factor applied to the bend segment (Refer to Table 1)

PN = The nominal pressure of the pipe.

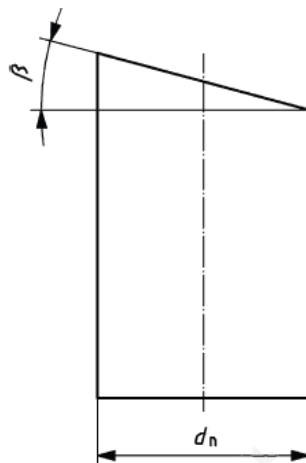


FIGURE 1 – SEGMENT DESIGN

d_n = nominal outside diameter

β = cut angle

The cut angle β , Figure 1, shall not be greater than 15° .

Table 1
De-rating Factors for Segmented Bends

CUT ANGLE	DE-RATING FACTOR f_B
$\leq 7.5^\circ$	1.0
$7.5 < \beta \leq 15^\circ$	0.8*

*In accordance to ISO 4427-3 Table B.1, the test results of the manufacturer may demonstrate a de-rating factor other than this value.

SWEEP BENDS, MACHINED SPIGOT ENDS AND TRANSITION PIECES

Sweep Bends

The design and dimensions of PE Sweep bend shall be provided by the fitting manufacturer. Sweep bends are manufactured by heating a single section of pipe, ranging from SDR21 to SDR9, and then using a forming tool to reshape the heated area. Typically, the pipe segment to be shaped is immersed in a hot liquid bath or hot air oven and heated to make it pliable. It's then removed from the heat source and reshaped in the forming tool. Care must be taken to hold the new shape without any induced stress until the part has sufficiently cooled. These manufacturing methods result in single piece bends at any angle up to 90°.

The bend sweep angle shall be as nominated, with an angular tolerance of $\pm 5^\circ$, when measured at the spigot ends. Bends shall not revert outside these tolerances in storage. The tolerance nominated above aligns with the requirements of ISO 4427.3 Table B2. It differs however from that nominated in AS 4129 which is $\pm 2^\circ$. This difference creates an anomaly between the two standards, but the recommendation of this guideline is to use the ISO tolerances as extensive industry experience has shown the resultant fittings to be fit for purpose.

When measured along the outside radius of the formed bend, the length of the bend shall be the nominated length with a tolerance of ± 5 mm. The centre-line radius of the bend shall be the nominated radius with a tolerance of ± 5 mm.

Sweep Bends are operated at the full pressure rating of the pipe without the need for de-rating, provided the minimum wall thickness of the fitting (taking into account wall thinning at the bend) complies with the requirements of AS/NZS 4130, for the rated nominal pressure of the pipeline. Where the minimum wall thickness fails to comply with AS/NZS 4130, results of testing to ISO 4427-3 Table B.1 will be required to demonstrate compliance with the performance requirements.

Spigot Ends and Transition Pieces

Spigot ends and transition pieces shall be straight for the length required to complete mechanical coupling, butt welding, or electrofusion jointing without sub-welded sections. The spigot ends, to be fusion welded, must be cut square and be of the same SDR as the mating pipe or fitting. Unmatched wall thickness will require machining or chamfering for SDR (fitting) to SDR (pipe) jointing compatibility. End chamfering pipe separated by no more than two classes is considered acceptable for butt fusion jointing, i.e., SDR 11 to SDR 13.6 or SDR 17.

Guidance regarding the geometry of spigot ends and transition pieces can be found in several documents including AS/NZS 4129, ISO 15494 and also for the case of butt fusion only in the APGA Code of Practice - Upstream PE Gathering Networks – CSG Industry. There are differences in the detail geometry nominated in these documents. However, the objective of these machined ends is consistent and that is:

- They are avoiding a sharp change in cross section that could otherwise create a stress concentration at the joint.
- In the case of butt welds ensure the compatibility of the wall thickness at the joint.
- In the case where EF welding is used it is to ensure the compatibility of the OD in cases where the fitting has added material in their design.
- The fitting length shall allow the following (in any combination): the use of clamps required in the case of butt fusion, assembly with an electrofusion fitting, assembly with a socket fusion fitting, the use of a mechanical coupling or the use of a mechanical scraper.

Results of testing to ISO 4427-3 Table B.1 will demonstrate compliance with the performance requirements.

Special measures may be taken to keep the pipe-bend angle in place during storage and handling of the fitting.

Note: APGA (Australian Pipelines and Gas Association) was previously known as APIA (Australian Pipeline Industry Association).

Segmented Tees and Y Junctions

Fabricated equal and reduced tees and y junctions, manufactured by butt fusion jointing PE pipe segments, shall be produced in accordance to ISO 4427-3 Section B.5. For a full set of fitting dimensions refer to the fitting manufacturer.

The fitting length shall allow the following (in any combination): the use of clamps required in the case of butt fusion; assembly with an electrofusion fitting; assembly with a socket fusion fitting; the use of a mechanical scraper.

For tees fabricated out of pipe segments cut from pipe complying with AS/NZS 4130, the following derating rules for the calculation of the PN shall apply:

$[PN] = f_r \times [PN]_{\text{pipe}}$ where

f_r is the derating factor for these tees, having a value of 0.5

$[PN]_{\text{pipe}}$ is the nominal pressure of the pipe, taken as a value.

Test results of the manufacturer may demonstrate that a derating factor > 0.5 may be applicable. Results of testing in accordance to ISO 4427-3 Table B.1, shall determine the applicable derating factor f_r .

Pull Out Reducing Tees

Pull Out Reducing Tee Fittings, also referred to as “Necking Tee’s”, are manufactured by thermoforming or pulling a branch outlet, from a pipe segment under the influence of heat and applied pulling stress. An extended branch outlet is formed by butt fusion welding a length of pipe onto the necked section, producing a spigot branch outlet.

Pull Out Tee Fittings should comply with the dimensions specified in DIN 16963-2 unless otherwise agreed between purchaser and manufacturer. For a full set of fitting dimensions refer to the fitting manufacturer.

For Pull Out Tees, the following de-rating rules for the calculation of the PN shall apply:

$[PN] = f_r \times [PN]_{\text{pipe}}$ where

f_r is the de-rating factor for these tees, having a value of 0.5 (see note below)

$[PN]_{\text{pipe}}$ is the nominal pressure of the pipe, taken as a value.

Note: No direct published reference could be found in relation to accepted derating factors for pull out tees. In the absence of published derating factors the value of 0.5 was carried over from that applied to segmented tees.

Manufacturer's test results might demonstrate that a derating factor > 0.5 may be applied. Results of testing in accordance to ISO 4427 Table B.1, determine the applicable manufacturer de-rating factor f_r or as stated in clause 3.1 existing agreements between purchaser and manufacturer may be used until 1 December 2015

The minimum wall thickness of the fitting, shall comply with the requirements of AS/NZS 4130, for the rated nominal pressure of the pipeline. The Tee branch outlet spigot end shall be straight for the length required to complete mechanical coupling, butt welding, or electrofusion jointing.

Reducing Tee with Welder Reducer

This type of Reducing Tee is manufactured by butt fusion welding an injection moulded PE reducer fitting onto the outlet of an injection moulded equal tee fitting. Alternatively, a reducer fitting machined from extruded billet may be used in place of the injection moulded fitting. Both injection moulded and machined fittings shall comply with the requirements of AS/NZS 4129.

Reducing Tee's with welded Reducers are operated at the full pressure rating of the fitting without the need for de-rating, provided the minimum wall thickness of the reduced spigot outlet, complies with the requirements of AS/NZS 4130, for the rated nominal pressure of the pipeline. The Tee branch reducer outlet spigot end shall be straight for the length required to complete mechanical coupling, butt welding, or electrofusion jointing.

Saddle Tees

This type of fitting is prepared by electrofusion welding an injection moulded or machined PE electrofusion saddle fitting onto a PE pipe segment. Outlet branches are available in both equal and reduced sizes in accordance to the dimensional requirements of AS/NZS 4130.

Branch saddle tees are available for pipe main sizes to DN2000, with outlets to DN500. This type of Saddle Tee is operated at the pressure rated SDR class for the pipe without the need for derating.

FREEDOM FROM DEFECTS

The assessment of defects shall be in accordance with AS/NZS 4129.

BUTT FUSION WELDING

When butt fusion welding fabricated fittings, reference to the welding parameters within ISO 21307 and/or PIPA POP003 should be used as a guideline.

Welding machine operators shall be:

1. certified welders,
2. trained in the operation of the equipment being used and
3. understand the welding parameters required to prepare acceptable joints.

The butt fusion weld must be marked (for example with the fabricators stamp) for permanent identification and traceability.

TESTING

OXIDATION INDUCTION TIME TESTING

When tested in accordance to ISO 11357-6, using oxygen at a test temperature of 200°C, fabricated fittings shall have an Oxidation Induction Time of 20 minutes or greater. Other test methods and procedures may be applied, provided they demonstrate equivalent accuracy to ISO 11357-6.

MELT MASS FLOW RATE (MFR) TESTING

The MFR of the material in the finished manufactured fitting shall not differ by more than $\pm 20\%$ from the MFR of the batch compound from which the fitting was manufactured, when tested in accordance to ISO 1133, with test parameters 190°C/5kg.

MARKING

All fittings shall be clearly marked with at least the following information:

- a) Manufacturers name or Trademark
- b) Identification of material type i.e., PE100 or PE80
- c) Nominal Pressure (PN) Rating and application (Water/Gas) as nominated by the manufacturer, based on this guideline
- d) Nominal size and SDR of the pipe for which the fitting is intended
- e) Code for traceability of manufacturing Date or Batch.



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