

Gas Industry Standard

GIS/PL2-4:2019

Specification for

**Polyethylene pipes and fittings for natural gas and
suitable manufactured gas**

Part 4: Fusion fittings with integral heating element(s)



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Foreword

Gas Industry Standards (GIS) are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition. Contractors and other users external to Gas Transporters should direct their requests for copies of a GIS to the department or group responsible for the initial issue of their contract documentation.

Comments and queries regarding the technical content of this document should be directed in the first instance to the contract department of the Gas Transporter responsible for the initial issue of their contract documentation.

This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with this engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

The UK Committee would like to emphasize that compliance with GIS/PL2-4 does not necessarily mean that products are fit for the purpose of conveying natural gas in the UK. It is recognised that fittings may not be fully compatible with existing UK practice in terms of applicable pressure tiers, preferred colours for gas pipe recognition, jointing and methods of installation and commissioning.

The requirements contained in GIS/PL2-4 are not necessarily indicative of all the performance requirements, or the suitability of pipework for the service conditions, likely to be encountered in the UK.

Relationship with other publications

GIS/PL2 *Polyethylene pipes and fittings for natural gas and suitable manufactured gas* consist of the following parts:

Part 1: General and polyethylene compounds for use in polyethylene pipes and fittings.

Part 2: Pipes for use at pressures up to 5.5 bar.

Part 3: Butt fusion machines and ancillary equipment.

Part 4: Fusion fittings with integral heating element(s).

Part 5: Electrofusion ancillary tooling.

Part 6: Spigot end fittings for electrofusion and/or butt fusion purposes.

Part 7: Squeeze-off tools and equipment.

Part 8: Pipes for use at pressures up to 7 bar.

Mandatory and non-mandatory requirements

For the purposes of a GIS the following auxiliary verbs have the meanings indicated:

- | | |
|---------------|---|
| can | indicates a physical possibility; |
| may | indicates an option that is not mandatory; |
| shall | indicates a GIS requirement; |
| should | indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection. |

Disclaimer

This engineering document is provided for use by Gas Transporters and such of their contractors as are obliged by the terms of their contracts to comply with this engineering document. Where this engineering document is used by any other party, it is the responsibility of that party to ensure that the engineering document is correctly applied.

Brief history

Edited by BSI in accordance with BS 0-3:1997	August 2006
Substantial review refer to Annex M	September 2007
Change summer testing condition from +30C to +23C	January 2008
Substantial review refer to Annex N	March 2012
Increase size range to 800mm and associated minor amendments	November 2014
Minor amendments	October 2019

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1 Scope

This part of GIS/PL2 specifies requirements for polyethylene (PE) fusion fittings with integral heating elements in the nominal size range 16 mm to 800 mm inclusive. They are intended for use with metric PE pipes conforming to GIS/PL2-2 and GIS/PL2-8 within an operating temperature range of $-20\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$.

It is applicable to fittings classified as class B (suitable for use at operating pressures not exceeding 5.5 bar) and class C (suitable for use at operating pressures not exceeding 7 bar).

This Gas Industry Standard provides for the supply of fusion fittings that are capable of connection to pipes at ambient temperature of $-5\text{ }^{\circ}\text{C}$ to $23\text{ }^{\circ}\text{C}$ using control boxes conforming to GIS/ECE1.

The use of alternative control boxes approved to equivalent standards (e.g. EN or ISO) may be proposed and shall be subject to agreement with the gas transporter.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Formal standards

BS EN 682 - *Elastomeric seals — Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids.*

BS EN 728, *Plastics piping and ducting systems — Polyolefin pipes and fittings — Determination of oxidation induction time.*

BS EN ISO 1167, *Plastics piping systems — Thermoplastics pipes — Determination of resistance to internal pressure at constant temperature.*

BS EN 1555-3, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 3: Fittings.*

BS EN 1716, *Plastics piping systems — Polyethylene (PE) tapping tees — Test method for impact resistance of an assembled tapping tee.*

BS EN ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics.*

BS EN ISO 472, *Plastics — Vocabulary.*

BS EN ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions.*

ISO 7005-1, *Metallic flanges — Part 1: Steel flanges.*

ISO 13954, *Plastics pipes and fittings — Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm.*

ISO 13955, *Plastics pipes and fittings — Crushing decohesion test for polyethylene (PE) electrofusion assemblies.*

ISO 11357 *Plastics Differential Scanning Calorimetry (DSC)*

Gas Industry Standards

GIS/ECE1, *Specification for electrofusion control boxes.*

GIS/PL2-1, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 1: General and polyethylene compounds for use in polyethylene pipes and fittings.*

GIS/PL2-2, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 2: Pipes for use at pressures up to 5.5 bar.*

GIS/PL2-5, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 5: Electrofusion ancillary tooling.*

GIS/PL2-6:2006, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 6: Spigot end fittings for electrofusion and/or butt fusion purposes.*

GIS/PL2-8, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 8: Pipes for use at pressures up to 7 bar.*

GIS/PL3:2006, *Self-anchoring mechanical fittings for natural gas and suitable manufactured gas.*

3 Terms, definitions, symbols, abbreviations and units

For the purposes of this standard the following terms, definitions, symbols, abbreviations and units apply.

3.1 Geometrical definitions

3.1.1

nominal size (DN)

numerical designation of the size of a component, other than a component designated by thread size, which is a convenient round number, approximately equal to the manufacturing dimension in millimetres (mm)

3.1.2

nominal size (DN/OD)

nominal size, related to the outside diameter

3.1.3

nominal outside diameter, d_n

specified outside diameter, in millimetres, assigned to a nominal size DN/OD

3.1.4

mean inside diameter, d_s

arithmetical mean of a number of measurements of the inside diameter of a socket through its cross-section regularly spaced around the circumference and in the same cross section, including the measured minimum and the measured maximum values of the inside diameter in that cross section, rounded to the next greater 0.1 mm

3.1.5

ovality (out-of-roundness)

difference between the maximum and the minimum outside diameter in the same cross-section of a pipe or spigot, rounded off to the nearest 0.1 mm

3.1.6

nominal wall thickness, e_n

numerical designation of the wall thickness of a component, which is a convenient round number, approximately equal to the manufacturing dimension in millimetres (mm)

3.1.7

standard dimension ratio (SDR)

numerical designation of a pipe series, which is a convenient round number, approximately equal to the dimension ratio of the nominal outside diameter, d_n , and the nominal wall thickness, e_n

3.1.8

maximum penetration depth, L_1

depth of penetration of the pipe or spigot fitting

NOTE *In the case of a coupler without a stop it is not greater than half the total length of the fitting.*

3.1.9

minimum apparent fusion length, L_2

L_2 is the length of the integral heating element from the 1st regular section of the element to the end of the regular section on one side of the fitting. The dimension shall be measured from outside edge to outside edge of wire

3.1.10

inner cold zone

unheated distance between the end of the fusion zone as declared by the manufacturer and the end face of the insert pipe or spigot

3.1.11

fusion sealing width

minimum width of the fusion zone applicable to saddle fittings

3.2 Material definitions

3.2.1

virgin material

material in a form such as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessible or recyclable materials have been added

3.2.2

Uncontaminated recyclate material (the use of yellow and orange polyethylene compound shall only be permitted)

material prepared from clean rejected unused pipes, fittings or valves, including trimmings from the production of pipes, fittings or valves, that will be reprocessed in a manufacturer's plant after having been previously processed by the same manufacturer in the production of components by, for example injection moulding or extrusion

3.2.3

compound

homogenous mixture of base polymer (polyethylene) and additives, i.e. antioxidants, pigments, UV-stabilizers and others, at a dosage level necessary for the processing and use of components conforming to the requirements of this standard

3.2.4

batch – moulded fittings

Production off a machine, from the time it commences to produce fittings conforming to this standard until the machine is closed down. A production batch should not exceed 170hrs machine time or 10,000 components, whichever is the lesser.

3.3 Material properties

3.3.1

lower predicted limit (LPL), σ_{LPL}

quantity, with the dimensions of stress in megapascals (MPa), which can be considered as a property of the material, and represents the 97.5 % lower predicted limit of the mean long term strength at 20 °C for 50 years with internal water pressure

3.3.2

minimum required strength (MRS)

value of σ_{LCL} , rounded down to the next smaller value of the R10 series or of the R20 series depending on the value of σ_{LCL}

NOTE R10 and R20 series are the Renard number series according to ISO 3 and ISO 497.

3.3.3

overall service (design) coefficient or safety factor, C

coefficient with a value of 2.9, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower confident limit

3.3.4**design stress, σ_s**

allowable stress, in megapascals (MPa) for a given application

NOTE *It is derived from the MRS by dividing it by the coefficient C, i.e.:*

$$\sigma_s = \frac{\text{MRS}}{C}$$

3.3.5**melt-mass flow rate (MFR)**

value relating to the viscosity of the molten material at a specified temperature and load, expressed in grams per 10 min (g/10 min)

3.4 Service conditions**3.4.1****gaseous fuel**

any fuel which is in gaseous state at a temperature of 15 °C, at atmospheric pressure

3.4.2**maximum operating pressure (MOP)**

maximum effective pressure of the fluid in the piping system, expressed in bar, which is allowed in continuous use. It takes into account the physical and the mechanical characteristics of the components of a piping system

NOTE *It is calculated using the following equation:*

$$\text{MOP} = \frac{20 \times \text{MRS}}{C \times (\text{SDR} - 1)}$$

3.4.3**reference temperature**

temperature for which the piping system is designed

NOTE *It is used as the base for further calculation when designing a piping system or parts of a piping system for operating temperatures different from the reference temperature.*

3.5 Fitting types**3.5.1****electrofusion socket fitting**

fitting with one or more cylindrical sockets into which pipes or fitting spigots can be inserted to form an assembly for subsequent jointing by electrofusion and the creation of an integral pipe/fitting connection

3.5.2**electrofusion saddle fitting**

fitting for placement on or around the outer surface of a pipe to form a saddle assembly for subsequent jointing by heat fusion and the creation of an integral pipe-to-fitting connection

3.5.3**electrofusion tapping tee**

saddle fitting, with various outlet configurations, containing an integral cutter designed to perforate the wall of the pipe whilst the pipe is under pressure

3.5.4

branch saddle

saddle fitting, with various outlet configurations, with provision made for the location of a separate tool designed to perforate the wall of the pipe whilst the pipe is under internal pressure or in a non-pressurized state

3.5.5

flange adapter

fitting used with a seal/gasket and flange backing ring(s) for making a joint in a polyethylene system

3.5.6

fusion compatibility

ability of two similar or dissimilar polyethylene materials to be fused together to form a joint which conforms to the performance requirements of this standard

3.6 Symbols

C	overall service (design) coefficient
d_n	nominal outside diameter
σ_s	design stress

3.7 Abbreviations

DN	nominal size
DN/OD	nominal size outside diameter related
LPL	lower predicted limit
MFR	melt mass-flow rate
MOP	maximum operating pressure
MRS	minimum required strength
SDR	standard dimension ratio

4 Material

4.1 General

The materials used in the manufacture of the fitting shall be suitable for the conveyance of natural gas with a composition in accordance with BS EN ISO 13686.

4.2 Polyethylene compound

The compound from which the fittings are made shall conform to GIS/PL2-1 or EN1555-1 and shall be classified by MRS as shown in Table 1

Table 1 Classification of polyethylene compounds

Designation	σ_{LPL} (20°C, 50 years, 97.5%) MPa	MRS MPa
PE80	$8.00 \leq \sigma_{LPL} \leq 9.99$	8.0
PE100	$10.00 \leq \sigma_{LPL} \leq 12.40$	10.0

The requirements shall be established and declared by the manufacturer of the compound using the ISO 9080 extrapolation method and stated in accordance with ISO 12162. Yellow,

orange or black PE compounds may be used, but any compound used shall be supplied by the resin manufacturer as a fully compounded material. The fittings shall be made from a single grade of virgin material or uncontaminated yellow or orange PE compound recyclate material.

Uncontaminated recyclate material (e.g. sprues, runners or preforms), generated from a manufacturer's own production of fittings to this standard, may be used provided it has not left the manufacturer's premises. Alternatively regrinding may be done outside the manufacturer's premises provided it is under their supervision.

Rework material shall not be blended with unprocessed compound, and shall be used on its own. Fittings produced using 100 % rework material shall be in accordance with this standard and shall be identifiable. Rework material shall be used once only and any reclaimed material from this run of rework shall be discarded. Fittings produced from reworked material shall be identifiable and/or traceable throughout the manufacturer's production records.

The approval of the gas transporter shall be sought for the introduction of any changes in the compound. The effect of the change on the ability of fittings to conform to this standard and the need for further approval tests shall be established.

4.3 Heating element material corrosion resistance

All exposed metallic components used in the electrical terminal connections of the fitting shall be corrosion resistant, or suitably protected against corrosion. Compliance with this requirement shall be demonstrated by meeting the requirements specified in **10.3**.

4.4 Elastomers

Elastomeric seals shall conform to BS EN 682

5 Fitting classification

5.1 General

Fittings shall be classified for pressure capability as either class B or C and shall be designed for use in gas pipe systems at operating pressures in accordance with Table 2.

Table 2 Fitting classes, operating pressures and connecting pipes

Fitting class	MOP bar	Pipe diameter range mm	SDR of connecting pipe
B	5.50 ^{a)}	$16 \leq d_n < 50$	11 ^{c)}
		$50 \leq d_n < 63$	11, 17.6 ^{d)}
		$63 \leq d_n < 140$	11, 17.6, 21 ^{d) f)}
		$140 \leq d_n < 355$ ^{b)}	11, 17.6, 21, 26 ^{d) e)}
		$355 \leq d_n \leq 800$ ^{b)}	11, 17.6, 21, 26 ^{d)}
C	7.00	$16 \leq d_n \leq 630$	11

a) MOP may be selected from pressures up to and including 5.50 bar.
b) Includes non-isometric fitting sizes 213 mm, 268 mm, and 469 mm.
c) SDR 7 & 9 pipes are covered in this size group.
d) SDR17.0 pipes are recognised in these size groups.
e) SDR 26 $d_n \geq 225$ except 213mm
f) For pipe sizes 63mm and 75mm, fittings shall be compatible with SDR 13.6 pipe

The performance of pipe/fitting assemblies shall be in accordance with Clause **10**.

Assessment of conformity shall be carried out in accordance with Clause **11**. The test schedule shall be in accordance with Annex A.

5.2 Class B fittings

Class B fittings shall be suitable for use with pipes conforming to GIS/PL2-2 (maximum operating pressure 5.5 bar for SDR11 pipes). Each type and size of fitting shall be suitable for jointing to pipe with SDR values specified in Table 2.

The fittings shall be coloured yellow or black. Black fittings shall have an approved yellow label securely affixed to indicate suitability for operation at a pressure selected from a range up to a maximum of 5.5 bar.

5.3 Class C fittings

Class C fittings shall be suitable for use with SDR11 pipes in accordance with GIS/PL2- 8 (maximum operating pressure 7.0 bar). Each type and size of fitting shall be suitable for jointing to pipe with SDR values specified in Table 2.

Class C fittings shall be coloured yellow, orange or black. Non orange fittings shall have an approved orange label securely affixed to indicate suitability for 7bar operation.

Fittings approved as class C may be offered for use with pipes to GIS/PL2-2 provided that, for a given size and type of fitting, the same fusion time is specified for each type of pipe for the SDR range specified in Table 2.

Suitability for use with GIS/PL2-2 pipes shall be established by the conduct of joint interface strength tests in accordance with **10.6.1** and **10.6.2** together with an 80 °C, 1000 h pressure test (class B conditions) in accordance with **10.7.3**. The fitting shall be labelled accordingly.

6 Fitting aspect, geometry and dimensions

6.1 General

Fittings shall be designed for connection to GIS/PL2-2 and GIS/PL2-8 pipes using electrofusion socket and saddle jointing methods and tooling in accordance with GIS/PL2-5.

The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling for installation and commissioning if different from that prescribed in GIS/PL2-5.

Fittings that incorporate a spigot end(s) shall also conform to GIS/PL2-6.

Fittings shall be free from cracks, voids, blisters, holes, distortion, dents, injurious damage, inclusions or other defects likely to impair their performance. To prevent stress concentrations, any changes in wall thickness of the fitting body shall be gradual.

Once a fitting has been manufactured it shall be left to normalise for a minimum period of 24 hours. The fitting shall then be conditioned at 23 °C ± 2 °C for a minimum of 4 hours prior to any measurement. Methods of measurement shall conform to BS EN ISO 3126.

A method of controlling pipe penetration within each socket shall be provided. The stops shall be removable without interference of the socket electrical wire.

Fittings shall be designed to minimize pressure drop in accordance with **10.10**.

6.2 Dimensions of electrofusion sockets (couplers, reducers, elbows, tees and end caps)

6.2.1 Diameters and lengths of electrofusion sockets

For electrofusion sockets (see Figure 1) having a nominal diameter in Table 3, the socket diameter and lengths shall be given by the manufacturer and should conform to Table 3 and with $L_3 \geq 5\text{mm}$

Key

D_1 is the mean inside diameter in the fusion zone measured in a plane parallel to the plane of the mouth at a distance of $L_3 + 0,5L_2$ from that face;

L_1 is the depth of penetration of the pipe or male end of a spigot fitting; in case of a coupling without stop, it is not greater than half the total length of the fitting;

L_2 is the length of the integral heating element from the 1st regular section of the element to the end of the regular section on one side of the fitting. The dimension shall be measured from outside edge to outside edge of wire;

L_3 is the distance between the mouth of the fitting and the start of the fusion zone as declared by the manufacturer to be the nominal unheated entrance length of the fitting.

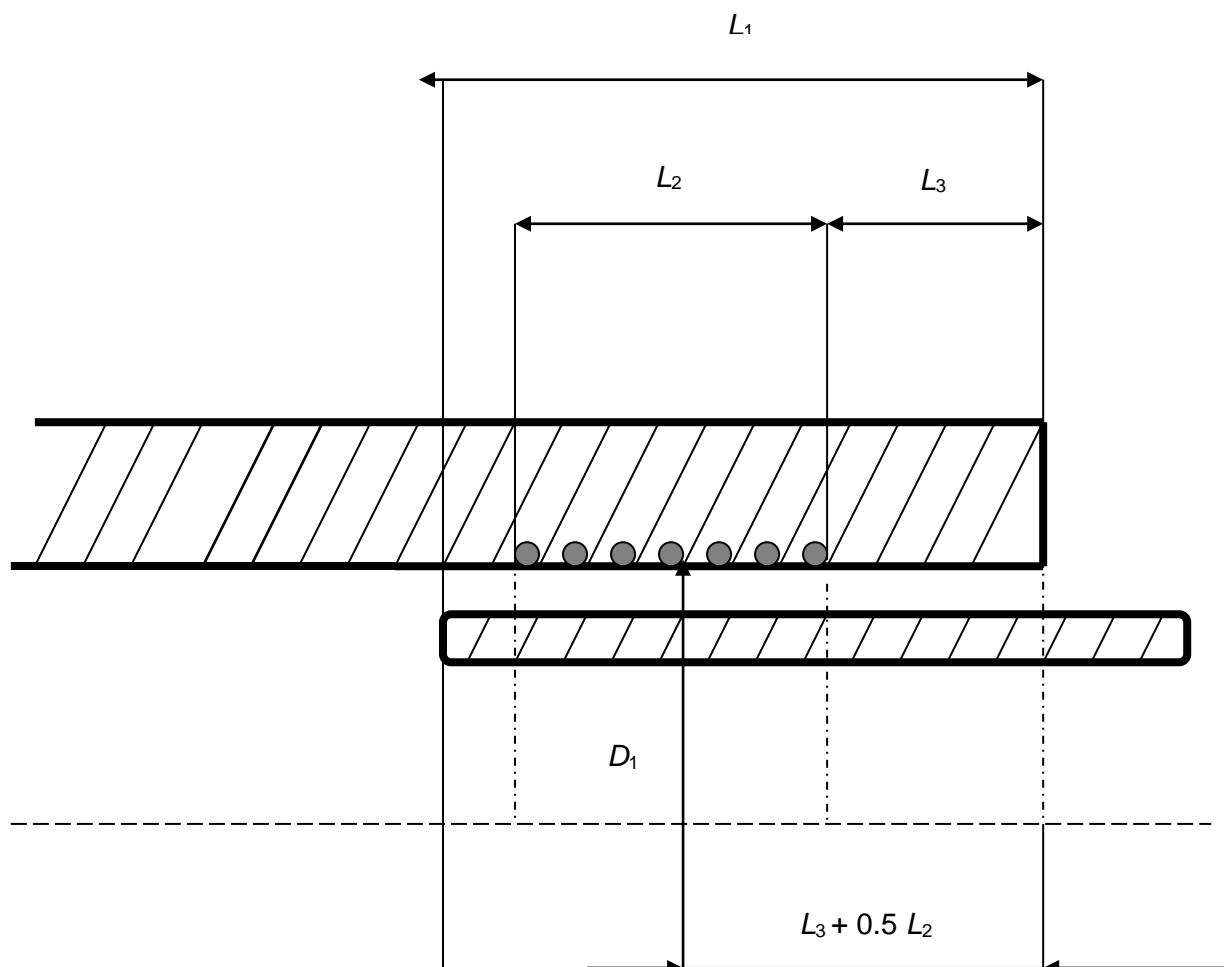


Figure 1.0 Dimensions of electrofusion socket fittings

Table 3 Dimensions of electrofusion socket fittings - dimensions in mm

Nominal diameter of pipe d_n	Mean internal diameter (D_1) Maximum (measured along L_2)	Mean internal diameter (D_1) Minimum (measured along L_2)	Penetration depth L_1 Max	Minimum nominal length of fusion zone L_2 min
16	16.6	16.4	41	15
20	20.6	20.4	41	16
25	25.6	25.4	41	18
32	32.9	32.5	44	18
40	41.0	40.6	49	18
50	51.1	50.7	55	20
55	56.1	55.7	63	21
63	64.1	63.7	63	23
75	76.3	75.9	70	25
90	91.5	91.1	79	28
110	111.6	111.1	82	32
125	126.7	126.2	87	35
140	141.7	141.2	92	38
160	162.1	161.4	98	42
180	182.1	181.5	105	46
200	202.1	201.4	112	46
225	227.6	226.5	120	48
250	252.6	251.7	129	50
280	282.9	281.8	139	50
315	318.3	317.1	150	50
355	Manufacturer shall declare, shall not be less than d_n	Manufacturer shall declare, shall not be less than d_n	164	50
400			179	50
450			195	51
500			212	56
560			235	61
630			255	67
710			280	73
800			300	80

NOTE For *Unscraped solid wall pipe compliant with PL2-2 or PL2-8 or Peelable Pipe with sacrificial outer layer removed (PL2-2)*, the manufacturer shall ensure that the internal diameter of the fitting shall be sized to allow sliding assembly over misaligned and stationary pipes followed by the subsequent fusion of a pipe to fitting joint. The manufacturer shall demonstrate this requirement in accordance with Clause 10.4. This is a critical requirement for UK installation practices.

In the case of a fitting having sockets of differing nominal diameters, each one shall conform to the requirements for the nominal diameter of the corresponding component.

6.2.2 Wall thicknesses of electrofusion socket fittings e_n

a. The wall thickness of the body of the fitting at any point, E , shall be greater than or equal to e_{min} for the corresponding pipe at any part of the fitting located at a distance beyond a maximum of $2 L_1/3$ from all entrance faces if the fitting and the corresponding pipe are made from a polyethylene having the same MRS.

If the fitting is produced from a polyethylene having an MRS that is different from that of the corresponding pipe, the relationship between the wall thickness of the fitting, E , and the pipe, e_{\min} , shall be in accordance with Table 4.

Table 4 Relation between fitting and pipe wall thicknesses

Pipe	Fitting	Relation between fitting wall thickness, E , and pipe wall thickness, e_{\min}
PE80	PE100	$E \geq 0,8e_{\min}$
PE100	PE80	$E \geq 1,25e_{\min}$

b. In the case of a wall thickness design different from that according to a), fittings and associated fusion joints shall additionally meet the performance requirements given in Clause 10.7.4.

NOTE PE80 fittings that have GIS/PL2-4:2008 approval will be exempt from testing.

6.2.3 Out-of-roundness of the bore of a fitting (at any point)

When a fitting leaves the site of the manufacturer, the out-of-roundness (ovality) of the bore of a fitting at any point shall not exceed $0,015d_n$.

6.2.4 Spigots

For fittings, which contain spigot outlets (e.g. electrofusion equal tee with a spigotted branch), the dimensions of the spigot shall conform to GIS PL2-6.

6.3 Dimensions of electrofusion saddle fittings

Outlets from tapping tees and branch saddles shall have spigots conforming to GIS/PL2-6 or an electrofusion socket conforming to Clause 6.2.1 of this standard.

The manufacturer shall specify the overall dimensions of the fitting. These dimensions shall include the maximum height of the saddle, H , and for tapping tees the height of the service pipe, H_1 or H_2 (see Figure 2).

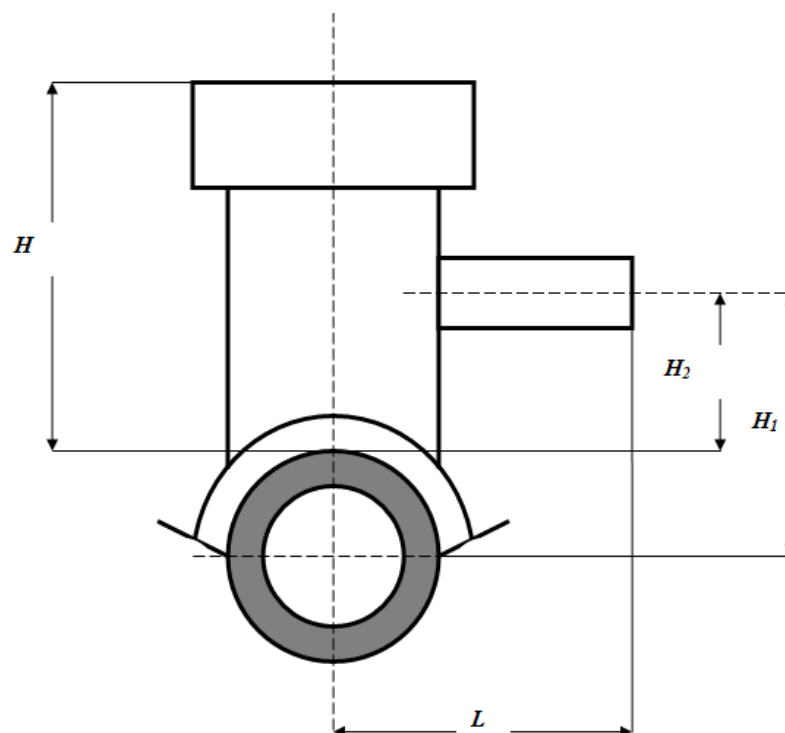


Figure 2 Dimensions of electrofusion saddle fittings

Key

H height of the saddle, which comprises the distance from the top of the main to the top of the tapping tee or saddle

H_1 height of service pipe, which comprises the distance from the axis of the main to the axis of the service pipe

H_2 height of service pipe, which comprises the distance from the top of the main pipe to the axis of the service pipe

L width of the tapping tee, which comprises the distance between the axis of the pipe and the plane of the mouth of the service tee

6.3.1 In-line electrofusion tees

The tee shall be configured with electrofusion sockets in longitudinal alignment for connection to the mains pipe and a spigot outlet located perpendicular to the centreline of the sockets for connection to the branch pipe. The nominal diameter of the branch spigot shall be equal to or less than the nominal diameter of the fitting sockets.

The wall thickness of the branch spigot shall not be less than wall thickness of the pipe to which connection is intended.

The fitting shall incorporate a permanent method of controlling pipe penetration within each socket to prevent obstruction of the spigot outlet.

6.3.2 Tapping tees

Tapping tees shall be designed for connection by saddle fusion, to pressurized and non-pressurized mains pipes and by socket fusion to the outlet service pipe, using GIS/PL2-5 approved alignment and re-rounding tooling.

The fitting manufacturer shall provide installation instructions and recommend /provide appropriate tooling if different from that prescribed in GIS/PL2-5.

NOTE Mains pipe sizes range in diameter from 40 mm to 800 mm Class B tees are intended for fusion jointing to pipe conforming to GIS/PL2-2 whilst class C fittings are intended for pipes conforming to GIS/PL2-8. Class C fittings may be attached to pipes conforming to GIS/PL2-2.

Provision for the integral location of a mains pipe cutter shall be made within the body of the tapping tee. Tapping tees shall provide a means of cutting through the pressurized main pipe and allowing gas to flow into the outlet pipe. Uncontrolled leakage of gas to atmosphere shall not occur. The cutting action shall not produce swarf and the coupon shall be retained by the cutting device. The integral cutter shall be operated with a 12 mm AF or 17 mm hexagonal key where the depth of hexagon shall not be less than 16 mm or 17 mm respectively. A stop shall be provided to prevent the key penetrating through the cutter.

Alternative cutter actuation mechanisms may be proposed by the contractor but shall be subject to agreement with the gas transporter.

All fittings shall have the integral heating element clear of the path of the cutter. The design of the tapping tee shall include provision for pressure testing, without removal of the pipe cutter before the mains pipe is cut, of the service pipe connection and the saddle fusion joint on the mains pipe.

6.3.2.1 Outlets

Tapping tee outlets shall be spigot type or electro-fusion type.

Spigot outlets shall have an outside diameter either $32_0^{+0.3}$ mm over a minimum spigot length of 46 mm, with a maximum Out of Round of 0.7mm, or $63_0^{+0.4}$ mm over a minimum spigot length of 70 mm, with a maximum Out of Round of 0.9mm. The spigot minimum wall thickness shall be in accordance with GIS/PL2-6: 2009, Table 3.

Outlets that provide an electrofusion socket shall conform to the requirements of this standard at the appropriate nominal socket diameter.

The permissible saddle base dimension, along the main, shall not be greater than 200 mm.

6.3.2.2 Installation jointing force

Tapping tees shall be capable of installation by a force between 1 kN and 1.5 kN applied from above, with its line of action along the centre line of the tapping tee stack and the diameter line of the mains pipe, using GIS/PL2-5 approved tooling

Alternative loading methods and tooling for fittings (e.g. temporary or permanent underclamps) may be proposed by the contractor, provided that the resultant joint meets the performance requirements of this standard, and shall be subject to agreement with the gas transporter.

The fitting manufacturer shall provide installation instructions and recommend /provide appropriate tooling if different from that prescribed in GIS/PL2-5.

6.3.2.3 Cutter torque requirements (Class B tapping tees)

For tees with 32 mm outlets, the cutter operating torque at -5°C shall not exceed 80 N·m (applied at 5 rpm) over the range of mains pipe sizes up to and including 180 mm nominal outside diameter. Specialist tooling (e.g. thread followers) shall not be used.

Cutter operating torque for 32 mm tees attached to mains pipe sizes greater than 180 mm nominal outside diameter shall be limited to 130 N·m (applied at 5 rpm) when cutting through at -5°C. The need for specialist tooling shall be declared by the contractor at the submission stage. Specialist tooling shall be provided by the contractor.

For tapping tees with 63 mm outlets, the cutter operating torque shall not exceed 270 N·m (applied at 5 rpm) across the mains pipe size range when cutting through at -5°C. The use of specialist tooling shall be declared by the Contractor at the submission stage. The specialist tooling shall be provided by the contractor.

6.3.2.4 Cutter torque requirements (Class C tapping tees)

For tapping tees with 32 mm outlets, the cutter operating torque shall not exceed 130 N·m (applied at 5 rpm) across the mains pipe size range when cutting through at -5°C. The use of specialist tooling shall be declared by the contractor at the submission stage. The specialist tooling shall be provided by the contractor.

For tapping tees with 63 mm outlets, the cutter operating torque shall not exceed 270 N·m (applied at 5 rpm) across the mains pipe size range when cutting through at -5°C. The use of specialist tooling shall be declared by the Contractor at the submission stage. The specialist tooling shall be provided by the contractor.

6.3.2.5 Tapping tee cap

The tapping tee cap shall be capable of passing all tests required of the fitting without additional fastenings or constraints to the cap. It shall not fail by cracking when a torque of 15 N·m is applied at a temperature of -5 °C.

Leakage shall not occur from the cap when tested in accordance with **10.5**.

Where an “O” ring is used as a seal, it shall remain in position in the cap when the cap is removed and refitted. For alternate ‘side seal design’ the “O” ring shall sit on a purposely moulded shoulder at the top of the stack of the body of the tapping tee.

6.4 Branch saddles

Branch saddles shall be designed for connection, by saddle fusion to pressurized and non-pressurized mains pipes in diameters from 40 mm to 800 mm and provide a spigot or mechanical flanged outlet for connection to the branch pipe system using GIS/PL2-5 approved alignment and re-rounding tooling. The fitting manufacturer shall provide installation instructions and recommend /provide appropriate tooling if different from that prescribed in GIS/PL2-5.

Heated-tool saddle fusion is not acceptable.

Class B saddles are intended for fusion jointing to pipe conforming to GIS/PL2-2 whilst class C fittings are for pipes conforming to GIS/PL2-8.

Branches shall be of sufficient length to accommodate all aspects of the branching installation.

The branch shall be an integral part of the fitting as supplied; where necessary a pipe pup extension may be incorporated that shall be butt fused or joined by an electrofusion coupler. Heated-tool socket fusion shall not be permitted.

Where branches are extended by butt fusion, the joint shall have both the internal and external beads removed and visually inspected for contamination and slit defects.

Where applicable, branch saddle off-takes involving a squeeze off operation, shall be evaluated to ensure that the branch has an adequate resistance to squeeze off in accordance with GIS/PL2-2 and GIS/PL2-8.

6.4.1 Outlet terminations

Class B branch terminations shall be in the form of a spigot or for outlet sizes equal to or greater than 90 mm the branch may incorporate a polyethylene stub flange and metallic backing ring.

Class C branch outlets shall be flanged with stub flanges with metallic backing rings.

The maximum length of the branch outlet measured from the crown of the main shall conform to Table 5 for flanged branches, as appropriate. Flanged assemblies shall be compatible with flanges to ISO 7005-1.

Table 5 Flanged branch saddle outlet lengths

Dimension in millimetres		
Offtake size	Maximum dimension from flange face to crown of main	
	Class B/C fittings	Flange size
63	180	DN 50
90	180	DN 80
125	180	DN 100
180	250	DN 150
250	250	DN 200

Fittings having flanged outlets shall be in accordance with GIS/PL3:2014, **8.6** and **8.7**.

The maximum diameter of the drill that can be used with the branch saddle shall be declared by the contractor.

6.4.2 Installation jointing force

Branch saddles having spigot outlets up to and including 63 mm shall be capable of installation by a force between 1 kN and 1.5 kN applied perpendicular to the pipe axis on the centre-line of the spigot using GIS/PL2-5 tooling.

Alternatively temporary or permanent under-clamps may also be used provided the resultant joint meets the performance requirements in Clause 10.6.

The fitting manufacturer shall provide installation instructions and recommend /provide appropriate tooling if different from that prescribed in GIS/PL2-5.

Note Alternative methods (e.g. temporary or permanent underclamps) may be proposed by the contractor subject to agreement, provided that the resultant joint meets the performance requirements.

6.5 Electrofusion end cap assemblies

Electrofusion end cap assemblies shall consist of an approved straight coupler or in-line reducer to 6.2 and an approved spigot cap to GIS/PL2-6, assembled and securely retained in such a way that they do not easily separate prior to electrofusion.

NOTE Alternatively, all-in-one electrofusion end caps may be proposed by the contractor subject to agreement by the gas transporter.

6.6 Electrofusion flange adaptors

The electrofusion portion of the flange adaptor shall meet the dimensional requirements of a straight coupler of half-length in accordance with **6.2.1**. The flanged portion on flange adaptors shall be in accordance with **6.4.1**.

7 Fitting stability

7.1 Dimensional stability

7.1.1 Socket fittings

All socket fitting dimensions shall conform to their specified values when the fitting has been stored for a minimum period of 120 minutes at a temperature of $80\text{ °C} \pm 2\text{ °C}$. The fitting shall then be conditioned at $23\text{ °C} \pm 2\text{ °C}$ for a minimum of 24 hours prior to measurement.

NOTE Alternative information to demonstrate dimensional stability may be offered.

7.1.2 Tapping tees and branch saddles

All tapping tee and branch saddle fitting dimensions shall conform to their specified values when the fitting has been stored for a minimum period of 120 minutes at a temperature of $80\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. The fitting shall then be conditioned at $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for a minimum of 24 hours prior to measurement.

NOTE *Alternative information to demonstrate dimensional stability may be offered.*

7.1.3 Spigot/pup end circumferential reversion

Spigot/pup ends shall conform to GIS/PL2-6:2009, **12.5**.

7.2 Thermal stability

When tested in accordance with BS EN 728, or ISO 11357, the PE material for class B fittings and class C fittings shall have an oxidation induction time greater than 20 min at $200\text{ }^{\circ}\text{C}$.

NOTE *The test may be carried out at $210\text{ }^{\circ}\text{C}$ provided that there is a clear correlation with the results at $200\text{ }^{\circ}\text{C}$.*

In case of dispute the reference temperature shall be $200\text{ }^{\circ}\text{C}$.

8 Fitting electrical characteristics

8.1 Heating element and terminals

8.1.1 Resistance

For each size and type of fitting, the contractor shall declare the nominal resistance of the heating element and specify the production tolerances.

The contractor shall demonstrate that a satisfactory joint can be made using the extremes of these tolerances using the method specified in Annex B.

8.1.2 Short/open circuits

The heating element shall be suitably designed to prevent short circuiting or local overheating/underheating during the fusion operation. Protective coatings applied to the heating element shall not have a detrimental effect on the joint.

The heating element wire shall not be disturbed during assembly.

For fittings wound with parallel heating wires, the indicators (**9.4**) shall not operate if any wire becomes open circuit during the first 50 % of the fusion cycle.

8.1.3 Terminal design

All fittings shall have mechanically shrouded male electrical terminals. The shroud shall be designed so as to minimize the potential for impact damage.

Fitting terminals and shrouds should conform to either Figure 3 and 4 for 40 volt electrofusion fittings.

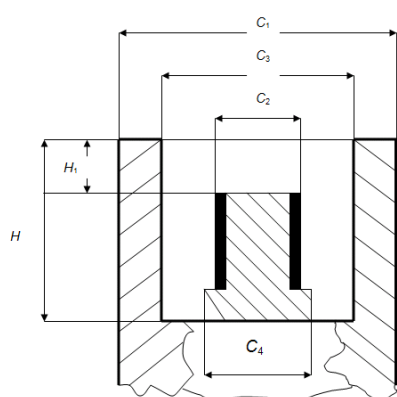
80 volt electrofusion fittings terminal and shrouds should conform to Figure 5 for 80 volt electrofusion fittings.

When hollow terminal pins are used, the hole at the top of the pin shall be less than 1 mm diameter.

The terminal pin material shall be corrosion resistant and the surface finish shall be in accordance with BS1134.

Fittings supplied with non-integral terminal shrouds shall be subject to 100 % inspection.

All dimensions in millimetres



Key

$$C_1 \geq 11.8$$

$$C_2 = 4.00 \pm 0.1$$

$$C_3 = 9.5 \pm 1.0$$

$$C_4 \leq 6.0$$

$$H \geq 12.0$$

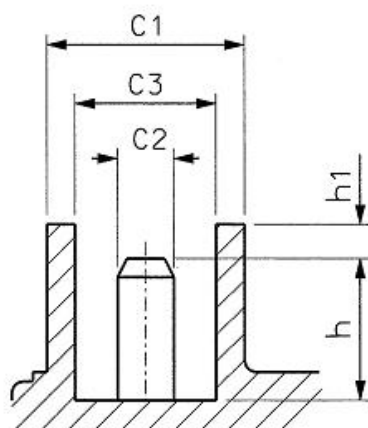
$$H_1 = 3.2 \pm 0.5$$

$$H_2 \geq 7$$

$$H_2 \leq H - H_1$$

Figure 3 Type A terminal connection for 40 volts electrofusion fittings

All dimensions in millimetres



Key

$$C_1 \geq 13.00 \pm 0.5$$

$$C_2 = 4.70 \pm 0.1$$

$$C_3 = 10.0 - 0.1/+0.5$$

$$h \geq 15.5$$

$$h_1 = 4.5 \pm 0.5$$

Key

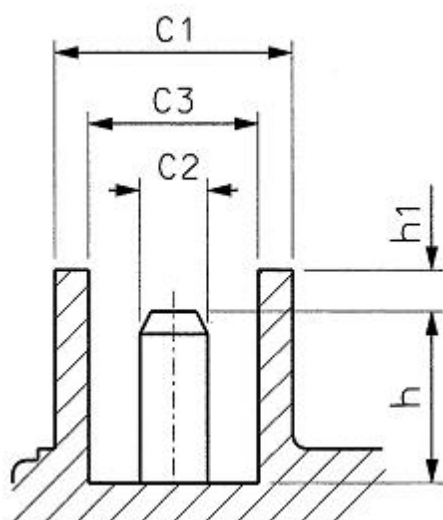
$$C_1 = 20.00 \pm 0.2$$

$$C_2 = 4.68 \text{ to } 4.73$$

$$C_3 = 12.20 \pm 0.15$$

$$h \geq 18.5 \pm 0.2$$

$$h_1 = 6.5 \pm 0.1$$

Figure 4 Type B terminal connection for 40 volts electrofusion fittings
All dimensions in millimetres

Key

$$C_1 = 20.00 \pm 0.2$$

$$C_2 = 5.69 \text{ to } 5.74$$

$$C_3 = 13.50 \pm 0.1$$

$$h \geq 16.0 \pm 0.2$$

$$h_1 = 6.5 \pm 0.1$$

Key

$$C_1 \geq C_3 + 2.0$$

$$C_2 \geq 2.0 \pm 0.1$$

h_1 : sufficient to ensure
a degree of protection
of IP 2 X as defined in
IEC 60529

$$h_2 \geq 7.0$$

Figure 5 Type C terminal connection for 80 volts electrofusion fittings

8.2 Power input

The maximum power requirement for socket fittings up to and including 280 mm and all saddle fittings shall be 2.5 kW at 40 V rms and the fitting voltage supply shall be 39 V to 40 V rms.

The maximum power requirement for socket fitting size 315mm to 400mm major diameters inclusive shall be either 4 kW at 40 V rms or 80 V rms, and the fitting voltage supply shall be either 39 V to 40 V rms or 78 V to 80 V rms.

The maximum power requirement for socket fitting sizes greater than 400 mm shall be 4.8 kW and the fitting voltage supply shall be 78 V to 80 V rms. 40V fittings in sizes >400mm are recognised by this GIS, provided they comply with clause 8.3.

8.3 Jointing Time

The power consumption of fittings shall not lead to excessively long fusion and cooling times.

Note When selecting the fusion time, consideration of joint cooling time before handling is necessary. Joint cooling time is the time taken for the joint interface material to fall to 110 °C or at the discretion of the gas transporter a lower temperature may be considered.

Based on a reference temperature of 110°C the cooling time shall be determined in accordance with Annex C. The cooling time for fittings up to and including 180mm in diameter shall not exceed 20 min. The jointing time (fusion plus cool time) shall not exceed 90 min for sizes >180mm up to a maximum of 355mm.

For reference temperatures below 110°C the cooling and jointing time may be extended at the discretion of the gas transporter.

For larger sizes jointing times may be proposed by the contractor and shall be subject to agreement with the gas transporter.

9 Fusion and jointing

9.1 Electrofusion control boxes

Control boxes specified in GIS/ECE/1 shall be capable of routinely fusing fittings to pipes. The fittings shall exhibit the strengths of, and fusion compatibility with, pipes in accordance with GIS/PL2-2 and GIS/PL2-8, without correction to fusion time or voltage for ambient conditions at which fusion is initiated in the range -5 °C to 30 °C. Compliance in this respect shall be demonstrated by the contractor by conforming to the requirements specified in Clause 10.

The use of alternative control boxes approved to equivalent standards (e.g. EN or ISO) may be proposed and shall be subject to agreement with the gas transporter.

9.2 Fusion time and pipe SDR

Whenever possible for each type of fitting the fusion time shall be the same, irrespective of pipe SDR. The pipe SDR details are given in Table 2 of this standard. Fittings where the fusion time is SDR dependant shall be clearly marked with a label.

Branch saddles may be offered that are restricted in use to mains pipe with an SDR rating up to and including SDR17.6, and shall be subject to agreement with the gas transporter.

NOTE The restriction should be displayed using a suitable label affixed to the fitting.

9.3 Pipe inserts

Where electrofusion socket fittings are supplied for connection to pipes, produced in accordance with GIS/PL2-2 and/or GIS/PL2-8, followed by an additional solid state shape forming process (e.g. swagelining) and where the use of pipe inserts are necessary to reform the pipe, the fitting and pipe insert shall be tested and supplied as a package. The fitting should be labelled to indicate suitability for use with the appropriate type of processed pipe.

NOTE Alternative forms of labelling may be offered.

Where applicable the use of pipe inserts in association with thin walled pipes (e.g. SDR26 or greater) shall also be tested and supplied as a complete package and labelled accordingly.

Inserts (metal or plastic) shall be sized such that when installed, the outside diameter of the polyethylene pipe is in accordance with the relevant size from GIS/PL2-2, Table 1 or GIS/PL2-8.

Pipe insert packages shall conform to Annex D.

The design of the inserts shall be such that they do not cause an undue restriction to gas flow.

9.4 Fusion indicators (one per fusion zone)

A permanent and obvious means of showing that the joint has been subjected to the fusion cycle shall be provided on the external surface of the fitting. It shall be shown to be reproducible and shall be demonstrated during batch release testing, see Table A.3.

9.5 Interface melt

With the exception of fusion indicators, melt from the fusion operation shall not exude outside the confines of the fitting or into the inner cold zone(s) of the fitting beyond the end of the inserted pipe.

The fusion process shall not create significant voids on the fusion interface or promote pipe collapse on the adjoining pipe(s). After the fusion cycle, where any moulding preform is used, there shall be no delamination between the moulding preform and the coated wires over the fusion areas during the performance testing of the fitting.

NOTE Voids are classed as "un-fused areas", and will be accounted for in the de-cohesion calculation.

9.6 Joint reheating

Each fitting designed for use on SDR11 and SDR17.6 pipe shall be capable of one reheat or fusion at the specified time plus 50% under assembly conditions for the full fusion cycle time without deterioration of the fusion joint. The fitting shall be allowed to cool to $23\text{ °C} \pm 2\text{ °C}$ prior to the reheating cycle.

The joint shall be assembled and tested in accordance with Table A.2 (stress crack resistance and tensile strength of couplers tests).

10 Performance of fitting/pipe assemblies

10.1 General

Jointed pipe and fitting assemblies, prepared in accordance with Annex A (Table A.1) and Annex E, shall conform to **10.3** to **10.10** inclusive.

10.2 Conditioning and test temperature

During type testing, or in any case of disagreement between the gas transporter and the contractor, assemblies shall be conditioned prior to test in accordance with Table 6.

Table 6 Minimum conditioning period

Minimum wall thickness mm	Minimum conditioning period h			
	In air 23 °C ± 2 °C.	In liquid at 20°C (± 1°C)	In liquid at 80°(± 2°C)	In liquid at 80°C (± 2°C) ^{a)}
≤12	6	1	6	3 ^{a)}
>12 and ≤25	10	2	10	5 ^{a)}
>25 and <60	24	3	24	12 ^{a)}
≥60	48	4	48	24 ^{a)}

^{a)} These conditioning times in liquid at 80 °C shall apply only if the assembly, instead of being cold-filled with liquid, is initially pre-filled with liquid at the same temperature as the hot tank.

Tests, other than those involving liquid immersion or otherwise specified, shall be conducted at a laboratory temperature of 23 °C ± 2 °C.

10.3 Corrosion resistance

The corrosion resistance of metallic parts shall be assessed by immersing the fitting for a minimum of 170 hrs in an aqueous sodium chloride solution (30 g/l) at 23 °C ± 2 °C. On completion of the test period there shall be no evidence of rust spots and corrosion of exposed metal.

10.4 Fitting assembly force (couplers above 180 mm)

When the coupler is assembled to pipe in accordance with Annex F, the measured assembly force shall not exceed 500 N. The assembly shall be fused and then subjected to a peel test in accordance with 10.6.1.

10.5 Pneumatic leak test (tapping tee cap)

When tested in accordance with Annex G no leakage shall be detected.

10.6 Joint interface strength

10.6.1 Peel strength (sockets)

The peel strength of electrofusion socket fittings equal to or greater than 90 mm shall be assessed in accordance with ISO 13954. Interface tearing along the fusion length shall be ductile over a minimum length of 66 % of the apparent fusion length.

NOTE *Socket fittings less than 90 mm may be tested using the peel test. A suitable test method may be proposed.*

10.6.2 Crush strength (sockets and saddles)

The interface strength of saddle fusion joints incorporated in tapping tee and branch fittings less than 90 mm diameter shall be assessed using the crush strength test specified in ISO 13955. No cracking shall occur at the fusion interface during the test period of 10 min. End effects over the first two complete turns of wire shall be ignored.

Fittings equal to or greater than 90 mm in diameter shall be tested by crushing in accordance with ISO 13955 unless the branch saddle is so large that it becomes impractical to crush.

In this case the contractor may propose an alternative test method, such as a peel test and this shall be subject to agreement with the gas transporter.

10.6.3 Tensile strength and leak-tightness at 80 °C (AREL) (16 mm to 75mm)

A socket joint assembly shall be tested in accordance with and meet the requirements of GIS/PL3: 20014, 8.7.

10.6.4 Tensile strength (branch saddles)

A branch saddle joint assembly shall not fail when tested in accordance with Annex H, unless the branch saddle is so large that the test becomes impractical.

Where it becomes impractical to conduct a pull off test on large branch saddles in accordance with Annex H, then the contractor may propose an alternative test and this shall be subject to agreement with the gas transporter.

10.7 Pressure strength

10.7.1 Resistance to internal pressure at 20 °C (test duration- see Table 7)

Class B and class C fitting/pipe assemblies shall be pressure tested at 20 °C in accordance with BS EN ISO1167 and the relevant test criteria given in Table 7. The fitting shall not fail at the following applicable circumferential pipe hoop stress:

- class B fittings: 10.00 MPa;
- class C fittings: 12.00 MPa.

The fitting/pipe assembly shall be sectioned and suitably prepared after testing for visual examination. There shall be no evidence of cracking or pipe collapse when the joint is examined using dye penetrant or other equivalent methods.

Table 7 Test Criteria

Supplier Band	Test Duration
Existing mature / approved UK suppliers At the gas transporters discretion new suppliers using European approved resins with a proven track record (at the discretion of the GT) of supply to gas transporters within the European Commission *Approved European resins to include those manufactured outside of Europe	100 hours
New suppliers/materials	5000 hours

NOTE the manufacturer shall seek clarification of banding from the Certification Body.

10.7.2 Resistance to internal pressure at 80 °C (165 h)

A fitting/joint assembly shall be pressure tested at 80 °C in accordance with BS EN ISO1167. for 165 h without failure at the following applicable circumferential pipe hoop stress:

- class B fittings: 4.5 MPa;
- class C fittings: 5.4 MPa.

The fitting/joint assembly shall be sectioned and suitably prepared after testing. There shall be no evidence of cracking or pipe collapse when the joint is examined using dye penetrant or other equivalent methods.

10.7.3 Resistance to internal pressure at 80 °C (1000 h)

A fitting/joint assembly shall be pressure tested in accordance with BS EN ISO1167 for 1000 h at 80 °C without failure at the following applicable circumferential pipe hoop stress:

- class B fittings: 4.0 MPa;
- class C fittings: 5.0 MPa.

The test shall be conducted at the minimum and maximum SDR ratings for which the fitting is claimed to be suitable in accordance with Table 1.

The fitting/joint assembly shall be sectioned and suitably prepared after testing. There shall be no evidence of cracking or pipe collapse when the joint is examined using dye penetrant or other equivalent methods.

10.7.4 Performance Requirements – electrofusion socket fittings

Where 6.2.2 b) applies, electrofusion socket fittings shall, additionally, be in accordance with Table 8.

Table 8 Performance Requirements

Short-term internal pressure resistance	Requirement	Test Parameter	Test Value	Test Method
Short-term internal pressure resistance	Failure pressure shall be > pressure equivalent of 2 × MRS calculated for thickest-walled pipe for which fitting has been designed	End caps Orientation Conditioning time Type of test Minimum pressure: PE 80 pipe, SDR 11 PE 100 pipe, SDR 11 Pressure increase rate Test temperature	Type A of EN ISO 1167-1:2006 Free 12 h Water-in-water 32 bar 40 bar 5 bar/min 20 °C	Annex K
Resistance to tensile load	No leakage or failure of the fusion joint after 25% pipe elongation	Test temperature	23 °C	Annex L
1 bar = 0,1 MPa = 105 Pa; 1 MPa = 1 N/mm ²				

10.8 Impact strength (tapping tee)

A tapping tee, when tested in accordance with BS EN 1716, shall withstand an impact energy of 100 J without failure.

10.9 Thermal stability

When tested in accordance with BS EN 728 or ISO 11357, class B fittings and class C fittings shall have an oxidation induction time greater than 20 min at 200 °C.

10.10 Pressure drop

10.10.1 Tapping tees

When class B applications only are tested in accordance with Annex I, the pressure drop shall not exceed the velocity head values specified in Table 9, for the appropriate natural gas flow at a working pressure of 25 mbar.

At the discretion of the gas transporter BS EN 12117 may be considered for calculation of pressure drop as an alternate to GIS PL2-4 Annex I. Equivalency in respect of calculated values shall be demonstrated.

Table 9 Tapping tee pressure drop ^{a)}

Outlet size mm	Mains pipe size mm	Flow rate of methane m ³ [st]/h	Maximum pressure drop in service pipe velocity heads ^{a)}
32	All	4.3	4
63	63 to 75	18	10
63	Greater than 75	18	4

^{a)} Tapping tee includes approved electrofusion fitting fused to spigot outlet.

11 Assessment and conformity

11.1 General

Type testing and batch release testing shall be carried out in accordance with **11.2** and **11.3**. Process verification shall be carried out in accordance with **11.4**.

Testing and sampling shall be carried out in accordance with Annex A. Type tests (TT) and batch release tests (BRT) shall be conducted on fittings to pipe test assemblies that incorporate pipes with the smallest SDR rating (largest wall thickness) for which the fitting was designed (see Table 2). Additionally, assemblies for the 80 °C type testing pressure test shall include pipes covering the minimum and maximum SDR ratings for which the fitting is claimed to be suitable, in accordance with Table 2.

A range of previously approved fittings produced in a new material may gain approval from a reduced number of test samples. Tests shall be performed on the smallest and largest size in the contractor's range, and on one intermediate size. Different fitting types may be used to demonstrate conformity. Once these three sizes have gained approval, approval shall be granted to any other sizes between the smallest and largest pipe size tested.

11.2 Type testing

Type testing of each type and size of fitting shall be carried out in accordance with **A.1** and **A.2** before a particular fitting shall be considered suitable for supply to the gas transporter.

NOTE *Sample test assemblies shall take account of manufacturing and assembly tolerances based on process control data of upper and lower variance ranges.*

11.2.1 Type testing – Modifications to approved Fittings and Low Volume Products.

Refer to Appendix J of this standard for details of the Type Approval Tests, which shall be performed in respect of modifications to approved fittings and low volume products.

11.3 Batch Release Tests (BRT)

Batch release tests shall be carried out in accordance with **A.1** and **A.3** in order to demonstrate a continuing satisfactory level of product quality in day-to-day production.

Batch release tests on fittings shall be carried out using approved pipe in accordance with GIS/PL2-2 (class B fittings) or GIS/PL2-8 (class C fittings), and GIS/PL2-5 tooling.

The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling if different from that prescribed in GIS/PL2-5.

11.4 Process verification tests (Approved Fittings)

Every two years after gaining Type Approval, one fitting per size group (rotating sizes), shall meet the requirements of clause 10.7.3 of this standard. The subsequent fitting test assemblies shall feature the minimum and maximum pipe SDR, and be fused at the minimum and maximum jointing conditions as shown in Table A.1 of this standard.

Size Groups: (I) 16- 63mm; (II) 75-225mm; (III) 250-800mm.

12 Marking

All fittings supplied in accordance with this standard shall be marked using characters of 3 mm dimension, where practical. Alternatives may be offered subject to agreement with the gas transporter.

Products conforming to GIS/PL2-4:2019 shall be permanently marked with the following information as a minimum:

- a) The name or trademark of the manufacturer or their appointed agent.
- b) The size of the fitting in mm.
- c) The date of manufacture (a code may be used for this, subject to agreement)
- d) The fusion time in seconds (preferably visible from above in installed position)
- e) The cooling time in minutes (preferably visible from above in installed position)
- f) SDR rating of fitting or MOP in bar.

NOTE Requirements d) and e) should be repeated on a label firmly fixed to the fitting packaging or on an individual bag.

Alternatively embossed or indented tags maybe attached to the fitting if agreed by the gas transporter. Any tag shall remain attached to the fitting in normal back fill conditions.

The information shall be embossed or indented on the fitting to a minimum depth of 0.15 mm

In addition to the above an orange label shall be securely affixed to each yellow or black Class C fitting to indicate the MOP of 7Bar.

Packaging: Minimum information required on a label securely attached to the fitting packaging:

- a) The mass of the fitting in kg for fittings of mass greater than 10 kg;
- b) For branch saddles, the maximum drill diameter that can be used.

Additional information, which may also be shown on the label:

- a) The number and date of this standard, i.e. GIS/PL2-4: 2019 (See Note)
- b) Where authorized, the product conformity mark of a third party certification body, e.g. BSI Kite-mark
- c) The manufacturers contact details.
- d) The SDR ratings of pipe that the fitting is approved for use with.

NOTE Marking GIS/PL2- 4:2019 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the specification. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

All marking shall remain legible under normal handling, storage and installation procedures. The method of marking shall not prevent the fitting from meeting the requirements of this standard.

13 Protection of fittings

Fittings shall be individually sealed in transparent polyethylene bags of at least 300 gauge thickness (75 µm thick) to ensure seal integrity is not compromised during storage, transit and handling in the field.

The outer pack shall be suitable for stacked storage and be marked with the information specified in GIS/PL2-4 Clause 12 b and f together with the fitting type and quantity in the pack.

Constituents of fitting packaging shall not create contamination which can prevent normal jointing.

The packaging or fitting design shall ensure protection of heating elements.

NOTE Fittings should be stored in their original packing. They should only be removed before installation in order to avoid contamination.

Annex A (normative)

Testing and sampling requirements

A.1 General

Test pieces for type testing, with the exception of those intended for tests to determine corrosion resistance, dimensional stability, thermal stability, MFR and electrical resistance, shall be assembled and fused in accordance with the manufacturer's procedure and under the conditions specified in Table A.1.

For batch release and batch release testing, fusion joints shall be constructed with the pipes and fittings at ambient temperature using a control box that conforms to GIS/ECE1. Ancillary equipment shall conform to GIS/PL2-5.

The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling if different from that prescribed in GIS/PL2-5.

Table A.1 Fusion conditions for test piece manufacture (type testing) ^{a)}

Condition	Pipe and fitting temperatures ^{b)}			Applied fitting voltage ^{c)}	Saddle fitting assembly force ^{e)}
	°C				
	Pipe	Pipe SDR	Fitting	V	N
I	-5	11 ^{d)}	-5	Minimum	1 000
II	-5	11 ^{d)}	23	Minimum	1 000
III	-5	11 ^{d)}	23	Maximum	1 500
IV	23	17.6 ^{d)}	23	Maximum	1 500

^{a)} Test piece component requirements are specified in Annex E.

^{b)} Pipes and fittings shall be conditioned for at least 8h at $-5\text{ °C} \pm 2\text{ °C}$ or $23\text{ °C} \pm 2\text{ °C}$ as applicable. Where the pipe is conditioned at -5 °C the test piece shall be fused at this temperature with assembly and start of fusion completed within 2 min.

^{c)} Joints shall be fused for the necessary time period using an adjustable output voltage control box in accordance with GIS/ECE/1. The output voltage shall be adjusted in accordance with Annex B to create minimum and maximum power conditions.

^{d)} Fitting manufacturers shall ensure that their fittings have been tested for use with the pipe SDR's intended e.g. SDR21 or 26. See Clause 5.1, Table 2 of this standard, which gives details of recognised pipe SDR's.

^{e)} The values indicated are applicable to mains sizes up to and including 250mm. Alternative values may be proposed by the contractor, for larger size saddles, and shall be subject to agreement with the gas transporter".

NOTE Results arising from tests conducted at conditions, which are equivalent or more extreme than those shown in Table A.1 above, such as -10 °C and or $+45\text{ °C}$ in the case of temperature, shall be considered acceptable under this GIS standard.

A.2 Type testing

Each size and type of fitting (class B and class C fittings) shall have been tested in accordance with A.3 or A.4 and shall be tested in accordance with Table A.2.

Table A.2 Type testing test requirements (class B and class C fittings) ^{a)}

Property	Requirement clause	Test method	No. of fittings	Fitting/pipe assembly parameters	No. of test pieces
Cooling time	8.3	Annex C	1 per size per type	Condition IV	1 per fitting
Corrosion resistance	4.3.2	10.3	1 ^{b)}	Not applicable	1 per fitting
Coupler assembly force (off-set pipes)	10.4 10.6.1	Annex F ISO 13954	1 per size ^{c)}	Assembly at 23 °C followed by jointing at minimum power (J.3.2)	4 per socket
Cutting torque (tapping tee)	6.3.2.3 6.3.2.4	6.3.2.3 6.3.2.4	2 per outlet size ^{d)}	Condition I	1 per fitting
Dimensional stability	7.1.1 7.1.2	7.1.1 7.1.2	1 per size per type	Not applicable	1 per fitting
Impact strength (tapping tees)	10.8	BS EN 1716	1 per outlet size	Condition I	1 per fitting
Joint interface peel strength	10.6.1	ISO 13954	1 per size per type	Condition I	4 per socket
Joint interface crush strength	10.6.2	ISO 13955	1 per size per type	Condition I	2 per socket 1 per saddle
Pneumatic leak test (tapping tee cap) ^{e)}	10.5	Annex G	1 per outlet size	Any Temperature Condition	1 per fitting
Pressure drop (equal tees, elbows, reducers)	10.10.2 10.10.3 10.10.4	BS EN 12117	1 per size per type	Any Temperature Condition	1 per fitting

Table A.2 Type testing test requirements (class B and class C fittings) ^{a)} (*continued*)

Property	Requirement clause	Test method	No. of fittings	Fitting/pipe assembly parameters	No. of test pieces
Pressure drop (tapping tee) ^{e)}	10.10.1	Annex I	1 per outlet size	Condition IV	1 per fitting
Resistance to internal pressure at 20 °C (100, or 5000(i) hours) – see Table 7	10.7.1	BS EN ISO1167	4 per type per size	Conditions I, II, III, IV	1 fitting per condition
Resistance to internal pressure at 80 °C, 1 000 h (stress crack resistance)	10.7.3	BS EN ISO1167	4 per type per size	Conditions I, II, III, IV ^{f)}	1 fitting per condition
Resistance to short term internal pressure	6.2.2 b & 10.7.4	Annex K	4 per type per size	Conditions I, II, III, IV ^{f)}	1 fitting per condition
Resistance to tensile load	6.2.2 b & 10.7.4	Annex L	4 per type per size	Conditions I, II, III, IV ^{f)}	1 fitting per condition
Spigot end reversion	7.1.3	GIS/PL2-6, Clause 12.5	1 per type per size	Not applicable	1 per fitting
Tensile strength of branch saddles	10.6.4	Annex H	2 per outlet size	Joint conditions I and IV	1 fitting per condition
Tensile strength of couplers (AREL) ^{g)}	10.6.3	GIS/PL3:2006, 8.7	1 per size ^{h)}	Conditions I, II, III, IV ^{f)}	1 fitting per condition

^{a)} Class B fittings shall be tested with pipes in accordance to GIS/PL2-2 and class C fittings with pipes in accordance to GIS/PL2-8.

^{b)} Where several combinations of metallic materials are used in a range of fittings one fitting for each combination shall be tested.

^{c)} For coupler sizes greater than 180 mm.

^{d)} One pipe shall be cut with the assembly at 23 °C and the other with the assembly at –5 °C. Each assembly shall be conditioned at the appropriate temperature for 1 h prior to the pipe being cut.

^{e)} For class B tapping tees only; requirements for class C tapping tees shall be determined in consultation with the gas transporter.

^{f)} Joints made under condition IV shall be allowed to cool to ambient temperature (23 °C) and then re-energized for the manufacturer's stated fusion time.

^{g)} Flange adaptors shall be tested in accordance with GIS/PL3:2006, **9**.

^{h)} The test applies up to and including 75mm size.

ⁱ⁾ A BSI Certification Report may be issued upon completion of 2500hrs. The report will clearly state that the test has been witnessed and verified, and that the intended purpose is to complete 5000hrs, in order for the products to be covered on the relevant Kitemark Licence. The report will also include a termination date (the completion date for the full 5000hr test) from which the report will no longer be valid.

A.3 Batch release tests (BRT)

Checks shall be carried out in accordance with Table A.3.

Table A.3. Part 1 Batch release test requirements (class B and C fittings) ^{a)}

Initially for a period of no less than 6 months, the checks given in Table A.3.Part 1 shall be carried out at the stated frequency on production from each injection-moulding machine or manufacturing process. When the contractor has shown by consistently good results that it is not necessary for him to check at this frequency, Table A.3.Part 2 shall be operated by formal agreement with the gas transporter and or BSI.

Note: Table A.3. Part 1 shall also be operated following a change of raw material compound / a fundamental change to the fitting outside the scope of Appendix J.

Property	Requirement clause	Test method	Initial No. of fittings/test frequency	Fitting/pipe assembly parameters	No. of test pieces
Joint interface crush strength	10.6.2	ISO 13955	1 per type per size Every 24 h rotating cavities as applicable ^{b)}	A.1	2 per socket 1 per saddle
Joint interface peel strength	10.6.1	ISO 13954	1 per type per size Every 24 h rotating cavities as applicable ^{b)}	A.1	4 per socket
Measurement of dimensions	6.1 ^{c)}	Measure to agreed procedure giving an appropriate degree of accuracy ^{d)}	1 per type per size Every 2 h ^{b)}	Not applicable	1 per fitting
Melt flow rate	GIS/PL2-1	ISO 1133	Daily ^{b)}	Not applicable	1 per fitting
Operation of fusion indicators	9.4	Visual examination to agreed limits	1 per type per size Every 24 h rotating cavities as applicable ^{b)}	A.1	1 per fitting
Resistance of heating element	8.1.1	Measure resistance of fitting at 23 °C excluding terminal pin contact resistance	Every fitting	Not applicable	1 per fitting

Table A.3 Part 1 Batch release test requirements (class B and C fittings) ^{a)} (*continued*)

Property	Requirement clause	Test method	No. of fittings /test frequency	Fitting/pipe assembly parameters	No. of test pieces
Resistance to internal pressure at 80 °C, 165 h (stress crack resistance)	10.7.3	BS EN ISO1167	1 fitting from the Start & End of each Batch (rotating cavities as applicable)	A.1	1 per fitting
Spigot end reversion	GIS/PL2-6	GIS/PL2-6	1 per batch	Not applicable	1 per fitting
Thermal Stability OIT	7.2	BS EN 728 or ISO 11357,	1 every 7 production days	Not applicable	1 per fitting

a) Valid for fitting sizes up to and including 400 mm; schedules for sizes greater than 400 mm shall be subject to agreement by the gas transporter and or BSI.

b) Or every 50th component whichever is least frequent.

c) All dimensions (specified and non specified) may be subject to measurement the extent of which shall be subject to agreement.

d) Dimensions of injection moulded fittings shall be checked on start up for cavity effects; thereafter on basis of fitting diameter. Frequency and method of checking machined and/or fabricated fittings shall be declared by the contractor at the submission stage.

Table A.3. Part 2 Batch release test requirements (class B and C fittings)

Size Groups (I) 16mm to 63mm (II) 75mm to 225mm, (III) 250mm to 800mm

The authorisation to operate BRT tests as per Table A.3. Part 2 may be withdrawn by the Gas Transporter or BSI at any time, if adverse change occurs in the relationship between the recorded results and the requirements of this Specification.

Property	Requirement clause	Test method	Reduced Frequency / No of Test Pieces	Fitting/pipe assembly parameters
Joint interface crush strength Sizes <90mm	10.6.2	ISO 13955	2 sockets & 2 saddle fittings, per size group, per week (if manufactured). (See Note 1)	A.1
Joint interface peel strength Sizes 90mm and above.	10.6.1	ISO 13954	2 sockets & 2 saddle fittings, per size group, per week (if manufactured) (See Note 1)	A.1

Table A.3. Part 2 continued

Property	Requirement clause	Test method	Reduced Frequency No of Test Pieces	Fitting/pipe assembly parameters
Measurement of dimensions	6.1	Measure to agreed procedure giving an appropriate degree of accuracy.	In Process check (Minimum of 1 fitting every 4hrs).	Not applicable
Melt flow rate On Fittings	GIS/PL2-1	ISO 1133	1 socket & 1 saddle fitting, per size group, per week (if manufactured) (See Note 1)	Not applicable
Operation of Fusion Indicators	9.4	Visual examination	2 sockets & 2 saddle fittings, per size group, per week (if manufactured) (See Note 1)	A.1
Resistance of heating element	8.1.1	Measure resistance of fitting at 23 °C excluding terminal pin contact resistance	100% Continuity check of every fitting during manufacture and Recorded resistance values a minimum of every 4hrs.	Not applicable
Resistance to internal pressure at 80 °C, 165 h (stress crack resistance)	10.7.3	BS EN ISO1167	1 socket & 1 saddle fitting, per size group, per week (if manufactured) (See Note 1)	A.1
Spigot End Reversion	GIS/PL2-6	GIS/PL2-6	1 socket & 1 saddle fitting, per size group, per week (if manufactured) (See Note 1)	Not Applicable
Thermal Stability OIT On Fittings	7.2	BS EN728 or ISO 11357,	1 socket & 1 saddle fitting, per size group, per (if manufactured) (See Note 1)	Not Applicable
Note 1: The contractor shall rotate the type and size of socket & saddle fittings to be tested within each size group.				

A.4 Batch release testing

Batch acceptance tests on fully normalized fittings shall be carried out if batch release tests by the contractor have been shown to be inadequate. For moulded fittings, a batch shall be defined as the production of a machine, from the time it commences to produce fittings conforming to this standard until the machine is closed down. A production batch should not exceed 170 h machine time.

For machined and/or fabricated fittings, the batch definition shall be agreed with the gas transporter.

When batch acceptance is carried out, the sampling plans specified in Table A.4 and Table A.5 shall be used. Samples shall be taken one each from batches preferably bearing different dates.

NOTE *Rejected batches may be split into sub-batches based on the date of production.*

Each sub-batch shall be tested for those aspects which were failed, to one of the sampling plans specified in Table A.6. All defective items shall be rejected.

Table A.4 Sample size code letter

Batch size	Dimensional tests	Destructive tests			Other tests	
		Short term pressure and operation of fusion indicators	Stress crack resistance and end reversion	Joint strength	Thermal stability	Melt flow rate
Less than 150	C	B	B	B	A	A
150 to 500	D	C	C	C	A	A
501 to 2 500	E	D	D	D	A	A
2 501 to 10 000	F	E	E	E	E	E

Table A.5 Double sampling plans

Sample size code	Sample sizes			Action to be taken on number of rejects				
	1st	2nd	Total	1st sample			Total of both samples	
				Accept batch	Reject batch	Take 2nd sample	Accept batch	Reject sample
A	1	3	4	0	≥2	1	1	≥2
B	2	6	8	0	≥2	1	1	≥2
C	3	9	12	0	≥2	1	1	≥2
D	5	15	20	0	≥2	1	1	≥2
E	8	24	32	0	≥2	1	1	≥2
F	13	39	52	0	≥2	1	1	≥2

Table A.6 Sub-batch sampling plans

Sub-batch size	Sample size	Action to be taken on number of rejects	
		Accept sub-batch	Reject sub-batch
Less than 500	5	0	1
500 and over	15	0	1

Annex B (normative)**Assessment of effect on joint integrity of fitting resistance tolerance****B.1 Principle**

Variation in fitting resistance has a significant effect on the applied fusion energy and joint integrity. The method is used to assess this effect.

B.2 Apparatus

B.2.1 *Four-wire resistance bridge*, or alternative resistance measuring device, with the specification specified in Table B.1 as a minimum.

B.2.2 *A true rms voltmeter*, with an accuracy of at least $\pm 0.1\%$ and a resolution of 10 mV in the 0 V to 100 V range.

B.2.3 *Temperature controlled air space*, which can be maintained at $-5\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and $23 \pm 2\text{ }^{\circ}\text{C}$

B.2.4 *Adjustable output voltage control box*, in accordance with GIS/ECE1.

Table B.1 Minimum specification for resistance measuring device

Range Ω	Resolution	Accuracy
0 to 1	100 $\mu\Omega$	$\pm 0.25\%$ of reading
0 to 10	1 m Ω	
0 to 100	10 m Ω	

B.3 Procedure**B.3.1 Minimum tolerance value (maximum voltage)**

Pipe shall conform to GIS/PL2-2 (class B fittings) or to GIS/PL2-8 (class C fittings), and shall be of the largest SDR for which the fitting is designed.

Condition the pipe and fitting at $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

Measure the resistance of the fitting under test (R_{23}).

Calculate the applied fitting voltage from:

$$\text{applied voltage} = V \sqrt{\frac{R_{23}}{R_{\min}}} \quad (\text{B.1})$$

where:

R_{\min} is the manufacturer's declared minimum fitting resistance;

V is 40 V or 80 V as applicable.

Using a resistive load on the output of the control box, set the control box output voltage to the voltage calculated in the equation above.

Assemble the pipe(s) and fitting and fuse for the specified time.

When the joint has cooled, section the sample and check for signs of pipe collapse or creasing of the pipe bore.

Subject the sectioned samples to the joint strength test specified in **10.6.1** or **10.6.2** as appropriate.

B.3.2 Maximum tolerance value (minimum voltage)

Pipe shall conform to GIS/PL2-2 (class B fittings) or to GIS/PL2-8 (class C fittings), and shall be of the smallest SDR for which the fitting is designed.

Measure the resistance of the fitting under test (R_{23}) at $23\text{ °C} \pm 2\text{ °C}$.

Condition the pipe and fitting at $-5\text{ °C} \pm 2\text{ °C}$.

Calculate the applied fitting voltage from:

$$\text{applied voltage} = V \sqrt{\frac{R_{23}}{R_{\max}}} \quad (\text{B.2})$$

where:

V is 39 V or 78 V as applicable;

R_{\max} is the manufacturer's declared maximum fitting resistance.

Using a resistive load on the output of the control box, set the control box output voltage to the voltage calculated in the equation above.

Assemble the pipe(s) and fitting and fuse for the specified time.

When the pipe has cooled, section the sample and subject it to the joint strength test specified in **10.6.1** or **10.6.2**, as appropriate.

Annex C (normative)

Determination of fitting cooling time

C.1 Principle

Pipe/fitting assemblies with thermocouples attached to the pipes in the area of the fusion joint are conditioned at 23°C and fused at maximum power. The temperature within the joint is continuously recorded and the fitting cooling time is determined.

C.2 Apparatus

C.2.1 *Four-wire resistance bridge*, or alternative resistance measuring device, with the specification specified in Table C.1 as a minimum.

C.2.2 *A true rms voltmeter*, with an accuracy of at least $\pm 0.1\%$ and a resolution of 10 mV in the 0 V to 100 V range.

C.2.3 *Thermocouples*, suitable for operation up to 400 °C connected to a temperature recording device.

C.2.4 *Adjustable output voltage control box*, in accordance with GIS/ECE1.

Table C.1 Minimum specification for resistance measuring device

Range Ω	Resolution	Accuracy
0 to 1	100 $\mu\Omega$	$\pm 0.25\%$ of reading
0 to 10	1 m Ω	
0 to 100	10 m Ω	

C.3 Specimen

Pipes shall be in accordance with GIS/PL2-2 (class B fittings) or GIS/PL2-8 (class C fittings).

C.4 Procedure

C.4.1 Condition pipes and fittings at a temperature of $23^\circ\text{C} \pm 2^\circ\text{C}$ for at least 8 h. For socket fittings, position two thermocouples diametrically opposite each other with the thermocouple's tip on the outside surface of the pipe. Position the thermocouples in the centre of the resulting fusion joint. One thermocouple shall be on the top of the pipe during the fusion operation. For reducing couplers, the cooling time of both ends shall be determined.

For saddle fittings, position two thermocouples on the crown of the pipe, one either side of the outlet stack, at a position in the centre of the resulting fusion joint.

C.4.2 Measure the resistance of the fitting under test. Adjust the voltage of the control box to simulate maximum power input into the fitting.

NOTE This can be calculated from:

$$\text{Applied voltage, } V = \sqrt{\frac{\text{actual fitting resistance}}{\text{minimum fitting resistance specified by manufacture}}} \quad (\text{C.1})$$

where $V = 40\text{ V}$ or 80 V as applicable.

Energize the fitting for the required fusion time. Record the temperatures.

On switching off the power, record the time for the thermocouples to reach 110°C .

The cooling time shall be the mean time for the thermocouples at one end to reach 110°C . For reducing couplers, the higher of the two cooling times shall be taken as the fitting cooling time.

Annex D (normative)

Specification for the assessment of pipe inserts

D.1 Purpose of specification

NOTE 1 *National Grid utilizes a number of techniques for the installation of polyethylene pipes. Most techniques do not involve any change in the properties of the polyethylene pipe and can therefore use electrofusion fittings, approved to GIS/PL2-4, to make joints between pipes.*

NOTE 2 *Some techniques, such as swagelining, involve a change in the dimensions of the pipe and historically this has been addressed by the provision of pipe inserts to return the pipe to its original specified dimensions. Guidance is given in the method statements, for example T/SP/DIS 5.11.1 but such guidance does not provide information on sizing of the inserts to match a given pipe/fitting combination.*

NOTE 3 *Historically the specifications have not permitted the use of plastic inserts, of any form, to be specified for pipes of SDR 26 or thinner wall section. With improvements in the types and grades of plastics materials available, this standard has been prepared to enable approval of such material variants. It is desirable to have plastic alternatives to provide lightweight fittings for compliance with manual handling regulations, and to enable the inserts to be packaged with electrofusion couplers without risk of contamination due to machining fluids or corrosion products.*

Inserts produced in accordance with this standard shall only be supplied as part of a package with a matched electrofusion coupler. Such packages shall also include documented instructions on the method of assembly to be used.

D.2 General

Electrofusion fittings for use with inserts made to this standard shall be in accordance with GIS/PL2-4 and shall have type testing approval.

Pipe suitable for use with inserts made to this standard shall be in accordance with GIS/PL2-2:2006, with dimensions in accordance with Table 3.

The contractor shall propose a design for the insert comprising material selection and product profile/dimensions.

The contractor shall declare the material grade as part of the type testing approval process.

The contractor shall propose the method of installation of the inserts and make available a written method statement to enable field installations to be made where pipe is in the temperature range $-5\text{ }^{\circ}\text{C}$ to $+23\text{ }^{\circ}\text{C}$.

Any specialist tools required for assembly of the inserts shall be supplied by the contractor.

D.3 Test requirements

D.3.1 Principle

Dimensions of the insert component are monitored by the tests specified in **D.3.2**, **D.3.3**, and **D.3.4** to assess the effect of storage time and temperature on dimensional stability. The ability of the insert to provide support to the pipe during the welding process with an electrofusion fitting is determined by **D.3.5**.

D.3.2 Dimensions

D.3.2.1 Procedure

Condition insert components for a period of 12 h at ambient temperature ($23\text{ }^{\circ}\text{C}$).

D.3.2.2 Performance

After conditioning:

- a) outside diameter shall be within the specified tolerance of the manufacturer's drawing;
- b) length shall be within the specified tolerance of the manufacturer's drawing.

D.3.3 Long-term dimensional stability

D.3.3.1 Procedure

Condition inserts to a temperature of 23 °C for a period of 12 months.

D.3.3.2 Performance

On completion of the conditioning period, the inserts shall still be within the dimensional tolerances as specified by the manufacturer.

D.3.4 Assembly dimensional stability

D.3.4.1 Apparatus

D.3.4.1.1 Coupler, of maximum internal diameter, in accordance with GIS/PL2-4.

D.3.4.2 Procedure

D.3.4.2.1 Fit an insert to polyethylene pipe which has previously been deformed using the swagelining process. The assembly shall comprise a coupler (**D.3.4.1.1**), and a pipe section of minimum outer diameter in accordance with GIS/PL2-2. The insert shall be fitted in accordance with the manufacturer's instructions and at an ambient temperature of 23 °C.

D.3.4.2.2 On completion of the manufacturer's specified relaxation period measure the dimensions of the assembly (outside diameter and ovality).

D.3.4.2.3 The assembly shall be measured at 24 h intervals for a further period of 5 days when stored at 23 °C.

D.3.4.2.4 Measurements taken in **D.3.4.2.2** and **D.3.4.2.3** shall conform to GIS/PL2-2 for pipe of the nominal diameter and SDR.

Measurements of diameter and ovality shall conform to GIS/PL2-2 for pipe of the nominal diameter and SDR.

D.3.5 Electrofusion compatibility tests

D.3.5.1 Procedure

D.3.5.1.1 Condition pipe, insert and coupler for a period of 12 h at ambient temperature (23 °C). Assemble the components in accordance with the contractor's method statement and weld the electrofusion fitting at maximum voltage (as specified in this standard). Allow the assembly to cool to ambient temperature and then apply a second fusion cycle. Make two fittings at this condition, evaluate in accordance with **D.3.4.2.2**.

D.3.5.1.2 Subject samples to a hydrostatic pressure test at 80 °C, at a test stress of 4 MPa, for a period of 1 000 h.

D.3.5.2 Performance

There shall be no failure of the sample.

When samples are sectioned and joints subjected to the electrofusion peel decohesion test in accordance with GIS/PL2-4, samples shall conform to **6.2.2** for minimum ductile fusion length.

Annex E (normative)

Test piece components

E.1 General

The preparation and assembly of test pieces shall be carried out using the tooling specified in GIS/PL2-5, except for approval testing of tapping tees and branch saddles, which shall be assembled as shown in Figure E.1 where the force is reacted through the stack of the fitting.

NOTE The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling if different from that prescribed in GIS/PL2-5.

NOTE For fittings where the force is not reacted through the stack, alternative assembly techniques should be employed.

E.2 Pipes

For approval testing, pipe shall conform to GIS/PL2-2 (class B fittings) or to GIS/PL2-8 (class C fittings). Pipe from coils shall be used in sizes equal to or less than 180 mm.

For batch release testing, pipe shall conform to GIS/PL2-2 (class B fittings) or to GIS/PL2-8 (class C fittings) but need not be coiled.

E.3 Socket fittings

Socket fittings shall be assembled to pipe to provide a gap between the pipe ends and the pipe penetration stop(s) of at least 0.05 times the pipe outside diameter. For approval test samples only, the pipe and fitting shall be measured to identify the maximum and minimum diameters. Assemblies shall give maximum clearance at one point, and minimum clearance at another.

For coupler sizes greater than 180 mm, the pipes shall be held in a clamping arrangement to restrain pipe movement. The clamps shall be arranged to produce a 1.5° offset between the pipes across the coupler.

E.4 Saddle fittings

Where saddle fittings are fused to coiled pipe, the fittings fused with a stack load of 1 000 N shall be positioned perpendicular to the minimum diameter of the pipe. Fittings fused with a stack load of 1 500 N shall be positioned perpendicular to the maximum diameter of the pipe. The pipe shall be removed from the coil immediately prior to conditioning, and the first 5 m from the coil shall not be used.

Where assemblies contain saddle fittings with integral cutters, the main shall be cut and the cutter retracted into the body of the fitting before testing.

Where assemblies contain saddle fittings with a separate cutter, the main pipe shall be cut and the cutter removed before testing. Tapping tee caps shall be tightened in accordance with **6.3.2.5**.

E.5 Test piece geometry

If assemblies contain more than one fitting the free length of pipe between fittings of any type shall not be less than three times the pipe outside diameter for sizes not greater than 250mm, or twice the pipe outside diameter for sizes greater than 250mm. For tapping tee fitting assemblies, the free length of pipe between fittings shall not be less than twice the pipe outside diameter for all sizes, provided adjacent fittings are rotated relative to each other by not less than 90°.

Specimens for pressure test shall be closed with pressure tight end-load bearing end caps, plugs or flanges which shall be provided with connections for the entry of water and release of air.

NOTE Spigots may be closed without the use of electrofusion fittings.

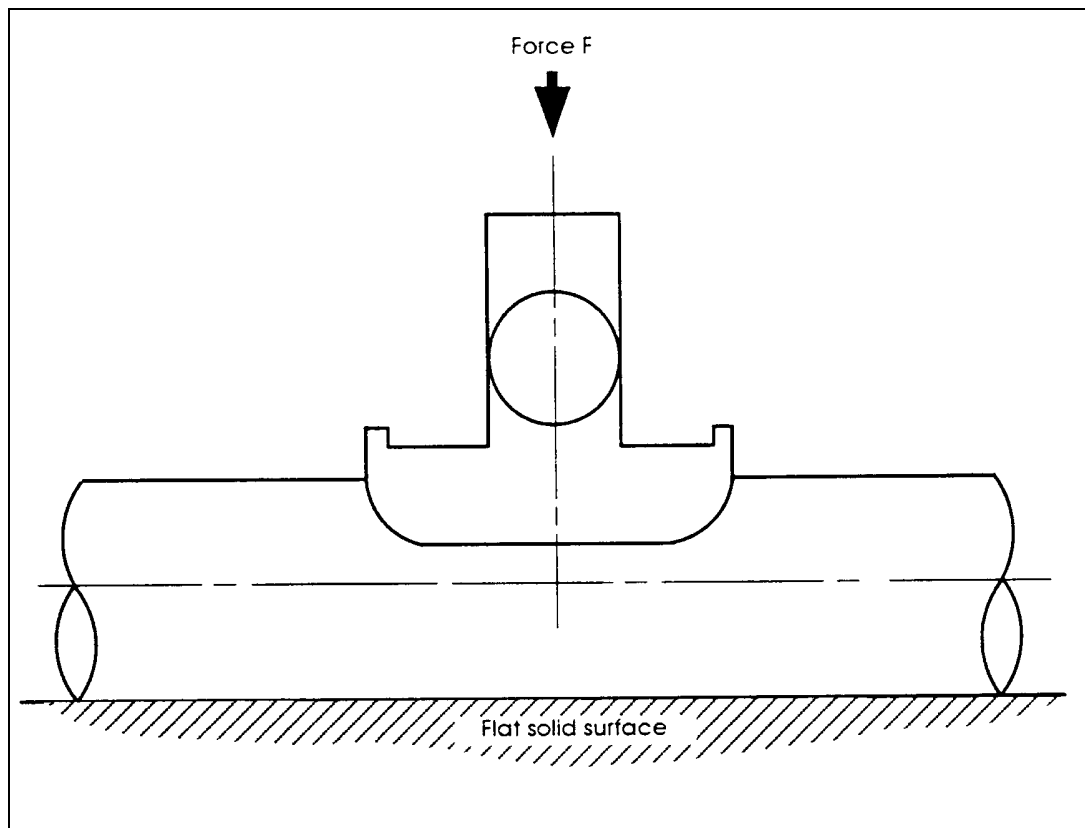


Figure E.1 Test specimen assembly

Annex F (normative)

Measurement of coupler assembly force

F.1 Principle

The test is designed to simulate in a tie-in situation, the assembly and fusion jointing of rigidly fixed and misaligned pipes using electrofusion socket couplers. The assembly force is measured and the strength of the joint is determined.

F.2 Procedure

Pipe shall conform to GIS/PL2-2 (class B fittings) or to GIS/PL2-8 (class C fittings). The pipes and fitting shall be at a temperature of $23\text{ °C} \pm 2\text{ °C}$.

Offset the pipes to be joined 1.5° and rigidly clamp to restrain pipe movement. The clamps shall be 2.5 times the nominal pipe diameter apart. Position the pipes centrally within the clamps.

Cut the pipe ends square and the maximum pipe end-to-end clearance shall be 10 mm.

Mark a distance equal to one half of the coupler overall length from the end of each pipe.

Slide the coupler, for its full length, on to one pipe. Measure the force required to position the fitting centrally between the marks on the pipe.

F.3 Performance

F.3.1 The fitting shall be capable of being slid from one pipe on to an adjoining pipe, offset at 1.5° , with a force of not greater than 500 N. There shall be no dislodgement of the heating element wire.

F.3.2 The assembled joint shall be fused at minimum power input (see **B.3.2**).

The assembly shall conform to **10.6.1**.

Annex G (normative)

Tapping tee cap pneumatic leak test

G.1 Principle

The tapping tee is internally pressurized using air as the pressurizing medium to assess the leaktightness of the fitting closure cap.

G.2 Apparatus

G.2.1 *Water bath or air chamber*, capable of maintaining the required temperature to within ± 1 °C and subjecting the specimen to the specified pressure to an accuracy of ± 2 %.

G.2.2 *Air*, which shall be used as the pressurizing medium.

G.2.3 *Torque wrench*, or other approved method, to tighten the tapping tee cap to the specified torque to an accuracy of ± 5 %.

G.3 Test piece

The test piece shall be prepared in accordance with Annex A, Tables A.1 and A.2, except that the main shall not be cut, and pressurization shall be effected through the outlet of the tapping tee.

G.4 Procedure

Appropriate precautions shall be taken to provide protection to personnel should a specimen fail under test.

NOTE This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Tighten the tapping tee cap to a maximum torque of 4 N·m.

Maintain the specimen at a temperature of $23\text{ °C} \pm 3\text{ °C}$ throughout the test.

Pressurize the specimen to 4 bar, and maintain this pressure within a range of ± 2 % for a period of 2 500 h.

Leak detect by immersing the pressurized specimen, at a depth not exceeding 250 mm, in a bath of clean water.

G.5 Performance

There shall be no leakage.

Annex H (normative)

Branch saddle pull off test (See schematic diagram below)

H.1 Principle

A fused assembly consisting of a branch saddle fused to a mains pipe and branch offtake is subjected to a tensile load until failure occurs.

H.2 Apparatus

H.2.1 *Tensometer*, capable of applying a tensile load through the axis of the outlet pipe.

H.3 Test specimen

The test specimen shall consist of a branch saddle fitting fused in accordance with Annex A to a length of polyethylene pipe conforming to GIS/PL2-2 (class B fittings) or GIS/PL2-8 (class C fittings).

A length of polyethylene pipe conforming to GIS/PL2-2 (class B fittings) or GIS/PL2-8 (class C fittings) shall be fused in accordance with Annex A to the spigot outlet of the saddle fitting. The length of the pipe shall be four times the nominal spigot outlet diameter.

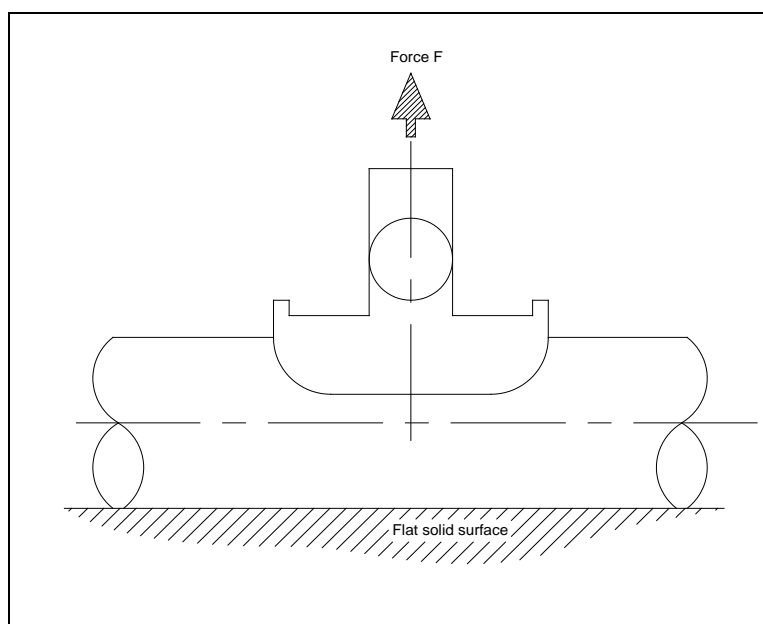
H.4 Procedure

Insert plain metal plugs in the ends of the polyethylene pipes to support the pipe under the action of the loading grips. Alternative methods of holding the pipe may be proposed by the contractor and shall be subject to agreement with the gas transporter. Rigidly hold the mains pipe of the test specimen in a clamp with the outlet pipe vertical. The distance between the clamp inside faces shall be saddle fitting width plus 30 mm.

Assemble the test specimen and clamp in a tensometer. Apply the tensile load at an extension speed of (25 ± 1) mm/min, until the specimen fails. Subject the outlet pipe of a branch saddle fitting to a tensile load. Increase the tensile load until the outlet pipe fails by 'necking' or the mains pipe fails.

H.5 Performance

There shall be no failure in the saddle joint fusion area, spigot outlet and pipe/fitting interface or saddle fitting body.



Annex I (normative)

Tapping tee pressure drop test

I.1 Principle

Measurements are made of tapping tee pressure drop and its corresponding flow rate. The equivalent flow rate of natural gas and the velocity head lost in the fitting is determined.

I.2 Apparatus

I.2.1 *Pressure controller (A)*, capable of giving a steady output of 25 mbar

I.2.2 *Flow meter (B)*, positive displacement or turbine meter type accurate to $\pm 5\%$.

I.2.3 *Inclined manometer*, for mains pressure.

I.2.4 *Inclined manometer*, for differential pressure.

I.2.5 *Outlet valve*.

I.3 Test specimen

The configuration of the specimen tee shall be in accordance with Figure I.1.

I.4 Procedure

I.4.1 Connect the inclined manometer across the tee and partially open the outlet valve (E).

Open the inlet valve so that gas starts to flow and check that gas flows from the outlet valve only.

By means of pressure controller (A), regulate the mains pressure (C) to 25 mbar and measure and record the flow rate, Q , on flow meter (B) and the pressure drop, ΔP , on manometer (D).

I.4.2 Open the outlet valve (E) sufficiently to reduce the mains pressure, C, by approximately 5 mbar. Increase the flow rate until the mains pressure (C) returns to 25 mbar and measure and record the flow rate, Q , and the pressure drop, ΔP .

I.4.3 Repeat **I.4.2** until the outlet valve (E) is fully open.

I.5 Expression of results

NOTE 1 *The procedure specified in I.4 gives a number of pressure drop values and the corresponding flow rate for each.*

From the relationship:

$$\Delta P = FQ^2 \tag{I.1}$$

where:

ΔP is the pressure drop, expressed in mbar;

F is a factor;

Q is the flow rate, expressed in m^3/h .

The factor F shall be calculated for each set of readings and the average value determined.

Using the average value, the pressure drop, ΔP , shall be determined for a gas flow rate, Q appropriate to the size of service fitting (see Table 7).

If air or nitrogen is used for this test, the flow rates shall be corrected using the following relationship:

$$Q_{\text{nat}} = Q_{\text{med}} \sqrt{\rho_{\text{med}} / \rho_{\text{nat}}} \quad (1.2)$$

where:

Q_{nat} is the flow rate using natural gas, expressed in m³/h;

Q_{med} is the flow rate using other gas (air or nitrogen), expressed in m³/h;

ρ_{med} is the density of other gas (air or nitrogen), expressed in kg/m³;

ρ_{nat} is the density of natural gas, expressed in kg/m³.

The number of velocity heads lost across the fitting shall be calculated from:

$$K = \left(\frac{\Delta P}{\rho} \right) \frac{200}{V_2^2} + \left(\frac{V_1^2}{V_2^2} - 1 \right) \quad (1.3)$$

where:

K is the velocity head lost in the fitting based on the velocity in the service pipe;

ΔP is the measured pressure drop, expressed in mbar;

ρ is the density of natural gas = 0.71 kg/m³;

V_1 is the velocity in main = Q_{nat}/A_1 = m/s;

where:

A_1 is the bore area of the main;

V_2 is the velocity in service pipe = Q_{nat}/A_2 expressed in m/s;

where:

A_2 is the bore area of service pipe under test.

NOTE 2 *The equation assumes the density effects due to velocity are negligible.*

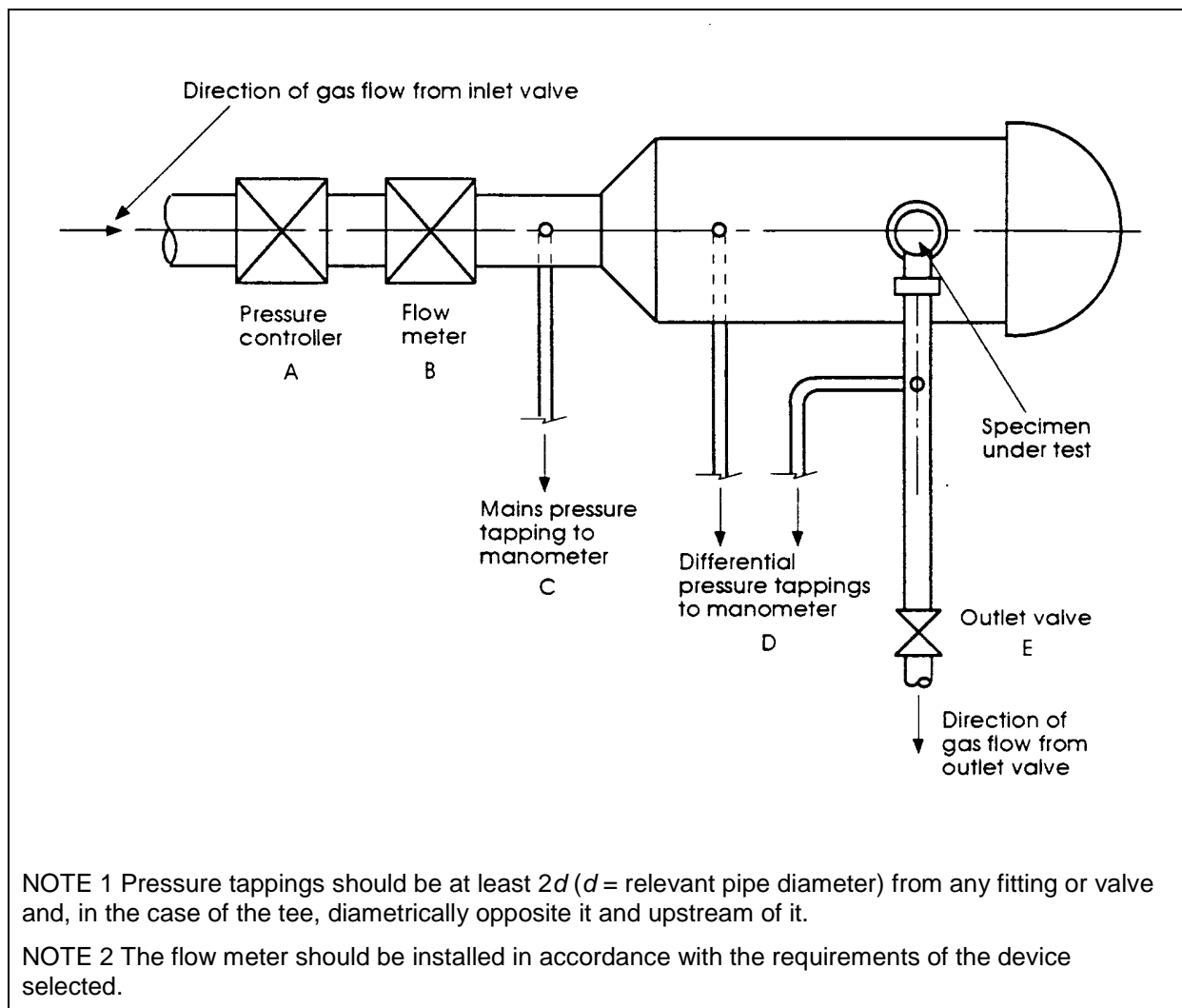


Figure I.1 Layout of test rig for tapping tee pressure drop test

Annex J (normative)**Type tests – Changes to approved fittings or tooling & Low Volume products****Change No.1 - Electrical Design (no change to Polymer or Mechanical Design)**

Shall include Wire change / Resistance change / Fuse time change / Fusion length change i.e. number of wire turns.

Tests, which shall be performed

Property	Requirement Clause	Test Method	No. of fittings	Fitting/pipe Assembly parameters
Joint Interface Peel Strength (See Note 1)	10.6.1	ISO13955	1 per size per type per condition	Conditions I & IV Table A.1
Joint Interface Crush Strength (See Note 1)	10.6.2	ISO13954	1 per size per type per condition	Conditions I & IV Table A.1
Resistance to internal pressure at 80°C, 1000hrs (stress crack resistance)	10.7.3	ISO1167	2 per size per type per condition	Condition I Table A.1

Note 1: Fuse and Cool Time to be determined whilst carrying out Joint Interface Strength tests.

Change No. 2 – New Product from existing Tooling/Cavities by “thickening” the fitting.**Tests, which shall be performed**

Property	Requirement Clause	Test Method	No. of fittings	Fitting/pipe Assembly parameters
Joint Interface Peel Strength (See Note 1)	10.6.1	ISO13955	1 per size per type per condition	Conditions I & IV Table A.1
Joint Interface Crush Strength (See Note 1)	10.6.2	ISO13954	1 per size per type per condition	Conditions I & IV Table A.1
Resistance to internal pressure at 80°C, 1000hrs (stress crack resistance)	10.7.3	ISO1167	2 per size per type per condition	Condition I Table A.1
Resistance to internal pressure at 20 °C for 100hrs	10.7.1	ISO1167	2 per size per type per condition	Condition I Table A.1
Thermal Stability OIT	7.2	BS EN 728 or ISO 11357,	1 per size per type	Not applicable

Note 1: Fuse and Cool Time to be determined whilst carrying out Joint Interface Strength tests.

Change No.3 - Changes to dimensions of the PE body (approved fittings)

Wall thickness of the fitting is not reduced or increased by more than 5%, including Socket Bore dimensions & Tapping Tee Saddle base radius.

Tests, which shall be performed

Property	Requirement Clause	Test Method	No. of fittings	Fitting/pipe Assembly parameters
Joint Interface Peel Strength (See Note 1)	10.6.1	ISO13955	1 per size per type per condition	Conditions I, II, III & IV Table A.1
Joint Interface Crush Strength (See Note 1)	10.6.2	ISO13954	1 per size per type per condition	Conditions I, II, III & IV Table A.1
Resistance to internal pressure at 80°C, 1000hrs (stress crack resistance)	10.7.3	ISO1167	2 per size per type per condition	Conditions I, II, III, & IV Table A.1
Resistance to internal pressure at 20 °C for 100hrs	10.7.1	ISO1167	2 per size per type per condition	Condition I, II, III & IV Table A.1
Note 1: Fuse and Cool Time to be determined whilst carrying out Joint Interface Strength tests.				

Note: If a “range” of existing PL2-4 approved fittings undergo one of the modifications shown in Annex J, the smallest, largest, and an intermediate size representative of the range will be tested, consistent with Clause 11.1 of this standard.

Change 4 – Qualifying a different pipe SDR, in PE80 or PE100 Material (approved fitting)

The tests, which shall be performed are as per those detailed for Change No.1.

Low Sales Volume requirement – Electro-fusion Fittings 16mm to 560mm (<250pcs per annum)

The tests, which shall be performed are as per those for Change 3 above, with the following amendments.

The Resistance to Internal Pressure test at 20°C for 100hrs shall be performed on Conditions I, and IV only. In addition, the Impact Test shall be performed on Saddle Fittings, with 1 sample being fused at each of the four Conditions shown in Table A.1.

Low Sales Volume requirement – Electro-fusion Fittings 630mm to 800mm (<250pcs per annum)

The annual requirements for fittings in the size range 630mm to 800mm may often be so small that the number of test samples required for type approval is often greater than the number of fittings sold. The reduced type testing detailed in Table J1 may therefore be adopted for fittings in this size range.

Table J.1 Type Testing of Low Volume Fittings (630-800 mm)

Mechanical properties	References	No. of test pieces ^{a)}	No. of fittings	Fitting/pipe Assembly parameters
Resistance to internal pressure at 20°C (100h or 5000h)	10.7.1	1	1 per size per type	Condition I Table A.1
Resistance to internal pressure at 80°C, (stress crack resistance) (165h)	10.7.2	1	1 per size per type	Condition I Table A.1
Joint Interface Peel Strength (See Note 1)	10.6.1	ISO13955	1 per size per type	Condition I, Table A.1
<p>a) The number of test pieces given in the table shall be the minimum.</p> <p>Note 1: Fuse and Cool Time to be determined whilst carrying out Joint Interface Strength tests.</p>				

Annex K (normative) Short term pressure test

K.1 Principle

A test piece, consisting of an electrofusion fitting assembled with one or more PE pipes having reduced free length sufficient to suppress pipe failure and create preferential failure in the fitting or in the connecting pipe-to-fitting joint, is placed in a controlled-temperature environment and subjected to an essentially continually increasing internal hydraulic pressure until failure occurs. The method is designed to establish the short-term failure pressure of the fitting/pipe assembly.

K.2 Apparatus

K.2.1 Constant-temperature water bath, in accordance with BS EN ISO 1167-1, capable of being maintained at (20 ± 2) °C.

K.2.2 Pressure test equipment, in accordance with BS EN ISO 1167-1, capable of applying a continuously increasing internal hydraulic pressure at a rate of (5 ± 1) bar/min 3) until the test piece fails.

K.2.3 Pressure gauge, having an accuracy of not less than 1 % of full-scale deflection and with a hand which indicates the maximum pressure reached.

A gauge shall be used that will indicate the failure pressure at approximately mid-scale. The gauge should preferably be equipped with a surge protection device. The gauge shall be located in a position within the pressure system such that it will indicate the internal pressure of the test piece without being affected by pressure transients within the pressure supply lines, etc.

K.3 Test piece

The test piece shall be an assembly of one or more electrofusion fittings connected to PE pipes, with a minimum free pipe length between fittings of any type not exceeding d_n . The pipes used shall be the thickest-walled pipe for which the fitting has been designed. The test piece shall be closed with type A end caps in accordance with EN ISO 1167-1:2006.

K.4 Procedure

Attach the end caps to the test piece and fill it with water at ambient temperature.

Connect the test piece to the pressure source, ensuring that no air is trapped in the test assembly.

Immerse the test piece in the constant-temperature bath and condition it at (20 ± 2) °C for at least as long as the period defined in EN ISO 1167-1 for the appropriate pipe wall thickness.

Increase the pressure uniformly at a rate of (5 ± 1) bar/min until failure of the test piece occurs.

Record the pressure at failure.

After testing, inspect the test piece and record the location and mode of failure.

K.5 Test report

The test report shall include the following information:

- a) Reference to GIS/PL2-4 Addendum;
- b) All details necessary for complete identification of the pipes and socket fusion fittings used, including manufacturer, type of material and size of fitting and pipe;
- c) Details of the fusion-jointing procedure used to assemble the test piece;
- d) Pressure at failure;
- e) Time to failure;
- f) Failure location;
- g) Mode of failure, e.g. ductile in fitting, brittle along fusion interface;
- h) Any factor that could have affected the results, such as any incidents or operating details not specified in this annex;
- i) Date of test.

Annex L (normative) Tensile test for fitting/pipe assemblies

L.1 Principle

A test piece consisting of an electrofusion fitting and two connecting PE pipes is subjected to an increasing tensile load at a constant pulling rate until ductile pipe failure occurs. The test is conducted at a constant temperature and is intended to simulate the creation of longitudinal tensile loading along a pipeline as a consequence of external mechanical interference. Rupture of the fitting or the connecting fusion joints is not an acceptable failure mode.

L.2 Apparatus

This shall be in accordance with ISO 13951:2001, with the additional requirement that the tensile-testing machine shall be capable of accommodating a test piece elongation of 25 % and of sustaining a constant test speed of $(5 \pm 1,25)$ mm/min.

L.3 Test piece

The test piece shall be in accordance with ISO 13951:2001.

In cases where $dn \geq 180$ mm and where the conduct of tensile tests on fitting/pipe assemblies is beyond the Limits of the available test equipment, the testing of joint segments may be appropriate. Testing of segment test pieces shall not be undertaken, however, unless a correlation with testing of complete pipe/joint assemblies has been established.

L.4 Procedure

This shall be in accordance with ISO 13951:2001, but without that International Standard's requirement for the load to be constant. The pulling rate shall be $5 \text{ mm/min} \pm 25 \%$, sustained until a test piece elongation of 25 % is reached.

L.5 Test report

The test report shall include the following information:

- a) Reference to GIS/PL2-4 Addendum;
- b) All details necessary for complete identification of the pipes and electrofusion fittings used, including manufacturer, type of material and size of fitting and pipe;
- c) Details of the fusion-jointing procedure used to assemble the test piece;
- d) Test temperature;
- e) Leaktightness and integrity of the fitting and fusion joint after 25 % elongation of the test piece;
- f) Any factor that could have affected the results, such as an incident or operating detail not specified in this annex;
- g) Date of test.

Annex K Summary of and rationale for changes to document – June 07

GIS/PL2-4 Clause	Comment & Rationale	Proposer	Action Required (if applicable)
Foreword	Review period, Wording on frequency currently shown in Draft GIS/PL2-4 to be removed	Declan Robinson	Change policy document advocated by NG & BSI governing the suite of GIS's. Topic referred to TSF for discussion/action as appropriate.
4.2	Polyethylene Compound, RCP	Trevor Nicholson	To submit alternative wording ideally for inclusion in the notes accompanying Table 2 – “Properties of the compound in the form of pipe, GIS/PL2-1” based on the response from Dr Martyn Greig.
6.2 Table 2.	Table 2. Socket dimensions, if pipe is manufactured with high OD then it will not fit into the socket dimensions proposed by GF. Minimum values below those specified in GIS:PL2: 4. GF on smaller diameters have a shorter apparent fusion length (based on BS EN 1555 dimensions). The longer the fusion zone the perceived greater resistance to joint abuse.	Bill Rose & Michael Gressman	Working Group Members reluctant to support a change to Table 2 of specification, hence Table to remain as is.
6.3.2 Table 3	Overall length of reducers 200, 225 & 250mm GF reducer extended length, concern over tooling and placing the fitting within the clamp, will not fit within the limits set in Figure 6. Changing the specification will render clamps in the field redundant.	Bill Rose & Michael Gressman	As 6.2 above Working Group Members reluctant to support a change to Table 3 of specification, hence Table to remain as is.
6.6.1	6.6.1 Tapping tees, request made to add 17mm hexagonal key to engage tapping tee cutter	Bill Rose & Michael Gressman	GF request to include 17mm hexagonal key not supported by Working Group, on the basis that additional tooling would need to be carried in the field. A major re-tooling would be required to progress this request.
6.6.2	Tapping tee outlets, dimensional tolerances 0.7 OOR 32mm 0.9 OOR 63mm	Various WG Members	Agreement reached to retain document as is, but add the OOR values.
6.6.2	20 & 25mm outlets, Customers other than NG, would like to have included these diameters. BSI commented that customers may use this product based on their own risk assessment.	Paul Thompson	Kimplas have a 20mm outlet tapping tee approved by Advantica which is currently outside the scope of this specification. To be considered in future update
6.6.2	Saddle base dimensions, GF dimension 165, specification requirement 120mm. Requirement for smaller dimension to minimise distance between fittings.	Bill Rose & Michael Gressman	As per comments reference 6.2 & 6.3.2. NG & BSI stated that GF product differences were “outside” the Terms of Reference for the Working Group. GF advised to submit request to TSF as per previous comments.
6.7.2	Class C, branch saddle outlets, PE100 stub flange as opposed to PECat. Transition to 7bar via PECat.	Dave Clayton	DC has raised a question with the TSF in advance of TSF meeting 14.7.07.
8.1.3	Terminal design, request made to include a sketch of the 4mm terminal pin shroud design, and to change the wording to reflect that an adaptor would “not” necessarily be supplied with every fitting. Requests triggered concerns over tooling / adaptor requirements. Uponor spoke about its “poor” experience with 4mm pin fittings supplied in the UK some years ago. This was further supported by Kimplas with PT commenting that he has discussed this with	Bill Rose & Michael Gressman	As 6.6.2, GF to submit request to the TSF for review, as request outside the Terms of Reference for the Working Group. GIS/PL2-4 Draft Specification wording to revert to that pre the Working Group meeting 25.4.07. (3 rd paragraph of clause to be removed).

	contractors who have requested not to proceed with the 4mm pin.		
7.1.2	120min to be preceded by minimum as per 7.1.1	Noel Taylor	
Figure 3	Terminal shroud		Agreement reached on C1 of 20mm +/- 2
9.5	Voids classed as an un-fused area and will go into the de-cohesion calculation.		Wording in 9.5 to be amended to reflect statement regarding unfused area.
10.7.2		Noel Taylor	Agreed with content
10.10.1	Pressure drop, tapping tees, request made to include BS EN 12117 as an alternative method for determination of pressure drop. National Foreword in BS EN12117 states that "since it does not determine the velocity head loss, it is not technically equivalent to either appendix E or F in BS7336: 1990". Given that BS7336 was a straight copy of British Gas PL2/Part 4: circa 1990, its equivalence to GIS: PL2: Part 4 has YET to be demonstrated.	Bill Rose & Paul Thompson	Should GF or Kimplas wish to request that BS EN 12117 be included as an alternative standard/test method, then a submission should be made to TSF evidencing the case for this standards inclusion.
11.1	General, Small medium and large fitting to be tested, is this for every type of fitting design or alternatively is it possible to test different fittings, i.e. couplers, elbows, reducers of alternative diameters	T Peach	Agreement reached, it is possible to test small medium and large fittings of alternative fitting design.
12	Marking Items a-f (Agreed) Character dimensions (3.0mm) Packaging rather than 'Poly bag'.	All	TP to update Marking Section based on comments made
12.Note 1	Marking date, not 2006.	Trevor Nicholson	
Annex A	Tests conducted at -10C & +45C	Bill Rose	Accepted, only if the testing is equivalent or more extreme. Wording introduced to reflect this.
Table A.2, i	BSI Certification report 2,500 hours		Accepted
Table A.3 Part 1	Batch Release 20°C 100hr test proposal seen as not relevant as a BRT on the grounds that it relates to material strength. Original 1hr test has produced no failure in two decades of testing so no value.	All	Agreement reached to remove this test
Table A.3 Part 1	Start & end of batch (what if only one fitting to be manufactured)	TP	To modify wording
Table A.3 Part 2	Batch Release Test 20 degree C requirement – As per Table A.3 Part 1	All	Agreement reached to remove this test.
E.5	Delete word 'is'	TP	
Annex H	Include sketch of branch saddle pull off test	TP	
Annex I	20 degree C test removed		Declared Obsolete/Remove from Draft Standard
Annex I	Already discussed above		
Annex J	Modifications - Request received to reduce the number of tests to be performed e.g. Test one size only per type if already approved to PL2-4/BS EN1555.	Bill Rose & Paul Thompson	Statement added to Appendix K stating that if a range of existing PL2-4 fittings undergo the same modification, then the smallest, largest, and an intermediate size shall be tested, which aligns with the wording in Clause 11.1 of this standard Does not apply to fittings already approved to BS EN1555.
Low sales volume	<250 pieces per annum' After some discussion concept of "large gap" necessitating "some action" in terms of Low Sales Volume Fittings, could not be readily substantiated.	All	Acceptance reached on the 250 piece value.
Clause 3.2.4	Greater detail required with regard to batch definition	TP	

Annex L Summary of and rationale for changes to document – March 2012

GIS/PL2-4 Clause	Comment & Rationale	Proposer	Action Required (if applicable)
Title Page	<p>Title modification: Polyethylene pipes and fittings for natural gas</p> <p>The standard is specific for natural gas only. Supporting evidence is required to show that the product is compatible with other gas media.</p>	GDN'S, GL Noble Denton	
Foreword	<p>Statement:</p> <p>The UK Committee would like to emphasize that compliance with GIS/PL2-4 does not necessarily mean that products are fit for the purpose of conveying natural gas in the UK. It is recognised that fittings may not be fully compatible with existing UK practice in terms of applicable pressure tiers, preferred colours for gas pipe recognition, jointing and installation methods.</p> <p>The requirements contained in GIS/PL2-4 are not necessarily indicative of all the performance requirements, or the suitability of pipework for the service conditions, likely to be encountered in the UK.</p> <p>GDN'S need to be aware that this standard assesses fitness for purpose in terms of functionality. Field testing will be critical to ensure compatibility with working practices.</p>	GL NOBLE DENTON	
Clause 3.3.2 & 4.2	<p>New requirement - only allow rework of yellow and orange PE compound. Black compound easily hides such contamination, allowing unscrupulous suppliers to produce fittings made from "less than perfect" material.</p>	GPS	
Clause 4.2	<p>Prescriptive requirement of compliance with GIS/PL2-1 removed. Polyethylene compliant with EN1555-1 permitted.</p> <p>Provision of further detail in respect to polyethylene characteristics – adopting Table and text from BS ISO 8085-1</p>	GL NOBLE DENTON	
Clause 5.1	<p>Table removed from Clause 5.3 and incorporated within Clause 5.1.</p> <p>Table placement was considered in appropriate.</p>	GL NOBLE DENTON	
Clause 5.3 Class C fittings Table 2	<p>Table removed and incorporated into Clause 5.1. Table placement was considered in appropriate.</p> <p>SDR26 addition to the SDR options shown for $355 \leq d_n \leq 630$</p> <p>SGN are looking to use SDR26 in preference to SDR21 for general application.</p> <p>Maximum threshold SDR26 $d_n \geq 250$</p>	Radius Systems	
Clause 6.1	<p>New Statement; The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling if different from that prescribed in GIS/PL2-5.</p> <p>This will remove prescriptive tooling</p>	GL NOBLE DENTON	

	<p>requirements barring entry of fittings with different design configuration which are not compatible with GIS/PL2-4.</p> <p>New Statement: The stops shall be removable without interference of the socket electrical wire. This should help negate the possibility of contamination / damage in the field.</p> <p>The following statement has been deleted to remove the prescriptive nature and align with EN1555-3:</p> <p>Fitting sockets shall be provided with a lead-in to ease joint assembly, see Figure 1.</p> <p>For socket sizes equal to or greater than 250 mm, means shall be provided to facilitate site handling and to protect fusion surfaces from handling damage.</p>		
Clause 6.2	<p>The 'shall' requirement replaced by 'should' in respect to coupler diameter and fusion zone requirements.</p> <p>An option to use tooling other than that of GIS/PL2-5</p> <p>The GNO's realise that the loss of the prescriptive design requirements designed specifically for the UK industry means that they will have to adopt a performance based methodology in terms of product selection and use. This will ensure that they aligned with the operating practices of polyethylene pipeline assets owners globally. The robust testing regime of GIS/PL2-4 has been retained in order to ensure only high quality fittings demonstrating equivalence in terms of functionality to existing products enter the UK. Thereafter stringent performance testing will ensure compatibility with UK working practices.</p>	GL NOBLE DENTON	
Clause 6.3.2.2	<p>Addition to accommodate European design - Alternatively temporary or permanent under-clamps may also used.</p>	George Fischer	
Clause 6.3.2.3	<p>Torques increased to accommodate European design.</p>	George Fischer	
Clause 6.3.2.4	<p>Torques increased to accommodate European design.</p>	George Fischer	
Clause 6.3.2.5	<p>Accommodation of alternate 'side seal design'.</p>	Radius Systems	
Clause 6.4.2	<p>Addition to accommodate European design - Alternatively temporary or permanent under-clamps may also used.</p> <p>Deletion of text: For outlet sizes greater than 63 mm, and for all class C branch saddles. Aim to accommodate European variable design.</p>	George Fischer	
Clause 7.2	<p>Introduction of ISO 11357 as an alternate thermal stability test method.</p> <p>Test method is considered equivalent.</p>	George Fischer	
Clause 8.1.3	<p>Clause changed to accommodate EN1555-3 terminal designs.</p>	GL NOBLE DENTON	
Clause 8.3	<p>The jointing time (fusion plus cool time) for sizes >180mm up to a maximum of</p>	Plasson , George	

	<p>355mm increased to 90 minutes to accommodate variable European design – this does affect performance other than fusion productivity</p> <p>Statement which allows lower reference temperature for joint cooling time and longer fusion times. Lower temperature beneficial in terms of giving increased joint strength. Possible impact on productivity.</p> <p>This change is removing prescriptive requirements to align with EN1555-3.</p> <p>Accommodation of European design variability by removal of statement: Fittings up to and including 400mm nominal size incorporating two electrofusion sockets shall have both sockets fused in a single operation.</p>	<p>Fischer</p> <p>George Fischer</p> <p>George Fischer</p>	
Clause 10.7.1 & Annex A, Table A2	<p>The 20°C 5000 hour test duration for UK and European manufactured fittings with proven history of supply to the gas industry has been reduced to 100 hours. Note the stress levels have been increased so that the test is aligned with EN1555-3.</p> <p>The test is considered by Fusion, Plasson, George Fisher and Steve Beech to be no more than a structural integrity test which also assesses ductility across the fusion zone. It gives a preliminary assessment of structural strength which can actually be achieved within 100 hours. The material performance in terms of ductility is considered to be tested more at 80°C at 1000 hours.</p> <p>GL Noble Denton is in agreement with these parties that at a temperature of 20°C the long term slow crack failure mechanisms are not likely to manifest within 5000 hours at such high stress levels unless there is fundamental problem with the polymer. Due to the time, temperature dependency of plastics it is considered that the 80°C tests at lower stress will give a more accurate prediction of long term performance and would identify issues with material quality.</p> <p>The 5000 hour test has been retained for non European grades with very little history of use in Europe as a precautionary measure. We would like to assess performance at high stress in order to assess material behaviour.</p>	<p>GL NOBLE DENTON</p> <p>PLASSON</p> <p>FUSION</p> <p>GEORGE FISCHER</p> <p>Steve Beech - Steve is involved in Sub-Committees and all Working Groups for polyolefin pressure pipes and fittings in both ISO/TC 138 and CEN/TC 155. He is Convenor of several Working Groups and notably TC 155/WG12 which has been revising the European system standards for PE gas and water systems.</p>	
Clause 10.7 & Table A2 & Annex K, L	<p>New Clause providing performance testing guidance for couplers which do not comply with Part b of Clause 6.2.2 Wall thicknesses of electrofusion socket fittings.</p> <p>Test requirement aligned with EN1555-3.</p>		
Clause 10.9 & Annex A Tables A3 part 1 and part 2, Annex J Change No. 3 Table	<p>Introduction of ISO 11357 as an alternate thermal stability test method.</p> <p>Test method is considered equivalent.</p>	George Fischer	
Clause 10.10.1	<p>New Statement: At the discretion of the gas transporter BS EN 12117 may be considered for calculation of pressure drop as an alternate to GIS PL2-4 Annex I. Equivalency in respect of calculated values shall be demonstrated.</p> <p>Alignment with EN1555-3.</p>	GL NOBLE DENTON	

Clause 11.2	<p>New statement: Sample test assemblies shall take account of manufacturing and assembly tolerances based on process control data of upper and lower variance ranges.</p> <p>The fitting manufacture must ensure that they have strict control of process parameters and that all possible combinations of product i.e. upper and lower tolerance range are compliant.</p>	GL NOBLE DENTON	
Clause 11.3	<p>New Statement; The fitting manufacturer shall provide installation instructions and recommend / provide appropriate tooling if different from that prescribed in GIS/PL2-5.</p> <p>This will remove prescriptive tooling requirements.</p>	GL NOBLE DENTON	
Clause 12	<p>An addition to Note: Requirements d) and e) may be repeated on a label firmly fixed to the fitting packaging or on an individual bag.</p> <p>Alignment with marking practices in Europe</p>	GL NOBLE DENTON	
Clause 13	<p>More comprehensive guidance in respect to the requirements of packaging in order to ensure protection of fittings when released into the field. This is an issue which needs addressing. Field experience shows that polyethylene packaging is not tolerant and is susceptible to damage.</p>	GL NOBLE DENTON	
Annex A, Table 1	<p>Additional note e) The values indicated are applicable to mains sizes up to and including 250mm. Alternative values may be proposed by the contractor, for larger size saddles, and shall be subject to agreement with the gas transporter".</p>	GPS	
Annex A, Table 2	<p>ISO1133 quoted as a standard for MFR testing in place of GIS/PL2-1</p>	Radius Systems	
Annex A4	<p>Amended to 170 hours machine time only.</p> <p>A production batch should not exceed 170hrs machine time or 10,000 components, whichever is the lesser" is a dated statement. Whilst Radius support the 170hrs, the advent of robotic technology managing moulding machines, means that 10,000 components can be achieved within 3 days, if you are manufacturing fittings such as 20mm Couplers. The figure of 10,000 components needs re-visiting (30,000pcs) would be better, or deleting completely so that the focus is firmly on 170hrs.</p>	Radius Systems	

Annex O Summary of and rationale for changes to document – October 2019

Section/Clause reference	Existing requirements/text	Suggested change	Comment/rationale for change
Title – GIS/PL2-4 Specification for Polyethylene pipes and fittings for natural gas Part 4: Fusion fittings with integral heating elements			This standard does not have “and suitable manufactured gas” per other standards in this series.
Formal standards	BS EN 681-1 & 2 Elastomeric seals – Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids	BS EN 682, Elastomeric seals - Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids	BS EN 681 & 2 are specifications for elastomeric seals for water and drainage applications
Formal standards	N/A	Add ISO 11357 reference	This is missing from formal standards but is referenced in Clause 7.2
4.4	“Elastomeric seals shall conform to BS EN 681–1 & 2”.	“Elastomeric seals shall conform to BS EN 682”.	BS EN 681 & 2 are specifications for elastomeric seals for water and drainage applications
Table 2 Note E	SDR 26 $d_n \geq 250$ except 213mm & 268mm	SDR 26 $d_n \geq 225$ except 213mm” Or SDR 26 $d_n \geq 200$ ”	The note precludes dn225 co-extruded PE100/PE80 pipe (GIS/PL2-2 Scope Para 5 & 6) and 268mm is already in the range above 250. GDNs may want to consider diameters less than dn225 and constructed in PE100/PE80 may be available / desired in the future
Note to 6.3.2	<i>Mains pipe sizes range in diameter from 40 mm to 630 mm</i>	<i>Mains pipe sizes range in diameter from 40 mm to 800 mm</i>	Pipe diameters now up to dn800
Clause 6.4.1, Sentence under Table 5	Fittings having flanged outlets shall be in accordance with GIS/PL3:2006, 7.6 and 7.7	Fittings having flanged outlets shall be in accordance with GIS/PL3:2014, 8.6 and 8.7	Clause 7.6 and 7.7 are not part of GIS/PL3 and this standard was updated in / to 2014
10.6.3	A socket joint assembly shall be tested in accordance with and meet the requirements of GIS/PL3: 2006, 8.7 .	A socket joint assembly shall be tested in accordance with and meet the requirements of GIS/PL3: 2014, 8.7 .	PL3 has been updated

Bibliography

Formal standards

BS EN ISO 13686, *Natural gas — Quality designation.*

ISO 3, *Preferred numbers – Series of referred numbers.*

ISO 497, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers.*

National Grid standards

T/SP/DIS 5.11.1, *Close fit PE lining of pipe.*