

Gas Industry Standard

GIS/PL2-6:2018

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**



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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/PL2-6 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/PL2-6 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;*

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 G	March 2009
Document update as required in conjunction with installation of new increased PE pipe diameters up to 800mm	November 2014
Updated to include additional test requirements for corrugated fittings (Annex H)	December 2018

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1 Scope

This part of GIS/PL2 specifies requirements for spigot end fittings (including flange adapters) for electrofusion and butt fusion purposes in the nominal size range 16 mm to 800 mm inclusive. They are made from polyethylene and are intended for use at operating temperatures in the range $-20\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$.

Fittings are classified as Class B, which are suitable for use at operating pressures not exceeding 5.5 bar, except for fittings fabricated by mitred butt jointing that are limited to operating pressures not exceeding 2 bar. Class C fittings are suitable for use at operating pressures not exceeding 7 bar.

The fittings covered are those produced by injection moulding or extrusion methods (with or without subsequent machining), fittings fabricated or formed from pipe, corrugated fittings or special purpose fittings fabricated by other procedures (e.g. block).

The outlet of the fitting is designed to be capable of electrofusion and/or butt fusion to pipe meeting the requirements of GIS/PL2-2 or GIS/PL2-8 at ambient temperature of $-5\text{ }^{\circ}\text{C}$ to $23\text{ }^{\circ}\text{C}$

Electrofusion jointing will use fittings to GIS/PL2-4, control boxes that conform to GIS/ECE1 and ancillary equipment to GIS/PL2-5. Butt fusion will be to polyethylene pipe, using tooling and equipment to GIS/PL2-3.

The use of alternative control boxes approved to equivalent standards (e.g. EN or ISO) and auxiliary equipment 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 5252, *Framework for colour co-ordination for building purposes*.

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

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

BS EN ISO 17778, *Plastics piping systems. Fittings, valves and ancillaries. Determination of gaseous flow rate/pressure drop relationships*.

BS EN ISO 472, *Plastics — Vocabulary*.

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

BS EN ISO 1133, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics*.

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

ISO 11357-3, *Plastics -- Differential scanning calorimetry (DSC) -- Part 3: Determination of temperature and enthalpy of melting and crystallization*.

BS ISO 13953, *Polyethylene (PE) pipes and fittings — Determination of the tensile strength and failure mode of test pieces from a butt-fused joint*.

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

BS EN ISO 12162, *Thermoplastics materials for pipes and fittings for pressure applications. Classification, designation and design coefficient.*

BS EN ISO 9080, *Plastics piping and ducting systems - Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

BS EN 1411 *Plastics piping and ducting systems – Thermoplastic pipes – Determination of resistance to external blows by the staircase method*

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/PL2-3, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 3: Butt fusion machines and ancillary equipment.*

GIS/PL2-4, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 4: Fusion fittings with integral heating element(s).*

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

GIS/PL2-7, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 7: Squeeze-off tools and equipment.*

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.*

3 Terms, definitions, symbols, abbreviations and units

For the purposes of this standard the terms and definitions, symbols, abbreviations and units given in BS EN ISO 472 and BS EN ISO 1043-1 and the following 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

outside diameter (at any point), d_e

value of the measurement of the outside diameter through its cross-section at any point of the pipe, rounded to the next greater 0.1 mm

3.1.5

mean outside diameter, d_{em}

value of the measurement of the outer circumference of the pipe or spigot end of a fitting in any cross-section divided by π ($= 3.142$), rounded to the next greater 0.1 mm

3.1.6**minimum mean outside diameter, $d_{em, min}$**

minimum value for the mean outside diameter as specified for a given nominal size

3.1.7**maximum mean outside diameter, $d_{em, max}$**

maximum value for the mean outside diameter as specified for a given nominal size

3.1.8**ovality**

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

3.1.9**circumferential reversion**

reduction in pipe diameter near the pipe ends produced by internal axial stresses in the pipe wall and caused by variations in cooling rates

3.1.10**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)

NOTE For thermoplastics components, the value of the nominal wall thickness, e_n , is identical to the specified minimum wall thickness, e_{min} .

3.1.11**wall thickness (at any point), e**

wall thickness at any point around the circumference of a component

3.1.12**minimum wall thickness (at any point), e_{min}**

minimum value for the wall thickness around the circumference of a component, as specified

3.1.13**maximum wall thickness (at any point), e_{max}**

maximum value for the wall thickness around the circumference of a component, as specified

3.1.14**mean wall thickness, e_m**

arithmetical mean of a number of measurements of the wall thickness, regularly spaced around the circumference and in the same cross-section of a component, including the measured minimum and the measured maximum values of the wall thickness in that cross-section

3.1.15**tolerance**

permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value

3.1.16 wall thickness tolerance

permitted difference between the wall thickness at any point, e , and the nominal wall thickness, e_n

NOTE $e_n = e_{min}$.

3.1.17**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

3.2 Material definitions

3.2.1

virgin material

material in a form such as granules or pellets 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

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

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

3.2.5

campaign batch

uninterrupted base polymer production run by the resin manufacturer

NOTE It should not exceed 1 month's production by the plant nor be larger than 4000 tonnes.

3.2.6

compound batch

clearly identifiable quantity of a given homogeneous compound manufactured under uniform conditions

NOTE The compound batch is defined and identified by the compound manufacturer. It should not exceed 700 tonnes.

3.2.7

peelable pipe

pipe made with polyethylene (PE100) core material over which is an outer skin, which is removed locally with the aid of dedicated proprietary tools prior to fusion jointing

NOTE The skin allows protection of the core pipe during installation, but does not contribute to the specified wall thickness or to the mechanical strength of the pipe. The skin carries all marking and colour identification of the pipe.

3.2.8

core pipe

polyethylene pipe without skin

NOTE The core pipe meets all the dimensional requirements of GIS/PL2-2 with the exception of colour.

3.2.9

multilayer pipe

Pipe consisting of a co-extruded PE inner layer and a PE outer layer.

3.2.10

batch release test (BRT)

batch release testing performed by the manufacturer on a batch of material or components, which has to be satisfactorily completed before the batch can be released.

3.2.11

process verification test (PVT)

process verification testing performed by the manufacturer on material, components and assemblies at specific intervals to confirm that the process continues to be capable of producing components conforming to the requirements given in the relevant standard.

3.2.12

type test (TT)

type testing (TT) testing performed to prove that the material, component, assembly is capable of conforming to the requirements given in the relevant standard.

3.3 Material properties

3.3.1

lower confidence limit (LCL), σ_{LCL}

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.:

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

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
bend
curved cylinder enabling a change of direction with a centre line radius of between one and five times nominal bore

3.5

Definitions

3.5.1

bend

curved cylinder enabling a change of direction with a centre line radius of between one and five times nominal bore

3.5.2

butt fusion joint (using heated tool)

joint made by heating the planed ends of pipes or spigot end fittings NOTE The surfaces of the joint match by holding them against a flat heating plate until the polyethylene material reaches fusion temperature, removing the heating plate quickly and pushing the two softened ends against one another.

3.5.3

pipe pup

short length of pipe, butt welded to the spigot end of a fitting, to increase the overall spigot length and also allow subsequent pipe-to-pipe butt joints in the field

3.5.4

elbow

curved cylinder enabling a change of direction with a maximum centre line radius of one nominal bore

3.5.5

electrofusion fitting

fitting which contains an integral heating element(s) and which conforms to GIS/PL2-4

3.5.6**flange adapter**

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

3.5.7**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

3.5.8**long radius bend**

curved cylinder enabling a change of direction with a centre line radius greater than five times nominal bore

3.5.9**formed bends**

short curved cylinder enabling a change of direction with a centre line radius of 1.5d

3.5.10**spigot end fitting**

fitting terminating with cylindrical end stubs with dimensions conforming to GIS/PL2-2 or GIS/PL2-8.

3.6 Symbols

C	overall service (design) coefficient
d_e	outside diameter (at any point)
d_{em}	mean outside diameter
$d_{em,max}$	maximum mean outside diameter
$d_{em,min}$	minimum mean outside diameter
d_n	nominal outside diameter
e	wall thickness (at any point) of a pipe
e_m	mean wall thickness
e_{max}	maximum wall thickness (at any point)
e_{min}	minimum wall thickness (at any point)
e_n	nominal wall thickness
σ_{LCL}	lower confidence limit
σ_s	design stress
P_c	critical pressure
T_{min}	minimum butt joint fusion temperature
T_{max}	maximum butt joint fusion temperature

3.7 Abbreviations

BRT	batch release testing
DN	nominal size
DN/OD	nominal size, outside diameter related
LCL	lower confidence limit

MFR	melt mass-flow rate
MOP	maximum operating pressure
MRS	minimum required strength
PVT	process verification testing
SDR	standard dimension ratio
TT	type testing

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**. The colour of the PE parts of fittings shall be either black, yellow, or orange.

Table 1—Classification of polyethylene compounds

Designation	$\sigma_{LCL}(20^{\circ}\text{C}, 50 \text{ years}, 97.5\%)$ MPa	MRS MPa
PE80	$8.00 \leq \sigma_{LCL} \leq 9.99$	8.0
PE100	$10.00 \leq \sigma_{LCL} \leq 12.40$	10.0

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

The fittings shall be made from either PE80 or PE100 virgin material or uncontaminated recyclate material from identical polyethylene compound. PE80 and PE100 uncontaminated recyclate materials shall not be mixed.

Uncontaminated recyclate material (**yellow and orange polyethylene compound shall only be permitted**) (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. Regrinding undertaken outside of the manufacturer's premises shall be under the manufacturer's supervision.

Uncontaminated recyclate material (yellow, orange, and black) from pipes shall be permitted provided it is generated from a manufacturer's own production to this standard and may be used provided it has not left the manufacturer's premises. Regrinding undertaken outside of the manufacturer's premises shall be under the manufacturer's 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.

5 Fitting classification

5.1 Operational pressures

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

Table 2 — Maximum operating pressures at 20 °C

PE Class	Fitting class	Maximum operating pressure (MOP) at 20 °C			
		bar			
		SDR11	SDR13.6	SDR17.6	SDR21 and SDR26 ^{a), b)}
PE80	B	5.5 ^{c)}	4 ^{c)}	3 ^{c)}	2
PE100	<u>B</u>			<u>4^{b)}</u>	2
PE100	C	7	—	—	—
	<p>a) SDR26 PE80 pipe is a special insertion size. For pipe sizes equal to or greater than 355 mm, the wall thickness is increased to SDR21.</p> <p>b) SDR21 / SDR26 / <u>SDR17.6</u> also refers to peelable pipes.</p> <p>c) Fittings fabricated by mitred butt fusion shall be limited to a maximum operating pressure of 2 bar.</p> <p>NOTE: The use of any SDR derived from the pipe series S given in ISO 4065: 1996 is permitted.</p>				

The performance of pipe / fitting assemblies shall be in accordance with Clause **13**.

Assessment of conformity shall be carried out in accordance with Clause **14**.

Fittings fabricated by mitred butt fusion are class B but shall be limited to a maximum operating pressure of 2 bar.

5.2 Spigot-end fittings and fitting assemblies with pipe pups – Factory fabrication only

Spigot end fittings shall be manufactured to have short integral spigot outlets or as spigot end assemblies with pipe pups butt welded on to these short integral spigot outlets (see **9.2** and **9.3**).

NOTE 1 Spigot end fittings may be produced from more than one spigot end fitting, e.g. spigot end flange + spigot end reducer + pup pipe.

Fittings with integral spigot outlets shall only be used for jointing with electrofusion fittings produced in accordance with GIS/PL2-4.

NOTE 2 Butt jointing is not permitted in the field between integral spigot outlets and pipes, due to differences in the properties and internal stresses of the parts at the weld and the practical difficulties associated with clamping. It is only permitted between two pipes.

Fittings with pipe pups shall be suitable for pipe-to-pipe butt fusion and also jointing with electrofusion fittings produced in accordance with GIS/PL2-4.

NOTE 3 Spigot end fittings with PE100 peelable pipe pups (SDR21/26) can be used for butt fusion to other PE100 standard pipes having the same SDR, as well as electrofusion jointing to any type of pipe (standard or peelable).

NOTE 4 it is permissible to butt weld black, PE100 spigot fittings to either yellow PE80 pipes or to PE100 peelable pipes, under factory conditions. The resulting assembly shall be designated according to the type of pipe pups used.

Spigot end fittings, which contain an electrofusion element (e.g. an equal tee with in-line electrofusion sockets and a spigot branch), shall also conform to GIS/PL2-4.

5.3 Class B fittings

Class B fittings shall be suitable for jointing with pipes conforming to GIS/PL2-2 (maximum operating pressure 5.5 bar for SDR 11 pipes). Each type and size of fitting shall be suitable for jointing to pipe with SDR values specified in **Table 2**.

Class B fittings shall be coloured yellow or black. Black fittings shall have a yellow label securely affixed to indicate suitability for operation at pressures selected from the range up to 5.5 bar.

Pup pipe outlets to class B fittings shall be PE80 pipes or PE100 SDR 21/26 pipes.

Spigot end fittings with PE100 SDR 21/26 pipe pups can be used for butt fusion to other PE100 standard pipes having the same SDR, as well as electrofusion jointing to any type of pipe (standard or peelable).

5.4 Class C fittings

Class C fittings shall be suitable for jointing with pipes conforming to GIS/PL2-8 (maximum operating pressure 7 bar). Each type and size of fitting shall be suitable for jointing to SDR11 pipe, as specified in **Table 2**.

Class C fittings shall be coloured yellow, or orange, or black. All class C fittings, except those orange in colour, shall have an orange label securely affixed on the fitting to indicate suitability for operation at pressures up to 7 bar.

Pup pipes joined to class C fittings shall be PE100, SDR11 pipes.

6 Fitting appearance

Fittings shall be free from cracks, voids, blisters, holes, distortion, dents, injurious incisions, inclusions or other defects likely to impair their performance.

7 Electrofusion compatibility

Electrofusion jointing to spigot ends shall not necessitate changes of fusion times of the electrofusion fitting. Fusion compatibility between the fittings spigot and the electrofusion fitting shall be demonstrated in accordance with **Clause 13**.

8 Conditioning

Fittings shall not be measured or used for testing within 24 h of manufacture to allow for normalization.

Fittings with peelable pipe pups shall be conditioned with the skin intact. The spigot end fittings and fitting assemblies with pipe pups shall be conditioned before measurement or testing in accordance with **Table 3**.

Table 3 — Minimum conditioning period

Minimum wall thickness mm	Minimum conditioning period h			
	In air at 23°C (±2°C)	In liquid at 20 °C(±1°C)	In liquid at 80 °C (±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 specimen, 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.

9 Dimensions

9.1 General

Methods of measurement should conform to BS EN ISO 3126. The fitting's dimensions shall be measured at 23 °C ± 2 °C, after conditioning in accordance with Clause 8.

9.2 Integral spigot end fittings (electrofusion only)

The integral spigot end fitting dimensions should conform to Figure 1 and Table 4.

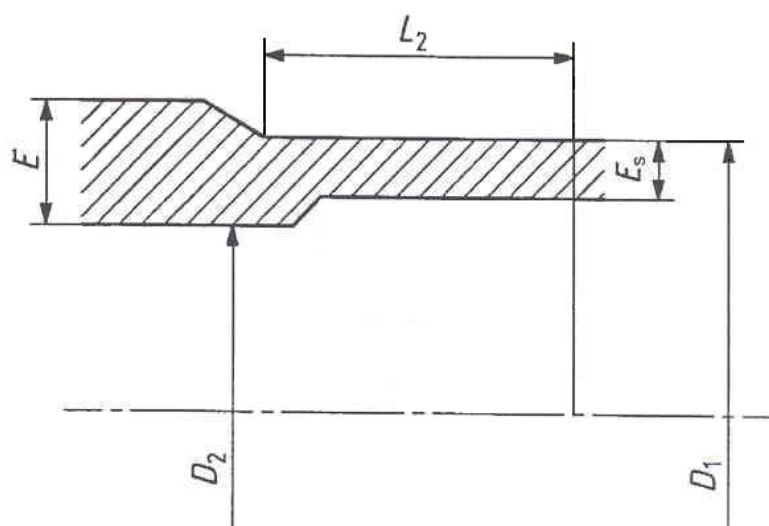
All fittings shall be suitable for use with clamps and equipment conforming to GIS/PL2-5.

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.

The ovality (out-of-roundness) tolerance of each integral spigot end shall not exceed that of straight pipe as specified in GIS/PL2-2 (class B) or GIS/PL2-8 (class C).

The out-of-square-values for fitting spigot ends shall conform to **Table 5**.

Over the minimum spigot length, the fitting shall conform to the outside diameter and wall thickness dimensions and tolerances specified in Table 6, ignoring the end 0.1d for sizes equal to or less than 90 mm and the end 10 mm for sizes 125 mm to 180 mm inclusive.



Key:

D_1 is the "mean outside diameter" of the fusion end piece, measured in any plane parallel to the plane of the entrance face at a distance not greater than L_2 (tubular length) from that plane;

D_2 is the "minimum bore" which comprises the minimum diameter of the flow channel through the body of the fitting. The measurement of the diameter does not include the fusion pad if any;

E is the "body wall thickness of the fitting", which comprises the thickness measured at any point of the wall of the fitting;

E_S is the "fusion face wall thickness" measured at any point at a maximum distance of L_1 (cut back length) from the entrance face; and shall be equal to the pipe wall thickness and tolerance to which it is intended to be butt fused;

L_2 is the "tubular length" of the fusion end piece, which comprises the initial length of the fusion end piece. This tubular length must allow (in any combination):

- a) the use of clamps required in the case of butt fusion;
- b) the assembly with an electrofusion fitting;
- c) the assembly with a socket fusion fitting;
- d) the use of a mechanical scraper.

Figure 1 – Dimensions of spigot fittings

Table 4 — Dimensions of integral spigot end fittings

Dimensions in millimetres

Nominal outside diameter of spigot	Mean outside diameter of the fusion end ^a		For electrofusion and butt fusion			For butt fusion only		
	Mean outside diameter, d_{em}	Mean outside diameter, d_{em}	Ovality	Min. bore	Tubular length ^b	Ovality	Tubular length Normal ^c	Tubular length Special ^d
	$D_{1,min}$	$D_{1,max}$	max.	D_2	$L_{2,min}$	max.	$L_{2,min}$	$L_{2,min}$
16	16.0	16.3	0.3	9	86	-	-	-
20	20.0	20.3	0.3	13	86	-	-	-
25	25.0	25.3	0.4	18	86	-	-	-
32	32.0	32.3	0.5	25	89	-	-	-
40	40.0	40.4	0.6	31	94	-	-	-
50	50.0	50.4	0.8	39	100	-	-	-
55	55.0	55.4	0.8	43	105	-	-	-
63	63.0	63.4	0.9	49	112	1.5	16	5
75	75.0	75.5	1.2	59	118	1.6	19	6
90	90.0	90.6	1.4	71	131	1.8	22	6
110	110.0	110.7	1.7	87	135	2.2	28	8
125	125.0	125.8	1.9	99	140	2.5	32	8
140	140.0	140.9	2.1	111	150	2.8	35	8
160	160.0	161.0	2.4	127	153	3.2	40	8
180	180.0	181.1	2.7	143	160	3.6	45	8
200	200.0	201.2	3.0	159	-	4.0	50	8
213	213.0	214.3	3.2	170	-	4.3	50	8
225	225.0	226.4	3.4	179	-	4.5	55	10
250	250.0	251.5	3.8	199	-	5.0	60	10
268	268.0	269.6	4.0	214	-	6.7	60	10
280	280.0	281.7	4.2	223	-	7.0	70	10
315	315.0	316.9	4.8	251	-	7.9	80	10
355	355.0	357.2	5.4	283	-	8.9	90	12
400	400.0	402.4	6.0	319	-	10.0	95	12
450	450.0	452.7	6.8	359	-	11.3	60	15
469	469.0	471.8	7.0	374	-	11.7	60	15
500	500.0	503.0	7.5	399	-	12.5	60	15
560	560.0	563.4	8.4	447	-	14.0	60	15
630	630.0	633.8	9.5	503	-	15.8	60	20
710	710.0	716.4	10.6			17.8	60	20
800	800.0	807.2	12.0			20.0	60	20

^a Tolerance grades are in accordance with ISO 11922-1.

^b Where not specified, the values of L_2 (electrofusion) shall be based on the following equation:

$$L_2 = d_n/3 + 45 \text{ mm.}$$

^c For field use, only.

^d For fittings fabricated in the factory, only.

Table 5 — Out-of-square values for fitting ends

Spigot end size mm	Maximum out-of-square of spigot end fittings mm
$d_n \leq 63$	1.5
$63 < d_n \leq 125$	2
$125 < d_n \leq 180$	3
$180 < d_n \leq 250$	4
$250 < d_n \leq 355$	5
$355 < d_n \leq 630$	7
710 / 800	10

9.3 Spigot end fitting assemblies (butt fusion and electrofusion)

Fittings for butt fusion shall terminate in a pipe conforming to GIS/PL2-2 (class B) or GIS/PL2-8 (class C) as appropriate. The minimum total spigot length (pipe and integral spigot outlet) shall be 500 mm.

The ovality tolerance of each pup pipe end shall not exceed that of polyethylene pipe as specified in GIS/PL2-2 (class B) or GIS/PL2-8 (class C).

The pup pipe ends shall meet the relevant out-of-square values specified in Table 5.

The pup pipe ends of the fitting shall conform to the outside diameter and wall thickness dimensions and tolerances of pipe to which the fitting is to be joined as specified in Tables 4 and 6.

The factory fused butt joints between the integral spigot end fitting and the pup pipe shall be free from contamination, slit defects and voids. Any misalignment of butt fusion joints shall not exceed 10 % of the pipe wall thickness, or 1 mm, whichever is the greater.

The external butt fusion beads on spigot end fitting assemblies shall be removed without detriment to the strength and performance of the fitting. The internal protrusion of bead material into the fitting bore shall be kept to a minimum.

The butt fusion joints of pipes to spigot ends in sizes 90mm and above shall meet the tensile test requirements of BS ISO 13953 where all the failures shall be ductile. The test specimens shall be prepared at normal ambient temperature using fusion conditions recommended by the manufacturer of the spigot fittings. The external bead shall be removed before testing.

10 Mitre-jointed butt fusion fittings

Fittings fabricated by the mitred butt jointing of pipe shall conform to Annex B.

11 Formed Bends (Class C)

Formed Bends (Class C) manufactured from PE100 shall conform to Annex F.

12 Pressure loss (16 mm to 180 mm)

The gaseous flow/pressure drop relationship shall be determined in accordance with BS EN ISO 17778.

Only 90° elbows, 45° elbows, equal tees, reducing tees, 90° bends and 45° bends in sizes up to and including 180 mm shall be tested.

The design of each fitting shall minimize pressure loss.

NOTE No pressure loss tests will be required for flange adapters.

The pressure loss for tees shall be measured between the main pipe and the branch outlet, and the main extension shall be blanked off.

For in-line reducers, and in order to minimize pressure drop, there shall be no sudden step changes in internal diameters.

Long radius bends or fittings fabricated from mitred butt joints shall not be subject to pressure loss requirements.

Formed Bends shall not be subject to pressure loss requirements.

Table 6 — Outside diameter and wall thicknesses of polyethylene pipes and spigot outlets

Dimensions in millimetres												
Nominal outside diameter, d_n	Mean outside diameter, d_{em}		Wall thickness, e									
			SDR11		SDR13.6		SDR17.6		SDR21		SDR26	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
16 ^{a)}	16	16.3	2.3	2.7	—	—	—	—	—	—	—	—
20 ^{a)}	20	20.3	2.3	2.7	—	—	—	—	—	—	—	—
25	25	25.3	2.3	2.7	—	—	—	—	—	—	—	—
32	32	32.3	3.0	3.4	—	—	—	—	—	—	—	—
40	40	40.4	3.7	4.2	—	—	—	—	—	—	—	—
50	50	50.4	4.6	5.2	3.7	4.2	2.9	3.3	—	—	—	—
55	55	55.4	5.1	5.8	—	—	—	—	—	—	—	—
63	63	63.4	5.8	6.5	4.7	5.3	3.6	4.1	3.0	3.4	—	—
75	75	75.5	6.8	7.6	5.6	6.3	4.3	4.9	—	—	—	—
90	90	90.6	8.2	9.2	6.7	7.5	5.2	5.9	4.3	4.9	—	—
110	110	110.7	10.0	11.1	8.1	9.1	6.3	7.1	5.2	5.9	—	—
125	125	125.8	11.4	12.7	9.2	10.3	7.1	8.0	6.0	6.7	—	—
140	140	140.9	12.7	14.1	10.3	11.5	8.0	8.9	—	—	5.4	6.1
160	160	161.0	—	—	11.8	13.1	9.1	10.1	7.6	8.5	6.2	7.0
180	180	181.1	16.4	18.2	13.3	14.8	10.3	11.5	8.6	9.6	7.0	7.8
200	200	201.2	18.2	20.2	14.7	16.3	11.4	12.7	9.5	10.6	7.7	8.6
213	213	214.3	—	—	—	—	—	—	—	—	8.2	9.2
225	225	226.4	—	—	—	—	—	—	10.7	11.9	8.6	9.6
250	250	251.5	22.7	25.1	18.4	20.4	14.2	15.8	11.9	13.2	9.6	10.7
268	268	269.6	—	—	—	—	—	—	—	—	10.3	11.5
280	280	281.7	25.4	28.1	20.6	22.8	15.9	17.6	13.4	14.9	10.7	11.9
315	315	316.9	28.6	31.6	23.2	25.7	17.9	19.8	15.0	16.6	12.1	13.5
355	355	357.2	32.3	35.7	26.1	28.9	20.2	22.4	16.9	18.7	13.7	15.2
400	400	402.4	36.4	40.2	29.4	32.5	22.8	25.2	19.0	21.0	15.4	17.1
450	450	452.7	40.9	45.1	33.1	36.6	25.6	28.3	21.4	23.7	17.3	19.2
469	469	471.8	—	—	—	—	—	—	22.3	24.7	18.0	20.0
500	500	503.0	45.5	50.2	36.8	40.6	28.4	31.4	23.8	26.3	19.2	21.3
560	560	563.4	50.9	56.1	41.2	45.5	31.9	35.2	26.7	29.5	21.5	23.9
630	630	633.8	57.3	63.2	46.3	51.1	35.8	39.5	30.0	33.1	24.2	26.8
710	710	716.4	64.5	71.1	52.2	57.6	40.3	44.5	33.9	37.4	27.2	30.1
800	800	807.2	72.6	80.0	58.8	64.8	45.4	50.1	38.1	42.1	30.6	33.8

^{a)} For pipe sizes 16 mm and 20 mm, the actual values are SDR7 and SDR9 respectively due to minimum wall thickness considerations.

13 Performance of fittings

13.1 Integral spigot end fittings (electrofusion only)

Class B fittings with integral spigot ends shall be tested with electrofusion coupler(s) and PE80 pipe(s) of the highest pressure rating (i.e. thickest wall) for which the fitting is designed.

NOTE Normally SDR11 will be used.

Class C fittings shall be tested with PE100 SDR11 pipes.

Electrofusion joints shall be constructed in accordance GIS-PL2-4. Samples shall be prepared for test in accordance with Annex C using pipes at the two extremes of the SDR range for which the spigot end fitting is designed.

13.2 Spigot end fittings with pipe pups

Class B or C fittings with pipe pups shall be tested using end caps on the pup pipes (butt, electrofusion or mechanically joined).

Performance tests for spigot end fittings with butt fused pipe pups shall apply to the whole assembly.

NOTE Separate approval testing of assemblies of more than one spigot end fitting are not required, provided each spigot end fitting is already approved to this standard. The combination assemblies are produced by factory butt or electrofusion joints between the spigot ends of the fittings, see 14.6.

13.3 Long-term hydrostatic strength test at 20°C

Class B and class C integral spigot end fittings and spigot end fittings with pipe pups 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.

For electro-fusion fitting/joint assemblies 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 – no history of supply / use (UK or European GT's)	5000 hours

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

13.4 Hydrostatic strength at 80 °C (stress cracking resistance)

13.4.1 Type test

When tested in accordance with BS EN ISO 1167, the integral spigot end fittings and spigot end fittings with pipe pups shall withstand the minimum test pressures and times in specified in Table 8 at 80 °C ± 1 °C.

The samples 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.

13.4.2 Batch release test

When tested in accordance with BS EN ISO 1167, the integral spigot end fittings and spigot end fittings with pipe pups shall withstand the minimum test pressures and times specified in Table 8 at 80 °C ± 1 °C.

The samples 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.

Table 8 — Hydrostatic pressures and times at 80 °C

Test programme	Fitting type	Stress MPa	Pressure bar					Time h
			SDR11	SDR13.6	SDR17.6	SDR21	SDR26	
Type test	Class B	4.0	8.00	6.35	4.82	4.00	3.20	1 000
	Class C	5.0	10.00	—	—	—	—	1 000
Batch release test	Class B	4.5	9.00	7.14	5.42	4.50	3.60	165
	Class C	5.4	10.80	—	—	—	—	165

13.5 Spigot/pup end circumferential reversion (≥ 180 mm)

13.5.1 General

For integral spigot end fittings and spigot end fittings with pipe pups, the circumferential reversion of the spigot end or pipe pup, with a d_n equal to or greater than 180 mm, shall be determined after a conditioning in water at 80 °C. Conditioning shall be in accordance with BS EN ISO 1167.

The samples shall be tested in accordance with 13.5.2 (requirement A) or 13.5.3 (requirement B).

13.5.2 Circumferential reversion: requirement A

With the reverted spigot or pup pipe at 23 °C ± 2 °C, circumferential measurement shall be made to establish d_{em} .

The difference between d_{em} measurement made at distance of $1.0d_n$ and $0.1d_n$ respectively from the end of the spigot or pup pipe shall not be greater than the d_{em} tolerance range specified in Table 5.

13.5.3 Circumferential reversion: requirement B

The reverted fitting shall be assembled with an electrofusion coupler at ambient temperature. The assembly shall meet the requirements of a joint strength (peel) test in accordance with GIS/PL2-4.

Satisfactory demonstration of joint strength shall allow this measured reverted spigot diameter at $0.1d_n$ to be taken as the acceptable reference value of d_{em} at $0.1d_n$ for use in batch release tests. Measurements at $1.0d_n$ shall not be required for batch release tests.

NOTE Where the fitting geometry prevents a suitable joint strength sample from being produced, it is acceptable to recreate the conditions by machining pipe to a diameter equal to the reverted diameter of the fitting. This pipe can then be used to produce a joint strength test sample.

14 Assessment of conformity

14.1 General

Type Testing and Type Testing of low volume products and Type Testing of low volume fittings 630-800mm inclusive shall be carried out in accordance with **14.2, 14.3** and **14.4**. Process verification testing shall be carried out in accordance with **14.5** Batch release testing shall be carried out in accordance with **14.10**

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 of the SDR rating for which the fitting was designed (see Table **2**).

Type Testing shall be carried out on each type and size of fitting unless specified otherwise.

14.2 Type testing

Type testing shall be in accordance with **A.1** and **A.2**, before a particular fitting shall be considered suitable for supply to a gas transporter.

Class B and Class C spigot end fittings shall be designated for use in one or more of the following applications:

- a) integral spigot end fittings;
- b) spigot end fittings with pipe pup(s);
- c) combination assemblies of more than one integral spigot end fitting;
- d) combination assemblies of more than one integral spigot end fitting with pipe pup(s).
- e) electrofusion fittings with spigot end;
- f) electrofusion fittings with spigot end with pipe pup(s).

The test samples shall be in accordance with **13.1** or **13.2**.

14.3 Type testing – Modifications to Approved Fittings & Low Volume Products (<250 pieces per annum) with diameters < 630mm

Refer to Annex **E** 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.

14.4 Type testing – Modifications to Approved fittings & Low Volume Products (<100 pieces per annum in the diameter range 630-800mm inclusive)

Refer to Annex **G** 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.

14.5 Process verification testing

Every two years after gaining Type Approval, one fitting per size group (rotating sizes), shall meet the requirements of clause 13.4.1 of this standard. The subsequent fitting test assemblies shall be fused at conditions A and C, as shown in Table **A.1** of this standard.

Size Groups = 16 mm to 63mm, 75 mm to 225 mm, 250 mm to 800 mm.

14.6 Combination assemblies

For assemblies of more than one spigot end fitting each spigot end fitting shall conform to this standard.

NOTE 1 Separate approval testing of the whole assembly is not necessary.

NOTE 2 The combination assemblies are produced by factory butt or electrofusion joints between the spigot ends of the fittings

14.7 Change of compound

Where a range of previously approved fittings is produced in a new material, type tests shall be performed in accordance with **A.1** and **A.2**, but on the smallest and largest size in the contractor's range, and on one intermediate size.

Once these three sizes have gained approval, approval shall be granted to any other sizes between the smallest and largest size tested.

14.8 Range extension

Additional sizes to a range of previously approved fittings may gain approval from a reduced number of test samples. Type Tests shall be performed in accordance with **A.1** and **A.2**, but on the smallest and largest size of the extended range. Different fitting types may be used to demonstrate conformity. Once these two sizes have gained approval, approval shall be granted to any other sizes between the smallest and largest size tested.

If the range is extended by any single size, full testing shall be carried out on that size.

14.9 Long radius bends

14.9.1 Type Approval Testing

Where approval for long radius bends manufactured from pipes fully conforming to GIS/PL2-8 (Class C) is being sought simultaneously for a number of sizes and angles, the tests shown in Annex **E** for Low Sales Volume requirement shall be carried out on the largest and smallest sizes, at the maximum angle for which approval is being sought.

Long Radius bends of 15° angle, or less, shall be considered to be equivalent to straight pipe and shall not need to be tested.

14.9.2 Annual Process Verification Testing

The following tests/checks shall be carried out annually on one "randomly selected" Orange Long Radius Bend.

1. The diameter and angle for test shall be rotated to cover the approved size range. Confirm that the stated angle of the Long Radius bend has not deviated by $\pm 2^\circ$ from the tolerance given by the Long Radius Bend supplier. This shall be achieved using a digital angle measuring device.
2. Hydrostatic Strength at 80°C at 9.0bar for a minimum of 165hrs, in accordance with GIS/PL2-8.
3. Following completion of item 2, mark out and number the long radius bend into a minimum of 16 equal segments. Take a photograph of the bend at this point. Section the bend into segments using an appropriate saw. Measure and record the wall thickness of each segment, paying particular attention to the area which forms the back of the bend, to ensure that no single value for wall thickness has fallen below the limits defined for each pipe diameter in GIS/PL2-8.
4. Compile a Test Report detailing all the results.
5. In the event that the bend fails one of the tests/checks listed, (2) further bends will be subjected to test. Any/all remaining Orange long radius bends held in stock shall be quarantined. The supplier of the Orange long radius bends shall be contacted.

14.10 Batch release testing (BRT)

14.10.1 General

The fittings manufacturer shall carry out a schedule of batch release testing (BRT) during production in accordance with **A.3** and Table **A.4**. The tests shall be carried out at the stated frequency from each machine or manufacturing process.

14.10.2 Batch acceptance

A production batch shall not exceed 170 h machine time. Any break in production that exceeds 14 h shall be deemed as the termination of a batch, see **3.2.4**.

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

NOTE 1 Users of this standard are advised to consider the desirability of third-party certification of product conformity with this standard or testing by an independent laboratory accredited to BS EN ISO/IEC 17025.

When batch acceptance is carried out, the sampling plans shall be in accordance with Annex **D**, Tables **D.1** and **D.2**. One sample shall be taken from each batch preferably bearing different dates.

NOTE 2 These sampling plans are derived from BS 6001-1:2011, Tables 1 and 3A for combined acceptance quality levels (AQL) of 10 %.

NOTE 3 Rejected batches may be split into sub-batches based on the date of production.

15 Marking

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

Products conforming to GIS/PL2-6:2018 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 & or a traceability code
- d) SDR rating of fitting or MOP in bar.

Alternatively, embossed or indented tags may be 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 to a minimum depth of 0.15 mm.

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

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

The mass of the fitting in kg for fittings of mass greater than 10 kg.

For branch saddles, the maximum drill diameter that can be used.

Additional information, which shall also be shown on a label:

- a) The number and date of this standard, i.e. GIS/PL2-6: 2018 (See Note 1);
- b) Where authorized, the product conformity mark of a third party certification body, e.g. BSI Kitemark.
- c) The manufacturer's contact details
- d) The SDR ratings of pipe that the fitting is approved for use with;

Note 1: Marking GIS/PL2- 6: 20018 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.

16 Protection of fittings

Spigot fittings shall be supplied in sealed 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 PL2-6 Clause 15b) and d) together with the fitting type and quantity in the pack.

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

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 (integral spigot end fittings for electrofusion only)

Class B and class C integral spigot end fittings shall be jointed to an electrofusion coupler under the conditions specified in Table A.1 to simulate the range of field conditions.

NOTE These requirements do not apply to pipped pipe fittings.

Test pieces for type testing, with the exception of those intended for tests to determine MFR and circumferential reversion, 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 butt welder that conforms to GIS/PL2-3, or an electrofusion control box that conforms to GIS/ECE1.

Table A.1 — Assembly conditions for electrofusion assemblies

Condition	Temperature before fusion		Applied voltage
	°C		
	Coupler	Spigot end fitting	
A	-5	-5	39
B	23	-5	40
C	23	23	40

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°C in the case of temperature, shall be considered acceptable under this GIS standard.

A.2 Type testing

Table A.2 — Mechanical properties of the spigot end fittings that require type testing (TT)

Properties		References	No. of test pieces ^{a)}	No. of measurements per test piece
Appearance		6	1	1
Colour:				
Class B		5.3	1	1
Class C		5.4	1	1
Integral Spigot End Fittings for electrofusion only	d_{em} , e , min spigot length	9.1/9.2, Table 4, Figure 1	3	1
	Out-of-square ends	9.1/9.2, Table 5	2	1
	General dimensions	9.1/9.2, Figure 1, Table 6	3	1
Spigot end fitting assemblies for Butt fusion and electrofusion fittings	d_{em} , e	9.1/9.2, Table 6 \exists	2	1 + 1
	Ovality	9.3, Table 4	2	1
	Out-of-square ends	9.3, Table 5	3	1
	Factory fused butt joints Defects, alignment ^{b), c)}	9.3	2	1
Mechanical properties	Tensile strength (factory butt fused joints) ^{b), c)}	9.3	2	In accordance with BS ISO 13953
	20°C Long-term hydrostatic strength	13.3	3: butt fusion ^{c)} A, B, C: electrofusion ^{d)}	1
	80°C Hydrostatic strength (stress crack resistance) 1000 h	13.4.1	3: butt fusion ^{c)} A, B, C: electrofusion ^{d)}	1
	Circumferential reversion Spigot ends and pupped pipe ends (≥ 180 mm)	13.5	2	1
	Pressure loss ^{e)} (≤ 180 mm)	Clause 12	1	1

^{a)} The number of test pieces given in the table shall be the minimum.

^{b)} Fittings fabricated by mitre butt jointing shall be in accordance with Clause **10** and Annex **B**.

^{c)} Test for spigot end fittings with factory butt-fused pipe pups.

^{d)} The fitness for purpose tests for integral spigot ends fittings. Electrofusion conditions (A, B & C) are specified in Clause **A.1** and Table **A.1**.

^{e)} Pressure loss tests not required for flange adapters or fittings made from mitred butt joints.

Table A.3 — Physical properties of spigot fittings that require type testing (TT)

Properties	Requirements	Test parameters		Test method
		Parameter	Value	
Oxidation induction time, OIT (thermal stability)	> 20 min	Test temperature	200°C ^{a)}	BS EN728 or BS EN ISO 11357-6:2013
		No. of test pieces ^{b)}	3	
Melt mass-flow rate (MFR)	After processing maximum deviation of $\pm 20\%$ of the value measured on the batch used to manufacture the pipe	Loading mass	5 kg	BS EN ISO 1133
		Test temperature	190 °C	
		Time	10 min	
		No. of test pieces ^{b)}	Shall conform to BS EN ISO 1133	
^{a)} Test may be carried out at 210 °C providing that there is a clear correlation with the results at 200 °C. In case of dispute the reference temperature shall be 200 °C. ^{b)} The numbers of test pieces given indicate the numbers required to establish a value for the property specified in the table.				

A.3 Batch release tests (BRT)

Checks shall be carried out in accordance with Table **A.4**.

Note: for Low Volume Products (<250 pieces per annum) Refer to Annex **E**

Initially for a period of no less than 6 months, the checks given in Table A.4.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.4**.Part 2 shall be operated by formal agreement with the gas transporter and / or BSI.

Note: Table **A.4**. Part 1 shall also be operated following a change of raw material compound or a fundamental change to the fitting outside the scope of Annex **E**.

Table A.4. Part 1 — Batch release test requirements (class B and C fittings) ^{a)}

Properties	References	Minimum sampling frequency	No./type of samples	No. of measurements per sample
Appearance	6	Every 4h ^{b)}	1	1
Dimensions: Spigot outlet	9.1, 9.2 Table 4	Every 2h ^{b), c)}	1	1
Overall & end squareness	9.2, 9.3 Table 6 & 5	Once/week ^{b), c)}	1	1
Oxidation induction time, OIT (Thermal stability)	Table A.4	Once/week	1	1
MFR	Table A.4	Once/week	1	1
Circumferential spigot/pipe end reversion (≥ 180 mm)	13.5	Once/week	1	1
80°C hydrostatic strength 165 h (stress crack resistance)	13.4.2	Once/week	1	1
Factory fused butt joints (Defects and alignment)	9.3	All fittings	1	1
Tensile test of butt weld	9.3	Once/year	1	1
Marking and labels	Clause 15	Once/batch	1	1
<p>^{a)} The number of test pieces given in the table shall be the minimum. All test pieces shall pass the relevant test(s).</p> <p>^{b)} Or every 25th component, whichever is least frequent</p> <p>^{c)} All specified dimensions of moulded fittings shall be checked on the first samples from each cavity. Thereafter, critical dimensions shall be checked to ensure compliance with this standard.</p>				

Table A.4. Part 2 — Batch release test requirements (class B and C fittings)
Size Groups 16mm to 63mm, 75mm to 225mm, 250mm to 800mm (BS EN1555)

The authorisation to operate BRT tests as per Table A.4. 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.

Properties	References	Minimum sampling frequency	Reduced Frequency / No of Test Pieces	No. of measurements per sample
Appearance	6	In Process check (minimum of 1 fitting every 4h)	1	1
Dimensions: outlet	9.1, 9.2 Table 4	In Process check (minimum of 1 fitting every 4h)	1	1
overall/squareness	9.2, 9.3 Tables 4 and 5	Once/week	1	1
Oxidation induction time, OIT (Thermal stability)	Table A.4	1 fitting per size group per week (if manufactured) ^{a)}	1	1
MFR	Table A.4	1 fitting per size group per week (if manufactured) ^{a)}	1	1
Circumferential spigot/pipe end reversion (≥180 mm)	13.5 ^{b)}	1 fitting per size group per week (if manufactured) ^{a)}	1	1
80°C hydrostatic strength 165 h (stress crack resistance)	13.4.2	1 fitting per size group per week (if manufactured) ^{a)}	1	1
Factory fused butt joints (Defects and alignment)	9.3	All fittings	1	1
Tensile test of butt weld	9.3	Once/year	1	1
Marking and labels	Clause 15	Once/batch	1	1
^{a)} The contractor shall rotate fittings to be tested within each size group. ^{b)} Fittings purchased from a known subcontractor, already tested in accordance with the requirements of BS EN 1555-7 Table 8 are compliant with the above requirements and hence are exempt from the above requirements, with the exception of Clause 13.5. It is proposed to conduct QA checking to confirm acceptability.				

Annex B (normative)

Fittings fabricated by the mitred butt jointing of pipe

B.1 Introduction

This Annex specifies additional requirements for class B polyethylene pipe fittings that are fabricated by the mitred butt jointing of pipe. Unlike moulded fittings, which can be designed to have curved sections and thickened walls to alleviate stress concentrations, fabricated fittings consist of angled joints with uniform thickness of pipe wall.

Fittings fabricated by this technique shall be limited to a **maximum operating pressure of 2 bar**.

NOTE It is essential that such products be manufactured to high standards of quality control, since the fusion welded joints carry not only the wall stresses of the main pipe but also the additional stresses dictated by the geometry of the fitting.

B.2 Materials selection

The pipe from which fittings are to be manufactured shall be approved to GIS/PL2-2 and shall, on a batch as well as type basis, have met the resistance to slow crack growth (notch pipe) test (GIS/PL2-2, Clauses **12** and **13**).

NOTE The improvements in polyethylene pipe material properties and the improvements in fusion jointing techniques have, however, led to confidence that fittings fabricated by these means can now be safely utilized in the gas industry, provided high standards are maintained in factory production.

Pipe for the production of fittings shall be stored in clean conditions and racked so that distortion from external loading is minimized. The pipe ovality shall not exceed 0.025 times the minimum specified outside diameter ($d_{em, min}$), for use for the production of fabricated fittings.

B.3 Jointing equipment

Fixed base factory jointing machines shall conform to GIS/PL2-3 but with the following additional requirements.

- a) Fusion parameters of hydraulic pressure, temperature, clamp displacement and time shall be controlled and monitored automatically with provision for recording and printing out all such data.
- b) There shall be provision for highly accurate cutting, trimming, and clamping of pipe ends, to maintain angular alignments within 0.5° , joint offsets to less than 10 % of wall thickness, and joint interface gaps to less than 0.25 mm, prior to the start of fusion jointing.
- c) The jointing equipment shall be sited in a clean, dust free environment, away from open doors and windows. The environment shall provide a reasonably steady ambient temperature without cold air draughts, i.e. between 8°C and 30°C .
- d) The hotplate shall be kept in a good, clean, scratch free condition and shall be regularly inspected, i.e. at least once per week.

B.4 Fusion jointing procedures

Fusion jointing procedures and parameters shall be documented by the manufacturer.

NOTE They should be based on established butt fusion procedures for equivalent size pipes but variations are permitted where justified.

B.5 Fitting design

No more than three fusion welded mitred joints shall be allowed in a fitting. Fusion welded joints shall only be made using flat, parallel sided hotplates.

B.6 Inspection

External and internal weld beads shall be inspected for uniformity and repeatability of appearance. Bead size shall be established and controlled within an optimum tolerance of ± 2 mm.

B.7 Approval testing

B.0.1 Type approval

Type approval shall be granted on the relevant requirements of this standard with the additional requirement that the stress crack resistance tests shall be conducted with an offset joint of 10 % of pipe wall thickness. The position of the offset shall be in an area of maximum stress concentration, when the fitting is subjected to internal pressure.

Minimum Samples for Type Approval Testing – Hydrostatic & Tensile

In all cases, test 3 off, 90° angled mitred elbows, representing the largest diameter in the size group, with the thickest wall, in the manufacturers range, and 3 off 90° angled mitred elbows representing the smallest diameter in the size group, with the thinnest wall, in the manufacturers range.

Note The gas transporter may also require an intermediate size to be tested.

The Tensile Test for assessing butt weld capability as defined in **BS ISO 13953**. The part of the joint to be tested shall be subject to agreement with the gas transporter.

B.7.2 Batch approval

The frequency for destructively testing samples of production shall be subject to agreement with the gas transporter. Two samples (normally the first and last of a batch) shall be required, one for tensile testing on the fusion welded joints and the other for hydrostatic pressure testing at 80 °C.

Annex C (normative)**Preparation of test assemblies (electrofusion)****C.1 Assembly components**

Fittings selected for test shall have spigot end dimensions in accordance with Tables 4&6. Pipe shall be in accordance with GIS/PL2-2 (class B) or GIS/PL2-8 (class C), and electrofusion couplers shall conform to GIS/PL2-4. An electrofusion control box in accordance with GIS/ECE/1 with a means of adjusting the output voltage shall be available.

C.2 Specimen assembly**C.2.1 Type testing**

Prior to fusion, pipes, electrofusion couplers and spigot fittings shall be conditioned in an environment maintained at a temperature of either $-5\text{ }^{\circ}\text{C}$ or $23\text{ }^{\circ}\text{C}$, as appropriate, for at least 1 h. Subsequent assembly and start of fusion jointing at normal laboratory temperature shall be undertaken within 2 min of removal from the conditioning environment.

The voltage from the control box shall be adjusted to give either 39 V or 40 V as specified in Table A.1. The voltage shall be measured using a true rms voltmeter with an accuracy of at least 0.1 % and a 10 mV resolution in the 0 V to 100 V range. The voltage shall remain constant within 0.1 V during fusion.

The electrofusion couplers shall be fused for the time stated on the fitting and allowed to cool for the time indicated before handling.

Where assemblies contain more than one fitting connected by pipe, the free length of pipe between fittings of any type shall be as defined in BS EN ISO 1167 Clause 4.6.1.

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

C.2.2 Batch release testing

The open ends of the spigot fittings shall be closed with pressure-tight, end-load bearing end caps or plugs, which shall be provided with connections for the entry of water and release of air.

NOTE Batch release test assemblies may be constructed without the use of electrofusion couplers.

Annex D (normative)
Batch acceptance

Table D.1 — Double sampling plans

Sample size code ^{a)}	Sample sizes			Action to be taken on number of rejects				
	First	Second	Total	First sample			Total of both samples	
				Accept batch	Reject batch ^{b)}	Take second sample	Accept batch	Reject batch ^{b)}
A	1	3	4	0	—	1	1	2
B	2	3	5	0	2	1	1	2
C	3	3	6	0	2	1	1	2
D	5	5	10	0	3	1 or 2	3	4
E	8	8	16	1	4	2 or 3	4	5
F	13	13	26	1 or 2	5	3 or 4	6	7

^{a)} See Table D.2.
^{b)} There shall be no failures for 80 °C hydrostatic strength test (stress crack resistance).

Table D.2 — Sample size code letter

Batch size	Dimensional tests	20 °C Short-term hydrostatic test	80 °C hydrostatic strength test (stress crack resistance test)	Oxidation induction time (OIT) (thermal stability test)	MFR test	Circumferential reversion test
Less than 150	C	B	B	A	A	A
150 to 500	D	C	C	A	A	A
501 to 2 500	E	D	D	B	B	B
2 501 to 10 000	F	E	E	C	C	C

Table D.3 — Sub-batch sampling plans

Sub-batch size	Sample size	Action to be taken on number of rejects	
		Accept batch	Reject batch ^{a)}
Less than 500	5	0	1
500 and over	15	1	2

^{a)} There shall be no failures for 80 °C hydrostatic strength test (stress crack resistance).

Annex E (normative)**Type tests – Changes to approved fittings or pupped assemblies or tooling & Low Volume products****Change No.1 – New product from existing tooling/cavities by “thickening” the fitting.**

The tests that shall be performed are: -

Mechanical properties	References	No. of test pieces ^{a)}	No. of measurements per test piece
80°C Hydrostatic strength (stress crack resistance)	13.4.1	3: butt fusion ^{c)} A, C: electrofusion ^{d)}	1
Tensile strength (factory butt fused joints) ^{b), c)}	9.3	2	In accordance with BS ISO 13953
Circumferential reversion Spigot ends and pupped pipe ends (≥180 mm)	13.5	2	1

a) The number of test pieces given in the table shall be the minimum.

b) Fittings fabricated by mitre butt jointing shall be in accordance with Clause **10** and Annex **B**.

c) Test for spigot end fittings with factory butt-fused pipe pups.

d) The fitness for purpose tests for integral spigot ends fittings. Electrofusion conditions (A, C) are specified in Clause **A.1** and Table **A.1**.

Change No.2 – Changes to dimensions of the PE body (approved fittings)

Wall thickness is not reduced or increased by more than 5%.

The tests that shall be performed are:-

Mechanical properties	References	No. of test pieces ^{a)}	No. of measurements per test piece
80°C Hydrostatic strength (stress crack resistance)	13.4.1	3: butt fusion ^{c)} A, C: electrofusion ^{d)}	1
Tensile strength (factory butt fused joints) ^{b), c)}	9.3	2	In accordance with BS ISO 13953
Circumferential reversion Spigot ends and pupped pipe ends (≥180 mm)	13.5	2	1

a) The number of test pieces given in the table shall be the minimum.

b) Fittings fabricated by mitre butt jointing shall be in accordance with Clause **10** and Annex **B**.

c) Test for spigot end fittings with factory butt-fused pipe pups.

d) The fitness for purpose tests for integral spigot ends fittings. Electrofusion conditions (A, C) are specified in Clause **A.1** and Table **A.1**.

Low Sales Volume requirement – Spigot Fittings or Pupped Assemblies (< 250 pieces per annum)

The tests that shall be performed are: -

Mechanical properties	References	No. of test pieces ^{a)}	No. of measurements per test piece
80°C Hydrostatic strength (stress crack resistance)	13.4.1	2: A, C: electrofusion ^{d)}	1
Tensile strength (factory butt fused joints) ^{b), c)}	9.3	2	In accordance with BS ISO 13953

a) The number of test pieces given in the table shall be the minimum.

b) Fittings fabricated by mitre butt jointing shall be in accordance with Clause **10** and Annex **B**.

c) Test for spigot end fittings with factory butt-fused pipe pups.

d) The fitness for purpose tests for integral spigot ends fittings. Electrofusion conditions (A, C) are specified in Clause **A.1** and Table **A.1**.

Annex F (normative) PE100 Orange / Black Formed Bends (Class C)

F.1 Introduction

This Annex specifies the test requirements for Class C, PE100, Orange Formed Bends, manufactured from PE100 Orange Pipe **produced from virgin compound** having “third party” approval to the requirements of GIS/PL2-8.

Alternatively Black PE100 Formed Bends, manufactured from Black PE100 Pipe **produced from virgin compound** having “third party” approval to the requirements of BS EN1555-2, may be offered for consideration by the gas transporter.

PE100 Orange or Black Formed Bends are typically available in the size range 250mm to 500mm SDR11, in the standard angles 11.25°, 22.5°, 45°, and 90°. Formed Bends are typically jointed in the field by electro-fusion. If required Formed Bends can be offered with factory butt fused pups.

F.2 Dimensional Requirements (Wall Thickness)

Mark out and number the formed bend into a minimum of 10 equal segments. Take a photograph of the bend at this point. Section the bend into segments using an appropriate saw. Measure and record the wall thickness of each segment, paying particular attention to the area which forms the back of the bend, to ensure that no single value for wall thickness has fallen below the limits defined for each pipe diameter in GIS/PL2-8.

Note: the wall thickness of a spigot end fitting body shall have a wall thickness equal to or greater than the nominal wall thickness of the pipe.

F.3 Dimensional Requirements (Outside Diameter / Ovality / Parallel Length / Angle Tolerance)

The outside diameter and ovality values for the parallel portion of the bends to be jointed (fusion end), either via butt fusion or electro-fusion, shall conform to the values shown in Table 4 in GIS/PL2-6.

The minimum length of the parallel section on formed bends are given in Table F.1:

Table F.1 — Minimum length of the parallel section on formed bends

Size range	Minimum parallel length	Angle tolerance (all cases)
110mm to 225mm	150mm	+/-2% a)
250mm to 315mm	250mm	
355mm to 450mm	300mm	
500mm to 630mm	350mm	
a) Bend angle will remain within this tolerance for 6 months from date of manufacture.		

F.4 Assessment of Conformity

Type Testing of what is a Low Sales Volume product range differs to that shown currently in Annex E in GIS/PL2-6, on the basis that the Formed Bend manufacturing process generates fittings which have known “high & low” wall thickness values versus specified limits.

The Type Test requirements shown in Table F.2 shall be performed on SDR11, 90° angled Formed Bends representing the smallest diameter, thinnest wall & largest diameter, thickest wall in the manufacturer’s product range.

NOTE: The gas transporter may also require an intermediate size to be tested

F.5 Type Test Requirements (No of Test Pieces shown is per diameter)

Table F.2—Type Test Requirements (No of Test Pieces shown is per diameter)

Properties	Properties	References	No. of test pieces	No. of measurements per test piece
Butt Fusion & Electro-fusion (that portion of the Formed Bend to be jointed)	Outside Diameter	9.1, 9.3, Table 3	2	1
	Wall Thickness	9.1 Table 5	1	1
	Ovality	9.3 Table 3	1	1
	Out of Square Ends	9.3 Table 4	1	1
	Parallel Length	(BS EN ISO 3126)		
	Angle Tolerance	F3 F3	1 1	1 1
Formed Bend Sectioning Cut into Segments	Measure & record Min & Max Wall Thickness values	Section 2 in this Annex (BS EN ISO 3126)	1	Minimum of 10
Mechanical	20°C Long term hydrostatic strength 5000hrs	13.3 (ISO1167-1)	2 : Electro-fusion Conditions A & C	1
Mechanical	80°C Hydrostatic Strength (stress crack resistance) 1000hrs	13.4.1 (ISO1167-1)	1 Bend (90°) Electro-fusion Condition A (-5°) Min Power	1
Mechanical	Circumferential Reversion	13.5 (ISO1167-1)	1	1
<u>Physical</u>	O.I.T	BS EN 728 or BS EN ISO 11357-6	1	3 Outer / Mid / Inner

F.6 Batch Test Requirements

The “BRT” tests to be performed on PE100 Formed Bends are shown in Table F.3.

Clause 3.2.4 in GIS/PL2-6 defines a “batch”, however, as PE100 Formed Bends are typically ordered in quantities of <10pieces, a Customer Order for Bends “irrespective of angle” constitutes the batch in this instance. If the Customer Order is made up of varied angles, then the 90° angle will be tested in all cases.

Table F.3—Batch Test Requirements (No of Test Pieces shown is per diameter)

Properties	References	Minimum Sampling Frequency	No. of test pieces	No. of measurements per test piece
Appearance	6	1 Bend Per Angle Per Customer Order (Batch)	1	1
Dimensions (that portion of the bend to be jointed) Outside Diameter Wall Thickness & Ovality Parallel Length Angle Tolerance	9.1 / 9.2 / 9.3 Tables 3 & 5 (BS EN ISO 3126)	Outside Diameter - Every Bend (Key Measurement) Wall thickness & Ovality 1 Bend Per Angle Per Customer Order (Batch)	1	1
80°C Hydrostatic Strength for 165hrs (Stress Crack Resistance)	13.4.2 (ISO1167-1)	1 Bend (90°)a if ordered per Customer Order (Batch)	1	1
Formed Bend Sectioning Cut into Segments	Measure & record Min & Max Wall Thickness values	1 Bend (90°) Section 2 in this Annex (BS EN ISO 3126)	1	Minimum of 10
<u>Physical</u>	O.I.T	BS EN 728 or BS EN ISO 11357-6	1	3 Outer / Mid / Inner
a) If the Customer order does not contain a 90° angled bend, test next highest angle e.g. 45°				

Annex G

Type Testing following modifications to approved fittings & Low Volume products (<250 pcs/annum) in the diameter range 630mm to 800mm

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 according to Annex E of GIS PL2 Part 6 is often greater than the number of fittings sold. The reduced type testing detailed in Annex G may therefore be adopted for fittings in this size range. (In this size range fittings with integral spigots are not available so spigots are provided by pupped pipe).

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

Mechanical properties	References	No. of test pieces ^{a)}	No. of measurements per test piece
Fittings manufactured in compliance with GIS PL2 Part 6 or BS EN1555 Part 3 that have been extended with pupped pipe which is fully compliant with GIS PL2 Part 2 or Part 8. (Includes pupped flanges, reducers, end caps, and branch saddles).			
20°C long term Hydrostatic strength (100h or 5000h)	13.3 (Table 7)	1	1
80°C Hydrostatic strength (stress crack resistance, 165h batch release test)	13.4.1 (Table 8)	1	1
Tensile strength (factory butt fused joints) ^{b), c), d)}	9.3	1	In accordance with BS ISO 13953
Circumferential reversion Spigot ends and pupped pipe ends	13.5	2	1
Fittings manufactured by mitred butt fusion welding from pipe which is fully compliant with GIS PL2 Part 2 or Part 8. Includes mitred bends of 11.25°, 22.5°, 45° and 90°.			
80°C Hydrostatic strength (stress crack resistance) (90° bend with central 10% offset 165h Batch release test)	B.7.1 (Table 8)	1	1
Tensile test (factory butt fused joints) ^{b), c), d)}	B.7.1	1	In accordance with BS ISO 13953
Circumferential reversion Spigot ends and pupped pipe ends	13.5	2	1
Short radius formed bends produced from pipe which is fully compliant with GIS PL2 Part 8.			
80°C Hydrostatic strength (stress crack resistance 165h Batch release test)	13.4.1 (Table 8)	1	1
20°C long term Hydrostatic strength (100h or 5000h)	13.3 (Table 7)	1	1
Circumferential reversion Spigot ends and pupped pipe ends	13.5	2	1

- a) The number of test pieces given in the table shall be the minimum.
- b) Fittings fabricated by mitre butt jointing shall be in accordance with Clause **10** and Annex **B**.
- c) Test for spigot end fittings with factory butt-fused pipe pups.
- d) The tensile weld strength test may be performed on specimens cut from the 20°C long term hydrostatic test sample after pressure testing. If specimens prepared in this way fail to meet the tensile test requirements then the test shall be repeated using a new fitting assembly.

Annex H (normative) *Additional* Testing Requirements for Corrugated Fittings

H.1 Introduction

This Annex specifies the *additional* test requirements for corrugated fittings. They are lengths of flexible corrugated pipe with the ends terminating in spigots or pipe pups. They are designed to connect pipes or fittings together when they are significantly misaligned, which involves bending the corrugated fitting.

The outside diameter of the corrugated section is greater than the spigot size/pipe pup. The wall thickness of the corrugations is generally thinner than the spigot ends.

The fittings are sized by the diameter of the spigot.

They are Class B fittings, SDR26 rating and for Low Pressure operation (a maximum operating pressure of 75 mbar).

They are designed for electrofusion jointing to GIS/PL2-4 or by butt fusion in the larger sizes of 90mm and above, when the fitting terminates with pipe pups.

H.2 Dimensions

The design, shape, dimensions and tolerances of the corrugations and the spigot ends shall be specified by the manufacturer and inspection shall be part of the manufacturer's quality control. These dimensions shall be made available to the user.

H.3 Long-term hydrostatic strength test at 20°C

Test according to clause **13.3** using an SDR26 rating to calculate the test pressure.

H.4 Long-term hydrostatic strength test at 80°C

Test according to clause **13.4** using an SDR26 rating to select the test pressures from **Table 8**.

H.5 Pressure loss (16mm to 180mm)

The gaseous flow/ pressure drop relationship shall be determined through the straight fitting.

The gaseous flow/ pressure drop relationship shall also be determined when the corrugated fitting is assembled with pipes of a typical service configuration i.e. in a S-bend configuration, **Figure 1**.

Test method as detailed in **section 12**.

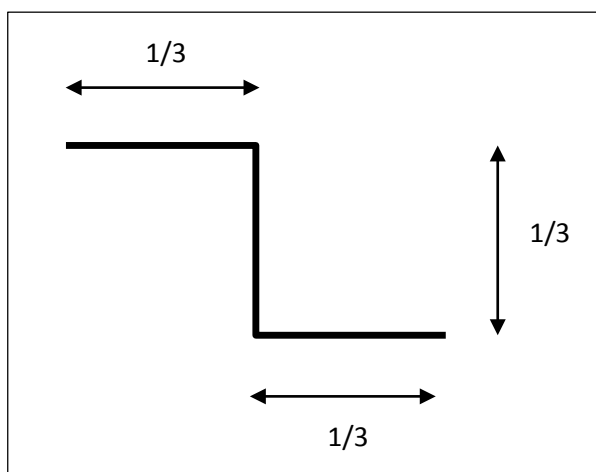


Figure 1 Schematic of the typical service “S-shaped” configuration of the corrugated fitting.
Each leg is 1/3 of the total fitting length

H.6 Resistance to external blows at -20°C (up to and including 90mm)

H.6.1 Principle

The corrugations naturally form grooves and notches, which if too sharp or the material too thin may break under impact loading in service.

The test pieces shall be tested at -20°C in accordance with BS EN 1411.

A striker of a defined mass is dropped from variable heights, using the staircase method, to determine the H_{50} value – the drop height that produces failure of 50% of the test samples.

H.6.2 Samples

Fitting samples shall be selected each from the largest and smallest and one intermediate size in the manufacturer’s range up to 90mm. Test pieces are cut to a length of (200 ± 10) mm from the fittings samples. More than one test piece may be cut from each fitting.

Typically, the number of test pieces required of each size would be about 20; excluding about 10 test pieces necessary for the preliminary test procedure.

H.6.3 Procedure

Samples shall be conditioned at -20°C for the times in **Table H.1** depending on wall thickness of the spigot.

Table H.1 Minimum conditioning times in air

Minimum wall thickness of spigot mm	Minimum conditioning time in air at -20°C, 0°C or +30°C h
≤ 12	6
>12 and ≤ 25	10
>25 and < 60	24
≥ 60	48

The test shall be carried out using the apparatus and procedures in accordance with BS EN 1411.

The initial test weight shall be 10kg.

The hemispherical nose of the striker shall be Type d90.

The samples shall be struck along the seam line, if present, otherwise use random orientation.

H.6.4 Interpretation of results

Calculate the H₅₀ value using the guidelines in BS EN 1411.

The minimum H₅₀ value shall be 1.5m

H.7 Bend test

H.7.1 Principle

The corrugated fittings are designed to be bent to tight radii. It is up to the manufacturer to specify the minimum bend radius of each size of corrugated fitting at 0°C.

Pressure tests will be conducted at 80°C, whilst the sample is held at the minimum radius specified by the manufacturer, to ensure the fittings are not damaged.

H.7.2 Samples

Two corrugated samples shall be selected each from the largest and smallest and one intermediate size in the manufacturer's range. A total of 6 samples.

H.7.3 Procedure

Note the minimum bend radius specified by the manufacturer for each size. Create round bars of a diameter that are equivalent to the minimum bend radii.

Condition the corrugated samples at 0°C according to **Table H.1**.

Bend, then reverse bend, the corrugated fitting around the appropriate size of round bar for a total of 10 times at 0°C.

Bend the samples around the appropriate size of round bar and attach them to a framework held under water in the 80°C test tank. The minimum bend radii are to be maintained during the test.

The SDR26 fitting samples are then pressurised according to **13.4.1** using the appropriate pressures in **Table 8** for 1000h.

H.7.4 Requirement

The samples shall not burst or crack during the test period.

H.8. Type testing & Batch release Testing

The collated tests requirements for corrugated fittings are given in **Annex I**.

Annex I Annex H (normative) Collated Type Testing and Batch Release Testing Requirements

(these are based upon the requirements in **Annex A** for fittings with spigots)

I.1 General (integral spigot end fittings for electrofusion only)

Class B integral spigot end fittings shall be jointed to an electrofusion coupler under the conditions specified in **Table I.1** to simulate the range of field conditions.

NOTE These requirements do not apply to pipped pipe fittings.

Test pieces for type testing to 13.3 and 13.4.1, shall be assembled and fused in accordance with the manufacturer's procedure and under the conditions specified in **Table I.1**.

For batch release and batch release testing, fusion joints shall be constructed with the pipes and fittings at ambient temperature using a butt welder that conforms to GIS/PL2-3, or an electrofusion control box that conforms to GIS/ECE1.

Table I.1 — Assembly conditions for electrofusion assemblies

Condition	Temperature before fusion °C		Applied voltage V
	Coupler	Spigot end fitting	
A	-5	-5	39
B	23	-5	40
C	23	23	40

Note: Results arising from tests conducted at conditions, which are equivalent or more extreme than those shown in **Table I.1** above, such as -10°C and or +45°C in the case of temperature, shall be considered acceptable under this GIS standard.

I.2 Type testing – Mechanical properties

Table I.2 – Mechanical properties of spigot end fittings that require type testing (TT)

Properties		References	No. of test pieces ^{a)}	No. of measurements per test piece
Appearance		6	1	1
Colour: Class B		5.3	1	1
Integral Spigot End Fittings for electrofusion only	d_{em} , e , min spigot length	9.1/9.2, Table 4 Figure 1	3	1
	Out-of-square ends	9.1/9.2, Table 5	2	1
	General dimensions	9.1/9.2, Figure 1 Table 6	3	1
Spigot end fitting assemblies for Butt fusion and electrofusion fittings	d_{em} , e	9.1/9.2, Table 6	2	1 + 1
	Ovality	9.3, Table 4	2	1
	Out-of-square ends	9.3, Table 5	3	1
	Factory fused butt joints Defects, alignment ^{c)}	9.3	2	1
Mechanical properties	Tensile strength (factory butt joints) ^{c)}	9.3	2	In accordance with BS ISO 13953
	20°C Long-term hydrostatic strength	13.3	3: butt fusion ^{c)} A, B, C: electrofusion ^{d)}	In accordance with BS EN ISO 1167
	80°C Hydrostatic strength (stress crack resistance) 1000 h	13.4.1	3: butt fusion ^{c)} A, B, C: electrofusion ^{d)}	1
	Circumferential reversion Spigot ends and pupped pipe ends (≥180 mm)	13.5	2	1
	Pressure loss (≤180 mm)	12 H.5	2	1
	Resistance to external blows at -20°C	H.6	20 + 10	1
	Bend test	H.7	2	1

^{a)} The number of test pieces given in the table shall be the minimum.

^{c)} Test for spigot end fittings with factory butt-fused pipe pups.

^{d)} The fitness for purpose tests for integral spigot ends fittings. Electrofusion conditions (A, B & C) are specified in Clause A.1 and Table A.1.

I.3 Type testing – Physical properties

As per **Table A.3**

I.4 Batch release tests (BRT)

Checks shall be carried out in accordance with **Table I.4**.

Note: for Low Volume Products (<250 pieces per annum) Refer to **Appendix E**

Initially for a period of no less than 6 months, the checks given in **Table I.4 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 I.4 Part 2** shall be operated by formal agreement with the gas transporter and / or BSI.

Note: **Table A.4 Part 1** shall also be operated following a change of raw material compound or a fundamental change to the fitting outside the scope of **Appendix E**.

Table I.4 Part 1 – Batch release test requirements (class B) ^{a)}

Properties	References	Minimum sampling frequency	No./type of samples	No. of measurements per sample
Appearance	6	Every 4h ^{b)}	1	1
Dimensions: Spigot outlet	9.1, 9.2 Table 4	Every 2h ^{b), c)}	1	1
Overall & end squareness	9.2, 9.3 Table 6 & 5	Once/week ^{b), c)}	1	1
Oxidation induction time, OIT (Thermal stability)	Table A.4	Once/week	1	1
MFR	Table A.4	Once/week	1	1
Circumferential spigot/pipe end reversion (≥180 mm)	13.5	Once/week	1	1
80°C hydrostatic strength 165 h (stress crack resistance)	13.4.2 Table 8	Once/week	1	1
Factory fused butt joints (Defects and alignment)	9.3	All fittings	1	1
Tensile test of butt weld	9.3	Once/year	1	1
Marking and labels	Clause 15	Once/batch	1	1
<p>^{a)} The number of test pieces given in the table shall be the minimum. All test pieces shall pass the relevant test(s).</p> <p>^{b)} Or every 25th component, whichever is least frequent</p> <p>^{c)} All specified dimensions of moulded fittings shall be checked on the first samples from each cavity. Thereafter, critical dimensions shall be checked to ensure compliance with this standard.</p>				

Table A.4. Part 2 — Batch release test requirements (class B)**Size Groups 16mm to 63mm, 75mm to 225mm, 250mm to 800mm (BS EN1555)**

The authorisation to operate BRT tests as per Table A.4. 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.

Properties	References	Minimum sampling frequency	Reduced Frequency / No of Test Pieces	No. of measurements per sample
Appearance	6	In Process check (minimum of 1 fitting every 4h)	1	1
Dimensions: outlet	9.1, 9.2 Table 4	In Process check (minimum of 1 fitting every 4h)	1	1
overall/squareness	9.2, 9.3 Tables 6 and 5	Once/week	1	1
Oxidation induction time, OIT (Thermal stability)	Table A.4	1 fitting per size group per week (if manufactured) ^{a)}	1	1
MFR	Table A.4	1 fitting per size group per week (if manufactured) ^{a)}	1	1
Circumferential spigot/pipe end reversion (≥180 mm)	13.5 ^{b)}	1 fitting per size group per week (if manufactured) ^{a)}	1	1
80°C hydrostatic strength 165 h (stress crack resistance)	13.4.2	1 fitting per size group per week (if manufactured) ^{a)}	1	1
Factory fused butt joints (Defects and alignment)	9.3	All fittings	1	1
Tensile test of butt weld	9.3	Once/year	1	1
Marking and labels	Clause 15	Once/batch	1	1
^{a)} The contractor shall rotate fittings to be tested within each size group. ^{b)} Fittings purchased from a known subcontractor, already tested in accordance with the requirements of BS EN 1555-7 Table 8 are compliant with the above requirements and hence are exempt from the above requirements, with the exception of Clause 13.5. It is proposed to conduct QA checking to confirm acceptability.				

Annex J Summary of and Rationale for changes to document – March 2009

GIS/PL2-6 Clause	Comment & Rationale	Proposer	Action required (if applicable)
3.1.8	Ovality is also known as out-of-roundness	N. Taylor	Not Accepted.
3.1.17	SDR is not always a round number. Delete "round".	N. Taylor	Not accepted.
3.2.1	Powder is not used in the UK	T. Peach	Delete "powder". Replace with "pellets"
3.2.4	Batch needs defining in more detail.	T. Peach	Adopt wording in GIS/PL2-4 clause 3.2.4 which is more specific in terms of duration i.e. not exceed 170hrs machine time or 10,000 components, whichever is the lesser.
3.2.9	Missing definition of batch release test	T. Peach	Added definition of batch release test
3.2.10	Missing definition of process verification test	T. Peach	Added definition of process verification test
3.2.11	Missing definition of type test	T. Peach	Added definition of type test
3.3.3	Value of C should be stated to align with other Parts	M. Greig	Delete "greater than 1". Replace with "of 2.9" to align with PL2-4
3.5	This section covers types of fittings rather than joints	N. Taylor	Delete "Joints". Replace with "Fitting types"
3.7	Add TT, BRT, and PVT to abbreviations	T. Peach	Consistent with GIS Parts 1,2, and 8.
4.2	Align wording with Part 4	N. Taylor	Add "and shall be classified as PE80 or PE100"
4.2	Align wording with other Parts	N. Taylor	After " provided it is under their supervision" and before "Fittings produced", insert "Rework material shall not be blended with unprocessed compound and shall be used on its own".
4.2	Align wording with Part 4	N. Taylor	Add another paragraph at end of clause. " 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 tests shall be established".
5.1	Align wording with Part 4	N. Taylor	Add another paragraph after first paragraph. " The performance of pipe / fitting assemblies shall be in accordance with Clause 12".
5.1	Align wording with Part 4	N. Taylor	Add "Assessment of conformity shall be carried out in accordance with clause 14".
5.2	Sometimes it is necessary to butt weld black PE100 fittings in order to make	All	Add a NOTE 4 " NOTE 4 It is permissible to butt weld black,

	pupped fittings.		PE100 spigot fittings to either yellow PE80 or to PE100 peelable pipes, under factory conditions. The resulting assembly shall be designated according to the pipe pups used.
5.3 Para 3	Correction	N. Taylor	Delete "s" from "pipes" to leave "pipe"
5.3 Para 3	Add SDR26 peelable pipes	T. Peach	Change "SDR21 only" to "SDR21/26"
5.4	Align colours with Part 4	N. Taylor	Delete "yellow-orange". Replace with "yellow or orange".
5.4	Fittings for Class C applications, irrespective of colour, should have an orange label securely affixed, not just black fittings as stated.	T. Peach	Amend wording to reflect comment.
5.5	There are no universal spigot fittings	N. Taylor	Delete 5.5
Table 1	Nominal pressure limit is MOP	N. Taylor	Change table heading to "maximum operational pressure (MOP) at 20°C"
Table 1	Note b) needs to recognise SDR26 Peelable pipes as well as SDR21.	T. Peach	Add SDR26 Peelable pipes.
Table 1	Use of SDR13.6 pipes is proposed. SDR13.6 should be added to the table.	N. Taylor	Add SDR13.6, Class B with an MOP of 4.3
Table 1	A footnote is needed to specifically allow the use of other SDRs.	N. Taylor	Add a Footnote " NOTE: The use of any SDR derived from the pipe series S given in ISO 4065:1969 is permitted."
Table 2	Align temperatures with Part 4 by adding tolerances	N. Taylor	Column headings to be : "In air at 23°C(±2°C)", "In liquid at 20°C (±1°C)", "In liquid at 80°C (±2°C), "In liquid at 80°C (±2°C)b)"
8 Last Para	Align with Part 4	N. Taylor	Add "Tests, other than those involving liquid immersion or otherwise specified, shall be conducted at a laboratory temperature of 23 °C ± 2 °C.
9.1	Measuring standard is BS EN ISO 3126	N. Taylor	Add "BS"
9.1 & 9.3 & Figure 1	Angles and tolerances were deleted from Part 4 and Part 6 should be aligned	N. Taylor	Delete all references to angles
9.1	The previous version used "should" instead of "shall". Reverting to the former wording will create greater flexibility of supply.	N. Taylor	Delete "shall". Replace with "should"
Figure 1	This Figure is far from clear. Sizes only go up to 180mm, but should go much larger. The Table in part a) refers to clause 5.5.2 which does not exist. Note B is in part a) and Note A is in part b). It is not clear what sort of fittings are designed for "clamping either side of an electrofusion coupler. For example a	N. Taylor	Delete Figure 1. Replace with new Table 3 and new Figure 1. Renumber all succeeding Tables.

	<p>90° elbow could be clamped either side of a couple in order to create a dogleg. In this case should the spigot length be the longer dimension given in part b)?</p> <p>It would be better to present the information in a Table.</p> <p>It would be preferable to align the minimum spigot length requirements with EN 1555. This leaves manufacturers free to supply longer spigots, if desired.</p>		
Table 3	Add sizes as appropriate up to 630mm and align with EN 1555-3. Correct errors in ovality for sizes 280 mm and above.	M. Greig	Agreed.
9.3 Final Para	The tensile test applies to size 90mm and above	N. Taylor	Add " in sizes 90mm and above" between "to spigot ends" and "shall meet the tensile test"
9.3 Final Para	Butt fusion machines in the UK are fully automatic. The likelihood of making extreme butt welds is remote. Recent test work confirms that satisfactory welds can be made under more extreme conditions than ISO 11414, so there is no need to continue to type test against ISO 11414 conditions.	All	After the first sentence insert "The test specimens shall be prepared at normal ambient temperature using fusion conditions recommended by the manufacturer of the spigot fittings and not under the extreme conditions specified in ISO 11414." The text "and not under the extreme conditions specified in ISO 11414" is not necessary
9.3 Final Para	Removal of the weld bead is optional. In final sentence change "shall" to "may"	N. Taylor	Not accepted.
Table 4 (now 5)	The use of SDR13.6 and SDR26 pipes has been suggested. If adopted, matching fittings will be needed.	N. Taylor	Add a new column for SDR 13.6. Add dimensions for SDR26 in sizes up to 630
12.3 Table 3	Align with Part 4 and delete these tests. Short term testing is unnecessary as long term hydrostatic test provide the necessary confidence in long term strength. (The short term hydrostatic testing is applicable to metallic pipes and fittings).	All	Delete 12.3 and Table 3. Renumber following clauses and Tables as necessary.
12.4 (now 12.3)	Replace BS EN 911	N. Taylor	Replace "BS EN 921" with " BS EN ISO 1167"
Table 6	SDR 13.6	N. Taylor	Add new row for SDR13.6
12.4.1 & 12.4.2 & 12.5.1 (new clause numbers)	Replace BS EN 911	N. Taylor	Change "BS EN 921" with " BS EN ISO 1167"
13 & Table 8	Align format with Part 4	N. Taylor	Delete and include in a new Annex
13.8	Long radius bends are never used for class B. Instead mitres are purchased.	T. Peach	New text for Type Testing and

	<p>Long radius bends are rarely used in class C.</p> <p>Given that Orange 7bar PE100 pipe business/orders are “project driven”, the requirement for Orange 7bar Long Radius Bends is very erratic in nature with the quantities ordered typically ranging from as little as 1 bend to a maximum of 15 bends.</p> <p>As a consequence, Orange 7bar Long Radius bends fall well within the limit for Low Volume products shown in Annex E of GIS/PL2-6 (≤ 250pcs per annum).</p> <p>The erratic nature of the orders and the quantities required also renders Batch Release Testing inappropriate hence an AnnualPVT test approach was agreed with British Gas/Transco Quality Assurance back in April 2002.</p>		Process verification tests has been inserted.
13.9 NOTE 2 & Bibliography	The reference to BS 6001-2: 1993 is incorrect	N. Taylor	Change to “BS 6001-1:1999”.
13.9.2	A break in production can be up to one shift long. That is 14 hours. Align with Part 4	T. Peach	Change 8 hours to 14 hours, as has been the case, historically since 1996. (Agreed with BG QA at Hinckley).
14	Change title of clause	N. Taylor	Delete “Type testing”. Replace with “Assessment of Conformity”
14.2 Para 2	Remove mention of universal fittings. The meaning of “qualified” is unclear	N. Taylor	Para 2 to read “Class B and Class C spigot end fittings shall be designated for use in one of more of the following applications:”
14	We need to align with Part 4. Include clauses for type testing – modifications to approved fittings and low volume products, Process verification testing and Range extension. Refer to new 14.3 & 14.4 in draft document	N. Taylor	Agreed
14.3 (now 14.6)	New clause number is 14.6. Wording is not clear What shapes of fittings shall be tested and what tests shall be performed?	N. Taylor	Refer to new text in draft document
14.4 (now 14.8)	New clause number 14.8. Opening sentence should state GIS/PL2-2 (Class B) or GIS/PL2-8 (Class C).	T. Peach	Delete GIS/PL2-8 (class B)
14.4 (now 14.8)	New clause number is 14.8. There is no need to test bends of 15° or less.	N. Taylor	Add a new paragraph. “Long radius bends of 15° angle, or less, shall be considered to be equivalent to straight pipe and shall not need to be tested.”
15 Tables 9 & 10 & 11	Align format with Part 4	N. Taylor	Delete and include in a new Annex
16 & 17	BRT. Renumber as clause 14.9	N. Taylor	Delete “Table 11”. Replace with

	respectively		"A.2/3"
18 &19 (now 15)	Align Marking with Part 4.	N. Taylor	Refer to new text in draft document
20 (now 16)	What is suitable protection?	N. Taylor	Refer to new text in draft document
17 (now 16)	Protection of fittings. Sealed plastic bags suitable for spigot fittings only. Pipped assemblies $\geq 250\text{mm}$ are typically supplied securely strapped to pallets.	T. Peach	Amend wording to recognise packaging for pipped assemblies.
Annex A	Renumbered as Annex B. Refer to new Annex A in draft document	N. Taylor	Agreed
Annex A	Table A.2 Delete electrofusion condition c to align with Table A.1	N. Taylor	Agreed
Annex A	Table A.3. Should there be any requirements for assessing fusion compatibility of new PE materials, as per EN 1555 – 5 clause		Fusion compatibility is a responsibility of the raw material manufacturer. Something that he should declare in his Technical File. Not Accepted
Annex A	Low volume is defined as less the 250 pieces. Is this to large, e.g. for 630 mm fittings	M. Greig	Considered.
Annex B	Renumber as Annex C		Agreed
Annex B (new lettering)	B.6 Inspection. Propose re-arranging second sentence to read "Bead size shall be established and controlled with an optimum tolerance of $\pm 2\text{mm}$."		Some of today's materials "may" push us outside of the $\pm 2\text{mm}$ tolerance, hence optimum gives us some breathing space.
B.7.1	Fittings fabricated by Mitred Butt Jointing of pipe. B.7.1 Type approval. Delete the last paragraph. Suppliers have been producing Mitres for over 15 years, during which various aged assemblies have been tested, with no loss in performance.	T. Peach	Delete the last paragraph
B.7.2	Fittings fabricated by Mitred Butt Jointing of pipe. B.7.2 Batch approval. The proof test should be deleted. Uponor carried out this test for several years, before it was dropped by agreement with British Gas QA. The test generated high numbers of samples based on volume production, creating a permanent queue for the 20°C test bath, and was a costly drain on end caps, for what is a 15minute test. No failures were reported over 2 years of testing.	T. Peach	Delete the last 2 paragraphs.
C.2.1	Change title to Type testing. Delete "Approval testing". Replace with "Type testing".	N. Taylor	Agreed
C.2.2	Change title to Batch release testing. Delete "Process control testing". Replace with "Batch release testing".	N. Taylor	
Annex C	Renumbered as Annex D	N. Taylor	Agreed
Annex E	Add a new Annex E to cover Type tests	N. Taylor	Agreed

	for changes to approved products and for low volume products. Refer to new text in draft document		
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Bibliography

BS 6001-1:1999, *Sampling procedures for inspection by attributes — Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection.*

BS EN ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories.

BS EN ISO 13686:2005, Natural gas — Quality designation.

ISO 3:1973, Preferred numbers — Series of referred numbers.

ISO 497:1993, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers.*