Gas Industry Standard

GIS/PL2-3:2021

Specification for

Polyethylene pipes and fittings for natural gas and suitable manufactured gas

Part 3: Butt fusion machines and ancillary equipment

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Contents

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.

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

Relationship with other publications

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

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

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

Part 3: Butt fusion machines and ancillary equipment.

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

Part 5: Electrofusion ancillary tooling.

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

Part 7: Squeeze-off tools and equipment.

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

Mandatory and non-mandatory requirements

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

can indicates a physical possibility;

may indicates an option that is not mandatory;

shall indicates a GIS requirement;

should indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection.

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Brief history

First published as BGC/PS/PL2: Part 3	June 1987
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Normative references reviewed and updated	July 2015
Reviewed and updated to increase scope to include pipes up to 800 mm in diameter	June 2021

1 Scope

This part of GIS/PL2 applies to equipment for butt jointing polyethylene (PE) pipes, 90 mm to 800 mm inclusive nominal diameter, conforming to GIS/PL2-2 or GIS/PL2-8.

It specifies general requirements for automatic butt fusion machines including specific design features of the chassis and clamps, the interface force transmission, the trimming tool, the heater plate and the application of automatic control. This Gas Industry Standard also gives guidance on ancillary equipment, and specifies testing and acceptance procedures and maintenance schedules to ensure that high quality equipment is available for butt fusion jointing.

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 2559-3, *Specification for screwdrivers — Part 3: Insulated screwdrivers.*

BS 3823, *Grading of ash and hickory wood handles for hand tools.*

BS EN 50525-2-12:2011, *Electric cables — Low voltage energy cables of rated voltages up to and including 450/750V (U0/U). Cables for general applications. Flexible cables with thermoplastic PVC insulation.*

BS EN 12983-1, *Cookware — Domestic cookware for use on top of a stove, cooker or hob — Part 1: General requirements*.

BS EN 60529, *Specification for degrees of protection provided by enclosures (IP code).*

BS EN 60309-2 *Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories.*

BS EN 60745-1, *Hand-held motor-operated electric tools —Safety — Part 1: General requirements.*

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

Gas Industry Standards

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

Gas Distribution Network standards

Gas Distribution Networks' mainlaying procedures.

Other standards

American National Standard, ANSI/(NFPA):

T3.20.15, *Hydraulic fluid power — Quick-action coupling — Flush face type*.

3 Terms and definitions

For the purposes of this standard the following terms and definitions apply.

3.1
fusion contact surface
that part of the tool which heats the pipe or fitting preparatory to forming a fusion joint

3.2
fusion tool
the complete assembly of heating plate and handles required to carry out a fusion operation

3.3
reference point
that point on the tool at which the reference temperature is checked for compliance with the requirements laid out within this standard

NOTE There may be more than one reference point, dependent on the design of the tool.

3.4
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)

3.5
nominal size (DN/OD)
nominal size, related to the outside diameter

3.6
nominal outside diameter, d_n
specified outside diameter, in millimetres, assigned to a nominal size DN/OD

3.7
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

3.8
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

4 General requirements for butt fusion machines

4.1 Machines shall be capable of butt fusing straight or coiled pipe.

Any individual pipe size shall be accommodated by the use of not more than two layers of clamp liners that shall be fully interchangeable within the machine.

4.2 Machines shall be designed to make satisfactory joints in all materials and pipe wall thicknesses conforming to GIS/PL2-2 or GIS/PL2-8 (including pipes at extremes of diameter tolerance) within an operating temperature range of −5 ˚C to 30 ˚C. Machines shall be sufficiently robust to withstand normal field usage without deterioration of performance. Proof of durability shall be required by the gas transporter through satisfactory completion of a period of field usage, followed by re-assessment of the machine for its ability to conform to all the requirements of this standard, see Clause **8**.

4.3 Electrically operated or powered components of machines shall be suitable for use with a nominal −55 V/0 V/+55 V ± 10 % ac power supply which incorporates current overload, earth leakage protection and mid-point earthing. The components shall be either double insulated in accordance with BS EN 60745-1 or be earthed to the mid-point of the power supply. Enclosed electrical equipment shall be protected to conform to the degree of protection specified in IP44 of BS EN 60529.

4.4 Machine performance and electrical safety shall not be degraded if the equipment is used in inclement weather or stored in damp conditions.

4.5 The manufacturer shall supply operating and safety instructions and a maintenance schedule. Essential jointing instructions for each pipe size range, standard dimension ratio (SDR) and material shall be agreed with the gas transporter. The effective operating area of hydraulic pistons, where fitted, shall be given so that the jointing force may be calculated from a pressure indicator.

4.6 The 110 V supply cable must be provided with a plug to BS EN 60309-2.

5 Specific design features for butt fusion machines

5.1 Chassis and clamps

5.1.1 The base framework of the machine shall provide rigidity and stability without unnecessary weight. Hydraulic power cylinders operating the machine shall be fitted as pairs, one each side of the pipe clamps to give a centre line action.

NOTE Bearing surfaces should be of the self-lubricating type, wherever possible.

5.1.2 The machine shall incorporate a facility for supporting the heating plate and facing tool when in use. The support shall not affect transmission of interface forces across the heater plate and shall not prevent the heater plate from self-alignment during the heating operation. The support shall incorporate a mechanism for separating the heater from the pipe faces during retraction.

5.1.3 The pipe clamp/alignment system shall provide the necessary frictional resistance for reacting the jointing forces at −5 ℃ and 30 ℃, and shall have a re-rounding action on the pipe such that ovality at the pipe end shall not exceed 5 % of the pipe wall thickness when measured in accordance with Annex A.

5.1.4 The leading faces of the clamps shall be flat and perpendicular to the clamp centreline and no part of the clamping mechanism shall protrude beyond these faces. The clamp support and bearing system shall maintain axial alignment within 0.2 mm over its entire length of travel when tested in accordance with Annex B (**B.3.1**).

5.1.5 Chassis alignment and rigidity shall be assessed in accordance with Annex B (**B.3.2)** and Figure B.1 for both supported (all sizes) and unsupported pipe (315 mm and below). With supported pipe, misalignment shall not exceed 0.5 mm. For machines designed for 315 mm or below, additional bending of the machine's chassis and clamps shall not cause additional misalignment of greater than 1 mm when the supports are removed.

5.1.6 On fixed clamp machines, no adjustment of the centreline of either pipe shall be required after changing the relevant parts to accommodate different pipe sizes. The design of the pipe clamp shall minimize the effects of wear on the hinges or the locking mechanism. The edges of the segments and liners shall have a suitable radius to avoid damage to the pipe.

5.2 Interface force transmission

5.2.1 A means of indicating the force applied at the pipe interface shall be incorporated and the accuracy shall be within 10 % measured in accordance with Annex C. Where the force is provided by hydraulic power rams, the force may be shown as applied cylinder pressure. In such cases, the pressure gauge shall be calibrated and readable (in bars) to an accuracy of 10 % over the operating range.

5.2.2 The machine shall be capable of maintaining the required interface force throughout each stage of the jointing cycle.

5.2.3 The machine shall be supplied with a motorized pump, which shall operate the machine in accordance with the required procedures in field conditions.

5.2.4 Hydraulic power actuating cylinders shall be capable of maintaining their applied force over the complete length of travel of the pipe clamps. The length of travel shall allow closure of the pipe clamps to within 20 mm of face-to-face contact.

5.2.5 Hydraulic connectors shall be of the quick release type in accordance with ANSI/(NFPA) T3.20.15.

5.3 Trimming tools

5.3.1 It shall be possible to interchange trimming tools between the size and type of butt fusion machine for which they are designed. They shall be suitable for trimming the complete range of pipe sizes for which the machine is designed.

5.3.2 The tool shall have a two-sided operation and have replaceable but not adjustable cutters. The tool shall cut a smooth flat face on each pipe end so that the maximum gap on closing the pipe ends together is not more than 0.25 mm. Facing tools shall ensure that cut material is deflected away from the cut face, the facing tool and the bore of the pipe. The swarf produced shall be visible to the operator, so that completion of trimming can be recognized.

5.3.3 The trimming tool shall operate in a vertical plane, at right angles to the axis of the pipe. It shall be power operated and be provided with suitable guards and cut-outs to prevent operation, except under the control of the operator and in the correct position in the machine.

5.3.4 The trimming tool shall be fitted with non-removable stops to limit the planing of the pipe ends without deterioration of the facing action. These stops shall provide for trimming of the pipe ends up to 15 mm ± 1 mm from the clamp face.

5.4 Hotplates

5.4.1 Hotplates shall be interchangeable between the size and type of butt fusion machine for which they are designed. They shall be suitable for fusion of the complete range of pipe sizes and SDRs for which the machine is designed. They shall be flat on both sides to within 0.1 mm/100 mm and shall not vary in thickness by more than 0.2 mm. Hotplates shall not have holes or set screws within their working area.

5.4.2 Hotplates shall have, at a reference point, a 2.1 mm, +0.04 mm or – 0.00 mm, diameter hole drilled to locate a thermocouple probe. The temperature measured at this reference point shall constitute and define the operating temperature of the hotplate.

5.4.3 Hotplates shall be capable of being heated throughout the butt fusion operation. When tested in accordance with **D.2.5**, the power supplied to the heater shall be such that a stabilized operating temperature can be reached within 20 min, with the hotplate in still air at an ambient temperature of 23 ℃ ± 3 ℃.

5.4.4 When tested in accordance with **D.2.6**, the thermal capacity and heat transfer efficiency of the hotplate shall be such that the pipe interface temperature of a pipe of maximum diameter and thickness can be raised from −5 ℃ to 200 ℃ in less than 20 s when the hotplate is at working temperature and the specified bead formation pressure is applied.

5.4.5 Under all-weather conditions considered acceptable for jointing, the temperature control system shall maintain the operating temperature of the hotplate at 233 ℃ ± 5 ℃, except when the hotplate is brought into contact with the pipe end.

NOTE It is expected that this temperature may drop when the hotplate is brought into contact with the pipe end, but it should recover during the heat soak phase of the fusion cycle.

5.4.6 In still air at 23 ℃ ± 3 ℃ with the hotplate stabilized at 233 ℃ ± 5 ℃, no point of the surface working area shall be less than 228 ℃ or greater than 238 ℃. The temperature control system shall meet these criteria before and after 50 test cycles of heating and cooling from ambient to the operating temperatures, when tested in accordance with **D.2.4**.

5.4.7 The temperature control system shall be independently monitored by a duplicate device. Any fault or imbalance between the controller and the monitor (outside the pre-set limits) shall automatically switch off all power to the hotplate and initiate a fault signal visible to the operator. All electrical heating elements shall cut out automatically in the event of a single element failing. The temperature control system shall not be capable of adjustment in the field.

5.4.8 The heating, temperature control and monitoring systems shall be capable of maintaining the requirements of this standard when subjected to electrical supply variations as follows:

a) voltage range from 97 V to 140 V inclusive;

b) frequency range of 40 Hz to 70 Hz inclusive;

c) distortion of the sinusoidal wave form of up to 25 %.

In order to ensure an improved margin for reliability, electrical generators shall have electrical supply variations as follows:

a) voltage range from 103 V to 142 V inclusive;

b) frequency range of 50 Hz ± 5%;

c) distortion of the sinusoidal wave form of up to 20 %.

5.4.9 The hotplate shall be fitted with a temperature indication device, which clearly and visibly indicates when the operating temperature has been reached. This temperature indicator shall be independent of any other temperature control or monitoring system. The device shall agree with the operating temperature, as measured at the reference point, within ±5 ℃. It shall be protected from mechanical, electrical or thermal damage and shall be replaceable.

5.4.10 Fusion contact surfaces of hotplates shall be coated with polytetrafluoroethylene (PTFE) of 0.03 mm to 0.05 mm thickness. The colour of the PTFE coating shall be such that, after the plate has been used for jointing operations, the presence of any surplus polyethylene (PE) on the plate shall be readily visible, regardless of any degradation of the PE or PTFE coating. The PTFE coating shall be laid down and cured on a metal surface prepared and primed in accordance with the coating and manufacturer’s recommendations.

NOTE Colours of polyethylene pipes conforming to GIS/PL2-2 and GIS/PL2-8 are yellow, orange, black and natural.

5.4.11 The surface coating shall be capable of withstanding for 1 h a temperature of 300 ℃ and the 50 cycles of heating and cooling used to test the control system in accordance with **D.2.2**. Following this treatment, the fusion contact surface shall still conform to the adhesion and scratch resistance tests in BS EN 12983-1.

5.4.12 Hotplates shall be fitted with at least one suitably shaped handle and, where the weight or the shape of the heater plate makes it necessary, a secondary handle shall be provided. Such handles shall be made of thermal insulating material that shall not split or degrade in normal use.

5.4.13 Where a handle carries electrical wiring inputs, it shall either be made of a material having electrical insulating properties conforming to BS 2559-3 for use with 110 V ac or, if made of wood, it shall conform to BS 3823. All input leads shall be in accordance with BS EN 50525-2-12:2011, Table D.2. Where input leads emerge from the handle, provision shall be made for their physical protection for a minimum distance of 150 mm from the handle.

5.4.14 Heater plates shall be capable of continuous operation in a vertical position at their operating temperature for a minimum period of 4 h. Following testing in accordance with **D.2.3** the temperature of the handle(s) shall not exceed 50 ℃.

5.4.15 If the hotplates cannot be easily removed from their operating position by one person for reasons of their weight or other factors, hydraulic, pneumatic or other mechanical assistance shall be provided as part of the machine.

5.5 Automatic controllers

5.5.1 Equipment for the automatic control of a butt fusion machine shall have outputs for electrical supply to the hotplate and trimmer plus hydraulic power supply to the butt fusion machine rams.

NOTE Generally, it consists of a single unit operable from a 110 V generator supply as specified in **5.4.8**.

The hydraulic power supply shall be capable of automatically following a pre-programmed sequence of conditions, appropriate to the fusion jointing cycle, as shown in general form in Figure 1. The range of butt fusion machines that can be controlled shall be clearly identified on the controller.

5.5.2 The controller shall allow for a minimum of forty (40) optional programmes to be selectable for different pipe sizes and materials. The selector switch or its access point shall be lockable. The butt welding programmes in Annex E shall be used coupled with the advice in Annex F and shall cover the full range of pipe sizes and materials for which the controller and associated butt fusion machines may be used. There shall be a facility to change the control programmes without disturbance of other components.

5.5.3 The pipe end trimming operation shall be under direct operator control. The fusion cycle shall feature an assessment of pipe drag by gradually raising the hydraulic pressure and monitoring its value when the pipe clamp begins to move. The bead formation and fusion pressures shall be additive to the drag pressure. The fusion cycle shall not be capable of starting until the hotplate temperature is correct.

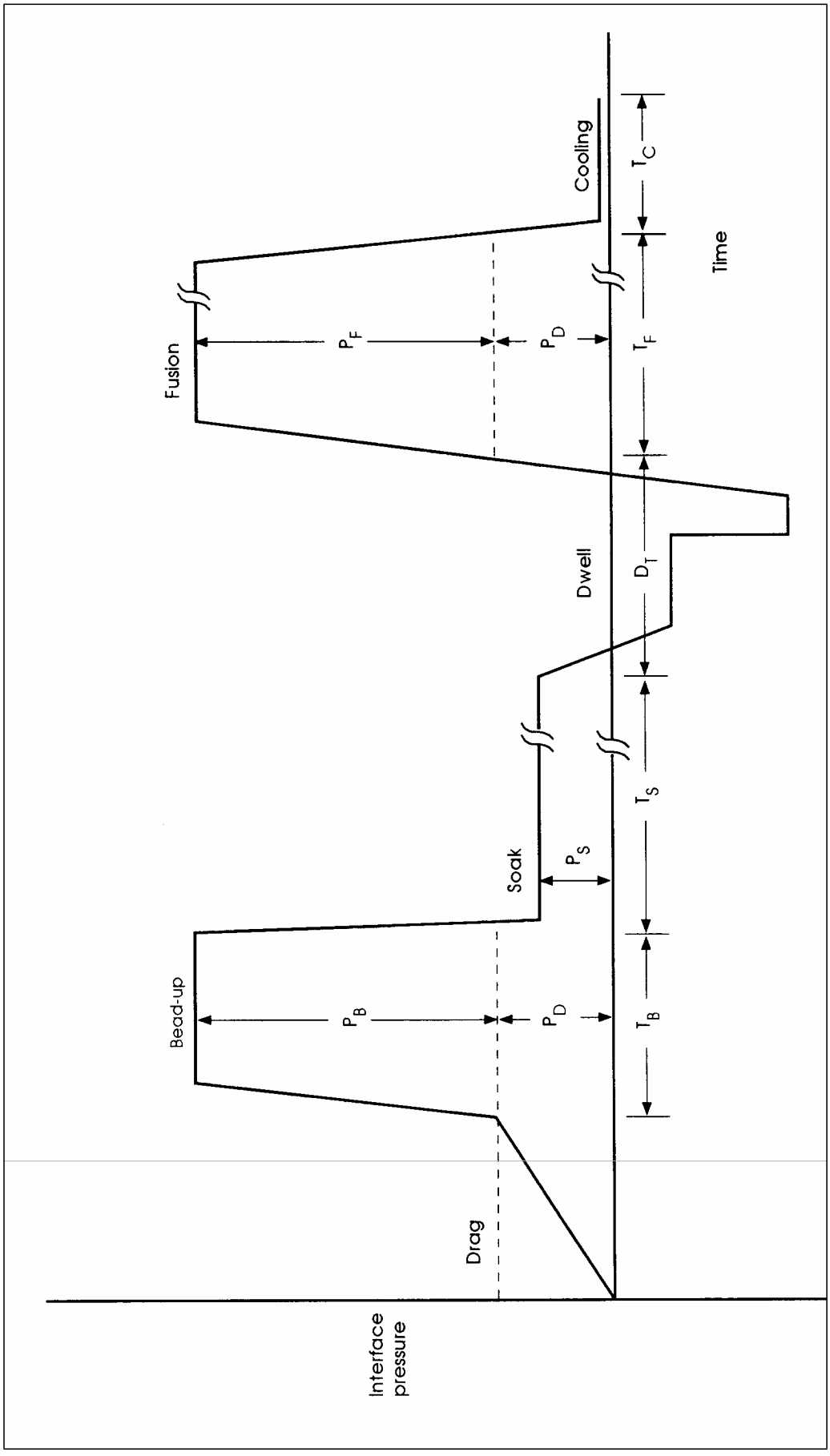

Figure 1 — Butt welding control cycle

5.5.4 At the end of the heat soak part of the fusion cycle, the automatic controller shall initiate retraction of the hotplate.

NOTE Where the controller is to drive hydraulic machines with a maximum pipe size of 250 mm, the retraction may be initiated by a pressure increase at the pipe retraction position. On larger sizes or on controllers matched to specific machine types, it may be necessary to provide a separate hydraulic power line in order to operate a hotplate retracting ram.

The controller shall monitor the hotplate movement and shall not close the pipe ends for fusion until the hotplate has withdrawn. The time duration for pipe opening, hotplate removal and pipe closure for fusion shall not exceed 4 s in automatic control for machines equal to or less than 315 mm nominal size, or 8 s for machines greater than 400 mm.

5.5.5 Where the controller is supplied as a separate item, it shall be easily lifted into and out of a vehicle by two persons. It shall weigh not more than 40 kg (a modular design shall be used if necessary) and have conveniently placed handles. No external dimension shall exceed 600 mm and total box volume shall not exceed 0.1 m^3. The equipment shall be designed for outdoor operation in inclement weather and all normal site conditions without degradation of safety or function. To facilitate maintenance, the equipment shall be constructed using replaceable modules with separation of major electrical and hydraulic assemblies.

Hydraulic power and electrical power outlets shall be on the same side of the controller. They shall be shielded from impact damage and shall be at least 100 mm above ground level. Limit switches (where fitted) and a temperature monitor shall be connected by one multi-cable plug, with its socket on the same side as the hydraulic power outlets.

NOTE This cable may, for protection, run alongside the hose.

5.5.6 The control panel shall be viewable by a person in a standing position. The panel shall be protected from impact damage. Pushbuttons for machine open and close shall be grouped together but clearly identifiable.

The automatic fusion starting button shall involve two discrete operations (e.g. use of two start switches or the lifting of a button cover then depressing the button) in order to prevent inadvertent starting. There shall be a prominent emergency stop button, colour coded red, and obvious to operate. An audible warning device shall indicate machine movements and cycle completion.

5.5.7 The control panel shall have a programme stage indicator and a fault indicator that indicates to an operator at what stage of the fusion cycle any failure has occurred. Such displays shall be readily visible in bright sunlight and in dull light, e.g. dusk.

5.5.8 The automatic controller shall have the facility for fusion data retrieval. The retrieved data shall include at least the following:

a) machine type;

b) serial number;

c) joint number;

d) date and time;

e) pipe diameter;

f) SDR;

g) fusion pressure;

h) fusion cycle time;

i) cooling time under pressure.

5.6 Butt fusion machine control features

5.6.1 No butt fusion machine shall be used under automatic control unless it has been specifically designed or specially modified for such use. Approval of a machine to be operated in automatic mode will be granted on successful completion of the acceptance procedures specified in Clause **8** to demonstrate that the machine operates safely and produces good quality joints with controllers operating as specified in **5.5**. In particular, the operating pressure and flow range of the hydraulic actuating cylinders shall be compatible with the controller in giving a satisfactory fusion cycle.

5.6.2 The machine shall have an automatically retracting hotplate. For hydraulically operated machines with pipe sizes equal to or less than 250 mm, the hotplate shall be manually inserted against a spring load and automatically released by a mechanism or by hydraulic latches operating in response to the retraction of the pipe clamps at the end of the heating period. The hotplate shall be fully guarded and thermally insulated in its withdrawn position. There shall be no access points where hands or fingers could be trapped as the hotplate releases.

NOTE For pipe sizes greater than 250 mm, and where the machine forms part of an integrated control system, the hotplate may be actuated by its own hydraulic power ram.

5.6.3 The pipe clamps on one side shall be fixed. The automatic movement of the other (active) clamp shall not create any risk of trapping fingers or clothing at the extreme of the retraction position. The end stop position, if carrying a limit switch, shall be guarded or gaitered.

5.7 Electrical tests

All electrical tools and equipment when subjected to insulation resistance, electrical strength and earth continuity tests, in that order, in accordance with BS EN 60745-1 shall conform to Annex G.

6 Ancillary equipment

For each size of machine, the manufacturer shall make available the following items.

a) *Hotplate protection and support*. Such covers shall provide for secure retention of the insulation material, stable stowage and carry a clearly visible 'HOT' warning.

NOTE 1 This is to provide thermal insulation, to protect and maintain surface cleanliness and to guard the surface from the risk of burns to persons or equipment.

b) *Trimmer stands*. These shall support the trimmers when they are out of the machine.

NOTE 2 These also keep the trimmers clean.

c) *Pipe support rollers*. These shall provide free movement of the pipe on both sides of the machine, to take bending loads off the pipe clamps and chassis and to reduce drag force during fusion jointing. They shall be adjustable for height.

NOTE The following are optional items that may be supplied in conjunction with the butt fusion machine.

a) Pipe cutters or sawing equipment for preparation of pipe ends and removing bad joints.

b) Weatherproof covers for carrying out butt fusion operations during wet or windy weather.

c) Bead removal tools for external or internal bead removal without damage to the pipe wall.

d) Electrical generator.

e) Storage facilities for machine when not in use.

f) Machine trolley. A wheeled support to facilitate transport of the machine between jointing positions.

g) Pipe support jack for pipe sizes equal to or greater than 250 mm to lift jointed pipe above butt fusion machine and allow re-positioning of pipe for next joint.

7 Maintenance service schedules

With each automatic machine the manufacturer shall supply a maintenance service schedule which, if adhered to, ensures the continued conformance of the machine with this standard throughout its working life. The manufacturer shall also undertake to provide a long-term service scheme.

The maintenance service schedule shall include instructions under the following classifications.

a) Routine checks and adjustments which are necessary on a regular, short term basis and which can be carried out by the user, e.g. hydraulic and electrical plug connections, clamp adjustments, trimmer blade replacement.

b) Longer term checks.

NOTE Longer term checks should be carried out by the user but which may require return of equipment to the supplier, e.g. electrical component damage, hotplate temperature drift, chassis alignment.

c) Expected wear and tear changes, which shall necessitate a renewal service by the supplier, e.g. hotplate surface re-coating, bearing wear, cylinder seal renewal.

d) Longer term re-validation of the complete equipment against this standard including re-certification of pressure and temperature indicators (excluding field trials).

The maintenance service schedule shall give timescales for each of the items on the above checklist.

8 Acceptance procedures

8.1 General

Acceptance shall be granted in two stages:

a) interim acceptance shall be given following successful completion of type tests in accordance with Clause **9** and annexes A - D and G and a field demonstration of the machine in accordance with **8.2.2**;

b) full acceptance shall be given following successful completion of a period of field use.

8.2 Procedure

8.2.1 The schedule for type tests and batch release tests of all items shall be in accordance with Annexes A, D, G and Table 1.

8.2.2 Following completion of the type tests, the manufacturer shall demonstrate that the machine will perform the duties it is designed for under field conditions. Three butt joints for each of the sizes claimed by the manufacturer shall be made and the weld beads of these joints examined for size and uniformity in accordance with Annex E, followed by tensile testing of the joints in accordance with Annex E. The sizes tested shall include a range of SDRs including SDR21 of peelable pipes.

8.3 Marking

8.3.1 Butt fusion machines conforming to GIS/PL2-3 shall be permanently marked with the following information:

a) the number and date of this standard, i.e. GIS/PL2-3:2021 [1)];

b) the name or trademark of the manufacturer or their appointed agent;

c) serial number;

d) the manufacturer's contact details;

e) where authorized, the product conformity mark of a third party certification body, e.g. BSI Kitemark.

NOTE Attention is drawn to the advantages of using third party certification of conformance to a standard.

8.3.2 Each hotplate shall be permanently marked to identify the manufacturer, butt fusion machine model number, a serial number, the wattage and voltage rating.

8.3.3 Pipe support rollers shall be clearly marked with the pipe size range for which they are designed.

8.3.4 All ancillary equipment shall be marked to identify the manufacturer.

8.4 Storage and transport

To ensure the retention of performance quality, as defined in this standard, the manufacturer shall suitably protect all butt fusion machines and ancillary equipment during transport and storage.

9 Test schedules

The schedule of tests for type testing (TT) and batch release testing (BRT) shall be in accordance with Table 1.

[1)] Marking GIS/ PL2-3:2021 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 standard. 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.

Table 1 —Schedule of type tests (TT) and batch release tests (BRT)

Type tests	Relevant clause reference	Batch release tests
Chassis and clamps:		
General	5.1.1, 5.1.2, 5.1.6	
Alignment	5.1.4, B.3.1	Alignment
Flatness and perpendicularity	5.1.4	
Rigidity	5.1.5, B.3.2	
Re-rounding	5.1.3, Annex A	
Interface force:		
General	5.2.3	
Calibration	5.2.1, Annex C	Calibration
Applied force	5.2.2, 5.2.4	
Trimming tool:		
General	5.3.1, 5.3.3, 5.3.4	
Trimming performance	5.3.2	Trimming performance
Hotplate:		
General	5.4.5, 5.4.12, 5.4.15	
Dimensions and flatness	5.4.1	Dimensions and flatness
Temperature probe hole	5.4.2	
Heating power	5.4.3, D.2.5	
Heat capacity and transfer efficiency	5.4.4, D.2.6	
Temperature uniformity (1 and 50 cycles)	5.4.6 and D.2.4	Temperature uniformity (1 cycle)
Temperature monitoring system	5.4.7	
Generator supply tolerance	5.4.8	
Temperature indicator	5.4.9	Temperature indicator
Surface coating	5.4.10, 5.4.11	
Handle temperature	5.4.14, D.2.3	
Automatic controllers		
Programmes	5.5.1, 5.5.2	
Trimming and drag	5.5.3	
Automatic plate retraction	5.5.4	
Design	5.5.5	
Control panel	5.5.6, 5.5.7	
Data retrieval	5.5.8	
Butt fusion machine		
General	5.6.1 – 5.6.3	
Electrical tools and equipment		
Safety	5.7, Annex G	Safety

Annex A (normative)
Determination of the effectiveness of re-rounding

A.1 Principle

The ability of each re-rounding clamp to re-round a polyethylene pipe that protrudes a short distance beyond the clamp is determined. During the butt fusion jointing procedure the two pipe ends now minimize any radial steps and distortion between the pipe ends.

A.2 Procedure

Select a pipe with an outside diameter in the bottom quarter of the tolerance band and at the maximum ovality specified in GIS/PL2-2 or GIS/PL2-8 as appropriate.

NOTE If necessary, the pipe may be conditioned to give the required ovality by over-squeezing in a press or vice arrangement.

Place the clamp over the pipe, as shown in Figure A.1 with a pipe length of $0.25d_n$ protruding.

Ensure that the pipe clamp is fully closed.

Measure, using a vernier caliper or other suitable method, the maximum and minimum diameters half way between the end of the pipe and the face of the clamp.

Determine the ovality.

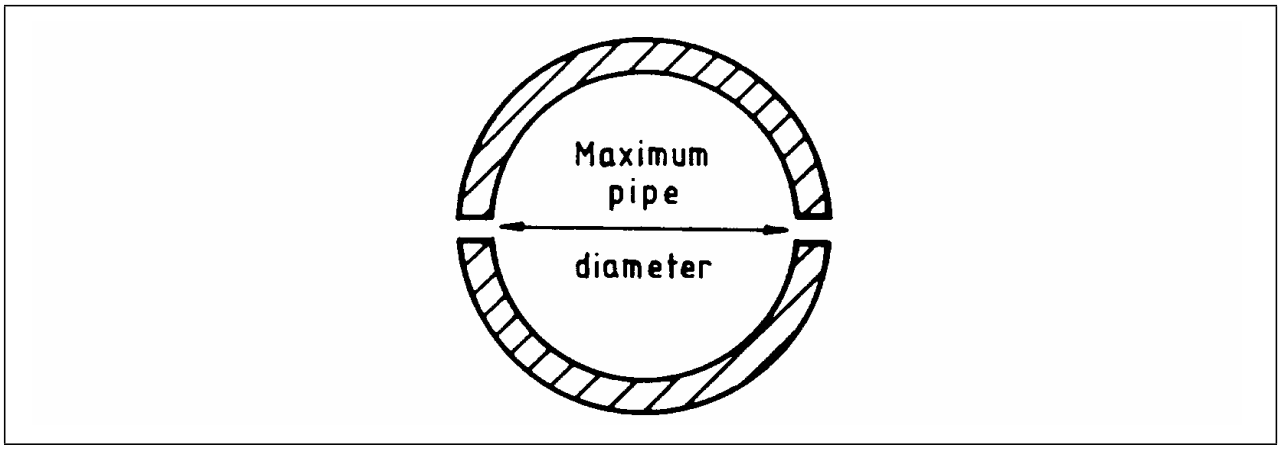

Figure A.1 — Clamp positioning

Annex B (normative)
Test for clamp alignment and rigidity

B.1 Principle

Axial alignment of the pipe clamps is established and confirmed by use of two rigid cylinders. The rigidity of the pipe clamping arrangement is determined with the polyethylene pipes supported by rollers for pipe diameters above 315 mm. For machines 315 mm and below, the polyethylene pipes are unsupported, i.e. with the roller supports removed.

B.2 Apparatus

B.2.1 *Two rigid cylinders*, machined to the same external diameter as the maximum pipe size for which the machine has been designed and with an ovality of less than 0.1 mm. The end faces of each cylinder shall be flat and perpendicular to its axis.

B.2.2 *Two polyethylene pipes*, of length 6 m and of the same external diameter as the maximum pipe size for which the machine has been designed. The end faces of each pipe shall be flat and perpendicular to its axis.

B.3 Procedure

B.3.1 *Misalignment*: hold the rigid cylinders in the pipe clamps at typical pipe jointing positions. Measure any resultant step at the cylinder interface, due to misalignment.

B.3.2 *Rigidity:* support the machine, such that the lowest point of a maximum size pipe, measured at the clamp, is 200 mm above ground level. With no pipe fitted, close up the clamps face-to-face or as close as possible (see **5.2.4**), and adjust if necessary, Figure B.1a). Separate the clamps and install two maximum diameter polyethylene pipes of length 6 m into the machine. Measure the distance between the clamp leading faces at the top, bottom and both sides of the pipe, with the pipe faces closed, Figure B.1b), and then with the clamps fully retracted, Figure B.1c).

NOTE At each clamp position, misalignment or bending of the framework will be evident as differences between each of the distances measured from one clamp face to the other.

Conduct the test with both the pipes supported horizontally, by support rollers at 1 m and 4 m from the machine and, for machines 315 mm and below, repeat with these roller supports removed.

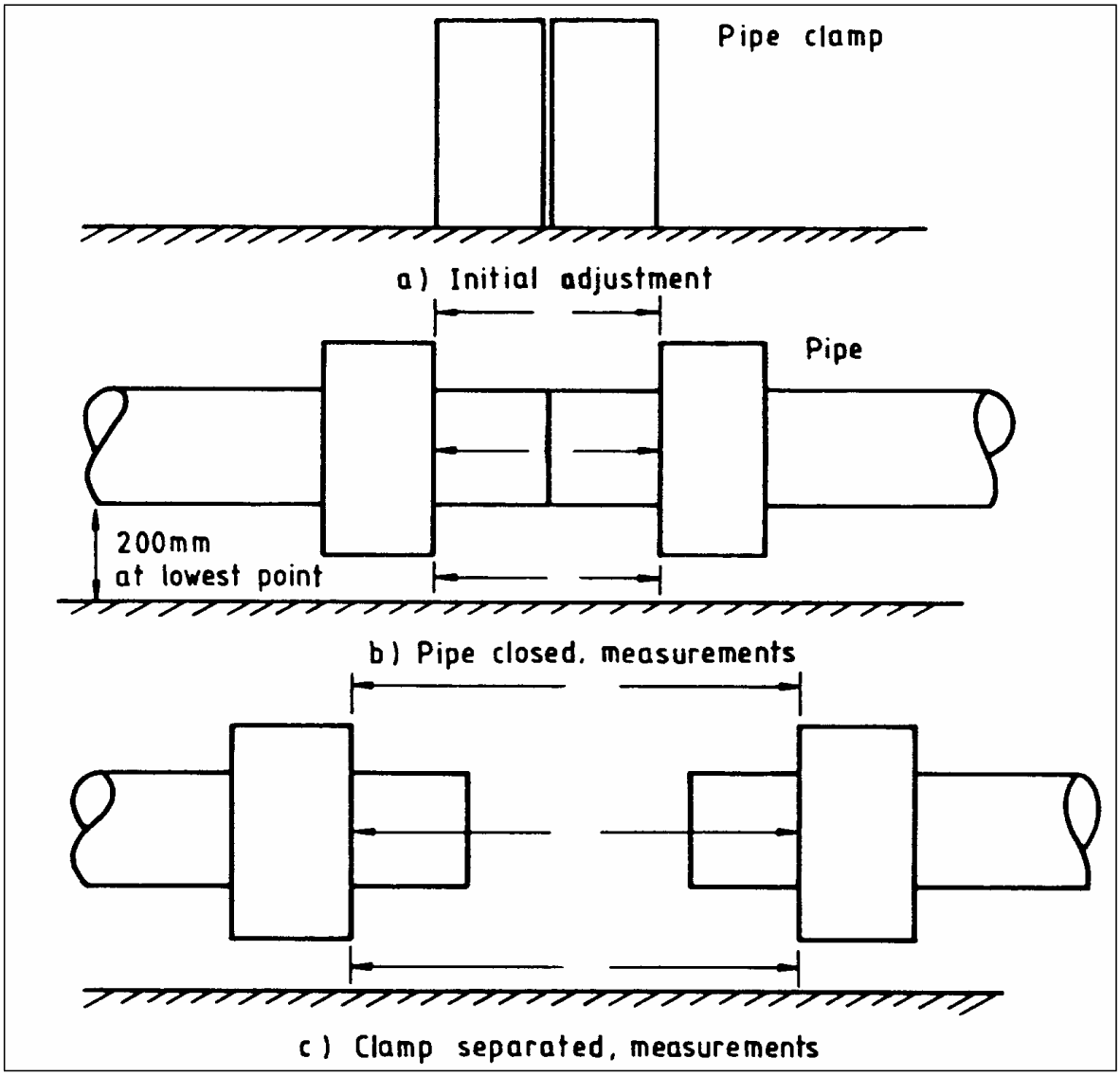

Figure B.1 — Test for clamp alignment and rigidity

Annex C (normative)
Calibration of interface force

C.1 Principle

The interface force between the pipe ends is calibrated to ensure the correct pipe end interface pressures are applied when allowing for errors and machine friction.

C.2 Procedure

Calibrate and certify any pressure or force-indicating plate used.

Measure the true force transmitted by the machine to pipe ends using a load-sensitive plate for comparison with the calculated forces determined from the product of applied pressure and actuating ram area.

Annex D (normative)
Thermal tests of hotplate

D.1 Principle

The thermal tests determine that:

a) the PTFE coating is properly bonded to the hot plate's surface and does not degrade in normal use;

b) the hot plate handle does not get too hot or it may burn operators;

c) the hot plate operating temperature is uniform over its entire surface;

d) the hot plate operating temperature is reached reasonably quickly;

e) the thermal capacity of the hot plate and heat transfer efficiency enable the pipe's surface to be raised reasonably quickly;

D.2 Procedure

D.2.1 All hotplate tests shall be conducted with the plate in a vertical position, in still air at 23 ℃ ± 2 ℃. The hotplate shall be fitted with a thermocouple probe at the reference point. The thermocouple probe, together with any measuring and recording instruments, shall have been re-calibrated within the past year.

D.2.2 To evaluate the thermal and adhesion performance of the PTFE surface coating, heat the hotplate to 300℃ ± 5 ℃ for 1 h and then cool to a maximum temperature of 25 ℃.

For all the subsequent tests, the hotplate temperature control shall be set to control at the reference temperature of 233 ℃ ± 5 ℃.

Then repeat the hotplate heating to 233 ℃ ± 5 ℃ and cooling to a maximum of 25 ℃ for 50 cycles.

The surface coating shall then conform to the adhesion and scratch resistance tests in BS EN 12983-1 (see **5.4.9**).

D.2.3 Measure the temperature of the handle after the hotplate has been maintained at 233 ℃ ± 5 ℃ for 4 h.

D.2.4 A surface probe device or an infrared, non-contact thermometer, previously calibrated, shall be used to assess the surface temperature in the working area of the plate. Before and after the 50 cycles (**D.2.2**) measure the temperature at a minimum of eight representative points on each side of the plate over a 30 min period during which the reference probe temperature remains within 233 ℃ ± 5 ℃.

D.2.5 During one of the cycles in **D.2.2**, measure the time to heat up from 23℃ ± 3 ℃ to 233 ℃ ± 5 ℃ in order to confirm the heater power requirement.

D.2.6 The test for heat transfer to the pipe surface shall be carried out at the time of the pipe jointing demonstration, when low temperature ambient conditions are available. Mount a thermocouple in the end surface of the pipe to be joined, after the pipe end has been trimmed.

NOTE 1 Small self-adhesive patch thermocouples are satisfactory for this purpose.

NOTE 2 Use of a recording instrument facilitates measurement of the temperature rise time.

Annex E (normative)
Polyethylene butt welding requirements

E.1 Butt fusion welding parameters

E.1.1 Butt fusion welding equipment shall incorporate a control sequence that conforms to **E.1.2** when an operator selects a combination of pipe geometry and material type.

E.1.2 The butt fusion machine design and welding parameters shall produce weld beads of the correct size and a shape in accordance with the bead inspection procedures specified in Gas Distribution Networks' mainlaying procedures using the fusion parameters specified in Table E.1.

Table E.1 — Fusion parameters

Parameter	**Value**
Hotplate temperature, ℃	233 ± 3
Interface pressure, MPa	0.15
Initial bead sizes, mm	
For pipe sizes ≤ 180 mm	2
For pipe sizes >180 mm to ≤315 mm	3
For pipe sizes >315 mm	4
Soak time (at drag pressure), s	10 $\sqrt{d_n}$
Dwell time (for plate removal and closure), s	
For pipe sizes ≤315 mm	4
For pipe sizes >315 mm	8
Fusion time (under pressure), s	30 $\sqrt{d_n}$
Cooling time (may be unclamped), min	1.5 $\sqrt{e_n}$ (up to a maximum of 20 min)
NOTE Initial bead size control may be achieved by setting appropriate times of hotplate contact under pressure or by using feedback from a displacement transducer.	

E.2 Final bead sizes

The final butt weld bead sizes shall be in accordance with the published sizes by National Grid.

E.3 Tensile testing of butt weld quality

Tensile tests of weld strength, shall be conducted in accordance with ISO 13953, which specifies two sample shapes. The tensile test piece (type A) shall be used for pipes having wall thickness less than 25 mm and is of the short dumbbell form. Larger size pipe shall be tested with a conventional long dumbbell shape (type B) of specified dimensions.

The minimum tensile strength shall be 15 MPa (PE80) and 20 MPa (PE100). The type of failure shall be ductile.

Annex F (informative)
Design guidance (advisory)

F.1 Interface pressure

Interface pressure is not usually monitored or controlled directly but is derived from the pipe end area and the applied force. The applied force is the product of hydraulic piston pressure and piston area less the resisting frictional forces arising from pipe drag and the machine's moving parts. The monitored and controlled quantity should be hydraulic pressure. The interface pressure should be controlled within software by first obtaining a friction (drag) force value by recording the hydraulic pressure needed to just cause pipe movement towards the hotplate and then adding a hydraulic pressure appropriate to a given pipe diameter and thickness.

F.2 Initial bead size

Initial bead size was originally intended to be judged by eye and is given to ensure complete hotplate contact around the complete circumference of the pipe end and as a test of the uniformity of pipe end trimming. Some butt fusion machines control the initial bead size by setting specific times of contact with the hotplate at full interface pressure. Now, at least one type of butt fusion machine controls the initial bead size by sensing the movement of the pipe clamp towards the hotplate. Both approaches remain acceptable provided final bead sizes are within specified limits.

F.3 Soak time at drag pressure

The objective of this phase is to build up sufficient melt depth at the pipe end to give high probability of a good weld. In principle, the pipe end should retain contact with the hotplate without squeezing out more melt material. For this to occur, the interface pressure should be near zero but slightly positive. In practice, the applied hydraulic pressure should balance the assessed frictional (drag) force. Pipe drag force can be particularly important when a machine with low internal friction is working against a real drag force (e.g. on a hillside) because this situation can result in a pipe end pulling away from the hotplate during heat soak. In most cases, a large component of "drag" is actually machine movement friction and this resists movement away from the hotplate as well as towards: so pull-off during heat soak should be rare. The time of heat soak is given by an equation that gives some increase with pipe size by relation to the square root of diameter, see Table E.1.

F.4 Dwell time

Dwell time is the time for hotplate removal and pipe end closure. The tight restrictions on this parameter are to minimize cooling and promote good fusion conditions. Machine control usually necessitates a "snap-off" at high hydraulic pressure, detection of clamp movement to ensure that hotplate can retract, then closure of ends at specified interface pressure. The machine should monitor the time between snap-off and pressure rise on closure. The maximum time between snap-off and pressure rise on closure is 4 s, for pipe sizes up to 315 mm. see Table E.1. For larger sizes, practicability of pipe movements and hotplate removal means this time has been increased to 8 s. Some protection from wind chill at the melt surface should be provided by using a tent enclosure and covering of the free pipe ends.

F.5 Fusion time (under pressure)

The fusion pressure is the same as the initial bead formation pressure and is maintained for a time reflecting some dependence on pipe size. On contact the fusion pressure causes shear within the joined fluid interface, contributing to melt mixing and fusion as the external and internal weld bead form. The objective of maintaining pressure as the molten joint zone cools, shrinks and hardens is to resist any pull-off and to avoid any distortion or microvoiding in the heat affected zone. The time required for cooling and hardening is dominated by the heat input

to the weld zone, which is itself dependent on the heat soak time. A fusion time of three times the soak time should be allowed and so a similar relationship to square root of diameter is used (see Table E.1).

F.6 Cooling time

This is the additional cooling time after the fusion time during which the pipe may be unclamped but should not be moved. This is an indicative time for operator attention since there is no requirement for machine controlled action. It may be appropriate to signal, by an audible and/or visual indication, the completion of fusion procedure. The equation to relate additional cooling to pipe dimensions should be 1.5× pipe wall thickness (mm) in min, but a practical maximum of 20 min should be applied for the largest sizes.

The pipe may be unclamped during this additional cooling time but it should continue to be supported. Excessive stress on the warm part of the pipes should be avoided around the new joint.

Annex G (normative)
Electrical tests

G.1 For acceptance, the insulation resistance, when tested in accordance with BS EN 60745-1, shall be not less than 1 MΩ. When the heater is removed electrically from the test circuit, the insulation resistance of the remainder shall be not less than 100 MΩ.

G.2 For acceptance, there shall be no electrical breakdown in any of the equipment under test when all current carrying components are joined together and subjected to the test voltage, as specified in BS EN 60745-1.

G.3 For acceptance, the earth continuity of all tools and equipment shall be satisfactory when tested in accordance with BS EN 60745-1.