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SPECIFICATION FOR BUTT FUSION JOINTING MACHINES

FOREWORD

This document is the specification for butt fusion jointing machines for use with polyethylene pipes and/or spigot fittings. It has been prepared by WRc plc under the direction of the UK Water Industry Engineering and Operations Committee in conjunction with machine and pipe manufacturers.

It details the equipment required to carry out the fusion jointing procedures set out in Issue 2 of WIS 4-32-08, and the tolerances detailed in BS 6572, BS 6730, WIS 4-32-03, WIS 4-32-05, WIS 4-32-09, WIS 4-32-13 and WIS 4-32-15. The set operating surface temperature of the heater plate is in accordance with WIS 4-32-08.

The type performance requirements, detailed in this specification, apply specifically at the point of sale of the machines.

The maintenance requirements of the equipment are specified in WIS 4-32-08:1994: Appendix A.

The in-field performance requirements of such equipment are normally assessed on the basis of the output joint quality specified in WIS 4-32-08.

Other documents considered include British Gas Specification GBE/PL2:Part 3, the draft European Standard CEN/TC249/SC3/WG3/AHG6 N2E and the draft International Standard ISO/TC138/SC4 N626 (updated).

Butt welding machines manufactured after the date of this specification shall conform to this specification and shall be marked with the specification number.

Machines manufactured prior to the date of this specification and conforming to GBE/PL2:Part 3:1993, are also acceptable.

Controllers and data loggers manufactured prior to the date of this specification shall record information for a minimum of 99 joints.

An initial 18 month period shall be allowed for automatic machines to be modified to monitor clamp slippage and early clamp release.

Compliance with this specification does not of itself confer immunity from legal obligations nor does this specification purport to include all the necessary provisions of a contract. Users of this specification are responsible for its correct application.

This specification 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.

Reference to a British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

It has been assumed in the drafting of this specification that the execution of its provision is entrusted to appropriately qualified and experienced people.

Information contained in this specification is given in good faith. Neither the UK Water Industry Research Ltd, the Water Services Association nor WRc plc can accept any responsibility for actions taken by others as a result.

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1. SCOPE

This document specifies the minimum requirements for manual, semi-automatic and fully automatic butt fusion jointing machines used for jointing polyethylene pipes and/or spigot fittings.

It covers manual machines for jointing pipes and/or fittings with nominal diameters 63 mm to 400 mm, and for semi-automatic and fully automatic machines for jointing pipes and/or fittings with nominal diameters 63 mm and greater.

2. OPERATING REQUIREMENTS

2.1 General

The requirements of Sections 2-7 shall be met before compliance with this specification can be claimed; in addition the requirements of Sections 8 and 9 shall be met for automatic and manual/semi-automatic machines respectively.

2.2 Manual machines

Manual machines shall have the following minimum requirements.

2.2.1 The heater plate temperature shall be electronically controlled.

2.2.2 The trimmer insertion, operation and removal shall be carried out manually.

2.2.3 The machine shall be capable of operation at ambient temperatures between -5° C and 30° C.

2.2.4 The heater plate shall be inserted and removed manually.

2.2.5 The heater plate shall be removed at the end of the heat soak period and the pipe ends brought together within a maximum of 10 seconds.

2.2.6 The jointing forces shall be applied and controlled manually.

2.2.7 The machine shall be capable of making an acceptable fusion joint in accordance with Appendix A of this specification.

NOTE 1: Manual machines over nominal size 400 mm are not covered by this specification.
NOTE 2: Recording of data by logger may be used.

2.3 Semi-automatic machines

Semi-automatic machines shall have the following minimum requirements.

2.3.1 The heater plate temperature shall be electronically controlled.

2.3.2 The trimmer shall be powered assisted and the trimming operation shall be under the control of the operator.

2.3.3 Insertion and removal of the trimmer shall be mechanically assisted for nominal diameters greater than 500 mm.

2.3.4 The machine shall be capable of operation at ambient temperatures between -5° C to 30° C.

2.3.5 The removal of the heater plate shall be mechanically assisted for nominal diameters greater than 500 mm.

2.3.6 The heater plate shall be removed at the end of the heat soak period and the pipe ends brought together within a maximum of 10 seconds.

2.3.7 The jointing forces shall be applied and controlled by an electro/hydraulic power pack or equivalent.

2.3.8 The machine shall be capable of making an acceptable fusion joint in accordance with Appendix A of this specification.

NOTE: Recording of data by logger may be used.

2.4 Automatic machines

Automatic machines shall conform to the requirements of 2.3 and with the following amendments.

2.4.1 The heater plate shall be removed automatically.

2.4.2 The jointing process shall be automatically controlled and recorded according to clause 8.

2.4.3 If any clamp slippage is monitored then the machine shall abort the joint.

2.4.4 If the clamps are removed before “Cooling time in clamps” is exceeded then the machine shall abort the joint.

3. CHASSIS

3.1 When tested in accordance with test A.2 of British Gas GBE/PL2:Part 3:1993 on two 6m sections of pipe of the largest nominal diameter applicable the acceptance limits specified in clauses 3.2 to 3.4 shall be met.

3.2 The clamp support and bearing system shall maintain an axial alignment not exceeding the limits in Table 1 over its entire length of travel.

Table 1 - Axial alignment limit

Maximum nominal pipe size (mm)	Axial alignment limit (mm)
up to and including 180	0.16
over 180 and up to/including 250	0.185
over 250 and up to/including 315	0.21
over 315 and up to/including 400	0.23
over 400 and up to/including 500	0.25
over 500 and up to/including 630	0.28
over 630 and up to/including 800	0.32
over 800 and up to/including 1000	0.36
over 1000	0.40

NOTE: Tolerances taken from (BS EN 20286-1)

3.3 Misalignment of the chassis with the pipe supported shall not exceed the limits in Table 2.

Table 2 - Permitted misalignment when pipe supported

Maximum nominal pipe size (mm)	Maximum permitted misalignment (mm)
up to and including 180	0.40
over 180 and up to/including 250	0.46
over 250 and up to/including 315	0.52
over 315 and up to/including 400	0.57
over 400 and up to/including 500	0.63
over 500 and up to/including 630	0.70
over 630 and up to/including 800	0.80
over 800 and up to/including 1000	0.90
over 1000	1.00

NOTE: Tolerances taken from (BS EN 20286-1)

3.4 Misalignment of the chassis with the pipe unsupported shall not exceed the limits in Table 3.

Table 3 - Permitted misalignment when pipe unsupported

Maximum nominal pipe size (mm)	Maximum permitted misalignment (mm)
up to and including 180	0.5
over 180 and up to/including 250	1.0
over 250 and up to/including 315	2.0
over 315 and up to/including 400	3.0
up to and including 630	4.0
over 630 mm	5.0

3.5 The chassis shall have a facility for supporting the trimmer and heater plate during operation.

3.6 The chassis shall have a self-lubricating mechanism for applying and maintaining the interface stresses in accordance with WIS 4-32-08:1994: clause 2.1.

4. CLAMPS

4.1 Two 2 m lengths of pipe of the largest applicable diameter shall be restrained with an ovality of 5% and conditioned for 24 hrs at a temperature of (23±3)° C. When tested in accordance with test A.3 of British Gas GBE/PL2:Part 3:1993, the requirements of 4.2 to 4.5 of this specification shall be met.

4.2 When operated and removed, at (23±3)°C, the clamps shall not damage the pipe surface to a depth greater than 5% of the minimum permitted pipe wall thickness of SDR 26 pipe of the smallest nominal size for which the machine is designed.

4.3 The clamps shall be capable of rerounding the pipe to a maximum ovality of 5% of wall thickness when measured halfway between the end of the pipe and the face of the clamp, using a verner calliper or other suitable method.

4.4 The clamps shall be capable of exerting axial forces greater than the forces required to successfully complete the jointing process when the pipe is at a temperature of -5° C.

4.5 The clamps at one end of the chassis shall be fixed in position. The clamps at the other end shall be fixed on to an active carriage way capable of applying the required interface forces.

5. INTERFACE FORCE TRANSMISSION

5.1 The machine shall be capable of maintaining the pipe end interface stresses throughout the jointing process in accordance with the performance requirements of WIS 4-32-08. This shall be demonstrated by conformance to the requirements of Appendix B of this specification.

5.2 Where a pressure gauge is used to indicate the interface stress, the gauge shall be accurate to ±10% over the operating range.

5.3 Where the interface stress is monitored or controlled by transducers, the transducer assembly shall be accurate to ±2.5%.

5.4 Any pressure or force indicating instrument attached to the machine or an associated pump unit, which is used to assess or control the interface stress at the pipe ends, shall be calibrated and certified in accordance with test A4 of British Gas GBE/PL2:Part 3:1993.

NOTE: Where the interface stress is applied by rams the effective ram area must be known so that the relationship between ram pressure and interface stress can be determined.

6. TRIMMER

6.1 The trimmer shall produce parallel pipe ends over the complete range of pipe sizes and SDR. The maximum gap on closing the pipe ends together, at zero pressure, shall be within the tolerances specified in Table 4.

Table 4 - Gap tolerances after trimming

Nominal diameter	Tolerance
up to and including 225 mm	0.3 mm
over 225 mm up to / including 400 mm	0.5 mm
over 400 mm	1.0 mm

It shall be sufficient to demonstrate this with the smallest nominal diameter pipe at SDR 26,

and with the largest permitted nominal pipe diameter at SDR 11.

6.2 The trimmer shall have a two sided operation (i.e. cut on both sides simultaneously).

6.3 The trimmer shall be fitted with suitable guards and cut outs to prevent operation except under the control of the operator and in the correct position in the machine.

6.4 Stops shall be fitted which shall provide for trimming of the pipe ends so that adequate material is left for welding.

7. HEATING PLATES

7.1 Construction and surface finish

7.1.1 The heater plate shall have a uniform thickness with tolerances not exceeding the limits in Table 5.

Table 5 - Tolerances on heater plate thickness

Maximum nominal pipe size (mm)	Thickness limits (mm)
up to and including 180	0.16
over 180 and up to/including 250	0.185
over 250 and up to/including 315	0.21
over 315 and up to/including 400	0.23
over 400 and up to/including 500	0.25
over 500 and up to/including 630	0.28
over 630 and up to/including 800	0.32
over 800 and up to/including 1000	0.36
over 1000	0.40

NOTE: Tolerances taken from (BS EN 20286-1)

7.1.2 The heater plate shall be flat to within 0.1 mm/100 mm in all directions

7.2 Surface coating

7.2.1 The heater plate surface shall be coated with a fluorocarbon based polymer (e.g. polytetrafluoroethylene (PTFE)) 0.03 mm to 0.05 mm thick.

7.2.2 The heater plate shall have a maximum surface roughness (R_a) of 0.025 mm when tested to ISO/ 468.

7.2.3 The coating shall meet the adhesion and scratch resistance tests of BS 7069 after the following heating cycle:

1 hr at a minimum 300° C followed by 50 cycles from ambient temperature to the set heater plate surface temperature as defined in WIS 4-32-08:1994:clause 2.1.4.

7.2.4 The colour of the coating shall be such that excess PE material, build up and any other contamination are readily visible.

7.3 Temperature control

7.3.1 The temperature controller shall be capable of controlling temperature to within ±3° C when operating in ambient conditions.

7.3.2 The temperature controller shall give a uniform operating heater plate surface temperature, as defined in WIS 4-32-08:1994:clause 2.1.4.

7.3.3 Manual and semi-automatic machines shall be fitted with an independent temperature indicating device accurate to ±5°C of the set heater plate surface temperature, as defined in WIS 4-32-08:1994:clause 2.1.4.

7.3.4 The surface temperature of each side of the heater plate shall be measured over a period of 30 minutes, in still air, at a minimum of four equally spaced points on the circumferential of the circle, defined by the position of the mid wall of the pipe of the largest diameter for which the heater plate is designed. These shall be denoted North, South, East and West (with North at the top of the plate) for plates used for pipes up to and including 250 mm diameter, and eight equally spaced points for pipe sizes greater than 250 mm. The probe shall be held square and flat against the heater plate for a minimum of 60 seconds before taking the temperature reading. The probe shall be protected from draughts and have a low thermal capacity.

NOTE: Pyrometer and infrared readings may be used provided they are confirmed with at least one surface probe reading per side of the plate for sizes up to 250 mm and two readings for over 250 nominal.

7.4 Operation

7.4.1 The heater plate shall be capable of continuous operation in a vertical position for a minimum of 4 hrs at the set surface temperature, as defined in WIS 4-32-08:1994:clause 2.1.4.

7.4.2 The heater plate shall be capable of reaching the set surface temperature, as defined in WIS 4-32-08:1994:clause 2.1.4, from (23±3)°C within 20 minutes.

7.4.3 When tested in accordance with test A.5.6 British Gas GBE/PL2:Part 3:1993 and operating at its set temperature, the heater plate shall have sufficient thermal capacity for heat transfer to the pipe of -5°C to 200°C within 20 seconds. The test shall be carried out on the largest pipe size and pipe wall thickness that the machine is designed for. The pipe samples shall be conditioned at -5°C for 12 hours prior to testing.

7.4.4 The temperature control system shall be independently monitored by a duplicate device. Any fault or imbalance between the temperature controller and the monitor, beyond the pre-set limits, shall automatically switch off all power to the hotplate and initiate a fault signal visible to the operator.

7.4.5 All electrical heating elements shall cut out automatically in the event of a single element failing.

8. PROCESS CONTROLLERS (Automatic Machines)

8.1 Design

8.1.1 The process controller may be integral to the machine or be supplied as a separate unit.

8.1.2 The controller shall control the jointing process.

8.1.3 The controller shall determine the dynamic drag, as defined in WIS 4-32-08, and then add this to the fusion pressure defined by WIS 4-32-08.

8.1.4 The automatic fusion start button shall involve two discrete operations in order to prevent inadvertent starting. There shall also be a prominent emergency stop button, colour coded red, which when operated switches all power off.

8.1.5 The process controller shall not start the jointing operation if the temperature controller is not indicating the correct operating temperature.

8.1.6 An audible warning shall sound when any part of the machine moves during the period of operation.

8.1.7 Any visual displays shall be visible in light levels from 1 lux to $5x10^4$ lux

8.2 Electromagnetic compatibility

8.2.1 The controller shall be designed and constructed to conform to BS EN 50081-2 for electromagnetic compatibility emission and checked for conformity in accordance with that standard.

8.2.2 The controller shall be designed and constructed to conform to BS EN 50082-2 for electromagnetic compatibility immunity and checked for conformity in accordance with that standard.

8.3 Electrical

8.3.1 The process controller and all connections to the process controller shall be IP657 rated in accordance with BS EN 60529. All connections shall be located at least 100 mm above ground level.

8.3.2 The process controller shall conform to BS 7671 Requirements for Electrical Installations (IEE Wiring regulations 16th edition Section 604 : Construction site installations).

8.4 Data

8.4.1 The process controller shall accept manual or automatic entry of the following data:
Operator code number
Pipe material
Pipe SDR
Pipe diameter

8.4.2 The process controller shall record the following information for a minimum of 240 joints:
Pipe material
Pipe SDR

Pipe diameter
Date and time of operation
Heater plate temperature / within limit
Heater plate removal time / within limit
Ram pressure variation with time
Drag pressure
Secondary pressure
Joint number
Job successful/abandoned
Operator code number/identifier

8.4.3 The process controller shall have a facility to display and either to print out or download to a personal computer details of all stored joints in an ASCII format.

9. DATA LOGGERS (Manual and semi-automatic machines)

9.1 Design

9.1.1 Any visual displays shall be visible in light levels from 1 lux to $5x10^4$ lux

9.2 Electromagnetic compatibility

9.2.1 The data logger shall be designed and constructed to conform to BS EN 50081-2 for electromagnetic compatibility emission and checked for conformity in accordance with that standard.

9.2.2 The data logger shall be designed and constructed to conform to BS EN 50082-2 for electromagnetic compatibility immunity and checked for conformity in accordance with that standard.

9.3 Electrical

9.3.1 The data logger and all connections to the data logger shall be IP657 rated in accordance with BS EN 60529. All connections shall be located at least 100 mm above ground level.

9.3.2 The data logger shall conform to BS 7671 Requirements for Electrical Installation (IEE Wiring regulations 16th edition Section 604 : Construction site installations).

9.4 Data

9.4.1 Data loggers for manual and semi-automatic machines shall record the following information for a minimum of 240 joints:
Pipe material
Pipe SDR
Pipe diameter
Date and time of operation
Heater plate temperature / within limit
Ram pressure variation with time
Joint number
Job successful/abandoned
Drag pressure
Secondary pressure
Operator code number/identifier

9.4.2 The data logger shall have a facility to display and either to print out or download to a personal computer details of all stored joints in an ASCII format.

10. TEST CONDITIONS

10.1 Unless specified otherwise in this specification, the machine and test pipes shall be conditioned at (23±3)° C for a minimum 3 hrs immediately prior to testing.

10.2 Use the lowest SDR pipe (or thickest wall) for which the machine is designed for.

10.3 Pipes must be in compliance with BS 6572, BS 6730, WIS 4-32-03, WIS 4-32-05, WIS 4-32-09 WIS 4-32-13 or WIS 4-32-15, as appropriate.

11. MARKING

Each machine shall be marked with the following information:

- the number of this specification (WIS 4-32-16);
- the manufacturer's name and model number;
- the machine serial number;
- the operational size range (i.e. minimum/ maximum pipe diameter);
- the maximum wattage and voltage requirements;
- the effective ram area.

12. REFERENCES

This specification makes reference to the latest edition of the following publications (except where otherwise stated) including all addenda and revisions, which should be consulted.

British Standards

BS 6572	Blue polyethylene pipes up to nominal size 63 mm for below ground use for cold potable water.
BS 6730	Black polyethylene pipes up to nominal size 63 mm for above ground use for cold potable water.
BS 7069	Specification for cookware
BS 7671	Requirements for electrical installations.

European Standards

BS EN 20286-1	ISO Limits and fits Part 1: General, tolerances and deviations. Section 1.1: Specification for bases of tolerances, deviations and fits.
BS EN 60529	Degrees of protection provided by enclosures (IP code).
BS EN 50081-2	Electromagnetic compatibility - Generic emission standard. Part 2. Industrial environment
BS EN 50082-2	Electromagnetic compatibility - Generic immunity standard. Part 2: Industrial environment (CLC/TC 110(sec)44)
CEN/TC	CEN/TC 249/SC3/WG3/AHG6 N2E Welding machines - Machines and equipment for the welding of thermoplastics heated tool welding.

International Standards

ISO/468	Surface roughness - Parameters, their values and general rules for specifying requirements.
ISO/TC	ISO TC 138 SC4 “Fusion equipment” N626 - Equipment for fusion jointing polyethylene systems.

Water Industry Specifications

4-32-03	Specification for blue polyethylene (PE) pressure pipe for cold potable water (nominal sizes 90 to 1000 for underground or protected use).
4-32-05	Specification for polyethylene (PE) pipes for sewer linings (non-pressure applications).
4-32-08	Specification for site fusion jointing of PE80 and PE100 pipe and fittings, 1994.
4-32-09	Specification for black polyethylene pressure pipes for potable water above ground or sewage (nominal sizes 90 to 1000).
4-32-13	Specification for blue higher performance polyethylene, HPPE/PE 100, pressure pipes, nominal size 90 to 1000, for underground or protected use for the conveyance of water intended for human consumption.
4-32-15	Specification for PE80 and PE100 spigot fittings and drawn bends for nominal sizes up to and including 1000.

Other References

British Gas	Technical specification GBE/PL2:Part 3 - Butt fusion tooling and ancillary equipment. November 1993

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APPENDIX A - WELD INTEGRITY

A.1 Principle

Carry out controlled jointing at a range of temperatures to assess the capability of the machine. Test joints shall be made on PE100 to WIS 4-32-08 using the largest thickest-walled pipe that the machine is designed to accommodate. The joints shall be tested. An acceptable machine will produce a ductile joint.

A.2 Procedure

A.2.1 Preparation

Take four pipe sections at the largest nominal size and wall thickness. Cut each to fit into the machine. Condition the pipe samples for a minimum 12 hrs at a temperature that is sufficient enough for the pipe samples to meet the test temperature after the trimming operation.

A.2.2 Joint preparation

To clean the heater plate make a dummy joint in accordance with WIS 4-32-08:1994:clause 2.2.3 prior to conducting the test.

Place two samples at the same temperature in the machine and trim the jointing faces. When the pipe temperature has reached the test temperature (-5 or 30℃ as appropriate) complete the fusion cyc le, and remove the jointed sample after the minimum cooling time out of the clamps.

NOTE: To avoid condensation problems when testing at -5^{o}C, the room temperature should also be controlled and should not be too hot.

Repeat the operation for the remaining pairs of pipe samples.

A.2.3 Testing

Machine each joint and test it in accordance with Appendix H of WIS 4-32-13:1993.

NOTE: For larger pipes the following is a recommended additional check. Machine a section of unjointed (parent) pipe to the same dimensions and apply the same test. Compare the degree of ductility of the failure surfaces of the joints with that of the parent pipe samples.

A.3 Report

The report shall include:

Reference to this Appendix of this specification
The date of the test;
The result (pass or fail) in each condition

APPENDIX B - SECONDARY PRESSURE PERFORMANCE TEST (to simulate field conditions)

B.1 Principle

The aim of this test is to infer the capability of the machine to exert, accurately and repeatably, the WIS 4-32-08 secondary interface stress of 0.025 MPa, when there is a relatively large drag pressure. This is intended to simulate representative field conditions.

The test involves measuring variations in the machine's internal hydraulic pressure during repeated carriage actuation's, the carriage being subjected to external imposed drag loads equivalent to 4 times the specified 0.025 MPa secondary interface stress.

B.2 Apparatus

A drag rig (Figure B1) capable of applying a load to the active carriage on the welding machine in excess of 4 times the WIS 4-32-08 calculated secondary interface stress ram pressure.

B.3 Procedure

B.3.1 Take two 2m lengths of pipe of the largest diameter for which the machine is designed. In the pipe section that is to be loaded into the active carriage drill two 12 mm diameter holes 180 degrees apart and 100 mm from one end. Load the pipe sections into the welding machine in accordance with Figure B1.

B.3.2 Apply a load, equivalent to 4 times the calculated secondary interface stress ram pressure (WIS 4-32-08:1994:Table 2), using the drag rig (Figure B1) to the active carriage

on the welding machine, via the previously loaded pipe pup.

B.3.3 The maximum dynamic drag value shall then be recorded.

B.3.4 Repeat B.3.3, five times to determine the maximum dynamic drag, with the drag rig attached to the end of the pipe, first at the 6 o'clock and then at the 12 o'clock position.

B.3.5 Disconnect the drag rig, unclamp the pipe samples and rotate them through 90° and reclamp. Re-attach the drag rig and repeat B.4.

B.3.6 All the recorded values of maximum dynamic drag should be the same to within 50% of the calculated net secondary pressure.

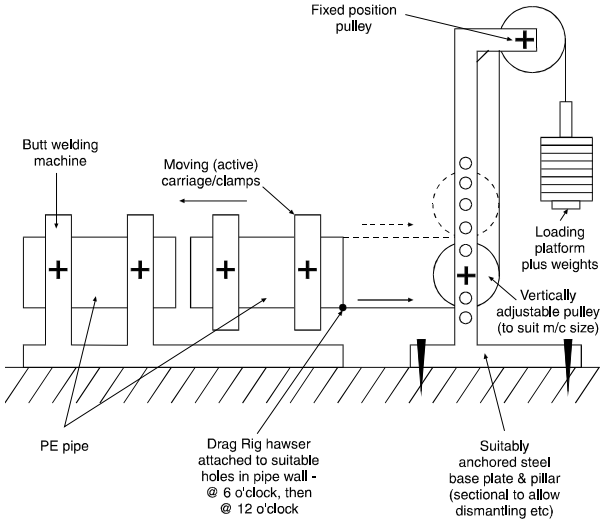

Figure B1 Example Drag Rig