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SPECIFICATION FOR MECHANICAL COUPLINGS AND REPAIR CLAMPS FOR IRON PIPES FOR THE CONVEYANCE OF COLD POTABLE WATER (UNDERGROUND USE) FOR THE SIZE RANGE 40 TO 1600mm/1.5 to 48" INCLUSIVE

FOREWORD

This document is the specification for bolted mechanical couplings and repair clamps for use with iron pressure pipes for cold potable water (underground use).

It has been prepared by WRc plc under the direction of the UK Water Industry Engineering and Operations Committee in consultation with the Water Industry and the principal product suppliers' associations. It defines the properties required for mechanical couplings and repair clamps for use with cast iron (vertically cast) pipes conforming to BS 78, cast iron (centrifugally cast) pipes to BS 1211 or BS 4622 and ductile iron pipes to BS 4772 as applicable.

Two types of fitting are covered by this specification:

Part 1: Repair clamps and couplings, designed for repair of existing pipes, and couplings for insertion of new pipe lengths to existing buried iron mains; and

Part 2: Mechanical couplings, designed for jointing new ductile iron pipe to pipe and pipe to fittings such as valves, tees and bends.

This specification includes basic performance-related type tests and quality control tests which have been agreed by the Water Industry and the principal product suppliers associations. Appendix I identifies those other performance issues for which test methods and/or performance criteria have yet to be established but which may ultimately be incorporated in a later issue of this specification. In particular no assessment for end-load resistance is included in this specification. Manufacturers and Purchasers are

referred to IGN 4-01-02 for guidance on the test loads.

Where fittings are designed to connect more than one pipe material, performance testing shall be carried out in accordance with IGN 4-21-04 (draft in progress).

Purchasers are reminded that this specification requires that the manufacturer shall operate a quality system relating to the manufacture of fittings to this specification in compliance with BS EN ISO 9002 which ensures that products claimed to comply with this specification consistently meet the required level of quality. Enquiries regarding the availability of third party certification should be addressed to an appropriate third party certification scheme or to WRc.

Compliance with this specification does not itself confer immunity from legal obligations.

This specification does not purport to include all the necessary provisions of a contract. Users of this specification are responsible for its correct application. Reference to a British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

This specification includes the use of substances and/or 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.

It has been assumed in the drafting of this specification that the execution of its provisions is

Technical enquiries to:
WRc, Frankland Road, Blagrove, Swindon, Wilts, SN5 8YF Tel: (01793) 865151 E-mail: wisign@wrcplc.co.uk

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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PART 0 - GENERAL

1. SCOPE OF PART 0

This specification specifies the materials and tolerances together with the basic testing requirements for mechanical repair clamps and couplings for the jointing and repair of plain-ended iron pipes. It covers fittings suitable for joining new ductile iron pipe of a given nominal size complying with BS 4772 to itself, to spun grey (BS 1211) and vertically cast (BS 78) iron pipe of a given nominal size and for repairing ductile iron, spun grey iron and vertically cast iron pipes of equivalent nominal sizes either individually or in any combination. This specification **does not** cover ductile iron pipes and fittings to BS 4772 which incorporate joints which are integral with pipe or fitting. However it does cover mechanical joints which can be used independently of ductile iron pipe. It specifies the quality assurance and sampling procedures together with the general design requirements.

Reference is made to the performance requirements of pr EN 545, the draft European Standard for ductile iron pipes and fittings.

2. FIELD OF APPLICATION

Fittings for use with plain-ended iron pipes in the nominal sizes DN 40 to 1600 and L.5 to 48 in, to be used for potable water pipelines below ground, are required to comply with Part 0 of this specification.

In addition:

Repair clamps and couplings, designed for repair of existing pipes, and couplings for insertion of new pipe lengths into existing buried mains are required to comply with Part 1 of this specification;

and

Mechanical couplings designed for jointing new ductile iron pipe to pipe and new ductile iron pipe to fittings such as valves, tees and bends are required to comply with Part 2 of this specification.

3. DEFINITIONS

Mechanical coupling -	Any device used in a pipe system for the purpose of connecting the pipes to each other and producing a seal by means of mechanical action.
Repair clamp -	A device which can be used to seal a defective pipe by mechanical action.
Pressure rating -	The maximum permissible sustained internal pressure, excluding surge, to which the pipe (or pipeline component) may be subjected in service.

NOTE: The term "fitting" is used in this document to cover mechanical couplings or repair clamps but excludes joints of ductile iron covered by BS 4772 which are integral with the pipe or other casting.

4. QUALITY ASSURANCE

4.1 Manufacturers shall operate a quality system relating to this specification in compliance with BS EN ISO 9002. In addition manufacturers shall:

- Establish and maintain procedures to control and verify the design of the product in order to ensure that the specified requirements are met.
- Identify and document design input requirements relating to the product. Their election shall be reviewed by the supplier for adequacy.
- Document all design outputs and express them in terms of requirements, calculations and analyses.

The design output shall:

- (a) Meet the design input requirements set out in this specification.
- (b) Refer to acceptance criteria set out in this specification.
- (c) Conform to applicable regulatory requirements whether or not these have been stated in the input information.

(d) Identify those characteristics of the design that are crucial to the safe and proper functioning of the product.

- Verify the design by establishing that design output requirements meet the design input requirements by means of design control measures such as
 - (a) Undertaking qualification tests and demonstrations
 - (b) Carrying out alternative calculations
 - (c) Comparing the new design with a similar proven design
- Establish and maintain procedures for the identification, documentation and appropriate review and approval of all changes and modifications.

4.2 Alternatively, manufacturers may operate a quality system relating to this specification in accordance with BS EN ISO 9001.

5. MATERIALS

5.1 The body of the fitting may be made of either plastic and/or metal. These materials shall comply with the relevant parts of 17.1.

5.2 Copper and copper alloy fittings shall be made from materials conforming to BS 1400 and shall be immune or resistant to dezincification (see BS 864: Part 2: 1987 Table 7).

5.3 Iron fittings shall be made from materials conforming to BS 1452, BS 2789 or BS 4772. Malleable cast iron fittings shall be made from the materials conforming to BS 6681. Low carbon (mild) steel fittings shall conform to BS EN 10025.

5.4 Stainless steel fittings shall be made from materials conforming to BS 1449 Part 2: Austenitic Grade 304 or better.

5.5 Where alternative materials are used, they shall comply with the relevant British Standard or equivalent where available.

5.6 Elastomeric sealing rings shall conform to Type W of BS 2494:1990.

5.7 All materials shall be chosen so as not to introduce a risk of bimetallic corrosion into the assembled fitting.

6. GENERAL DESIGN REQUIREMENTS

6.1 Fittings to this specification shall be suitable for use with iron pipelines having a nominal pressure rating of 16 bar.

Where the pressure rating for a fitting to Part 1 of this specification varies from this i.e. for repair, the manufacturer shall declare the fitting to have a nominal pressure rating of 6, 10, 16, 25 or 40 bar, as appropriate, and the fitting shall withstand an internal test pressure as specified in Table 3.

6.2 Fittings designed for repair of iron pipes shall be capable of meeting the requirements of Part 1 of this specification when assembled on test pipes in accordance with Appendix F.

Mechanical couplings for jointing new ductile iron pipe shall be capable of meeting the performance requirements of Part 2 of this specification when assembled on test pipes in accordance with Appendix F.

Note 1: For the purposes of this specification, vertically cast iron to BS 78, cast iron to BS 1211 or BS 4622 and ductile iron to BS 4772 are considered, dimensionally, to be different materials.

Note 2: Users are reminded that external anchoring may be required when using stepped couplings and when using wide tolerance couplings for jointing pipe of similar nominal size but of different material or material grade.

6.3 Intrusions of fitting components within the bore of the pipe shall not be more than 3% of the pipe nominal diameter or 5mm on bore radius whichever is the lesser.

Note: For couplings capable of joining dissimilar nominal pipe diameters, intrusions into the bore of the smallest pipe shall not exceed the requirements of this clause when the coupler and pipe are axially aligned.

6.4 Metallic fittings shall be protected against corrosion. Where components are protected by polymeric anti-corrosion coatings this shall be in accordance with WIS 4-52-01 (Class B) unless otherwise agreed between the manufacturers and the purchasers. Where components are hot dip galvanised this shall be carried out in accordance

with BS 729. Where components are zinc plated this shall be in accordance BS 3382: Part 2.

6.5 Flanged joints shall be constructed such that they may be attached to ductile iron pipe or fitting flanges whose dimensions are shown in BS 4504: Section 3.2.

Note: For repair purposes, it may be necessary to cover other dimensions which should be agreed between the supplier and purchaser.

7. SAMPLING FREQUENCY

Production quality control activities shall be carried out in accordance with an appropriate sampling plan drawn from BS 6001: Part 1. Guidance on the use of BS 6001 and sampling procedures for inspection by attributes is given in BS 6000.

The manufacturer shall not knowingly supply a defective unit in any batch.

Table 1 - Pipe dimensions for metric iron pipes to BS 4772 (for information only)

Nominal Size	Outside Diameter (mm)	Tolerance (mm) on External Diameter of Spigots	Maximum Ovality of Spigots on External Diameter
40	56	+ 1.0 -3.0	5
50	66		
65	82		
80	98		
100	118		
150	170	+ 1.0-3.5	10
200	222		
250	274		
300	326		
350	378	+ 1.0-4.0	20
400	429		
450	480		
500	532	+1.0-4.5	30
600	635		
700	738		
800	842	+1.0 - 5.0	40
900	945		
1000	1058	+ 1.0-6.0	50
1100	1152		
1200	1255	+1.0-7.0	55
1400	1462		
1600	1668		
		+1.0-8.0	65

Note 1: This table is for ease of reference only and the latest issue of BS 4772 should always be consulted.

Note 2: The tolerances above for pipes up to and including DN300 apply to the whole length of pipe; tolerances for DN350 and greater apply only to the pipe spigot. Attention is drawn to Appendix H of BS 4772. In addition, users are reminded that some degree of spigot ovality may exist up to a maximum given above. Spigot ovality correction may be required prior to jointing.

8. MARKING

The marking shall include:

- (a) The manufacturer's identification and date of manufacture (the last two digits of the year of manufacture, e.g. '94' are acceptable);
- (b) The number of this specification, i.e. 4-21-02. The use of this mark is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of this specification. The claim is solely his responsibility;
- (c) The nominal size of the fitting;
- (d) The maximum hydraulic working pressure of the fitting in bar in accordance with clause 6.1. The marking may be combined with the specification number, e.g. WIS 4-21-02/16.

NOTE: Where pressure ratings of fittings are different for corroded and new pipe, the product shall be clearly marked with both ratings and their application, e.g. WIS 4-21-02/Part 1/10, WIS 4-21-02/Part 2/16.

- (e) The words "This coupling shall not be used without anchoring", where required by 17.6 of this specification;
- (f) The gasket shall be clearly marked as complying with the requirements of BS 2494 Type W;

In addition, the marking may also include:

- (g) Third party certification mark, if applicable;
- (h) The word "WATER".

9. ASSEMBLY INSTRUCTIONS

The manufacturer shall supply limited instructions for assembly with each fitting. These shall include assembly torque, pipe end chamfering, cleaning and lubrication requirements. Fuller instructions should be provided but may be supplied separately. Manufacturers shall include reference to any need for pipe ovality correction.

10. PROTECTION OF FITTINGS

Fittings complying with this specification shall be suitably protected following manufacture against subsequent damage prior to receipt by the customer. Manufacturers are referred to IGN 4-52-02 Section 4 (The use of polymeric anti-corrosion (barrier) coatings) for guidance on protection of coated products.

PART 1 – MECHANICAL REPAIR CLAMPS AND COUPLINGS

11. SCOPE OF PART 1

Part 1 specifies the materials and tolerances together with the basic testing requirements for mechanical repair clamps and couplings designed for repair of existing iron pipes, and couplings for insertion of new ductile iron pipe lengths to existing iron mains. This part covers couplings suitable for joining new ductile iron pipe of a given nominal size complying with BS 4772 to spun grey iron and vertically cast iron pipes of a given nominal size, and repair clamps for repairing ductile iron, spun grey iron and vertically cast iron pipes of equivalent nominal sizes either individually or in any combination, as specified by the manufacturer.

12. FIELD OF APPLICATION

Part 1 applies to fittings for the repair of ductile and cast iron pipes in the nominal sizes DN 40 to 1600 and 1.5 to 48 in. respectively, to be used for potable water pipelines below ground. The manufacturer shall declare the fitting to have a nominal pressure rating of 6, 10, 16, 25 or 40 bar, as appropriate. Testing should be carried out at the appropriate level. The fittings shall be capable of withstanding a site hydrostatic test pressure at least as great as that specified in Table 3.

13. TYPE TEST REQUIREMENTS

Where fittings of the type given in Table 2 are manufactured and supplied, they shall be tested for and comply with the performance requirements indicated in Table 2 and specified in Part 3. Associated methods of test are described in the Appendices.

Table 2 - Applicable requirements

Fitting type	Clause												
	6.1	6.2	6.3	6.4	6.5	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8
Bolted coupler (including glanded & bands)	√	√	√	√	n	√	√	√	√	√	√	√	√
Bolted repair clamp	√	√	√	√	n	√	√	√	√	√	√	√	√
Flange adaptor	√	√	√	√	√	√	√	√	√	√	n	√	√
n Not applicable													

Each of the specified tests shall be carried out on test pipes in accordance with Appendix F. The fittings shall be assembled in accordance with the manufacturer's installation instructions.

Each of the tests (excluding the Resistance to Differential Pressure Movement test, Clause 17.6) shall be carried out at the appropriate test pressure as specified in Table 3.

These type tests may be carried out on a size representative of the manufacturer's range of production. A minimum of one size shall be tested from each of the following nominal size ranges:

- (a) ≤150mm/6"
- (b) >150mm/6" - 300mm/12"
- (c) >300mm/12" - 600mm/24"
- (d) >600mm/24"

Fittings of all sizes in the product range must meet the requirements of this specification.

If a grouping covers products of different designs and/or manufactured by different processes, the grouping shall be sub-divided accordingly.

Table 3 - Test pressures

Size Ranges	Short-Term Hydrostatic Pressure at 1 Hour (bar)	Short-Term Negative Pressure (bar)
DN 40 – 600	PN x 1.5	-0.8 (0.2*)
DN >600	PN + 3	
Applications	17.2, 17.5, 17.6, 17.7, 17.8, 18.1	17.3, 18.2
* Absolute pressure (i.e. below atmospheric)		
Note 1: PN is the nominal pressure rating of the fitting i.e. 6, 10, 16, 25 or 40 bar as declared by the manufacturer.		
Note 2: The pressures used in Table 3 have been chosen to reflect those specified in prEN805.		

PART 2 – MECHANICAL COUPLINGS

14. SCOPE OF PART 2

Part 2 specifies the materials and tolerances together with the basic testing requirements for mechanical couplings for use with new ductile iron pipes complying with BS 4772 (ductile iron). This specification does not cover integral joints of ductile iron pipes and fittings covered by BS 4772.

15. FIELD OF APPLICATION

Part 2 applies to mechanical couplings for use with new ductile iron pipes in the nominal sizes DN 40 to 1600 to be used for potable water pipelines below ground. The mechanical couplings shall be suitable for use with iron pipes, have a nominal pressure rating of 16 bar and be capable of withstanding a site hydrostatic test pressure at least as great as that specified in Table 5.

Note: Fittings may also be supplied for use in 25 and 40 bar systems. Testing should be carried out at the appropriate level

16. TYPE TEST REQUIREMENTS

Where mechanical couplings of the type given in Table 4 are manufactured and supplied, they shall be tested for and comply with the performance requirements indicated in Table 4 and specified in Part 3. Associated methods of test are described in the Appendices.

Table 4 - Applicable requirements

Fitting type	Clause												
	6.1	6.2	6.3	6.4	6.5	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8
Bolted coupler (including glanded & bands)	√	√	√	√	n	√	√	√	√	√	√	√	√
Flange adaptor	√	√	√	√	√	√	√	√	√	√	n	√	√
* Addition test required for connecting couplings capable of joining dissimilar nominal ductile iron pipe diameters													
n Not applicable													

Each of the specified tests shall be carried out on test pipes in accordance with Appendix F. The mechanical couplings shall be assembled in accordance with the manufacturer's installation instructions.

Each of the tests (excluding the Resistance to Differential Pressure Movement test, Clause 17.6) shall be carried out at the appropriate test pressure as specified in Table 5.

These type tests may be carried out on a size representative of the manufacturer's range of production. A minimum of one size shall be tested from each of the following nominal size ranges:

- (a) ≤ 150mm/6"
- (b) >150mm/6" - 300mm/12"
- (c) >300mm/12" - 600mm/24"
- (d) >600mm/24"

Mechanical couplings of all sizes in the product range must meet the requirements of this specification.

If a grouping covers products of different designs and/or manufactured by different processes, the grouping shall be sub-divided accordingly.

Table 5 - Test pressures

Size Ranges	Test Pressure	
	Short-Term Hydrostatic Pressure at 1 Hour (bar)	Short-Term Negative Pressure (bar)
DN 40 - 600	PN x 1.5	} -0.8 (0.2*) }
DN >600	PN + 3	
Applications	17.2, 17.5, 17.6, 17.7, 17.7, 17.8, 18.1	17.3, 18.2
* Absolute pressure (i.e. below atmospheric)		

Note 1: PN is the manufacturer's stated pressure rating of the mechanical couplings but shall not be less than the maximum permissible working pressure of the system i.e. 16 bar. Fittings may also be supplied for use in 25 and 40 bar systems.

Note 2: See Note 2 to Table 3.

PART 3 – TEST METHODS AND CONDITIONS

17. TYPE TEST METHODS AND REQUIREMENTS

17.1 Effect of materials on water quality

When used under the conditions for which they are designed, all materials in contact with, or likely to come into contact with, water for public supply shall be introduced in accordance with the requirements of Regulation 25 of the Water Supply (Water Quality) Regulations 1989. [Water Supply (Water Quality) Regulations 1989. [Water Supply (Water Quality) (Scotland) Regulations 1990 in Scotland].

For products not approved under the former voluntary system, and not eligible for use under regulation 25(1) (b) or 25(1) (c), Secretary of State Approval shall be obtained via submission of the product to the "Department of the Environment Committee on Chemicals and Materials of Construction for Use in Public Water Supply and Swimming Pools" for consideration. Products shall comply with the requirements of BS 6920: Part 1: 1990; evidence of compliance shall be submitted to the above committee by the manufacturer.

NOTE 1: A list of approved substances and products is published annually and is available from the Technical Secretary of the Committee at the Drinking Water Inspectorate, Room B 153, 43 Marsham Street, London SW1 3PY.

NOTE 2: Regulation 25 applies only to products used by water companies in the treatment and distribution of public water supplies; it does not apply to use of fixtures and fittings on consumers' own premises. Approval under the Water Byelaws Scheme and listing in the Water Fittings and Materials Directory is desirable.

17.2 Short-term internal hydrostatic pressure test

When tested in accordance with Appendix A, each jointed assembly shall withstand the pressure requirements in Table 3 or Table 5 of this specification, as appropriate, for a minimum of one hour. The assembly is required to show no signs of leakage. The gasket shall be visually inspected on completion for signs of stress cracking, the presence of which shall constitute a test failure.

17.3 Short-term negative pressure test

When tested in accordance with Appendix B, each jointed assembly shall withstand a negative internal test pressure as specified in Table 3 or Table 5 of this specification, as appropriate, for a minimum of one hour at the end of which time the pressure shall not have changed by more than 0.08 bar. Fittings shall be tested with the test pipes withdrawn to the manufacturer's maximum recommended gap. The jointed assembly shall then immediately be subjected to and comply with the requirements of the short-term internal hydrostatic test in 17.2. The gasket shall be visually inspected on completion for signs of stress cracking, the presence of which shall constitute a test failure.

17.4 Bolt-load relaxation test

When tested in accordance with Appendix C, the predicted bolt load on an assembled joint after 50 years life shall be not less than 1.2 times the bolt load at which leakage occurs.

17.5 Leaktightness test under angular deflection

When tested in accordance with Appendix D, each jointed assembly shall withstand the short-term internal hydrostatic test pressure requirements in Table 3 or Table 5 of this specification, as appropriate, for a minimum of one hour. Each jointed assembly shall withstand this pressure for a further hour when deflected to the manufacturers' maximum recommended angular deflection. This deflection is to be recorded and stated by the manufacturer. The assembly is required to show no signs of leakage. The gasket shall be visually inspected on completion of signs of stress cracking, the presence of which shall constitute a failure.

17.6 Resistance to differential pressure movement test

When tested in accordance with Appendix E, each assembled joint shall withstand a minimum internal pressure of $1.5 \times PN$ for a minimum of 24 hours without showing signs of leakage. As defined in Appendix E, the resultant movement shall not be greater than 0.05mm. Fittings which do not meet the requirements of this test shall be clearly marked with "This coupling shall not be used without anchoring".

17.7 Resistance to shear test

When tested in accordance with Appendix G, each jointed assembly shall withstand a minimum shear load expressed in Newtons equal to $(25 \times DN)$ for a minimum of one hour without showing signs of leakage. The gasket shall be visually inspected on

completion for signs of stress cracking, the presence of which shall constitute a failure.

17.8 Leaktightness test under axial draw

When tested in accordance with Appendix H, each jointed assembly, having been withdrawn under internal hydrostatic pressure, shall withstand the short-term internal hydrostatic test pressure requirements in Table 3 or Table 5 of this specification, as appropriate, for a minimum of one hour without showing signs of leakage.

The gasket shall be visually inspected on completion for signs of stress cracking, the presence of which shall constitute a failure.

18. QUALITY CONTROL TEST REQUIREMENTS

18.1 Short-term internal hydrostatic pressure test

When tested in accordance with Appendix A, each jointed assembly shall withstand the short-term internal hydrostatic test pressure requirements in Table 3 or Table 5 of this specification, as applicable, for a minimum of one hour at ambient temperature without signs of leakage.

18.2 Short-term negative pressure test

When tested in accordance with Appendix B, each jointed assembly shall withstand the short-term negative test pressure as specified in Table 3 or Table 5 of this specification, as applicable, for a minimum of one hour at ambient temperature. Fittings shall be tested with the test pipes withdrawn to the manufacturer's maximum recommended gap.

19. TEST CONDITIONS

In any case of dispute and unless specified otherwise, specimens for type tests shall be conditioned and tested at a minimum of 20°C, or greater if agreed between the manufacturer and the certification body. The temperature shall be controlled to $\pm 2^\circ\text{C}$. Specimens shall be conditioned in air or water for not less than 12 hours for fittings of wall thickness up to and including 12.7mm, or not less than 24 hours for Fittings of wall thickness over 12.7mm. The test pressure shall be controlled to -0, +1 bar or +10% of the test pressure whichever is the greater.

20. REFERENCES

This specification makes reference to the latest edition of the following publications (except where otherwise stated) including all addenda and revisions, which should also be consulted. Where reference is made to a draft standard, it is assumed that this will be superseded by the requirements of the final standard when published.

British Standards

BS 78	Specification for cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings.
BS 729	Specification for hot dip galvanised coatings on iron and steel articles.
BS 864	Capillary and compression tube fittings of copper and copper alloy: Part 2 - Capillary and compression fittings for copper tubes.
BS 903	Methods of testing vulcanized rubber: Part A 42 Method for determination of stress relaxation in compression at ambient and at elevated temperatures.
BS 1211	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
BS 1400	Specification for copper alloy ingots and copper alloy and high conductivity copper castings.
BS 1449	Steel plate, sheet and strip. Part 2 Specification for stainless and heat-resisting steel plate, sheet and strip.
BS 1452	Flake graphite cast iron. Knurling wheels.
BS 1759	Knurling wheels
BS 2494	Specification for elastomeric seals for joints in pipework and pipelines.
BS 2789	Specification for spheroidal

graphite or nodular graphite cast iron.

BS 3382	Specification for electroplated coatings on threaded components. Part 2 Zinc on steel components.
BS 4504	Specification for circular flanges for pipes, valves and fittings. Metric series. Part 3 Steel, cast iron and copper alloy flanges. Section 3.2 Cast iron flanges.
BS 4622	Grey iron pipes and fittings.
BS 4772	Specification for ductile iron pipes and fittings.
BS EN ISO 9002	Quality systems Part 1 Specification for design/development, production, installation and servicing. Part 2 Specification for production and installation (to be published to replace BS 5750: Parts 1 and 2).
BS 6000	Guidance to the use of BS 6001.
BS 6001	Sampling procedures for inspection by attributes.
BS 6681	Malleable cast iron.
BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. Part 1 Specification.

European Standards

EN 10025	Hot rolled products of non-alloy structural steels and their technical delivery conditions.
EN 29001	Quality systems - Model for quality assurance in design, development, production, installation and servicing.
PrEN 545	(Draft) Ductile iron pipes, fittings, accessories and their joints for

water pipelines requirements and test methods.

PrEN 805 Water Supply: Requirements for external systems and components.

Water Industry Specifications

IGN 4-01-02 The determination of end-loads to be applied in the performance testing of end-load resistant pipeline fittings.

IGN 4-21-04 (draft) Guidance on the testing of universal fittings and change couplings.

WIS 4-52-01 Polymeric anti-corrosion (barrier) coatings.

IGN 4-52-02 The use anti-corrosion coatings.

Other References

WRc UM 1022. Development of specifications for mechanical connectors and repair clamps for use with water pipeline materials. August 1989.

British Gas BGC/PS/LC8 Methods of repairing leaking ferrous gas mains. Part 4 - Pipe repair clamps, split collars and under pressure branch connections.

Swedish Standards Institute SIS 05 5900 Pictorial surface preparation standards for painting steel surfaces.

APPENDIX A – SHORT-TERM INTERNAL HYDROSTATIC PRESSURE TEST

A.1 TEST PIECE

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned on test pipes as specified in clause 19.

A.2 PROCEDURE

The pipe/fitting assembly shall be connected to a suitable device capable of applying and maintaining the relevant internal hydrostatic pressure as specified in Tables 3 or 5 of this specification and held at a constant temperature in accordance with Clause 19. Fittings not designed to be end-load resistant shall be provided with a jig or tie-bars to hold the test pipes and end-caps against the end thrust due to the test pressure.

The short-term internal test pressure requirements in Tables 3 or 5, as appropriate, of this specification shall be applied for a minimum of one hour at a constant temperature in accordance with Clause 19.

A.3 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;
- (e) The date of the test.

APPENDIX B – SHORT-TERM NEGATIVE PRESSURE TEST

B.1 TEST PIECE

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned on test pipes as specified in clause 19.

B.2 PROCEDURE

The pipe/fitting assembly shall be connected to a suitable device capable of applying and maintaining the relevant negative pressure as specified below and held at a constant temperature in accordance with Clause 19.

The test assembly shall be evacuated to 0.8 bar below atmosphere (approximately 0.2 bar absolute) and then isolated from the vacuum pump. The assembly shall be left under vacuum for a minimum of one hour at a constant temperature in accordance with Clause 19.

B.3 REPORT

The test report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;
- (e) The date of the test.

APPENDIX C – BOLT-LOAD RELAXATION TEST

The bolt-load relaxation test carried out at 60°C is designed to assess whether a fitting which relies upon compression of a gasket by tightening of bolts to create a seal, is capable of achieving a minimum working life of 50 years.

The test procedure can be described in four distinct sections.

NOTE: The criteria for this test have been based upon the assumption that the bolt load relaxation curve will be modified using the 20°C slope determined by C.4. However, if the bolt load relaxation curve measured at 60° exceeds the requirement of 17.4 without modification by C.4, then this modification may be omitted.

C.1 ELASTOMERIC STRESS RELAXATION BEHAVIOUR

The experimental relationship between stress relaxation and time at 20, 40, 60, 80 and 100°C for the elastomeric seal material shall be determined in accordance with BS 903: Part A42. For each temperature, plot the percentage load to maintain a constant displacement of elastomer (strain) against log time (Figure 1).

Determine the value of, the shift factor by:

- determine the slope of the best straight line before the onset of chemical degradation (as indicated by a knee in the curve) for the 20°C plot;

- draw a straight line tangential to the curve of the 20°C plot after chemical degradation has begun;
- determine the log (time) at the intersection of the two straight lines and record the log (time) as 't₂₀';
- repeat the above sequence for all other temperature plots and record the log times as 't₄₀'; etc;
- plot the log times 't₂₀' etc. against temperature;
- draw the best straight line through the plots and determine the number of log decades of time between the intersection of the line and the temperatures 60°C and 20°C. Record as 'f'.

NOTE 1: Should the 20°C plot not exhibit a knee at the expiry of the test time, determine 'f' by extrapolation of the higher temperature results or, if it results in a higher value of 'f', by assuming the 't₂₀' is at the expiry of the test.

NOTE 2: If a knee is not established at any temperature (as can occur with peroxide-cured EPDM) assume that 'f' = 0.

NOTE 3: The temperatures have been selected for determining the behaviour of seals under UK conditions.

C.2 DETERMINATION OF MINIMUM BOLT LOAD TO SEAL

C.2.1 Test pieces

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and held at a constant temperature in accordance with Clause 19. Where the fitting contains four or fewer bolts each shall be fitted with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt. Where a fitting contains more than four bolts, the additional bolts up to a total of 8 shall be fitted with a minimum of two strain gauges or load cells, placed diametrically opposite on the bolt, (or one strain gauge along the centre axis of the bolt) and uniformly spaced around the fitting.

C.2.2 Procedure

The bolt load (F_1) at which leakage just occurs shall be determined on a minimum of five samples as follows:

- the bolts shall be tightened to the manufacturer's recommended torque and the test pressure of 1.2 times PN applied;
- the bolts shall then be progressively loosened, by equal turns on each bolt until leakage occurs. Record the average bolt load, as a percentage of the bolt load at recommended torque.

The 95% Upper Confidence Limit (UCL) of the five average bolt loads (expressed as a percentage) recorded at the point of leakage shall be taken as F_1 .

C.3 DETERMINATION OF BOLT LOAD RELAXATION CURVE

C.3.1 Test piece

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions. Where the fitting contains four or fewer bolts each shall be fitted with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt. Where a fitting contains more than four bolts, the additional bolts up to a total of 8 shall be fitted with a minimum of two strain gauges or load cells, placed diametrically opposite on the bolt, (or one strain gauge along the centre axis of the bolt) and uniformly spaced around the fitting. The assembly shall be conditioned in air or water in accordance with clause 19 and held at a constant temperature of 60°C.

C.3.2 Procedure

The bolts shall be tightened to the manufacturer's recommended torque and the nominal internal pressure PN applied. A constant temperature of 60°C ($\pm 2^\circ\text{C}$) shall be maintained throughout the test. The bolt loads (F_m) shall be recorded over a period of six months. A minimum of two results shall be recorded per logarithmic decade of time.

C.4 DETERMINATION OF INITIAL SLOPE

C.4.1 Test Piece

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and held at a constant temperature of 20°C in accordance with clause 19. The fitting shall be strain gauged as set out in C.3.1.

C.4.2 Procedure

The bolts shall be tightened to the manufacturer's recommended torque and the nominal internal pressure PN applied. The bolt loads shall be recorded over a period of up to 6 months as set out in C.3.2.

C.5 ANALYSIS OF RESULTS

The following procedure for the analysis of the results is to predict the 50 year performance at 20°C from the experimental curve.

The experimental values of F_m shall be plotted as a percentage of the originally applied bolt load taken at time $t = 0.1$ hr (for each gauged bolt) against \log_{10} time. A best fit curve shall be plotted from these results.

NOTE: Whilst the analysis of the data and experimental curve fitting should preferably be done mathematically (e.g. by fitting the data to a binomial or polynomial curve as appropriate), fitting of the experimental curve to the data by eye is acceptable.

From the point $t = 0.1$ hr, shift the curve horizontally by the shift factor f . The resultant plot is the predicted 20°C behaviour of the joint (see Figure 2).

If the initial slope at 20°C has been determined in accordance with C.4, the results of this determination can be superimposed on the above resultant plot to give the modified predicted 20°C curve.

By extrapolation of the predicted 20°C curve, the remaining bolt-load relaxation at 50 years can then be read from the final graph. This value shall be greater than or equal to 1.2 times the minimum bolt load to seal, F_1 .

NOTE: The value "1.2" is a factor of safety intended to compensate for experimental and extrapolation errors.

The assembly shall be visually inspected for any signs of deterioration. Where a gasket shows evidence of cracking, splitting or shear failure, the result shall constitute a failure.

C.6 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;

- (e) The date of the test;
- (f) The characteristics of the seal material specified against BS 2494.

APPENDIX D – LEAKTIGHTNESS TEST UNDER ANGULAR DEFLECTION

D.1 TEST PIECE

A fitting shall be assembled on test pipes axially aligned and as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned on test pipes as specified in clause 19.

D.2 PROCEDURE

The pipe/fitting assembly shall be subjected to the short-term internal hydrostatic test pressure as specified in Tables 3 or 5 of this specification as appropriate for a minimum of one hour at a constant temperature in accordance with clause 19.

The test pipes shall then be depressurised and deflected to the manufacturer's maximum recommended angular deflection measured between the pipe and the fitting and the test pressure reapplied. The test pressure shall be held for a minimum of one hour.

NOTE: It is acceptable to carry out this test by deflection of one pipe relative to the fitting.

D.3 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;
- (e) The date of the test.

APPENDIX E – RESISTANCE TO DIFFERENTIAL PRESSURE MOVEMENT TEST

E.1 TEST PIECE

A fitting shall be assembled on test pipes of the relevant different pipe materials as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned on test pipes as specified in clause 19.

E.2 PROCEDURE

The pipe/fitting assembly shall be connected to a suitable device capable of applying and maintaining a constant short-term internal hydrostatic test pressure of 1.5 x PN, and held at a constant temperature in accordance with clause 19. The test pressure of 1.5 x PN shall be applied for 24 hours. One hour before the end of the 24-hour period, the average axial movement of the fitting relative to the pipe shall be measured and the measurement repeated at the end of the 24-hour period. It is recommended that axial movement is measured at a minimum of two points. The resultant movement during this one-hour period shall not be greater than 0.05mm.

Where a fitting is designed to connect different pipe materials, the test pressure is to be chosen as the lowest specified value for a mechanical fitting of the appropriate material when tested on either of the two pipe materials individually (see IGN No. 4-21-04).

E.3 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions and pressure;
- (d) Observations and results of test, including resultant movement along the pipe;
- (e) The date of the test.

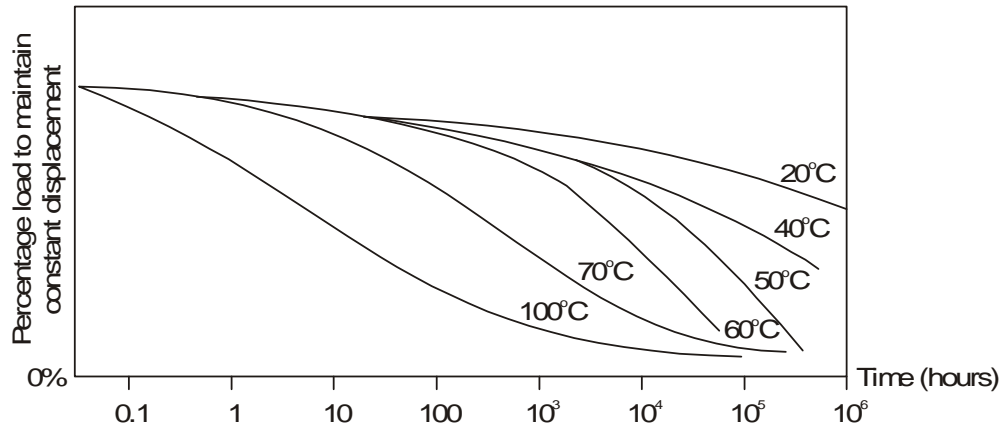


Figure 1 – Stress Relaxation Curves at a range of temperatures

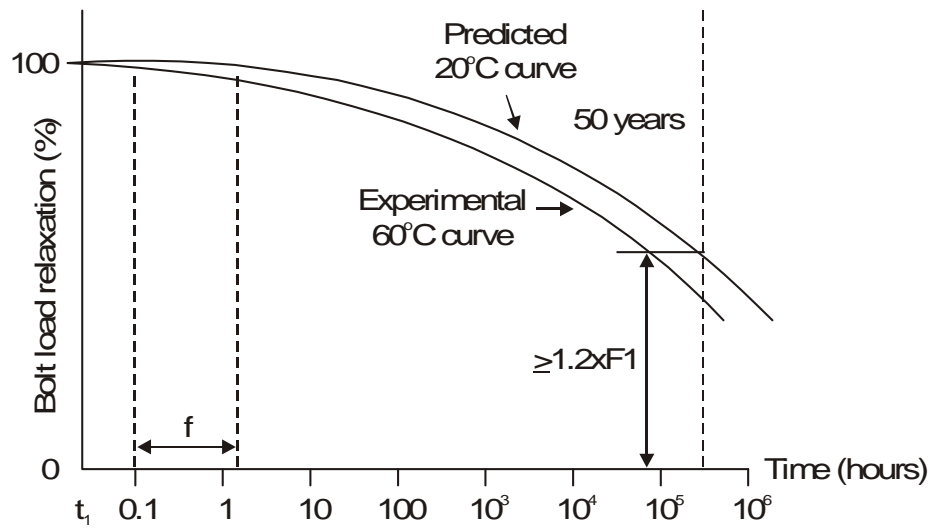


Figure 2 – Predicted 20°C Bolt Load Relaxation Curve

APPENDIX F – THE SURFACE TOPOGRAPHY OF TEST PIPES

This appendix details the surface topography of test pipes for use with this specification.

F.1 TEST PIPE COMBINATIONS

Part 1 - Except for 17.4 and 17.6 (as specified), fittings shall be assembled and tested on both:

- (i) simulated corroded surface in accordance with F.2,

and

- (ii) maximum outside diameter new iron pipe. The test pipe shall be the manufacturer's declared maximum diameter but shall not be less than the dimensions given in Table 7. Note: It is permitted to substitute the maximum outside diameter pipe by a special casting of the same material or a steel dummy prepared as specified in F.3.

Part 2 - Fittings shall be assembled and tested on each combination of extreme tolerance, i.e. maximum pipe outside diameter/minimum fitting diameter and minimum pipe outside diameter/maximum fitting diameter. The test pipes shall be:

- (i) minimum outside diameter pipe - this shall be the manufacturer's declared minimum but shall not be greater than the dimensions given in Table 6,

and

- (ii) maximum outside diameter pipe - this shall be the pipe manufacturer's declared maximum but shall not be less than the dimensions given in Table 7. Note: It is permitted to substitute the maximum outside diameter pipe by a special casting of the same material or a steel dummy prepared as specified in F.3.

Where it is not practicable to provide mechanical couplings of maximum or minimum diameter, it is permitted to compensate by reduction or increase of the pipe diameter to achieve the equivalent gap dimensions.

Part 1 (tests 17.4 and 17.6) - Fittings shall be assembled and tested on:

- (i) minimum outside diameter pipe - as specified for Part 2,

and

- (ii) maximum outside diameter pipe - as specified for Part 2.

Table 6 - Minimum outside diameters of corroded pipes, measured by the UK Water Industry

Nominal Pipe Diameter		Minimum Pipe Diameter (mm) For Guidance Only	
(in)	(mm)	Grey Cast	Ductile Iron
3		85.4	
4	100	111.8	113.8
5		139.8	
6	150	167.2	165.8
7		194.6	
8	200	222.1	
9		249.0	
10	250	275.9	269.2
12	300	323.7	321.1
14		376.5	
15		402.9	
16	400	429.3	423.4
18	450	482.2	474.3
20		535.0	
21		561.4	
22		587.8	
24	600	640.1	628.5

Table 7 - Specified outside diameter of new ductile and grey iron pipe

Nominal Pipe Diameter		Ductile Iron (BS 4772)		Grey Iron (BS 78)
(in)	(mm)	Minimum (mm)	Maximum (mm)	Maximum (in)
3	80	95	99	3.76
4	100	115	119	4.80
5				5.90
6	150	167	171	6.98
7				8.06
8	200	218.5	223	9.14
9				10.20
10	250	270.5	275	11.26
12	300			
14				
15				
16	400			
18	450	To be	defined by	manufacturer
20				
21				
22				
24	600			

F.2 KNURLED AND PITTED SURFACE (MINIMUM OD PIPES)

This surface preparation shall be used for the testing of fittings to Part 1 of this specification, except where otherwise specified.

Test pipes shall be prepared in each of the nominal size ranges specified in Section 13.

The test pipes shall be prepared to the manufacturer's declared minimum outside diameter and incorporate the surface defects shown in Figure 4.

Note: Minimum outside diameters of corroded pipe, measured by the UK Water Industry, are provided for guidance in Table 6.

Note that the section of each test pipe over which the knurled surface must be prepared should be at least that of the maximum insertion depth of the fitting plus 20% of that depth.

F.3 SHOT-BLAST SURFACE

This surface preparation shall be used for the testing of fittings to Part 1 (tests 17.4 and 17.6 only) and for Part 2, where a steel dummy is permitted as a substitute for new pipe, of this specification.

Pipe test surfaces shall be prepared by shot-blasting to a minimum standard of SIS 05 59 00 - Sa 2½ quality. The surface profile shall be 75µm (±25µm) peak to trough height.

APPENDIX G - RESISTANCE TO SHEAR TEST

G.1 TEST PIECE

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned on test pipes as specified in Clause 19.

G.2 PROCEDURE

The pipe/fitting assembly shall be connected to a suitable device capable of applying and maintaining an internal hydrostatic pressure as specified in Tables 3 or 5 of this specification and held at a constant temperature in accordance with Clause 19. Fittings not designed to be end-load resistant shall be provided with a jig or tie-bars to hold the test pipes and end-caps against the end thrust due to the test pressure.

The shear load shall be applied to one pipe by means of a v-shaped block with an included angle of 120°, located at approximately 0.5 times DN or 200mm from the end of the fitting (whichever is the largest) as shown in Figure 5.

The short-term internal test pressure requirements in Tables 3 or 5, as appropriate, of this specification shall be applied for a minimum of one hour in accordance with Clause 19.

G.3 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;
- (e) The date of the test.

APPENDIX H - LEAKTIGHTNESS TEST UNDER AXIAL DRAW

H.1 TEST PIECE

A fitting shall be assembled on test pipes as specified in Appendix F of this specification in accordance with the manufacturer's instructions and conditioned as specified in Clause 19.

H.2 PROCEDURE

The pipe/fitting assembly shall be connected to a suitable device capable of applying and maintaining an internal hydrostatic pressure as specified in Table 3 or 5 of this specification as appropriate for a minimum of one hour at a constant temperature in accordance with Clause 19.

The test pipes shall then be axially extended at the applied internal hydrostatic test pressure until displaced to the manufacturer's maximum recommended value. The test pressure shall be maintained for a minimum of one hour from completion of the axial displacement.

NOTE: It is acceptable to carry out this test by displacement of one pipe relative to the fitting.

H.3 REPORT

The report shall include the following:

- (a) A full identification of the specimens;
- (b) Description of pipe/fitting assembly;
- (c) Test conditions;
- (d) Observations and results of test;
- (e) The date of the test.

APPENDIX I - TESTS FOR DEVELOPMENT

This appendix does not form a mandatory part of the specification and is included for information only.

The following additional tests are considered to be important and will be considered for inclusion in later issues of the specification for:

(a) Product type test evaluation:

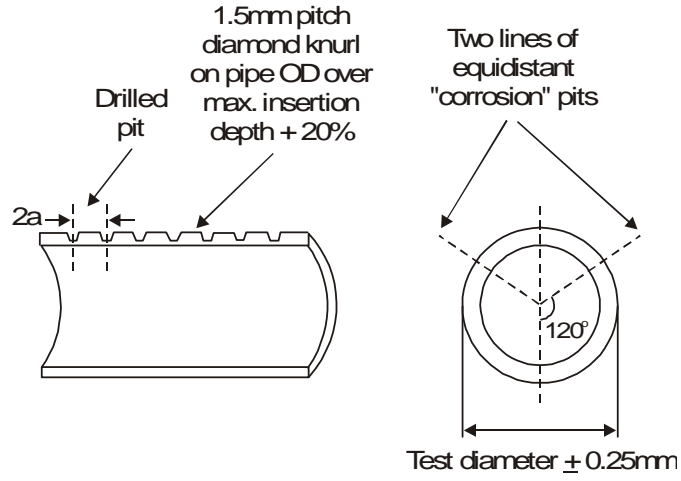
Tolerance to ovality
Durability and damage tolerance for plastic-bodied fittings
Leaktightness under external loading or diametrical deflection
Resistance to internal pressure fatigue
Leaktightness after impact
End-load resistance
Ease of assembly

and

(b) Quality control:

Tolerance to pipe dimensional variation
Leaktightness after impact
Leaktightness under angular deflection

These aspects are discussed in WRc report UM 1022.



Pit detail

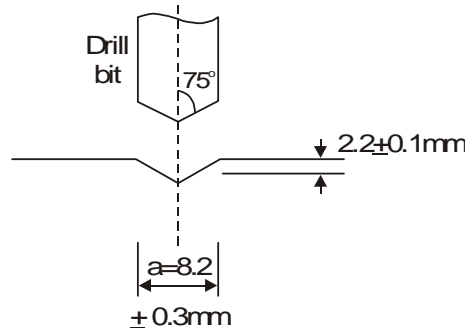


Figure 4 – Surface Defects on Test Pipe

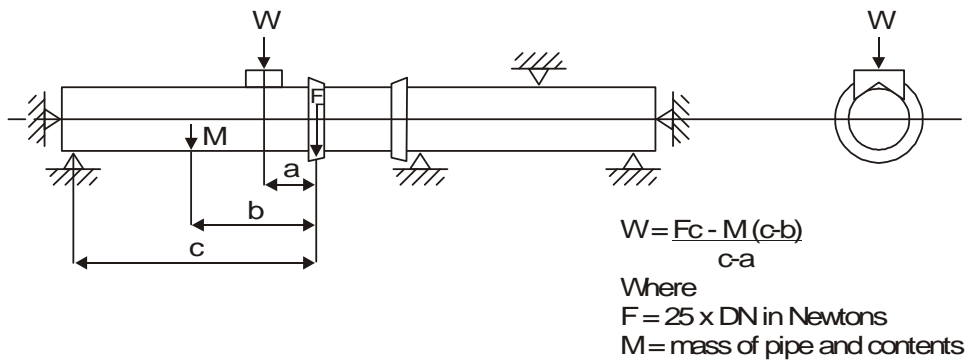


Figure 5 – Method of Shear Testing Joint Assembly