Gas Industry Standard

GIS/P5:2024

Specification for

Welding and Inspection of Austenitic Stainless Steel Pipework

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.

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

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

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

Mandatory and non-mandatory requirements

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

can indicates a physical possibility;

may indicates an option that is not mandatory;

shall indicates a GIS requirement;

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

Disclaimer

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

Brief History

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1. Scope

This Gas Industry Standard specifies requirements for the site and workshop fusion welding and inspection of austenitic stainless steel pipework designed to work at pressures up to 110 bar and temperatures up to 150 °C. This scope of work covers austenitic grades manufactured and supplied in accordance with the stainless steel grades in Section 7.

2. Normative References

This Specification makes references to the documents listed in Appendix A. Unless otherwise specified, the latest editions of the documents apply, including all amendments.

3. Definitions

The definitions for use in the specification are as per Appendix B

4. Quality Requirements

The Contractor, and if applicable, any nominated sub-contractors shall be operating in full accordance with the requirements of BS EN ISO 3834-1 and BS EN ISO 3834-2.

The Contractor shall appoint a Responsible Welding Coordinator (RWC) in accordance with the requirements of BS EN ISO 3834-2 and BS EN ISO 14731.

The Contractor shall issue a quality plan for approval that shows all requirements of BS EN ISO 3834 are capable of being met, and where required, documented.

4.1 Technical Review of Requirements

The Contractor shall ensure that all technical requirements of this specification have been reviewed and can be demonstrated to be met in full. The review of technical requirements, as required by BS EN ISO 3834-2 shall be documented and the Contractor shall ensure that this is reflected on the quality plan issued for the project. The quality plan shall include, but not be limited to:

- HSE / Safety plan
- Fabrication drawings
- Overview of proposed sub-contractors (if applicable)
- Details of materials (if non GT free issue) demonstrating compliance with certification requirements of this Specification and associated positive material identification (PMI) procedure
- Weld map and weld procedure specification matrix
- Qualified WPS (pWPS in the case where no pre-qualified procedures exist) and supporting WPQR
- Qualified repair WPS (pWPS in case where no pre-qualified procedures exist)
- Detailed method statements and procedures for material preparation, heat treatment, NDT, leak & hydro testing and coating etc.
- Details of NDT personnel including qualifications
- Inspection and test plan
- Details of transport and handling as applicable

4.2 Quality Records

Records shall meet the requirements of Section 15.

5. Equipment

The Contractor shall use only welding plant and equipment which meets BS EN IEC 60974-1, which is subject to periodical inspection and testing to BS EN 60974-4 and calibration shall be to BS EN 60974-14.

All welding equipment shall be capable of operating and controlling the welding parameters detailed within this specification.

The Contractor shall have available during all welding performed in accordance with this specification, appropriate weld process monitoring equipment that is independent of the welding plant. The monitoring equipment shall meet the requirements of Section 11.17 and be able to report and capture the essential variables needed to demonstrate compliance with the GT approved WPS. Such equipment shall be available for use at the request of the GT at any time during manufacture as well as used for internal weld surveillance activities by the Contractor.

Pipe and material handling equipment such as rollers and line up clamps shall be designed so that they cannot damage or contaminate any surfaces of the stainless steel components as well as facilitating acceptable alignment and access to apply the approved and qualified WPS.

6. Welding Process

Welding of stainless steel shall be by the tungsten inert gas (TIG) / gas tungsten arc welding (GTAW) process. This specification permits the use of manual, partly mechanised or mechanised welding as defined by BS 499-1.

The use of other processes in combination with TIG shall be permitted only by approval by the GT. For these multi process welds, if approved, the root (1st) and hot (2nd) pass of all welds shall be made using TIG, with other processes being used for the fill and capping passes only. Such incidences will be subject to complete weld procedure qualification testing (WPQT) on project materials and may require consistency trial welds. Other processes considered shall be limited to manual metal arc (MMA) / shielded metal arc welding (SMAW), metal inert gas (MIG) and metal active gas (MAG) only.

The use of mechanised and automated delivery platforms for the welding process shall be subject to consistency trials.

The use of prequalified procedures shall not be permitted for a WPS containing any processes other than TIG.

For pipe of 88.9 mm outside diameter and less, welds shall be fully TIG welded, no other processes may be submitted for consideration.

All TIG welding shall be with appropriate grade of filler metal. Autogenous welding shall not be permitted.

TIG equipment shall use high frequency arc initiation and have a current decay device fitted. An appropriate size gas lens shall be used.

7. Materials

7.1 General

The stainless steel types covered by the scope of this specification are presented in Table 1. This identifies the generic material type based on specified chemistry across the most common designation systems.

The specific product form required in a specific grade as identified below shall be identified by the designer. All materials used shall be suitable for pressure purposes.

All stainless steel pipe and components shall be supplied in the fully solution treated condition. All branches shall be made with specialised forged or pressed fittings only.

It shall be the Contractor's responsibility to use in an economic manner all materials that are free issue from the GT.

Table 1 – Stainless steel grades and designations

AISI designation	BS EN 10216 & 10217	Steel/Wr. Number
304	X5CrNi18-10	1.4301
304L	X2CrNi18-9	1.4307
316	X5CrMo17-12-2	1.4401
316L	X2CrMo17-12-2	1.4404
321	X6CrNiTi18-10	1.4541

7.2 Storage and handling

All components and assemblies (both partially complete and completed) shall be stored in a manner that maintains the surface condition and integrity of the materials. All lifting and ancillary handling equipment shall be suitable for use with stainless steel grades to ensure there is no mechanical damage of the contact surface(s) as well and no opportunity for contamination of the stainless steel to occur. Equipment that is carbon steel but protected with polymer inserts or surfaces shall be regular inspected for damage and splits in the polymer. Damaged handling equipment shall not be used and shall be removed completely from the workshop(s) within which any GT project is being fabricated and welded.

If present in a workshop alongside other non-ferrous alloys, other materials shall be sufficiently and clearly segregated from each other and clearly identified so as to prevent incorrect materials being issued.

7.3 Workshop

All stainless steel assembly and welding fabrication shall take place in a dedicated "clean" stainless steel workshop area or completely segregated workshop. There shall be no carbon steel tooling or other potential sources of contamination to stainless steel grades present. During assembly and production welding and inspections, all stainless steel components shall be protected from dust and debris that may be generated by any close/adjacent carbon steel machining and fabrication activities etc.

7.4 Positive materials identification and marking

It is expected by the GT that the Contractor or Contractor has present a method of positive material identification (PMI) and this is implemented during all production welding and prior to the release of stainless steel pipework assemblies. If required by the GT, the checking of materials using this method shall be requested at any stage of the fabrication and welding process. The information from the PMI exercise shall be used to qualitatively compare chemistries with material test certification and to confirm the grade of the component / pipe.

All materials shall be clearly marked using the principals of */SP/DAT/29 and methods identified in this specification to
During fabrications etc. all cut-offs shall have the relevant identification information transferred. All paint markers for use on stainless steels shall be free from chlorides, halides, zinc and other low melting point metals.

Material which has no identity present shall be rejected for use unless it is verified by full chemical analysis and mechanical testing at the Contractors expense. Acceptance of the results of these tests shall be at the discretion of the GT.

7.5 Materials issued for production

The Contractor shall be entirely responsible for the interpretation of the design and drawings and shall ensure the requirements are met by the materials and that they are located correctly on the pipeline or pipework assembly or system.

8. Welding Consumables

8.1 General

The welding consumables selected for use shall be from a reputable[1] Manufacturer and selected to optimise the physical, chemical and corrosion resistance properties in relation to the parent material(s) being welded. The yield strength and tensile strength of the resultant weld metal shall not be less than the respective specified minimum values of the base material being welded. In the case of welds jointing materials of differing strength levels, the specified minimum values of the higher strength grade shall be exceeded.

8.2 Filler metals

Consumables shall conform to the following standards in Table 2.

Table 2 –Stainless steel welding consumables

Steel grade	Wires & rods		Covered electrodes	
	AWS 5.9	**BS EN ISO 14343 ***	**AWS 5.4**	**BS EN ISO 3581**
304	ER 308	G/W 19 9 L	E 308	E 19 9
304L	ER 308L ER 347	G/W 19 9 L G/W 19 12 3 L	E 308L E 347	E 19 9 L E 19 12 3 L
316	ER 316	G/W 19 12 3	E 316	E 19 12 2
316L	ER 316L	G/W 19 12 3	E 316L	E 19 12 3
321	ER 347	G/W 19 12 3 L	E 347	E 19 12 3 L
** The prefix symbol for the wire or rod is G for metal active gas (MAG) or W for tungsten inert gas (TIG) welding.*				

Each batch of welding consumable filler metal shall be accompanied by a BS EN 10204 3.1 consumable test certificate.

[1] Consumables manufacturer shall have a UK / EU presence, if not based, and have a track record of providing pipeline and pipework specific welding consumables conforming to the required standards and specifications to the UK gas industry. Examples of Brands include but are not limited to Lincoln Electric, Oerlikon, Bohler and ESAB etc.

8.3 Gases

Gases for both shielding, back purging and where applicable, trailing shall conform to the appropriate composition in BS EN ISO 14175.

All argon shall be of a purity of 99.997% or greater. The composition of argon used for production welding WPS shall be equivalent to, or purer, than that used in the supporting qualified WPQR test welds.

Gas mixes shall be supplied in proprietary pre-mixed gas bottles or bottle banks from the gas Manufacturer and not mixed on site or elsewhere by the Contractor.

8.4 Storage and Handling

All stainless steel welding consumables shall be completely segregated from all other type of welding consumables and gases. Within this dedicated storage layout, consumable types, related to grade, Manufacturer and separate heats of consumables shall be adequately segregated to ensure no mixing of consumables can occur.

The Contractor shall have as part of its quality management system a consumables control procedure which shall prescribe the controls in place for receipt of consumables, storage and issue (including re-issue if applicable).

Consumables identified to have damaged packaging shall be discarded.

Storage and handling of gases shall be in accordance with industry guidelines and best practice (e.g British Compressed Gases Association Guidance Notes 2 and 3).

9. Testing and Approval of Welding Procedures

9.1 General

The Contractor shall produce welding procedure specifications (WPS) to cover the full range of materials to be welded also taking into account all essential variable limitations. It is the Contractor's responsibility to ensure the WPS remains in compliance with the requirements of this specification for all materials.

Welding shall be qualified and applied for production welding in accordance BS EN ISO 15614-1 and the requirements of this specification. The use of existing ASME Section IX welding procedures and qualifications may be proposed. Use of ASME Section IX is by prior agreement and acceptance limited to proposed WPS and supporting PQR(s) only.

All new qualifications for projects being manufactured in accordance with this specification shall be in accordance with BS EN ISO 15614-1.

If required by the GT, this shall be accompanied at the time of submission for approval by a completed WPS matrix (weld map). The weld map shall identify the WPS to be used for production welding, the relevant supporting WPQR and reference the materials (by heat number if available) to which they will be applied.

All WPS submitted for approval for production welding shall be either:

1. A proposed WPS (pWPS) to produce test welds for the purpose of welding procedure qualification (WPQ). In this case, an overview of NDT and mechanical testing to be performed on the qualification test pieces should also be submitted with the pWPS for approval. If these are not included and the testing performed does not meet the requirements of this specification, the resultant qualification will not be accepted.
2. A WPS supported by a previously qualified welding procedure qualification record (WPQR). The WPS shall be GT specific and if required by the GT, shall also be project specific.

It is not expected that WPS will require post weld heat treatment (PWHT) for the welding of the stainless steel grades covered by this specification. The use of PWHT shall be subject to approval by the GT and shall require qualification on project materials. Previously qualified procedures that include PWHT shall not be accepted. The use of backing rings is not permitted.

Where joint type and geometry allows, all root welding shall be completed with backing gas. This shall be qualified.

9.2 Welding documentation

9.2.1 Welding procedure specification

The WPS used for welding shall be in conformance with BS EN ISO 15614-1. With the agreement of the GT, ASME Section IX WPS may be submitted for approval. Acceptance shall be at the discretion of the GT and on a project only basis.

An ASME Section IX WPS and supporting WPQR approved for use on one GT project does not allow use on another without resubmission for project approval.

All WPS shall contain the information as detailed in Appendix G.

9.2.2 Welding procedure qualification record

The WPQR used to support production WPS shall be in accordance with BS EN ISO 15614-1, or where approved, ASME Section IX and shall contain the information detailed in Appendix H.

The GT reserve the right to request that additional testing (NDT and / or mechanical) is carried out to supplement existing WPQR data and the requirements of this specification.

9.3 WPS supported by a new WPQR

All WPQR to support a project to this specification shall be qualified in accordance with BS EN ISO 15614-1.

The stages involved in the qualification of a new welding procedure for use on GT projects is as follows:

1. Review materials and joint configurations to be welded and select appropriate process and variables
2. Develop optimum welding parameters, essential variables and supplementary essential variables, if required, in advance of final pWPS submission.
3. Produce pWPS with associated overview of NDT and mechanical testing (optional) and submit to GT for technical review and approval.
4. Revise pWPS and test information as required by GT comments and re-submit for approval
5. Use approved pWPS to generate qualification test welds under conditions outlined in 9.6
6. Process test welds as per NDT and mechanical test instruction
7. Review results
8. Establish if results are acceptable to this specification
    a. Procedure unacceptable – Review cause of failure.
    b. Retest existing material or generate new test weld using approved pWPS
    c. If retest acceptable, go to step 9
    d. If retest fails, procedure is rejected by GT – Return to step 2
9. Produce WPS from WPQR test data and submit, along with comprehensive WPQR document package collated with information required by this specification to GT for approval
10. Revise WPS and/or WPQR as required and re-submit to GT for approval
11. Issue approved WPS for fabrication/production.

9.4 WPS supported by a previously qualified WPQR

The stages involved in submitting a WPS supported by a previously qualified / existing WPQR are as follows:

1. Review materials and joint configurations to be welded and select appropriate process and variables
2. Select and review suitable WPQR and essential variable and supplementary essential variable data.
3. Generate WPS for GT based on WPQR data and submit for approval, along with supporting WPQR documentation (noting requirements for WPQR below)
4. Revise WPS as required by GT and resubmit. If WPS is rejected by GT, return to step 2.
5. Issue approved WPS for production

9.5 Previously qualified WPQR

All previously qualified WPQR documents submitted for approval shall, as a minimum, include the following information relating to the qualification welding and testing:

- Material certification for the materials used in qualification test
- Consumables certification used for test welding
- As ran welding data generated using appropriate and calibrated monitoring equipment to enable the essential variables of submitted proposed WPS to be verified and scrutinised if required
- Original non-destructive testing reports, signed by qualified personnel
- Original mechanical test reports from UKAS approved laboratory (with acceptable quality macro graphs with correct magnification as required).

Summary style WPQR documents containing information populated from above on a small / limited number of pro-formed pages (such as those offered in some standards, software or by third parties) will not be accepted by GT without the accompanying original documents, irrespective of any third party approval.

Previous qualifications shall not be accepted to support a WPS containing any welding processes other than TIG (141).

A WPS utilising a combination of welding processes shall be supported by a WPQR generated using the same welding processes in the same welding sequences. The use of a number of WPQR's to select the individual process variables from each and combine in a multi-process WPS which has not been tested is not permitted.

9.6 Welding of test pieces

For WPS supported by a new qualification, WPQT welding shall be carried out on pipe and / or fittings made from the same material grade and the same nominal diameter and wall thickness as that to be used in production.

Unless otherwise agreed, all qualification test welds shall be carried out on full pipe lengths. If shorter pipe / pup lengths are approved by the GT for WPQT welding, they shall be no less than 150 mm in length. Test welds in plate shall not qualify welding pipe of any diameter.

For weld configurations where the required specimens cannot be extracted for mechanical testing, the GT shall require an accompanying butt weld, made under the same controlled conditions and to

the same pWPS as the WPQT to be carried out to facilitate completion of mechanical testing, as per BS EN ISO 15614-1 Table 2 note f.

The use of backing rings or consumable inserts shall not be permitted.

PMI shall be carried out on all materials to be used for WPQT prior to welding.

All WPQTs shall be coordinated and monitored, in full, by a CSWIP-BGAS qualified Welding Inspector or Senior Pipeline Inspector. Other personnel qualifications (e.g. PCN) may be considered to be acceptable by the GT subject to approval.

The Contractor shall provide suitable instrumentation and equipment for the measurement of all welding parameters. This shall include, but not be limited to:

- Portable voltmeter
- Clamp type ammeter with full scale deflection between 2 and 3 times the weld current
- Stop watch
- Steel tape/rule
- Taper gauge
- Portable oxygen analyser
- Contact digital thermometer

All measuring equipment shall have valid calibration certification available, where applicable.

The following information shall be recorded on an individual weld record sheet for each test weld:

- WPS number
- Test weld specimen/coupon identification number
- Material identification, dimensions and cast/heat no.
- Welding consumable diameter, classification, name and batch no.
- Welder identification
- Weld preparation and root gap dimensions – these shall be as measured prior to welding
- Preheat temperature
- Purging gas flow rate, pre-weld purge time and O_2 measurement
- For each weld pass
    - Consumable grade and diameter
    - Current
    - Voltage
    - Polarity
    - Run out length and burn off/arc time or travel speed
- Shielding Gas Flow Rate
- Inter-pass temperature
- Number of Passes completed before removal of alignment clamp and purging gas
- Any other information specific to the procedure, e.g. transfer mode, waveform, treatment of second side, controlled or forced cooling.

No repair welding shall be permitted on test welds.

9.7 Qualification of repair welds

Repair weld WPS based on an existing pipe butt weld WPQR shall only be permitted for partial penetration and cap repairs. In both cases a repair specific WPS shall be generated. The use of the original butt weld WPS for repair welding shall not be permitted. If the essential variables

identified in Table 4 are not satisfied when applying the repair WPS, a specific repair qualification shall be required for partial penetration and cap repairs as for full penetration repairs below.

Full thickness repair welds and internal repairs shall be fully supported by specific repair qualification tests carried out in accordance with this specification.

Repair WPQR test welding shall be carried out on a main WPQR test coupon or a test joint produced under controlled conditions using the WPS to be used in production. The qualification of a repair weld on a weld that has not been generated under the controls and monitoring required by this specification shall not be permitted.

Full penetration repairs and partial penetration repairs shall be made between the 4 o'clock and 6 o'clock pipe position. Partial penetration repair welds if required shall be centered on the weld cap toe and shall be equal to or greater in depth than 50% of the pipe wall thickness Testing of repair welds shall be as follows:

- Macro
- Tensile Test
- Charpy Impact test. Weld metal and fusion line. Note that for partial penetration welds, both fusion lines shall be tested (i.e. repair into parent material and repair into original weld)
- Additional tests as specified by the GT

9.8 Non-destructive testing of welding procedure test welds

The extent of non-destructive testing (NDT) of test pieces shall be as per Table 6.

Acceptance criteria shall be as per Section 13.

Failure of the NDT of any weld qualification test piece coupons shall require the test welding to be repeated.

9.9 Destructive testing of welding procedure test welds

9.9.1 General

The number and type of destructive test specimens required shall be in accordance with BS EN ISO 15614-1 and the requirements of this specification.

9.9.2 Transverse tensile test

Specimen location, preparation and testing shall be in accordance with BS EN ISO 15614-1 and ISO 4136.

The tensile strength of the test specimen shall not be less than the corresponding specified minimum value for the parent metal.

The tensile strength of joints between dissimilar parent metals shall not be less than the minimum value specified for the parent material having the higher tensile strength.

9.9.3 Bend test

Specimen type, location, preparation and testing shall be in accordance with BS EN ISO 15614-1 and ISO 5173.

The bend test specimens shall not have any single flaw > 3 mm in any direction. Flaws appearing at the corners of the specimen during testing shall be ignored unless there is definite evidence that they are a result of a lack of fusion defect or a crack.

9.9.4 Macroscopic examination

For welds in all pipe diameters, two macro specimens shall be taken, one from the 3 o'clock and the other from the 6 o'clock positions in the weld[2].
The specimens shall be prepared and tested in accordance with BS EN ISO 15614-1, ISO 17639 and the requirements of this specification.

Each specimen shall clearly reveal the fusion line, the HAZ and the weld deposition sequence. All macro test specimens shall be examined at a magnification of x25 and shall be free of cracks or lack of fusion. Any other defects revealed shall meet BS EN ISO 15614-1 Section 7.5, Table 4 and the requirements of this specification.

Quality photographs of each macro specimen shall be provided with the mechanical test records. The degree of photographic magnification of the specimens shown on the test report shall be accurately recorded.

9.9.5 Impact testing

When specified by the pipework designer for the intended service conditions, impact testing shall be carried out in accordance with BS EN ISO 15641-1, ISO 148-1 and ISO 9016.

Notch locations shall be weld metal and HAZ.

Where the materials either side of the weld are from different (specifications, grades, or different heats of the same grade), HAZ specimens shall be taken from each material.

The impact test acceptance requirements shall be 0.38 mm minimum lateral expansion for both the HAZ and weld metal.

Unless specified otherwise by the pipe work designer, Charpy impact test specimens shall be tested at a test temperature of -196°C.

9.9.6 Additional Testing

The GT may require additional mechanical testing to be carried out, either as part of the initial weld procedure qualification testing, supplementary testing to support an existing WPQR or during production welding. Examples of such test are (but not limited to):

- Hardness test
- Micrographic assessment
- Ferrite count
- Intergranular corrosion testing

9.9.7 Retests

To be considered acceptable each test specimen shall meet the requirements of the specified acceptance standard. In the event of failure of any test specimen the GT shall be informed and will decide whether re-testing can be carried out in accordance with Table 3.

[2] For fixed position welds – PH and PJ. For 1G rotated and 2G weld positions, the macros shall be separated by an angle of 90°.

The reason for the original failure shall be established and reported to the GT. All re-test results shall be reported to the GT who will determine if the welding procedure can be approved, or whether complete re-qualification of the welding procedure is required.

Table 3 - Permitted retests for mechanical testing during weld procedure qualification

Type of destructive test	Failure type	Re-test allowed	Re-testing requirements
Any specimen type	Failure due to a geometric or volumetric weld imperfection	Yes	Two additional specimens[1]
Transverse tensile test	Failure to meet test requirements	Yes	Two additional specimens[2]
Charpy impact test specimens	Failure to meet test requirements	Yes[3]	One additional set of specimens[3]
Macro specimen	Failure to meet test requirements	No	Welding procedure rejected

1: For each invalid specimen, a further two specimens shall be tested. Where three individual specimens comprise a set of specimens and failure is due to an invalid specimen, one additional set of three individual specimens shall be tested.

2: Providing that not more than one of the original valid specimens tested failed to meet test requirements, two additional test specimens shall be taken from a location either side of the failed specimen.

3: If the value of lateral expansion for one specimen in a group of three is below 0.38 mm but not below 0.25 mm, and if the average value of the three specimens tested equals or exceeds 0.38 mm, a retest of three additional specimens may be made. Each of the re-tested specimens shall equal or exceed the minimum specified value of 0.38 mm.

9.10 Essential variables

Changes to a WPS outside the essential variable ranges specified in BS EN 15614-1 and Table 4 of this specification shall require a new welding procedure test to be fully qualified.

Where the GT has agreed for a specific project / application that the qualification of welding procedures shall be in accordance with ASME Section IX, the essential variables, supplementary essential variables and non-essential variables listed in that document for the appropriate welding process shall apply. These can only be applied to the project, or limited scope of a project for which they were specifically approved.

Table 4 – WPS Essential Variables

Item		WPS details	Essential variable
Welding process	a1	The specific arc welding process (or combination of processes and order thereof)	Any change
	a2	Manual, mechanised or semi-automatic	Any change
Parent material	b1	Specified strength grade	Any change other than that permitted by BS EN ISO 15614-1 and PD CEN ISO/TR 15608
	b2	Heat treatment condition [A)]	
	b3	Composition [A)]	
Diameter	c	Nominal outside diameter, *D*, of pipe	Any change outside the qualified range permitted by BS EN ISO 15614-1
Thickness	d	Nominal wall thickness, *t*, of pipe	Any change outside the qualified range permitted by BS EN ISO 15614-1
Joint configuration	e1	Type of bevel	Any change
	e2	Angle(s) of bevel [B)]	Any change outside approved tolerances
	e3	Size of root face [B)]	Any change outside approved tolerances
	e4	Width of root gap [B)]	Any change outside approved tolerances
	e5	Use of backing rings	Any addition, deletion or change of material
	e6	Dimensions of fillet welds [B)]	Any change from a multi-run deposit to a single run
Number of runs and number of sides welded	f1	Number of runs from each side	A change from single to multi-run or vice versa
	f2	Sequence of welding double sided joints	Any change to side welded first or last
Electrode or filler material	g	The following information is needed for each weld run:	
	g1	Filler material size	Any change outside the qualified range permitted by BS EN ISO 15614-1
	g2	Trade name	Any change other than that permitted by BS EN ISO 15614-1
	g3	Designation / Classification	Any change other than that permitted by BS EN ISO 15614-1
	g4	Any pre-treatment or drying of hydrogen controlled electrodes	Any relaxation
	g5	Number of wires for each run	Any change
	g6	The addition of metal powders (process 121)	Any change
	g7	Welding with filler material or welding without filler material	Any change

Shielding gas, backing gas [C] or flux	h1	Choice of shielding gas	Qualification is restricted to the symbol of the gas according to BS EN ISO 14175.
	h2	Composition of any gas mixture for welding process 141	Restricted to the symbol of the gas according to BS EN ISO 14175.
		*Shielding gases not covered by BS EN ISO 14175 are restricted to the nominal composition used in the test	
	h3	Gas flow rate [B] [C]	Any change exceeding ± 10%
	h4	Trade name and flux type	Any change
Electrical characteristics	i	Current (AC. or DC.) and polarity	Any change
Welding parameters	j	The following information is required for each wire size (different values [B] may be used for different runs):	
	j1	Electrical stick out [B]	Any change exceeding ±5 mm
	j2	Wire feed speed [B]	Any change exceeding ± 10%
		(Processes 121,136 & 137)	
	j3	Welding current [B]	Any change exceeding ± 10%
	j4	Arc voltage [B]	Any change exceeding ± 10%
	j5	Calculated value of heat input / arc energy (calculated in accordance with ISO/TR 18491) [B]	Any change greater or lower than 25% of that tested
Welding Position	k	Angle of pipe axis to the horizontal	Any change exceeding ± 25°
Direction of welding	l	Vertical up, vertical down, or horizontal	Any change
Welding technique	m	The following information is needed for each wire size used (different values [B] may be used for different runs)	
	m1	Maximum amplitude of any mechanised weave	To be agreed between the contacting parties
	m2	Frequency of any mechanised weave	To be agreed between the contacting parties
	m3	Dwell time at the side of any mechanised weave	To be agreed between the contacting parties
	m4	Number of welding torches used to deposit a single layer (e.g. single torch or twin torch systems)	Restricted to the torch system used in the procedure test
	m5	Wire system used in the procedure test (single wire or multiple wire system)	Restricted to the wire system used in the procedure test
	m6	Metal transfer mode for solid and metal cored wires	Dip transfer qualifies dip transfer only. Spray, pulse or globular transfer qualifies spray, pulse and globular transfer
Number of welders	n	Number of welders for each pass	Any reduction

Partially completed joint	o	Number of runs before cooling to ambient temperature	Joint to be fully welded with no interruptions
Line-up clamp	p1	Internal, external, or alternative method detailed on the WPS sheet	A change from internal to external, or from clamp to alternative method
	p2	Number of runs before removal of the clamp	Any reduction
Pipe or fitting manipulators	q	Mechanical manipulators, jigs or other mechanical means of supporting or moving the joint during welding	Any change from mechanical to manual methods of manipulation
Cleaning of bevel and weld	r1	Whether by power or hand driven tools [A)]	No restriction
	r2	Whether weld back gouging is carried out using mechanical or thermal means	A change from mechanical to thermal means of metal removal
Pre-heating	s	In general pre-heating is not required for the welding of materials covered by this specification. Special circumstances might occur, however, where the thickness, mass or rigidity of the part to be welded may require pre-heating.	
	s1	Pre-heat temperature	Any change to that qualified
	s2	Method of applying heat	A change from an electrical heating method to a gas heating method
	s3	Method of controlling temperature	Any change
	s4	Method of measuring temperature	Any change
	s5	Maximum or minimum inter-pass temperature for each weld run	The upper limit is the maximum temperature attained during the test. The lower limit is the minimum pre-heat temperature used during the test
Post-weld heat treatment [A)]	t	In general procedures should be designed to avoid the need for post weld heat treatment. However, where PWHT is specified by the designer the essential variables for heat treatment will be agreed between the Contractor and the GT before the welding of test welds.	
Repair welds	u1	Welding procedure details for repair welding	Any of the changes affecting approval listed above
	u2	Welding procedure details for the weld to be repaired	Any change affecting the approval of the procedure for the weld on which the repair welding procedure was qualified

Notes:
A) These items shall be specified on the pWPS sheet but are not mandatory for the production WPS sheet if they are controlled through other procedures.

B) These parameters shall be specified as single nominal values on the pWPS sheet but as qualified ranges (nominal values ± permitted variation) on the production WPS sheet. In cases where the mean value measured in qualification differs from the pWPS nominal value, the qualified range for each weld pass location and electrode / filler metal diameter shall be calculated from the mean value measured in qualification representing that pass location and / or electrode / filler metal diameter.

C) A welding procedure test made without backing gas qualifies a welding procedure with backing gas.

10. Qualification of welders and welding operators

10.1 General

Welders shall be qualified in accordance with BS EN ISO 9606-1 and to the applicable requirements of this specification.

Welding Operators shall be qualified in accordance with BS EN ISO 14732 and the applicable requirements of this specification.

All qualification test welds shall be carried out in the presence of a GT representative and / or an independent inspection authority.

Separate fillet weld qualification tests are required.

The welder shall use the same welding technique and proceed at the same speed they will work if they pass the test and are permitted to do production welding.

Noting the requirements for fillet welds, prior to welding the region of the joint where the largest gap is present shall be marked for macro examinations. Similarly, the location of a start / stop shall also be recorded for test house macro selection.

When the WPS is qualified using a proprietary type of mechanised or automated equipment, the welding operator test welding shall be carried out on the same equipment and this shall be demonstrable from the welding operator qualification. A qualification carried out on a different system shall not be considered by the GT.

Welding operators shall be qualified in each position in which they will carry out production welding.

10.2 Acceptance of welder and welding operator qualification tests

Completed qualification test welds shall be examined visually by an approved Welding Inspector to confirm that the requirements of this specification have been met. The weld shall then be tested in accordance with BS EN ISO 9606-1 (or to BS EN ISO 14732 for welding operators) and shall meet the acceptance requirements for destructive test pieces.

10.3 Visual inspection

Visual inspection by an approved inspector is required to determine that the weld meets the defect acceptance standard specified for quality level B of ISO 5817 and this document.

10.4 Non-destructive testing

Butt welds in pipe shall be examined by radiography (X-ray only) to establish that the weld meets the specified acceptance criteria.

10.5 Macro-examination

For fillet welds, two macro examinations shall be taken from the test piece. One macro specimen shall be removed from the area with the largest gap and one from a stop/start position. The specimens shall be prepared as detailed in 9.9.4 and examined up to a magnification of x 25 above.

The macro sections shall show good penetration and absence of lack of fusion, cracks or other features which would be cause for rejection.

In the case of welding corrosion welding alloys, in some cases the skill and technique of the welder can significantly impact the final weld properties. In such cases this may be critical to the specific design, the GT reserves the right to request supplementary tests are carried out as part of welder qualification.

10.6 Permitted re-tests

If the test fails, a re-test is allowed if it can be demonstrated that the failure was due to conditions beyond the control of the welder. Furthermore, if in the mutual opinion of the GT and the Contractor's representative there is reasonable chance of a second test being successful, it shall be permitted.

10.7 Records

A complete record of all tests and re-tests undertaken by the welder shall be produced and maintained by the Contractor on a welder qualification test certificate for each GT contract. The certificate shall satisfy the requirements of BS EN ISO 9606-1 or BS EN ISO 14732. Copies and records of all test reports and welders and welding operators' qualifications records shall be submitted for the approval of the GT.

10.8 Period of validity

A welder or welding operator's qualification shall remain valid provided that it can be shown that the welder has, subsequent to the tests, been employed with reasonable continuity on that procedure and has continued to produce satisfactory welds verified, as applicable, by radiographic examination or destructive testing.

Prolongation of qualifications are permitted as defined by BS EN ISO 9606-1 and BS EN ISO 14732. NDT and mechanical testing reports shall be available as appropriate for each prolongation entry if requested by the GT. Failure to produce the supporting evidence will invalidate the qualification of the welder / welding operator and the GT reserves the right to reject welds generated by affected personnel.

11. Production welding (shop and site)

11.1 Safety

All welding and inspection of stainless steel pipework shall be carried out working under appropriate safe working practices. Irrespective of general ventilation of the workshop or workspace a minimum level of fume extraction shall be used. In the workshop or any enclosed areas, all activities involving thermal cutting and / or welding of stainless steels shall be carried out by local exhaust ventilation (LEV) supplemented by respiratory protective equipment (RPE) if deemed necessary to control exposure. Site activities involving thermal cutting and / or welding of stainless steels shall be carried out with RPE as a minimum.

Attention shall also be paid to the precautions required for protection from hexavalent chromium during welding and cutting operations involving stainless steel.

11.2 General

All equipment for use during fabrication, production welding and all associated activities shall be dedicated (and if appropriate specifically identified) for stainless steel use only and segregated at all times from any adjacent activities that involve carbon steel.
Files, grinding discs, flapper wheels and other abrasive materials, e.g. emery cloth shall not have been used previously on iron or carbon steels. Wire brushes used to clean welds shall be made from stainless steel.

For all welding processes a stainless steel shim shall be placed between the earth clamp and work piece to prevent arcing directly between the clamp and work piece which would require complete removal if present.

Site welds shall be kept to a minimum, with the maximum number of welds on an assembly or subassembly being produced under workshop conditions and controls.

Pipe and components shall be adequately supported during all assembly and welding operations, acknowledging the relatively high coefficient of expansion and propensity for distortion compared to carbon steel if handled incorrectly.

All welding, including tack welding shall be performed by qualified welders in accordance with the approved WPS.

All welds shall be welded in accordance with the approved WPS and the weld completed in a single heat cycle.

Copies of the approved welding procedure(s) shall be available at the work location. Welders, Welding Operators and Welding Inspectors shall be fully familiar with the approved welding procedures.

11.3 Proximity of welds

All welds should be separated by the maximum possible distance, but not less than one pipe diameter toe to toe distance separation between circumferential welds.

Production routes shall be planned by Contractor to ensure that the longitudinal seam welds of adjacent pipes shall be offset by not less than 100 mm at the girth weld.
Joints where the seams welds of adjoining pipes and / or fittings coincide shall be avoided in all cases.

The weld toes of adjacent fillet welds and set-on welded attachments shall be separated by not less than four times the nominal pipe thickness or 40 mm (whichever is the greater), from any other weld.

The GT shall be informed of any deviation, with accompanying technical justification to this requirement and will decide whether the joint may be welded or whether further modification to the pipe-work is required to ensure compliance.

11.4 Joint design

The joint design proposed by the Contractor shall control the effects of shrinkage and distortion and require a minimum amount of deposited weld metal. Square butt joints shall not be used without the approval of the GT and shall in all cases be specifically qualified under the supervision of a GT representative.

11.5 Preparation of pipe and fittings

11.5.1 Fusion faces

All pipe ends and faces forming part of the welded joint shall be cleaned down to sound metal ensuring complete removal of all surface contaminants, moisture, paint, grease or other extraneous matter, immediately prior to making the joint. Cleaning shall be with dedicated stainless steel equipment only, followed by degreasing with a suitable solvent.

The cleaning shall extend for at least 25 mm from the fusion faces of the joint on both the internal and external surfaces of the component.

When metallic tapes are used for identification purposes or to facilitate back purging techniques they shall be as free as practicable from chlorides or fluorides. When tapes are removed, a suitable cleaner shall be used to remove any contaminants deposited on the steel surface from their use.

11.5.2 Weld bevels and cut pipe

Weld bevels shall be smooth and uniform.

The dimensions shall be in accordance with the qualified welding procedure.

Mechanical cutting by machine tool is preferred but if thermal plasma cutting of pipe ends or holes for attachment fittings is adopted, the burnt edge shall be cut back by mechanical means or grinding for a distance of 3 mm minimum.

Holes for branches of nominal outside diameter of 33.7 mm and less shall be made by drilling only.

Small score marks, indentations or other small defects within the joint preparation shall at the discretion of the Inspector, be blended out by grinding, otherwise the damage to the joint shall be removed and re-prepared. There shall be no repairs by welding to damaged fusion faces.

11.6 Alignment and fit-up

Tolerances for linear dimensions, bends, branch positioning and flange alignment shall be in accordance with the approved design.

Metallic backing rings and consumable inserts shall not be permitted. Ceramic backing shall be permitted when qualified by the approved WPS and accompanied by an appropriate machining

method statement or procedure for removal. The method statement shall be approved by GT prior to WPS use in production.

Permitted internal misalignment and bore difference of components of the same nominal size shall be as follows in Table 5.

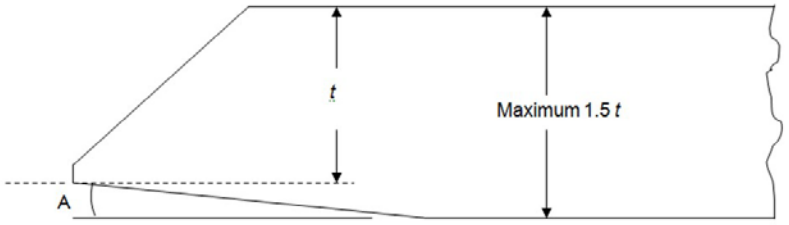
Table 5 - Maximum permissible joint misalignment

Bore	TIG Welding with no root gap	Tig welding with root gap	Other processes with root gap
Maximum permissible difference in bore			
≤ 100 mm	0.8 mm	0.8 mm	0.8 mm
> 100 mm and ≤ 300 mm	0.8 mm	1.6 mm	1.6 mm
> 300 mm	1.2 mm	2.5 mm	2.5 mm
Maximum misalignment at the bore			
≤ 100 mm	0.8 mm	0.8 mm	0.8 mm
> 100 mm and ≤ 300 mm	0.8 mm	1.6 mm	1.6 mm
> 300 mm	0.8 mm	1.6 mm	1.6 mm
Notes The cumulative values for bore difference and misalignment may be applied provided any misalignment is evenly distributed around the full circumference of the joint. No backing rings are permitted.			

Where materials have been randomly selected for use and the above cannot be met, components shall be selected based on matching end dimensions to minimize misalignment to within tolerances distributed evenly around the circumference of the joint. Excessive misalignment shall not be rectified by any hammering, cold working or heating of the pipe / components. Under no circumstances shall brackets, cleats or other temporary attachments be welded to the components for alignment purposes.

The use of internal or external clamps may be used to rectify misalignment issues, if permitted by the approved WPS, noting the percentage of root weld qualified that shall be deposited prior to clamp removal.

In the case of jointing material of dissimilar wall thicknesses the thicker walled items shall be prepared as per Figure 1.



t = design thickness of thinner pipe

A = 14° +4 ° - 0 °

Figure 1 – Weld preparation for thicker pipe or component of a dissimilar thickness weld

The Contractor shall submit a method statement for the correction of excessive joint misalignment for approval by the GT.

For socket joints, the pipe end shall be inserted fully into the socket and then withdrawn 2.0 mm + 0.5 mm - 0 mm (see Figure 2). This gap is vital to the integrity of the finished joint. The assembly shall be checked to be squarely aligned and any necessary adjustment made prior to tack welding (see 11.8).

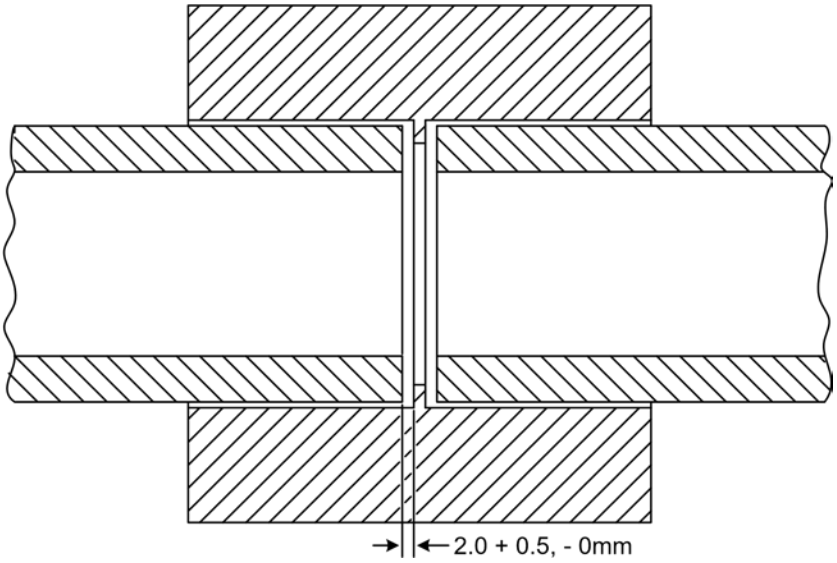


Figure 2 – Configuration for socket joints required prior to welding

When required by the GT, the Contractor shall demonstrate that the correct alignment and expansion spacing has been achieved for socket welded joints by destructively testing a production weld chosen at random by the GT or their representative. Alternatively, the joint can be examined by radiography to confirm the original joint fit-up is acceptable.

11.7 Tack welds

Tack welds shall only be deposited by qualified Welders in accordance with the approved WPS root pass parameters and conditions.

The minimum preheat specified on the WPS shall be applied for all tack welding and components shall be dry, free from any form of contamination and shall be degreased if required.

For clarity, the two types of tack welds permitted by the GT's are:

1. Root tacks – where the tack weld is to remain as part of the final weld root. These shall be feathered at the edges by grinding and free from visual defects to facilitate good fusion during subsequent root pass welding

2. Bullet tacks – where a section of round bar material of appropriate dimension is used to bridge the weld preparation and is tack welded to the fusion faces. The material used shall be the matching / same grade as the components being welded and certification shall be available. The tack welds to the bullets shall be contained within the fusion faces of the weld preparation and under no circumstances encroach onto the inside or outside surfaces of the material adjacent to the fusion faces. Bullet tacks shall be removed with care as root welding progresses

The use of either tack welding option shall be specifically captured in the supporting weld qualification and this should be demonstrable in the WPQR document.

Bridge tacks, where weld metal build up on each fusion face bridges above the root region (i.e. with no bullet) shall not be permitted in any case.

Bullets fabricated from carbon steel buttered with the grade of stainless steel filler being used in the WPS shall not be permitted.

Tack weld lengths shall align with the following:

- Outside diameter up to and including 60.3 mm — Minimum tack weld length 15 – 25 mm
- Outside diameter >60.3 up to <168.3 mm — Minimum tack weld length 25 – 50 mm
- Outside diameter 168.3 mm and above — Minimum tack weld length 50 mm

The number of tack welds shall be sufficient to maintain a consistent root gap and counter the effects of distortion during welding but shall be not less than three in all cases.

11.8 Tack welding socket joints

Socket joints assemblies shall be dry before welding and shall be tack welded to maintain alignment during the welding cycle. Tack welds shall be equally spaced and of sufficient number to prevent distortion. The tacks shall be ground smooth and the ends tapered to ensure fusion of the remainder of the weld run.

11.9 Working clearance

Sufficient access shall be provided adjacent to and around the weld for all activities associated with preparation, welding, inspection and testing and of the welded joint.

11.10 Background lighting

Attention is drawn to the need for adequate workplace lighting, both in a workshop and on site, to provide safe working conditions and to meet specified illumination levels for the inspection of welds. Background lighting should be in accordance with The GT procedure for interior or exterior illumination levels for working areas, */PM/EL/1. The GT specification for the non-destructive testing of welds (*/SP/NDT/2) shall define the required illumination levels for visual and dye penetrant inspection.

11.11 Weather conditions

For work on site, the GT will decide in consultation with the Contractor, whether the weather conditions are such that work has to cease or whether with adequate weather protection, welding can proceed or continue.

Weather canopies or habitats shall be of adequate size to provide unhindered access for all heating, welding and inspection activities. Provision shall be made for adequate welding fume extraction as required and in accordance with HSE guidance.

The weld joint and an area 150 mm either side minimum shall be kept dry at all times.

No welding shall be attempted when ambient temperature is below 5 °C unless adequate provisions are in place for the commencement and maintenance of preheat as required for the duration of welding.

When using gas shielded processes, extra care shall be taken that winds do not disrupt or remove the gas shield.

Open ends of pipes and assemblies shall be blocked off using appropriate end caps and plates as required.

11.12 Back purging

When back purging is required the Manufacture or Contractor shall provide a procedure that fully describes the back purging operation, the procedure shall be approved by the GT.

To prevent oxidation of the internal surface of the root bead and HAZ, it is essential that all air shall be removed by the admission of a volume of purging gas at least six times the volume of air being displaced. Prior to welding, the back purge shall be set up in accordance with the approved method statement and WPS. It is recommended that “purge monitoring devices” should be used, following a sufficient period of time, to ensure an Oxygen content of less than 0.5%.

Where different purging and maintenance flow rates have been qualified as part of the WPS these shall be replicated for all applicable welds during production and reflected in the approved procedure.

Back purging gas shall be maintained at the qualified flow rate for all weld passes or unless qualified otherwise by the approved welding procedure. Purge dams and seals shall be left in place until completion of the joint.

11.13 Pre-heating

Pre-heating or PWHT is not usually required for the grades of stainless steel covered by this specification, however, if a specific requirement for pre-heating or PWHT is required it shall be in accordance with an approved and qualified welding procedure. All components shall be dry immediately before welding, when the ambient temperature is below 5°C a minimum pre-heat temperature of 10°C shall be applied.

When a specified pre-heat is required, the minimum pre-heating temperature shall be confirmed using temperature-indicating crayons (which melt when the required temperature is reached) or by contact digital thermometer. Crayons or paints that indicate temperature by colour change or infrared pyrometers are not permitted. The component temperature shall be measured immediately prior to welding and around the entire periphery of the joint while welding is taking place.

Temperature indicating crayons uses shall be suitable for stainless and not contain chlorides etc.

The method of thermocouple attachment and removal if applicable, shall be approved by the GT.

11.14 Heat input

Heat input shall be controlled as identified in BS EN ISO 15614-1 and this specification.

The maximum heat input for welding austenitic stainless steels shall 2.5 kJ/mm.

11.15 Weld inter-pass temperature

The weld inter-pass temperature shall not exceed 150°C or the maximum inter-pass temperature qualified and specified in the approved WPS sheet if lower. Weld inter-pass temperatures shall be regularly monitored during welding.
Temperature-indicating crayons will only indicate that a particular temperature has been reached, they will not indicate how much the temperature has been exceeded, therefore, care is required when monitoring maximum weld inter-pass temperatures and the GT had the right to request interpass temperature is demonstrated using digital contact thermometer.

11.16 Inter-run cleaning

The weld should be visually inspected during the deposition of individual runs to ensure, as far as possible, that the correct, stipulated welding procedure is being implemented.

All weld deposits shall be cleaned using stainless steel wire brushes, grinding wheels or tools. Such tools and equipment shall be dedicated for use on stainless steel only and shall not be allowed to come into contact with other types of steel.

Individual weld runs shall be free from visible defects, including convexity, which could affect the deposition of subsequent runs and the acceptability of the completed joint. Irregular weld profiles constituting a sharp section change outside specification requirements shall be dressed so as to blend smoothly with the associated weld metal or parent body.
In all cases the weld as deposited shall be free from cracks and other deposition faults within the limits applied.

11.17 Weld surveillance

During all production welding activities on site and in the workshop, the Contractor shall have available a means of monitoring the welding parameters, essential variables and demonstrate the heat input requirements of the WPS are being met. The Contractor shall ensure the personnel operating the equipment are competent to do so.

Weld surveillance provides assurance and evidence that throughout the duration of production welding that the approved WPS has been adhered to.

The equipment used for the purpose of production welding surveillance shall be within calibration and shall be independent of the welding plant and equipment. The methods and equipment used for production welding surveillance shall be capable of providing a record of the following:

- Welding current
- Welding voltage
- Arc time (with Welding Inspector inputs of run out length to derive welding speed)
- Wire feed speed
- Shielding gas flow rate
- Backing gas flow rate (if applicable)

The expectation is that internal surveillance activities are carried out at sufficient frequency to demonstrate that welding is being carried out in accordance with the approved WPS. Whilst the appropriate frequency to ensure this is demonstrated will vary depending on the components being welded, number of WPS and number of welders, the general expectation is that a weld surveillance is performed once per shift per WPS being used or every 10% of production welds when welding

continuously with the same WPS. Note that it is expected this shall increase though the use of multiple WPS and / or increased number of welders.

Records of weld surveillance activities shall be made and presented in the final document package.

In the case where quality issues arise during production welding, weld surveillance can enable the extent of production affected to be determined and remedial action more focused and potentially limited.

11.18 Post weld heat treatment

PWHT is not typically required for the austenitic grades of stainless steel covered by the scope of this specification. However if the design application required the production welds to be subject to a subsequent heat treatment process the PWHT procedures shall be submitted for approval.

The WPQR shall be generated for the proposed PWHT using project materials. The use of previously qualified WPQR on other non-project materials to support a WPS for production welding shall not be permitted.

As a minimum, the procedure submitted for PWHT shall contain the following:

- Name of PWHT contractor
- Design code and specification for PWHT
- Material details – referencing specifications and grades
- Heating method – gas or electric
- PWHT – local or full body furnace
- Thermocouple arrangement drawing indicating type and locations of master and reference thermocouples on all applicable items
- Attachment method of thermocouples
- Furnace loading temperature
- Heating rates
- Holding time and temperature
- Cooling rates
- Furnace loading diagram
- Furnace opening temperature
- Thermocouple removal method
- PWHT chart recording equipment and speed and calibration details

12. Inspection of welded joints

12.1 General

All non-destructive testing (NDT) procedures shall be approved by the GT prior to the examination of procedure test welds or production welds.

NDT of procedure test welds and production welds shall be as per Table 6

Table 6 – Non-destructive testing requirements

Test piece configuration	Type of test	Extent of testing	BS EN ISO – 15614-1 Section 7.3
Butt weld full penetration	Visual	100%	BS EN ISO 17637
	Dye Penetrant testing	100%	BS EN ISO 3452-1
	Radiography Or Ultrasonic testing	100%	BS EN ISO 17636-1 / 2 Or BS EN ISO 17640
T-butt full penetration	Visual	100%	BS EN ISO 17637
	Dye Penetrant testing	100%	BS EN ISO 3452-1
	Radiography Or Ultrasonic testing	100%	BS EN ISO 17636-1 / 2 Or BS EN ISO 17640
Fillet weld	Visual	100%	BS EN ISO 17637
	Dye Penetrant Testing	100%	BS EN ISO 3452-1
	Radiographic testing[1]	Film	BS EN ISO 17636-1 / 2
Welds not subject to hydrostatic testing (golden welds)	Visual	100%	BS EN ISO 17637
	Dye Penetrant testing	100%	BS EN ISO 3452-1
	Radiographic testing	100%	BS EN ISO 17636-1 / 2
	Ultrasonic testing	100%	BS EN ISO 17640

Note:
[1] Radiographic testing required to confirm the gap in socket welded joints (clause 11.6).

In order to allow the identification and accurate evaluation of weld defects and to ensure that the specified defect acceptance criteria have been met, the proposed method(s) of non-destructive testing shall be capable of finding all imperfections or flaws in both parent materials and weld metal. The results of all NDT shall be recorded and shall include the location, size and nature of all flaws detected.

The NDT of welds shall be planned to minimise the need for site radiography. Consideration shall be given to less hazardous NDT methods for the site examination of welds where this is a practical alternative. The extent of NDT to be applied to welds that will not be subject to hydrostatic testing (golden welds) shall be agreed with the GT prior to welding.

Where local dressing is used to aid the interpretation of non-destructive testing or to confirm defect indications, care shall be taken to maintain the material minimum design thickness.

All austenitic stainless steel fillet test welds shall be examined visually and by DPI.

Complementary NDT methods may be required to identify flaw characteristics.

Should it be required to confirm that a welded joint fully meets the acceptance criteria of a qualified welding procedure (e.g. that the correct expansion gap has been allowed in a socket welded joint) and NDT methods prove inconclusive, additional destructive testing may be needed to prove that the requirements of the appropriate welding standard or specification have been met.

The GT reserves the right to require the complete removal of production welds to confirm the results of NDT and to prove that the mechanical properties of the weld conform to specification criteria. When required by the GT destructive testing shall consist of the removal of complete welds for mechanical testing in accordance with the appropriate welding standard or specification.

12.2 Qualification of personnel

Personnel performing NDT in accordance with this specification shall be qualified to the appropriate grade(s) in the BGAS-CSWIP Inspector approval scheme. As an alternative the GT may consider personnel approved in an equivalent grade by the CSWIP or PCN certification schemes.

Operators of all types of NDT equipment should be required to demonstrate to the approval of the GT the capability of the equipment and examination procedure to detect flaw indications. Operators may be asked to demonstrate their ability to make correct interpretation of defect indications given by the equipment.

12.3 Visual acuity

All NDT personnel responsible for the visual examination of components, the interpretation of radiographs and the application and interpretation of surface breaking defect detection methods (e.g. dye penetrant inspection) shall be capable of meeting the following eyesight requirements as per BS EN ISO 9712:

a) Near vision acuity shall permit reading a minimum of Jaeger number 1 or times roman N 4.5 or equivalent letters at not less than 30 cm with one or both eyes, either corrected or uncorrected.

b) Colour vision shall be sufficient that the inspector can distinguish and differentiate contrast between the colours used in the NDT method concerned.

c) Shades of grey test shall be used to assess the ability to distinguish between different shades of grey

12.4 Safety considerations

All personnel engaged in activities associated with this specification shall comply with all the relevant safety requirements of the particular work location, such as the requirement for personnel protective equipment (PPE), safety passport, confined space training where applicable and site induction.

Where a method statement or risk assessment for the inspection activity is available then this shall be read and understood and all requirements adhered to. However, if the documents are not available then advice shall be sought before work commences.

12.5 Visual inspection

12.5.1 General

All fusion faces, joint set-ups and welds shall be visually inspected before and during welding to ensure that the requirements of the approved WPS are complied with. The external and internal surfaces (where accessible) of the completed weld shall be examined to confirm that the weld reinforcement blends smoothly with the associated pipe wall without overflow or lack of toe fusion.

The GT reserves the right to specify the visual inspection of the root of single sided welds be carried out. In the cases where this requires the use of optical aides, i.e. fiber optic devices or mirrored borescopes, the equipment shall be able to take both moving and still images for reporting purposes.

All welds shall be accepted by visual inspection prior to subsequent NDT methods and a formal record made of this activity.

12.5.2 Stray arc strikes

Arc strikes are not permitted. Arcs shall be struck only on the fusion faces of the joint and not on other areas of the pipe. In order to reduce the risk of unintentional arc strikes, electrode holders shall be of the fully insulated type. Material affected by an arc strike, shall with the agreement of the GT, either be repaired or rejected. Arc strikes not caused specifically by the electrode, i.e. damaged cable shrouds, electrode holders and earth connections; shall be rejected in all cases and the pipe or component containing the defect cut-out.

If it is not possible to verify the origin of an arc strike it shall be cut out.

Where the GT agrees that an arc strike may be repaired, it shall be removed in accordance with a documented procedure that required approval by the GT. The procedure shall define the method(s) of removal of the arc strike, blending of the excavation, DPI and ultrasonic wall thickness measurement of the dressed area to confirm that the pipe or fitting is within permitted tolerances.

If the GT is not satisfied with the remedial work carried out to rectify an arc strike it reserves the right to reject the affected component(s).

12.6 Dye penetrant inspection

12.6.1 General

Dye penetrant inspection (DPI) shall be carried out as described in BS EN ISO 3452-1. Inspection personnel shall be qualified to the BGAS-CSWIP dye penetrant inspector level 2. The GT may also consider the use of personnel approved to a CSWIP or PCN Level 2 for Liquid Penetrant Testing.

A specific examination procedure shall be submitted for the approval of the GT prior to commencement of any DPI. Mechanical pre-cleaning shall not be carried out prior to test and a chloride free penetrant shall be used.

12.6.2 Extent of dye penetrant inspection

Fusion faces shall be examined by the DPI method before welding. If for any reason a weld is left in an uncompleted condition and allowed to cool to ambient temperature, a DPI test shall be carried out in the event the GT allows the weld to be completed. Prior to recommencing welding all traces of the DPI test residue shall be removed.

After all welding has been completed DPI shall be carried out on the external weld zone and where possible, the internal surface of the root bead and adjacent HAZ.

The results of all DPI shall be recorded, assessed to the relevant specification and reported in an appropriate format for inclusion in final documentation packages for all fabricated assemblies, pipework and / or pipelines produced.

12.7 Radiographic testing

When conditions exist that would preclude the use of ultrasonic inspection, all butt welds shall be examined 100% by radiography. The extent of radiographic inspection of fillet welds when required shall be agreed with the GT. The preferred method of radiographic examination is by X -radiography, the use of gamma ray sources shall require the explicit approval of the GT in all cases.

Radiography shall be carried out in accordance with Appendices C, D and E.

Radiographs shall be stored in a secure and dry environment. The films shall be retained for at least one year or for the life of the contract. After this period, where it can be confirmed that other records of the inspection results exist, the films may be disposed of.

12.8 Ultrasonic Testing

Ultrasonic testing shall be carried out in accordance with Appendix F

12.9 Positive material identification

If requested by the GT, a procedure covering the use of PMI shall be submitted for approval.

PMI shall be carried out on the final completed assemblies or sub-assemblies / fabrications etc.

PMI shall not be used to supplement or replace a lack of traceability. Where material cannot be identified by material certification and marking it shall be rejected by the GT.

13. Standards of acceptability

13.1 General 13.1.1 Scope

These standards of acceptability are applicable to the determination of the size and type of defects located by visual inspection and / or other NDT methods.

13.1.2 Rights of rejection

Standard radiographic methods produce a two dimensional image only, therefore the GT reserves the right to reject a defect that appears to meet the acceptance criteria on length but may prove detrimental to weld integrity due to the through wall extent of the defect.
Weld geometry

13.1.3 Weld reinforcement

Weld reinforcement on the internal and external weld profiles shall be as given in Table 7.

Table 7 – Weld reinforcement limits

Internal weld reinforcement		
Nominal pipe size	**Maximum penetration in bore**	**Maximum restriction**
< 12 mm	0.8 mm	1.6 mm
≥ 12 mm to < 50 mm	1.5 mm	3 mm
≥ 50 mm to < 100 mm	2.5 mm	5 mm
≥ 100 mm	3 mm	6 mm
External weld reinforcement		
Pipe wall thickness	**Weld reinforcement**	
	Minimum	**Maximum**
≤ 2.9 mm	Shall not be lower than the adjacent parent metal	2.5 mm
> 2.9 mm to ≤ 4.5 mm		3.0 mm
> 4.5 mm		4.0 mm

13.1.4 Undercut on branch connections

Undercut on branch connections is unacceptable and should be ground out to blend with the adjacent weld and tube material prior to NDT. Such grinding shall not reduce the wall thickness below the specified minimum or form a notch effect.

13.2 Defect acceptance criteria

The defect acceptance criteria for welded joints shall be in accordance with quality level B of BS EN ISO 5817 and the requirements of this specification.

Linear misalignment shall be assessed in accordance with clause 11.6 of this specification.

13.3 Cracks

The cause of any visible crack or crack-like indications found during welding shall immediately be investigated by the Contractor and reported to the GT or to the GT's representative.

Should a crack be confirmed then the complete joint shall be cut-out and removed. When a cracklike indication is proven not to be a crack, it may be removed by grinding and the joint completed.

If the cause of cracking is not immediately identifiable but is considered to be attributable to either the WPS being used or the materials being welded, the Contractor shall immediately withdraw the WPS from use and quarantine any suspect material until a definitive cause of cracking is established and corrective action agreed with the GT.

14. Rectification of defective welds

14.1 General

No weld shall be repaired without the approval of the GT. The Contractor shall record and report to the GT all remedial and / or repair welding carried out to each welded joint. Welds that fail to meet the acceptance criteria shall be repaired locally or removed completely.

14.2 Removal of defects or flaws

Defects or flaws in butt or fillet welds shall be removed by chipping, machining or grinding or air-arc gouging, followed by grinding. When air-arc gouging is used for a full penetration repair, the last 3 mm of the original weld shall be removed by mechanical means, such as grinding.
The weld repair excavation shall be sufficiently deep and long enough to ensure complete removal of the defect or flaw. A gradual taper (e.g. one in one) shall transition from the weld surface to the base of the excavation at each end. The angle or slope of the sides of the excavation shall be in accordance with the approved repair WPS.

The minimum length of a repair excavation shall be 70 mm.

No more than two repair regions are permitted in a single weld.

Individual repairs shall be separated by a minimum 100 mm circumferential length. If this cannot be satisfied, the two regions shall be joined into a single repair excavation, providing the maximum length requirement below is satisfied.

Repairs shall be limited to 30% of the weld length for a partial penetration repair or 20% of the weld length for a full penetration repair. If repairs cannot be completed within the stated tolerances the joint shall be completely removed.

Complete welds shall be removed by mechanised plasma thermal or cold cutting methods, such as saw cutting or machining. Following thermal cutting, fusion faces shall be prepared by machining or grinding to the original bevel dimensions specified in the approved WPS. The removal process shall be such that all traces of original weld and HAZ are completely removed from the pipe end(s) to be prepared for re-welding.

14.3 Re-welding

Weld repairs shall be carried out in accordance with a written repair WPS. The welding procedure details contained therein shall be in accordance with the original approved WPS or to a qualified and approved repair WPS supported by a specific repair WPQR.

All repairs shall be a minimum of three weld passes. No single pass repair welding is permitted.

Repair welding shall only be performed by qualified welders. Separate welder qualification tests may be required for repair welding subject to the limitations of clause 10.

The weld cap deposition sequence of the repair weld shall match the original weld profile and width i.e. single or multiple pass, and shall be in accordance with the approved WPS.

Weld repairs shall only be implemented under constant supervision and shall be monitored by the GT's and the Contactor's representative in accordance with the approved quality plan (see 4.2).

More than one attempt to repair the same area of original weld is not permitted.

14.4 Re-examination of repair welds

Weld repair areas shall be subject to the same level of inspection as the original weld joint.

NDT of the repair area shall extend for a minimum of 25 mm from the weld toe on each side of the repaired portion of the joint and beyond each end of the repair excavation.

The GT shall approve all re-examination methods prior to production welding commencing.
Should re-examination of the repair area reveal further flaws or defects they shall be evaluated as new flaws or defects in accordance with clause 13.

If the repair fails to meet the acceptance criteria, the entire weld shall be removed in accordance with clause 14.2.

15. Records

Records shall be produced by the Contractor to confirm that the requirements specified in this document for welding, examination, inspection and testing of each weld have been met. The records shall ensure complete identification and traceability for all activities associated with the planning, design, qualification, execution, inspection and testing of the welded components.

The records shall include but not be limited to, when applicable:

- Welding procedure specifications (pWPS and WPS)
- Welding procedure qualification records
- Welder and welding operator qualifications
- Quality plan
- Inspection and test plan
- NDT procedures
- NDT personnel qualifications
- NDT and visual inspection reports
- As built drawings
- GA drawings
- Material traceability records
- Material certificates
- Welding consumable certificates
- Dimensional survey reports
- Fabrication reports
- Weld surveillance reports
- PMI reports
- Calibration certificates

APPENDIX A - REFERENCES

This Specification makes reference to the documents listed below: There no date is identified specifically, the latest version / edition shall be used.

	British Standards
BS EN ISO 9606-1	Qualification test of welders – Fusion welding. Steels
BS EN ISO 3452-1	Non-destructive testing. Penetrant testing. General principles.
BS EN ISO 14732	Welding personnel. Qualification testing of welding operators and weld setters for mechanised and automatic welding of metallic materials.
BS EN ISO 11699-1	Non-destructive testing. Industrial Radiographic film. Classification of film systems for industrial radiography
BS EN 1011-1	Welding. Recommendations for welding of metallic materials. General guidance for arc welding
ISO/TR 18491	Welding and allied processes. Guidelines for measurement of welding energies.
BS EN ISO 17636-1	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film
BS EN ISO 17636-2	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors
BS EN ISO 3581	Welding consumables. Covered electrodes for manual metal arc welding of stainless and heat-resisting steels. Classification
BS EN 10204	Metallic products. Types of inspection documents
BS EN 12668-1	Characterisation and verification of ultrasonic examination Equipment. Instruments
BS EN ISO 3834-1	Quality requirements for fusion welding of metallic materials. Criteria for the selection of the appropriate level of quality requirements
BS EN ISO 3834-2	Quality requirements for fusion welding of metallic materials. Comprehensive quality requirements
BS EN ISO 3834-5	Quality requirements for fusion welding of metallic materials. Documents with which it is necessary to conform to claim conformity to the quality requirements of ISO 3834-2, ISO 3834-3 or ISO 3834-4
BS EN ISO 4063	Welding and allied processes. Nomenclature of processes and reference numbers
BS EN ISO 5817	Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections
BS EN ISO 9001	Quality management systems. Requirements.
BS EN ISO 14175	Welding consumables. Gases and gas mixtures for fusion welding and allied processes
BS EN ISO 15609-1	Specification and qualification of welding procedures for metallic materials. Welding procedure specification. Arc welding
BS EN ISO 15614-1	Specification and qualification of welding procedures for metallic materials. Welding procedure test. Arc and gas welding of steels and arc welding of nickel and nickel alloys

BS EN ISO 26848	Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding – Codification.
BS EN 10204	Metallic products. Type of inspection documents
BS EN 10216-7	Welded steel tubes for pressure purposes. Technical delivery conditions. Stainless steel tubes.
PD CEN ISO/TR 15608	Welding. Guidelines for a metallic materials grouping system
BS EN ISO 22825	Non-destructive testing of welds. Ultrasonic testing. Testing of welds in austenitic steels and nickel based alloys
BS EN 12668-1	Non-destructive testing. Characterization and verification of ultrasonic examination equipment. Instruments
BS EN 12668–2	Non-destructive testing. Characterization and verification of ultrasonic examination equipment. Probes
BS EN 12668–3	Non-destructive testing. Characterization and verification of ultrasonic examination equipment. Combined equipment
BS EN ISO 18563-1	Non-destructive testing. Characterization and verification of ultrasonic phased array equipment. Instruments
BS EN ISO 18563-2	Non-destructive testing. Characterization and verification of ultrasonic phased array equipment. Probes
BS EN ISO 18563-3	Non-destructive testing. Characterization and verification of ultrasonic phased array equipment. Combined systems
BS EN IEC 60974-1	Arc welding equipment. Welding power sources
BS EN IEC 60974-4	Arc welding equipment. Periodic inspection and testing
BS EN IEC 6097414	Arc welding equipment. Calibration, validation and consistency testing
	American Standards
ASME Section IX	ASME Boiler & Pressure Vessel Code. Qualification standard for welding, brazing, and fusing procedures, and welding, brazing, and fusing operators
	Internal Documents
*/PM/EL/1	Procedures for the selection, maintenance and installation of luminaires and lamps
*/SP/NDT/2	Specification for non-destructive testing of welded joints in steel pipelines and pipework
*/SP/DAT/29	Specification for permanent identification of steel components and pipes

APPENDIX B - DEFINITIONS

Approved welder	A qualified welder who has demonstrated competence by producing a test weld or welds that meet the requirements of the welding standard or specification.
Design temperature	The minimum test temperature based on minimum design temperature defined by the designer for weld metal and HAZ impact testing.
Approved welding operator	A qualified welding operator who has demonstrated competence by producing a test weld or welds that meet the requirements of the welding standard or specification.
Bell-hole	An excavation that permits access to below ground pipe work to facilitate the welding, inspection, coating or any other activity required to conduct the works.
Consistency trials	A series of consecutive pre construction welds made by the Contractor intended to demonstrate to the GT that the proposed welding process or welding system has the technical capability to consistently produce sound welds with the desired mechanical and metallurgical properties using the approved welding procedure.
Contractor	Person(s), firm, Manufacturer or Fabricator who has been engaged by the GT to perform the welding and inspection of austenitic stainless steel pipework to this specification.
Dressing	Light grinding in the weld area to remove surface flaws, defects and / or surface irregularities without reducing wall thickness below the minimum thickness required in the pipe purchase specification.
Golden weld	A production weld that will not be subject to hydrostatic testing.
Gas Transporter (GT)	Cadent Gas Limited, Gas Networks Ireland, National Grid, Northern Gas Networks, SGN or Wales & West Utilities
Inspector	The body, association or person who monitors that the materials and construction are in accordance with this specification.
Statutory Authority	The body or organisation that, through the power vested in it by Government Statute regulates the requirements with which particular pipelines have to comply.

APPENDIX C – RADIOGRAPHIC EXAMINATION

General

The main requirement of the Ionising Radiations Regulations is that NDT contractors should adopt working practices capable of keeping radiation exposures of employees as low as reasonable practicable.

If work involves routine radiography of readily moveable articles, an assessment shall be made to establish whether site radiography is appropriate or if the articles may be taken to a cell for examination. Appendix D provides a flowchart and guidance to facilitate the assessment.

Before any radiography is carried out a copy of the local rules as defined by the Ionising Radiations Regulations shall be given to the GT. These will identify the names and contact details for both the radiation protection adviser (RPA) and the radiation protection supervisor (RPS). The local rules shall be displayed on the site office notice board and at all locations where radiography is being carried out.

The Radiography shall be carried out in accordance with BS EN ISO 17636-1 or 2 and to the requirements of this specification. The minimum standard of radiography produced shall be in accordance with Class B (improved techniques). Class A shall not be permitted without the written agreement of the GT and only where Class B cannot be achieved for sound technical reasons.

All butt welds tested shall be completely examined (100% of the weld length) by X-radiography or manual phased array ultrasonic inspection.

It is not the GT policy to use sealed sources i.e. Gamma isotopes for weld examination. However, conditions may exist that prevent the practical use of X-ray or ultrasonic methods, in such circumstances the GT may consider the use of alternative NDT methods. Any proposed alternative procedure or method of weld examination shall be qualified and approved by the GT prior to weld testing commencing.

The use of pre-packed films is dependent upon continuing satisfactory field performance. The GT has the final decision whether the use of pre-packed films is acceptable.

To provide acceptable film contrast the radiographic film shall be placed in close contact with the intensifying screens and the object under examination. Lack of film screen contact, even if local, may be cause for rejection of the radiograph.

Fine grain high contrast direct type film or ultra-fine grain high contrast direct type film meeting the requirements of BS EN ISO 11699-1 Class C4 should be used. Any variation to this requirement shall be stated on the radiographic procedure sheet and shall be approved for use by the GT. All radiographs shall be interpreted when dry

Permanent marking of the pipe for identification and re-location purposes as described in BS EN ISO 17636-1 or 2, Clause 6.5 shall be by non-contaminant indelible material only. No hard stamping shall be permitted.

Suitable padding shall be used on external X-ray sets to prevent damage or contamination to the pipe.

The minimum information to be displayed on the radiograph to ensure traceability will be agreed between the GT and the Contractor prior to work commencing.

Radiographic Personnel

Radiography shall be carried out in accordance with national and GT safety standards. All personnel engaged in radiography shall be familiar with the current legislation with respect to carrying out work with ionising radiation.

Each radiographic crew shall consist of at least two people. Each member of the crew shall hold, as a minimum, a valid Radiographic Assistant qualification grade in the BGAS/CSWIP approval scheme or CSWIP / PCN Radiographer Level 2 qualification. Prior to submitting radiographs to the GT, the

films shall be viewed by personnel holding a valid Radiographer grade in the BGAS/CSWIP scheme or CSWIP / PCN Radiographer Level 2 qualification. They shall confirm that the quality of the radiographs meets the requirements of this specification before submission to the GT.

Radiation Protection

The exposure of the human body to X-rays or Gamma-rays can be injurious, therefore it is essential that when radiographic equipment is used, adequate precautions are taken to protect all persons in the vicinity of the operation

Radiography shall not be undertaken unless the radiographers fully comply with the requirements of The Ionising Radiation Regulations (IRR99) and the recommendations given in the Approved Code of Practice and Guidance (Working with ionising radiation). Attention is drawn to the need for audible and visual warning arrangements. Regular monitoring of radiation levels by the radiographers is required.

Radiation Safety Monitoring

The GT has an obligation to the GT representatives, contractors and members of the public to monitor the standard of radiological safety maintained by radiographic Contractors on our sites. The items listed in Appendix D shall be regularly monitored by the GT or their representative and the results recorded

Radiographic Procedures

Radiographic examination of fusion welded circumferential butt welds in steel pipes shall be carried out as described in BS EN ISO 17636, using techniques 7.1.4, 7.1.3, 7.1.8 or 7.1.6 (i.e. the preferred order), as appropriate.

Where fittings are welded to other fittings or to short lengths of pipe, technique number 7.1.3 of BS EN ISO 17636 may be used. When using technique 7.1.3 then the number of exposures required shall be calculated using BS EN ISO 17636 figure A.1

Where BS EN ISO 17636 technique No 6.1.6 is used for pipe to pipe weld exposures, a minimum of three exposures 120° or 60° apart in that order (i.e. the preferred order), shall be made. Pipe to fitting and fitting-to-fitting butt welds shall require a greater number of exposures to achieve satisfactory coverage. Superimposed images are not permitted.

When using technique 7.1.8 then the number of exposures required shall be calculated using BS EN ISO 17636 figure A.2. Where technique 7.1.8 is used to examine pipeline butt welds, the 6 o'clock weld location shall be positioned in the center of the diagnostic film length.

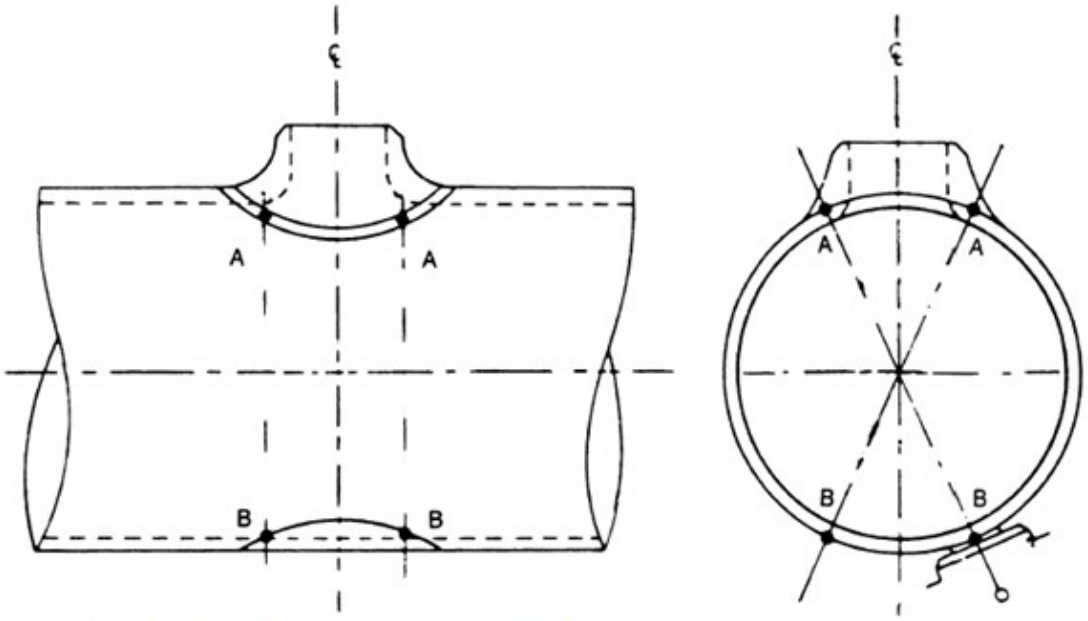
When a complete circumferential weld is radiographed in a single exposure with the source inside the pipe (technique 7.1.4) and there is the possibility of backscatter from an adjacent object, at least one of the image quality indicators (IQI) shall be placed outside the pipe with the wires across the weld in a position opposite to the object. When a circumferential weld is radiographed using multiple exposures, an IQI shall be located at each end of the diagnostic film length with the thinnest wire outermost.

Forged set-in branch welds shall not be examined in a single exposure using a panoramic technique. The weld shall be examined in separate exposures with the X-ray focal point positioned at normal incidence to the area being examined to within 5 as shown in Figure A.1.

Either the single-wall, single-image or the double-wall, single-image technique may be used. When the single-wall, single-image technique (technique 7.1.3) is used, the film shall be placed against the inner pipe or fitting surface with the X-ray tube focal spot on the outside. The focal-spot-to-film distance shall be not less than 690 mm.

When access and/or other fittings prevent correct alignment of the beam, the double-wall, singleimage technique (technique 7.1.8) shall be used (each exposure shall be spaced equidistantly around the weld circumference):

Branches ≤ 150 mm nominal bore shall be examined in a minimum of four exposures. Branches of 200mm nominal bore require a minimum of six exposures. The number of exposures for branches > 200 mm nominal bore or branches with proportions significantly different to the type of fitting shown in Figure 3, shall be subject to agreement with the GT.



A = FILM CENTRES (4 FILM EXPOSURES)
B = Focal spot

Figure 3 – X-ray focal spot positioning

Radiographic Density

For pipe and fittings of the same nominal wall thickness, the radiographic density measured immediately adjacent to the weld reinforcement shall be within the range 2.5 to 3.5.

For pipe to pipe joints between pipes of different nominal wall thicknesses, where the thicker pipe has been transitioned to match the bore of the thinner pipe, the radiographic density measured immediately adjacent to the weld reinforcement shall be within the range 2.5 to 3.8.

Where the difference in wall thickness between the components being joined is substantial, i.e. certain types of fitting to pipe and fitting to fitting, the radiographic density measured in sound weld metal (typical of the average weld and reinforcement through thickness) shall be within the range 2.3 to 3.3.

If a film density within this range cannot be achieved in one exposure, either a sandwich technique using fine grain, high contrast film and ultra fine grain, high contrast film (technique 7.1.9), or two separate exposures of the weld shall be made.

Approved Radiographic Procedure

All radiographic procedures, details of the radiographic techniques and test radiographs* for each procedure shall be submitted to the GT for approval prior to production radiography commencing.

The procedure details shall include the following:

- Technique.
- Type of equipment and kV rating.
- Type of film.
- Intensifying screens.
- Shielding.
- Geometric relationship defined by sketch.
- Limit of film coverage.
- Tube voltage and exposure.
- Material thickness range.
- Type of image quality indicator and positions.
- Processing.

**To qualify a radiographic procedure three individual radiographs shall be made of each weld configuration covered by that procedure (preferably using the procedure test weld), this is used to establish consistency of the radiographic procedure. The x-ray equipment shall be re-positioned for each exposure.*

Film Processing and Storage

All unexposed film shall be stored in a clean, dry place where the surrounding conditions should not detrimentally affect the emulsion. At the discretion of the GT, the radiographic contractor shall demonstrate to the GT's satisfaction that the film can be processed, using the site facilities, to have a fog level not greater than 0.3.

The film shall be processed such as to allow storage without deterioration for a minimum of three years. Adequate washing of the processed film is required to reduce residual fixer content. .When the number of individual radiographs produced on a project exceeds 50, a thiosulphate test is required on 1 film in every 50 films processed. The results of the thiosulphate tests shall be recorded in a register and made available at site for audit purposes. The procedure for this test shall be submitted to the GT for approval prior any work commencing.

Processed film shall be stored in a suitable dry location separate from the processing dark room.

If radiographic images are to be stored digitally, the proposed method of storage, retrieval and the definition and sensitivity of the recorded image shall be approved by the GT prior to storage commencing.

Any software required to view the results shall be included on the data disc. Any software licenses shall be agreed prior to production welds being examined. The software version/number shall be clearly visible on all display presentations. The software shall be capable of displaying the retrieved radiographic image in the original format viewed by the interpreter at the time of sentencing.

Disposal of Processing Chemicals

Processing chemicals or wash water shall not be dispersed to the ground. The arrangements for disposal shall be to an agreed procedure that meets the GT environmental policy

APPENDIX D- MANAGEMENT OF SITE RADIOGRAPHY

Scope

This procedure identifies the controls necessary for the management of site radiography. A checklist is provided in Appendix E to facilitate the monitoring and audit of site radiographic operations to ensure compliance with the requirements of the Ionising Radiation Regulations and this specification.

This procedure shall also be used to determine the most appropriate method of conducting radiography. The procedure provides a decision tree, which shall be used to determine whether items requiring radiography testing should be transported off-site to a purpose built enclosure for radiography.

Implementation of these requirements does not imply that sufficient data has been included to demonstrate compliance with Ionising Radiation Regulations, it is the responsibility of the Radiographic sub-contractor and the main works contractor to ensure these regulations are complied with in full.

Introduction

The main requirement of the Ionising Radiations Regulations is that NDT Contractors should adopt working practices capable of keeping radiation exposures of employees as low as reasonably practicable.

The HSE guidance on complying with Ionising Radiations Regulations clearly states that if work involves routine radiography of readily moveable articles it is nearly always reasonably practicable to carry it out in an adequately shielded enclosure or cabinet. Where practicable, using a suitable shielded enclosure shall always be the first choice for radiography work. This enclosure can either be constructed on site or articles can be transported to a purpose built enclosure off site.

The flowchart in Figure 4 of this Appendix, provides a process which shall demonstrate that the selected method for conducting radiography keeps radiation exposures of employees as low as reasonably practicable.

Where site radiography is the only practicable option the objective of this document is to provide best practice guidelines to enable radiographic sub-contractors to undertake site radiography in a safe, consistent and auditable manner across all projects.

Roles & Responsibilities

The main responsibility for the implementation of this procedure lies with the specialist radiographic sub-contractor and the main works contractor.

Adequate information on radiation safety shall be included within the contractor's site induction talk and relevant toolbox talks shall be provided to personnel likely to be in the vicinity of radiographic works.

A Radiographic Protection Supervisor (RPS) will be appointed by the Radiographic sub-contractor and their details shall be displayed on the site office notice board and at all locations where radiography is being carried out.

All personnel are responsible for ensuring that site radiography is undertaken in a safe manner, any deviation to the planned safe system of work shall be reported immediately to the project supervisor or safety officer for rectification. Radiographic operations shall be subject to random monitoring and formal audit by the principal Contractor and the GT to ensure these requirements are implemented.

Options for Site Radiography

When radiography is required during the construction or modification of a pipeline or installation, the following options are available to the NDT contractor:

Articles are transported off site to permit radiography to be carried out in a purpose built radiographic cell.

Radiography is carried out on site in a temporary radiographic cell or enclosure.

Radiography is carried out on site in a controlled area with suitable local shielding and boundary monitoring.

Radiography is carried out in-situ with suitable local shielding and boundary monitoring

Radiography Decision Tree

The flowchart in Figure 4 shall be used to determine the most appropriate option for site radiography. The ability to safely transport pipe work assemblies during a project will vary as fabrication progresses, factors such as the overall size and weight of the assembly shall be considered. The fabrication and erection of pipe work assemblies that require radiographic inspection shall be planned to minimise the need for site radiography. It may be necessary to review the available options during the course of a project and revisit the flowchart.

The factors, which may influence the selection of the most appropriate radiographic method for each stage of a project, are:

- The ability to pre-fabricate and radiograph pipe work off site.
- The ability to safely transport pipe work fabricated on site due to weight, size and geometry, factors to consider are:
- Can the fabrication be safely transported off site to a radiographic cell?
- Can the fabrication which only be transported safely within the confines of the site?
- The locality of a purpose built radiographic cell or enclosure to the construction site.
- The availability of a controlled safe area for radiography on the construction site.

General Radiographic Requirements

Quality Management System

The principal contractor shall operate a quality management system in accordance with BS EN ISO 9001. Any radiographic sub-contractor employed by the principal contractor shall implement and maintain a similar quality management system that meets national standards.

Quality Management System Operated by the Radiographic sub-contractor

Personnel responsible for monitoring and auditing radiographic operations shall be fully conversant with the quality management system operated by the radiographic sub-contractor in order that any checks on radiographic activities and records may be undertaken in a controlled and auditable manner.

Personnel Protective Equipment (PPE)

All radiographic personnel shall wear the appropriate PPE identified by the project risk assessment.

Mobile Phones

All radiographic crew(s) shall have access to a mobile phone and/or two-way radio for contact purposes.

Personal radiation Monitoring Devices

Named personal radiation monitoring devices such as Thermo Luminescent Dosimeter (TLD) or film badges shall be worn at all times by classified workers and shall be clearly visible at all times whilst on site, under no circumstance are they to be left in overall pockets, in crew cabins etc. Consideration should also be given to the use of electronic dosimeters / alarms. The use of an unnamed (i.e. a numbered spare) TLD badge shall only be permitted during the first month of a new workers contract period or for additional monitoring purposes.

Responsibilities of the Radiological Protection Supervisor (RPS)

The role and responsibilities of the RPS shall be clearly identified and communicated in writing to the individual. The name of the RPS shall be clearly stated in the Local Rules.

Training Requirements for Radiographers

In addition to other pertinent training, the RPS and other site radiographers shall have received adequate instruction in the following:

- Understanding / Interpretation of Ionising Radiation Regulations
- Requirements of the site local rules and contingency requirements
- Requirements for method statements and suitable risk assessments.

Training of Personnel Responsible for Transporting Sealed Sources

Personnel responsible for the transportation of sealed sources shall receive appropriate training in dealing with emergency situations and the application of contingency plans.

Radiographic Documentation for Client Review

In accordance with the requirements of the Ionising Radiation Regulations and this specification the following documentation shall be produced by the radiographic sub-contractor and submitted for client review:

Risk assessments

Prior risk assessments and a methodology for dealing with the risks. The risk assessment shall take into account specific risks associated with working within the confines of an installation and the close proximity to other site and project personnel.

Radiographic technique sheets

Technique sheets are required for each radiographic technique to be used.

Method statements / working procedures

The Method Statement should identify the practical aspects of undertaking site radiography including:

- Equipment to be used
- Equipment ratings
- Type of film
- Storage of film
- Film processing
- Handling of chemicals
- Manual handling of radiographic equipment.

HSE Notification

Notification shall be sent to the HSE within the required notification period (28 and 7 days respectively) prior to site radiography being undertaken. This shall include advising of the location and timescales for the proposed radiography. A copy of all notifications shall be available on site for audit purposes.

Specific Radiographic Requirements

Radiation Protection Supervisor (RPS) Contact Details

When the use of a sealed source is permitted by the GT, a telephone number to contact the named RPS shall be displayed on the cabin and container where the sealed source is stored. These details shall also be displayed on the project notice board (s).

Storage Sealed Sources

When not in use, sealed sources shall be stored in a suitable approved transport container, secured within a secondary non-flammable container identified with appropriate radiation signs.

Transportation of Sealed Sources

When sealed sources are transported on the site, relevant radiation signs shall be posted on both sides and to the rear of the vehicle. When the source is in the vehicle and is left unattended for any reason, the vehicle shall be left in a secure state to prevent unauthorised access.

Fire Extinguishers

Appropriate fire extinguishers shall be available within the darkroom, sealed source storage area and site vehicles.

Lifting Equipment

All lifting equipment (slings, belts, chains etc) shall be suitably controlled, identified and have current test certification.

Inspection & Test Equipment

All inspection and test equipment used to provide primary measurement shall be uniquely identified, subject to formal control and calibrated to a known national standard.

Daily Checks

All equipment shall be maintained in a serviceable condition and daily equipment checks should be carried out on all radiographic equipment, radiation monitors and cables.

Site Radiation Safety

Precautions

Barriers shall be erected to prevent access to the controlled area. Suitable radiation signs and warning lights shall be displayed (including the contact details of the RPS). On pipeline sections the spoil heap and right of way fencing may provide natural barriers, however where there is a likelihood of access by unclassified persons, all relevant points of access shall have barriers and relevant signage. It is the responsibility of the radiographic sub-contractor to ensuring that the requirements of the Ionising Radiation regulations are complied with.

Monitoring of the Controlled Area

No amount of precautions can replace the importance of vigilance and proactive monitoring of the controlled area, to ensure that corrective action can be taken in the event of persons not involved in the work approaching the controlled area. The radiographers shall carry out continuous monitoring of the barrier boundaries during radiographic exposures. The radiographic sub-contractor shall ensure that the requirement to monitor the controlled area before and during radiographic exposure is clearly stated in the Local Rules.

Recording Boundary Dose Rates

Boundary does rates shall be recorded in a formal manner identifying the location of the area monitored. Formal measurement shall be undertaken for the first production exposure on each day, details of the person undertaking the test and the equipment used shall be recorded. Formal monitoring shall be carried out for each designated controlled area within the work site and verification made that the requirements of the Ionising Radiation regulations have been met. Any change to the size and type of controlled area shall require formal re-measurement of boundary dose rates.

Record Keeping

The responsible person shall undertake daily mobile sealed source accounting and formal records shall be kept to verify this. As a minimum the record shall identify source number, location, date and time of inspection, details of person undertaking inspection.

Movement Logs

Sealed source movement logs shall be kept to identify location of sealed source, this shall be completed when the source is issued for use, as a minimum the record should contain, source number, date and time issued, recipient of source, date and time returned.

Calibration Radiation Detector

All radiographers carrying out site radiography shall have a spare calibrated radiation monitor available. Personal monitoring devices cannot be considered as a spare radiation monitor. **Spare Accessories**

Spare bulbs and batteries shall be available with the crew(s) for all safety critical equipment.

Portable Electrical Equipment

All relevant portable electrical equipment shall be PAT tested.

Suitable Shielding

Where risk assessment requires, suitable shielding shall be available with the crew(s).

Radiographic Audits

In addition to routine monitoring the RPS shall undertake a formal documented audit on all crews within 5 days of commencement of site radiography to ensure safety controls are in operation and remain effective. Where site radiography is carried out intermittently during a project, the RPS shall carry out a formal documented audit once every five site visits.

Audit Records/Documentation

The following records/documentation shall be available for reference during site audits. If any of the following documentation is not present on site, work shall not be allowed to commence / continue:

- Certificate of registration for radioactive source's (Environment Agency)
- HSE notification of site radiography document
- Local rules and risk assessment (with crews)
- Technique sheets (with crews)
- Procedures / method statement (with crews)
- A copy of Ionising radiations regulations
- Passbooks for outside workers (if applicable)
- Calibration records for inspection and test equipment
- Sealed source wipe test results (2 yearly)
- Lifting equipment register and certification
- Daily source accounting records
- Source movement log
- Records of boundary dose rates
- Records of RPS crew audits
- Relevant personnel training records (RPS training, Driver training, QMS inductions,
- BGAS/CSWIP approvals or approved alternative, Safety passport etc.)

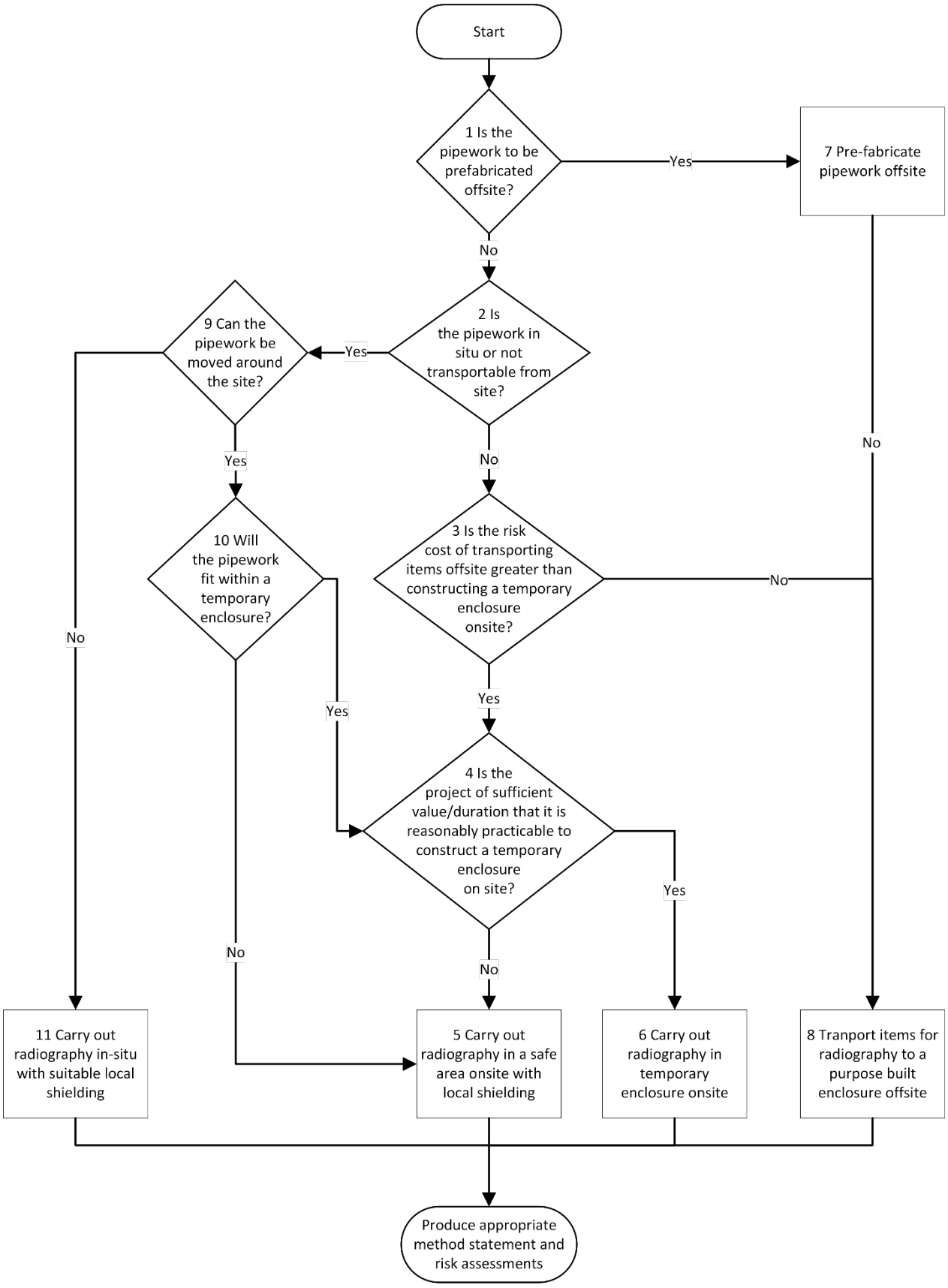


Figure 4 – Radiography decision tree

RADIOGRAPHY DECISION TREE - EXPLANATORY NOTES

The need for site radiography shall form part of the risk assessment process.
When feasible, pipe work should be pre-fabricated off site and examined by radiography in a purpose built cell or enclosure.

When it is reasonably practicable to transport pipe work off site for radiographic inspection this shall be the preferred option, however constraints such as the size or weight of a fabricated assembly may preclude this. Pipe work that can only be constructed in situ cannot be transported from site.

Where pipe work fabricated on site is transportable the cost of transporting to a purpose built enclosure for radiography should be compared against the cost of constructing a temporary enclosure on site. Where it can be demonstrated that the least cost option is to transport pipe work assemblies off site for radiographic inspection and it can be done safely then this shall be done. If transportation of the assembly would present a greater risk to personnel or other site pipe work due to for example; lifting operations, this shall be considered in the risk assessment.

1. An assessment should be carried out to determine whether it is reasonably practical to construct a temporary enclosure on site. Consideration needs to be given to the duration/value of the project and the amount of radiography which may actually be taking place on site. To avoid the construction of a temporary site enclosure it shall be demonstrated that the cost is grossly disproportionate to the reduction in risk which may be gained.
2. Where the assessment in item 4 concludes that radiography is to be carried out on site in a controlled area, the appropriate HSE guidance shall be followed to ensure that the exposures to radiation of employees is kept as low as reasonably practicable.
3. Where the assessment in item 4 concludes that a purpose built or temporary enclosure shall be constructed on site to carry out radiography. The temporary enclosure shall be constructed in accordance with the appropriate HSE guidance. Consideration shall be given to the installation of appropriate interlocks which prevent or terminate an exposure if the door of the enclosure is opened.
4. Although it may not be practicable to transport certain items off site due to the size of the assembly, where they can be safely moved within the confines of the site, and subject to the size of the assembly, then they shall be examined either in the temporary enclosure or the designated controlled zone/area.
5. For items constructed in situ that cannot be moved, in the first instance consideration shall be given to the use of less hazardous NDT methods. Where the only practical option to meet the inspection requirements is to carry out radiographic examination of the weld in situ, then additional appropriate local radiation shielding shall be used. Consideration may have to be given to conducting radiography ‘out of hours’ to ensure that radiation exposure to employees is kept as low as reasonably practicable.

APPENDIX E – SITE RADIATION SAFETY MONITORING CHECKLIST AND REPORT SHEET

Project:		**Date:**	
Location:			
Radiographic Contractor:			

a	General notes: Radiography is a hazardous activity. The GT has a responsibility to members of the public, its own employees and other contractors to ensure that site radiography is carried out in a safe manner. No one should enter 'controlled or supervised radiography zones' without the permission of the Radiographer and only when it is safe to do so. 'Classified personnel 'are permitted to enter these zones during an exposure.
b	Only suitably trained personnel may monitor and report on radiation levels and site radiation safety issues. Prior to starting radiography on site, a review of the appropriate preparations required shall be made using this checklist. Where work is ongoing, regular monitoring of site radiography is required. Should any of the checks reveal that the work cannot be carried out in a safe manner and in accordance with the Regulations (or any related documentation or procedures), work shall not commence or cease immediately until rectified.
c	The use of this checklist by the GT does not relieve the Radiation sub-contractor of their duties and responsibilities under the Ionising Radiation Regulations.
d	This record sheet should be circulated to the Project Manager, the Site Occupier and the Site Safety Officer as appropriate.
e	These records should be retained for the duration of the contract unless there are other requirements to keep them longer.

Abbreviations used:

HSE	Health & Safety Executive	RCD	Residual Current Device
RPS	Radiation Protection Supervisor	TLD	Thermo-luminescence Dosemeter

Item	Question	Finding ☑ ☒	Comments
	Authorisation for site radiography		
1	Has prior authorisation been granted by the HSE for industrial radiography using specified practices?		
2	Is there a copy of the authorisation document available? (A generic authorisation from the HSE Internet website may suffice).		
3	Have the HSE been notified that site radiography is to take place? (28 days (or in some cases 7 days) notice is required).		
4	Have the HSE acknowledged receipt of notification? (The HSE may not always provide documentary evidence of receipt of notification).		
	Radiographers		
5	Are the radiographers qualified to the BGAS/CSWIP approval scheme or to an approved equivalent?		
6	Has the RPS been identified in the local rules?		
7	Are the RPS contact details displayed on notice board and at work location		
8	Is (are) the RPS(s) in attendance?		
9	Is all equipment in good visual condition?		
10	Are all cables and connectors in good condition?		
11	Is the power generator earthed?		
12	Is an RCD fitted and operable?		
13	Is local shielding required?		

Finding

☑ **Item checked - Satisfactory** ☒ **Item checked - Unsatisfactory**

SAFETY MONITORING CHECKLIST AND REPORT SHEET (CONTINUED.)			
Item	**Question**	**Finding** ☑ ☒	
14	Are local shielding materials available?		
	Barriers, Warning Notices and Signals		
15	Have barriers been erected at the correct distance?		
16	Are the correct warning notices displayed?		
17	Are spare warning boards available?		
18	Is the boundary patrolled?		
19	Are records of boundary dose rate monitoring available?		
20	Is the x-ray control panel key adequately controlled?		
21	Are audible/visual warning signals available and working satisfactorily?		
22	Are spare light bulbs etc. available?		
23	Have all site staff been briefed on the dangers associated with radiographic operations (Site safety induction).		
	Dosimeters		
24	Are film badges or TLD being worn by the radiographers?		
25	Are the TLD's named, or if numbered are they traceable to the wearer?		
26	Are badge holders in good condition?		
27	Are surplus badges available on site? (If specified on contingency plan)		
28	Are TLD readers in use? (If specified on contingency plan)		
	Risk assessment, Local rules and Contingency plans		
29	Has a prior risk assessment been made?		
30	Is a copy of the Risk assessment available?		
31	Are Local rules and contingency plans available on site?		
32	Is the Local rules site specific?		
33	Are the radiation employees familiar with the above documentation? (see 29 -31).		
	Radiation Monitor		
34	Is there a monitor available and suitable for each source in use?		
35	Is a spare calibrated monitor available?		
36	Are the monitors in current calibration with valid certificates?		
37	Are the monitors in good condition without obvious damage?		
38	Are the monitor battery levels satisfactory?		
39	Are spare batteries available?		
40	What type(s) of radioactive isotope (s) may be used?		
41	Are the source container's design, construction and maintenance appropriate?		
42	Have test to detect leakage been regularly carried out and recorded?		
Finding	☑ **Item checked - Satisfactory**	☒ **Item checked - Unsatisfactory**	
			APPENDIX E sheet 2 of 3

SITE RADIATION SAFETY MONITORING CHECKLIST AND REPORT SHEET (CONTINUED.)			
Item	**Question**	**Finding** ☑ ☒	**Comments**
Sealed sources Note: In general it is not the GT policy to allow the use of sealed sources. However, when they are permitted (in addition to the above list) the Radiographic sub-contractor shall confirm the following items:			
43	Is a record sheet (updated daily), available that details the type, strength and location of each radiographic isotope in site?		
44	Are all sealed sources stored and transported on site in accordance with the Ionising Radiations Regulations?		
45	Are contingency plans included in the local rules in the event of loss or damage to a radiographic isotope?		
46	Are all emergency tools and equipment listed in the contingency plan available for use?		
Finding	☑ **Item checked - Satisfactory**	☒ **Item checked - Unsatisfactory**	
Notes:			

	Print name	**Signature**
The GT, Auditor or representative:		

APPENDIX F – ULTRASONIC EXAMINATION OF WELDED JOINTS

GENERAL

Proposed ultrasonic examination procedures for the examination of austenitic steel welded joints shall be submitted for the approval of the GT prior to any production welding commencing. The ultrasonic testing technique used can be conventional or phased array, manual, semi-automated (using encoders and scanners) or fully-automated. The proposed ultrasonic procedures, equipment checks and calibration methods shall comply with the relevant national or international standards, mainly BS EN ISO 22825.

Due to the heterogeneous, coarse and anisotropic nature of austenitic steel welds, the ability to adequately detect weld defects is entirely dependent on the use of appropriate and suitable ultrasonic examination equipment, techniques and procedures. Where the GT approves the use of manual ultrasonic or manual phased array inspection of welded joints, it will be subject to qualification. The specific ultrasonic procedure and technique shall be tested on austenitic test welds or blocks made from the same materials as the production welds to be examined. The austenitic test welds or blocks shall contain actual or simulated embedded and surface breaking weld defects in the form of notches and holes to demonstrate accurate defect detection and the sizing capability of the ultrasonic examination procedure.

QUALIFICATION OF PERSONNEL

Details of the contractors proposed operators/interpreters shall be submitted to the GT for review and approval prior to the start of any weld examination.

Operators /interpreters shall be qualified to PCN / CSWIP level 2 in the technique to be used, ultrasonic testing 3.2 or phased array ultrasonic operator. Operators /interpreters possessing an equivalent qualification in an alternative scheme or having provided evidence of training and competency to the satisfaction of the GT, may be proposed for consideration by the GT.

In addition to a general knowledge of ultrasonic weld testing, the operators shall be familiar with and have practical experience in testing problems specifically associated with the type of materials and weld joints to be tested. Specific training and examination of personnel should be performed on representative pieces (austenitic stainless steel) containing welds. This training and the examination results should be documented. If this is not the case, specific training and examination should be performed with the finalized ultrasonic testing procedures and selected ultrasonic testing equipment on representative samples containing natural or artificial reflectors similar to those expected. This training and the examination results should be documented.

All operators/interpreters shall be trained and competent in the use of the particular equipment that they may be expected to operate. Documentary evidence of adequate training and ongoing practical ability shall be provided to the GT for each proposed operator/interpreter.

TEST PROCEDURE AND ULTRASONIC TECHNIQUES

The test procedure and ultrasonic testing techniques shall conform to the requirements of BS EN ISO 22825.

Prior to the examination of any production welds the proposed examination procedure shall be submitted to the GT for review and acceptance. The procedure shall contain but not be limited to the following:

- Brief functional description of the system
- Any limitations of the system with regard to material or weld features including sound velocity variations, geometry, size, surface finish, material composition etc.
- Transducer configuration(s), characteristics, types, coverage
- Gate settings
- Recording and processing of data

- Temperature range for testing and limitations
- Maximum scanning speed and direction
- Reporting of indications and documentation of calibration and sensitivity settings
- Description of calibration block(s) including type, size and location of all calibration reflectors
- Calibration intervals
- Calibration records
- Identification of inspection starting point, scanning direction
- Method for scanner alignment and maintenance of alignment
- Transducer and overall functional checks
- Height, width and length sizing methodology
- Instructions for reporting including examples of recorder chart and forms.
- Diagram showing the weld scan zones for the weld prep to be tested.
- Frequency of calibration.

A technique sheet will be produced for each pipe wall thickness to be tested, detailed the actual scan settings to be used including a diagram showing ultrasonic coverage of the weld being tested.

The Scanning sensitivity will be set to 1.5 mm Side Drilled hole DAC/TCG, using a minimum of three holes. The use of other reference reflectors and sensitivity settings as per BS EN ISO 22825 are subject to approval by the GT.

The weld will be inspected using a combination of sectorial and linear scans designed to cover the HAZ, root, fusion face, cap and weld volume.

Welds in pipe with a nominal wall thickness over 9.0 mm shall be inspected using the following three scans:

- A scan of the weld root area with either a linear or sectorial set up but concentrated on looking for weld root defects
- Weld Fusion face scan using a linear scan with an angle set to impinge on the fusion face at an angle as near as practicable to 90°
- Weld volume and Cap scan using a sectorial scan

All scans will be gated to cover the HAZ and weld volume. Where both sides of a weld are being tested at the same time or the nominal pipe wall thickness is under 9.00 mm, then the number of scans may be reduced to prevent the system being overloaded with data, this shall be agreed with the GT during qualification of the system and before any inspections are carried out.

When an inspection of a pipe to fitting is carried out this should be carried out from both sides of the weld whenever possible, where this is not possible then a single sided scan is acceptable providing additional scans are carried out from the accessible side to supplement the missing data. The additional scans will be included in the procedure submitted for approval by the GT. Single sided weld ultrasonic examinations shall be supplemented by inspection of the weld cap using the dye penetrant inspection method.

Transition welds joining pipes of different wall thickness may only be examined by PAUT when the thicker material is counter-bored back by machining at least 50mm from the weld face or where it can be demonstrated that the heat effected zone (HAZ), both fusion faces and the weld volume can be inspected with the proposed procedure.

All scan settings should allow for the probe standoff to move slightly during scanning.

QUALIFICATION OF PROCEDURE

Before any system is used for the inspection of production welds it shall be qualified to the satisfaction of the GT. When required by the GT the procedure for qualification may include the scanning of a weld or welds* and to report any flaws that are outside the acceptance criteria in

accordance with the relevant standard. The results from the qualification scan shall be analysed by the GT to confirm acceptance of the system and operators.

[*When required by the GT the proposed PAUT system shall be used to scan a pre-production weld produced using the approved contract weld bevel design. The pre-production weld shall be manufactured during the welding procedure qualification stage and shall contain deliberately induced weld defects typical of the welding process being employed. The test weld shall be subject to radiographic examination to confirm the type and orientation of defects produced.]

The results of the PAUT scan and radiographic inspection including details of the length, width and where possible, the estimated depth of all defects found shall be reported to the GT.

In addition to the qualification of the system a number of items shall be agreed by the GT before the system is used to inspect any production welds these include

- System calibration requirements
- Inspection procedure
- Operator experience
- Method of probe positioning/manipulation

Where there are any significant changes to a qualified system, the equipment may require requalification to an agreed procedure. Significant change shall include, but not be limited to.

- Welding method and groove geometry
- Probe scanning plan
- Probe type
- System, data acquisition and data treatment
- Software version (except changes affecting viewing or display only)
- System operator

PREPARATION:

The scanning area shall be free of spatter and other irregularities, which may interfere with the movement of the transducers, or the transmission of acoustic energy into the material. Longitudinal seam welds shall be ground flush and smooth for a specified distance, normally in the range of 100 mm from the factory bevel face to ensure that no transducers are lifted from the pipe surface. The pipe coating shall be cut back from the original factory bevel face for a distance, of 100 mm. The internal pipe seam shall be ground back 50 mm from the weld bevel to prevent interference with the ultrasonic beam during scanning

Waviness of the test surface shall not result in a gap between the probe and test surfaces greater than 0,5 mm. These requirements shall be ensured by dressing, if necessary. Local variations in surface contour, e.g. along the edge of the weld, which result in a gap beneath the probe of up to 1 mm, can only be permitted if at least one additional beam angle is employed from the affected side at the weld. This additional scanning is necessary to compensate for the reduced weld coverage that will occur with a gap of this dimension.

The “0” starting point and the scanning direction shall be clearly marked on the surface of the pipe by non-contaminant indelible material only. No hard stamping shall be permitted.

Parent material testing

The parent metal, in the scanning zone area (see Figure 2), shall be tested with straight-beam probes prior to or after welding, unless it can be demonstrated (e.g. by previous testing during the fabrication process) that the angle-beam testing of the weld is not influenced by the presence of the imperfections or high attenuation.

Where imperfections are found, their influence on the proposed angle-beam testing shall be assessed and, if necessary, the techniques adjusted correspondingly. When satisfactory coverage

by ultrasonic testing is seriously affected, other test techniques (e.g. radiographic testing) shall be considered.

REQUIREMENTS FOR CONVENTIONAL ULTRASONIC TESTING GENERAL

This specification details the minimum GT requirement for a conventional UT system, conventional UT procedure approval and conventional UT system operator/interpreter competency.

Any conventional UT system and examination procedure proposed for use shall, as a minimum, meet the requirements of this specification and be approved by the GT prior to qualification and use in production.

Only welds in pipes 60.3 mm outside diameter and above, and 8.00 mm wall thickness and above shall be examined with conventional UT.

CONVENTIONAL ULTRASONIC TESTING SYSTEMS

The inspection shall also include scans specifically designed to detect transverse defect indications.

The weld scanning direction (clockwise or anti-clockwise relative to a fixed datum) shall be agreed with the GT and shall be consistent for all production weld examination. In addition to BS EN ISO 22825, each examination system shall provide:

- A frame for holding the probe(s) in the correct scanning position (if applicable)
- Detailed scan plan
- A-scan data storage (if applicable)
- Encoder to record position of probe accurately to within ± 2.0 mm (if applicable)
- Adjustable gain control with maximum 2 dB steps over a range of at least 60 dB
- One or more gates, each adjustable for start position and length
- Recording threshold between 5 and 100% of full screen height (if applicable)
- Signal outputs that record signal amplitude and time/ beam travel distance

Any semi or fully automated system shall provide an overlap at the start and/or end of the scans of at least 30 mm. The encoder (if used) shall clearly indicate the location of imperfections relative to the 12 o'clock position of the weld. The system resolution shall be such that each segment of recorded data does not represent more than 1 mm of circumferential weld distance.

The ultrasonic examination equipment performance characteristics shall meet the requirements of BS EN 12668-1 and BS EN 12668-2, as appropriate. The verification of the combined equipment shall be done in accordance with BS EN 12668-3,with the exception of dual-element compression wave angle-beam probes, which may be verified on appropriate reference blocks other than the blocks mentioned in EN 12668-3.

Focal curves shall be available for the dual-element probes to be used, determined on a material representative of the material to be tested.

Instrument amplitude linearity shall be within 5% of the ideal amplitude and shall be assessed prior to qualification and production examination. Calibration certificates shall be made available upon request.

REQUIREMENTS FOR PHASED ARRAY ULTRASONIC INSPECTION (PAUT)

GENERAL

This specification details the minimum GT requirement for a PAUT system, PAUT procedure approval and PAUT system operator/interpreter competency.

Any PAUT system and examination procedure proposed for use shall, as a minimum, meet the requirements of this specification and be approved by the GT prior to qualification and use in production.

Only welds in pipes 60.3 mm outside diameter and above, and 5.00 mm wall thickness and above shall be examined with PAUT.

PAUT SYSTEMS

The inspection shall also include scans specifically designed to detect transverse defect indications, with the approval of the GT, these scans may be by a standard manual ultrasonic scan.

The weld scanning direction (clockwise or anti-clockwise relative to a fixed datum) shall be agreed with the GT and shall be consistent for all production weld examination.

In addition to the requirements of BS EN ISO 22825, each examination system shall provide:

- A frame for holding the phased array probe(s) in the correct scanning position (if applicable)
- A-scan data storage (if applicable)
- Encoder to record position of probe accurately to within ± 2.0 mm (if applicable)
- Adjustable gain control with maximum 2db steps over a range of at least 60db
- One or more gates, each adjustable for start position and length
- Recording threshold between 5 and 100% of full screen height (if applicable)
- Signal outputs that record signal amplitude and time/ beam travel distance

Any semi or fully automated system shall provide an overlap at the start and/or end of the scans of at least 30 mm. The encoder (if used) shall clearly indicate the location of imperfections relative to the 12 o'clock position of the weld. The system resolution shall be such that each segment of recorded data does not represent more than 1mm of circumferential weld distance.

The phased array ultrasonic examination equipment performance characteristics shall meet the requirements of BS EN ISO 18563-1 and BS EN ISO 18563-2, as appropriate. The verification of the combined equipment shall be done in accordance with BS EN ISO 18563-3,with the exception of dual-element compression wave angle-beam probes, which may be verified on appropriate reference blocks other than the blocks mentioned in EN 18563-3.

Focal curves shall be available for the phased array probes to be used, determined on a material representative of the material to be tested.

SOFTWARE

Any software required to view the results shall be included on the data disc which may be provided as part of the final results. Any software licenses shall be agreed before any of the production welds are examined.

The version number of any software shall be clearly visible on all display and printout presentations.

RE-EXAMINATION

Welds shall be re-examined whenever any of the following occur:

- Scanning exhibiting a loss of coupling i.e. a drop in echo amplitude of more than 10dB from the level through a clean weld for more than 3 lines of data per 20mm scanned.
- Any calibration scan that shows that the system is "out of calibration".

ELECTRONIC EXAMINATION RECORDS

The following electronic records shall be provided.

- An assessment of the weld quality according to the acceptance criteria
- Examination data in electronic form
- The electronic data shall display the results in the same manner that the operator viewed at the time of inspection. A print option shall be provided as part of the software.
- The electronic data for each weld scanned shall be saved and provided to the GT at agreed intervals during the project, it shall be stored such that each weld can be identified by the file name

SCANNING

Acoustic coupling shall be achieved using a non-toxic liquid medium. When choosing the medium, consideration shall be given to the Health, Safety and Environmental impact of any materials used.

No residue from the liquid medium shall remain on the pipe surface after the ultrasonic examination.

The operator shall keep a log book detailing the performance/characteristics data and identification for instruments and transducers. The log book shall be updated as changes are made, or, as additional information is gathered. The log book shall be kept at the place of inspection and be made available for review upon request

Each weld shall be numbered in the sequence used in the pipe tracking system as specified by the GT inspection team.

TEMPERATURE

When not using special high temperature phased array probes and couplants, the surface temperature of the object under testing shall be in the range 0 °C to 50 °C.

For temperatures outside this range, the suitability of the equipment shall be verified.

The weld and adjacent pipe shall be allowed to cool to a maximum temperature of 60 °C before scanning can commence unless otherwise agreed with the GT. The difference in temperature between the calibration block and weld being tested shall be less than 10 °C.

SENSITIVITY CHECKS

The system sensitivity shall be checked before each scan.

TRANSVERSE SCANNING

Scanning shall be conducted to detect the incidence of cracking which may be transverse to the weld line.

REPAIRS

Defective welds that have been repaired shall be re-examined visually and in accordance with the original examination method.

ACCEPTANCE/REJECTION CRITERIA

Acceptance/Rejection shall be to the requirements of this specification or to an alternative standard approved by the GT.

Where two or more defects occur in close proximity to each other consideration shall be given to the effects of their interaction

All transverse indications that exceed the threshold shall be evaluated as cracks.

EVALUATION AND REPORTING

Indications recorded from sources other than weld imperfections shall be evaluated. Their nature shall be clearly identified on the examination report.

The exact position of the defect shall be marked on the pipe surface using permanent markers.

Before any weld is accepted by UT/PAUT any complementary inspection shall be taken into account, such as visual inspection, so that all examinations are considered as part of the total weld sentencing.

INSPECTION RECORDS

The results of all non-destructive testing examinations shall be recorded on an appropriate record form. The examination report shall include, as a minimum, the information required by the appropriate national standard and this specification.

APPENDIX G – CONTENTS OF WELDING PROCEDURE SPECIFICATION (WPS)

All WPS submitted for use to GT for approval shall include the following as a minimum:

1. WPS Number
2. Revision number and date of revision
3. Supporting WPQR reference
4. Qualification code/standard and specification
5. Welding process(es)
6. Details of mechanisation/automation equipment qualified.
7. Materials – covering specification, grade, P-No and any restrictions based on heat number and/or chemistry (CEV or PREN)
8. Wall thickness range qualified
9. Deposited thickness of weld metal for each process qualified; if applicable
10. Diameter range qualified
11. Joint configuration to include sketch of welding preparation complete with dimensions and applicable tolerances
12. Pass locations for welding including any requirements for position of last capping pass etc.
13. Welding positions qualified
14. Direction of welding qualified
15. Method of fit up and joint alignment
16. Details of tack welding including type, number of tack welds, minimum length and details of spacing
17. Preheat temperature qualified, method of preheat and location of temperature measurement
18. Inter-pass temperature and location of temperature measurement
19. Method of measurement of preheat and inter-pass temperatures
20. Details of forced cooling; if applicable
21. Shielding gas – flow rates and specification/grade of gas
22. Backing gas – flow, rates, specification/grade of gas and number of weld passes deposited prior to removal. Max O_2 level.
23. Post weld heat treatment to include details of heating and cooling rates, and soaking time and temperature.
24. Consumables for all weld passes – specification, classification and trade names
25. Consumable diameters qualified for each weld pass
26. Consumable handling requirements; if applicable
27. Time between root pass and hot pass and time between hot pass and first fill pass; if required.
28. Clamp removal restrictions where applicable
29. Polarity qualified
30. Current range qualified for each weld pass
31. Voltage range qualified for each weld pass
32. Welding speed range qualified for each weld pass
33. Heat input range qualified for each weld pass (instantaneous power or energy may be used if appropriate to welding process)
34. Transfer mode for GMAW to include specific waveform technologies (i.e. STT)
35. Oscillation for mechanised/automatic welding, frequency, weave distance and dwell time.
36. Contact tip to work distance / electrode stick out
37. Electrode type for GTAW – specification and diameter
38. Shroud and gas lens diameter for GTAW
39. Weave or stringer technique
40. Weave width qualified (as a factor of electrode diameter for each weld pass when multiple diameter)
41. Notes section if required.

APPENDIX H – CONTENTS OF WELDING PROCEDURE QUALIFICATION RECORDS (WPQR)

All WPQR submitted to GT for approval shall include the following as a minimum:

1. Document front sheet
2. Document contents page/index
3. WPQR Number
4. Date(s) of test welding
5. Revision number and date of revision
6. Qualification code/standard and specification
7. Welding process(es)
8. Details of mechanisation/automation used during test welding.
9. Welder identification
10. Materials – covering heat/cast used for test welding, specification, grade, P-No
11. Wall thickness of test weld
12. Deposited thickness of weld metal for each process during test weld
13. Diameter of test weld
14. Joint configuration to include sketch of welding preparation complete with dimensions of root face, root gap, included angle and misalignment recorded during test welding
15. Pass locations for welding including any requirements for position of last capping pass etc.
16. Welding position of test weld
17. Direction of welding during test weld
18. Method of fit up and joint alignment during test weld
19. Details of tack welding during test welding including , type number of tack welds, minimum length and details of spacing
20. Preheat, method of preheat and location of temperature measurement
21. Inter-pass temperature and location of temperature measurement
22. Method of measurement of preheat and inter-pass temperatures
23. Details of forced cooling used during test weld; if applicable
24. Shielding gas – flow rates and specification/grade of gas
25. Backing gas – flow, rates, specification/grade of gas and number of weld passes deposited prior to removal during test. Maximum O_2 level recorded prior to commencement of welding
26. Consumables for all weld passes – specification, classification and trade names
27. Consumable diameters qualified for each weld pass
28. Consumable handling requirements; if applicable
29. Time recorded between root pass and hot pass and time between hot pass and first fill pass; if required.
30. Clamp removal restrictions where applicable
31. Polarity used for each weld pass
32. Current range qualified for each weld pass (as recorded by weld monitoring equipment)
33. Voltage range qualified for each weld pass (as recorded by weld monitoring equipment)
34. Run out length for each weld pass (as recorded during test weld)
35. Time of each for each weld pass (as recorded by weld monitoring equipment)
36. Welding speed for each weld pass (as recorded by weld monitoring equipment)
37. Heat input for each weld pass. Instantaneous power or energy may be used if appropriate to welding process (as recorded by weld monitoring equipment)
38. Transfer mode for MIG to include specific waveform technologies (i.e. STT)
39. Oscillation for mechanised/automatic welding, frequency, weave distance and dwell time.
40. Contact tip to work distance / electrode stick out
41. Electrode type for TIG – specification and diameter
42. Shroud and gas lens diameter for TIG
43. Weave or stringer technique as qualified

44. Weave width qualified (as a factor of electrode diameter for each weld pass when multiple diameter)
45. Notes section if required.
46. Non-destructive testing report
47. Mechanical test report (to included photo-macrographs and photomicrographs as required)
48. Material certificates for test welds
49. Consumable certificates for test welds
50. Heat treatment chart recorder report
51. Calibration certificates for weld process monitoring equipment used for generating as ran welding data.

The WPQR package shall contain individual weld pass information from the test welds. The data recorded by the weld monitoring equipment used during test welding shall be submitted as part of the WPQR document package. A summary of electrical parameters, essential variables and supplementary essential variables populated from the weld monitoring data may only be provided as an addition to the full data recorded.