

THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

Construction Specification for fixed offshore structures

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ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

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Preface

This Specification was originally developed by the EEMUA Materials for Offshore Service (MOS) technical committee in 1991 and covered the construction of fixed offshore steel structures for installation primarily within the United Kingdom Continental Shelf. Though the original document was created for use in the North Sea, it has been applied successfully in other locations. Therefore changes in this 3rd Edition now reflect the global nature of the offshore oil and gas industry, with the Specification having a much broader applicability. Furthermore, wind turbine installations now constitute a significant proportion of new constructions offshore.

The requirements specified meet the general recommendations contained in the UK Health and Safety Commission document 'Offshore Installations and Wells (Design and Construction etc.) Regulations 1996'. However, because the Regulator's recommendations require that all production welding should be carried out in accordance with accepted standards such as AWS D 1.1M:2010⁽¹⁾, those documents have been used as a regular source in compiling this specification. There is, therefore, no 'ruling code', but reference is made to a number of standards, which apply with only minor amendment. In producing this and all previous editions of the specification, account has been taken from experience gained by the industry and from the latest developments in technology.

EEMUA has published EEMUA Publication 197⁽²⁾ as a companion volume to this Specification. It is recommended that, where appropriate, reference be made to EEMUA 197.

Note: In all instances where a reference is made, the quoted edition is the most recent at the time of publishing. If a newer version becomes available then users should refer to the later edition. In cases where specific clauses within a standard, which are referred to, are amended, users should use discretion to determine if the advice still applies.

Contents

Preface.....	iv
Principal changes in the 3rd Edition	1
1 Introduction and objectives	3
1.1 Scope	3
1.2 Definitions.....	3
1.3 Abbreviations.....	4
1.4 Units.....	6
1.5 Glossary of technical terms.....	6
1.6 References	7
2 Quality assurance and safety	9
2.1 Quality Assurance.....	9
2.2 Health, safety and environmental issues	9
2.3.1 Welding engineers	10
2.3.2 Welding coordinators	10
2.3.3 Welding inspectors	11
3 Materials	13
3.1 Weldable structural materials.....	13
3.2 Welding consumables.....	13
3.3 Miscellaneous materials.....	14
3.3.1 Bolts, nuts and washers	14
3.3.2 Castings and forgings	14
3.4 Materials substitution.....	14
3.5 Materials handling	14
3.5.1 Receipt of materials.....	14
3.5.2 Maintenance of identity	15
3.5.3 Storage conditions.....	15
4 Qualification of welding procedures and personnel.....	17
4.1 General requirements	17
4.2 Approval process for welding procedures	17
4.2.1 Initial submission	17
4.2.3 Procedure qualification records	21
4.2.4 Submission of the qualification package	23
4.3 Restrictions on welding practices	23
4.4 Welding procedure qualification tests	24
4.4.1 General requirements	24
4.4.2 Types of test weld	27
4.4.3 Inspection and NDT requirements and acceptance criteria	30
4.4.4 Mechanical testing requirements and acceptance criteria	32
4.4.5 Failed procedures	41
4.5 Essential variables.....	41
4.5.1 Materials related variables.....	42
4.5.2 Weld geometry related variables	42
4.5.3 Consumables and equipment variables.....	43
4.5.4 Procedural variables	44
4.5.5 Welding parameter variables	44
4.6 Qualification of welding personnel	45
4.6.2 Existing qualifications	45

4.6.3 Categories of qualification and testing requirements	46
4.6.4 Re-testing	48
4.6.5 Requalification	48
4.6.6 Qualification test records.....	48
5 Construction.....	49
5.1 General requirements	49
5.2 Preparation and assembly	49
5.2.1 Handling procedures	49
5.2.2 Efficient use of free issue materials	49
5.2.3 Spacing of seams and splices.....	49
5.2.4 Design of welded connections	51
5.2.5 Forming and straightening.....	52
5.2.6 Edge preparation.....	52
5.2.7 Alignment and fit-up of welded joints.....	53
5.2.8 Rat-holes, penetrations and cut-outs	54
5.3 Control of production welding	54
5.3.1 Welding environment.....	54
5.3.2 Welding consumables and equipment	55
5.3.3 Preheat and interpass temperature requirements	55
5.3.4 Temporary and non-structural attachments, ancillaries and miscellaneous steelwork	57
5.3.5 Weld execution	57
5.3.6 Weld interruptions	58
5.3.7 Weld repairs	58
5.3.8 Welding restrictions on PWHT items.....	59
5.3.9 Weld profile, surface finish and clean-up	59
5.3.10 Production controls	60
5.4 Post Weld Heat Treatment (PWHT)	61
5.4.1 Welds requiring PWHT.....	61
5.4.2 PWHT procedures	61
5.4.3 Certification.....	62
5.5 Bolted connections	63
5.5.1 General.....	63
5.5.2 Bolting details.....	63
5.6 Piles and followers.....	64
6 Fabrication tolerances.....	65
6.1 General	65
6.2 Local tolerances for structural components and sub-assemblies.....	67
6.2.1 Fabricated tubulars and cones.....	67
6.2.2 Rectangular plated sections	81
6.2.4 Cruciform joints	88
6.2.5 Joint misalignment	88
6.3 Global tolerances for the completed structure	89
6.3.1 Jacket and deck node work points	89
6.3.2 Final alignment of bracings and jacket legs.....	89
6.3.3 Appurtenances.....	90
6.3.4 Padeyes, padears and lifting trunnions.....	92
6.4 Miscellaneous structural steelwork tolerances	92
6.4.1 Handrails.....	92
6.4.2 Deck plating, walkways, stairways and landings	92
6.4.3 Openings/penetrations.....	92
6.4.4 Pile length	92

7 Inspection and non-destructive testing	93
7.1 General	93
7.2 Inspection and NDT	93
7.2.1 Extent of inspection and NDT	93
7.2.2 Timing of final inspection and NDT.....	94
7.3 Qualification of inspection and NDT procedures and personnel	95
7.3.1 Non-destructive testing procedures	95
7.3.2 Qualification of inspection and NDT personnel	95
7.4 Non-destructive testing techniques	95
7.4.1 Visual inspection	95
7.4.2 Ultrasonic testing	96
7.4.3 Radiography	96
7.4.4 Magnetic particle inspection	97
7.4.5 Leak testing.....	97
7.5 Acceptance criteria for flaws	97
7.5.1 General	97
7.5.2 Visual acceptance.....	98
7.5.3 Ultrasonic acceptance	98
7.5.4 Radiographic acceptance	98
7.5.5 Magnetic particle examination acceptance	99
8 References.....	101
9 Bibliography	107
Appendix: CTOD testing of HAZs for welding procedure qualification...	109
A1 Introduction	109
A2 Testing requirements.....	109
A2.1 Number of tests	109
A2.2 Specimen preparation.....	109
A2.3 Testing	116
A2.4 Procedure for validation	116
A2.5 Reporting	122
A2.6 Acceptance criteria and retesting	123
EEMUA Publications Catalogue	125

List of Figures

Figure 1 Example of a welding procedure specification	19
Figure 2 Example of a site welding instruction sheet for semi-automatic and manual welding.....	22
Figure 3 Example of a PQR mechanical test report.....	25
Figure 4 Demonstration piece for T, K and Y joints	28
Figure 5 Examples of acceptable weld profiles for tubular intersections	29
Figure 6 Hardness indentation locations for grout bead procedures.....	30
Figure 7 All weld tensile test piece locations	34
Figure 8 Locations of indents for hardness surveys	36
Figure 9 Locations and notch positions for weld metal/HAZ Charpy specimens ..	37
Figure 10 Charpy Specimen locations for weld repairs.....	38
Figure 11 Location of Charpy specimens in punch-through weld	38
Figure 12 CTOD Test piece geometries and notch locations.....	41
Figure 13 Welder test piece for single sided welds	47
Figure 14 Welder test piece for special applications	47
Figure 15 Prohibited areas for node barrel and stub welds.....	50
Figure 16 Circumferential tolerance	67
Figure 17 Ovality tolerance.....	68
Figure 18 Procedure for determination of out-of-circularity	71
Figure 19 Out-of-circularity tolerance.....	73
Figure 20 Out-of-roundness tolerance	74
Figure 21 Local straightness tolerance for tubulars	75
Figure 22 End perpendicularity tolerance.....	76
Figure 23 Node barrel and stub lengths.....	77
Figure 24 Out of straightness tolerance for members	77
Figure 25 Node stub location	78
Figure 26 Node and tube stiffener locations	79
Figure 27 Ring stiffener cross section tolerances	80
Figure 28 Out-of-straightness tolerance for stiffeners in tubulars.....	80
Figure 29 Plate girder cross section tolerances	82
Figure 30 Plate girder out-of-straightness tolerance.....	83
Figure 31 Plate girder stiffener tolerances	84
Figure 32 Box girder tolerances.....	85
Figure 33 Girder node lengths.....	86
Figure 34 Tolerances for stiffened plate panels.....	87
Figure 35 Joint mismatch tolerance	88
Figure 36 Global positioning tolerance for tubular nodes.....	89
Figure 37 Tolerances for stab-in node mating surfaces.....	90
Figure 38 Pile sleeves positioning tolerances.....	90
Figure 39 Conductor guides positioning tolerances	91
Figure 40 Caisson and J-tube guides and riser clamps positioning tolerances	91
Figure A1 Illustration of GCHAZ location relative to the weld beads	110
Figure A2 Sketch micro-map of microstructures and grain sizes in HAZ.....	111
Figure A3 Illustration of idealised CTOD notch line.....	112
Figure A4 Idealised straight-line micro-map of HAZ	113
Figure A5 Details of notch placement for notched CTOD specimen	114
Figure A6 Details of notch placement for surface notched CTOD specimen.....	115
Figure A7 Details of post-test sectioning for through thickness specimens	117
Figure A8 Micro-map showing microstructures and grain sizes	119
Figure A9 Details of post-test sectioning for surface notched specimens.....	121

List of Tables

Table 1 Welding consumables and recommended lot classifications	13
Table 2 Requirements for extent and type of inspection and NDT	31
Table 3 Types and number of mechanical tests required for WPQ	33
Table 4 Weld metal and HAZ Charpy test requirements.....	39
Table 5 Recommended inspection/NDT categories	62
Table 6 Allowable ovality	68
Table 7 Checking positions for ovality and O of R tolerance	69
Table 8 Ovality measuring positions.....	70
Table 9 Procedure for determination of out-of-circularity	72
Table 10 Tolerances for plate girders	81
Table 11 Tolerances for plate girder stiffeners.....	84
Table 12 Box girder tolerances.....	85
Table 13 Tolerances of stiffened plate panels	87
Table 14 Visual inspection acceptance criteria	98
Table 15 Ultrasonic testing acceptance criteria	99

Principal changes in the 3rd Edition

Since the previous editions and amendments to this document were published, the character and location of the fabrication undertaken for the UK Continental Shelf has substantially changed. Additionally, this Specification has been successfully applied to other geographical locations, including the Caspian Sea where it is widely used.

Whilst the use of fixed offshore structures for the oil and gas industry has declined, the use of floating production storage and offloading vessels has increased with a strong emphasis on subsea completions, (EEMUA 194⁽³⁾ is directly relevant in this respect). Nevertheless, fixed offshore installations still have a significant role in the oil and gas industry, both in the North Sea and other areas of operation, and a potentially increasing role in offshore renewable energy.

Workforce skills in the fabrication industry have also changed and there is more emphasis on the application of semi-automatic welding techniques as opposed to the manual process.

Other changes relate to steel plate production, which has largely changed to thermo-mechanically produced lean alloy compositions. This has substantially influenced weldability. Another notable change has been to large tonnage fabrication - which has decreased in the UK, Scandinavia and the rest of Europe - moving largely to South East Asia.

These changes have raised a number of different challenges for the industry and the EEMUA Materials Technical Committee (MTC), largely comprised of metallurgical and welding engineers, have consequently undertaken a critical review of the earlier document and incorporated revisions to account for the industrial changes based on the experience and lessons of recent projects.

Attention is also drawn to ISO 19900:2013⁽⁴⁾, 19901-3:2010⁽⁵⁾ and EN ISO 19902:2007⁽⁶⁾ and EN ISO 13628:2011⁽⁷⁾.

The Certifying Authority's statutory, independent assessment and survey activities are recognised, but are considered to be a matter for agreement between the purchaser and the Authority and are not addressed within this Specification.

1 Introduction and objectives

1.1 Scope

This Specification defines the basic requirements for the fabrication of the primary structures of offshore installations. These will normally include but not be limited to the following:

- Jacket structure including nodes, cones, braces, legs and conductor framing;
- Piles and followers;
- J-tubes and caissons;
- Riser clamps;
- Flotation tanks and buoyancy tubes;
- Module support frame including nodes, cones, braces, padears;
- Module framing including nodes, columns, fabricated beams and padears;
- Flareboom;
- Helideck - when constructed of steel;
- Subsea structures such as manifold and production system support frames;
- Renewable energy structures, both surface and subsea; and
- Other areas designated 'primary' on the Purchaser approved drawings.

The attachment by welding to primary steelwork (but not the fabrication) of items such as doubler plates, riser supports and walkways, also comes within the scope of this Specification.

This Specification may also be used for the fabrication of deck mounted module framing on floating offshore structures.

This Specification may also be used for modifications to existing structures, subject to the limitations imposed by the original materials and fabrication techniques.

All other structural components shall be fabricated to EEMUA 197 or other document approved by the purchaser.

The requirements of this Specification are necessarily of a general nature, and individual projects will normally apply short supplements to reflect any peculiarities of design or duty which affect them.

Pipeline risers are not covered by this Specification.

1.2 Definitions

Throughout this Specification, the following definitions apply:

Purchaser	Refers the client who has placed the contract for construction;
Contractor	Refers to the fabricator to whom the contract has been awarded;

Sub-contractor	Refers to a fabricator to whom the contractor awards any part of the work.
Shall	This term is used to indicate that the contractor/sub-contractor is required to take action.
Should	Used to indicate that the contractor/sub-contractor is advised to take action.
May	This is used to indicate that the contractor/sub-contractor is permitted to do something, or that the purchaser reserves the right to do something, according to context.
Approved/approval	Unless otherwise qualified, means formal, written agreement by the purchaser to a proposal by the contractor/sub-contractor.
Carbon equivalent (CE_{IW})	$CE_{IW} = C + Mn/6 + (Cr+Mo+V)/5 + (Cu+Ni)/15$
Pcm	$Pcm = C + Si/30 + (Mn+Cu+Cr)/20 + Ni/60 + Mo/15 + 5B$
Agreement	A verbal or written response from the purchaser confirming concurrence with a proposal by the contractor/sub-contractor.
Primary structure	Refers to all those components of offshore/subsea installations the failure of which would seriously endanger the safety of the installation; this includes all attachments welded to the primary structure.
Drawings	These are purchaser approved design drawings, or purchaser approved AFC shop drawings.

1.3 Abbreviations

The following abbreviations are used in this Specification. The meaning of each is indicated alongside:

AFC	Approved For Construction
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
BINT	British Institute of Non-destructive Testing
BS/BSI	British Standard/s Institution
CE_{IW}	Carbon Equivalent
CSWIP	Certification Scheme for Welding and Inspection Personnel
CTOD	Crack Tip Opening Displacement
DAC	Distance Amplitude Curve

ECA	Engineering Critical Assessment
ECIA	Engineering Construction Industries Association
EEMUA	Engineering Equipment and Materials Users Association
EN	European Standard
EWf	European Welding Federation
FL	Fusion Line
GCHAZ	Grain Coarsened Heat Affected Zone
GMAW	Gas Metal Arc Welding
GSFCAW	Gas Shielded Flux Cored Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HSC/HSE	Health and Safety Commission/Executive
IIW	International Institute of Welding
ILAC	International Laboratory Accreditation Cooperation
IQI	Image Quality Indicator
ISO	International Organization for Standardization
MCAW	Metal Core Arc Welding
MPI	Magnetic Particle Inspection (or examination)
NDT	Non-Destructive Testing
Pcm	Parameter crack measurement (weldability parameter indicating the equivalent carbon content and composition of steels, from Japan Welding Engineering Society (JWES))
PCN	Personnel Certification in Non-destructive Testing
BSI PD	(BSI) Published Document
PQR	Procedure Qualification Record
PWHT	Post-Weld Heat Treatment (or treated)
pWPS	preliminary Welding Procedure Specification
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
QP	Quality Plan
Q&T	Quenched and Tempered
ROL	Run-Out Length
RT	Radiographic Testing
SAW	Submerged Arc Welding
SI	International System of Units

SMAW	Shielded Metal Arc Welding
SMYS	Specified Minimum Yield Stress
SSFCAW	Self Shielded Flux Cored Arc Welding.
SWIS	Site Welding Instruction Sheet(s)
TMCR	Thermo-Mechanical Controlled Rolled
TOFD	Time Of Flight Diffraction.
TS	Tensile Strength
TWI	The Welding Institute
UKAS	United Kingdom Accreditation Service
UT	Ultrasonic Testing
WPQ	Welding Procedure Qualification
WPQT	Weld Procedure Qualification test
WPS	Welding Procedure Specification

1.4 Units

SI units are used throughout this Specification. Consistent units shall be used in all documentation submitted to the purchaser by the contractor/sub-contractor.

All dimensions shown in Figures and Tables are in mm unless otherwise specified.

'Bar' signifies gauge pressure.

1.5 Glossary of technical terms

The following technical terms are used within this Specification with the meanings indicated:

Can	A tube or pipe rolled from plate and longitudinally seam welded.
Node barrel	A main continuous tubular or chord tubular at a node.
Node	An assemblage of structural members meeting at an intersection point.
Tubular	An assemblage of cans or seamless pipes forming a member or part of a member.
Weld pass	A single progression of welding or surfacing along a joint or substrate. The result of a pass is a weld bead, layer or spray deposit.
Weld bead	A weld deposit resulting from a pass.
Single-sided weld	A joint welded from one side only.
Double-sided weld	A joint welded from both sides irrespective of the weld preparation.

Semi-automatic welding	A welding process in which the welding wire is continuously fed to a manually operated welding torch by a mechanised wire feed system.
Flaw	The indication of an imperfection or discontinuity revealed by NDT.
Defect	An unacceptable flaw.

1.6 References

A list of documents referenced in the text of this Specification is given under References in Section 8. The contractor/sub-contractor shall ensure that he has ready access to all current documents. Except where otherwise stated the latest editions of the documents including all published amendments current at the contract date (or at some other date agreed between purchaser and contractor/sub-contractor) shall normally apply. However where reference is made to a particular Section/Clause of a document, the applicable edition of the referenced document (including amendments) shall be that current on 1st February 2014.

2 Quality assurance and safety

2.1 Quality Assurance

The contractor and any sub-contractor shall establish and maintain a Quality Management System (QMS), in accordance with EN ISO/TS 29001:2010⁽⁸⁾, EN ISO 9001:2008⁽⁹⁾ or a purchaser approved equivalent. Further, all welding activities shall comply with ISO 3834:2005⁽¹⁰⁾ Part 2 or a purchaser approved equivalent. Compliance with these Standards will ensure that the goods or services supplied comply in all respects with the requirements of this EEMUA Specification. The contractor shall ensure that the QMS proposed by any sub-contractors meet the above requirements.

Prior to the commencement of any fabrication activity, including material preparation and welding procedure or welder/welding operator testing, the contractor and any sub-contractor shall submit a Quality Plan (QP) for the approval of the purchaser. The QP shall detail the full scope of activities related to the fabrication and erection of the structures.

The personnel responsible for the implementation of the QMS and QP shall be identified and their CVs shall be available for purchaser review and approval.

The purchaser's nominated representative(s) shall have the right to audit the contractor/sub-contractor's QMS at any time during the contract, subject to one day's notice.

The purchaser's nominated representative(s) shall have the right to undertake inspection or testing of the goods or services during any stage of manufacture at which the quality of the finished goods may be affected, and to undertake inspection or testing of raw materials or purchased components.

2.2 Health, safety and environmental issues

The purchaser and contractor/sub-contractor shall at all times maintain awareness of the legislation and regulations concerning safe working practices and environmental issues. It is essential to ensure compliance with these in all fabrication and testing operations concerning constructions for offshore including subsea installations.

All parties shall institute and adopt the use of safe working practices and procedures, and encourage, train and require their workforce and personnel to comply with such practices at all times.

Appropriate personal protective equipment shall be provided to the workforce and attention is drawn to the need for written procedures dealing with aspects such as:

- Working at height (scaffolding/access platforms/fall arrest equipment);
- Working below grade;
- Energy isolation (electrical and pressure);
- Confined space entry; and
- Lifting.

Specific issues related to the safety of welding and its allied activities are detailed in AWS Z49.1:2012⁽¹¹⁾. However, particular attention is drawn to the need to provide adequate ventilation in enclosed fabrication areas in order to control the level of welding fume and the build-up of welding gases.

With regard to Non-Destructive Testing(NDT), particular attention is drawn to the dangers of ionizing radiation and the need to comply with local regulations concerning the use, storage and transport of radioactive isotopes and X-ray machines. For example, in the UK, radiographic operations shall be undertaken in accordance with the Ionising Radiations Regulations 1999⁽¹²⁾ and the Approved Code of Practice L121⁽¹³⁾.

Substances such as those listed below may also present health and environmental issues:

- Liquids employed as UT couplants;
- Magnetic inks; and/or
- Penetrant test cleaning, penetrant and developing liquids;

Consequently, compliance with safety procedures and Health & Safety legislation is required at all times.

EN 14717:2005⁽¹⁴⁾ provides some guidance on environmental issues associated with welding and allied processes.

Attention is also drawn to the ECIA Safety Health and Environmental Manual⁽¹⁵⁾, which is referenced in many contracts, both offshore and onshore.

2.3 Welding personnel

The contractor and any sub-contractor personnel associated with welding operations shall be trained and qualified to recognised industry standards.

2.3.1 Welding engineers

Welding engineers shall be experienced professional engineers holding a degree or equivalent qualification in welding engineering/metallurgy, engineering/metallurgy or materials science. Certification as either, EWF - European Welding Engineer, or, IIW - International Welding Engineer, shall be held. The certified level according to these requirements is a minimum of 5 years active experience, based on evidence or equivalent qualifications.

Certification in accordance with an alternative standard may be approved by the purchaser.

The CV of the contractor's and sub-contractor's welding engineer shall be available for purchaser review and approval.

2.3.2 Welding coordinators

The contractor welding engineer shall be appointed as the principal EN ISO 14731:2006⁽¹⁶⁾ welding coordinator and shall provide technical oversight of the fabrication techniques and production welding. The welding engineer shall also

be responsible for the technical approval of sub-contractors, the sub-contractors' welding coordinator and the sub-contractors' welding and allied procedures.

The contractor may appoint additional welding coordinators meeting the specific knowledge requirements of EN ISO 14731:2006 as required by the scope of the fabrication contract.

Sub-contractors welding coordinators shall comply with the requirements of EN ISO 14731:2006.

The responsibilities of welding coordinators shall be as detailed in EN ISO 14731:2006, Annex B.

The CVs of the sub-contractors' welding coordinators shall be available for purchaser review and approval.

2.3.3 Welding inspectors

The contractor and any sub-contractor shall employ competent and certificated welding inspection personnel in sufficient numbers to ensure that welding related activities are adequately inspected in accordance with the approved QP.

Welding inspectors shall hold, as a minimum, current certification to any of the following Standards:

- AWS QC1⁽¹⁷⁾ (1996 or later edition) – CWI;
- CSWIP⁽¹⁸⁾ (TWI, UK) – Welding Inspector 3.1;
- PCN⁽¹⁹⁾ (BINDT, UK) – Weld Inspection level 2;
- IIW⁽²⁰⁾ Certified Welding Inspector Standard (CWI – S).

Alternative welding inspector certification may be approved by the purchaser.

For major scope of works (e.g. in fabrication yards involving multiple work fronts), a senior welding inspector should be appointed to coordinate and supervise the work of the welding inspectors. Senior welding inspectors shall have:

- At least 10 years of relevant experience and sound knowledge of welding and construction processes and their application;
- Formal engineering training through apprenticeship and technical college education.

Senior welding inspectors shall hold, as a minimum, current certification to any of the following Standards:

- AWS QC1 (1996 or later edition) – SCWS;
- CSWIP (TWI, UK) – SWI 3.2;
- PCN (BINDT, UK) – Weld Inspection level 3;
- IIW Certified Welding Inspector – Comprehensive (CWI – C).

Alternative senior welding inspector certification may be approved by the purchaser.

The CV and current certification of the contractor and any sub-contractor weld

inspection personnel shall be available for purchaser review and approval.

3 Materials

3.1 Weldable structural materials

Steel plate, sections and hollow sections specified on the purchaser approved drawings shall be in accordance with EN 10225:2009⁽²¹⁾.

Alternative, equivalent, impact tested, materials such as seamless and Submerged Arc-Welding Longitudinal (SAWL) tubulars manufactured in accordance with ISO 3183:2012⁽²²⁾, PSL 2 may also be approved by the purchaser.

3.2 Welding consumables

Welding consumables shall be purchased from manufacturers operating a QMS based on ISO 9001, EN 12074:2000⁽²³⁾, or purchaser approved equivalent. The consumables proposed shall enable the lowest possible hydrogen welding practice to be achieved when employed in accordance with the manufacture's recommendations. The trade names and classifications of all welding consumables proposed shall be submitted to the purchaser for approval.

All consumables shall comply with EN, ISO or AWS standards or a purchaser approved alternative.

As a minimum, consumables shall be supplied in accordance with test Schedule 4 (EN ISO 14344:2010⁽²⁴⁾) or Schedule I (AWS A5.01⁽²⁵⁾). Recommended lot classifications are shown below in Table 1.

Table 1 Welding consumables and recommended lot classifications

	AWS	EN ISO	Recommended Lot Classification
GMAW wire	A5.18/A5.18M ⁽²⁶⁾ A5.28/A5.28M ⁽²⁷⁾	14341:2011 ⁽³⁴⁾	S3
GSFCAW wire	A5.36/A5.36M ⁽²⁸⁾	17632:2008 ⁽³⁵⁾	T2
SSFCAW wire	A5.36/A5.36M	17632:2008	T2
MCAW wire	A5.36/A5.36M	17632:2008	T2
SAW wire / flux	A5.17/A5.17M ⁽²⁹⁾ A5.23/A5.23M ⁽³⁰⁾	14171:2010 ⁽³⁶⁾ /26304:2011 ⁽³⁷⁾	Wire S3 / Flux F2
GTAW wire	A5.18/A5.18M A5.28/A5.28M	636:2008 ⁽³⁸⁾	S3
SMAW electrodes	A5.1/A5.1M ⁽³¹⁾ A5.5/A5.5M ⁽³²⁾	2560:2009 ⁽³⁹⁾ /18275:2012 ⁽⁴⁰⁾	C4 or C5
Shielding gas	A5.32 ⁽³³⁾	14175:2008 ⁽⁴¹⁾	-

Submerged arc wires shall be used in combination with the manufactures recommended flux.

If the consumables are proposed for welding procedures which require Crack Tip Opening Displacement (CTOD) testing, the contractor/sub-contractor shall submit evidence that the deposited weld metal will meet the specified requirements.

The purchaser shall maintain the right to specify the need for any additional testing of consumables.

3.3 Miscellaneous materials

3.3.1 Bolts, nuts and washers

Unless specified otherwise on the purchaser approved drawings, structural bolts and nuts shall comply with EN ISO 898, Parts 1⁽⁴²⁾ and 2⁽⁴³⁾, Grade 8.8. The maximum hardness shall be 34HRc. Washers shall comply with EN ISO 887:2000⁽⁴⁴⁾.

Fasteners to be used in air shall be hot dipped galvanised in accordance with BS 7371 Parts 1⁽⁴⁵⁾ and 6⁽⁴⁶⁾.

Fasteners to be used subsea (fully immersed) shall be provided with a thin (≈ 10 micron) coating. The coating may be applied by hot spun galvanising (BS 7371-7⁽⁴⁷⁾), sherardizing (BS 7371-8⁽⁴⁸⁾) or Zn/Ni electroplating (EN ISO 4042:2000⁽⁴⁹⁾).

Fully immersed fasteners shall be electrically continuous with the structure to ensure effective cathodic protection.

For partially wetted applications where full cathodic protection cannot be applied or guaranteed, e.g. the splash zone, fasteners made from a purchaser approved corrosion resistant material may be used.

3.3.2 Castings and forgings

Structural steel castings shall comply with EEMUA 176⁽⁵⁰⁾ or an alternative purchaser approved specification.

Structural forgings shall be supplied to an appropriate steel specification selected by the purchaser.

3.4 Materials substitution

The materials used for the structure shall be of the grade and size defined on the purchaser approved drawings unless approval is given to alternative proposals made by the contractor/sub-contractor.

3.5 Materials handling

3.5.1 Receipt of materials

The materials and sub-assemblies delivered to the site shall be held in quarantine until the items have been identified against the relevant documentation.

The contractor/sub-contractor shall also verify that the information provided complies with the requirements of the appropriate specification. If any item has

inadequate identification or unsatisfactory documentation, it shall be held in quarantine and the purchaser shall be notified as soon as possible.

3.5.2 Maintenance of identity

The contractor/sub-contractor's QMS shall ensure full traceability of materials during storage and fabrication.

3.5.3 Storage conditions

The materials shall be stored in conditions which will avoid damage and deterioration. Different materials and materials used for separate contracts shall be segregated. Warehouse storage is preferred for all small painted or coated items and for portable sub-assemblies.

4 Qualification of welding procedures and personnel

4.1 General requirements

Welding shall be undertaken in accordance with procedures approved by the purchaser and qualified in accordance with this Specification (Sections 4 and 5) and EN ISO 15614-1 2004+A2:2012⁽⁵¹⁾.

The transfer of qualified welding procedures between contractor and sub-contractors is not acceptable.

4.2 Approval process for welding procedures

4.2.1 Initial submission

The contractor/sub-contractor shall submit the following documents, (Sections 4.2.1.1 – 4.2.1.6) in an electronic format agreed by the purchaser.

4.2.1.1 Welding procedure schedule

A schedule of all proposed welding procedures necessary for completion of the work in accordance with the essential variables. This shall contain the following information:

- Types of weld;
- Consumables;
- Welding position;
- Material types;
- Qualified thickness range; and
- Welding procedure specification number.

The Welding Procedure Specifications (WPS) should be grouped and cross - referenced to the relevant welding procedure qualifications (PQR) and, where appropriate, to the Site Welding Instruction Sheets (SWIS) (see Section 4.2.1.6).

The schedule shall indicate the dates by which each new qualification is intended to be completed.

4.2.1.2 Existing welding procedure qualifications

If the contractor/sub-contractor hold appropriate existing welding procedure qualifications, they should be submitted to the purchaser for consideration, together with a list of any deviations between the testing requirements of this Specification and those of the specification to which they were tested.

Note: Existing procedures qualified to EEMUA 158, Edition 2, shall be acceptable without reference to EN ISO 15614-1:2004+A2:2012.

If the purchaser considers an existing procedure qualification to be immediately acceptable or acceptable after additional testing, the contractor will be notified of the steps necessary to obtain approval for construction (AFC).

Any existing procedure qualification which the contractor/sub-contractor proposes to utilise in satisfying the requirements of this Specification shall have been witnessed and verified by a competent third party, acceptable to the purchaser.

A typical example format for the WPS is shown in Figure 1. However, the contractor/sub-contractor may submit proposals on his own documentation if it contains details of the relevant variables.

4.2.1.3 New welding procedures

New welding procedures required to meet the requirements of this Specification shall be submitted as preliminary Welding Procedure Specification (pWPS) for purchaser approval prior to qualification.

The pWPS shall be based on a table of standard parameters proposed for use for all welding with the process-consumable combination nominated. Standard welding parameters shall be provided for each electrode diameter, welding position and location in the joint (i.e. root, 'hot pass', fill, cap, and any other distinctions normally made by the contractor/sub-contractor). The ranges of parameters shall not exceed the limits in Section 4.5.5, and the values shall be selected to represent the welding parameters currently in use.

4.2.1.4 Standard welding practices

The statement of standard welding practices shall include, as a minimum:

- Weld preparation method;
- Standard weld preparation details;
- Preparation cleaning (if any);
- Use of weldable primers (if any);
- Alignment, fit-up and restraint methods;
- Preheat-temperature for each material grade/thickness/welding process, method and control;
- Maximum interpass temperature and method of control;
- Weld cleaning;
- Gas purging (if relevant);
- Back-gouging method and control; and
- Consumables handling.

4.2.1.5 Repair welding procedure/statement

The repair welding procedure/statement shall include, as a minimum:

- scope of application;
- repair method(s), process(es), relevant welding procedures, method of excavation and final preparation including NDT; and
- preheat temperatures, method and controls.

				FABRICATOR								
				LOCATION		SHOP SITE		WELDING PROCEDURE NO.				
Welding Procedure Specification												
QUALIFICATION IN ACCORDANCE WITH EEMUA PUBLICATION 158 AND EN ISO 15614-1:2004+A2:2012												
PARENT METAL			PLATE/PIPE THICKNESS			PIPE DIAMETER						
CARBON EQUIVALENT			PLATE/PIPE NO.			CAST NO.						
QUALIFIED THICKNESS RANGE						QUALIFIED DIAMETER RANGE						
WELD PREPARATION (WITH DIMENSIONS AND TOLERANCES)						WELDING SEQUENCE/PASS LOCATION						
MAXIMUM WELD BEAD WIDTH FOR EACH WIRE/ELECTRODE DIAMETER												
PREHEAT TEMP °C			PREHEAT METHOD		MAX INTERPASS TEMP °C			CHECK/CONTROL METHOD				
PREPARATION METHOD			GOUGING METHOD & PURPOSE				GOUGE CHECK METHOD					
TACK WELD TECHNIQUE TACK LENGTH:						TACK SEPARATION:						
SIDE	RUN NOS	WELDING PROCESS	WELDING POSITION & DIRECTION	ELECTRODE(S)			FLUX OR GAS SHIELD	GAS FLOW RATE	AMPS	VOLTS	WELDING SPEED OR R.O.L.	HEAT INPUT kJ/mm
				SIZE mm	TRADE NAME	POLARITY						
POST WELD HEAT TREATMENT				NOTES								
HEATING RATE												
SOAK TEMP °C												
SOAK TIME												
COOLING RATE												
WITHDRAWAL TEMP. °C												
			Specification completed by		Accepted for testing by		Test witnessed by		Procedure approved by			
COMPANY												
SIGNATURE												
PRINT NAME												
DATE												

Figure 1 Example of a welding procedure specification

4.2.1.6 Site welding instruction sheets

Where the contractor/sub-contractor proposes to use SWIS, these should cover all welding procedures for each combination of process and consumable proposed regardless of preparation, thickness, or heat treatment condition (Depending on the contractor/sub-contractor's selection of process and consumables, it is possible that a single SWIS could be developed for each main fabrication area).

Where the SWIS is intended as the primary shop floor communication, it should include all of the information necessary for consistent application of all of the associated qualified weld procedures. As a minimum it shall contain the following information:

- General requirements:
 - preheat and interpass temperature;
 - tack welds-size and technique;
 - controls related to root beads, including maximum root closure gaps;
 - permitted weld interruptions; and
 - restrictions on back-gouging.
- For SMAW (by welding position where appropriate):
 - electrode brand name and diameter;
 - individual welders electrode storage (Section 5.3.2);
 - ROL and assumed stub length per electrode size;
 - weld bead width;
 - controls on any use of temper bead; and
 - current.
- For Submerged Arc-Welding (SAW):
 - wire and flux brand names;
 - number and orientation of wires;
 - travel speed; and
 - for each wire:-
 - diameter;
 - polarity;
 - voltage;
 - current;
 - stickout;
 - separation; and
 - feeding direction/angle.
- For semi-automatic processes (by welding position and joint geometry):
 - electrode brand name and diameter;
 - nozzle size relative to wire diameter/joint geometry;
 - weld bead width;
 - controls on any use of temper bead;
 - stickout;
 - travel speed;
 - voltage;
 - current/wire feed speed;
 - polarity; and
 - gas composition and flow rate (where applicable).

To avoid the need for a separate submission, the SWIS may also include all the relevant elements of Section 4.2.1.4, if appropriate, and any other information which the fabricator considers necessary for the instruction of the welder.

The parameter ranges in the AFC submission shall be based on those recorded on the associated PQR's, taking into account the allowable tolerances for essential variables identified in Section 4.5.

Specific situations may impose exclusions which shall be noted on the SWIS, e.g. wide-gap single-sided closure welds.

An example of a SWIS is illustrated in Figure 2.

Where the contractor or sub-contractor has an existing system of work instructions for welders then this may, subject to purchaser approval, be used in preference to the above referenced SWIS.

SWIS, WPS or other work instructions shall be available in the welders' first language and English.

In addition to written instructions concerning welding operations, welders should be required to attend regular tool box talks at which the elements of good welding practice related to the fabrication contract are emphasised.

4.2.3 Procedure qualification records

The first part of the PQR shall consist of an 'as-run' sheet which is a pass-by-pass record of the test weld, giving the information and measured values of each of the welding parameters detailed below:

- PQR number;
- Test code and relevant specifications;
- Date of test;
- Parent materials, specification, sizes and heat/cast numbers;
- Consumable (including SAW flux) classification, brand name, batch certificate number;
- Welders identification number(s) and name(s);
- Welding position;
- Weld preparation sketch and dimensions;
- Sketch detailing actual pass locations;
- Shielding and backing gases, trade name, composition and flow rates;
- Preheat temperature and method of application/measurement;
- Inter-pass temperature (pass by pass) and method of measurement;
- Consumable diameter for each pass;
- Tungsten type and size for Gas Tungsten Arc Welding (GTAW);
- Shroud diameter and type for GTAW;
- Nozzle diameter for semi-automatic processes;
- Wire feed speed;
- Wire stick out length;
- Polarity for each pass;
- Current and voltage for each pass;
- Pulse shape and duration for pulsed welding;
- Welding speed/electrode run out length for each pass;
- Time for each pass;

- Calculated heat input for each pass;
- Details of any post weld hydrogen release treatment;
- Post weld heat treatment report number; and
- NDT report numbers.

SITE WELDING INSTRUCTION SHEET NO.					
Process(es):			Consumable(s):		
Approved WPQRs:					
Preparations Covered:					
Materials Qualified: <i>eg. Up to 460 grade structural steels in TMCR and Q&T Conditions, max CEq. 0.40</i>					
GSFCAW Table of Parameters			SMAW Table of Parameters		
Ø 1.2mm	Polarity	S/P. Fillet DC+ve	2nd Pass * DC+ve	Fill DC+ve	Cap DC+ve
1G	Wire Feed				
	Volts				
	Speed				
2G/2F	Wire Feed				
	Volts				
	Speed				
3G/3F	Wire Feed				
	Volts				
	Speed				
4G/4F	Wire Feed				
	Volts				
	Speed				
Shield Gas:		litres/min			
Preheat Instructions					
(Combined) Thickness Range		Preheat			
Control: <i>eg. Temperature Crayon</i>					
Method: <i>eg. Electrical Mats or Propane for Weld Length <= 300mm</i>					
Interpass: <i>eg. 250°C maximum</i>					
Approved Heat Input Ranges					
		SMAW Root:			
		SMAW 2nd Pass:			
		GSFCAW Single Pass Fillets:			
		GSFCAW 2nd Pass (* or first pass of backgouged welds):			
		GSFCAW Fill:			
		GSFCAW Cap:			
Heat Inputs shown are: unfactored Arc Energy / ~~factored by efficiency factor, 0.8~~					
Other Variables, Comments etc.					
<i>eg. Vertical down welding not permitted</i>					
<i>eg. For repairs increase preheat by 50°C up to maximum 150°C</i>					
<i>eg. GSFCAW fill parameters also used for multipass fillets.</i>					
Rev	Approved	Date			

Figure 2 Example of a site welding instruction sheet for semi-automatic and manual welding

During procedure qualification the above parameters shall be monitored by automatic arc monitoring equipment, which shall also record arc time. This equipment shall be subject to approval by the purchaser.

Welding parameters for pulsed current and wave form controlled processes shall be recorded using an instantaneous power meter.

The original field report will be acceptable subject to it being legible and to a purchaser approved format. This completed form shall be submitted to the witness, who will sign it if it is a factual record of the information and if the visual examination of the test weld confirms that it meets the requirements of Section 7.5.2.

The second part of the PQR shall consist of the full set of mechanical test results for the test pieces taken from the weld. These tests shall be undertaken by a test laboratory accredited by an ILAC member organisation, e.g. UKAS. Alternatively, a purchaser approved test house may be used. The completed form shall be submitted to the witness, who will endorse it if it is a factual record of the information. A typical mechanical test result format is shown in Figure 3.

4.2.4 Submission of the qualification package

If the NDT and mechanical testing results meet the requirements specified, the following documents shall be compiled and submitted to the purchaser for each qualified procedure:

- The WPS based on as-run information;
- All parts of the PQR, bearing the signatures of the witnesses;
- Parent material and consumables certificates; and
- NDT and Post Weld Heat Treatment (PWHT) records.

Each qualification package will be reviewed for approval by the purchaser, and the contractor/sub-contractor notified in writing of the results of this review.

Where used, SWIS shall be prepared in accordance with Section 4.2.1.6 once any relevant welding procedure has been approved. All SWIS will be subject to approval by the purchaser prior to issue for production welding. SWIS shall be revised, re-approved and re-issued as necessary when additional associated weld procedures are approved by the purchaser.

4.3 Restrictions on welding practices

For certain welding practices, the purchaser will require extensive background data and assurance of adequate QC. It should be noted that the processes and techniques listed below are not necessarily prohibited but will require additional technical justification before approval.

- SMAW for heat inputs exceeding 3kJ/mm;
- SMAW bead widths exceeding three times the core wire diameter;
- SMAW vertical down;
- GMAW (except for the root pass in double-sided SAW welds);
- Gas shielded welding processes (except where adequate environmental shielding is provided to ensure security of the gas shield);
- Semi-automatic welding without the voltage and wire-feed speed pre-set;
- Semi-automatic welding with weave beads (i.e. not stringer beads);

- Semi-automatic welding vertically up (except for root passes);
- Flux cored weld passes followed by any high dilution process;
- The use of semi-automatic welding for the root of single sided joints;
- Butt welds, where both edges are square, greater than 8mm thick;
- Full penetration T-butt welds without bevels where the incoming member is greater than 8mm thick;
- Included angles of bevelled welds below 45° (except as covered by 4.5.2(g));
- Included angles below 60° for closing welds in tubulars above 40mm thick;
- Welding on the second side of a joint without back-gouging or grinding except for SAW procedures using the punch-through technique;
- Use of SAW punch-through technique for Grade 460 steels
- Use of a 'temper bead' technique;
- Maximum interpass temperature exceeding 250°C;
- Single-pass fillet welds (other than by SAW) with a design leg length greater than 6mm;
- Use of backing strips; and/or
- Use of ceramic inserts.

4.4 Welding procedure qualification tests

4.4.1 General requirements

The contractor or sub-contractor welding engineer shall be present during the qualification of welding procedures.

Since the purpose of the test is to demonstrate that the procedures are suitable for use in construction, the test conditions shall be a realistic simulation of the actual conditions that will be experienced.

Procedures qualified in shops may be used in the open if adequate temporary protection is provided.

Weld test pieces shall be restrained to a similar degree to the corresponding production weldments.

				FABRICATOR								
				LOCATION		SHOP SITE						WELDING PROCEDURE NO.
Welding Procedure Specification				TEST WELD THICKNESS				mm				
				TEST WELD WIDTH				mm				
				TEST WELD LENGTH/DIA				mm				
TRANSVERSE OR ALL WELD		THICKNESS mm	WIDTH mm	DIA-METER mm	GAUGE LENGTH	YIELD N/mm ²	TS N/mm ²	ELONG %	RED'N OF AREA %	LOCATION OF FRACTURE		
BEND TESTS						STANDARD HAZ HARDNESS SURVEY Hv10						
TYPE	THICKNESS mm	RADIUS mm		RESULT		1		6		11		16
						2		7		12		17
						3		8		13		18
						4		9		14		19
						5		10		15		20
WELD METAL C.T.O.D. TESTS TO EN ISO 15653												
NOTCH LOCATION (IT/SURFACE)		T °C	W mm	B mm	L mm	a mm	P N/mm ²	V _p mm	c mm	u mm	m mm	COMMENTS
NDT (ACCEPTABILITY & REPORT NO.)												
VISUAL						MAGNETIC PARTICLE						
X-RAY/GAMMA RAY						UNTRASONIC						
CHARPY V-NOTCH IMPACT TESTS (10 x mm at °C)												
WELD CAP	J	WELD ROOT		J					J			
WELD METAL		WELD METAL										
WELD METAL		WELD METAL										
WELD METAL		WELD METAL										
FUSION LINE		FUSION LINE										
FUSION LINE		FUSION LINE										
FUSION LINE		FUSION LINE										
FL-2 mm		FL-2 mm										
FL-2 mm		FL-2 mm										
FL-2 mm		FL-2 mm										
FL-5 mm		FL-5 mm										
FL-5 mm		FL-5 mm										
FL-5 mm		FL-5 mm										
					MACRO (PHOTO ATTACHED)							
					DATE(S) OF TESTS							
		Tested by		Form completed by		Test witnessed by		Results approved by				
COMPANY												
SIGNATURE												
PRINT NAME												
DATE												

Figure 3 Example of a PQR mechanical test report

When PWHT of nodes or other sub-assemblies is required, all relevant procedures and qualifications shall include PWHT over the full range of material thickness.

The purchaser may choose to nominate certain plates, tubulars or sections for use in welding procedure tests and the contractor/sub-contractor shall comply with any such requirement. Test welds in plate shall be made parallel to the rolling direction of the plate with at least 250mm of plate width on each side of

the weld (note that wider plates will be needed for CTOD testing) Test welds in seamless tubulars and sections shall normally be made perpendicular to the rolling direction.

Welding procedures for butt welds shall be qualified in two positions which represent the highest and the lowest heat inputs as agreed with the purchaser.

Plate butt welds qualify T-butt welds provided that the test joint preparation has one square edge, but the test in 4.4.2.3 (b) is still required for stub to barrel welds. Only consumables which have been qualified on butt welds may be used, and testing requirements shall be agreed with the purchaser. T-butt welds may also be qualified separately.

On node joints where 'point-to-point' fabrication techniques are proposed, such that the closure joint will be welded single sided, a full size joint mock up shall be undertaken for NDT and mechanical test purposes as per 4.4.2.3 (b). The brace to be welded to the continuous member shall have a cover, tack welded over the open end, to prevent internal access prior to the weld completion and NDT. This mock up shall also be used for NDT procedure qualification.

Single pass fillet welds shall be qualified on plate of minimum thickness 30mm. Qualification shall be in the 2F and 4F positions at the minimum specified leg length.

Additionally, the consumables employed for fillet welds shall have been tested in a plate butt weld.

When procedures require PWHT, the soak time for the test weld shall not be less than 1 hour per 25mm of section thickness or 4 hours whichever is greater. The PWHT soak time qualified shall be the maximum the contractor/sub-contractor intends to use in practice. This shall allow for one repeat PWHT cycle to cover weld repairs made after the first PWHT.

Post-weld hydrogen release treatments may be used subject to agreement with the purchaser.

If the contractor/sub-contractor becomes aware of an error likely to result in rejection of the test weld, welding shall be stopped immediately, the test weld discarded, and a new one welded. Weld repairs to a test weld shall not be undertaken without the agreement of the purchaser.

For butt welds, all passes in the cap of the qualification weld shall use the same electrode diameter, although the diameter may be increased for production welds within the limits of 4.5.3 (d).

The interpass temperature prior to the deposition of the capping passes of the Weld Procedure Qualification Test (WPQT) shall be limited to the minimum preheat temperature.

4.4.2 Types of test weld

4.4.2.1 Comprehensive tests

Three types of weld require full qualification testing:

- Butt welds in plate;
- Butt welds in tubulars below 600mm diameter; and
- Single pass fillet welds.

4.4.2.2 Optional tests

The following types of weld do not require separate qualification if the conditions specified are observed:

- partial penetration welds made with qualified full penetration butt weld parameters;
- multipass fillet welds made with qualified full penetration butt weld parameters;
- tack welds made with qualified root pass parameters;
- weld metal buttering deposited with qualified full penetration butt weld parameters.

If the contractor/sub-contractor wishes to work outside these conditions, the purchaser shall specify the testing to be undertaken.

4.4.2.3 Single tests and demonstrations

The following types of weld require 'one-off' demonstrations of the suitability of the contractor/sub-contractor's qualified procedures for each type of welding process and consumable to be used. However, additional tests will be specified if the purchaser is not satisfied with the results of the demonstration.

The NDT applied to these tests and demonstrations shall be specified by the purchaser.

4.4.2.3.1 Repair welds using a different procedure from that of the original weld

A fusion line excavation to mid-thickness shall be made in a test weld of the greatest thickness to be qualified. This shall be repaired in the vertical position using the qualified full penetration butt weld parameters for the repair consumable. The Heat Affected Zone (HAZ) mechanical tests required shall be taken from both sides of the repair, i.e. parent material and original weld. The requirements for PWHT or CTOD testing of the repair weld shall be the same as those for the original weld. Separate tests are necessary for as-welded and PWHT procedures.

4.4.2.3.2 T-K-Y joints

A joint between two tubulars shall be assembled as illustrated in Figure 4. With the approval of the purchaser, the tubular dimensions may be varied to sizes appropriate to those on the purchaser approved drawings.

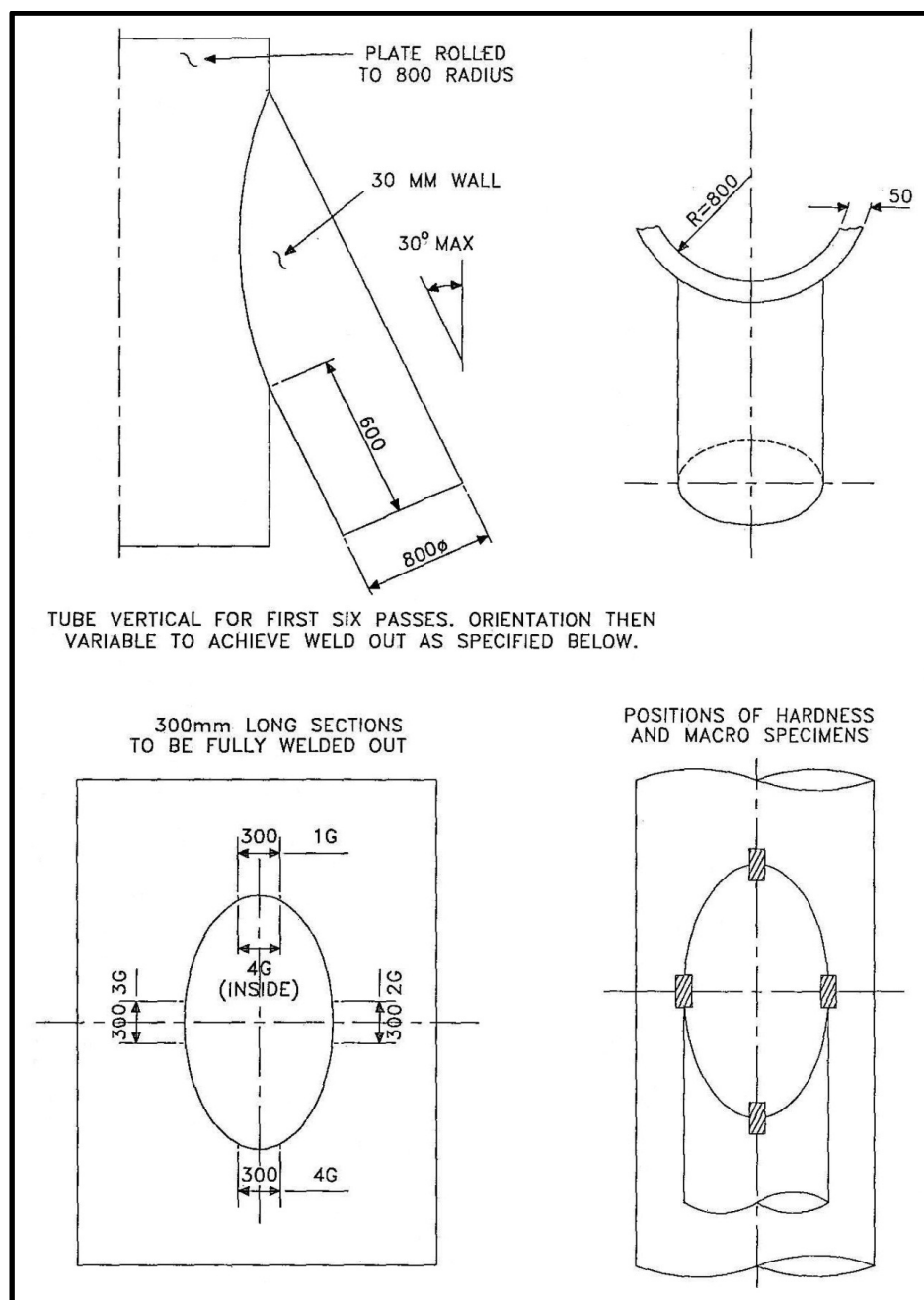
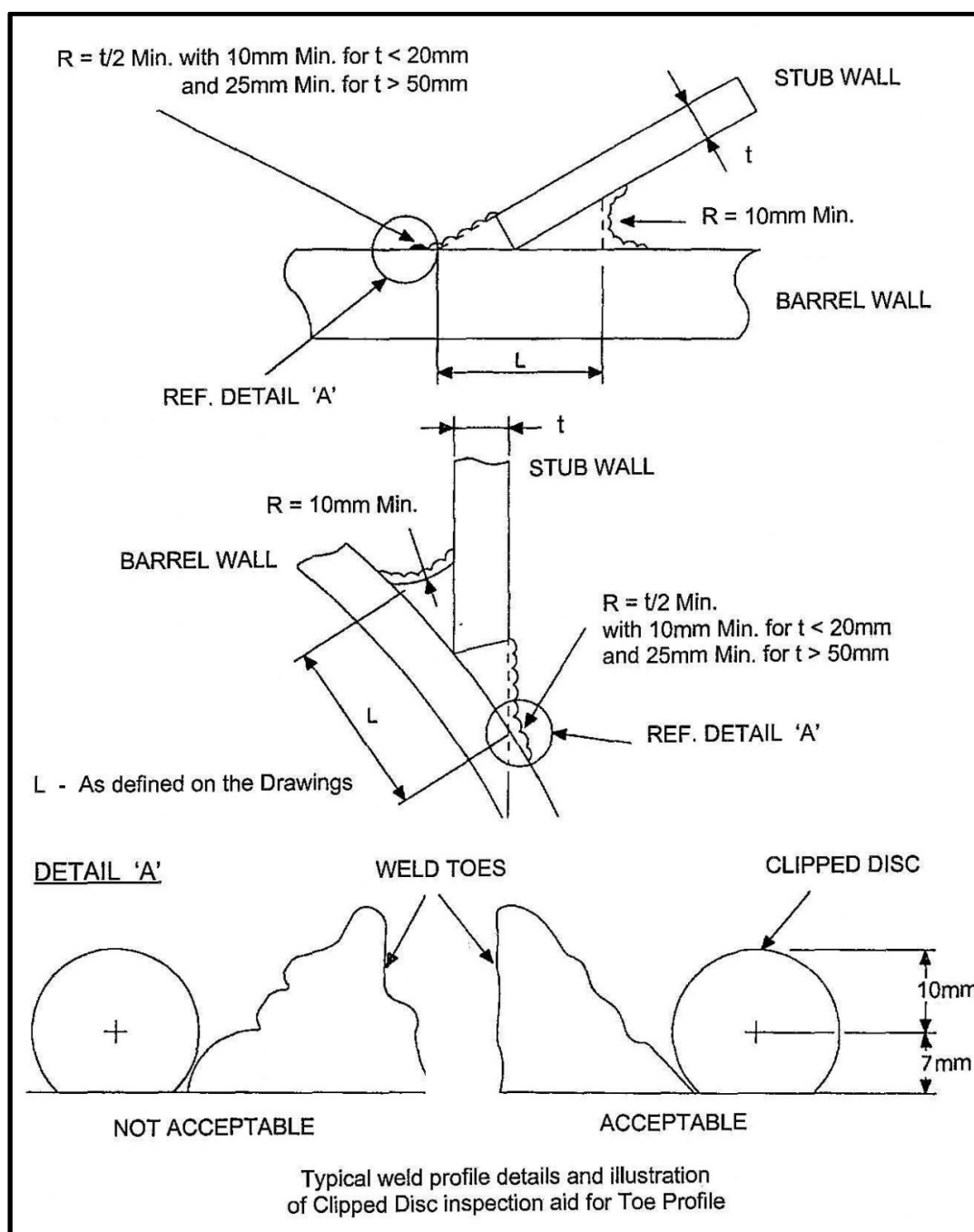


Figure 4 Demonstration piece for T, K and Y joints

Six passes shall be completed externally all around the joint, with the weld being filled and capped along 300mm sections, as illustrated in Figure 4. Where the test is required to demonstrate double-sided welding, an additional pass (or passes) shall be deposited in the 4G position as shown in Figure 4. Weld surface profiles shall be as illustrated in Figure 5. Similar joints in plate structures shall be subject to agreement between the purchaser and the contractor/sub-contractor.



Note: Other locations shall be in accordance with the purchaser approved drawings and Section 7.5.2

Figure 5 Examples of acceptable weld profiles for tubular intersections

4.4.2.3.3 Wide gap tubular closing butts

For tubular closing butts a single-sided joint between two tubulars at least 600mm diameter and at least 40mm thick shall be assembled, with the tubulars in the fixed horizontal position. The root pass shall be deposited using root gap dimensions agreed with the purchaser.

The test joint shall be welded out completely and then tested at the 3, 6 and 12 o'clock positions by macro-examination, hardness and root Charpy tests against the requirements of this Specification.

Testing requirements for plate closing butts shall be agreed between the purchaser and the contractor/sub-contractor.

4.4.2.3.4 Grout beads

Welding procedure qualification for depositing 'grout beads' on piles or pile sleeves shall be undertaken by depositing a full circumferential bead on a can of the material of the diameter and thickness shown on the purchaser approved drawings, using appropriate production welding equipment. Surfaces on to which grout beads are to be deposited shall be identical in qualification tests and production. Visual examination shall show that bead height, bead width and toe profile are as specified on the purchaser approved drawings. 100% Magnetic Particle Inspection (MPI) shall be performed and show freedom from defects. Macro-examination (two sections, 1m apart) shall show freedom from solidification cracking and other defects. Hardness indents shall be made as shown in Figure 6 and shall not exceed 325HV10.

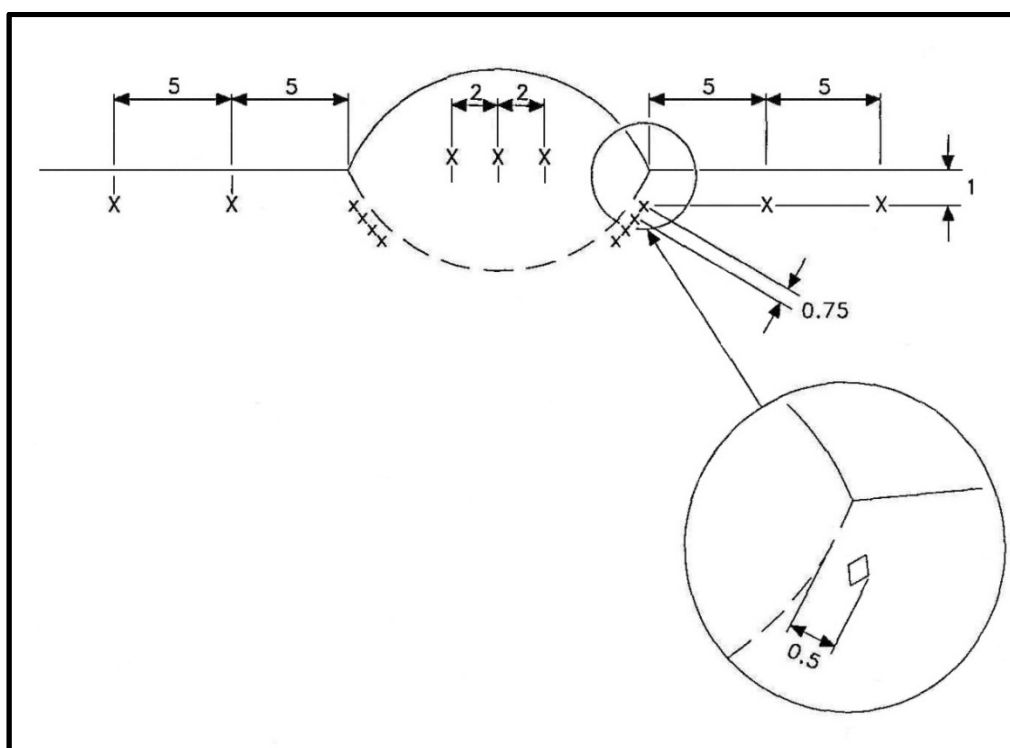


Figure 6 Hardness indentation locations for grout bead procedures

4.4.3 Inspection and NDT requirements and acceptance criteria

4.4.3.1 Visual inspection

Each completed test weld shall be visually inspected and shown to comply with the relevant clauses in Section 7 of this Specification.

If inspection of the root of a single-sided weld reveals an unacceptable profile, the purchaser may require the contractor/sub-contractor to repeat the test using a different technique. This change would apply to all single-sided production welds using the same root pass consumables in the same position as the test welds.

4.4.3.2 Non-destructive testing

Not less than 48 hours following completion of welding, the test weld shall be non-destructively tested in accordance with Section 7 of this Specification, using test procedures which have been approved by the purchaser. Extent and type of NDT shall be in accordance with Table 2 Category I for butt welds and 100% MPI for fillet welds. When a test weld is to receive PWHT, final NDT examination shall take place after PWHT.

Table 2 Requirements for extent and type of inspection and NDT

Inspection/ NDT category	Extent of visual examination	Extent of ultrasonic examination ^(a)	Examination level to EN ISO 17640:2010 ⁽⁵²⁾	Extent of Magnetic Particle Inspection ^(f)
I	100%	100%	Nodes Level B, or, D if specified by purchaser. Others joint details Level C.	100%
II	100%	100%	Level B	100%
III^(e)	100%	100% ^(b)	Level B	100% ^(b)
IV^(e)	100%	10% ^(c)	Level B	10% ^(c)
V	100%	-	-	10% ^(c, d)

Notes:

- (a) For thicknesses where the use of UT is impractical, radiography shall be used.
- (b) This may be reduced to 20% when the contractor/sub-contractor has been able to demonstrate to the satisfaction of the purchaser that a consistently low repair rate has previously been achieved.
- (c) 10% examination is defined as examination of 10% of the length of each weld, unless the length of the weld is less than 1m, in which case 10% of all similar welds shall be inspected (see Section 7.2.1.5),
- (d) Alternative inspection requirements may be specified for pipe grout beads, e.g. creeping waves.
- (e) Fillet welds falling into Categories III and IV shall be subjected to visual examination and MPI only
- (f) MPI shall only be applied to the external surface of weldments unless otherwise specified by the purchaser.

Preliminary NDT may be conducted immediately after welding, but repair welding is not permitted. Flaws exceeding the acceptance criteria of Section 7 may be permitted on condition that they can be categorized as welder induced. In this case the weld shall not be considered as qualifying the welder.

If ultrasonic examination reveals no flaws exceeding the reference level, but more than three reflectors in any metre of weld length exceed 50% of the reference level, then the procedure and consumables shall be considered suspect. If a further test piece using the same consumables and a similar procedure also shows reflectors above 50% of the reference level, the purchaser may reject all procedures using the consumables or joint geometry which the purchaser considers to be responsible.

The locations of all imperfections exceeding 50% of the reference level shall be marked, and the cutting of test pieces shall be arranged to avoid these regions.

4.4.4 Mechanical testing requirements and acceptance criteria

Mechanical testing shall be undertaken as detailed below.

The number and types of tests required for any test weld are specified in Table 3. The purchaser shall be notified of all test failures, even where retests are permitted, before additional testing is undertaken. Where dissimilar material welds will involve a thickness transition to compensate for a difference in strengths, the mechanical test requirements shall comply with those of the stronger material.

4.4.4.1 Transverse tensile tests (EN ISO 4136:2012⁽⁵³⁾)

The tests shall take the form of the 'reduced transverse test' except that the parallel length of the test piece shall not exceed 6mm on each side of the weld. For acceptance, the tensile strength shall not be less than the minimum value specified for the parent material. In the case of welds between materials of different specified minimum tensile strengths, the acceptance level shall be the lower of the two.

If fracture occurs at less than 95% of the specified minimum tensile strength on one or both specimens, the procedure shall be rejected. If fracture occurs at between 95% and 100% of the specified tensile strength then two retests shall be carried out for each failure recorded, all of which shall meet the specified minimum tensile strength.

4.4.4.2 All weld metal tensile tests (EN ISO 5178:2011⁽⁵⁴⁾)

The locations from which the test pieces shall be taken are illustrated in Figure 7. The upper yield or 0.5% proof stress (total extension) and the tensile strength shall not be less than those specified for the parent material, and the elongation shall not be less than 20%. The test house shall state whether the measured value is upper yield or 0.5% proof stress. In the case of welds between materials of different specified minimum strengths, the acceptance level shall be the higher of the two.

If the test fails to meet the specified minimum properties, two retests shall be carried out on pieces taken from the original weld, both of which shall meet the specified requirements.