

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

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 GHAZ 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