



BSI Standards Publication

Execution of steel structures and aluminium structures

Part 3: Technical requirements for aluminium structures

National foreword

This British Standard is the UK implementation of EN 1090-3:2019. It supersedes BS EN 1090-3:2008, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/525/9, Structural use of aluminium.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019

Published by BSI Standards Limited 2019

ISBN 978 0 580 95871 7

ICS 91.080.13; 77.150.10; 91.080.17

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2019.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

English Version

Execution of steel structures and aluminium structures -
Part 3: Technical requirements for aluminium structures

Exécution des structures en acier et des structures en
aluminium - Partie 3: Exigences techniques pour
l'exécution des structures en aluminium

Ausführung von Stahltragwerken und
Aluminiumtragwerken - Teil 3: Technische
Anforderungen an Aluminiumtragwerke

This European Standard was approved by CEN on 6 January 2019.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European foreword.....	7
Introduction	8
1 Scope	9
2 Normative references	9
3 Terms and definitions	16
4 Specifications and documentation.....	17
4.1 Execution specification	17
4.1.1 General.....	17
4.1.2 Execution classes.....	18
4.1.3 Tolerance types.....	18
4.1.4 Tolerance class for shell structures	18
4.1.5 Testing and acceptance criteria for welding.....	18
4.2 Constructor's documentation	18
4.2.1 Quality documentation	18
4.2.2 Quality plan	19
4.2.3 Safety during erection	19
4.2.4 Execution documentation	19
5 Constituent products	19
5.1 General.....	19
5.2 Identification, inspection documents and traceability	19
5.3 Parent material.....	20
5.4 Aluminium products	23
5.5 Welding consumables.....	24
5.6 Mechanical fasteners	24
5.6.1 Bolts, nuts and plain washers	24
5.6.2 Studs.....	26
5.6.3 Rivets.....	26
5.6.4 Self-drilling and self-tapping screws.....	26
5.6.5 Bearings.....	26
5.7 Adhesive bonding.....	26
6 Preparation	26
6.1 General.....	26
6.2 Identification	27
6.3 Handling, storage and transportation	27
6.4 Cutting.....	27
6.5 Forming.....	28
6.6 Holing for fasteners.....	28
6.7 Cut outs	30
6.8 Full contact bearing surfaces	30
6.9 Assemblies.....	30
6.10 Heat treatment.....	30
6.11 Straightening	30
7 Welding.....	30

7.1	General	30
7.2	Welding plan.....	31
7.2.1	Requirement for a welding plan.....	31
7.2.2	Content of a welding plan	31
7.3	Welding process.....	31
7.4	Qualification of welding procedures and welding personnel.....	32
7.4.1	Qualification of welding procedures	32
7.4.2	Validity of the welding procedure qualification.....	33
7.4.3	Qualification of welders and welding operators.....	33
7.4.4	Welding coordination personnel.....	34
7.5	Preparation and execution of welding.....	34
7.5.1	General	34
7.5.2	Joint preparation	35
7.5.3	Weather protection.....	35
7.5.4	Assembly for welding.....	35
7.5.5	Temporary attachments	35
7.5.6	Tack welds.....	35
7.5.7	Preheating and interpass temperature	36
7.5.8	Butt welds.....	36
7.5.9	Slot and plug welds	36
7.5.10	Fillet welds	36
7.5.11	Single sided welds	36
7.5.12	Friction stir welding	37
7.5.13	Other welds.....	37
7.6	Acceptance criteria	37
7.7	Post-weld heat treatment.....	37
8	Mechanical fastening and adhesive bonding.....	38
8.1	Joint assembly for mechanical fastening	38
8.1.1	Preparation of contact surfaces	38
8.1.2	Fit-up	38
8.1.3	Preparations of contact surfaces in slip-resistant connections.....	39
8.2	Bolting assemblies	39
8.2.1	General	39
8.2.2	Bolts.....	39
8.2.3	Fitted bolts	39
8.2.4	Countersunk bolt	40
8.2.5	Nuts.....	40
8.2.6	Washers.....	40
8.3	Tightening of bolting assemblies.....	41
8.3.1	Non-preloaded bolting assemblies.....	41
8.3.2	Preloaded bolting assemblies	41
8.4	Riveting	42
8.4.1	General	42
8.4.2	Installation of rivets	43
8.5	Adhesive bonded connections	43
9	Erection	43
9.1	General	43
9.2	Site conditions	43
9.3	Erection method statement	43
9.4	Supports.....	43
9.5	Execution on site.....	44
9.5.1	Site survey	44

9.5.2	Marking.....	44
9.5.3	Handling and storage at site.....	44
9.5.4	Erection methods	44
9.5.5	Alignment and grouting.....	44
9.6	Protection of surfaces, cleaning after erection.....	45
10	Surface treatment	45
10.1	General.....	45
10.2	Protection of the structure and components	45
10.3	Protection of contact surfaces and fasteners.....	45
10.3.1	General.....	45
10.3.2	Contact surfaces aluminium-to-aluminium and aluminium-to-plastics.....	45
10.3.3	Contact surfaces of aluminium and steel or wood	46
10.3.4	Contact surfaces of aluminium and concrete, brickwork and plaster, etc.	46
10.3.5	Fasteners.....	46
10.3.6	Bonded joints.....	46
10.4	Fire protection	46
11	Geometrical tolerances	47
11.1	Types of tolerances.....	47
11.2	Essential tolerances	47
11.2.1	General.....	47
11.2.2	Manufacturing tolerances	47
11.2.3	Erection tolerances.....	48
11.3	Functional tolerances	49
11.3.1	General.....	49
11.3.2	Manufacturing tolerances	49
12	Inspection, testing and corrections	50
12.1	General.....	50
12.2	Constituent products and components	50
12.2.1	Constituent products	50
12.2.2	Components	50
12.3	Preparation	51
12.3.1	Forming.....	51
12.3.2	Geometrical dimensions of components	51
12.4	Welding.....	51
12.4.1	Inspection stages.....	51
12.4.2	Methods of inspection and personnel qualification	51
12.4.3	Extent of inspection.....	53
12.4.4	Acceptance criteria for welds	55
12.4.5	Acceptance criteria for ultrasonic testing.....	57
12.4.6	Repair welds	58
12.4.7	Inspection of temporary attachment locations after removal.....	58
12.5	Mechanical fasteners	58
12.5.1	Inspection of connections with non-preloaded bolting assemblies.....	58
12.5.2	Inspection of connections with preloaded bolting assemblies	59
12.5.3	Inspection of riveted connections.....	59
12.6	Adhesive bonding.....	59
12.7	Inspection of the erected structure geometry	59
12.8	Nonconforming products	59
12.8.1	Nonconforming constituent products.....	59
12.8.2	Nonconforming components and structures	60

Annex A (normative) Required additional information, options to be specified and requirements for execution classes	61
A.1 List of required information	61
A.2 List of options to be specified	62
A.3 Requirements related to execution classes	63
Annex B (informative) Checklist for the content of a quality plan	66
B.1 Introduction	66
B.2 Content	66
Annex C (normative) Cruciform weld test	68
C.1 Introduction	68
C.2 Test piece	68
C.3 Examination and testing	70
Annex D (normative) Procedure for determination of slip factor	72
D.1 The purpose of testing	72
D.2 Significant variables	72
D.3 Test specimens	72
D.4 Slip test procedure and evaluation of results	74
D.5 Extended creep test procedure and evaluation	74
D.6 Test results	75
Annex E (informative) Surface treatment	77
E.1 Anodic oxidation	77
E.2 Coatings	77
E.3 Passivation	79
Annex F (normative) Geometrical tolerances – Essential tolerances	80
F.1 Manufacturing tolerances	80
F.2 Erection tolerances	88
Annex G (normative) Geometrical tolerances - Functional tolerances	92
G.1 General	92
G.2 Manufacturing tolerances	92
G.3 Erection tolerances	98
G.4 Bridges	100
Annex H (normative) Geometrical tolerances – Shell structures	102
H.1 General	102
H.2 Out-of-roundness tolerances	102
H.3 Non-intended eccentricity due to execution	103
H.4 Dent tolerances	104
H.5 Interface flatness tolerances	106

Annex I (informative) Designation of requirements to welds on drawings	107
I.1 General.....	107
I.2 Global specification	107
I.3 Specific designations for welds, part of welds, details	108
Annex J (informative) Recommendations for description of site conditions and erection in the execution specification.....	109
J.1 Site conditions.....	109
J.2 Erection method statement.....	109
Annex K (informative) Guide for preparation of the execution specification for quality requirements of welds	112
K.1 General.....	112
K.2 Utilization grades and utilization ranges	113
K.3 Extent of additional NDT	113
K.4 Extent of destructive testing for friction stir welds.....	114
K.5 Acceptance criteria for welds	114
Annex L (informative) Guide for specification of quality requirements for components and structures in service category SC2	116
Annex M (informative) Chart for development and use of a welding procedure specification (WPS).....	121
Annex N (informative) Weld studs connected by arc stud welding with tip ignition.....	122
N.1 Introduction	122
N.2 Area of application.....	122
N.3 Construction.....	122
N.4 Design.....	123
N.5 Qualification of the welding procedure	124
Bibliography.....	126

European foreword

This document (EN 1090-3:2019) has been prepared by Technical Committee CEN/TC 135 “Execution of steel structures and aluminium structures”, the secretariat of which is held by SN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2019, and conflicting national standards shall be withdrawn at the latest by October 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1090-3:2008.

The main changes with respect to the previous edition are contained in the following clauses: Clause 1, Clause 2, Clause 3, 4.1.1, 4.1.2, Table 1, Table 5, 5.6.2, 6.1, 7.3, 7.4.1, 7.4.3, 7.4.4, 7.5.1, 7.5.9, 7.5.10, 7.5.11, 7.5.12, 7.5.13, 7.6, 8.3.1, 11.2.3.1, 12.4.2.1, 12.4.2.2, 12.4.3.2, 12.4.4.3, 12.4.5 and 12.7. Annex E has been deleted and the annexes correspondingly renumbered. The main changes in the annexes are contained in the following sub-clauses: E.2.2, Table F.3, I.1, Table I.1, Table I.2, Table K.1, Table K.2 and K.4. Annex N is a new annex. The Bibliography has been revised. In addition to the major changes in the clauses listed above, some editorial changes have been made.

This document is part of the EN 1090 series, which comprises the following parts:

- EN 1090-1, *Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components*
- EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*
- EN 1090-3, *Execution of steel structures and aluminium structures - Part 3: Technical requirements for aluminium structures*
- EN 1090-4, *Execution of steel structures and aluminium structures - Part 4: Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, ceiling, floor and wall applications*
- EN 1090-5, *Execution of steel structures and aluminium structures - Part 5: Technical requirements for cold-formed structural aluminium elements and cold-formed structures for roof, ceiling, floor and wall applications*

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard specifies requirements for the execution of aluminium structures, in order to ensure adequate levels of mechanical resistance and stability, serviceability and durability.

This document specifies requirements for the execution of aluminium structures, in particular those that are designed according to EN 1999-1-1, EN 1999-1-2, EN 1999-1-3, EN 1999-1-4 and EN 1999-1-5.

This document presupposes that the work is carried out with the necessary skill and adequate equipment and resources to perform the work in accordance with the execution specification and the requirements of this document.

1 Scope

This document specifies requirements for the execution of aluminium structural components and structures made from:

- a) rolled sheet, strip and plate;
- b) extrusions;
- c) cold drawn rod, bar and tube;
- d) forgings;
- e) castings.

NOTE 1 The execution of structural components is referred to as manufacturing, in accordance with EN 1090-1.

This document specifies requirements independent of the type and shape of the aluminium structure, and this document is applicable to structures under predominantly static loads as well as structures subject to fatigue. It specifies requirements related to the execution classes that are linked with consequence classes.

NOTE 2 Consequence classes are defined in EN 1990.

NOTE 3 Recommendations for selection of execution class in relation to consequence class are given in EN 1999-1-1.

This document covers components made of constituent products with thickness not less than 0,6 mm for welded components not less than 1,5 mm.

For components made from cold formed profiled sheeting that are within the scope of EN 1090-5, the requirements of EN 1090-5 take precedence over corresponding requirements in this document.

This document applies to structures designed according to the relevant parts of EN 1999. If this document is used for structures designed according to other design rules or used for other alloys and tempers not covered by EN 1999, a judgement of the reliability elements in these design rules is intended to be made.

This document specifies requirements for surface preparation prior to application of a protective treatment, and gives guidelines for application for such treatment in an informative annex.

This document gives options for specifying requirements to match project specific requirements.

This document is also applicable to temporary aluminium structures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 485-1, *Aluminium and aluminium alloys - Sheet, strip and plate - Part 1: Technical conditions for inspection and delivery*

EN 485-3, *Aluminium and aluminium alloys - Sheet, strip and plate - Part 3: Tolerances on dimensions and form for hot-rolled products*

EN 485-4, *Aluminium and aluminium alloys - Sheet, strip and plate - Part 4: Tolerances on shape and dimensions for cold-rolled products*

EN 515, *Aluminium and aluminium alloys - Wrought products - Temper designations*

EN 573-1, *Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 1: Numerical designation system*

EN 573-2, *Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 2: Chemical symbol based designation system*

EN 573-3, *Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 3: Chemical composition and form of products*

EN 586-1, *Aluminium and aluminium alloys - Forgings - Part 1: Technical conditions for inspection and delivery*

EN 586-3, *Aluminium and aluminium alloys - Forgings - Part 3: Tolerances on dimensions and form*

EN 754-1, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 1: Technical conditions for inspection and delivery*

EN 754-3, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 3: Round bars, tolerances on dimensions and form*

EN 754-4, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 4: Square bars, tolerances on dimensions and form*

EN 754-5, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 5: Rectangular bars, tolerances on dimensions and form*

EN 754-6, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 6: Hexagonal bars, tolerances on dimensions and form*

EN 754-7, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 7: Seamless tubes, tolerances on dimensions and form*

EN 754-8, *Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 8: Porthole tubes, tolerances on dimensions and form*

EN 755-1, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 1: Technical conditions for inspection and delivery*

EN 755-3, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 3: Round bars, tolerances on dimensions and form*

EN 755-4, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 4: Square bars, tolerances on dimensions and form*

EN 755-5, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 5: Rectangular bars, tolerances on dimensions and form*

EN 755-6, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 6: Hexagonal bars, tolerances on dimensions and form*

EN 755-7, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 7: Seamless tubes, tolerances on dimensions and form*

EN 755-8, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 8: Porthole tubes, tolerances on dimensions and form*

EN 755-9, *Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 9: Profiles, tolerances on dimensions and form*

EN 1011-1, *Welding - Recommendations for welding of metallic materials - Part 1: General guidance for arc welding*

EN 1011-4, *Welding - Recommendations for welding of metallic materials - Part 4: Arc welding of aluminium and aluminium alloys*

EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*

EN 1301-1, *Aluminium and aluminium alloys - Drawn wire - Part 1: Technical conditions for inspection and delivery*

EN 1301-3, *Aluminium and aluminium alloys - Drawn wire - Part 3: Tolerances on dimensions*

EN 1337-3, *Structural bearings - Part 3: Elastomeric bearings*

EN 1337-4, *Structural bearings - Part 4: Roller bearings*

EN 1337-5, *Structural bearings - Part 5: Pot bearings*

EN 1337-6, *Structural bearings - Part 6: Rocker bearings*

EN 1337-8, *Structural bearings - Part 8: Guide Bearings and Restraint Bearings*

EN 1337-11, *Structural bearings - Part 11: Transport, storage and installation*

EN 1559-1, *Founding - Technical conditions of delivery - Part 1: General*

EN 1559-4, *Founding - Technical conditions of delivery - Part 4: Additional requirements for aluminium alloy castings*

EN 1706, *Aluminium and aluminium alloys - Castings - Chemical composition and mechanical properties*

EN 1999-1-1, *Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules*

EN 1999-1-2, *Eurocode 9 - Design of aluminium structures - Part 1-2: Structural fire design*

EN 1999-1-3, *Eurocode 9: Design of aluminium structures - Part 1-3: Structures susceptible to fatigue*

EN 1999-1-4, *Eurocode 9 - Design of aluminium structures - Part 1-4: Cold-formed structural sheeting*

EN 1999-1-5, *Eurocode 9 - Design of aluminium structures - Part 1-5: Shell structures*

EN 10204, *Metallic products - Types of inspection documents*

EN 12020-1, *Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063 - Part 1: Technical conditions for inspection and delivery*

EN 12020-2, *Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063 - Part 2: Tolerances on dimensions and form*

EN 14399-2, *High-strength structural bolting assemblies for preloading - Part 2: Suitability for preloading*

EN 14399-3, *High-strength structural bolting assemblies for preloading - Part 3: System HR - Hexagon bolt and nut assemblies*

EN 14399-4, *High-strength structural bolting assemblies for preloading - Part 4: System HV - Hexagon bolt and nut assemblies*

EN 14399-5, *High-strength structural bolting assemblies for preloading - Part 5: Plain washers*

EN 14399-6, *High-strength structural bolting assemblies for preloading - Part 6: Plain chamfered washers*

EN 14399-7, *High-strength structural bolting assemblies for preloading - Part 7: System HR - Countersunk head bolt and nut assemblies*

EN 14399-8, *High-strength structural bolting assemblies for preloading - Part 8: System HV - Hexagon fit bolt and nut assemblies*

EN 14399-10, *High-strength structural bolting assemblies for preloading - Part 10: System HRC - Bolt and nut assemblies with calibrated preload*

EN 15048-1, *Non-preloaded structural bolting assemblies - Part 1: General requirements*

EN 15088, *Aluminium and aluminium alloys - Structural products for construction works - Technical conditions for inspection and delivery*

EN 28839, *Mechanical properties of fasteners - Bolts, screws, studs and nuts made of non-ferrous metals (ISO 8839)*

EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1)*

EN ISO 898-2, *Mechanical properties of fasteners made of carbon steel and alloy steel - Part 2: Nuts with specified property classes - Coarse thread and fine pitch thread (ISO 898-2)*

EN ISO 1479, *Hexagon head tapping screws (ISO 1479)*

EN ISO 1481, *Slotted pan head tapping screws (ISO 1481)*

EN ISO 2009, *Slotted countersunk flat head screws - Product grade A (ISO 2009)*

EN ISO 3452-1, *Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1)*

EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs (ISO 3506-1)*

EN ISO 3506-2, *Mechanical properties of corrosion-resistant stainless steel fasteners - Part 2: Nuts (ISO 3506-2)*

EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements (ISO 3834-2)*

EN ISO 3834-3, *Quality requirements for fusion welding of metallic materials - Part 3: Standard quality requirements (ISO 3834-3)*

EN ISO 3834-4, *Quality requirements for fusion welding of metallic materials - Part 4: Elementary quality requirements (ISO 3834-4)*

EN ISO 4014, *Hexagon head bolts - Product grades A and B (ISO 4014)*

EN ISO 4016, *Hexagon head bolts - Product grade C (ISO 4016)*

EN ISO 4017, *Fasteners - Hexagon head screws - Product grades A and B (ISO 4017)*

EN ISO 4018, *Hexagon head screws - Product grade C (ISO 4018)*

EN ISO 4032, *Hexagon regular nuts (style 1) - Product grades A and B (ISO 4032)*

EN ISO 4034, *Hexagon regular nuts (style 1) - Product grade C (ISO 4034)*

EN ISO 4063, *Welding and allied processes - Nomenclature of processes and reference numbers (ISO 4063)*

EN ISO 4288, *Geometrical product specifications (GPS) - Surface texture: Profile method - Rules and procedures for the assessment of surface texture (ISO 4288)*

EN ISO 4762, *Hexagon socket head cap screws (ISO 4762)*

EN ISO 6520-1:2007, *Welding and allied processes - Classification of geometric imperfections in metallic materials - Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 6789 (all parts), *Assembly tools for screws and nuts - Hand torque tools (ISO 6789)*

EN ISO 7046-2, *Countersunk flat head screws (common head style) with type H or type Z cross recess - Product grade A - Part 2: Steel screws of property class 8.8, stainless steel screws and non-ferrous metal screws (ISO 7046-2)*

EN ISO 7049, *Cross-recessed pan head tapping screws (ISO/FDIS 7049)*

EN ISO 7089, *Plain washers - Normal series - Product grade A (ISO 7089)*

EN ISO 7090, *Plain washers, chamfered - Normal series - Product grade A (ISO 7090)*

EN ISO 7091, *Plain washers - Normal series - Product grade C (ISO 7091)*

EN ISO 7093-1, *Plain washers - Large series - Part 1: Product grade A (ISO 7093-1)*

EN ISO 7093-2, *Plain washers - Large series - Part 2: Product grade C (ISO 7093-2)*

EN ISO 7094, *Plain washers - Extra large series - Product grade C (ISO 7094)*

EN ISO 8062-1, *Geometrical product specifications (GPS) - Dimensional and geometrical tolerances for moulded parts - Part 1: Vocabulary (ISO 8062-1)*

CEN ISO/TS 8062-2, Geometrical Product Specifications (GPS) - Dimensional and geometrical tolerances for moulded parts - Part 2: Rules (ISO/TS 8062-2)

EN ISO 8062-3, Geometrical Product Specifications (GPS) - Dimensional and geometrical tolerances for moulded parts - Part 3: General dimensional and geometrical tolerances and machining allowances for castings (ISO 8062-3)

EN ISO 9013:2017, Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances (ISO 9013:2017)

EN ISO 9017, Destructive tests on welds in metallic materials - Fracture test (ISO 9017)

EN ISO 9018, Destructive tests on welds in metallic materials - Tensile test on cruciform and lapped joints (ISO 9018)

EN ISO 9606-2, Qualification test of welders - Fusion welding - Part 2: Aluminium and aluminium alloys (ISO 9606-2)

EN ISO 9712, Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712)

EN ISO 10042:2018, Welding - Arc-welded joints in aluminium and its alloys - Quality levels for imperfections (ISO 10042:2018)

EN ISO 10642, Hexagon socket countersunk head screws (ISO 10642)

EN ISO 13918, Welding - Studs and ceramic ferrules for arc stud welding (ISO 13918)

EN ISO 13920, Welding - General tolerances for welded constructions - Dimensions for lengths and angles - Shape and position (ISO 13920)

EN ISO 14555, Welding - Arc stud welding of metallic materials (ISO 14555)

EN ISO 14731, Welding coordination - Tasks and responsibilities (ISO 14731)

EN ISO 14732, Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732)

EN ISO 15480, Hexagon washer head drilling screws with tapping screw thread (ISO 15480)

CEN ISO/TR 15608, Welding - Guidelines for a metallic materials grouping system (ISO/TR 15608)

EN ISO 15609-1, Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1)

EN ISO 15612, Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure (ISO 15612)

EN ISO 15613, Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test (ISO 15613)

EN ISO 15614-2, Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 2: Arc welding of aluminium and its alloys (ISO 15614-2)

EN ISO 17635, Non-destructive testing of welds - General rules for metallic materials (ISO 17635)

EN ISO 17636-1, *Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1)*

EN ISO 17636-2, *Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2)*

EN ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637)*

EN ISO 17639, *Destructive tests on welds in metallic materials - Macroscopic and microscopic examination of welds (ISO 17639)*

EN ISO 17640, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640)*

EN ISO 17659, *Welding - Multilingual terms for welded joints with illustrations (ISO 17659)*

EN ISO 18273, *Welding consumables - Wire electrodes, wires and rods for welding of aluminium and aluminium alloys - Classification (ISO 18273)*

EN ISO 25239-2, *Friction stir welding - Aluminium - Part 2: Design of weld joints (ISO 25239-2)*

EN ISO 25239-3, *Friction stir welding - Aluminium - Part 3: Qualification of welding operators (ISO 25239-3)*

EN ISO 25239-4, *Friction stir welding - Aluminium - Part 4: Specification and qualification of welding procedures (ISO 25239-4)*

EN ISO 25239-5, *Friction stir welding - Aluminium - Part 5: Quality and inspection requirements (ISO 25239-5)*

ISO 4463-1, *Measurement methods for building - Setting-out and measurement - Part 1: Planning and organization, measuring procedures, acceptance criteria*

ISO 7976-1, *Tolerances for building - Methods of measurement of buildings and building products - Part 1: Methods and instruments*

ISO 7976-2, *Tolerances for building - Methods of measurement of buildings and building products - Part 2: Position of measuring points*

ISO 10509, *Hexagon flange head tapping screws*

ISO 17123-1, *Optics and optical instruments - Field procedures for testing geodetic and surveying instruments - Part 1: Theory*

ISO 17123-3, *Optics and optical instruments - Field procedures for testing geodetic and surveying instruments - Part 3: Theodolites*

ISO 17123-4, *Optics and optical instruments - Field procedures for testing geodetic and surveying instruments - Part 4: Electro-optical distance meters (EDM measurements to reflectors)*

ISO 17123-7, *Optics and optical instruments - Field procedures for testing geodetic and surveying instruments - Part 7: Optical plumbing instruments*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

supplementary NDT

supplementary non-destructive testing

NDT techniques which are supplementary to visual examination (VT), e.g. penetrant (PT), ultrasonic (UT) or radiographic testing (RT)

3.2

component

part of the works, which may itself be an assembly of several smaller components

Note 1 to entry: A component might in itself be a structure.

3.3

constituent products

materials and products with properties which enter into structural calculations or otherwise relate to the mechanical resistance and stability of works and parts thereof and/or their fire resistance including aspects of durability and serviceability

3.4

construction works

everything that is constructed or results from construction operations

Note 1 to entry: This term covers both buildings and civil engineering works. It refers to the complete construction comprising both structural and non-structural components.

3.5

constructor

person or organization executing the works (the supplier in EN ISO 9000)

3.6

design basis method of erection

outline of a method of erection upon which the design of the structure is based

3.7

erection method statement

documentation describing the procedures to be used to erect a structure

3.8

execution

activities performed for the physical completion of the works

Note 1 to entry: i.e. manufacturing, erection, and the inspection and documentation thereof.

3.9

execution class

classified set of requirements specified for the execution of the works as a whole, of an individual component or of a detail of a component

3.10**execution specification**

set of documents covering the technical data and requirements necessary to execute a particular structure including those specified to supplement and qualify the rules of this document

Note 1 to entry: The execution specification includes requirements where this document identifies items to be specified by provision of additional information or adoption of permitted options (see Annex A).

3.11**manufacturer**

any natural or legal person who manufactures a construction product or who has such a product designed or manufactured, and markets that product under his name or trademark

Note 1 to entry: This definition is according to the Construction Products Regulation, CPR (EU 305/2011).

3.12**manufacturing**

all activities required to produce and deliver a component.

Note 1 to entry: As relevant, this comprises e.g. procurement, preparation and assembly, welding, mechanical fastening, transportation, surface treatment and the inspection and documentation thereof

3.13**preparation**

all activities performed on the constituent products to produce the parts ready for assembly and inclusion into components.

Note 1 to entry: As relevant, this comprises e.g. identification, handling and storage, cutting, shaping and holing

3.14**service category**

category that characterizes a component or structure in terms of the circumstances of its use

3.15**structure**

organized combination of connected parts designed to carry loads and provide adequate rigidity

[SOURCE: EN 1990:2002, 1.5.1.6 (2)]

3.16**works**

parts of the construction works that is the aluminium structure

4 Specifications and documentation**4.1 Execution specification****4.1.1 General**

The necessary information and technical requirements for execution of each part of the works shall be agreed and completed before commencement of execution of that part of the works. There shall be procedures for making alterations to previously agreed execution specifications. Execution specification shall consider such of the following items as are relevant:

- a) additional information as listed in A1;

- b) execution classes required, see 4.1.2;
- c) service category;
- d) options as listed in A2;
- e) technical requirements regarding the safety of the works, see Annex J;
- f) quality plan, see 4.2.2;
- g) additional specified execution requirements concerning the functionality;
- h) which of the informative annexes shall apply within the limits given in the National Annexes (NA) for EN 1999-1-1 to EN 1999-1-5.

4.1.2 Execution classes

Four execution classes 1 to 4, denoted EXC1 to EXC4, are given in EN 1999-1-1, for which the required strictness increases from EXC1 to EXC4.

The execution specification should specify the relevant execution class or classes.

Execution classes may apply to the whole structure, to a part of the structure or to specific details. A single structure may include several execution classes.

Guidance on the choice of execution class is given in EN 1999-1-1.

NOTE 1 See Annex A of EN 1999-1-1:2007.

If no execution class is specified, EXC2 applies.

NOTE 2 The list of requirements related to execution classes is given in Table A.3.

4.1.3 Tolerance types

Two types of geometrical tolerances are defined in 11.1:

- a) essential tolerances;
- b) functional tolerances.

4.1.4 Tolerance class for shell structures

For shell structures, four tolerance classes 1 to 4 are given in EN 1999-1-5, for which the required strictness increases from class 1 to class 4.

The requirements for the tolerance classes for shell structures are given in Annex H.

4.1.5 Testing and acceptance criteria for welding

The amount of testing and the acceptance criteria shall be given in the execution specification.

NOTE Recommendations for the extent of testing are given in Annex K and recommendations for the acceptance criteria are given in 12.4.4.

4.2 Constructor's documentation

4.2.1 Quality documentation

The following points shall be documented for EXC3 and EXC4, and for EXC2 if specified:

- a) organization chart and managerial staff responsible for each aspect of the execution;

- b) the procedures, methods and work instructions to be applied;
- c) an inspection and test plan specific to the works;
- d) a procedure for handling of changes and modifications;
- e) a procedure for handling of nonconformities, requests for concessions and quality disputes;
- f) specified hold points or requirement to witness inspections or tests, and any consequent access requirements.

4.2.2 Quality plan

It shall be specified if a quality plan for execution of the works is required.

A quality plan shall include:

- a) a general management document which shall address the following points:
 - 1) review of specification requirements against process capabilities;
 - 2) organization chart and managerial staff responsible for each aspect of the execution;
 - 3) principles and organization arrangements for inspection including allocation of responsibilities for each inspection task;
- b) quality documentation prior to execution. The documents shall be produced before execution of the construction step to which they relate;
- c) execution records, which are actual records of inspections and checks, carried out, or which demonstrate qualification or certification of implemented resources.

Annex B gives a check-list for the content of a quality plan recommended for the execution of structural work with reference to the general guidelines in ISO 10005.

4.2.3 Safety during erection

Method statements giving detailed work instructions shall comply with the technical requirements relating to the safety of the erection works as given in Annex J.

4.2.4 Execution documentation

Sufficient documentation shall be prepared during execution and as a record of the as-built structure to demonstrate that the works have been carried out according to the execution specification.

5 Constituent products

5.1 General

Generally, constituent products to be used for the execution of aluminium structures shall be selected from the relevant European Standards listed in the following clauses, EN 15088 or any other relevant European Technical Specification. The constituent products to be used shall be specified.

5.2 Identification, inspection documents and traceability

The properties of the constituent products shall be documented in a way that enables them to be compared with the required properties. Their conformity to the relevant product standard shall be checked in accordance with 12.2.

For metallic products, in agreement with EN 10204, the following inspection documents shall be requested, according to the relevant execution classes as stated in Table 1:

Table 1 — Inspection documents for metallic products

Constituent product	Inspection document Types
Structural aluminium (plates, extrusions, forgings, castings ^d)	
EXC1	2.2
EXC2, EXC3, EXC4	3.1
Welding consumables	
EXC1	2.2
EXC2, EXC3, EXC4	3.1
Structural bolting assemblies to the EN 14399 series	3.1 a
Structural bolting assemblies conform to Table 6	2.1 c
Bolts ^b , nuts ^b , or washers ^b	2.1 ^c
Self-tapping and self-drilling screws and blind rivets	2.1 ^c
Studs for arc stud welding according to Annex N	2.1 ^c
^a If assemblies are marked with a manufacturing lot number and the manufacturer can trace the measured characteristic values from the internal (factory) production control records on the basis of this number, the 3.1 inspection certificate as in EN 10204 may be omitted. ^b Applicable if bolts, nuts or washers are supplied for use in non-preloaded applications and not as a component of a fastener assembly to the EN 14399 series or the EN 15048 series. ^c For inspection document Type 2.1, the main standardized requirements (i.e. ultimate strength, yield strength, elongation, chemical composition) of the product shall be confirmed in the declaration of compliance with the order ^d Quality requirements for castings are given in EN 1999-1-1:2007, C.3.4.2.	

For EXC3 and EXC4, constituent products shall be traceable at all stages of execution between delivery and incorporation in the structure.

This traceability may be based on documentary records for batches of product allocated to a common production process, unless unique traceability is specified.

For EXC2, EXC3 and EXC4, if different alloys and/or tempers of a constituent product are in circulation together, each item of material shall be designated with a mark that identifies its alloy and temper.

Methods of marking constituent products shall be in accordance with that for components given in 6.2.

If marking is required, unmarked products shall be treated as nonconforming.

5.3 Parent material

Tables 2 to 4 list standardized alloys and tempers corresponding to EN 1999-1-1. The selection of material shall take into account the expected execution procedures. The following particularities should be considered if relevant:

- a) use of material with anisotropic behaviour (including extrusion seam welds in porthole and bridge die profiles);
- b) applying cold forming operation;

- c) applying welding on material some of which might influence the material properties unfavourably in the short transverse direction.

NOTE Where rolled products of the material EN AW-6082 are welded using wire electrodes or rods to EN ISO 18273: Al 5356 or Al 5556 or Al 5356A (or similar) are stressed in service in tension perpendicular or shear parallel to the rolling plane, the manufacturer of the constituent products will preferably confirm by means of 3.1 certificates that the performance in the short transverse direction is not reduced to an unacceptable degree due to thermal influence. If such confirmation does not exist, the constructor will preferably carry out and evaluate a welding procedure test according to Annex C for the product to be used. If welding consumables EN ISO 18273: Al 4043A are used such confirmation is not necessary.

- d) use of heating operations during execution, which might change the material properties, e.g. while stove lacquering;
- e) applying means to secure an appropriate surface condition for decorative treatment.

For the cases listed above, a communication between supplier and purchaser of the material is recommended at the time of order.

Table 2 — Wrought aluminium alloys – Plates, sheets and extrusions

Alloy according to		Temper according to EN 515
EN 573-1 and -3 Numeric	EN 573-2 and -3 Symbol	
EN AW-3103	EN AW-Al Mn1	H14; H16; H24; H26
EN AW-3004	EN AW-Al Mn1Mg1	H14; H16; H24; H26; H34; H36
EN AW-3005	EN AW-Al Mn1Mg0,5	H14; H16; H24; H26
EN AW-5005	EN AW-Al Mg1(B)	O/H111; H12; H14; H22; H24; H32; H34
EN AW-5005A	EN AW-Al Mg1(C)	O/H111; H12; H14; H22; H24; H32; H34
EN AW-5049	EN AW-Al Mg2Mn0,8	O; H14; H111; H24; H34
EN AW-5052	EN AW-Al Mg2.5	H12; H14; H22; H 24; H32; H34
EN AW-5083	EN AW-Al Mg4,5Mn0,7	O/H111; H12; H14; H22; H24; H32; H34; F; H112; H116; H321
EN AW-5383	EN AW-Al Mg4,5Mn0,9	O/H 111; H116; H321
EN AW-5454	EN AW-Al Mg3Mn	O/H111; H14; H24; H34
EN AW-5754	EN AW-Al Mg3	O/H111; H12; H14; H22; H24; H32; H34
EN AW-6005A	EN AW-Al SiMg(A)	T6
EN AW-6060	EN AW-Al MgSi	T5; T6; T64; T66
EN AW-6061	EN AW-Al Mg1SiCu	T4; T6; T451; T651
EN AW-6063	EN AW-Al Mg0,7Si	T5; T6; T66
EN AW-6082	EN AW-Al Si1MgMn	T4; T5; T6; T651; T61; T6151; T451
EN AW-6106	EN AW-Al MgSiMn	T6
EN AW-7020	EN AW-Al Zn4,5Mg1	T6; T651
EN AW-8011A	EN AW-AlFeSi(A)	H14; H16; H24; H26

Table 3 — Wrought aluminium alloys – Forgings

Alloy according to		Temper according to EN 515
EN 586 Numeric	EN 586 Symbol	
EN AW-5083	EN AW-Al Mg4,5Mn0,7	H112
EN AW-5754	EN AW-Al Mg3	H112
EN AW-6082	EN AW-Al SiMgMn	T6

Table 4 — Aluminium alloys – Castings (die- or sand-cast)

Alloy ^a according to		Temper according to EN 1706
EN 1706 Numeric	EN 1706 Symbol	
EN AC-42100	EN AC-Al Si7Mg0,3	Permanent mould: T6; T64
EN AC-42200	EN AC-Al Si7Mg0,6	Permanent mould: T6; T64
EN AC-43000	EN AC-Al Si10Mg(a)	Permanent mould: F
EN AC-43300	EN AC-Al Si9Mg	Sand cast: T6 Permanent mould: T6; T64
EN AC-44200	EN AC-Al Si12(a)	Sand cast, Permanent mould: F
EN AC-51300	EN AC-Al Mg5	Sand cast, Permanent mould: F
^a Requirements for quality testing of cast parts shall be specified. Guidance is given in EN 1999-1-1.		

5.4 Aluminium products

Aluminium constituent products according to Table 5 produced with aluminium and aluminium alloys according to 5.3 shall be used.

Table 5 — Standards for aluminium products

Product	General provisions / Assessment and test methods	Tolerances
Extruded rods, bars, tubes and profiles	EN 755-1	EN 755-3 Round bars EN 755-4 Square bars EN 755-5 Rectangular bars EN 755-6 Hexagonal bars EN 755-7 Seamless tubes EN 755-8 Porthole tubes EN 755-9 Profiles
Extruded precision profiles	EN 12020-1	EN 12020-2
Cold drawn rods, bars and tubes	EN 754-1	EN 754-3 Round bars EN 754-4 Square bars EN 754-5 Rectangular bars EN 754-6 Hexagonal bars EN 754-7 Seamless tubes EN 754-8 Porthole tubes
Forgings	EN 586-1	EN 586-3
Sheet, strip and plate	EN 485-1	EN 485-3 Hot rolled products EN 485-4 Cold rolled products

Product	General provisions / Assessment and test methods	Tolerances
Castings	EN 1559-1, EN 1559-4	EN ISO 8062-1 EN ISO 8062-3 CEN ISO/TS 8062-2
Wires	EN 1301-1	EN 1301-3

5.5 Welding consumables

Welding consumable shall conform to the requirements of EN ISO 18273. The combination of parent material and welding consumables shall be specified.

NOTE Suitable consumables for the different constituent aluminium wrought products are listed in EN 1999-1-1.

5.6 Mechanical fasteners

5.6.1 Bolts, nuts and plain washers

The category of bolted connections (bolt, nut and washer), product standard, property class and any other requirement, i.e. surface treatment, shall be specified.

Fasteners in accordance with Table 6 shall be used. All parts of high strength fastener assemblies shall be supplied with the same surface treatment if surface treatment is specified.

The elements of a bolting assembly shall exhibit uniform corrosion resistance characteristics. The hot galvanization of high strength bolts, nuts and washers shall have been carried out under the responsibility of the manufacturer of those.

Table 6 — Bolt, nut, washer combinations for connection categories

Category of the connection according to EN 1999-1-1	Bolts		Nuts		Washers ^b
	Product standard	Property class	Product standard	Property class	Product standard
A, D	EN ISO 4014 EN ISO 4017 EN 15048-1	Aluminium according to EN 28839 ^a	EN ISO 4032 EN 15048-1	Aluminium according to EN 28839 ^a	EN ISO 7091
A, D	EN ISO 4014 EN ISO 4017 EN ISO 4762 EN ISO 2009 EN 15048-1	Stainless steel grade 50 according to EN ISO 3506-1	EN ISO 4032 EN 15048-1	Stainless steel grade 50 according to EN ISO 3506-2	EN ISO 7089 EN ISO 7090
A, D	EN ISO 4014 EN ISO 4017 EN ISO 4762 EN ISO 2009 EN ISO 7046-2 EN 15048-1	Stainless steel grade 70 according to EN ISO 3506-1	EN ISO 4032 EN 15048-1	Stainless steel grade 70 according to EN ISO 3506-2	EN ISO 7089 EN ISO 7090

Category of the connection according to EN 1999-1-1	Bolts		Nuts		Washers ^b
	Product standard	Property class	Product standard	Property class	Product standard
A, D	EN 15048-1	Stainless steel grade 80 ^c according to EN ISO 3506-1	EN 15048-1	Stainless steel grade 80 ^c according to EN ISO 3506-2	
A, D	EN ISO 4016 EN ISO 4018 EN 15048-1	Steel grade 4.6 according to EN ISO 898-1	EN ISO 4034 EN ISO 4032 EN 15048-1	≤ M16: steel grade 5 > M16: steel grade 4 or 5 according to EN ISO 898-2	EN ISO 7091 EN ISO 7089 EN ISO 7090
A, D	EN ISO 4014 EN ISO 4017 EN 15048-1	Steel grade 5.6 according to EN ISO 898-1	EN ISO 4032 EN 15048-1	Steel grade 5 according to EN ISO 898-2	EN ISO 7091 EN ISO 7089 EN ISO 7090
A, D	EN ISO 4014 EN ISO 4017 EN ISO 4762 EN ISO 7046-2 EN ISO 10642 EN 15048-1	Steel grade 8.8 according to EN ISO 898-1	EN ISO 4032 EN 15048-1	Steel grade 8 according to EN ISO 898-2	EN ISO 7091 EN ISO 7089 EN ISO 7090
A, D	EN 14399-7	Steel grade 8.8	EN 14399-3	Steel grade 8	EN 14399-5 EN 14399-6
A, D	EN ISO 10642 EN 15048-1	Steel grade 10.9 according to EN ISO 898-1	EN ISO 4032 EN 15048-1	Steel grade 10 according to EN ISO 898-2	EN ISO 7091 EN ISO 7089 EN ISO 7090
A, D	EN 14399-7	Steel grade 10.9	EN 14399-3	Steel grade 10	EN 14399-5 EN 14399-6
A, B, C, D, E	EN 14399-3	Steel grade 8.8	EN 14399-3	Steel grade 8	EN 14399-5 EN 14399-6
A, B, C, D, E	EN 14399-3 EN 14399-10	Steel grade 10.9	EN 14399-3 EN 14399-10	10	EN 14399-5 EN 14399-6
A, B, C, D, E	EN 14399-4 EN 14399-8	Steel 10.9	EN 14399-4	10	EN 14399-6

NOTE The category of the bolted connections according to EN 1999-1-1 are the following:

A – Shear connection, bearing type;

B – Shear connection, slip-resistant at serviceability limit state;

C – Shear connection, slip-resistant at ultimate limit state;

D – Tension connection, connection with non-preloaded bolts;

E – Tension connection, connection with preloaded high strength bolts.

Category of the connection according to EN 1999-1-1	Bolts		Nuts		Washers ^b
	Product standard	Property class	Product standard	Property class	Product standard
^a Only aluminium materials listed in EN 1999-1-1 shall be used. ^b For oversized and slotted holes, washers according EN ISO 7093-1, EN ISO 7093-2 and EN ISO 7094 can also be used. ^c A4-80 bolts may be used if specified.					

NOTE Standardized products for locking devices are for instance those in EN ISO 2320, EN ISO 7040, EN ISO 7042, EN ISO 7719, EN ISO 10511, EN ISO 10512 and EN ISO 10513.

5.6.2 Studs

Dimensions and shape of studs shall be in accordance with EN ISO 13918.

NOTE See informative Annex N on weld studs connected by arc stud welding with tip ignition.

5.6.3 Rivets

Rivets shall be in accordance with EN 1999-1-1.

5.6.4 Self-drilling and self-tapping screws

Self-drilling screws shall conform to the requirements of EN ISO 15480 and self-tapping screws with the requirements of EN ISO 1481, EN ISO 7049, EN ISO 1479 or ISO 10509.

If self-drilling or self-tapping screws are used for applications similar to fixing of trapezoidal sheeting (i.e. fixing thin material parts on a thick substructure), it is necessary to predrill holes if the thickness of the component to be fixed exceeds 2 mm or use screws with an undercut thread.

5.6.5 Bearings

Structural bearings shall conform to the requirements of EN 1337-3, EN 1337-4, EN 1337-5, EN 1337-6 or EN 1337-8 as relevant.

5.7 Adhesive bonding

Requirements for material characteristics for short and long term behaviour need to be specified in each case.

NOTE There are no European Standards giving requirements to properties of adhesives to be used for structural bonded connections.

6 Preparation

6.1 General

This clause specifies the requirements for the preparation part of the execution of aluminium structures.

Structural aluminium components shall be manufactured within the tolerances specified in 11.2.

NOTE Welding and mechanical fastening are dealt with in Clauses 7 and 8.

Requirements for inspection, testing and corrections are given in 12.3.

6.2 Identification

For EXC2, EXC3 and EXC4, the constituent products shall be marked clearly or shall be uniquely identifiable (e.g. different extruded sections) if products from different alloys or the same alloy but of different tempers are used. Marking shall be by a permanent method such as paint, sticker, tag, bar code, etc. Manufacturer and constructor shall agree about the method of marking.

It shall be assured that marking does not harm the final usage of the product. Marking by chisels and by overlay welding is not allowed. Hard stamping shall not be used, unless permitted by the specification.

During each step of the manufacturing for EXC2, EXC3 and EXC4 any part or batch of similar parts of the aluminium structure shall be clearly and permanently marked or shall be otherwise uniquely identifiable, until erection.

6.3 Handling, storage and transportation

Constituent products and components shall be packed, handled, transported and stored in a safe manner, so that permanent deformation does not occur and surface damage is minimized. Any instructions from the relevant manufacturer shall be conformed to.

Constituent products that have deteriorated such that they no longer conform to the relevant standards shall be treated as a nonconformity.

6.4 Cutting

Cutting shall be carried out in such a way that the requirements to the quality of cut surface as stated in this document are met.

Cutting shall be carried out by sawing, shearing, punching, thermal cutting or water jet cutting. Unacceptable tolerances or surface roughness shall be corrected by a suitable mechanical method, e.g. milling, grinding, filing or scraping.

The surface of the cuts shall be within the limits given in Table 7, unless otherwise specified.

Table 7 — Cutting tolerances in accordance with EN ISO 9013

Execution classes	Perpendicularity and angularity tolerances, u	Mean height of the profile, Rz5
EXC1	Cut edges to be free from significant irregularities and dross shall be removed	
EXC2	Range 5	Range 4
EXC3 and EXC4	Range 4	Range 4

Sheared cuts and punched holes shall be free of cracks and notches. If not, the cut edges shall be dressed to remove all cracks and notches.

If sharp edges shall be removed due to technical reasons, it shall be specified.

Products of the alloy EN AW-7020 shall only be sheared or punched if the following subsequent operations are carried out:

- if welded, the sheared or punched edges shall be fully fused on their whole length. If the edges will not be fully fused by the welding, the edge shall be removed by the amount equal to 0,4 times the thickness or 3 mm, whichever is less, prior to welding;
- if unwelded and not machined as defined above, an additional artificial ageing may be carried out. This is only permitted for wall thicknesses up to 5 mm.

NOTE For execution of artificial ageing of EN AW-7020, see 7.7.

6.5 Forming

Forming should preferably be carried out by cold-forming processes, e.g. bending, folding or pressing to the required shape. Operations that significantly affect the material properties (e.g. softening by the application of heat, or hardening as a result of strain during the forming operation) shall only be carried out if permitted and tested as specified.

Forming shall be carried out such that cracks do not occur.

The deformed zones shall be checked according to 12.3.1 immediately following the forming process.

Marking of the bend line shall only be done using a soft pencil or felt-tip pen.

6.6 Holing for fasteners

Holes shall be formed by drilling, punching or water jet cutting. Hole sizes shall be specified. If not otherwise specified, the maximum clearance shall be according to Table 8. The internal surface of the holes produced by water cutting shall be within the limits of Range 4 given in EN ISO 9013:2017, unless otherwise specified. This shall apply to perpendicularity, angular tolerance and mean height of the profile. Burrs shall be removed.

For all connection categories punching shall only be permitted up to a maximum thickness of 25 mm. Punched holes in parts under tensile loads with a thickness between 16 mm and 25 mm shall be punched at least 2 mm undersize in diameter, followed by reaming.

Products of the alloy EN AW-7020 may be punched only if the requirements according to 6.4 are followed. If holes are tightly closed by bolt, the finishing work according to 6.4 is not necessary.

Where holes for bolts and rivets are drilled in parts assembled and tightly clamped together, these parts shall be subsequently separated to remove burrs, if specified.

Coolants or lubricants shall be neutral.

Table 8 — Maximum clearances for fastener and pin holes

Fastener type and category of connection	Fastener material	Nominal fastener diameter, d mm	Maximum clearance on diameter ^a mm
Fitted bolting assemblies (A, D, E) ^b	-	Any	≤ 0,3
Non-fitted bolting assemblies and pins (A, B, D, E) (normal holes)	-	Any	≤ 1
Fasteners in oversized holes (A, D, E)	-	Any	Greater of: 2 and 0,15 x diameter.
Solid rivets (A), see 5.6.3	Aluminium	< 13 ≥ 13	≤ 0,4 ≤ 0,8
	Stainless steels	< 13 ≥ 13	≤ 0,8 ≤ 1,6
High strength bolting assemblies according to EN 14399-3, or -4 (all plies, or outer two plies if greater than three plies) (C)	Steel	≤ 24 > 24	≤ 2 ≤ 3
High strength bolting assemblies according to EN 14399-3, or -4 (above three plies, inner plies) (C)	Steel	Any	≤ 3
^a The clearance should not be increased on account of irregular or excess zinc coatings on the bolts. ^b For holes in combination with bolts according to EN 14399-8, the tolerance for the hole is H11 according to EN ISO 286-2.			

Holes for fitted bolting assemblies are drilled at least 2 mm smaller than the diameter of the thread or shaft respectively and reamed subsequently. Where the fastener is to fit through multiple plies the components shall be held firmly together during reaming.

Holes generally can also be drilled without reaming after fixing the components, if the maximum clearance is met.

Nominal dimensions of the countersinking shall be specified, which shall be such that after installation the bolt shall be flush with the outer face of the outer ply.

The angle of countersinking shall correspond to the angle of the countersunk head.

In the case of a countersunk rivet, the countersinking shall be such that after riveting the head of the rivet will fill the countersinking completely and the outer face of the ply shall be flush. The dimensions of the countersinking shall be specified.

NOTE In case of holing for self-drilling and self-tapping screws, see 5.6.4.

The effective length of slotted holes shall be specified with a deviation of +/- 1 mm for a bolt diameter < 20 mm and +/- 2 mm for bolt diameter ≥ 20 mm. The width shall not exceed (d + 1) mm (see EN 1999-1-1). The maximum length values of 1,5 (d + 1) mm for short slotted holes or 2,5 (d + 1) mm

for long slotted holes shall not be exceeded. Slotted holes shall exist only in one component that shall be joined.

6.7 Cut outs

Re-entrant angles and notches shall be rounded off with a minimum radius of 5 mm unless otherwise specified.

At punched cut outs in alloy EN AW-7020, the requirements in 6.6 and 6.4 apply.

6.8 Full contact bearing surfaces

The contact surfaces shall be prepared so that the requirements in 11.2.2.3 are satisfied.

6.9 Assemblies

Assembly checks shall be carried out to ensure the fitting between components. If a complete assembly check is required, it shall be specified.

The assembly checks shall be carried out in a way that the required dimensions and geometry of the components and the type and the size of any welds can be achieved as specified.

6.10 Heat treatment

Any heat treatment of constituent aluminium material shall follow a qualified procedure. Such qualified procedure can be part of the specification of the manufacturer of the constituent product. It shall only be executed if appropriate equipment is used.

6.11 Straightening

Corrections of distortion by warm straightening are not allowed with the following exceptions:

- a) if strain-hardening alloys in temper O are used;
- b) if other alloys and/or tempers are used and the straightening operations (by flame or straightening welds) are performed in low stressed zones under strict temperature control to be recorded.

The requirements to such operations shall be given in the execution specification.

NOTE Heat (temperature and duration) may influence strength and sometimes also the internal metal structure, depending on alloy and temper.

7 Welding

7.1 General

Welding shall be undertaken in accordance with the requirements of the relevant part of EN ISO 3834.

NOTE 1 Guidance on implementing EN ISO 3834 for quality requirements for fusion welding of metallic materials is given in CEN ISO/TR 3834-6.

With respect to execution classes, the following applies:

- EXC1 EN ISO 3834-4 "Elementary quality requirements";
- EXC2 EN ISO 3834-3 "Standard quality requirements";
- EXC3 and EXC4 EN ISO 3834-2 "Comprehensive quality requirements".

NOTE 2 For welds on the surface of sheets or plates, see Note 1 in 5.3.

7.2 Welding plan

7.2.1 Requirement for a welding plan

For EXC2, EXC3 and EXC4 a welding plan shall be drawn up in accordance with the requirements of EN ISO 3834-2 or EN ISO 3834-3, as applicable.

7.2.2 Content of a welding plan

The welding plan shall at least include the following items, as relevant:

- a) connection details;
- b) weld size and type;
- c) joint preparation including removal of oxide layer;
- d) welding procedure specifications including welding consumable requirements and any pre-heating and interpass requirements;
- e) measures to take to avoid distortion during and after welding;
- f) sequence of welding with any restrictions or acceptable locations for start and stop positions, including intermediate stop and start positions where joint geometry is such that welding cannot be executed continuously;

If welding assembly overlaps or masks previous welds, special consideration is needed concerning which welds are to be executed first and the possible need to inspect/test a weld before the second weld is executed or before the masking components are assembled.

- g) any requirements for intermediate checking;
- h) any turning of components in the welding process, in connection with the sequence of welding;
- i) details of any restraints to be applied;
- j) any heat treatment specifications;
- k) any special equipment for welding consumables (storage and handling, etc.);
- l) cross reference to 12.4 of the inspection plan;
- m) requirements for acceptance criteria for welds in accordance with 12.4.4;
- n) any requirements for weld identification.

7.3 Welding process

Welding may be performed by the following welding processes defined in EN ISO 4063, unless otherwise specified:

- a) 131: metal inert gas welding, MIG-welding;
- b) 141: tungsten inert gas welding, TIG-welding;
- c) 43: friction stir welding (FSW).

If no welding process is specified, the MIG welding process shall be used.

7.4 Qualification of welding procedures and welding personnel

7.4.1 Qualification of welding procedures

For EXC2, EXC3 and EXC4, the welding shall be carried out with welding procedure specifications in accordance with EN ISO 15609-1. Welding procedures for FSW shall be in accordance with EN ISO 25239-4.

For EXC3 and EXC4, qualification of arc welding procedures shall be performed in accordance with EN ISO 15614-2 or if applicable with EN ISO 15613. For EXC2, qualification of welding procedures shall be performed in accordance with one of the following standards: EN ISO 15612, EN ISO 15613, EN ISO 15614-2.

For other welding processes EN ISO 15613 and the relevant part of EN ISO 15614 shall apply, as applicable.

Where EN ISO 15613 or EN ISO 15614-2 qualification procedures are used, the following conditions shall apply:

- a) butt welds tests shall not qualify fillet welds;
- b) for fillet weld qualification, the procedure test in Annex C shall be included.

The qualification of the welding procedures for partial penetration butt welds for $t < 12$ mm shall document consistent penetration depth. This can be documented by 2 macro graphics examination for each type of geometry of joint. The examination can be valid for a range of thicknesses with similar joint geometry (partial penetration single Y-butt or partial penetration single-bevel butt with different angles for the joint preparation).

NOTE Documentation of penetration depth for partial penetration butt welds for $t \geq 12$ mm can be done by UT.

For joints in hollow section lattice structures shall define the start and stop zones, and the method to be used in order to cope with the situation where the welds change from a fillet to a butt around the joint.

Where forged pieces are to be welded, depending on the shape of the forged piece, it may be necessary to prove the mechanical-technological values of the weld by a pre-production test.

Cast parts shall not be welded, unless particularly specified.

A guide for development and use of a welding procedure specification is given in Annex M.

The tensile testing of FSW should be executed according the provisions of EN ISO 4136:2012. The tensile test specimen should comprise the full cross section of the weld, i.e. the full section test with $t = t_s$, consider Figure 1a) of EN ISO 4136:2012. The gauge length L_0 should be 100 mm, i.e. $L_c \geq L_s + 100$, consider Figure 2a) of EN ISO 4136:2012. If extrusions with protruding details are welded, the tensile specimen should be correspondingly machined parallel, so that $t = t_s$.

Acceptance criteria for tensile test for FSW of non heat-treatable alloys shall be in accordance with EN ISO 25239-4. For heat treatable alloys, the acceptance criteria as given in Formulae (7.1) and (7.2) apply.

$$\sigma_{\min,w} \geq f_{u,haz} \quad (7.1)$$

$$R_{p0,2,100} \geq f_{o,haz} \quad (7.2)$$

where

$\sigma_{\min,w}$ is the tensile strength of the welded material in accordance with EN ISO 4136;
 $R_{p0,2,100}$ is the 0,2-proof strength in accordance with EN ISO 4136 with reference length of $L_0 = 100$ mm;
 $f_{u,haz}$
 and $f_{o,haz}$ are given in EN 1999-1-1.

7.4.2 Validity of the welding procedure qualification

If any welding procedure qualified in accordance with EN ISO 15614-2 has not been used by the constructor for more than 1 year, a production welding test, where shape and dimensions are according to the requirements of EN ISO 15614-2 and Annex C of this document, if applicable, shall be carried out by the constructor. Examination and testing shall include visual inspection, radiographic inspection, surface crack detection and macro-examination.

7.4.3 Qualification of welders and welding operators

Welders shall be qualified in accordance with EN ISO 9606-2 and welding operators shall be qualified in accordance with EN ISO 14732. The operators for FSW shall be qualified in accordance with EN ISO 25239-3.

For welding hollow section lattice structures, welders shall also be qualified by a single-side welding test carried out on a branch connection, according to Figure 1.

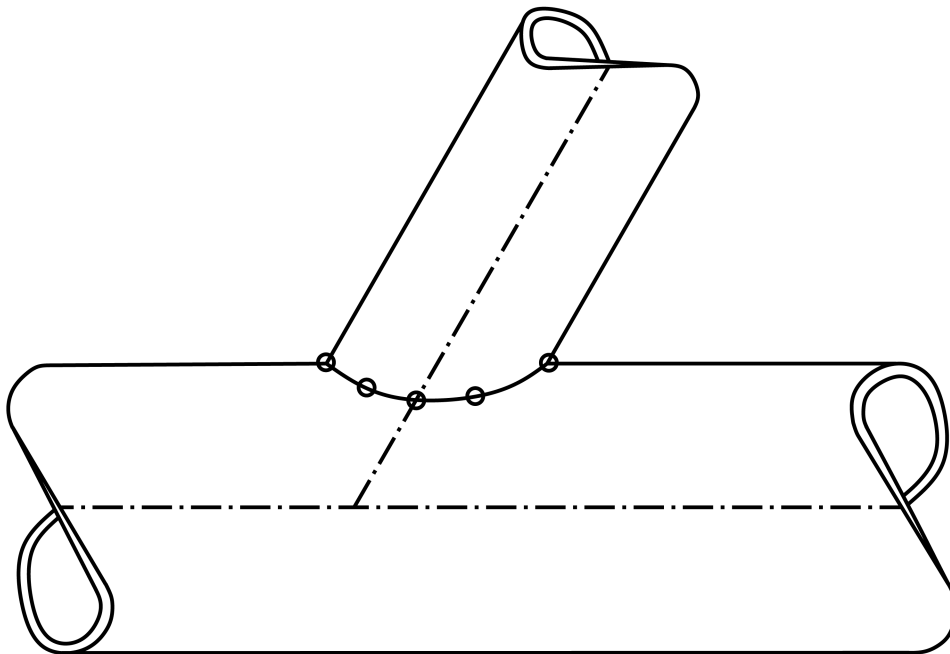


Figure 1 — Branch connection

In branch connections the weld may change between butts and fillets around the perimeter.
 Certificates of all welder and welding operator qualification tests shall be retained for inspection.

7.4.4 Welding coordination personnel

For EXC2, EXC3 and EXC4, welding coordination shall be maintained during the execution of welding by welding coordination personnel suitably qualified for, and experienced in the welding operations they supervise as defined in EN ISO 14731.

The required technical knowledge of welding coordination personnel for EXC2, EXC3 and EXC4 is given in Table 9.

The welding coordinator is responsible for the process of qualification of the welders/operators. Welding coordinators may act as examiners if this is within their competence. If qualification is undertaken by external examiners/examination bodies, this should be done in accordance with the procedures of EN ISO/IEC 17024 or EN ISO/IEC 17020.

Table 9 — Required technical knowledge of welding coordination personnel

Execution class	Parent material	Type of welding consumables			
		Type 3, Type 4		Type 5	
		Nominal thickness of material in mm		Nominal thickness of material in mm	
		t ≤ 12 ^a	t > 12	t ≤ 12 ^a	t > 12
EXC2	3xxx, 5xxx	B	S	B	S
	Other			S	
EXC3	3xxx, 5xxx	S	S	S	C
	Other		C	C	
EXC4	all	C			
B	Basic technical knowledge according to EN ISO 14731;				
S	Specific technical knowledge according to EN ISO 14731;				
C	Comprehensive technical knowledge according to EN ISO 14731.				
NOTE This table gives no recommendation about possible combinations of constituent materials (parent materials and filler metal) to be welded. For allowed and recommended combinations, see EN 1999-1-1.					
^a Endplates up to 25 mm.					

7.5 Preparation and execution of welding

7.5.1 General

Welding shall be carried out in accordance with the recommendations given in EN 1011-1 and EN 1011-4.

If other welding processes than stated in 7.3 are used, the requirements for welding shall be specified and be qualified by an appropriate welding procedure test.

The time interval between cleaning and welding shall be as short as possible and shall not exceed 4 h.

Any requirements for grinding of the surface of completed welds shall be specified.

7.5.2 Joint preparation

The recommendations given in EN 1011-1 and EN 1011-4 shall apply. In addition, the following requirements apply:

- a) the joint preparation including tolerances and fit-up shall conform to the preparation of the welding procedure test;
- b) if errors in the joint geometry shall be corrected by overlay welding a qualified welding procedure shall be used. It shall be demonstrated that the property of the structure is not harmed.

7.5.3 Weather protection

Both the welder/operator and the working area shall be adequately protected against weather effects, especially wind.

Surfaces to be welded shall be maintained dry and free of condensation.

If temperatures of material to be welded are below 5 °C, suitable heating can be necessary.

7.5.4 Assembly for welding

The recommendations given in EN 1011-1 and EN 1011-4 shall apply. In addition, the following requirements apply:

- a) components to be welded shall be brought into alignment and held by tack welds or external devices and the alignment shall be maintained during initial welding;
- b) assembly shall be carried out such that the fit-up of joints and the final dimensions of the components are within the specified tolerances, suitable allowance shall be made for distortion and shrinkage;
- c) the components to be welded shall be assembled and held in position such that the joints to be welded are readily accessible and easily visible to the welder/operator/inspector.

7.5.5 Temporary attachments

It shall be specified if welding of temporary attachments is permitted. If permitted, the locations where this welding is not allowed shall be specified.

The recommendations given in EN 1011-1 and EN 1011-4 shall apply. In addition, the following requirements apply:

- a) all welds for temporary attachments shall be made in accordance with the welding procedure specification;
- b) if temporary attachments have to be removed by cutting or chipping, the surface of the parent metal is subsequently to be carefully ground smooth and flush;

7.5.6 Tack welds

The recommendations given in EN 1011-1 and EN 1011-4 shall apply. In addition, the following requirements apply:

- a) tack welds shall be located in positions suitable for the start/stop position;
- b) for joints welded by an automatic or fully mechanized welding process for EXC3 and EXC4 the conditions for deposition of tack welds shall be included in the welding procedure specification.

7.5.7 Preheating and interpass temperature

Preheating and interpass maximum temperature shall be as recommended in EN 1011-4.

7.5.8 Butt welds

The recommendations given in EN 1011-1 and EN 1011-4 shall apply. In addition, the following requirements apply:

- a) the location of butt welds used as splices to accommodate available lengths of constituent products shall be specified;
- b) for EXC3 and EXC4, and for EXC2 if specified, run-on/run-off pieces shall be used to ensure full throat thickness at the edge;
- c) after completion of the welds any run-on/run-off pieces or supplementary material shall be removed and their removal shall conform to 7.5.5.

7.5.9 Slot and plug welds

Holes for slot and plug welds shall be proportioned so that adequate access can be provided for welding. Dimensions shall be specified.

The first pass shall complete the circumference of the hole.

Plug welds shall be made only after the fillet welding in the slot has been checked as satisfactory. Plug welds performed without previous slot welding are not permitted unless otherwise specified.

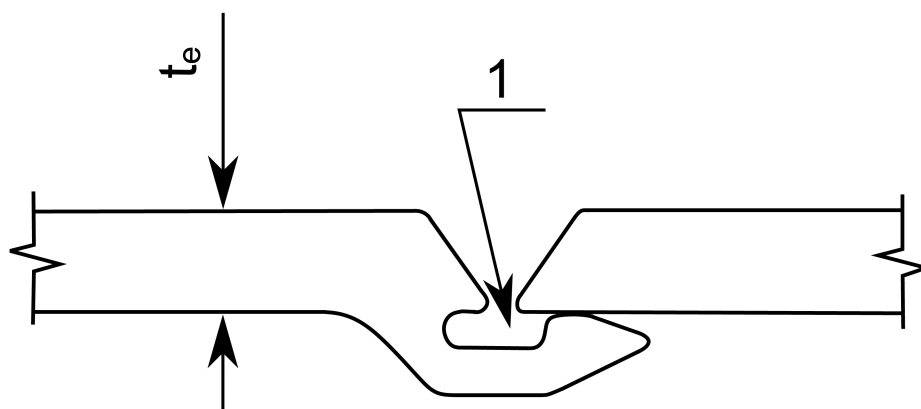
7.5.10 Fillet welds

If specified, fillet welds finishing at the ends or sides of parts should be returned continuously, full size, around the corner for a distance of at least twice the throat thickness of the weld.

7.5.11 Single sided welds

Full penetration welds welded from one side should have backing. The backing shall have a space for contamination in the bottom of the joint and outside the required penetration. The size and form of the backing shall be included in the WPS. The backing shall be continuous and may be a part of an extrusion. See Figure 2 for an example.

If backing is not used, a special WPS shall be followed, adapted to the given structural situation.



Key

- 1 space for contamination

Figure 2 — Example of extruded backing for single sided weld with penetration depth, t_e , where the shape of the space for contamination is dependent of the thickness of the welded part

For partial penetration welds, the geometries of the joint shall be included in the WPS. The penetration depth shall be specified. Welding in accordance with the WPS shall give consistent penetration depth.

7.5.12 Friction stir welding

For friction stir welding, FSW, the inspection and testing before and during welding shall be in accordance with EN ISO 25239-5. The lay-out of the FSW joints shall be in accordance with EN ISO 25239-2.

7.5.13 Other welds

The requirements for other welds made by other processes than stated in 7.3 shall be specified and shall be subject to the same welding requirements as specified in this document.

For weld studs connected by arc stud welding with tip ignition, see Annex N.

7.6 Acceptance criteria

The acceptance criteria are given in 12.4.4 and 12.4.5.

7.7 Post-weld heat treatment

If a complete heat treatment (solution treatment, quenching and ageing) or an artificial ageing of welded components is required, a qualified procedure shall be used. The influence of the heat treatment on strength shall be proved by a procedure test according to EN ISO 15614-2. This is also required if repair welding needs a post-welding treatment, except for the alloy EN AW-7020 where recommendations are given in Note 3.

The procedure test has to prove that the chosen method meets the requirements for the strength, stability of shape and dimensional accuracy. Further agreed quality requirements have to be considered as well, e.g. anodic oxidation treatment.

NOTE 1 Guidance on post-weld heat treatment can be obtained from EN ISO 17663. Further specific guidance can be obtained from the manufacturer of the constituent product.

NOTE 2 A heat treatment in the form of artificial ageing has practically no influence on shape and dimensional accuracy of the structure.

NOTE 3 For artificial ageing of products of the alloy EN AW-7020 and the post welding artificial ageing of welded components of this alloy, the following temperature steps have been shown to be appropriate:

- 1st step > 3 days at room temperature;
- 2nd step 8 h to 10 h at + 90 °C ± 5 °C (metal temperature);
- 3rd step 14 h to 16 h at + 145 °C ± 5 °C (metal temperature).

In case of repairing structures of EN AW-7020 by welding the weld repair area can be heat treated using heating blankets.

The following temperature treatment has been shown to be appropriate:

- 22 h to 26 h at + 120 °C ± 5 °C (metal temperature).

Welded products of the alloy EN AW-7020 that have not been the subject of a post welding heat treatment shall not be subjected to full load before a natural ageing period of 30 days. The natural ageing period may be shortened if a special treatment is carried out according to the procedure specification.