

NORSOK STANDARD

ALUMINIUM STRUCTURAL MATERIAL

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Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, the NORSOK standard will be withdrawn.

Annex A is normative

INTRODUCTION

The enclosed Material Data Sheets are prepared as separate documents to be used in purchasing of plates and profiles in aluminium for structural use. The MDS specifies the selected options of the referred standard and additional requirements which shall be added or supersede the corresponding requirements of the referred standard.

The following technical information has to be defined in the purchase order:

- material grade and temper
- product form, dimensions and special tolerances
- marking requirements

1 SCOPE

This standard is a collection of the Aluminium structural Materials Data Sheets (MDS) applicable to selected Aluminium reference standards and grades for use in Aluminium structures. In addition, this standard gives recommendations for selections of relevant MDS, alloy grade and temper dependent of the structural application.

2 NORMATIVE REFERENCES

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements of the selected referred standards.

BS 8118	Structural use of aluminium
NORSOK N-001	Structural design

Other relevant standards are stated in the individual material data sheets.

3 DEFINITIONS

BS	British Standard
Company	Purchasing body (buyer)
DIN	Deutsche Industrie Normen
EN	Euronorm
MDS	Material data sheet (material specification)
MTDS	Material test data sheet

4 SELECTION OF MATERIAL

The prime alloy selection for main structure component should be alloy 5083 to MDS M01 for plates and alloy 6005 or 6082 to MDS M04/M05 for profiles. The other alloys listed should only be used for secondary applications. For weld filler material Alloy 5183 should be the prime selection. For further details reference is made to table 4 which also summarise the alloys and tempers included in the established MDS's. Other alloys and tempers may also be used if found more relevant for the particular construction.

The number of alloys, tempers and type of filler materials to be selected for one structure should be limited to ease material purchasing and fabrication, and to avoid exchange of material by mistake.

For structures submerged in seawater, the Alloy 5083 should be used. Galvanic couplings to steel or other materials more nobel than aluminium shall be avoided.

When designing structures for use at elevated temperatures creep and strength properties shall be specially considered. Table 4.1 gives recommendations and guidelines for selection of aluminium

alloy, temper and relevant MDS and weld filler material for use in offshore and marine environments.

For secondary structures, such as e.g. stairs, walkways, access platforms, the requirements in recognized, international standards may be used instead of enclosed MDS's.

Table 4.1 give recommendations and guidelines for selection of aluminium alloys, tempers, relevant MDS's and weld filler materials for structural use in offshore and marine environments.

Table 4.2 gives explanations of the temper designations.

Table 4. 3 gives examples of use.

Table 4.1 Guidelines for selection of MDS's, alloy, temper and weld filler material for welded aluminium structures.

MDS	Product	Alloy desig.	Alloy type	Temper ¹⁾	Weld filler material	Recommendations for use ²⁾
M01	Rolled products	5052	AlMg2,5	O H11/H12 H22/H24	5356, 5183 ³⁾	Only recommended used for architectural applications defined with joints in Inspection Category D ⁷⁾ .
		5454	AlMg3Mn	O H11/H12 H22/H24/H26 H32/H34		Recommended used where medium strength is required and if Alloy 5083 can not be used due to operation temperature above 65°C.
		5083	AlMg4,5Mn	O H112/H116/ H22/H24/H26 H32/H34		The recommended alloy for plates and for subsea structures. Not to be used for operation temperature > 65°C in humid saliferous environments. An alternative may be to use Temper H323.
		6082	AlSi1MgMn	O/T4/T6	4043 ⁴⁾ 5356, 5183	Recommended used if no 5000 serie alloy is suitable or available. Limited to Inspection Category C and D ⁷⁾ .
M02	Rolled products	6082	AlSi1MgMn	O/T4/T6	5356, 5183	Recommended used if no 5000 serie alloy is suitable, and if improved properties regarding ductility, fracture toughness and reduced tendency to heat affected zone cracking are found relevant.
M03	Profiles Group A ⁶⁾	6005	Al0,5SiMg	T4/T6	4043 5356, 5183	Recommended for profiles due to the formability, strength and weldability properties.
		6063	AlMg0,7Si	T4/T6		Only recommended used for secondary structures limited to Inspection Categories D ⁷⁾ .
		6082	AlSi1MgMn	T4/T6		Recommended used for structures requiring high strength and for structures with joints in Inspection Category C and D ⁷⁾ .
M04	Profiles Group A ⁶⁾	6082	AlSi1MgMn	T4/T6	5356, 5183	Recommended used for structures requiring high strength and for welded structures with joints in Inspection Category A and B ⁷⁾ .
M05	Profiles Group B ⁶⁾	6005	Al0,7SiMg	T4/T6	4043 5356, 5183	This MDS shall be specified for large and relative complex profiles and where the strength and integrity of the extrusion welds are important for the structural design function. Ref. Note 2, and 6.
		6082	AlSi1MgMn	T4/T6		

NOTES TO TABLE 4.1

1. This table only lists the most used tempers. Other tempers may be used as found relevant by the designer.
2. Within each alloying system, 5- or 6000 serie, the alloy with lowest alloying content and adequate strength shall be selected.
3. Alloy 5183 can be used for welding both 5- and 6000 serie alloys and is the filler material with highest strength properties.
4. Alloy 4043 can only be used for welding 6000 serie alloys and have limited strength properties and has relative low ductility.
5. When welding Alloy 6082 with Alloy 5183 or similar as filler material, there is a risk for micro cracking in the heat affected zone of the base material. To limit this risk, Alloy 6082 with modified chemical composition, ref. MDS M04/M05, should be used. In addition, a welding method with low dilution of base material in the weld deposit should be used, i.e. Metal/Tungsten Inert Gas method.
6. See clause 5 “Quality control testing of extruded profiles - selection of relevant MDS”.
7. Reference is made to NORSOK N-001 Structural design.

Table 4.2. Temper designation explanations.

Condition/temper	Hardness	Temper des.	Extruded products	
			Temper	Temper des.
Annealed	soft	O	Annealed (soft)	O
Strain hardened to specified strength	1/8 hard 1/4 hard 1/2 hard 3/4 hard 1/1 hard	H11 H12 H14 H16 H18	Solution heat treated and naturally aged	T4
Strain hardened and partially annealed	1/8 hard 1/4 hard 1/2 hard 3/4 hard 1/1 hard	H21 H22 H24 H26 H28	Cooled from an elevated temperature and artificially aged	T5
Strain hardened and stabilised	1/4 hard 1/2 hard 3/4 hard 1/1 hard	H32 H34 H36 H38	Solution heat treated and artificially aged	T6
Special tempers: - Less hardened than H11 - No controlled strain hardening but with mechanical property limits - Treatment against exfoliation corrosion for AlMg alloys - For optimum resistance against stress corrosion for alloys with Mg > 4% before stabilising		H111 H112 H116 H117 H323 H343		

Table 4.3 Examples of use based on former practise and experiences with Aluminium for offshore and marine applications.

Alloy	Use	Comments
5052 5454	Shipbuilding superstructures and deck equipment. Offshore applications.	Medium mechanical properties. Highly resistant to corrosion by marine environments.
5083	Shipbuilding and offshore applications	Medium to high mechanical properties. Highly resistant to corrosion by marine environments.
6005	Light to medium size structural sections and applications.	Medium to high mechanical properties. Good corrosion resistance to marine environments.
6063	Light to medium size structural sections and components	Medium mechanical properties. Good corrosion resistance to marine environments.
6082	Structural sections and components. Offshore applications Both as plates and profiles.	Medium to high mechanical properties. Good corrosion resistance to marine environments. Special note to max. alloying content in material for welded constructions. Ref. MDS M04, M05

5 QUALITY CONTROL TESTING OF EXTRUDED PROFILES AND SELECTION OF RELEVANT MDS

Extruded profiles shall be divided into 2 separate Groups "A" and "B" based on complexity of geometry, extrusion welds etc., for the selection of the most appropriate MDS. The purpose is to apply a quality control test programme for the production of the actual extrusion, relevant to the service performance of the extrusion. The criteria for the division into group A and B are as follows:

Group A:

Relatively simple extrusions to be purchased in accordance with MDS M03 and MDS M04.

- profiles without extrusion welds
- profiles with simple extrusion welds not covered by Group B.

Group B:

Relatively complex extrusions to be purchased in accordance with MDS M05 and meeting one or more of the following criteria:

- more than 3 extrusion welds
- the largest transverse section/profile dimension is more than 200 mm
- the wall thickness at the location of an extrusion weld is larger than 10 mm
- 2 or more hollow compartments
- an extrusion weld will be subject to tensile stresses normal to the weld during lifetime.

5.1 Prequalification of Group B extrusions

Group B extrusions shall be prequalified by test runs and tests, in order to define and agree a specially designed quality control test programme for the production of the extrusions. The supplier shall in his bid provide a proposal for a prequalification test programme. Relevant production experience with similar profiles may replace such prequalification if agreed between the parties.

5.2 Production testing of Group B extrusions

Based on the results of the prequalification test programme for Group B profiles (or previous production experience), the supplier shall before the actual production starts, provide a Material Test Data Sheet (MTDS), ref. MDS M05 Annex A, filled in with the required information, and a proposal for a quality control test programme defining the types and extent of testing relevant for each specific extrusion. This shall be agreed with Company and implemented in production.

ANNEX A MATERIAL DATA SHEETS (NORMATIVE)**Aluminium and aluminium alloys**

M01	Sheet, strip and plate for offshore structural applications	Rev. 1
M02	Plates	Rev. 1
M03	Wrought products - Extruded rod/bar, tube and profile	Rev. 1
M04	Wrought products - Extruded rod/bar, tube and profile	Rev. 1
M05	Wrought products - Extruded rod/bar, tube and profile	Rev. 1

MATERIAL DATA SHEET		MDS - M01	Rev. 1
TYPE OF MATERIAL: ALUMINIUM ALLOYS			
PRODUCT	STANDARD	GRADE	TEMPER
Sheet, strip and plate for offshore structural applications	EN 485	EN-AW: 5052 5454 5083 6082	O/H11/H12/H22/24 O/H11/H12/H22/H24/H26/H32/H34 O/H112/H116/H22/H24/H26/H32/H34 O/T4/T6
SCOPE	This MDS specifies the selected options in the referred standard and additional requirements which shall be added to or supersede the corresponding requirements in the referred standard.		
CHEMICAL COMPOSITION	Chemical analysis shall be carried out for each melt and each subsequent 10 000 kg of production. Iron content shall be modified to maximum 0,4% Fe.		
TENSILE TESTING	The minimum elongation shall be as specified in the standard, but not less than 8 % for thickness ≥ 2 mm.		
NON DESTRUCTIVE TESTING	Visual inspection shall verify the surface finish and quality.		
SURFACE FINISH	Surface defects shall not encroach on the minimum dimensions of the product and shall not exceed the following limitations: - for thickness 2-20 mm the maximum imperfection depth shall be 0,3 mm - for thickness > 20 mm the maximum imperfection depth shall be 0,5 mm The total area of defects shall not exceed 5% of the surface.		
REPAIR OF DEFECTS	Repair welding is not permitted.		
MARKING	Identification marking shall be done for traceability with the certificate (ID no.)		
CERTIFICATION	Inspection certificate to EN 10204 3.1B shall contain ID no. and all test results.		
PACKING	Packing shall be such that, under usual transport conditions, the product condition complies with the standard and this MDS upon receipt. ASTM B 660 shall be used as a guideline.		

MATERIAL DATA SHEET		MDS - M02		Rev. 1
TYPE OF MATERIAL: ALUMINIUM ALLOYS				
PRODUCT	STANDARD	GRADE	TEMPER	
Plates	EN 485	EN-AW: 6082	O/T4/T6	
SCOPE	This MDS specifies the selected options in the referred standard and additional requirements which shall be added to or supersede the corresponding requirements in the referred standard.			
CHEMICAL COMPOSITION	Chemical analysis shall be carried out for each melt and each subsequent 10 000 kg of production. The chemical composition shall be modified to: Si 0,7-1,10%; Mg 0,6-0,90%; Mn 0,40-0,80%; Fe <0,3%; Cu <0,1%; Zn <0,1%			
TENSILE TESTING	The minimum elongation shall be as specified in the standard, but not less than 8 % for thickness ≥ 2 mm.			
NON DESTRUCTIVE TESTING	Visual inspection shall verify the surface finish and quality.			
SURFACE FINISH	Surface defects shall not encroach on the minimum dimensions of the product and shall not exceed the following limitations: - for thickness 2-20 mm the maximum imperfection depth shall be 0,3 mm - for thickness > 20 mm the maximum imperfection depth shall be 0,5 mm The total area of defects shall not exceed 5% of the surface.			
REPAIR OF DEFECTS	Repair welding is not permitted.			
MARKING	Identification marking shall be done for traceability with the certificate (ID no.)			
CERTIFICATION	Inspection certificate to EN 10204 3.1B shall contain ID no. and all test results.			
PACKING	Packing shall be such that, under usual transport conditions, the product condition complies with the standard and this MDS upon receipt. ASTM B 660 shall be used as a guideline.			

MATERIAL DATA SHEET		MDS - M03	Rev. 1
TYPE OF MATERIAL: ALUMINIUM ALLOYS			
PRODUCT	STANDARD	GRADE	TEMPER
Wrought products - Extruded rod/bar, tube and profile.	prEN 755	EN-AW: 6005	T4/T6
		6060	T4/T6
		6063	T4/T6
		6082	T4/T6
SCOPE	This MDS specifies the selected options in the referred standard and additional requirements which shall be added to or supersede the corresponding requirements in the referred standard.		
CHEMICAL COMPOSITION	Chemical analysis shall be carried out for each melt and each subsequent 10 000 kg of production.		
DIMENSIONAL TOLERANCES	According to product standard/purchase order.		
NON DESTRUCTIVE TESTING	Visual inspection shall verify the surface finish and quality.		
SURFACE FINISH	Surface defects shall not encroach on the minimum dimensions of the product and shall not exceed the following limitations: - for thickness 2-20 mm the maximum imperfection depth shall be 0,3 mm - for thickness > 20 mm the maximum imperfection depth shall be 0,5 mm The total area of defects shall not exceed 5% of the surface.		
REPAIR OF DEFECTS	Unacceptable defects may be repaired to meet the requirements of this MDS. Repair welding is not permitted.		
MARKING	Identification marking shall be done for traceability with the certificate (ID no.)		
CERTIFICATION	Inspection certificate to EN 10204 3.1B shall contain ID no. and all test results.		
PACKING	Packing shall be such that, under usual transport conditions, the product condition complies with the standard and this MDS upon receipt. ASTM B 660 shall be used as a guideline.		

MATERIAL DATA SHEET		MDS - M04	Rev. 1
TYPE OF MATERIAL: ALUMINIUM ALLOYS			
PRODUCT	STANDARD	GRADE	TEMPER
Wrought products - Extruded rod/bar, tube and profile.	prEN 755	6082	T4/T6
SCOPE	This MDS specifies the selected options in the referred standard and additional requirements which shall be added to or supersede the corresponding requirements in the referred standard.		
CHEMICAL COMPOSITION	Chemical analysis shall be carried out for each melt and each subsequent 10 000 kg of production. The chemical composition of alloy 6082 shall be modified to: Si 0,7-1,10%; Mg 0,6-0.90%; Mn 0,40-0,80%; Fe <0,3%; Cu <0,1%; Zn <0,1%.		
EXTENT OF TESTING	6082 T4: According to referred standard. 6082 T6: Samples shall be taken from front and rear end of one extrusion run out length per melt and heat treatment batch.		
EXTRUSION WELDS	The first and last two profile run out lengths in a production lot shall be tested by a split test (DIN 50135) or an other agreed deformation test. The entire fracture surface shall show a ductile fracture, if not; all runout lengths shall be tested.		
NON DESTRUCTIVE TESTING	Visual inspection shall verify the surface finish and quality.		
SURFACE FINISH	Surface defects shall not encroach on the minimum dimensions of the product and shall not exceed the following limitations: - for thickness 2-20 mm the maximum imperfection depth shall be 0,3 mm - for thickness > 20 mm the maximum imperfection depth shall be 0,5 mm The total area of defects shall not exceed 5% of the surface.		
REPAIR OF DEFECTS	Unacceptable defects may be repaired to meet the requirements of this MDS. Repair welding is not permitted.		
MARKING	Identification marking shall be done for traceability with the certificate (ID no.)		
CERTIFICATION	Inspection certificate to EN 10204 3.1B shall contain ID no. and all test results.		
PACKING	Packing shall be such that, under usual transport conditions, the product condition complies with the standard and this MDS upon receipt. ASTM B 660 shall be used as a guideline.		

MATERIAL DATA SHEET		MDS - M05		Rev. 1
TYPE OF MATERIAL: ALUMINIUM ALLOYS				
PRODUCT	STANDARD	GRADE	TEMPER	SUPPL. REQ.
Wrought products - Extruded rod/bar, tube and profile.	prEN 755	6005 6082	T4/T6 T4/T6	Test and qualification programme for extrusion welds
SCOPE	This MDS specifies the selected options in the referred standard and additional requirements which shall be added to or supersede the corresponding requirements in the referred standard.			
PREQUALIFICATION TEST	In order to define the relevant quality control measures for the actual production of profiles, a prequalification test shall be performed before production start-up or as agreed upon. Samples shall be taken from the front and rear end of at least 3 extrusion run out lengths and shall be of the same temper as the final product. The test specimen type and size to be agreed for each type of profile. Applicable tests for the prequalification and production quality control test are as follows: 1. tensile test transvers to extrusion weld 2. split test (DIN 50135) or any other kind of deformation 3. side bend tests transvers to extrusion weld 4. macro/micro test of a cross section <i>Acceptance criteria to test 1, 2 and 3 above:</i> Any fracture shall show a ductile fracture surface with evidence of plastic yielding in the entire surface.			
CHEMICAL COMPOSITION	Chemical analysis shall be carried out for each melt and each subsequent 10 000 kg of production. The chemical composition of alloy 6082 shall be modified to: Si 0,7-1,10%; Mg 0,6-0.90%; Mn 0,40-0,80%; Fe <0,3%; Cu <0,1%; Zn <0,1%.			
EXTENT OF TESTING	6005 all tempers and 6082 T4: According to referred standard. 6082 T6: Samples shall be taken from front and rear end of one extrusion run out length per melt and heat treatment batch.			
EXTRUSION WELD TESTS	According to the type and extent of tests as found relevant from the qualification test			
NON DESTRUCTIVE TESTING	Visual inspection shall verify the surface finish and quality.			
SURFACE FINISH	Surface defects shall not encroach on the minimum dimensions of the product and shall not exceed the following limitations: - for thickness 2-20 mm the maximum imperfection depth shall be 0,3 mm - for thickness > 20 mm the maximum imperfection depth shall be 0,5 mm The total area of defects shall not exceed 5% of the surface.			
REPAIR OF DEFECTS	Unacceptable defects may be repaired to meet the requirements of this MDS. Repair welding is not permitted.			
MARKING	Identification marking shall be done for traceability with the certificate (ID no.)			
MATERIAL TEST DATA SHEET	The Material Test Data Sheet (MTDS) added to this MDS shall be filled in by the Supplier.			
CERTIFICATION	Inspection certificate to EN 10204 3.1B shall contain ID no. and all test results.			
PACKING	Packing shall be such that, under usual transport conditions, the product condition complies with the standard and this MDS upon receipt. ASTM B 660 shall be used as a guideline.			

MATERIAL TEST DATA SHEET (MTDS) FOR EXTRUDED ALUMINIUM PROFILES (INFORMATIVE)

Material Test Data Sheet (MTDS) for Extruded Aluminium Profiles			
Alloy and Temper:			
Dimensions:			
Sketch: ¹⁾			
Ordered length:			
Test Method:	Testing frequency	Test Samples Identification Location ²⁾	Test Standard Reference
Split Test, (S)			
Chemical Analysis (C)			
Macro/Micro examin., (M)			
Tensile Testing, (T) - Transverse - Longitudinal			
Bend Test (B)			
Other			

NOTES

- 1) The location of extrusion welds to be identified and marked on sketch. Extrusion welds to be numbered and identified by the letter W.
- 2) The location of mechanical test samples to be identified and marked on sketch/MTDS by:
 - I) Letter of type of test:
Split test/S, Chemical analysis/C, Macro/Micro examination/M, Tensile testing transverse/TT, longitudinal/TL, Bend testing transverse/BT
 - II) Sequential Number of test specimen
 - III) Distance from start of runout length
 - IV) Distance from end of runout length