BS EN 4500-003:2012

BSI Standards Publication

Aerospace series — Metallic materials — Rules for drafting and presentation of material standards

Part 003: Specific rules for heat resisting alloys

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National foreword

This British Standard is the UK implementation of EN 4500-003:2012.

The UK participation in its preparation was entrusted to Technical Committee ACE/61, Metallic materials for aerospace purposes.

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

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Série aérospatiale - Matériaux métalliques - Règles pour la rédaction et la présentation des normes de matériaux - Partie 003: Règles spécifiques aux alliages résistant à chaud

Luft- und Raumfahrt - Metallische Werkstoffe - Regeln für das Erstellen und die Gestaltung von Werkstoffnormen - Teil 003: Besondere Regeln für hochwarmfeste Legierungen

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Foreword

This document (EN 4500-003:2012) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

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of an identical text or by endorsement, at the latest by April 2013, and conflicting national standards shall be withdrawn at the latest by April 2013.

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

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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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Introduction

This standard is part of the series of EN metallic material standards for aerospace applications. The general organisation of this series is described in EN 4258.

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1 Scope

This European Standard specifies the specific rules for the drafting and presentation of heat resisting alloy material standards for aerospace applications.

It should be used in conjunction with EN 4500-001.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 2032-1, *Aerospace series — Metallic materials — Part 1: Conventional designation*

EN 4258, *Aerospace series — Metallic materials — General organization of standardization — Links between types of EN standards and their use*

EN 4500-001, *Aerospace series — Metallic materials — Rules for drafting and presentation of material standards — Part 001: General rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 4500-001 apply.

4 Rules for drafting and presentation

4.1 Page 1: Title

4.1.1 General

See EN 4500-001 and Example 1 of this standard.

The following are examples of descriptions which shall be used.

4.1.2 Method of melting

Complete in accordance with EN 4500-001 using one or more of the following terms:

— air melted;

— vacuum melted;

— vacuum refined;

— vacuum arc melted;

— vacuum arc remelted;

— electro-slag remelted;

— consumable electrode remelted;

— inert gas atomised;

— rotating electrode atomised;

— rotating crucible atomised;

— water atomised.

4.1.3 Form entries

a) sheet, strip, plate;

The term may be qualified with one of the following terms:

— rolled;

— cold rolled;

— hot rolled.

b) bar;

The term may be qualified with one or more of the following terms:

— hot rolled;

— cold rolled;

— drawn;

— extruded.

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c) section;

The term may be qualified with one or more of the following terms:

— extruded;

— hot rolled.

d) tube;

The term may be qualified with one or more of the following terms:

— rolled;

— drawn;

— extruded;

— seamless;

— welded.

e) wire;

The term may be qualified with one or more of the following terms:

— drawn;

— hot rolled.

f) forging stock;

g) forgings;

The term may be qualified with one or more of the following terms:

— die;

— hand.

h) remelting stock;

i) castings;

The term may be qualified with one or more of the following terms:

— sand;

— chill;

— investment;

— centrifugal;

— precision;

— hot isostatically pressed (hipped).

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4.1.4 Form entries for powder metallurgy

— powder;

— compacted material;

— part.

The term may be qualified with one or more of the following terms:

— hot isostatically pressed (hipped);

— extruded;

— forged.

4.1.5 Additional information entries

— for structural applications;

— for pressure applications;

— for rivets;

— for forged fasteners;

— for forged rings;

— for machined fasteners;

— for welding.

4.2 Page 2

See EN 4500-001.

4.3 Page 3

See EN 4500-001 and Example 2 of this standard.

4.4 Page 4

4.4.1 Page 4, line 1: Material designation

See EN 4500-001 and Example 3 of this standard.

4.4.2 Page 4, line 2: Chemical composition

The chemical composition shall be written in accordance with EN 4500-001 and the order of presentation of elements shall conform to the following rules:

— C, Si, Mn, P, S;

— alloying elements in alphabetical order using their chemical symbol;

— ratio and/or total of above elements in alphabetical order;

— trace elements in alphabetical order.

4.4.3 Page 4, line 3: Method of melting

See EN 4500-001 and Example 3 of this standard, using the terms listed in 4.1.2.

4.4.4 Page 4, line 4.1: Form

See EN 4500-001, and Example 3 of this standard.

4.4.5 Page 4, line 4.2: Method of production

See EN 4500-001, and Example 3 of this standard, using the applicable terms given in 4.1.

4.4.6 Page 4, line 4.3: Limit dimension(s)

See EN 4500-001 and Example 3 of this standard.

4.4.7 Page 4, line 5: Technical specification

See EN 4500-001 and Example 3 of this standard.

4.4.8 Page 4, line 6.1: Delivery condition and Heat treatment

See EN 4500-001 and Example 3 of this standard. Use one or more of the following terms:

— not heat treated;

— annealed;

— solution treated;

— precipitation treated;

— tempered;

— cold worked;

— hot isostatically pressed (hipped);

— descaled;

— machined;

— ground;

— as cast;

— as forged.

4.4.9 Page 4, line 6.2: Delivery condition code

See EN 4500-001 and Example 3 of this standard.

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4.4.10 Page 4, line 7: Use condition and Heat treatment

See EN 4500-001 and Example 3 of this standard. Use the terms given in 4.4.8 or state:

— Delivery condition.

4.4.11 Page 4, line 8.1: Test sample(s)

See EN 4500-001 and Example 3 of this standard.

4.4.12 Page 4, line 8.2: Test piece(s)

See EN 4500-001 and Example 3 of this standard.

4.4.13 Page 4, line 8.3: Heat treatment

See EN 4500-001 and Example 3 of this standard.

4.4.14 Page 4, line 9: Dimensions concerned

See EN 4500-001 and Example 3 of this standard.

4.4.15 Page 4, line 10: Thickness of cladding on each face

Not applicable to heat resisting alloys.

4.4.16 Page 4, line 11: Direction of test piece

See EN 4500-001 and Example 3 of this standard.

4.4.17 Page 4, lines 12 to 16: Tensile (T)

See EN 4500-001 and Example 3 of this standard.

4.4.18 Page 4, line 17: Hardness

See EN 4500-001 and Example 3 of this standard.

4.4.19 Page 4, line 18: Shear strength

See EN 4500-001 and Example 3 of this standard.

4.4.20 Page 4, line 19: Bending

See EN 4500-001 and Example 3 of this standard.

4.4.21 Page 4, line 20: Impact strength

See EN 4500-001 and Example 3 of this standard.

4.4.22 Page 4, lines 21 to 26: Creep (C)

See EN 4500-001 and Example 3 of this standard.

4.4.23 Page 4, line 27: Notes (see line 98)

See EN 4500-001 and Example 3 of this standard.

4.5 Page 5, lines 28 to 99

4.5.1 Page 5, line 29: Reference heat treatment

See EN 4500-001 and Example 4 of this standard.

4.5.2 Page 5, lines 30 to 94

The relevant lines shall be completed in accordance with EN 4500-001, see Example 4 of this standard.

4.5.3 Page 5, line 95: Marking inspection

See EN 4500-001 and Example 4 of this standard.

4.5.4 Page 5, line 96: Dimensional inspection

See EN 4500-001 and Example 4 of this standard.

4.5.5 Page 5, line 98: Notes

See EN 4500-001 and Example 4 of this standard.

4.5.6 Page 5, line 99: Typical use

See EN 4500-001 and Example 4 of this standard.

4.6 Page 6, line 100: "Product qualification"

See EN 4500-001 and Example 5 of this standard.

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Example 1:
Completion of title

Aerospace series
Heat resisting alloy
NiCr19Fe19Nb5Mo3 (2.4668)
Vacuum melted and vacuum arc remelted
Solution treated and precipitation treated
Forgings
$D_e \leq 300$ mm

Série aérospatiale
Alliage résistant à chaud
NiCr19Fe19Nb5Mo3 (2.4668)
Élaboré sous vide et refondu sous vide par arc
Mis en solution et précipité
Pièces forgées et pièces matrices
$D_e \leq 300$ mm

Luft- und Raumfahrt
Hochwarmfeste Nickellegierung
NiCr19Fe19Nb5Mo3 (2.4668)
Vacuumerschmolzen und vacuumlichtbogenumgeschmolzen
Lösungsgeglüht und ausgelagert
Gesenk- und Freiformschmiedestücke
$D_e \leq 300$ mm

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Example 2:
Completion of page 3

Introduction

This standard is part of the series of EN metallic material standards for aerospace applications. The general organisation of this series is described in EN 4258.

This standard has been prepared in accordance with EN 4500-003.

1 Scope

This European Standard specifies the requirements relating to:

Heat resisting alloy
NiCr19Fe19Nb5Mo3 (2.4668)
Vacuum melted and vacuum arc remelted
Solution treated and precipitation treated
Forgings
$D_e \leq 300$ mm

for aerospace applications.

NOTE Other common designation:
Alloy 718,
AECMA: NI-P 100HT,
ASD STAN: NI-PH 2601.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies..

EN 4258, *Aerospace series — Metallic materials — General organization of standardization — Links between types of EN standards and their use*

EN 4500-003, *Aerospace series — Metallic materials — Rules for drafting and presentation of material standards — Part 003: Specific rules for heat resisting alloys*

EN 4700-001, *Aerospace series — Steel and heat resisting alloys — Wrought products — Technical specification — Part 001: Plate, sheet and strip*

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Example 3:
Completion of page 4

1	Material designation			Heat resisting alloy CoCr22NiW (2.4683)											
2	Chemical composition %	Element		C	Si	Mn	P	S	Cr	Fe	La	Ni	W	B	Co
		min.		0,050	0,20	–	–	–	20,0	–	0,020	20,0	13,0	–	Base
		max.		0,15	0,50	1,25	0,020	0,015	24,0	3,00	0,12	24,0	16,0	0,015	
3	Method of melting			Vacuum melted and consumable electrode remelted											
4.1	Form			Sheet and strip											
4.2	Method of production			Hot rolled											
4.3	Limit dimension(s)		mm	$1{,}5 \leq a \leq 3$											
5	Technical specification			EN 4700-001											

6.1	Delivery condition	Solution treated and precipitation treated
	Heat treatment	955 °C / t = 2 h / AC + 720 °C / t = 8 h / Cool at 50 °C per h to 620 °C / t = 8 h / AC
6.2	Delivery condition code	U
7	Use condition	Delivery condition
	Heat treatment	–

					Characteristics	
8.1	Test sample(s)				Separately cast	
8.2	Test piece(s)				See EN 4700-001.	
8.3	Heat treatment				See line 29.	
9	Dimensions concerned			mm	$1{,}5 \leq a \leq 3$	
10	Thickness of cladding on each face			%	–	
11	Direction of test piece				L	
12	T	Temperature	θ	°C	Ambient	
13		Proof stress	$R_{p0,2}$	MPa	≥ 1 035	
14		Strength	R_m	MPa	≥ 1 275	
15		Elongation	A	%	≥ 5	
16		Reduction of area	Z	%	≥ 15	
17	Hardness				350 < HBW < 450	
18	Shear strength		R_c	MPa	–	
19	Bending		k	–	0,75; α = 180°	
20	Impact strength				KU = 300 J/cm^2; notch direction LT	
21	C	Temperature	θ	°C	700	700
22		Time		h	$t_R \geq 23$	t = 23
23		Stress	σ_a	MPa	–	300
24		Elongation	a	%	–	≤ 0,2
25		Rupture stress	σ_R	MPa	400	–
26		Elongation at rupture	A	%	≥ 5	–
27	Notes (see line 98)				–	

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Example 4:
Completion of page 5

29	Reference heat treatment	–	Solution heat treated and precipitation treated 955 °C / t = 2 h / AC + 720 °C / t = 8 h / Cool at 50 °C per h to 620 °C / t = 8 h / AC

30	Microstructure	–	EN 4700-001		
		2	One per batch		
		3	Cross section		
		7	EN 2950 Annex B Microstructure references	Acceptable microstructure	Unacceptable microstructure
			1 Carbides, carbonitrides borides 1.1 1.2 1.3 1.4	 A-B-C A-B-C A-B A-B-C-D	 D-E-F D-E-F C-D-E-F E-F
			2 Incipient melting	None	A-B
			3 Delta phase precipitation 3.1 3.2 3.3	 A-B A-B-F B-C-D	 C C-D-E A
			4 Aluminium silicate	None	A
			5 Oxides	None	A
			6 Sigma phase	None	–
			7 Laves phase	None	A-B
			8 Freckles	A-B-C-D	–
			9 White spots 9.1 9.2	 C None	 A-B A-B
			10 Cracks	None	A-B

33	Flattening of tubes	–	EN 4700-003

34	Grain size	–	EN 4700-001
		1	See EN ISO 643.
		7	$8 \leq G \leq 6$

36	Reverse torsion test for wires	–	EN 4700-004
		7	No rupture after three turns

40	Fracture toughness (K_{1C})	–	EN 4700-002
		2	One per material batch
		3	In accordance with order
		7	80 MPa $\sqrt{m}$

41	Flarability	–	EN 4700-004

42	Simple torsion test for wires	–	EN 4700-004
		7	No rupture after five turns

43	Wrapping test for wires	–	EN 4700-004

44	External defects	–	EN 4700-001

46	Fatigue	1	See Appendix 1.
		2	One per heat
		3	Top of ingot: pancake - See EN 2957.
		4	See Appendix 1.
		6	Strain elongation – $\Delta\varepsilon$ = 0,60 % / θ = 600 °C / R = 0 Sinusoidal wave – f = 1 Hz
		7	Rupture after 2 500 cycles

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Example 4:
Completion of page 5 *(continued)*

51	Macrostructure	–	EN 4700-001		
		7	EN 2950 Annex A Macrostructure references	Acceptable macrostructure	Unacceptable macrostructure
			1 Tree ring		
			1.1	A-B-C	D-E
			1.2	A-D	B-C-E-F
			2 Dendritic aspect	A-B	C-D-E
			3 Grain flow		
			3.1	–	–
			3.2	–	–
			4 Macro-recrystallisation		
			4.1	A	–
			4.2	A	–
			4.3	A	–
			4.4	–	A
			4.5	A-E-G-H	B-C-D-F
			4.6	–	A
			5 Freckles	A-B	C-D-E-F-G-H
			6 White spots		
			6.1	A-B-C-D	E
			6.2	None	–
			7 Cracks	None	–
			8 Non-metallic inclusions	A	–
			9 Metallic inclusions	–	A

54	Tube leakage	–	EN 4700-003
		6	Pressure = 10^6 kPa $\times \frac{e}{r}$, ambient temperature
		7	See EN 4700-003.

55	Deformation under pressure of tubes	–	EN 4700-003

60	Internal cleanliness of hydraulic tube	–	EN 4700-003
		1	Boroscope inspection
		7	See EN 4700-003 and no particle larger than 0,1 mm, no local dressing.

61	Internal defects	–	EN 4700-XXX
		5	Delivery condition
		7	No indications higher than 5 % of the reference indication. Noise less than 15 % of the reference indication (FBH ∅ = 0,8 mm). Products with 5 or more acceptable indications to be submitted to the purchaser.

64	Surface condition roughness	–	EN 4700-001
		5	R_a = 1,6 μm

68	Density	–	EN 6018
		2	One per cast
		7	$\rho \leq$ 8 250 kg/m^3

69	Elastic modulus (E)	1	See EN 2002-001.
		2	One per batch
		7	164 GPa ≤ E ≤ 171 GPa

71	Crack propagation (Fatigue)	1	See EN XXXX.
		2	One per batch
		3	According to the order, axial direction
		4	CT specimen, e = 25 mm
		6	Stress load = 600 kN
		7	da / dN ≤ 10^{-6} m / cycle for ΔK = 25 MPa $\sqrt{m}$

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Example 4:
Completion of page 5 *(concluded)*

74	Surface contamination	1	Visual
		2	All
		3	100 % of the hot compacted forging stock
		7	No reaction zone

83	Particle size	–	EN 4700-001
		7	No change in density by more than 1 %

84	Cleanliness of powder	–	EN 4700-001
		7	– Ceramic particle ≤ 60 μm; – Less than 50 particles of each 500 g sample.

95	Marking inspection	–	EN 4700-001

96	Dimensional inspection	–	EN 4700-001

98	Notes	–	–

99	Typical use	–	–

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Example 5A:
Completion of page 6

When no qualification programme is available, but the Technical Specification contains qualification requirements:

100	–	Product qualification	–	EN XXXX
				Qualification programme to be agreed between manufacturer and purchaser.

Example 5B:
Completion of page 6

When no qualification programme is available, and the Technical Specification does not contain qualification requirements:

100	–	Product qualification	–	EN 2043
				Qualification programme to be agreed between manufacturer and purchaser.

Example 5C:
Completion of page 6

For forgings and castings only:

100	–	Product qualification	–	Qualification programme to be agreed between manufacturer and purchaser.

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Example 5D:
Completion of page 6

When a qualification programme is available, and the Technical Specification does not contain qualification requirements:

100	–	Product qualification	–	EN 2043		
			2	Qualification thicknesses are a = 12 mm and a = 50 mm unless otherwise agreed.		
	2	Chemical composition %	–	See line 2.		
	13	Proof stress	–	See line 13.		
	14	Strength	–	See line 14.		
	15	Elongation	–	See line 15.		
	30	Microstructure	–	EN 4700-001		
			1	See EN 2950.		
			2	One per batch		
			3	Cross section		
			7	EN 2950 Annex B Microstructure references	Acceptable microstructure	Unacceptable microstructure
				1 Carbides, carbonitrides borides		
				1.1	A-B-C	D-E-F
				1.2	A-B-C	D-E-F
				1.3	A-B	C-D-E-F
				1.4	A-B-C-D	E-F
				2 Incipient melting	None	A-B
				3 Delta phase precipitation		
				3.1	A-B	C
				3.2	A-B-F	C-D-E
				3.3	B-C-D	A
				4 Aluminium silicate	None	A
				5 Oxides	None	A
				6 Sigma phase	None	–
				7 Laves phase	None	A-B
				8 Freckles	A-B-C-D	–
				9 White spots		
				9.1	C	A-B
				9.2	None	A-B
				10 Cracks	None	A-B
	40	Fracture toughness (K_{1C})	–	See line 40.		
			2	Testing thicknesses to be 8 mm and 50 mm.		
	44	External defects	–	See line 44.		
	46	Fatigue (Tension)	1	See Appendix 1.		
			2	One per heat		
			3	Top of ingot: pancake - See EN 2957.		
			4	See Appendix 1.		
			6	Strain elongation – $\Delta\varepsilon$ = 0,60 % / θ = 600 °C / R = 0 Sinusoidal wave – f = 1 Hz		
			7	Rupture after 2 500 cycles		

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Example 5E:
Completion of page 6

When a qualification programme is available, and the Technical Specification contains qualification requirements:

100	–	Product qualification	–	EN XXXX		
			2	Qualification thicknesses are a = 12 mm and a = 50 mm unless otherwise agreed.		
	2	Chemical composition %	–	See line 2.		
	13	Proof stress	–	See line 13.		
	14	Strength	–	See line 14.		
	15	Elongation	–	See line 15.		
	30	Microstructure	–	EN 4700-001		
			1	See EN 2950.		
			2	One per batch		
			3	Cross section		
			7	EN 2950 Annex B Microstructure references	Acceptable microstructure	Unacceptable microstructure
				1 Carbides, carbonitrides borides		
				1.1	A-B-C	D-E-F
				1.2	A-B-C	D-E-F
				1.3	A-B	C-D-E-F
				1.4	A-B-C-D	E-F
				2 Incipient melting	None	A-B
				3 Delta phase precipitation		
				3.1	A-B	C
				3.2	A-B-F	C-D-E
				3.3	B-C-D	A
				4 Aluminium silicate	None	A
				5 Oxides	None	A
				6 Sigma phase	None	–
				7 Laves phase	None	A-B
				8 Freckles	A-B-C-D	–
				9 White spots		
				9.1	C	A-B
				9.2	None	A-B
				10 Cracks	None	A-B
	40	Fracture toughness (K_{1C})	–	See line 40.		
			2	Testing thicknesses to be 8 mm and 50 mm.		
	44	External defects	–	See line 44.		
	46	Fatigue (Tension)	1	See Appendix 1.		
			2	One per heat		
			3	Top of ingot: pancake - See EN 2957.		
			4	See Appendix 1.		
			6	Strain elongation – $\Delta\varepsilon$ = 0,60 % / θ = 600 °C / R = 0 Sinusoidal wave – f = 1 Hz		
			7	Rupture after 2 500 cycles		

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Example 5E:
Completion of page 6 *(concluded)*

100	51	Macrostructure	–	EN XXXX-XXX		
			7	EN 2950 Annex A Macrostructure references	Acceptable macrostructure	Unacceptable macrostructure
				1 Tree ring		
				1.1	A-B-C	D-E
				1.2	A-D	B-C-E-F
				2 Dendritic aspect	A-B	C-D-E
				3 Grain flow		
				3.1	–	–
				3.2	–	–
				4 Macro-recrystallisation		
				4.1	A	–
				4.2	A	–
				4.3	A	–
				4.4	–	A
				4.5	A-E-G-H	B-C-D-F
				4.6	–	A
				5 Freckles	A-B	C-D-E-F-G-H
				6 White spots		
				6.1	A-B-C-D	E
				6.2	None	–
				7 Cracks	None	–
				8 Non-metallic inclusions	A	–
				9 Metallic inclusions	–	A
	61	Internal defects	–	See line 61.		
	69	Elastic modulus (E)	1	See EN 2002-001.		
			2	One per batch		
			7	164 GPa ≤ E ≤ 171 GPa		
	71	Crack propagation (Fatigue)	1	See EN XXXX.		
			2	One per batch		
			3	According to the order, axial direction		
			4	CT specimen, e = 25 mm		
			6	Stress load = 600 kN		
			7	da / dN ≤ 10^{-6} m / cycle for ΔK = 25 MPa $\sqrt{m}$		

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1) Published as ASD-STAN Prestandard at the date of publication of this standard (www.asd-stan.org).

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