BS 3HR 1:2010

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Specification for nickel-chromium-titanium-aluminium heat-resisting alloy billets, bars, forgings and parts (Nickel base, Cr 19.5, Ti 2.2, Al 1.4)

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Contents

List of tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 10, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 January 2010. It was prepared by Panel ACE/61/-/48, *Heat resisting alloys*, under the authority of 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.

Supersession

This standard supersedes BS 2HR 1:1973, which is withdrawn.

Information about this document

This is a full revision of BS HR 1. The principal change from the previous edition is that the requirements are stated in tabular format in accordance with EN 4500-1 and EN 4500-3.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

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

1 Scope

This British Standard specifies requirements for nickel-chromium-titanium-aluminium heat-resisting alloy supplied in the following forms, and as parts.

a) Bars and extruded sections for machining: solution treated, designation HR 1A.

b) Extruded sections for subsequent forming: softened, designation HR 1B.

c) Billets and bars for forging: hot or cold worked and subsequently machined or ground, designation HR 1C.

d) Forgings: solution treated, designation HR 1D.

2 Normative references

The following referenced documents are indispensable for the application 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.

BS HR 100, *Procedure for inspection, testing and acceptance of wrought heat-resisting alloys*

3 Technical requirements

3.1 Material to this standard shall conform to Table 1, Table 2, Table 3 and Table 4.

NOTE The format and symbols used in Table 1, Table 2, Table 3 and Table 4 are derived from EN 4500-1 and EN 4500-3.

3.2 Parts finally heat-treated after machining shall conform to Section **1** and Section **8** of BS HR 100.

3.3 Parts shall be supplied in the solution treated and precipitation treated condition.

3.4 If required by the purchaser and stated on the drawing or order, finished parts shall be precipitation treated at a temperature of (750 ±10) °C for 4 h, followed by cooling in air.

Table 1 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy bars and extruded sections for machining**

1	**Material designation**			**BS HR 1**							
2	**Chemical composition %**	Element		C	Si	Mn	S	Ag	Al	B	Bi
		Min.		0.040	—	—	—	—	1.0	—	—
		Max.		0.10	1.0	1.0	0.015	5 ppm	1.8	0.008	1 ppm
		Element		Co	Cr	Cu	Fe	Pb	Ti	Ni	
		Min.		—	18.0	—	—	—	1.8	Base	
		Max.		2.0	21.0	0.2	1.5	20 ppm	2.7		
3	**Method of melting**			Air melted; vacuum melted; air melted and vacuum refined; consumable electrode remelted							
4.1	**Form**			Bars and extruded sections for machining (HR 1A)							
4.2	**Method of production**			Extruded							
4.3	**Limit dimension(s)**		mm	—							
5	**Technical specification**			Sections 1 and 2 of BS HR 100							

6.1	**Delivery condition**			Solution treated
	Heat treatment			θ = (1 080 ±10) °C / t = 8 h / AC or OQ or WQ [1)]
6.2	**Delivery condition code**			W
7	**Use condition**			Solution treated + precipitation treated
	Heat treatment			Delivery condition + θ = (700 ±10) °C / t = 16 h / AC

					Characteristics	
8.1	**Test sample(s)**				See Section 2 of BS HR 100	
8.2	**Test piece(s)**				See Section 2 of BS HR 100	
8.3	**Heat treatment**				Delivery condition	Use condition
9	**Dimensions concerned**			mm	—	
10	**Thickness of cladding on each face**			%	—	
11	**Direction of test piece**				—	L
12	T	**Temperature**	θ	°C	Ambient	Ambient
13	T	**Proof stress**	$R_{p0.2}$	MPa	—	⩾ 600 [2)]
14	T	**Strength**	R_m	MPa	—	⩾ 1 000 [2)]
15	T	**Elongation**	A	%	—	⩾ 20 [2)]
16	T	**Reduction of area**	Z	%	—	
17	**Hardness**				a or D ⩽ 75 mm: HBW ⩽ 250 or HV ⩽ 270 75 mm < a or D ⩽ 100 mm: HBW ⩽ 269 or HV ⩽ 290 100 mm < a or D ⩽ 150 mm: HBW ⩽ 300 or HV ⩽ 325 a or D > 150 mm: HBW ⩽ 350 or HV ⩽ 385	HBW ⩾ 285 or HV ⩾ 310
18	**Shear strength**		R_c	MPa	—	
19	**Bending**		κ	—	—	
20	**Impact strength**				—	
21	C	**Temperature**	θ	°C	—	750
22	C	**Time**		h	—	t_R ⩾ 30
23	C	**Stress**	σ_a	MPa	—	
24	C	**Elongation**	a	%	—	
25	C	**Rupture stress**	σ_R	MPa	—	340
26	C	**Elongation at rupture**	A	%	—	
27	**Notes** (see line 98)				1), 2)	

Table 1 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy bars and extruded sections for machining** *(continued)*

44	**External defects**	—	See Section 2 of BS HR 100
51	**Macrostructure**	—	See Section 2 of BS HR 100
61	**Internal defects**	—	See Section 2 of BS HR 100
95	**Marking**	—	See Section 2 of BS HR 100
96	**Dimensional inspection**	—	See Section 2 of BS HR 100
98	**Notes**	—	[1] For material of a or D ⩽ 12.5 mm, the solution heat treatment time at temperature may be reduced to the following minima: a or D ⩽ 3 mm: 1 h; 3 mm < a or D ⩽ 6 mm: 2 h; 6 mm < a or D ⩽ 12.5 mm: 4 h. [2] When required by the order.

Table 2 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy extruded sections for subsequent forming**

1	**Material designation**			**BS HR 1**							
2	**Chemical composition %**	Element		C	Si	Mn	S	Ag	Al	B	Bi
		Min.		0.040	—	—	—	—	1.0	—	—
		Max.		0.10	1.0	1.0	0.015	5 ppm	1.8	0.008	1 ppm
		Element		Co	Cr	Cu	Fe	Pb	Ti	Ni	
		Min.		—	18.0	—	—	—	1.8	Base	
		Max.		2.0	21.0	0.2	1.5	20 ppm	2.7		
3	**Method of melting**			Air melted; vacuum melted; air melted and vacuum refined; consumable electrode remelted							
4.1	**Form**			Extruded sections for subsequent forming (HR 1B)							
4.2	**Method of production**			Extruded							
4.3	**Limit dimension(s)**		mm	—							
5	**Technical specification**			Sections 1 and 2 of BS HR 100							

6.1	**Delivery condition**		Softened	
	Heat treatment		θ = (1 080 $\pm$10) °C / t $\leqslant$ 30 min / WQ	
6.2	**Delivery condition code**		A	
7	**Use condition**		Delivery condition	
	Heat treatment		—	

Characteristics

8.1	**Test sample(s)**			See Section 2 of BS HR 100		
8.2	**Test piece(s)**			See Section 2 of BS HR 100		
8.3	**Heat treatment**			Delivery condition	Reference (see line 29)	
9	**Dimensions concerned**		mm	—		
10	**Thickness of cladding on each face**		%	—		
11	**Direction of test piece**			—	L	
12	T	**Temperature**	θ °C	Ambient	Ambient	
13	T	**Proof stress**	$R_{p0.2}$ MPa	—	$\geqslant$ 600 [1)]	
14	T	**Strength**	R_m MPa	—	$\geqslant$ 1 000 [1)]	
15	T	**Elongation**	A %	—	$\geqslant$ 20 [1)]	
16	T	**Reduction of area**	Z %	—		
17	**Hardness**			a or D $\leqslant$ 70 mm: HBW $\leqslant$ 250 or HV $\leqslant$ 270	HBW $\geqslant$ 285 or HV $\geqslant$ 310	
18	**Shear strength**		R_c MPa	—		
19	**Bending**		κ —	—		
20	**Impact strength**			—		
21	C	**Temperature**	θ °C	—	750	
22	C	**Time**	h	—	$t_R \geqslant 30$	
23	C	**Stress**	σ_a MPa	—		
24	C	**Elongation**	a %	—		
25	C	**Rupture stress**	σ_R MPa	—	340	
26	C	**Elongation at rupture**	A %	—		
27	**Notes** (see line 98)			[1)]		

Table 2 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy extruded sections for subsequent forming** *(continued)*

29	**Reference heat treatment**	—	Solution treated + precipitation treated θ = (1 080 $\pm$10) °C / t = 8 h / AC or OQ or WQ + θ = (700 $\pm$10) °C / t = 16 h / AC
44	**External defects**	—	See Section 2 of BS HR 100
51	**Macrostructure**	—	See Section 2 of BS HR 100
61	**Internal defects**	—	See Section 2 of BS HR 100
95	**Marking**	—	See Section 2 of BS HR 100
96	**Dimensional inspection**	—	See Section 2 of BS HR 100
98	**Notes**	—	[1)] When required by the order.

Table 3 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy billets and bars for forging**

1	**Material designation**			**BS HR 1**							
2	**Chemical composition %**	Element		C	Si	Mn	S	Ag	Al	B	Bi
		Min.		0.040	—	—	—	—	1.0	—	—
		Max.		0.10	1.0	1.0	0.015	5 ppm	1.8	0.008	1 ppm
		Element		Co	Cr	Cu	Fe	Pb	Ti	Ni	
		Min.		—	18.0	—	—	—	1.8	Base	
		Max.		2.0	21.0	0.2	1.5	20 ppm	2.7		
3	**Method of melting**			Air melted; vacuum melted; air melted and vacuum refined; consumable electrode remelted							
4.1	**Form**			Billets and bars for forging (HR 1C)							
4.2	**Method of production**			—							
4.3	**Limit dimension(s)**		mm	—							
5	**Technical specification**			Sections 1 and 3 of BS HR 100							

6.1	**Delivery condition**		Hot or cold worked and subsequently machined or ground [1)]	
	Heat treatment		—	
6.2	**Delivery condition code**		F	
7	**Use condition**		Delivery condition	
	Heat treatment		—	

					Characteristics		
8.1	**Test sample(s)**				See Section 3 of BS HR 100		
8.2	**Test piece(s)**				See Section 3 of BS HR 100		
8.3	**Heat treatment**				Delivery condition	Reference (see line 29)	
9	**Dimensions concerned**			mm	—		
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	—	$\geqslant 600$ [2)]	
14		**Strength**	R_m	MPa	—	$\geqslant 1\,000$ [2)]	
15		**Elongation**	A	%	—	$\geqslant 20$ [2)]	
16		**Reduction of area**	Z	%	—		
17	**Hardness**				—	HBW $\geqslant$ 285 or HV $\geqslant$ 310	
18	**Shear strength**		R_c	MPa	—		
19	**Bending**		κ	—	—		
20	**Impact strength**				—		
21	**C**	**Temperature**	θ	°C	—	750	
22		**Time**		h	—	$t_R \geqslant 30$	
23		**Stress**	σ_a	MPa	—		
24		**Elongation**	a	%	—		
25		**Rupture stress**	σ_R	MPa	—	340	
26		**Elongation at rupture**	A	%	—		
27	**Notes** (see line 98)				[1), 2)]		

Table 3 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy billets and bars for forging** *(continued)*

29	**Reference heat treatment**	—	Solution treated + precipitation treated θ = (1 080 $\pm$10) °C / t = 8 h / AC or OQ or WQ + θ = (700 $\pm$10) °C / t = 16 h / AC
44	**External defects**	—	See Section 3 of BS HR 100
51	**Macrostructure**	—	See Section 3 of BS HR 100
61	**Internal defects**	—	See Section 3 of BS HR 100
95	**Marking**	—	See Section 3 of BS HR 100
96	**Dimensional inspection**	—	See Section 3 of BS HR 100
98	**Notes**	—	[1] Material of other than round section may be supplied in the descaled condition. [2] When required by the order.

Table 4 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy forgings**

1	**Material designation**			**BS HR 1**							
2	**Chemical composition %**	Element		C	Si	Mn	S	Ag	Al	B	Bi
		Min.		0.040	—	—	—	—	1.0	—	—
		Max.		0.10	1.0	1.0	0.015	5 ppm	1.8	0.008	1 ppm
		Element		Co	Cr	Cu	Fe	Pb	Ti	Ni	
		Min.		—	18.0	—	—	—	1.8	Base	
		Max.		2.0	21.0	0.2	1.5	20 ppm	2.7		
3	**Method of melting**			Air melted; vacuum melted; air melted and vacuum refined; consumable electrode remelted							
4.1	**Form**			Forgings (HR 1D)							
4.2	**Method of production**			Forged from HR 1C stock							
4.3	**Limit dimension(s)**		mm	—							
5	**Technical specification**			Sections 1 and 4 of BS HR 100							

6.1	**Delivery condition**			Solution treated
	Heat treatment			θ = (1 080 ±10) °C / t = 8 h / AC or OQ or WQ [1)]
6.2	**Delivery condition code**			W
7	**Use condition**			Solution treated + precipitation treated
	Heat treatment			Delivery condition + θ = (700 ±10) °C / t = 16 h / AC

					Characteristics	
8.1	**Test sample(s)**				See Section 4 of BS HR 100	
8.2	**Test piece(s)**				See Section 4 of BS HR 100	
8.3	**Heat treatment**				Delivery condition	Use condition
9	**Dimensions concerned**			mm	—	
10	**Thickness of cladding on each face**			%	—	
11	**Direction of test piece**				—	L
12	**T**	**Temperature**	θ	°C	Ambient	Ambient
13		**Proof stress**	$R_{p0.2}$	MPa	—	⩾ 600 [2)]
14		**Strength**	R_m	MPa	—	⩾ 1 000 [2)]
15		**Elongation**	A	%	—	⩾ 20 [2)]
16		**Reduction of area**	Z	%	—	
17	**Hardness**				OQ or WQ: HBW ⩽ 230 or HV ⩽ 245 AC: HBW ⩽ 300 or HV ⩽ 325	HBW ⩾ 285 or HV ⩾ 310
18	**Shear strength**		R_c	MPa	—	
19	**Bending**		κ	—	—	
20	**Impact strength**				—	
21	**C**	**Temperature**	θ	°C	—	750
22		**Time**		h	—	t_R ⩾ 30
23		**Stress**	σ_a	MPa	—	
24		**Elongation**	a	%	—	
25		**Rupture stress**	σ_R	MPa	—	340
26		**Elongation at rupture**	A	%	—	
27	**Notes** (see line 98)				1), 2)	

Table 4 **Technical requirements for nickel-chromium-titanium-aluminium heat-resisting alloy forgings** *(continued)*

34	**Grain size**	—	See Section 4 of BS HR 100
44	**External defects**	—	See Section 4 of BS HR 100
51	**Macrostructure (grain flow)**	—	See Section 4 of BS HR 100
61	**Internal defects**	—	See Section 4 of BS HR 100
95	**Marking**	—	See Section 4 of BS HR 100
96	**Dimensional inspection**	—	See Section 4 of BS HR 100
98	**Notes**	—	[1] For material of a or D $\leqslant$ 12.5 mm, the solution heat treatment time at temperature may be reduced to the following minima: a or D $\leqslant$ 3 mm: 1 h; 3 mm < a or D $\leqslant$ 6 mm: 2 h; 6 mm < a or D $\leqslant$ 12.5 mm: 4 h. [2] When required by the order.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 4500-1, *Metallic materials – Rules for the drafting and presentation of material standards – Part 1: General rules* [1)]

EN 4500-3, *Metallic materials – Rules for the drafting and presentation of material standards – Part 3: Specific rules for heat-resisting alloys* [1)]

[1)] Published as ASD-STAN Prestandard at the date of publication of this standard.

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