BS 2HR 650:2011

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AEROSPACE SERIES

Specification for high expansion heat-resisting steel bar and wire for the manufacture of bolts, studs, set screws and nuts (Ni 25.5, Cr 15, Ti 2, Mn 1.5, Mo 1.25, Si 0.7, V 0.3) (Limiting ruling section 50 mm)

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Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 6, 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 2011. 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

Together with BS EN 2398 and BS EN 2399, this standard supersedes BS HR 650:1972, which is withdrawn.

Information about this document

This standard is a full revision of BS HR 650 and introduces the following principal changes:

a) the requirements are stated in tabular format in accordance with EN 4500-1 and EN 4500-3;

b) the limiting ruling section covered in this standard has been increased from 20 mm to 50 mm;

c) the bar for machining diameters covered in this standard have been limited to include measurements above 25 mm, up to and including 50 mm;

d) the supplied bar for forging (softened, cold worked and machined or ground) diameters covered in this standard have been limited to include measurements above 25 mm, up to and including 50 mm.

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 methods are expressed either as a set of instructions or 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 high expansion heat-resisting steel bar and wire in the following forms for the manufacture of bolts, studs, set screws and nuts.

a) Bar with a diameter over 25 mm up to and including 50 mm and wire with a maximum diameter of 50 mm for machining: softened, cold worked, solution treated and machined or ground, designation HR 650A.

b) Bar with a diameter over 25 mm up to and including 50 mm and wire with a maximum diameter of 50 mm for machining: softened, cold worked, solution treated, precipitation treated and machined or ground, designation HR 650B.

c) Bar with a diameter over 25 mm up to and including 50 mm and wire with a maximum diameter of 50 mm for forging: softened, cold worked and machined or ground, designation HR 650C.

d) Bar and wire with a maximum diameter of 50 mm for forging: softened, cold worked, solution treated and machined or ground, designation HR 650D.

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 the technical requirements specified in Table 1 and Table 2.

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

3.2 Parts finally heat-treated after machining shall conform to Sections 1 and 9 of BS HR 100.

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

Table 1 **Technical requirements for nickel-chromium-titanium-molybdenum heat-resisting steel for machining**

1	**Material designation**			**BS HR 650**						
2	**Chemical composition %**	Element		C	Si	Mn	P	S	Al	B
		Min.		—	—	—	—	—	—	0.003
		Max.		0.08	1.0	2.0	0.020	0.015	0.35	0.010
		Element		Cr	Mo	Ni	Pb	Ti	V	Fe
		Min.		13.5	1.0	24.0	—	1.9	0.10	Base
		Max.		16.0	1.5	27.0	50 ppm	2.3	0.50	
3	**Method of melting**			Electric process followed by consumable electrode vacuum arc remelting.						
4.1	**Form**			Bar and wire for machining (HR 650A)			Bar and wire for machining (HR 650B)			
4.2	**Method of production**			—						
4.3	**Limit dimension(s)**		mm	Bar: 25 < D ≤ 50		Wire: D ≤ 50	Bar: 25 < D ≤ 50		Wire: D ≤ 50	
5	**Technical specification**			Sections 1 and 9 of BS HR 100						

6.1	**Delivery condition**			Softened + 15% ≤ reduction ≤ 25% [1] + solution treated + machined or ground	Softened + 15% ≤ reduction ≤ 25% [1] + solution treated + precipitation treated + machined or ground
	Heat treatment			θ = (900 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (980 ±10) °C/t ≥ 1 h/AC or OQ or WQ	θ = (900 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (980 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (720 ±10) °C/t ≥ 16 h/AC
6.2	**Delivery condition code**			W	U
7	**Use condition**			Softened + cold worked + solution treated + precipitation treated	Delivery condition
	Heat treatment			Delivery condition + θ = (720 ±10) °C/t ≥ 16 h/AC	—

					Characteristics	
8.1	**Test sample(s)**				See Section 9 of BS HR 100	
8.2	**Test piece(s)**				See Section 9 of BS HR 100	
8.3	**Heat treatment**				Softened + cold worked + solution treated	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	—	≥590
14	T	**Strength**	R_m	MPa	—	≥900
15	T	**Elongation**	A	%	—	≥12
16	T	**Reduction of area**	Z	%	—	≥20
17	**Hardness**				HBW ≤ 200	248 ≤ HBW ≤ 341 or 260 ≤ HV ≤ 360
18	**Shear strength**		R_c	MPa	—	
19	**Bending**		κ	—	—	
20	**Impact strength**				—	
21	C	**Temperature**	θ	°C	—	650 [2]
22	C	**Time**		h	—	$t_R \geq 23$ [2]
23	C	**Stress**	σ_a	MPa	—	—
24	C	**Elongation**	a	%	—	—
25	C	**Rupture stress**	σ_R	MPa	—	480 [2]
26	C	**Elongation at rupture**	A	%	—	≥4.0 [2), 3)]
27	**Notes (see line 98)**				1), 2), 3)	

Table 1 **Technical requirements for nickel-chromium-titanium-molybdenum heat-resisting steel for machining** *(continued)*

34	**Grain size**	—	See Section 9 of BS HR 100
		3	Transverse sample
		5	Use condition
		7	Uniform average grain size ≤0.065 mm
44	**External defects**	—	See Section 9 of BS HR 100
51	**Macrostructure**	—	See Section 9 of BS HR 100
61	**Internal defects**	—	See Section 9 of BS HR 100
74	**Surface contamination**	—	See Section 9 of BS HR 100
95	**Marking**	—	See Section 9 of BS HR 100
96	**Dimensional inspection**	—	See Section 9 of BS HR 100
98	**Notes**	—	[1] Reduced 15% to 25% in cross-sectional area during final drawing or rolling at a temperature of not more than 870 °C. [2] Combined notch and un-notched test piece. [3] Rupture shall occur in the un-notched portion of the test piece.

Table 2 **Technical requirements for nickel-chromium-titanium-molybdenum heat-resisting steel for forging**

1	**Material designation**			**BS HR 650**						
2	**Chemical composition %**	Element		C	Si	Mn	P	S	Al	B
		Min.		—	—	—	—	—	—	0.003
		Max.		0.08	1.0	2.0	0.020	0.015	0.35	0.010
		Element		Cr	Mo	Ni	Pb	Ti	V	Fe
		Min.		13.5	1.0	24.0	—	1.9	0.10	Base
		Max.		16.0	1.5	27.0	50 ppm	2.3	0.50	
3	**Method of melting**			Electric process followed by consumable electrode vacuum arc remelting.						
4.1	**Form**			Bar and wire for forging (HR 650C)			Bar and wire for forging (HR 650D)			
4.2	**Method of production**			—						
4.3	**Limit dimension(s)**		mm	Bar: 25 < D ≤ 50		Wire: D ≤ 50	Bar and wire: D ≤ 50			
5	**Technical specification**			Sections 1 and 9 of BS HR 100						

6.1	**Delivery condition**		Softened + 15% ≤ reduction ≤ 25% [1] + machined or ground	Softened + 15% ≤ reduction ≤ 25% [1] + solution treated + machined or ground	
	Heat treatment		θ = (900 ±10) °C/t ≥ 1 h/AC or OQ or WQ	θ = (900 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (980 ±10) °C/t ≥ 1 h/AC or OQ or WQ	
6.2	**Delivery condition code**		U	U	
7	**Use condition**		Delivery condition	Delivery condition	
	Heat treatment		—	—	

Characteristics

8.1	**Test sample(s)**			See Section 9 of BS HR 100			
8.2	**Test piece(s)**			See Section 9 of BS HR 100			
8.3	**Heat treatment**			Softened + cold worked	Softened + cold worked + solution treated	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	T	**Proof stress**	$R_{p0.2}$ MPa	—	—	≥590	
14	T	**Strength**	R_m MPa	—	—	≥900	
15	T	**Elongation**	A %	—	—	≥12	
16	T	**Reduction of area**	Z %	—	—	≥20	
17	**Hardness**			—	HBW ≤ 200	248 ≤ HBW ≤ 341 or 260 ≤ HV ≤ 360	
18	**Shear strength**		R_c MPa	—			
19	**Bending**		κ —	—			
20	**Impact strength**			—			
21	C	**Temperature**	θ °C	—	—	650 [2]	
22	C	**Time**	h	—	—	$t_R \geq 23$ [2]	
23	C	**Stress**	σ_a MPa	—	—	—	
24	C	**Elongation**	a %	—	—	—	
25	C	**Rupture stress**	σ_R MPa	—	—	480 [2]	
26	C	**Elongation at rupture**	A %	—	—	≥4.0 [2), 3)]	
27	**Notes (see line 98)**			1), 2), 3)			

Table 2 **Technical requirements for nickel-chromium-titanium-molybdenum heat-resisting steel for forging** *(continued)*

29	**Reference heat treatment**	—	Softened + 15% ≤ reduction ≤ 25% [1] + solution treated + precipitation treated θ = (900 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (980 ±10) °C/t ≥ 1 h/AC or OQ or WQ + θ = (720 ±10) °C/t ≥ 16 h/AC
34	**Grain size**	—	See Section 9 of BS HR 100
		3	Transverse sample
		5	Reference (see line 29)
		7	Uniform average grain size ≤0.065 mm
44	**External defects**	—	See Section 9 of BS HR 100
51	**Macrostructure**	—	See Section 9 of BS HR 100
61	**Internal defects**	—	See Section 9 of BS HR 100
74	**Surface contamination**	—	See Section 9 of BS HR 100
95	**Marking**	—	See Section 9 of BS HR 100
96	**Dimensional inspection**	—	See Section 9 of BS HR 100
98	**Notes**	—	[1] Reduced 15% to 25% in cross-sectional area during final drawing or rolling at a temperature of not more than 870 °C. [2] Combined notch and un-notched test piece. [3] Rupture shall occur in the un-notched portion of the test piece.

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.

BS EN 2398, *Aerospace series – Heat resisting steel FE-PA2601 (X6NiCrTiMoV26-15) – Rm ≥ 900 MPa – Bars for machined bolts – D ≤ 25 mm*

BS EN 2399, *Aerospace series – Heat resisting steel FE-PA2601 (X4NiCrTiMoV26-15) – Rm ≥ 900 MPa – Bars for forged bolts – D ≤ 25 mm*

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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