INTERNATIONAL STANDARD

ISO 9723

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Nickel and nickel alloy bars

Barres en nickel et alliages de nickel

Reference number
ISO 9723:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9723 was prepared by Technical Committee ISO/TC 155, *Nickel and nickel alloys*, Sub-Committee SC 2, *Wrought and cast nickel and nickel alloys*.

Annex A forms an integral part of this International Standard.

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Nickel and nickel alloy bars

1 Scope

This International Standard specifies requirements for nickel and nickel alloy bars in the finished condition and for further working in the following size ranges:

— cold-worked bars up to and including 65 mm diameter or width across flats

— hot-worked bars up to and including 315 mm diameter or width across flats.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO/R 204:1961, *Non-interrupted creep testing of steel at elevated temperatures.*

ISO/R 206:1961, *Creep stress rupture testing of steel at elevated temperatures.*

ISO 6372-1:1989, *Nickel and nickel alloys — Terms and definitions — Part 1: Materials.*

ISO 6372-3:1989, *Nickel and nickel alloys — Terms and definitions — Part 3: Wrought products and castings.*

ISO 6892:1984, *Metallic materials — Tensile testing.*

ISO 7003:1990, *Unified format for the designation of metals.*

ISO/TR 9721:1992, *Nickel and nickel alloys — Rules for material description based on chemical symbols.*

ISO 9722:1992, *Nickel and nickel alloys — Composition and forms of wrought products.*

ASTM E 112:1988, *Standard methods for determining average grain size.*

3 Definitions

For the purposes of this International Standard, the following definitions and those for nickel and nickel alloys in ISO 6372-1 and for bars in ISO 6372-3 apply.

3.1 heat: The product of a furnace melt or a number of melts that are mixed prior to casting.

3.2 lot: Bars of the same cross-sectional dimensions, from the same heat, heat treated together or sequentially heat treated in a continuous furnace, but in no case for longer than 16 h of production. For bars not identified by heat, the lot shall be either one piece of the forging or 500 kg, whichever is larger.

4 Alloy identification

For the purposes of this International Standard, the principles for alloy identification in ISO/TR 7003 and ISO/TR 9721 apply.

5 Ordering information

Orders for bars according to this International Standard shall include the following information.

5.1 The number of this International Standard.

5.2 Quantity (mass or number of bars).

5.3 Alloy identification (see table 1).

NOTE 1 For alloy identification, either the number or the description may be used.

5.4 Alloy temper, for finished bars only (see table 2).

5.5 Dimensions: diameter, width across flats, thickness, width, length.

5.6 Specify whether the purchaser will hot work the product.

5.7 Optional requirements:

a) tolerances for bars to be hot worked by the purchaser;

b) samples for product analysis (see 7.1.2);

c) determination of 1 % proof stress (see 9.2.3);

d) surface condition (see 6.1.8 or 6.2.4);

e) marking (see clause 10);

f) purchaser or third party inspection (see clause 11);

g) declaration of conformity (see clause 12).

6 Requirements

6.1 Requirements for bars supplied in a finished condition

6.1.1 Composition

Heat analysis shall meet the composition limits specified in table 1.

The composition limits do not preclude the possible presence of other elements that are not specified. If the purchaser's requirements necessitate limits for any other element that is not specified, these shall be agreed between the purchaser and the supplier. The percentage content of elements shown as "remainder" shall be calculated by difference from 100 %.

6.1.2 Temper

Unless otherwise specified, bars of precipitation-hardenable alloys shall be supplied in the solution-treated temper.

6.1.3 Tensile properties

Bars shall have the tensile properties specified in table 2.

6.1.4 Heat treatment

Precipitation-hardenable alloy bars shall be heat treated in accordance with table 3 to the condition as ordered.

6.1.5 Grain size

Bars of alloys NW8810 (FeNi32Cr21AlTi-HC) and NW8811 (FeNi32Cr21AlTi-HT) shall have a grain size ASTM No. 5 or coarser (average diameter 0,06 mm or greater).

6.1.6 Creep or stress rupture properties

Bars of precipitation-hardenable alloys shall meet the creep or stress rupture properties specified in table 4.

6.1.7 Dimensional tolerances

6.1.7.1 Diameter, thickness or width across flats

The tolerances for cross-sectional dimensions shall be as specified in tables 5 to 7.

6.1.7.2 Length

The length tolerance of hot-worked and cold-worked bars shall be as specified in table 8.

6.1.7.3 Straightness

The maximum curvature (depth of chord) shall not exceed 4 mm multiplied by the length in metres. Bars shall be free of sharp bends and kinks.

6.1.8 Surface condition

Bars shall be clean and free from detrimental surface imperfections.

NOTE 2 Where appropriate, the acceptance criteria should be agreed between the purchaser and the supplier.

6.1.9 Finish

Bars may be supplied in one of the following finishes:

a) hot worked;

b) cold drawn;

c) descaled;

d) machined;

e) ground.

6.2 Requirements for bars to be further worked by the purchaser

6.2.1 Composition

Heat analysis shall meet the composition limits specified in table 1, as in ISO 9722.

The composition limits do not preclude the possible presence of other elements that are not specified. If the purchaser's requirements necessitate limits for any other element that is not specified, these shall be agreed between the purchaser and the supplier. The percentage content of elements shown as "remainder" shall be calculated by difference from 100 %.

6.2.2 Temper

Unless otherwise specified, bars to be further worked by the purchaser shall be supplied in the hot-worked temper, without specified mechanical properties.

6.2.3 Precipitation-hardenable alloys

The supplier of precipitation-hardenable alloy bars shall demonstrate the capability of meeting the requirements specified in table 2 and/or table 4, by testing samples heat treated in accordance with table 3.

6.2.4 Surface condition

Bars shall be clean and free from detrimental surface inperfections.

Unless otherwise agreed between the purchaser and the supplier, bars shall be supplied with a machined surface.

NOTE 3 Where appropriate, the acceptance criteria should be agreed between the purchaser and the supplier.

7 Sampling

7.1 Chemical analysis

7.1.1 Representative heat analysis samples shall be taken during pouring or subsequent processing.

7.1.2 Product analysis samples shall be taken from the finished product.

7.2 Tensile and creep or stress rupture test

Tensile and creep or stress rupture test samples shall be taken from material in the final heat-treated condition and tested in the longitudinal direction.

Samples from products to be supplied in other than the fully heat-treated condition shall be heat treated in accordance with table 3 before testing.

8 Number of tests

8.1 Chemical analysis, one test per heat.

8.2 Tensile test, one test per lot.

8.3 Creep or stress rupture test, one test per lot.

8.4 Grain size determination, one test per lot.

9 Test procedures

9.1 Chemical analysis

9.1.1 The method of chemical analysis shall be at the option of the supplier, however, in cases of dispute the method specified in the relevant International Standard shall be used.

If no International Standard exists, an analytical method that can be calibrated to a reference standard agreed upon by the purchaser and the supplier shall be used.

9.1.2 For a list of ISO analytical standards, see annex A.

9.2 Tensile testing

9.2.1 Testing shall be carried out in accordance with ISO 6892.

9.2.2 Bars shall be tested over their total cross-section, if possible. When a test over the total cross-section cannot be performed, the largest possible round specimen, not exceeding 15 mm in diameter on the gauge length, shall be used.

Longitudinal strip specimens shall be prepared for rectangular bars, with thicknesses up to and including 15 mm, which are too wide to be tested in full cross-section.

See annexes C and D of ISO 6892.

9.2.3 The offset method shall be used for the determination of proof stress. An offset of 0,2 % ($R_{p0,2}$) shall be standard. However, a 1 % proof stress ($R_{p1,0}$) shall be determined and reported for information when requested by the purchaser.

9.3 Creep and stress rupture testing

9.3.1 Creep tests shall be carried out in accordance with ISO/R 204, except that only the final total plastic strain need be reported.

9.3.2 Stress rupture tests shall be carried out in accordance with ISO/R 206.

9.4 Grain size determination

A transverse sample representative of the full thickness shall be examined in accordance with ASTM E 112.

9.5 Rounding-off

For the purpose of determining compliance with the specified limits of the properties listed below, an observed value or a calculated value shall be rounded as follows.

When the figure immediately after the last figure to be retained is lower than 5, the last figure to be retained remains unchanged.

When the figure immediately after the last figure to be retained is 5 or greater, the last figure to be retained is increased by one.

Composition, creep, stress rupture, grain size, hardness and dimensions	Nearest unit to the last right-hand place of figures of the specified limit
Tensile strength (R_m)	Nearest 10 N/mm ^{2}
Proof stress ($R_{p0,2}$)	Nearest 5 N/mm ^{2}
Elongation (A)	Nearest 1 %

9.6 Retests

If any one of the test pieces first selected fails to pass the specified tests, two further samples from the same lot shall be selected for testing, one of which shall be from the original bar tested, unless that bar has been withdrawn by the supplier. If the test pieces from both these additional samples pass, the lot represented by the test samples shall be deemed to comply with the requirements of this International Standard. If the test pieces from either of these additional samples fail, the lot represented by these samples shall be deemed not to comply with the requirements of this International Standard.

10 Marking

10.1 Each bundle or shipping container shall be marked with the number of this International Standard, the alloy identification (either the number or the description), the heat number, heat-treated condition, the size, the gross, tare and net weight, the consignor and consignee address, contract or order number, and any other information requested in the contract or order.

10.2 If agreed between the purchaser and supplier, the supplier shall mark each bar with the number of this International Standard, the alloy identification, the heat number and the manufacturer's name. The method of marking will be at the option of the supplier, unless otherwise agreed. Marking shall not result in harmful contamination.

11 Purchaser or third party inspection

On-site inspection of bars by the purchaser or third parties shall be in accordance with agreements made between the purchaser and the supplier as part of the purchase contract.

12 Declaration of conformity

When requested by the purchaser in the contract or order, the supplier shall certify that the bars were manufactured and tested in accordance with this International Standard. The declaration of conformity shall detail the results of all tests required by this International Standard and the order.

Table 1 — Composition and density of wrought nickel and nickel alloys (selected from table 1 of ISO 9722:1992)

Alloy identification[1]		Composition % (m/m)[2]																Density[3]
Number	Description	Al	B	C	Co[4]	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	Ti	W	Others[5]	g/cm³
NW2200	Ni99,0			0,15			0,2	0,4	0,3		99,0		0,010	0,3				8,9
NW2201	Ni99,0-LC			0,02			0,2	0,4	0,3		99,0		0,010	0,3				8,9
NW3021	NiCo20Cr15Mo5Al4Ti	4,5 4,9	0,003 0,010	0,12 0,17	18,0 22,0	14,0 15,7	0,2	1,0	1,0	4,5 5,5	Remainder		0,015	1,0	0,9 1,5		Ag: 0,0005(5) Bi: 0,0001(1) Pb: 0,0015(15)	8,4
NW7263	NiCo20Cr20Mo5Ti2Al	0,3 0,6	0,005	0,04 0,08	19,0 21,0	19,0 21,0	0,2	0,7	0,6	5,6 6,1	Remainder		0,007	0,4	1,9 2,4		Ag: 0,0005(5) Bi: 0,0001(1) Pb: 0,0020(20) Ti+Al: 2,4 to 2,8	8,4
NW7001	NiCr20Co13Mo4Ti3Al	1,2 1,6	0,003 0,010	0,02 0,10	12,0 15,0	18,0 21,0	0.10	2,0	1,0	3,5 5,0	Remainder	0,015	0,015	0,1	2,8 3,3		Ag: 0,0005(5) Bi: 0,0005(0,5) Pb: 0,0010(10) Zr: 0,02 to 0,08	8,4
NW7090	NiCr20Co18Ti3	1,0 2,0	0,020	0,13	15,0 21,0	18,0 21,0	0,2	1,5	1,0		Remainder		0,015	1,0	2,0 3,0		Zr: 0,15	8,2
NW7750	NiCr15Fe7Ti2Al	0,4 1,0		0,08		14,0 17,0	0,5	5,0 9,0	1,0		70,0		0,015	0,5	2,2 2,8		Nb+Ta: 0,7 to 1,2	8,3
NW6600	NiCr15Fe8			0,15		14,0 17,0	0,5	6,0 10,0	1,0		72,0		0,015	0,5				8,4
NW6602	NiCr15Fe8-LC			0,02		14,0 17,0	0,5	6,0 10,0	1,0		72,0		0.015	0.5				8,4
NW7718	NiCr19Fe19Nb5Mo3	0,2 0,8	0,006	0,08		17,0 21,0	0,3	Remainder	0,4	2,8 3,3	50,0 55,0	0,015	0,015	0,4	0,6 1,2		Nb+Ta: 4,7 to 5,5	8,0
NW6002	NiCr21Fe18Mo9		0,010	0,05 0,15	0,5 2,5	20,5 23,0		17,0 20,0	1,0	8,0 10,0	Remainder	0,040	0,030	1,0		0,2 1,0		8,2
NW6601	NiCr23Fe15Al	1,0 1,7		0,10		21,0 25,0	1,0	Remainder	1,0		58,0 63,0		0,015	0,5				8,0
NW6333	NiCr26Fe20Co3Mo3W3			0,10	2,5 4,0	24,0 27,0		Remainder	2,0	2,5 4,0	44,0 48,0	0,030	0,030	1,5		2,5 4,0		
NW6690	NiCr29Fe9			0,05		27,0 31,0	0,5	7,0 11,0	0,5		Remainder		0,015	0,5				8,2
NW6455	NiCr16Mo16Ti			0,015	2,0	14,0 18,0		3,0	1,0	14,0 17,0	Remainder	0,040	0,030	0,08	0,7			8,6
NW6022	NiCr21Mo13Fe4W3			0,015	2,5	20,0 22,5		2,0 6,0	0,5	12,5 14,5	Remainder	0,025	0,020	0,08		2,5 3,5	V: 0,35	8,7
NW6625	NiCr22Mo9Nb	0,40		0,10	1,0	20,0 23,0		5,0	0,50	8,0 10,0	58,0	0,015	0,015	0,50	0,40		Nb+Ta: 3,15 to 4,15	8,5

Alloy identification[1]		Composition % (*m/m*)[2]																Density[3]
Number	Description	Al	B	C	Co[4]	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	Ti	W	Others[5]	g/cm³
NW6621	NiCr20Ti			0,08 0,15	5,0	18,0 21,0	0,5	5,0	1,0		Remainder		0,020	1,0	0,20 0,60		Pb: 0,0050(50)	8,4
NW7080	NiCr20Ti2Al	1,0 1,8	0,008	0,04 0,10	2,0	18,0 21,0	0,2	1,5	1,0		Remainder		0,015	1,0	1,8 2,7		Ag: 0,0005(5) Bi: 0,0001(1) Pb: 0,0020(20)	8,2
NW4400	NiCu30			0,30			28,0 34,0	2,5	2,0		63,0		0,025	0,5				8,8
NW4402	NiCu30-LC			0,04			28,0 34,0	2,5	2,0		63,0		0,025	0,5				8,8
NW5500	NiCu30Al3Ti	2,2 3,2		0,25			27,0 34,0	2,0	1,5		Remainder	0,020	0,015	0,5	0,35 0,85			8,5
NW8825	NiFe30Cr21Mo3	0,2		0,05		19,5 23,5	1,5 3,0	Remainder	1,0	2,5 3,5	38,0 46,0		0,015	0,5	0,6 1,2			8,1
NW9911	NiFe36Cr12Mo6Ti3	0,35	0,010 0,020	0,02 0,06		11,0 14,0	0,2	Remainder	0,5	5,0 6,5	40,0 45,0	0,020	0,020	0,4	2,8 3,1			8,2
NW0276	NiMo16Cr15Fe6W4			0,010	2,5	14,5 16,5		4,0 7,0	1,0	15,0 17,0	Remainder	0,040	0,030	0,08		3,0 4,5		8,9
NW0665	NiMo28			0,02	1,0	1,0		2,0	1,0	26,0 30,0	Remainder	0,040	0,030	0,1				9,2
NW0001	NiMo30Fe5			0,05	2,5	1,0		4,0 6,0	1,0	26,0 30,0	Remainder	0,040	0,030	1,0			V: 0,2 to 0,4	9,2
NW8800	FeNi32Cr21AlTi	0,15 0,60		0,10		19,0 23,0	0,7	Remainder	1,5		30,0 35,0		0,015	1,0	0,15 0,60			8,0
NW8810	FeNi32Cr21AlTi-HC	0,15 0,60		0,05 0,10		19,0 23,0	0,7	Remainder	1,5		30,0 35,0		0,015	1,0	0,15 0,60			8,0
NW8811	FeNi32Cr21AlTi-HT	0,25 0,60		0,06 0,10		19,0 23,0	0,7	Remainder	1,5		30,0 35,0		0,015	1,0	0,25 0,60		Al+Ti: 0,85 to 1,2	8,0
NW8801	FeNi32Cr21Ti			0,10		19,0 22,0	0,5	Remainder	1,5		30,0 34,0		0,015	1,0	0,7 1,5			8,0
NW8020	FeNi35Cr20Cu4Mo2			0,07		19,0 21,0	3,0 4,0	Remainder	2,0	2,0 3,0	32,0 38,0	0,040	0,030	1,0			Nb+Ta: 8 x C to 1,0	8,1

1) For alloy identification either the number or the description may be used.

2) Single values are maximum limits, except for nickel where single values are minimum.

3) Density values are average values and are given for information only.

4) Where no limits are specified, cobalt up to a maximum of 1,5 % is allowed and counted as nickel. In this case, an indication of cobalt content is not required.

5) Values for Ag, Bi and Pb may be expressed in mass percentage [% (*m/m*)] or in parts per million (ppm).

Table 2 — Tensile properties

Alloy identification[1]		Cross-section	Temper	Diameter or width across flats or thickness, mm		Tensile strength	0,2 % proof stress	Minimum elongation[2]
Number	Description			over	up to and including	R_m, min N/mm²	$R_{p0,2}$, min N/mm²	A_5/A_{50} %
NW2200	Ni99,0	Round	Cold worked	—	25	550	415	10[3]
				25	105	520	345	15
		Square Hexagon Rectangle	Cold worked	All		450	275	25[3]
		All	Hot worked	All		410	105	35[4]
		All	Annealed	All		380	105	35[3]
NW2201	Ni99,0-LC	All	Hot worked	All		340	65	35[4]
		All	Annealed	All		340	65	35[3]
NW3021	NiCo20Cr15Mo5Al4Ti	All	Solution treated, stabilized and prescription treated	All		—	—	—
NO7263	NICo20Cr20Mo5Ti2Al[5]	All	Solution and precipitation treated	All		540[5]	400[5]	12[5]
NW7001	NiCr20Co13Mo4Ti3Al	All	Solution and precipitation treated	All		1 100	755	15
NO7090	NiCr20Co18Ti3	All	Solution and precipitation treated	All		1 080	695	25
NW7750	NiCr15Fe7Ti2Al	All	Solution and precipitation treated	—	65	1 170	790	18
				65	100	1 170	790	15
NW6600	NiCr15Fe8	Round	Cold worked	—	12	830	620	7[3]
				12	25	760	585	10
				25	65	720	550	12
		Square Hexagon Rectangle	Cold worked	—	6	690	550	5[3]
				6	10	650	480	7
		Round	Hot worked	> 6	12	650	310	27
				12	75	620	275	27
				75	—	590	240	27
		All	Hot worked	All		590	240	27
		All	Annealed	All		550	240	30
NW6602	NiCr15Fe8-LC	All	Annealed	All		550	180	30

Alloy identification[1]		Cross-section	Temper	Diameter or width across flats or thickness mm		Tensile strength	0,2 % proof stress	Minimum elongation[2]
Number	Description			over	up to and including	R_m, min N/mm²	$R_{p0,2}$, min N/mm²	A_5/A_{50} %
NW7718	NiCr19Fe19Nb5Mo3	All	Solution and precipitation treated	—	100	1 270	1 030	12
NW6002	NiCr21Fe18Mo9	Round	Annealed	All		660	240	30
NW6601	NiCr23Fe15Al	All	Annealed	All		550	205	30
NW6333	NiCr26Fe20Co3Mo3W3	Round	Solution treated	All		690	280	35
NW6690	NiCr29Fe9	Round	Annealed	All		590	240	30
NW6455	NiCr16Mo16Ti	Round	Solution treated	All		690	275	35
NW6022	NiCr21Mo13Fe4W3	All	Solution treated	All		690	310	45
NW6625	NiCr22Mo9Nb	All	Annealed		100	830	415	30
				100	250	760	345	25
		All	Solution treated	All		690	275	30
NW6621	NiCr20Ti	All	Annealed	All		640	230	30
NW7080	NiCr20Ti2Al	All	Solution treated and precipitation treated	All		No tensile test required		
NW4400	NiCu30	Round	Cold worked	—	15	760	585	8[3]
		Square Hexagon Rectangle	Cold worked	—	15	580	375	10[3]
		Round	Cold worked and stress relieved	—	15	580	340	10[3]
				15	40	600	415	20
				40	100	580	380	20
		Square Hexagon Rectangle	Cold worked and stress relieved	All		580	345	20[3]
		Round Square Rectangle	Hot worked	All		550	275	27[6]
		Hexagon	Hot worked	—	55	550	275	27[6]
				55	—	520	205	27
		Round	Hot worked and stress relieved	100	300	550	275	27
				300	—	520	275	27
		All	Annealed	All		480	170	35

Alloy identification[1]		Cross-section	Temper	Diameter or width across flats or thickness mm		Tensile strength	0,2 % proof stress	Minimum elongation[2]
Number	Description			over	up to and including	R_m, min N/mm²	$R_{p0,2}$, min N/mm²	A_5/A_{50} %
NW4402	NiCu30-LC	All	Annealed	All		430	160	35
NW5500	NiCu30Al3Ti	All	Hot worked and precipitation treated	—	100	970	690	15
				100	—	830	550	15
		Round	Cold worked and precipitation treated	6	25	1 000	755	14
				25	75	970	690	16
				75	100	930	655	20
		Hexagon	Cold worked and precipitation treated	6	25	970	585	15
		All	Solution and precipitation treated	—	25	900	620	20
				25	100	900	585	20
				100	300	830	500	15
NW8825	NiFe30Cr21Mo3	All	Annealed	All		590	240	30[4]
NW9911	NiFe36Cr14Mo6Ti3[7]	All	Solution treated, stabilized and precipitation treated	All		960[7]	690[7]	8[7]
NW0276	NiMo16Cr15Fe6W4	All	Solution treated	All		690	275	40
NW0665	NiMo28	Round	Solution treated	7	90	760	350	35
NW0001	NiMo30Fe5	Round	Solution treated	7	40	790	315	30
				40	90	690	315	27

Alloy identification[1]		Cross-section	Temper	Diameter or width across flats or thickness mm		Tensile strength	0,2 % proof stress	Minimum elongation[2]
Number	Description			over	up to and including	R_m, min N/mm²	$R_{p0,2}$, min N/mm²	A_5/A_{50} %
NW8800	FeNi32Cr2AlTi	All	Hot worked	All		550	240	25[8]
		All	Annealed	All		520	205	30
NW8810	FeNi32Cr21AlTi	All	Annealed	All		450	170	30
NW8811	FeNi32Cr21AlTi4	All	Annealed	All		450	170	30
NW8801	FeNi32Cr20Ti	All	Annealed	All		450	170	30
NW8020	FeNi35Cr20Cu4Mo2	All	Annealed	All		550	240	27[6]

1) For alloy identification either the number or the description may be used.

2) The elongation values listed are based on either

— a proportional gauge length of $5{,}65\sqrt{S_0} = A_5$, where S_0 is the original cross-sectional area, or

— a fixed gauge length of 50 mm = A_{50}.

3) Elongation is not applicable to diameters, width across flats or thicknesses under 2,5 mm.

4) Elongation shall be a minimum of 25 % for rectangles with thicknesses up to and including 8 mm.

5) For alloy NW7263/NiCo20Cr20Mo5Ti2Al, the tensile test shall be carried out at 780 °C.

6) Elongation shall be 20 % minimum for rectangles with thicknesses up to and including 8 mm.

7) For alloy NW9911/NiFe36Cr12Mo6Ti3, the tensile test shall be carried out at 575 °C.

8) Elongation shall be 15 % minimum for cold-worked and annealed bars.

Table 3 — Heat treatment of precipitation-hardenable alloys

Alloy identification[1] Number	Description	Solution or annealing treatment[2]	Stabilizing and/or precipitation treatment
NW3021	NiCo20Cr15Mo5Al4Ti	(1 150 ± 10) °C, 4 h, air cool.	1 050 °C, 16 h, air cool + 850 °C, 16 h, air cool.
NW7263	NiCo20Cr20Mo5Ti2Al	1 150 °C, air cool or faster.	800 °C, 8 h, air cool.
NW7001	NiCr20Co13Mo4Ti3Al	995 °C to 1 040 °C, 4 h, oil or water quench.	845 °C, 4 h, air cool + 760 °C, 16 h, air cool or furnace cool.
NW7090	NiCr20Co18Ti3	1 050 °C to 1 100 °C, 8 h, air cool or faster.	700 °C, 16 h, air cool.
NW7750	NiCr15Fe7Ti2Al	980 °C to 1 100 °C, air cool or faster.	730 °C, 8 h, cool at 55 °C/h to 620 °C, hold at 620 °C for 8 h, air cool. Alternatively, cool to 620 °C at any speed and hold at 620 °C to give a total precipitation treatment time of 18 h.
NW7718	NiCr19Fe19Nb5Mo3	940 °C to 1 060 °C, air cool or faster.	720 °C, 8 h, cool at 55 °C/h to 620 °C, hold at 620 °C for 8 h, air cool. Alternatively, cool to 620 °C at any rate and hold at 620 °C to give a total precipitation treatment time of 18 h.
NW7080	NiCr20Ti2Al	1 050 °C to 1 100 °C, 8 h, air cool or faster.	700 °C, 16 h, air cool.
NW5500	NiCu30Al3Ti	980 °C minimum, water quench.	590 °C, 8 h to 16 h, furnace cool to 480 °C at between 8 °C/h and 15 °C/h, air cool. Alternatively, furnace cool to 535 °C, hold at 535 °C for 6 h, furnace cool to 480 °C, hold for 8 h, air cool.
NW9911	NiFe36Cr12Mo6Ti3	1 090 °C, air cool.	770 °C, 2 h to 4 h, air cool + 700 °C, 24 h, air cool.

1) For alloy identification either the number or the description may be used.

2) The tolerance on the selected temperature shall be within ± 15 °C, unless stated otherwise in the table.

Table 4 — Creep or stress rupture test requirements

Alloy identification[1] Number	Description	Thickness	Temperature	Stress	Minimum time to rupture	Elongation at rupture on 50 mm	Duration	Total plastic strain
		mm	°C	N/mm²	h	%	h	%
NW3021	NiCo20Cr15Mo5Al4Ti	All	815	360[2]	30	—	—	—
NW7263	NiCo20Cr20Mo5Ti2Al	All	780	120	—	—	50	0,10
NW7001	NiCr20Co13Mo4Ti3Al	All	730	550[2]	23	5	—	—
NW7090	NiCr20Co18Ti3	All	870	140[2]	30	—	—	—
NW7718	NiCr19Fe19Nb5Mo3	max. 100	650	690[2]	23	5	—	—
NW7080	NiCr20Ti2Al	All	750	340[2]	30	—	—	—
NW9911	NiFe36Cr12Mo6Ti3	All	575	590	—	—	100	0,10

1) For alloy identification either the number or the description may be used.

2) An initially higher stress may be used but shall not be changed while the test is in progress. Specified time to rupture and elongation requirements have to be met. Alternatively, stress may be increased after the minimum rupture life has been met at the specified stress; however, the specified minimum elongation has to be met.

Table 5 — Tolerances for cold-worked bars (including cold-worked, heat-treated and descaled bars)

Values in millimetres

Specified dimension[1]			Tolerance
Cross-section	over	up to and including	
Round	—	10	$^{+0,03}_{-0,08}$
	10	25	$^{+0,03}_{-0,11}$
	25	65	$^{+0,05}_{-0,13}$
Square Hexagon Rectangle	—	10	$^{+0,03}_{-0,08}$

1) The following dimensions and tolerances apply.

a) Round bars: diameter.

The circularity tolerance is half the total diameter tolerance and shall be within the diameter tolerance.

b) Square and hexagonal bars: width across flats.

c) Rectangular bars: thickness and width.

Table 6 — Tolerances for hot-worked bars (including hot-worked, heat-treated and descaled bars)

Dimensions in millimetres

Specified dimensions[1]		Tolerance[1]		
over	up to and including	Hot rolled	Forged	
			up to and including 3 500 mm in length	over 3 500 mm in length
	25	± 0,5	± 0,9	± 2,6
25	50	± 0,8	± 1,1	± 2,9
50	100	± 1,3	± 1,7	± 3,6
100	150	± 1,8	± 2,3	± 4,6
150	(315)	—	± 4,2	± 7

1) The following dimensions and tolerances apply.

a) Round bars: diameter.

The circularity tolerance for bars

— up to and including 15 mm is the total diameter tolerance;

— over 15 mm is half the total diameter tolerance.

The circularity tolerance is within the diameter tolerance.

b) Square and hexagonal bars: width across flats.

c) Rectangular bars: thickness and width.

Table 7 — Tolerances on diameter for hot-worked and machined round bars (including hot-worked and rough turned or ground bars)

Dimensions in millimetres

Specified diameter		Tolerances
over	up to and including	
—	50	$^{+0,8}_{0}$
50	75	$^{+1,0}_{0}$
75	100	$^{+1,5}_{0}$
100	—	By agreement

Table 8 — Tolerance on length

Length	Tolerance
Random mill lengths: Hot worked Cold worked	 Lengths between 1 800 mm and 7 800 mm, with short lengths of not more than 25 % of mass between 1 800 mm and 2 750 mm [1] Lengths between 1 800 mm and 6 100 mm, with short lengths of not more than 25 % of mass between 1 800 mm and 3 000 mm
Multiple lengths	Furnished in multiples of a specified unit length, in lengths between 1 800 mm and 7 300 mm. For each multiple the cutting tolerance is $^{+7}_{0}$ mm, unless otherwise specified. At the manufacturer's option, individual specified unit lengths may be furnished.
Nominal lengths	Specified lengths of minimum 600 mm with no shorter length allowed.[2]
Cut lengths	Specified lengths to which all bars are cut with the following tolerances, for cross-sectional dimensions — up to and including 200 mm : $^{+4}_{0}$ mm; — over 200 mm : $^{+7}_{0}$ mm

1) For hot-worked bars weighing over 35 kg/m and for smooth forged bars with all cross-sections, short lengths down to 600 mm may be supplied.

2) For cold-worked bars with cross-sections up to and including 15 mm, ordered to nominal or stock lengths with a 600 mm range, at least 93 % of such bars shall be within the range specified. The remainder may be in shorter lengths, but in no case less than 1 200 mm.

Annex A
(normative)

List of ISO methods of analysis

[1] ISO 6351:1985, *Nickel — Determination of silver, bismuth, cadmium, cobalt, copper, iron, manganese, lead and zinc contents — Flame atomic absorption spectrometric method.*

[2] ISO 7523:1985, *Nickel — Determination of silver, arsenic, bismuth, cadmium, lead, antimony, selenium, tin, tellurium and thallium contents — Electrothermal atomic absorption spectrometric method.*

[3] ISO 7524:1985, *Nickel, ferronickel and nickel alloys — Determination of carbon content — Infra-red absorption method after induction furnace combustion.*

[4] ISO 7525:1985, *Nickel — Determination of sulfur content — Methylene blue molecular absorption spectrometric method after generation of hydrogen sulfide.*

[5] ISO 7526:1985, *Nickel, ferronickel and nickel alloys — Determination of sulfur content — Infra-red absorption method after induction furnace combustion.*

[6] ISO 7527:1985, *Nickel, ferronickel and nickel alloys — Determination of sulfur content — Iodimetric titration method after induction furnace combustion.*

[7] ISO 7528:1989, *Nickel alloys — Determination of iron content — Titrimetric method with potassium dichromate.*

[8] ISO 7529:1989, *Nickel alloys — Determination of chromium content — Potentiometric titration method with ammonium iron(II) sulfate.*

[9] ISO 7530-1:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 1: General requirements and sample dissolution.*

[10] ISO 7530-2:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 2: Determination of cobalt content.*

[11] ISO 7530-3:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 3: Determination of chromium content.*

[12] ISO 7530-4:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 4: Determination of copper content.*

[13] ISO 7530-5:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 5: Determination of iron content.*

[14] ISO 7530-6:1990, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 6: Determination of manganese content.*

[15] ISO 7530-7:1992, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 7: Determination of aluminium content.*

[16] ISO 7530-8:1992, *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 8: Determination of silicon content.*

[17] ISO 7530-9:—[1], *Nickel alloys — Flame atomic absorption spectrometric analysis — Part 9: Determination of vanadium content.*

[18] ISO 9388:1992, *Nickel alloys — Determination of phosphorus content — Molybdenum blue molecular absorption spectrometric method.*

[19] ISO 9389:1989, *Nickel alloys — Determination of cobalt content — Potentiometric titration method with potassium hexacyanoferrate(III).*

1) To be published.