INTERNATIONAL STANDARD

ISO 9725

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Nickel and nickel alloy forgings

Pièces forgées en nickel et alliages de nickel

Reference number
ISO 9725:1992(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 9725 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 forgings

1 Scope

This International Standard specifies requirements for nickel and nickel alloy forgings for general purposes.

NOTE 1 Bars used for the manufacture of forgings should conform to the requirements for bars to be further worked by the purchaser, specified in subclause 5.2 of ISO 9723:1992.

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/TR 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.*

ISO 9723:1992, *Nickel and nickel alloy bars.*

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 forgings in 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: Forgings 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 forgings 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 forgings 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 pieces).

5.3 Alloy identification (see table 1).

NOTE 2 For alloy identification, either the number or the description may be used.

5.4 Alloy temper (see table 2).

5.5 Dimensions and tolerances: marked on the sketch or drawing.

5.6 Specify if purchaser will heat treat the product.

5.7 Optional requirements:

a) samples for product analysis (see 7.1.2);

b) type of test sample (see 7.2);

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

d) hardness as acceptance test (see 6.1.6);

e) individual forging marking (see 10.2);

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

g) declaration of conformity (see clause 12).

6 Requirements

6.1 Requirements for forgings heat treated by the manufacturer

Unless required in the hot-finished temper, forgings shall be supplied in the annealed, solution treated or solution and precipitation treated temper.

Unless otherwise specified, precipitation-hardenable alloy forgings shall be supplied in the solution treated temper.

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 Tensile properties

Forgings shall have the tensile properties specified in table 2.

6.1.3 Heat treatment

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

6.1.4 Grain size

Forgings 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).

6.1.5 Creep or stress rupture properties

Where applicable, forgings of precipitation-hardenable alloys shall meet the creep or stress rupture requirements of table 4.

6.1.6 Hardness

If it is required that qualification and acceptance of forgings be based on hardness instead of tensile properties, the hardness values to be met and the method of hardness test to be used shall be specified on the order form or drawing.

6.1.7 Dimensional tolerances

Dimensions and tolerances shall be as specified on the order form or drawing.

6.1.8 Surface condition

Forgings shall be clean and free from detrimental surface imperfections.

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

6.2 Requirements for forgings to be heat treated by the purchaser

6.2.1 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 %.

6.2.2 Temper

Unless otherwise specified, forgings to be heat treated by the purchaser shall be supplied in the hot-worked temper.

6.2.3 Precipitation-hardenable alloys

The supplier of precipitation-hardenable alloy forgings 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 Dimensional tolerances

Dimensional tolerances shall conform to the requirements specified on the order form or drawing.

6.2.5 Surface condition

Forgings shall be clean and free from detrimental surface imperfections.

NOTE 4 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, creep or stress rupture test

Test specimens shall be taken either as separate test samples (see 7.2.1), as integral test samples (see 7.2.2) or as test samples machined from the body of the forgings.

Unless otherwise specified, the sampling procedure and the location of samples representing the lot shall be at the option of the supplier.

7.2.1 Separate test samples shall be prepared from the same heat from which the forgings are made and forged to obtain samples. Separate test samples shall be identifiable to the forgings they represent.

7.2.2 Integral test samples shall be provided by extensions or prolongations on one or both ends of the forgings; they shall not be separated from the forgings until all heat treatment has been completed.

If the forgings are to be supplied in other than the fully heat-treated condition, the test samples shall be separated from the forgings only if required by the purchaser.

7.2.3 Test samples machined from the body of the forgings shall be taken in the final heat-treated condition.

7.3 Heat treatment of test samples

7.3.1 Forgings supplied in hot-worked temper

If appropriate, test samples selected in accordance with 7.2 shall be annealed or solution and precipitation treated in accordance with table 3 prior to testing.

7.3.2 Forgings supplied in heat-treated temper

Test samples selected in accordance with 7.2 shall be heat treated with the forging they represent.

8 Number of tests

8.1 Chemical analysis, one test per heat.

8.2 Forgings heat treated by the manufacturer

Tensile strength and creep of stress rupture and grain size shall be tested at a frequency of one test per lot.

8.3 Forgings to be heat treated by the purchaser

Capability tests for tensile strength, creep or stress rupture shall be tested at a frequency of 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 Tensile testing shall be carried out in accordance with ISO 6892.

9.2.2 The largest possible round specimen, not exceeding 15 mm in diameter on the gauge length, shall be used. (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 sample in the final heat-treated condition shall be examined in accordance with ASTM E 112, on a section transverse to the greatest metal flow.

9.5 Rounding-off

For the purpose of determining compliance with the specified limits of the properties listed below, an observed value or 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 forging tested, unless that forging 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 shipping container shall be marked with the number of this International Standard, the alloy identification (either the number or the description), heat-treated condition, drawing number, the gross, tare and net weight, the consigner 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 forging with the number of this International Standard, the alloy identification (either the designation or the UNS-Number), 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 forgings 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 forgings were manufactured and tested in accordance with this International Standard. The declaration of conformity shall detail the heat treatment applied to the forgings and/or the test samples and 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
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
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
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

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
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]		Temper	Diameter or thickness mm		Tensile strength R_m, min	0,2 % proof stress $R_{p0,2}$, min	Minimum elongation[2] A_5/A_{50}
Number	Description		over	up to and including	N/mm²	N/mm²	%
NW2200	Ni99,0	Hot worked	All		410	105	35
		Annealed	All		380	105	35
NW2201	Ni99,0-LC	Hot worked	All		340	65	35
		Annealed	All		340	65	35
NW3021	NiCo20Cr15Mo5Al4Ti[3]	Solution treated, stabilized and precipitation treated	All		—[3]	—[3]	—[3]
NW7263	NiCo20Cr20Mo5TiAl[3], [4]	Solution and precipitation treated	All		540[3], [4]	400[3], [4]	12[3], [4]
NW7001	NiCr20Co13Mo4Ti3Al[3]	Solution and precipitation treated	All		1 100[3]	755[3]	15[3]
NW7090	NiCr20Co18Ti3[3]	Solution and precipitation treated	All		[3]	[3]	[3]
NW7750	NiCr15Fe7Ti2Al[3]	Solution and precipitation treated		65	1 170[3]	790[3]	18[3]
			65	100	1 170	790	15
NW6600	NiCr15Fe8	Hot worked	All		590	240	27
		Annealed	All		550	240	30
NW6602	NiCr15Fe8-LC	Annealed	All		550	180	30
NW7718	NiCr19Fe19Nb5Mo3[3]	Solution and precipitation treated		100	1 280[3]	1 030[3]	12[3]
NW6002	NiCr21Fe18Mo9	Annealed	All		660	240	30
NW6601	NiCr23Fe15Al	Annealed	All		550	205	30
NW6455	NiCr16Mo16Ti	Solution treated	All		690	275	35
NW6625	NiCr22Mo9Nb	Annealed		100	830	415	30
			100	250	760	345	25
		Solution treated	All		690	275	30
NW6621	NiCr20Ti	Annealed	All		640	230	30

Alloy identification[1]		Temper	Diameter or thickness mm		Tensile strength R_m, min	0,2 % proof stress $R_{p0,2}$, min	Minimum elongation[2] A_5/A_{50}
Number	Description		over	up to and including	N/mm²	N/mm²	%
NW7080	NiCr20Ti2Al[3]	Solution treated and precipitation treated	All		[3]	[3]	[3]
NW4400	NiCu30	Hot worked and stress relieved	100	300	550	275	27
			300		520	275	27
		Annealed	All		480	170	35
NW4402	NiCu30-LC	Annealed	All		430	160	35
NW5500	NiCu30Al3Ti	Hot worked and precipitation treated		100	970[3]	690[3]	15[3]
			100		830[3]	550[3]	15[3]
		Solution and precipitation treated		25	900	620	20
			25	100	900	585	20
			100	300	830	500	15
NW8825	NiFe30Cr21Mo3	Annealed	All		590	240	30
NW9911	NiFe36Cr12Mo6Ti3[3], [5]	Solution treated, stabilized and precipitation treated	All		960[3], [5]	690[3], [5]	8[3], [5]
NW0276	NiMo16Cr15Fe6W4	Annealed	All		690	280	35
NW0665	NiMo28	Solution treated	7	90	760	350	35
NW0001	NiMo30Fe5	Solution treated	7	40	790	315	30
			40	90	690	315	27

Alloy identification[1]		Temper	Diameter 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	FeNi32Cr21AlTi	Hot worked	All		550	240	25
		Annealed	All		520	205	30
NW8810	FeNi32Cr21AlTi-HC	Annealed	All		450	170	30
NW8811	FeNi32Cr21AlTi-HT	Annealed	All		450	170	30
NW8801	FeNi32Cr20Ti	Annealed	All		450	170	30
NW8020	FeNi35Cr20Cu4Mo2	Annealed	All		550	240	27

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) If forgings of heat-treatable alloys are supplied in the solution-treated temper, the supplier shall demonstrate that forgings will meet the fully heat-treated properties after precipitation treatment in accordance with table 3.

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

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

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 to 610 °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 to 720 °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.

Table 4 — Creep or stress rupture test requirements

Alloy identification[1] Number	Description	Thickness mm	Temperature °C	Stress N/mm²	Minimum time to rupture h	Elongation at rupture on 50 mm %	Duration h	Total plastic strain %
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.

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).*

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