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Nickel and nickel alloy forgings

Pièces forgées en nickel et alliages de nickel

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 155, *Nickel and nickel alloys*.

This second edition cancels and replaces the first edition (ISO 9725:1992), Clause 2 and Table 2 of which have been technically revised.

Nickel and nickel alloy forgings

1 Scope

This document specifies requirements for nickel and nickel alloy forgings for general purposes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 204, *Metallic materials — Uniaxial creep testing in tension — Method of test*

ISO 6372, *Nickel and nickel alloys — Terms and definitions*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6892-2, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature*

ASTM E112, *Standard test methods for determining average grainsize*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6372 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
heat
molten metal poured from a single furnace or molten metal from two or more furnaces poured into a single ladle

3.2
lot
forgings of the same cross-sectional dimensions, from the same *heat* (3.1), heat treated together or sequentially heat treated in a continuous furnace, but in no case for no longer than 16 h of production

Note 1 to entry: For forgings not identified by heat, the lot either consists of one piece or is less than 500 kg.

4 Alloy identification

For the purposes of this document, the principles for alloy identification are given in Annex A.

5 Information to be supplied by the purchaser

The purchaser shall give clear information in the enquiry and order, in particular, on the following:

a) the number of this document, i.e. ISO 9725;

b) quantity (mass or number of pieces) of forgings required;

c) alloy name or alloy number of the material of which the forgings are made (see Table 1);

d) alloy temper (see Table 2);

e) the forgings dimensions or the drawing number(s) containing the dimensions, tolerances on dimensions, shape and surface finish, to which the forgings shall conform;

f) if the purchaser will heat treat the product;

g) optional requirements:

1) samples for the finished product analysis (see 7.1.2);

2) type of test sample for mechanical tests (see 7.2);

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

4) hardness as acceptance test (see 6.1.7);

5) surface condition (see 6.1.9 Note);

6) individual forging marking (see 10.2);

7) purchaser or third party inspection (see Clause 11);

8) declaration of conformity (see Clause 12);

9) any other special requirements, e.g. alloy making process, hot working process and degree of hot working, information on the forging procedure and the calculated forging reduction, greater tolerance to chemical composition, etc.

6 Requirements

6.1 Requirements for forgings heat treated by the manufacturer

6.1.1 General

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.

6.1.2 Composition

The composition shall meet the composition limits specified in Table 1.

The composition limits do not exclude the possible presence of other elements that are not specified. If the purchaser's requirements necessitate limits for 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 %.

6.1.3 Tensile properties

Forgings shall have the tensile properties specified in Table 2.

6.1.4 Heat treatment

Precipitation-hardenable alloy forgings shall be heat treated in accordance to the information given in Table 3 to the condition as ordered.

6.1.5 Grain size

Forgings of alloys NW8810 (FeNi32Cr21AlTi-HC) and NW8811 (FeNi32Cr21AlTi-HT) shall have a grain size ASTM n°5 as coarser (average diameter 0,06 mm maximum).

6.1.6 Creep or stress rupture properties

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

6.1.7 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 hardness test to be used shall be specified on the order or drawing.

6.1.8 Dimensional tolerances

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

6.1.9 Surface condition

Forgings shall be clean and free from detrimental surface imperfections.

NOTE Where appropriate, the acceptance criteria are agreed between the purchaser and the supplier.

6.2 Requirements for forgings to be heat treated by purchaser

6.2.1 Composition

The specifications of 6.1.2 apply.

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 capacity 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

The specifications of 6.1.8 apply.

6.2.5 Surface condition

The specifications of 6.1.9 apply.

7 Sampling

7.1 Chemical analysis

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

7.1.2 For the composition control of the finished product, samples shall be taken from the forging(s).

7.2 Tensile, creep or stress rupture test

7.2.1 Test specimens shall be taken either as separate test samples (see 7.2.2), as integral test samples (see 7.2.3) 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.

7.2.2 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 traceable to the forgings they represent.

7.2.3 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.

7.2.4 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 the information given in Table 3 prior to testing.

7.3.2 Forgings supplied in heat-treated temper

Test samples selected in accordance with 7.2.1 shall be heat treated with the forgings they represent.

8 Number of tests

8.1 Determination of the chemical composition

One analysis per heat.

NOTE For further information on the standardized methods available, see References [1] to [20].

8.2 Forgings heat treated by the manufacturer

Tensile strength, creep or 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

Acceptance tests for tensile strength, creep or stress rupture shall be tested at a frequency of one test per lot.

9 Test procedures

9.1 Determination of the chemical composition

The methods of chemical analysis shall be at the option of the supplier. However, in cases of dispute, the method shall be selected by agreement between the manufacturer and the purchaser.

9.2 Tensile tests

9.2.1 Tensile tests shall be carried out in accordance with ISO 6892-1 or ISO 6892-2 when appropriate.

9.2.2 The largest possible round specimen, not exceeding 15 mm in diameter on the gauge length, shall be used.

9.2.3 The offset method shall be used for the determination of proof stress. An offset of 0,2 % ($R_{p0,2}$) is generally used. 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 tensile

9.3.1 Creep tests shall be carried out in accordance with ISO 204 in order to determine the final total plastic strain.

9.3.2 Stress rupture tests shall also be carried out in accordance with ISO 204.

9.4 Grain size determination

A sample in the final heat-treated condition shall be examined in accordance with ASTM E112, on a section transverse to the greatest metal flow.

9.5 Rounding of results

For the purpose of determining compliance with the specified limits of the properties listed below, results 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.

Depending on the characteristics to be reported, the following rules should be followed:

a) composition, creep stress rupture, grain size, hardness and dimensions: nearest unit to the last right-hand place of figures of the specified limit;

b) tensile strength (R_m): nearest 10 MPa;

c) proof stress ($R_{p0,2}$): nearest 5 MPa;

d) 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 forgings tested, unless these forgings have been removed 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 document. 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 document.

10 Marking

10.1 If agreed between the purchaser and supplier, the supplier shall mark each forging with the number of this document, 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.

10.2 Each shipping container shall be marked with the number of this document, 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.

11 Purchaser or third part inspection

On-site inspection of forgings by the purchaser or any third party shall be in accordance with agreements made between the purchaser and the supplier at the time of enquiry and order.

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 document. 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 document and the order.

Table 1 — Composition and density of wrought nickel and nickel alloys

Alloy identification[a]		Composition % (mass fraction)[b]																Density[c]
Number	Description	Al	B	C	Co[d]	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	Ti	W	Others[e]	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: 0,000 5 Bi: 0,000 1 Pb: 0,001 5	8,4
NW7263	NiCo20Cr20Mo5Ti2Al	0,3 0,6	0,005	0,04 0,08	19,0	19,0 21,0	0,2	0,7	0,6	5,6 6,1	Remainder		0,007	0,4	1,9 2,4		Ag: 0,000 5 Bi: 0,000 1 Pb: 0,002 0 Ti + Al: 2,4 to 2,8	8,4
NW7001	NiCr20Co13Mo4Ti3Al	1,2 1,6	0,003 0,010	0,02 0,10	21,0	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: 0,000 5 Bi: 0,000 05 Pb: 0,001 0 Zr: 0,02 to 0,08	8,4
NW7090	NiCr20Co18Ti3	1,0 2,0	0,020	0,13	12,0 15,0	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	15,0 21,0	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		0,15	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

Table 1 *(continued)*

Alloy identification[a]		Composition % (mass fraction)[b]																Density[c]
Number	Description	Al	B	C	Co[d]	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	Ti	W	Others[e]	g/cm³
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	3,0	1,0		Remainder		0,020	1,0	0,20 0,60		Pb: 0,005 0	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: 0,000 5 Bi: 0,000 1 Pb: 0,002 0	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		37,0 34,0		2,0	1,5		Remainder	0,020	0,015	0,5	0,35 0,85			8,5
NW8825	NiCu30Cr21Mo3	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

Table 1 *(continued)*

Alloy identification[a]		Composition % (mass fraction)[b]															Density[c]
Number	**Description**	**Al**	**B**	**C**	**Co[d]**	**Cr**	**Cu**	**Fe**	**Mn**	**Mo**	**Ni**	**P**	**S**	**Si**	**Ti**	**W**	**Others[e]**	g/cm³
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 × C to 1,0	8,1

[a] For alloy identification, either the number or the description may be used.

[b] Single values are maximum limits, except for nickel where single values are minimum.

[c] Density values are average values and are given for information only.

[d] 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.

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

Table 2 — Tensile properties

Alloy identification[a]		Temper	Diameter or thickness mm		Tensile strength R_m, min	0,2 % proof stress $R_{p0,2}$, min	Minimum elongation[b] A_5/A_{50}
Number	Description		Over	Up to and including	MPa	MPa	%
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[c]	Solution treated, stabilized and precipitation treated	All		—[c]	—[c]	—[c]
NW7263	NiCo20Cr20Mo5AlTi[c,d]	Solution and precipitation treated	All		540[c,d]	400[c,d]	12[c,d]
NW7001	NiCr20Co13Mo4Ti3Al[c]	Solution and precipitation treated	All		1100[c]	755[c]	15[c]
NW7090	NiCr20Co18Ti3[c]	Solution and precipitation treated	All		[c]	[c]	[c]
NW7750	NiCr15Fe7Ti2Al[c]	Solution and precipitation treated		65	1170[c]	790[c]	18[c]
			65	100	1170	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[c]	Solution and precipitation treated		100	1280[c]	1030[c]	12[c]
NW6002	NiCr21Fe18Mo9	Annealed	All		660	240	30
NW6601	NiCr23Fe15Al	Annealed	All		550	205	30
NW6455	NiCr16Mo16Ti	Solution treated	All		690	275	35
NW6625	NiCr22Mo9N[b]	Annealed		100	830	415	30
			100	250	760	345	25
		Solution treated	All		690	275	30
NW6621	NiCr20Ti	Annealed		75	640	230	30
			75		580	210	23
NW7080	NiCr20Ti2Al[c]	Solution treated and precipitation treated	All		[c]	[c]	[c]
NW4400	NuCu30	Hot worked and stress relieved	100	300	550	275	27
			300		520	275	27
		Annealed	All		480	170	35

Table 2 *(continued)*

Alloy identification[a]		Temper	Diameter or thickness mm		Tensile strength R_m, min	0,2 % proof stress $R_{p0,2}$, min	Minimum elongation[b] A_5/A_{50}
Number	Description		Over	Up to and including	MPa	MPa	%
NW4402	NiCu30-LC	Annealed	All		430	160	35
NW5500	NiCu30Al3Ti	Hot worked and precipitation treated		100	970[c]	690[c]	15[c]
			100		830	550	15
		Solution and precipitation treated		25	900	620	20
			25	100	900	585	20
			100	300	830	500	15
NW8825	NiFe30Cr21Mo3	Annealed		50	590	240	30
			50		590	200	30
NW9911	NiFe36Cr12Mo6Ti3[c,e]	Solution treated, stabilized and precipitation treated	All		960[c,e]	690[c,e]	8[c,e]
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
NW8800	FeNi32Cr21AlTi	Hot worked		50	550	240	25
			50		500	170	25
		Annealed		50	520	205	30
			50		480	160	30
NW8810	FeNi32Cr21AlTi-HC	Annealed	All		450	170	30
NW8811	FeNi32Cr21AlTi-HT	Annealed	All		450	170	30

Table 2 *(continued)*

Alloy identification[a]		Temper	Diameter or thickness mm		Tensile strength R_m, min	0,2 % proof stress $R_{p0,2}$, min	Minimum elongation[b] A_5/A_{50}
Number	**Description**		**Over**	**Up to and including**	MPa	MPa	%
NW8801	FeNi32Cr20Ti	Annealed	All		450	170	30
NW8020	FeNi35Cr20Cu4Mo2	Annealed	All		550	240	27

[a] For alloy identification, either the number or the description may be used.

[b] 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}.

[c] 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 the information given in Table 3.

[d] For alloy NW7263/NiCo20Cr20Mo5Ti2Al, the tensile test shall be carried out at 780 °C.

[e] For alloy NW 9911/NiFe36Cr21Mo6Ti3, the tensile test shall be carried out at 575 °C.

Table 3 — Heat treatment of precipitation-hardenable alloys

Alloy identification[a]		Solution or annealed treatment[b]	Stabilizing and/or precipitation treatment
Number	Description		
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, air cool	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 to 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, holt at 620 °C for 8 h, air cool. Alternatively, cool to 620 °C at any speed and holt at 620 °C to give a total precipitation treatment time to 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

[a] For alloy identification, either the number or the description may be used.

[b] The tolerance on the selected temperature shall be within ±15 °C.

Table 4 — Creep or stress rupture test requirements

Alloy identification[a]		Thickness	Temperature	Stress	Minimum time to rupture	Elongation at rupture on 50 mm	Duration	Total plastic strain
Number	Description	mm	°C	MPa	h	%	h	%
NW3021	NiCo20Cr-15Mo5Al4Ti	All	815	360[b]	30	—	—	—
NW7263	NiCo20Cr-20Mo5Ti2Al	All	780	120	—	—	50	0,10
NW7001	NiCr20Co-13Mo4Ti3Al	All	730	550[b]	23	5	—	—
NW7090	NiCr20CO18Ti3	All	870	140[b]	30	—	—	—
NW7718	NiCr19Fe19N-b5Mo3	Max 100	650	690[b]	23	5	—	—
NW7080	NiCr20Ti2Al	All	750	340[b]	30	—	—	—
NW9911	NiFe36Cr-12Mo6Ti3	All	575	590	—	—	100	0,10

[a] For alloy identification, either the number or the description may be used.

[b] 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 shall be met. Alternatively, stress may be increased after the minimum time to rupture has been met at the specified stress; however, the specified minimum elongation shall be met.

Annex A
(normative)

Rules for nickel and nickel alloys identification based on chemical symbols

A.1 Basis of identification

The identification of nickel and its alloys is based on the chemical composition limits.

All identifications shall have the prefix "ISO". This prefix may be omitted for brevity in International Standards and also in correspondence where it is obvious that ISO identifications are used.

Chemical symbols shall be used for the identification of the base element and the major alloying elements, followed by numbers indicating the metal grade or indicating the nominal alloying elements content.

A.2 Identification of unalloyed nickel

The identification of unalloyed nickel consists of the chemical symbol of nickel (Ni), followed by its percentage purity, expressed to one, two or more decimal places as required.

A.3 Identification of alloys

The identification for nickel alloys consists of the chemical symbols of the base element (Ni) and the alloying elements, following by integer indicating their amounts, if these elements are present in nominal amounts of about 1 % or more.

The alloying elements are listed according to the nominal alloying elements contents specified. The alloying elements are listed in decreasing order of percentage by mass (e.g. NiCr15Fe8) or, if of equal percentage, in alphabetical order of the chemical symbols (e.g. NiCo20Cr20Mo5Ti2Al).

Due to similar composition limits, wrought and cast alloys may have the same identification. Therefore, cast alloys are identified by the prefix "C-".

If varieties of an alloy are specified, these varieties are designated by a suffix added to the base identification. The following suffixes are defined:

"-LC" in the case of low carbon contents;

"-MC" in the case of medium carbon contents;

"-HC" in the case of high carbon contents;

"-HT" in the case of an application at a high temperature.

EXAMPLE Ni99,0 and Ni99,0-LC.

In a case where more than two alloying elements are present, it is not necessary to list all of the minor constituents in the identification, except where they are essential for the proper identification of the alloy.

In all cases where two or more alloys have the same composition and differ only in the limits of an impurity, the symbol of this trace element is followed by the highest amount that should be added to the identification in brackets.