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Nickel and nickel alloy forgings

Pièces forgées en nickel et alliages de nickel

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Foreword

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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).

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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