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Nickel and nickel alloy castings

Pièces moulées 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).

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For an explanation of 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 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 12725:1997) which has been technically revised. The main changes compared with the previous edition are as follows:

— the normative references have been updated;

— Clause 5, “General requirements for delivery”, has been added.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Nickel and nickel alloy castings

1 Scope

This document specifies requirements for nickel and nickel alloy castings.

The grades specified represent types of alloys suitable for a broad range of application in a wide variety of corrosive and high temperature environments.

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

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

3 Terms and definitions

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

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

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

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

4 Alloy identification

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

5 General requirements for delivery

5.1 Information to be supplied by the purchaser

The enquiry and order should include the following information.

a) A description of the casting(s) by pattern number and/or drawing. When a pattern is supplied, a complete list of the pattern equipment should be included. When a drawing is not supplied, the casting is purchased on the basis of the pattern. In this case, the foundry shall not be responsible for the dimensions of the part.

NOTE Machining allowances, dimensional tolerances, and geometrical tolerances can be selected from ISO 8062-3.

All modifications to be made to the drawing, for the technical requirements of the manufacturer, shall be agreed between the manufacturer and the purchaser.

b) The material standard, delivery condition and grade.

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5.2 Additional information to be supplied

Where appropriate, the enquiry and order should include additional information, for example:

a) any supplementary requirements in accordance with Annex B;

b) the non-destructive testing procedures to be used, the extent of the non-destructive testing and the acceptance criteria;

c) the type of inspection document to be provided at the time of supply;

d) the size of a test lot, (see B.2.2);

e) the procedures for marking (in accordance with Clause 8), machining, protection, packaging, loading, dispatching and the destination;

f) the submission of sample castings for approval before production quantities are produced;

g) the methods of statistical control to be used.

6 Manufacture

6.1 Melting

Nickel and nickel alloys shall be melted by the electric furnace process with or without separate refining, such as argon-oxygen decarburization (AOD) or by the vacuum induction melting process.

6.2 Heat treatment

Castings shall be heat treated in accordance with the procedures given in Table 1.

6.3 Welding

6.3.1 General

Selection of welding material, which shall be compatible with the casting composition, is generally left to the discretion of the manufacturer. However, as a supplementary requirement, selection of weld material may be agreed between the manufacturer and the purchaser.

NOTE ISO 11970 gives terms and definitions used for welding purposes for steel castings.

6.3.2 Restriction

Castings made from grades NC2000 and NC4030 shall not be welded.

7 Requirements

7.1 Composition

Materials shall conform to the chemical composition requirements given in Table 2.

The methods of determination of the chemical composition shall be at the discretion of the manufacturer. However, in cases of dispute, the method specified in an appropriate document shall be used. If no International Standard exists, an analytical method appropriately validated and acceptable by the purchaser shall be used.

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Table 1 — Heat treatment for nickel and nickel alloy castings

Alloy identification[a]		Heat treatment
Number	Description	
NC2100	C-Ni99, -HC	As cast.
NC4020	C-NiCu30Si	As cast.
NC4135	C-NiCu30	As cast.
NC4030	C-NiCu30Si3	As cast.
NC4130	C-NiCu30Nb2Si2	As cast.
NC0012	C-NiMo31	Heat to 1 095 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC0007	C-NiMo30Fe5	Heat to 1 095 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC6985	C-NiCr22Fe20Mo7Cu2	Heat to 1 095 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC6625	C-NiCr22Mo9Nb4	Heat to 1 175 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC6455	C-NiCr16Mo16	Heat to 1 175 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC0002	C-NiMo17Cr16Fe6W4	Heat to 1 175 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC6022	C-NiCr21Mo14Fe4W3	Heat to 1 205 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC0107	C-NiCr18Mo18	Heat to 1 175 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC6040	C-NiCr15Fe	Class 1: As-cast. Class 2: Heat to 1 040 °C minimum, hold for sufficient time to bring castings to temperature and quench in water or rapid cool by other means.
NC8826	C-NiFe30Cr20Mo3CuNb	Heat to 930 °C to 980 °C, hold for sufficient time to bring castings to temperature and allow to air cool.
NC2000	C-NiSi9Cu3	Heat to 970 °C to 1 000 °C, hold for sufficient time to bring castings to temperature and allow to air cool.

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

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Table 2 — Chemical composition of nickel and nickel alloy castings

Alloy identification[a]		Percentage in mass[b]												
Number	Description	C	Co	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	W	Others
NC2100	C-Ni99, -HC	1,00	—	—	1,25	3,0	1,50	—	95,0	0,030	0,030	2,00	—	—
NC4020	C-NiCu30Si	0,35	—	—	26,0 to 33,0	3,5	1,50	—	Balance	0,030	0,030	2,00	—	Nb: 0,5
NC4135	C-NiCu30	0,35	—	—	26,0 to 33,0	3,5	1,50	—	Balance	0,030	0,030	1,25	—	Nb: 0,5
NC4030	C-NiCu30Si3	0,30	—	—	27,0 to 33,0	3,5	1,50	—	Balance	0,030	0,030	2,7 to 3,7	—	—
NC4130	C-NiCu30Nb2Si2	0,30	—	—	26,0 to 33,0	3,5	1,50	—	Balance	0,030	0,030	1,0 to 2,0	—	Nb: 1,0 to 3,0
NC0012	C-NiMo31	0,03	—	1,0	—	3,0	1,00	30,0 to 33,0	Balance	0,030	0,030	1,00	—	—
NC0007	C-NiMo30Fe5	0,05	—	1,0	—	4,0 to 6,0	1,00	26,0 to 33,0	Balance	0,030	0,030	1,00	—	V: 0,20 to 0,60
NC6985	C-NiCr22Fe20Mo7Cu2	0,02	5,0	21,5 to 23,5	1,5 to 2,5	18,0 to 21,0	1,00	6,0 to 8,0	Balance	0,025	0,030	1,00	1,50	Nb + Ta: 0,5
NC6625	C-NiCr22Mo9Nb4	0,60	—	20,0 to 23,0	—	5,0	1,00	8,0 to 10,0	Balance	0,030	0,030	1,00	—	Nb: 3,2 to 4,5
NC6455	C-NiCr16Mo16	0,02	—	15,0 to 17,5	—	2,0	1,00	15,0 to 17,5	Balance	0,030	0,030	0,80	1,00	—
NC0002	C-NiMo17Cr16Fe6W4	0,06	—	15,5 to 17,5	—	4,5 to 7,5	1,00	16,0 to 18,0	Balance	0,030	0,030	1,00	3,8 to 5,3	V: 0,20 to 0,40
NC6022	C-NiCr21Mo14Fe4W3	0,02	—	20,0 to 22,5	—	2,0 to 6,0	1,00	12,5 to 14,5	Balance	0,025	0,025	0,80	2,5 to 3,5	V: 0,35
NC0107	C-NiCr18Mo18	0,03	—	17,0 to 20,0	—	3,0	1,00	17,0 to 20,0	Balance	0,030	0,030	1,00	—	—
NC6040	C-NiCr15Fe	0,40	—	14,0 to 17,0	—	11,0	1,50	—	Balance	0,030	0,030	3,00	—	—
NC8826	C-NiFe30Cr20Mo-3CuNb	0,05	—	19,5 to 23,5	1,5 to 3,0	28,0 to 32,0	1,00	2,5 to 3,5	Balance	0,030	0,030	0,75 to 1,20	—	Nb: 0,70 to 1,00
NC2000	C-NiSi9Cu3	0,12	—	1,0	2,0 to 4,0	—	1,50	—	Balance	0,030	0,030	8,5 to 10,0	—	—

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

[b] Single values are maximum limits, except in the case of nickel for which single values are minimum.

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7.2 Mechanical properties

Materials shall be tested in accordance with ISO 6892-1 and shall conform to the mechanical property requirements given in Table 3.

Mechanical properties shall be measured on test pieces taken from test blocks. The test blocks may be cast separately, attached to the castings or cast integrally on the castings. When more than one ladle is used, the test block shall be cast integrally. The test blocks shall be produced from the same cast (heat) of nickel alloy and shall be heat treated in the production furnaces to the same procedure as the casting(s) they represent.

Unless otherwise specified, the test blocks shall be 28 mm minimum and the test pieces used for the mechanical tests shall be taken from test blocks with their axes at least 7 mm from the surface.

Table 3 — Mechanical properties of nickel and nickel alloy castings

Alloy identification[a]		Tensile strength	0,2 % proof stress	Elongation
Number	Description	R_m MPa	$R_{p0,2}$ min. MPa	$A_{5,\,min.}/A_{50,\,min.}$ %
NC2100	C-Ni99, -HC	345 to 545	125	10
NC4020	C-NiCu30Si	450 to 650	205	25
NC4135	C-NiCu30	450	170	25
NC4030	C-NiCu30Si3	690 to 890	415	10
NC4130	C-NiCu30Nb2Si2	450	225	25
NC0012	C-NiMo31	525 to 725	275	6
NC0007	C-NiMo30Fe5	525 to 725	275	20
NC6985	C-NiCr22Fe20Mo7Cu2	550 to 750	220	30
NC6625	C-NiCr22Mo9Nb4	485 to 685	275	25
NC6455	C-NiCr16Mo16	495 to 695	275	20
NC0002	C-NiMo17Cr16Fe6W4	495 to 695	275	4
NC6022	C-NiCr21Mo14Fe4W3	550	280	30
NC0107	C-NiCr18Mo18	495 to 695	275	25
NC6040	C-NiCr15Fe	485 to 685	195	30
NC8826	C-NiFe30Cr20Mo3CuNb	450 to 650	170	25
NC2000	C-NiSi9Cu3	—	—	—

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

[b] 300 HBW minimum.

7.3 Supplementary requirements

7.3.1 Supplementary requirements shall apply only when specified in the inquiry or purchase order and agreed upon by the manufacturer.

7.3.2 A list of supplementary requirements for use at the option of the purchaser is given in Annex B.

7.3.3 Other supplementary requirements may be specified in the inquiry and purchase order, such as, but not limited to, welding production procedures.

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8 Marking

By agreement between the manufacturer and the purchaser, each casting shall be marked. Unless specified by the purchaser, the locations of the markings shall be at the discretion of the manufacturer. The marks may include the following:

a) the symbol of the manufacturer;

b) the test lot identification;

c) the grade designation (name or number) of the cast;

d) other marks requested by the purchaser.

These marks shall be located at a place agreed upon by the manufacturer and the purchaser.

By agreement between the manufacturer and the purchaser, small castings may be batched and the identifying marks applied to a label attached to each batch.

9 Supplementary requirements

Other requirements may be specified upon agreement between the manufacturer and the purchaser.

The supplementary requirements shall only apply when agreed upon by the manufacturer and the purchaser as specified on the enquiry and purchase order.

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Annex A
(informative)

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 alloy 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 of 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 alloy 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 a low carbon content;

— "-MC" in the case of a medium carbon content;

— "-HC" in the case of a high carbon content;

— "-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 the impurity element which is allowed is the highest amount that should be added to the identification in brackets.

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When a range is specified for an alloying element, the rounded off mean is used in the identification. When the mean of the range is halfway between two numbers, it should be rounded off the nearest integer.

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Annex B
(informative)

Supplementary requirements

B.1 General

One or more of the following supplementary requirements may be applied when specified in the order. Details of these supplementary requirements shall be as agreed upon by the manufacturer and the purchaser at the time of enquiry and order. The specified tests shall be carried out before delivery of the castings.

B.2 Manufacturing considerations

B.2.1 Manufacture process

The manufacture process shall be reported to the purchaser.

B.2.2 Mass of test lots

The mass of the test lot may be specified from one of the following:

a) up to 500 kg;

b) up to 1 000 kg;

c) up to 5 000 kg.

Other methods for making up the test lots for testing by statistical means may be used. Such alternative methods shall be specified in the enquiry and order.

B.2.3 Mass and tolerance on mass

If applicable, mass and tolerance on mass shall be agreed upon at the time of the enquiry and order.

B.3 Determination of the content of residual elements

The determination of the content of residual elements not listed in the specification shall be agreed upon between the manufacturer and the purchaser.

B.4 Heat treatment

B.4.1 Type of heat treatment

The type of heat treatment applied to the castings shall be reported to the purchaser.

B.4.2 Details of the treatment

When agreed upon between the manufacturer and the purchaser in the enquiry and the order, the time/temperature cycle of the applied heat treatment shall be reported to the purchaser.

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B.5 Production welds

B.5.1 Prior agreement relating to major production welds

Unless otherwise agreed upon, production welds shall be considered major when the depth of the cavity prepared for welding exceeds 40 % of the wall thickness or 25 mm, whichever is smaller.

Major production welds are subject to prior approval of the purchaser, by agreement in the enquiry or the order.

B.5.2 Weld maps (sketches)

Major production welds shall be documented on drawings or photographs showing the location and extent of the weld. Documentation shall be submitted to the purchaser at the completion of the order.

B.6 Non-destructive tests

B.6.1 Liquid penetrant testing

The castings shall be examined by liquid penetrant testing in order to detect any surface discontinuities.

The examination shall be carried out by normal agreed procedures or, in case of dispute, by appropriate national standards.

The area(s) to be examined and the levels of acceptance shall be agreed upon between the manufacturer and the purchaser.

B.6.2 Radiographic testing

The castings shall be examined by radiography in order to detect internal discontinuities.

The examination shall be carried out by normal agreed procedures or, in case of dispute, by appropriate national standards.

The extent of the examination and the levels of acceptance shall be agreed upon between the manufacturer and the purchaser.

B.7 Intergranular corrosion tests

The criteria for acceptance shall be agreed upon between the manufacturer and the purchaser at the time of the enquiry and the order.

The test shall be carried by normal agreed procedures or, in case of dispute, by appropriate national standards.

B.8 Pressure tightness

Castings shall be tested with the specified fluid at the specified pressure and for the time indicated.

The castings submitted to the test shall not be oxidized and shall not receive any coating, covering or impregnation before the tests.

In the case of pressure vessel castings, reference shall be made to the test conditions indicated in the test standards for these vessels.

The manufacturer is responsible for the satisfactory performance of the castings under the pressure tightness test. It is realized that the foundry might be unable to perform the test prior to shipment or

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