International Standard 4990

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Steel castings — General technical delivery requirements

Pièces en acier moulées — Conditions générales techniques de livraison

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Steel castings — General technical delivery requirements

1 Scope and field of application

1.1 This International Standard specifies the general technical delivery requirements for the supply of steel castings, including the requirements for the selection and preparation of samples and test pieces.

1.2 When material or product standards differ from this general delivery specification, the material or product standards apply. In special cases, variations from these conditions may be agreed upon at the time of order.

1.3 This International Standard also specifies a group of supplementary requirements which may be applied to steel castings. These requirements are provided for use when additional testing or inspection is desired and apply only when individually specified by the purchaser.

2 References

ISO 148, *Steel — Charpy impact test (V-notch).*

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test.*

ISO 2605/1, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part 1 : Yield or proof stress of carbon and low alloy steel products.*

ISO 2605/2, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part 2 : Proof stress of austenitic steel products.*

ISO 3452, *Non-destructive testing — Penetrant inspection — General principles.*

ISO 3651/2, *Austenitic stainless steels — Determination of resistance to intergranular corrosion — Part 2 : Corrosion test in a sulphuric acid/copper sulphate medium in the presence of copper turnings (Monypenny Strauss test).*

ISO 5579, *Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules.*

ISO 6506, *Metallic materials — Hardness test — Brinell test.*

ISO 6892, *Metallic materials — Tensile testing.*

ISO 8062, *Castings — System of dimensional tolerances.*

3 Definitions

3.1 non-specific inspection and testing : Inspection and testing carried out by the manufacturer in accordance with his own procedures, on test blocks or castings made by the same manufacturing process, but not necessarily on the test blocks or castings actually supplied.

3.2 specific inspection and testing : Inspection and testing carried out on the test lot to be supplied, in order to verify whether these products comply with the requirements of the order.

3.3 statement of compliance with the order; SC : Document in which the manufacturer states that the products sup-

plied are in compliance with the requirements of the order, without mention of any test result.

3.4 test report; TR : Document in which the manufacturer states that the products supplied are in compliance with the requirements of the order and in which he supplies the results of the routine works inspection tests, carried out on test blocks or castings made by the same manufacturing process as the consignment, but not, therefore, necessarily applying to the actual products supplied.

3.5 inspection certificate; IC : Certificate containing the results of all the tests specified.

By agreement when ordering, the inspection and testing procedures may be carried out, at the discretion of the purchaser :

a) by the qualified department (see the note) of the manufacturer's works (IC);

b) in the presence of the purchaser or a body designated by him (ICP).

The inspection certificate is signed in case a) by the representative of the qualified department, and in case b) by the purchaser or the representative of the designated body.

In certain special cases, by agreement when ordering, the inspection and testing procedures may also be carried out by a body independent of the purchaser and the manufacturer, the tests being carried out outside the production works. In that case, the inspection certificate shall be signed by the representative of that body.

NOTE — **qualified department** : An inspection and testing department different from the production department.

In certain cases, this department may be subject to approval by the purchaser.

3.6 inspection report; IR : Where the inspection certificate specified in case b) of 3.5 shall, by agreement, be signed by the manufacturer and purchaser of his representative, it is known as the inspection report.

4 Information to be supplied by the purchaser

4.1 The enquiry and order shall include the particulars given in 4.1.1 to 4.1.3.

4.1.1 A description of the casting(s) by pattern number and/or drawing. When a pattern is supplied, a description of the pattern equipment shall be included. When no drawing is supplied the casting is purchased on the basis of as per pattern. In that case the foundry shall not be responsible for the dimensions of the part.

Dimensional tolerances including machining allowances and the datum points for machining and measuring shall be noted on the drawing.

All modifications to be made to the drawing, or patterns, for the technical requirements of the manufacturer, shall form the subject of an agreement between the manufacturer and the purchaser.

4.1.2 The material standard and grade of steel.

4.1.3 The type of document (see table 1 and clause 6).

4.2 Where appropriate, the enquiry and order shall include additional information, for example that listed in 4.2.1 to 4.2.6.

4.2.1 Indication of any supplementary requirements in accordance with clause 9.

4.2.2 Size of a test lot (see 6.2.2.1).

4.2.3 Procedures for marking, in accordance with clause 7 and 9.2.1, machining, protection, packaging, loading, dispatching and the destination.

4.2.4 The submission, when appropriate, of sample castings for approval before production quantities are produced. (See 5.3.)

4.2.5 Methods of statistical control to be used (if any).

4.2.6 Other options in the specification.

4.3 Inspection procedures shall conform to the annex, including the place of inspection for the purchaser, if the inspection cannot be performed at the manufacturer's works.

5 Conditions of manufacture

5.1 Steelmaking

Unless otherwise specified, the steelmaking process is left to the discretion of the manufacturer. (See 9.1.1, 9.1.2, 9.1.3 and 9.1.4.)

5.2 Foundry practice — Heat treatment

Unless otherwise agreed at the time of enquiry and order or specified in the material standard, the selection of the method of casting, moulding, heat treatment, etc., is left to the discretion of the manufacturer. (See 9.5, 9.7.1, 9.7.2 and 9.7.3.)

5.3 Cleaning and dressing

All the castings shall be cleaned and dressed sufficiently to determine compliance with the requirements of 6.2.3.1. Additional dressing may be agreed to at the time of enquiry and order.

5.4 Welding

Unless specified to the contrary at the time of the enquiry and order, the castings may be repair welded without the previous approval of the purchaser. Repair welding is understood to be welding operations which are carried out by the manufacturer within the manufacturing process in order to comply with the quality requirements for the casting. A weld procedure approval test may be defined by agreement between the parties. Restrictive clauses may be specified in the material standards. The repair welding shall be carried out according to the agreed procedure.

For major repair welds, see 9.8.1 and 9.8.2.

6 Inspection, testing and requirements

6.1 Non-specific inspection

Castings and/or the procedures shall be examined in accordance with the requirements of a suitable inspection, arranged by the manufacturer, and drawn up to ensure that the specified requirements are complied with. Written reports of the inspections are not normally supplied.

At the request of the purchaser at the time of enquiry and ordering, the manufacturer shall supply a statement of compliance or a test report (see table 1) on the basis of these non-specific inspections or tests. (See also 9.2.1.)

6.2 Specific inspection

6.2.1 Documents

If one of the documents for specific inspection and testing (see table 1) is ordered, the inspections and tests are to be carried out in accordance with the annex, 6.2.2, 6.2.3 and clause 7. (See also 9.2.1.)

6.2.2 Sampling, preparation of test pieces and mechanical and chemical test methods and requirements

6.2.2.1 Formation of test lots

The method of forming test lots shall be stated in the order. The size of the test lot may be defined in terms of mass or number of castings. For example it may be done as follows :

a) by cast : the products are of the same type. They come from the same cast and, where necessary, have undergone the same heat treatment in the same furnace;

b) by batch : the products may come from casts of the same grade and/or from heat treatments having the same cycles, which may or may not be identified; in this case, the batch is limited to a number of castings or to a tonnage fixed between the parties concerned and constituting the unit of acceptance.

c) by piece : for certain products where made necessary by technical requirements;

d) by supplementary agreement (see 9.1.5).

6.2.2.2 Test blocks

Unless otherwise specified, the test blocks whether cast separately or attached to the castings shall be produced from the same cast of steel and shall be heat treated in the production furnaces in the same manner as the casting they represent.

Unless otherwise specified at the time of enquiry and order (see 9.6.1), the ruling thickness of the block shall be 28 mm and the test pieces used for mechanical tests shall be taken from test blocks with their axes approximately 14 mm from the surface.

The mechanical properties required are obtained from test blocks, cast either separately from, or attached to, the castings

Table 1 — Type of document required for various types of inspection and testing

Type of inspection and testing	Type of document	Symbol
Non-specific inspection and testing	No document or Statement of compliance or Test report	— SC TR
Specific inspection and testing carried out by the qualified department[1] of the manufacturer's factory	Inspection certificate signed by the representative of the qualified department of the works	IC
Specific inspection and testing carried out in the presence of the purchaser or of a body named by him	Inspection certificate signed by the purchaser or the representative of the body named by him, or Inspection report signed by the manufacturer and the purchaser or his representative	ICP IR
Specific inspection and testing carried out by an independent body, the tests being carried out outside the production works	Inspection certificate signed by the independent body	ICP
Continuous inspection	By agreement between the interested parties	—

1) See the note to 3.5.

they represent. The test results represent the quality of steel from which the castings have been poured; they do not necessarily represent the properties of the castings themselves, which may be affected by solidification conditions and rate of cooling during heat treatment, which in turn are influenced by casting thickness, size and shape.

6.2.2.3 Mechanical tests

When required by the specification, the mechanical tests specified in 6.2.2.3.1 and 6.2.2.3.2 shall be performed.

6.2.2.3.1 Tensile tests at ambient temperature

One tensile test shall be carried out per test lot (see 6.2.2.1). The shape and the dimensions of the test piece, as well as the method, shall comply with ISO 6892. The test results shall comply with the specification for the grade of steel in question. (See 9.2.1, 9.4.1, 9.4.2, 9.4.3 and 9.5.)

6.2.2.3.2 Impact test

When this test is specified, the absorbed energy values, in joules, are determined using three Charpy test pieces with V-notches at the temperature shown in the specification. The test pieces shall be prepared and tested in accordance with 6.2.2.2. The average value of absorbed energy from the three test pieces shall not be less than the value indicated in the material specification for the grade specified; one value may be below that specified value, provided that it is no less than two-thirds of the minimum specified average. (See 9.2.1 and 9.4.4.)

6.2.2.4 Re-tests

Except as provided in clause A.4, when the results of the mechanical test do not comply with the requirements of the material standard, the manufacturer may, unless otherwise agreed upon at the time of enquiry and order, adopt one of the procedures specified in 6.2.2.4.1 to 6.2.2.4.3.

6.2.2.4.1 Repeat the mechanical test (including the intergranular corrosion test when required) which failed, on two additional test pieces. If any of the two new test pieces do not give satisfactory results, the manufacturer may then follow the procedure specified in 6.2.2.4.3.

6.2.2.4.2 In the case of impact tests, if the average value obtained from three tests does not reach the specified value, or if one of the individual values does not reach the specified minimum, the manufacturer may test three additional test pieces selected from the same test block or from another block from the same cast and heat treated test lot to represent the castings in question, and add these results to the results previously obtained, then recalculate the average. If this new average satisfies the average value specified, the material represented may be considered to satisfy the requirements of the material standard. Where the new average value or one of these new individual values does not satisfy the specified requirements, the manufacturer may then follow the procedure specified in 6.2.2.4.3.

6.2.2.4.3 Submit the castings and test blocks to a new heat treatment within the limits of the material standard, and then carry out all the mechanical tests required in the material standard on the test blocks, (as well as the intergranular corrosion test if specified). In no case shall the castings and test bars be submitted to more than two additional heat treatments (excluding tempering), without consulting the purchaser.

6.2.2.5 Chemical composition

6.2.2.5.1 Cast analysis

Samples for chemical analysis shall be obtained either from the test block or, more generally, from the cast. The sample shall be sufficient to allow three determinations.

In the case of disagreement about the results, only those obtained by wet chemical analysis shall apply. Wet chemical analysis shall be made on chips taken at least 6 mm below the surface of the rough cast.

The chemical composition determined from the cast analysis shall meet the requirement of the specification relating to the grade in question.

6.2.2.6 Check and product analysis

6.2.2.6.1 Check analysis

A check analysis may be made by the customer on test blocks or test pieces which represent each cast, batch or casting. The number of samples shall be agreed between the parties. Chips taken shall be at least 6 mm below the cast surface. Table 2 gives the permissible deviations of the check analysis in relation to the specified cast analysis.

Table 2 — Permissible deviations of the check analysis with respect to the specified cast analysis

a) non-alloyed and low alloyed steels

Element	Range [% (*m*/*m*)]	Tolerances
Carbon	Up to and including 0,30	± 0,03
Silicon	Up to and including 0,50	± 0,05
Manganese	Up to and including 1,40	± 0,06
Sulfur and Phosphorus	Less than 0,035	± 0,005
Chromium	Up to and including 2,00 Over 2,00 and up to and including 6,00	± 0,05 ± 0,10
Molybdenum	Up to and including 0,35 Over 0,35 and up to and including 1,5	— ± 0,05
Vanadium	Less than 0,35	± 0,03
Nickel	Up to and including 1,0 Over 1,0 and up to and including 2,0 Over 2,0 and up to and including 5,0	± 0,03 ± 0,05 ± 0,07

b) high alloyed steels

Element	Range [% (m/m)]	Tolerances
Carbon	Up to and including 0,03	± 0,005
	Over 0,03 and up to and including 0,06	± 0,01
Manganese	Over 0,50 and up to and including 0,70	± 0,03
	Over 0,70 and up to and including 1,00	± 0,04
	Over 1,00 and up to and including 2,00	± 0,05
Silicon	Up to and including 1,20	± 0,05
Sulfur and Phosphorus	Up to and including 0,050	± 0,005
Chromium	Up to and including 10,0	± 0,10
	Over 10,0 and up to and including 15,0	± 0,15
	Over 15,0 and up to and including 20,0	± 0,20
Molybdenum	Up to and including 1,0	± 0,04
	Over 1,0 and up to and including 2,0	± 0,05
	Over 2,0 and up to and including 3,0	± 0,08
Nickel	Up to and including 1,0	± 0,03
	Over 1,0 and up to and including 2,0	± 0,05
	Over 2,0 and up to and including 5,0	± 0,07
	Over 5,0 and up to and including 10,0	± 0,10
	Over 10,0 and up to and including 20,0	± 0,15
	Over 20,0	± 0,20
Niobium	Any range	± 0,05
Vanadium	Up to and including 0,35	± 0,03

6.2.2.6.2 Product analysis

A product analysis may be carried out by the customer on a finished product representative of each cast, batch or casting. The number of samples, their location and the permissible deviations of chemical composition specified for each grade shall form the subject of an agreement between the interested parties at the time of enquiry and order. The samples shall be taken at least 6 mm below the surface of the rough cast. The purchaser is responsible for any damage to the castings due to the taking of samples.

6.2.3 Inspection of castings and requirements on surface appearance and dimensions

6.2.3.1 Visual examination

Examination of the accessible surfaces of the casting shall be carried out visually. (See 9.9.5.)

Surface imperfections not detrimental to the proper use of the product shall not be reason for rejection.

Unless specified to the contrary at the time of enquiry and order, the castings shall be delivered in the unmachined condition, trimmed, with heads and gates removed. Accessible surfaces shall be free from adhering sand and heat treatment scale.

Supplementary requirements may be used when additional inspection is desired. (See 6.2.3.2.)

If the order so specifies, the unmachined or machined castings may be subjected to a protective treatment.

6.2.3.2 Non-destructive tests

The castings may be subjected to certain non-destructive examinations (liquid penetrant, magnetic particle, radiography, ultrasonic examination). (See 9.9.)

6.2.3.3 Shapes — dimensions — machining allowances and dimensional tolerances

6.2.3.3.1 Shapes — dimensions

The shapes and dimensions of the casting shall comply with agreed machining allowances and dimensional tolerances and the requirements of the order whether in the form of drawing, pattern or template. (See 9.1.6.)

6.2.3.3.2 Machining allowances and dimensional tolerances

Machining allowances and dimensional tolerances are given in ISO 8062, unless otherwise agreed upon at the time of enquiry and order.

In case of dispute, verification of the dimensions shall be carried out on castings in the as-delivered state, at the reference temperature of 20 ± 5 °C.

When required, the purchaser shall indicate the datum points for machining and marking. It is desirable to supply to the manufacturer the machining drawing of the casting.

7 Marking

If the purchaser requests and the manufacturer agrees, each casting shall bear, either recessed or raised and at a place which shall remain unmachined, all or some of the following marks :

a) symbol of the manufacturer;

b) test lot identification;

c) if necessary, other marks requested by the purchaser (see 9.7.3).

It is recommended that a minimum of markings be used.

By agreement, small castings may be batched and the identifying marks stamped on the label attached to each batch.

8 Complaints

If a complaint is made, the manufacturer shall be given a reasonable time to examine the merits of the complaint. The castings in question will remain available for this examination.

9 Supplementary requirements

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

9.1 General considerations

9.1.1 Steelmaking process

The steel shall be made by one of the following methods :

a) in an open hearth furnace;

b) in an electric arc furnace;

c) in an induction furnace;

d) in a basic oxygen vessel.

9.1.2 Reporting of the steelmaking process

The steelmaking process shall be reported to the purchaser.

9.1.3 Agreed manufacturing procedure

When the castings are manufactured in bulk, the purchaser may ask to approve the manufacturing process. A programme of manufacture and inspection shall be agreed upon. The parties shall agree to a certain number of satisfactory preliminary tests and the manufacture of a sample series of castings. All these conditions taken together constitute an approved test of manufacture by the purchaser. When the results are satisfactory, the purchaser may place subsequent orders with the manufacturer in accordance with these programmes of manufacture and inspection.

9.1.4 Dividing up the cast

The castings shall be delivered according to casts.

9.1.5 Mass of test lots

The mass of the test lot shall be one of the following :

a) 500 kg;

b) 1 000 kg;

c) 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 for bulk manufacture.

9.1.6 Mass and tolerance on mass

Castings made of carbon or low-alloy steel : the mass shall be calculated on the basis of a density of 7,80 kg/dm^3.

Castings made of high-alloy steel : the mass shall be calculated on a basis of a density given in the corresponding product standard.

The mass of a casting shall correspond either to the mass calculated in accordance with the drawing, or to the mass of a sample with true dimensions. In the first case, possible modifications adopted for casting or moulding as well as machining allowance, shall be taken into account.

Castings having an excess mass of over 15 % calculated in relation to actual dimensions may be rejected.

Castings made in accordance with the same drawing and with the same material pattern shall not exceed the mass of a casting having true dimensions and complying with the definitions in clauses by more than

a) 5 % for machine-moulded castings;

b) 7 % for castings manufactured individually in accordance with a pattern;

c) 10 % for castings manufactured individually in accordance with a template or frame.

For machine-moulded castings, the mass of a casting which has true dimensions may be considered to be the average mass of the first five castings manufactured.

9.2 Inspection documents

9.2.1 Certificates

9.2.1.1 A test report shall be submitted to the purchaser. The test report shall contain the results of the chemical analysis and/or mechanical tests, including the results of any other tests required by the specification and/or ordered by the purchaser. It shall also include a statement that castings were manufactured in accordance with all the requirements of the specification.

9.2.1.2 The test report shall be signed by an authorized agent of the manufacturer.

9.2.1.3 The test report shall be furnished within 7 working days of shipment of the castings.

9.2.2 Test reports shall provide the required traceability of the castings they represent.

9.3 Chemical analysis for residual elements

9.3.1 The manufacturer shall determine the percentage of unintentionally present elements (residual elements) listed for the composition of steel being poured and shall report the results to the purchaser.

9.3.2 Chemical analysis for other residual elements not listed in the specification shall be agreed between the interested parties.

9.4 Mechanical tests

9.4.1 Proof stress at 0,2 % at elevated temperature

The dimensions of the test pieces and the method of tests shall meet the conditions of ISO 6892. The proof stress at elevated temperature shall be determined in accordance with the requirements of ISO/R 783. The test temperature shall be as specified in the material standard or shall be agreed between the interested parties.

Verification of the proof stress at elevated temperature shall be carried out in compliance with ISO 2605/1 or ISO 2605/2.

9.4.2 Brinell hardness test (specific to certain products)

The tensile test may be replaced by a Brinell hardness test to be carried out in compliance with specifications in ISO 6506. The hardness range shall be specified in the order.

9.4.3 Brinell hardness test

Measuring of the hardness at certain points of the castings shall be carried out in compliance with specifications of ISO 6506. The location on the castings where hardness tests are to be taken shall be specified in the order.

9.4.4 Impact test at low temperatures

Impact properties at low temperatures shall be determined. The requirements of test blocks and the test method shall be in accordance with 6.2.2.2 and 6.2.2.3.2. Test temperatures and energy values shall be as specified in the individual specifications of the product or shall be agreed between the interested parties.

9.4.4.1 Energy absorbed.

9.4.4.2 Lateral expansion.

The value of lateral expansion shall be agreed between the interested parties.

9.4.4.3 Percentage of shear area.

The percentage of shear area shall be agreed between the interested parties.

9.5 Homogeneity of the test lot

The homogeneity of the test lot shall be verified by hardness test carried out on 5 % of the castings (or at least five castings) per test lot.

The hardness is measured at the same place on each casting.

Each hardness value shall not deviate by more than 15 % or by more than a percentage agreed upon between the parties from the average of the hardness values of all the castings representing the test lot. If results do not comply, the manufacturer may

a) subject all the castings in the test lot to testing, eliminating those which do not correspond to the condition of homogeneity, and then subjecting them to a new heat treatment;

b) subject the whole test lot to a new heat treatment, before presenting it for the purchaser's inspection.

9.6 Test blocks

9.6.1 Test blocks representative of the castings

Test blocks shall be taken at an agreed location in the castings. The size of the test blocks, the corresponding mechanical properties, and the conditions under which the test block are to be taken (site for test pieces, location in the case of the attached blocks, cutting etc.) shall be agreed between the interested parties.

9.6.2 Heat treatment of separately cast test blocks

Test blocks shall be heat treated in the same furnace and together with the castings which they represent.

9.6.3 Test blocks attached to the castings

When the test blocks are attached to the castings, the attachment zone and the method shall be agreed between the interested parties.

The attached test blocks shall not be detached before the manufacturer has finished heat treatment of the castings, or if the purchaser or his representative is present for these tests, before the castings have been marked by the purchaser or his representative. The test blocks are marked after heat treatment.

9.6.4 Test block $d \times d$

The dimensions of the test block may be $d \times d$ instead of 28 mm × 28 mm, where d is the ruling section thickness. The ruling section shall always be indicated by the purchaser in the enquiry and in the order.

9.6.5 Test block $d \times 3d \times 3d$

When the ruling section thickness of a casting is greater than 50 mm, the dimensions of the test block can be taken as : $d \times 3d \times 3d$ (where d is the ruling section). The test pieces should be taken as shown in the figure.