
**Investment castings (steel, nickel
alloys and cobalt alloys) — General
technical requirements**

*Pièces moulées en cire perdue (acier, alliages de nickel et alliages de
cobalt) — Exigences techniques générales*

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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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 11, *Steel castings*.

This second edition replaces the first edition (ISO 16468:2005), which has been technically revised with the following changes:

- [Clause 2](#), two standards added;
- [3.3](#), revised;
- 3.4, deleted;
- [10.6](#), reference made to ISO 4992-1 and ISO 4992-2.

Investment castings (steel, nickel alloys and cobalt alloys) — General technical requirements

1 Scope

This International Standard specifies technical requirements for castings (steel, nickel alloys, and cobalt alloys) produced by the investment-casting process. The International Standards specifying metallurgical material requirements for steel, nickel alloy, and cobalt alloy casting grades are listed in the Bibliography.

The requirements stated in this International Standard form an integral part of the material specification. In cases of conflict, the requirements of this specification take precedence over the individual material specification requirements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4986, *Steel castings — Magnetic particle inspection*

ISO 4987, *Steel castings — Liquid penetrant inspection*

ISO 4990, *Steel castings — General technical delivery requirements*

ISO 4992-1, *Steel castings — Ultrasonic examination — Part 1: Steel castings for general purposes*

ISO 4992-2, *Steel castings — Ultrasonic examination — Part 2: Steel castings for highly stressed components*

ISO 4993, *Steel castings — Radiographic inspection*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 11970, *Specification and approval of welding procedures for production welding of steel castings*

ISO 13520, *Determination of ferrite content in austenitic stainless steel castings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

primary heat

master

mother heat

melt

quantity of metal processed in a single furnace or refining vessel at one time, in such a manner, as to produce the desired composition and properties

3.2
sub-heat
melt
production heat
daughter heat

portion of a primary heat remelted for pouring into castings

3.3
investment casting
lost wax casting

metal casting that is produced in a ceramic shell or mould using an expendable pattern

Note 1 to entry: The expendable pattern may consist of wax, plastics, or other material, and is removed prior to filling the mould with liquid metal.

4 Materials and manufacture

4.1 Melting process

Primary heats shall be made by the electric furnace process, with or without separate refining, such as argon-oxygen-decarburization (AOD), vacuum-oxygen-decarburization (VOD), vacuum-induction-melting (VIM), etc., unless otherwise specified in the individual specification or agreed upon between the purchaser and manufacturer. Primary heats may be used directly for producing castings or converted into ingot, bar, shot, or other suitable form, for later remelting as a sub-heat.

4.2 Remelting process

Sub-heats shall be produced from primary-heat metal in suitable batch sizes by an electric induction furnace, with or without atmosphere protection, such as vacuum or inert gas, unless otherwise specified in the individual specification or agreed upon between the purchaser and manufacturer. Revert (gates, sprues, risers, and rejected castings) shall not be remelted except in primary heats. Additions of up to 5 %, by mass, are permitted for compositional adjustments and deoxidation.

5 Inspection and testing

5.1 General requirements

The general requirements for inspection and testing shall be in accordance with ISO 4990, except as described in [5.2](#).

5.2 Sampling

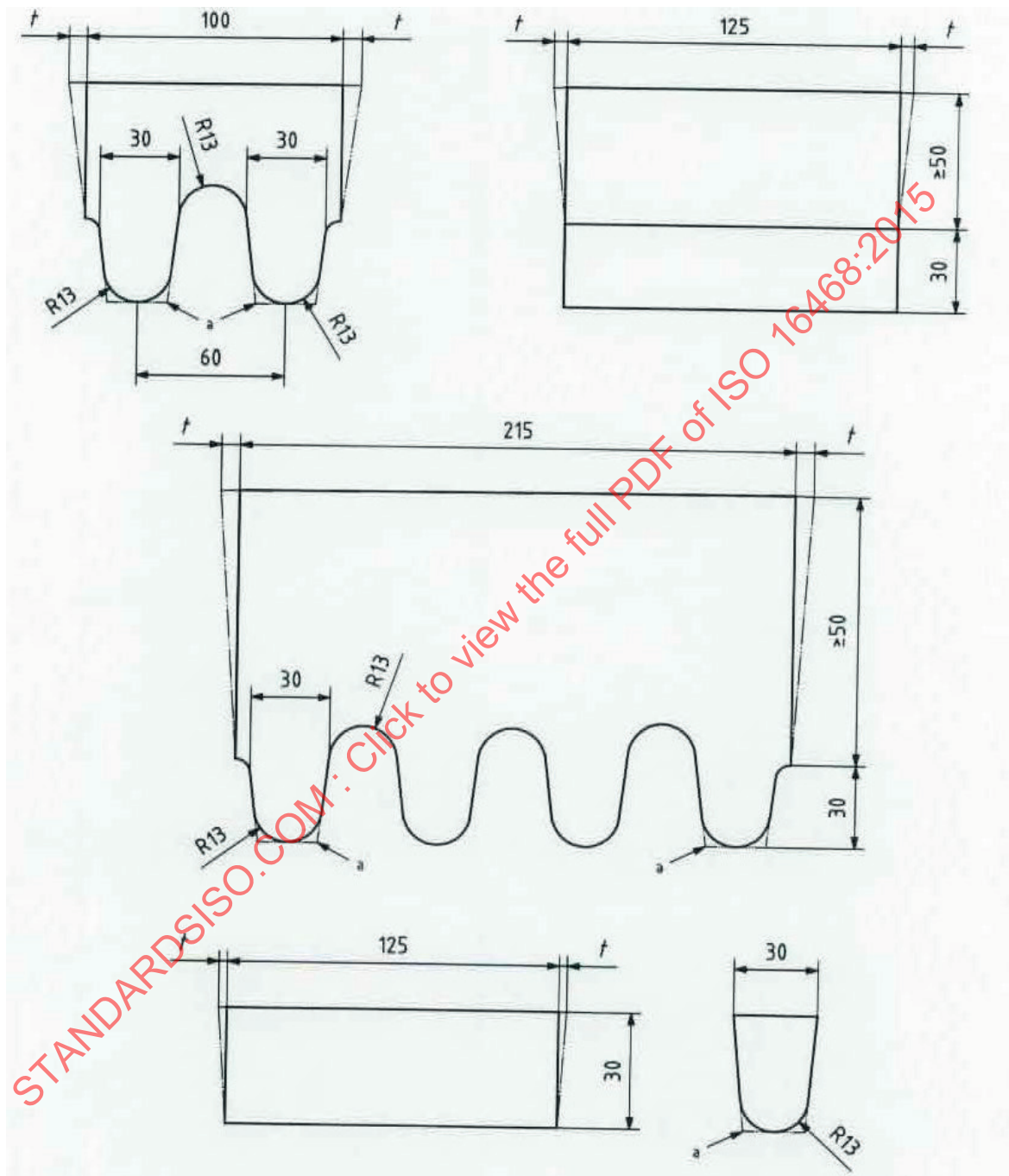
5.2.1 If castings are poured directly from one or more primary heats, then the samples for chemical and other required testing shall also be poured directly from each of the primary heats.

5.2.2 Unless otherwise specified by the purchaser, test blocks may be taken from castings, may be cast integrally with the castings, or may be cast in separate moulds of the same type and materials as those used for the castings. Samples for the determination of the chemical composition may be cast in other types of mould.

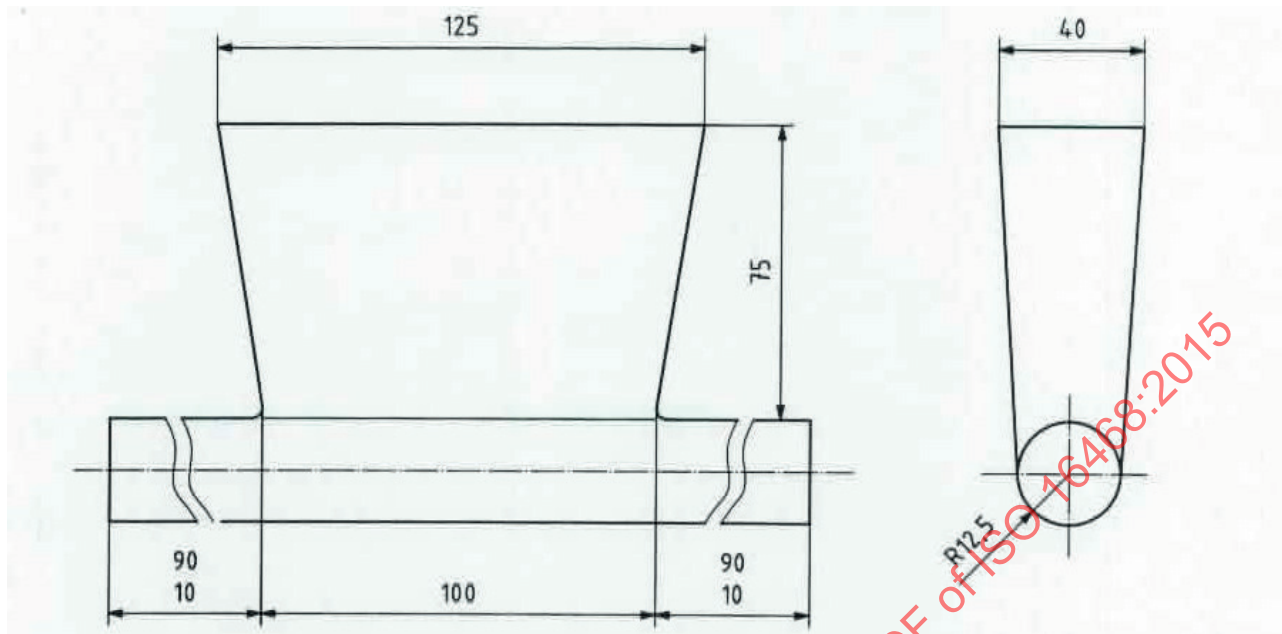
5.2.3 If castings are poured from a sub-heat, then the samples for chemical and other required tests shall also be poured from a sub-heat of the same primary melt, but not necessarily from the same sub-melt as the castings. The sub-melt used for the test samples shall be produced using the same practices and additions as used for the castings.

5.2.4 Examples of test blocks which may be used for mechanical testing are shown in Figure 1, except when 10.14 is specified. The test block in Figure 1 d) may be employed only for austenitic alloy castings with a ruling thickness less than 65 mm.

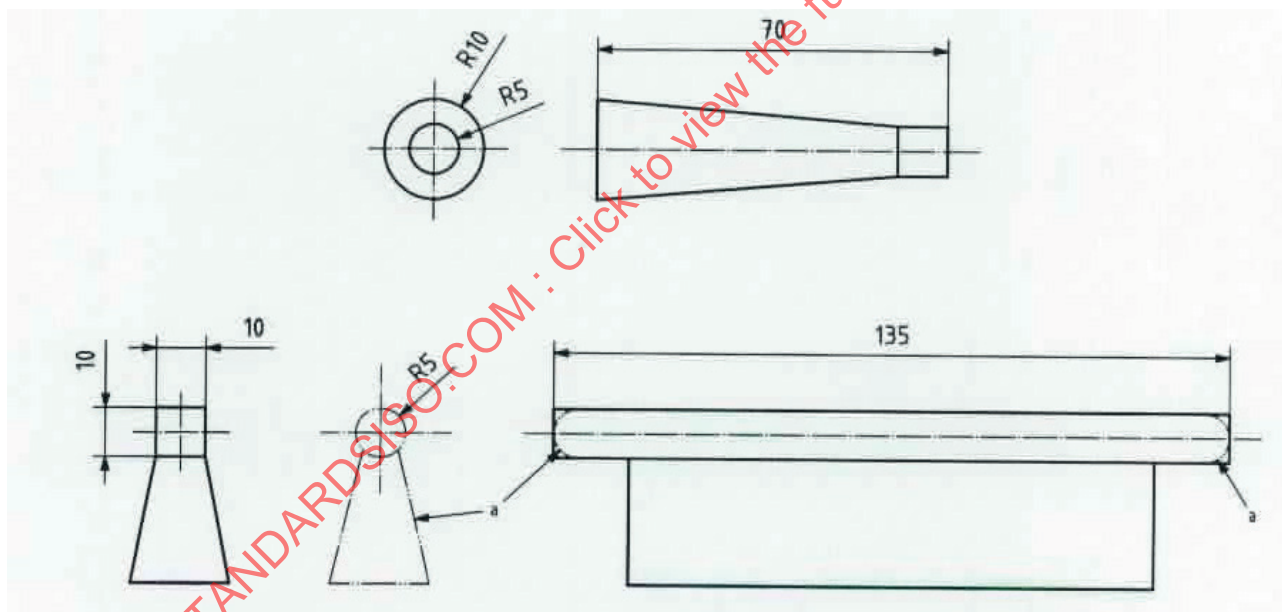
Dimensions in millimetres



a)

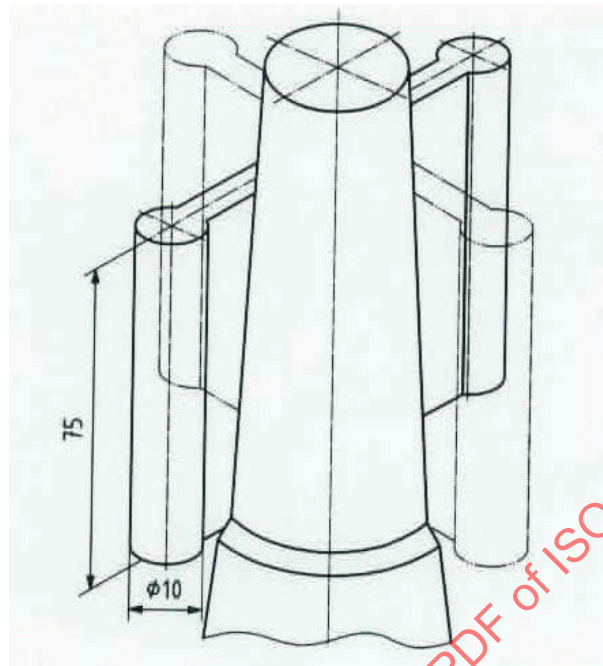


b)

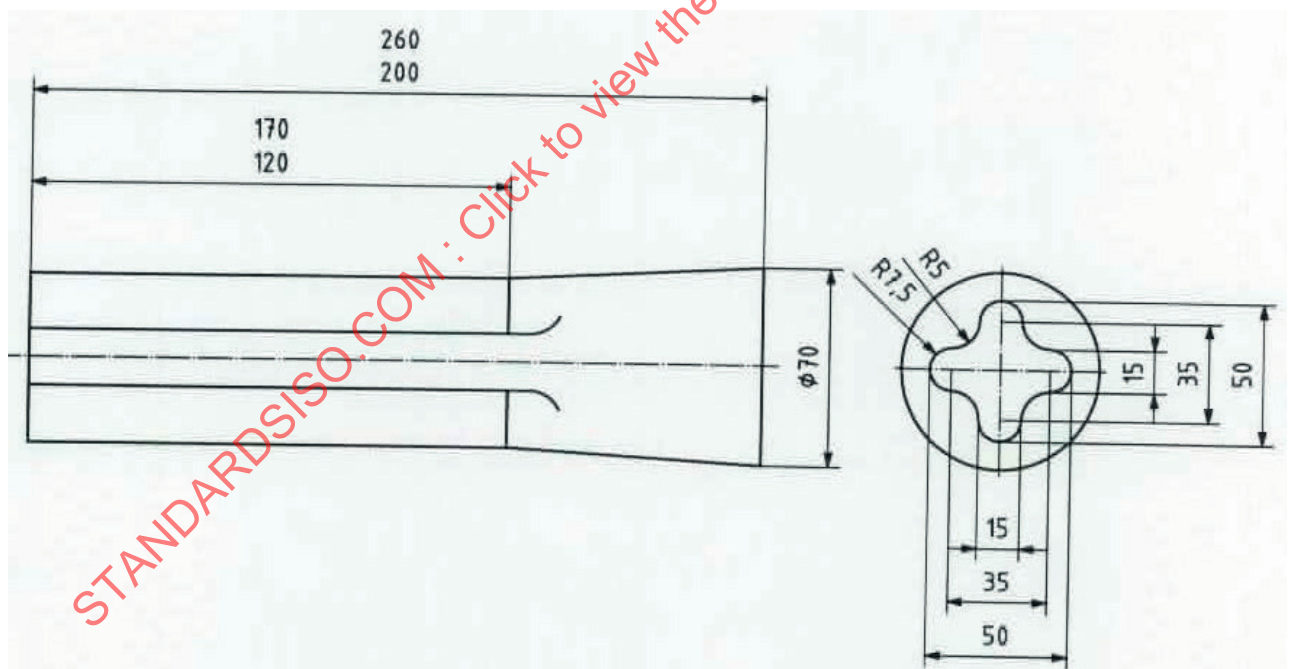


c)





g)



h)

Key

- t* taper
a alternative

Figure 1 — Test blocks

6 Retests

In addition to the requirements of ISO 4990, if any specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted from the same primary heat.

7 Cleaning and dressing

All the castings shall be cleaned and dressed sufficiently to determine compliance with the requirements of [Clause 8](#). Additional dressing may be agreed at the time of the enquiry and order.

If the pattern is supplied by the purchaser, or is produced using a die supplied by the purchaser, the dimensions of the casting shall be as produced by the pattern or die.

8 Quality

8.1 Visual standards for acceptance shall be agreed between the purchaser and manufacturer. ISO 11971 may be used to specify visual surface standards. Other surface conditions shall meet the visual acceptance standards specified in the order. Unacceptable visual surface discontinuities shall be removed and their removal verified by visual examination.

8.2 When additional inspection is desired, [10.3](#), [10.4](#), [10.5](#), [10.6](#), or [10.7](#) may be specified.

9 Production welds

Production welding shall be in accordance with the requirements of ISO 11970.

10 Supplementary requirements

10.1 General

One or more of the following supplementary requirements may be applied when specified in the enquiry and order. Additional supplementary requirements may also be found in ISO 4990. Details of these supplementary requirements shall be agreed upon by the manufacturer and purchaser at the time of the enquiry and order. The specified tests shall be carried out before delivery of the castings.

10.2 Agreed manufacturing procedure

At the time of enquiry and order, the purchaser may require prior approval of the manufacturing process.

10.3 Magnetic particle inspection

Castings shall be inspected for surface and near-surface discontinuities by magnetic particle inspection. The inspection shall be in accordance with ISO 4986. The extent of inspection and the basis for acceptance shall be agreed upon between the manufacturer and the purchaser.

10.4 Radiographic inspection

Castings shall be inspected for internal defects by means of X-rays or gamma rays. The procedure shall be in accordance with ISO 4993. The extent of inspection and the basis for acceptance shall be agreed upon between the manufacturer and purchaser.

10.5 Liquid penetrant inspection

Castings shall be inspected for surface discontinuities by means of liquid penetrant inspection. The inspection shall be in accordance with ISO 4987. Areas to be inspected, methods and types of liquid penetrants to be used, developing procedure, and the basis for acceptance shall be agreed upon between the manufacturer and purchaser.

10.6 Ultrasonic inspection

Castings shall be inspected for internal defects by means of ultrasonic inspection. The procedure shall be in accordance with ISO 4992-1 or ISO 4992-2. The extent of inspection and the basis for acceptance shall be agreed upon between the manufacturer and purchaser.

10.7 Inspection of weld preparation

Surfaces prepared for welding shall be inspected, using the same methods and acceptance criteria as specified for the casting, to verify removal of discontinuities.

10.8 Prior agreement relating to major finishing welds

The requirements related to major finishing welds shall be in accordance with ISO 4990.

10.9 Impact test at low temperatures

The requirements related to the impact test at low temperatures shall be in accordance with ISO 4990.

10.10 Hardness test

10.10.1 Brinell

Brinell hardness tests at specified locations of the castings shall be carried out in accordance with ISO 6506-1, and shall be reported.

10.10.2 Rockwell

Rockwell hardness tests at specified locations of the castings shall be carried out in accordance with ISO 6508-1, and shall be reported.

10.10.3 Vickers

Vickers hardness tests at specified locations of the castings shall be carried out in accordance with ISO 6507-1, and shall be reported.

10.11 Specified ferrite range in austenitic and austenitic ferritic stainless steels

10.11.1 The chemical composition of the melt shall be controlled such that the ferrite content, as determined by the chemical composition procedure of ISO 13520, shall be in conformance with the specified ferrite content range.

10.11.2 The specified ferrite content shall be as agreed upon between the manufacturer and the purchaser. If both minimum and maximum ferrite contents are specified, the minimum specified range of ferrite content shall be 10 %. The minimum specified ferrite content shall not be lower than the percent necessary to achieve the minimum mechanical properties required for the alloy.

10.11.3 Should the purchaser wish to have the ferrite content determined by either the magnetic response or metallographic methods, the purchaser should impose these requirements at the time of the enquiry.

10.12 Unspecified elements

Chemical analysis and limits for elements not specified for the grade ordered shall be as agreed upon between the manufacturer and purchaser.

10.13 Test material removed from castings

In addition to the tests required by the material specification, test material shall be removed from the casting. The properties and location of the test material shall be agreed upon between the manufacturer and purchaser.

10.14 Tensile test blocks and specimen locations for castings

10.14.1 Test blocks may be cast integrally with the shell in which the castings are produced or in separate shells. Test blocks shall be heat treated together with the castings they represent.

10.14.2 The dimensions of the test block, the number and locations of the specimens, and the limits for the mechanical properties shall be agreed upon between the manufacturer and purchaser.

10.15 Weld maps (sketches)

The requirements related to weld maps shall be in accordance with ISO 4990.

10.16 Chemical analysis — Testing frequency

The frequency of chemical analysis shall be as agreed upon between the purchaser and manufacturer.

10.17 Tensile test — Testing frequency

The frequency of tensile tests shall be as agreed upon between the purchaser and manufacturer.

10.18 Inspection documents

Documents for specific inspection and testing shall be supplied in accordance with ISO 10474.

10.19 Marking

The castings shall be marked for identification, or traceability, or both. The content of the marking and the method of marking, including size, location, and style, shall be as agreed upon between the purchaser and the producer.

10.20 Decarburization

A casting or block shall be evaluated for the degree and depth of decarburization. The test method, location and preparation of samples, and the basis for acceptance shall be agreed upon between the purchaser and manufacturer.

10.21 Metallurgical cleanliness

10.21.1 The details of the method for inspection and the basis for acceptance shall be agreed upon between the purchaser and manufacturer.