

BS EN 4700-005:2010



BSI Standards Publication

**Aerospace series — Steel  
and heat resisting alloys —  
Wrought products — Technical  
specification**

Part 005: Forging stock

**bsi.**

...making excellence a habit.™

EUROPEAN STANDARD

**EN 4700-005**

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2010

ICS 49.060

English Version

## Aerospace series - Steel and heat resisting alloys - Wrought products - Technical specification - Part 005: Forging stock

Série aérospatiale - Aciers et alliages résistant à chaud -  
Produits corroyés - Spécification technique - Partie 005:  
Produits destinés à la forge

Luft- und Raumfahrt - Stahl und Hochwarmfesten  
Legierungen - Umgeformte Erzeugnisse - Technische  
Lieferbedingungen - Teil 005: Schmiede Vormaterial

This European Standard was approved by CEN on 9 January 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Management Centre: Avenue Marnix 17, B-1000 Brussels**

## Contents

Page

|                                       |   |
|---------------------------------------|---|
| Foreword.....                         | 3 |
| Introduction .....                    | 4 |
| 1 <b>Scope</b> .....                  | 4 |
| 2 <b>Normative references</b> .....   | 4 |
| 3 <b>Terms and definitions</b> .....  | 6 |
| 4 <b>Wording of order</b> .....       | 6 |
| 5 <b>Health and safety</b> .....      | 6 |
| 6 <b>Technical requirements</b> ..... | 6 |

## Foreword

This document (EN 4700-005:2010) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2011, and conflicting national standards shall be withdrawn at the latest by March 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

## Introduction

This European Standard is part of the series of EN metallic material standards for aerospace applications. The general organization of this series is described in EN 4258.

## 1 Scope

This European Standard defines the requirements for the ordering, manufacture, testing, inspection and delivery of steel and heat resisting alloy forging stock. It shall be applied when referred to and in conjunction with the EN material standard unless otherwise specified on the drawing, order or inspection schedule.

## 2 Normative references

The following referenced documents are indispensable for the application 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.

EN ISO 3651-1, *Determination of resistance to intergranular corrosion of stainless steels — Part 1: Austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in nitric acid medium by measurement of loss in mass (Huey test) (ISO 3651-1:1998)*

EN ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid (ISO 3651-2:1998)*

EN ISO 3887, *Steels — Determination of depth of decarburization (ISO 3887:2003)*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:2005)*

EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1:2005)*

EN 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 6508-1:2005)*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

prEN ISO 6892-2, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature (ISO/DIS 6892-2:2009)*

EN 2002-001, *Aerospace series — Metallic materials — Test methods — Part 001: Tensile testing at ambient temperature*

EN 2002-002, *Aerospace series — Metallic materials — Test methods — Part 002: Tensile testing at elevated temperature*

EN 2002-005, *Aerospace series — Test methods for metallic materials — Part 005: Uninterrupted creep and stress-rupture testing*

EN 2002-16, *Aerospace series — Metallic materials — Test methods — Part 16: Non-destructive testing — Penetrant testing*<sup>1)</sup>

EN 2032-1, *Aerospace series — Metallic materials — Part 1: Conventional designation*

EN 2032-2, *Aerospace series — Metallic materials — Part 2: Coding of metallurgical condition in delivery condition*

EN 2078, *Aerospace series — Metallic materials — Manufacturing schedule, inspection schedule, inspection and test report — Definition, general principles, preparation and approval*

EN 2950, *Aerospace series — Test method — Wrought heat resisting alloys — Semi-finished products and parts — Conditions for macrographic and micrographic examination — Atlas of structures and defects*

EN 2951, *Aerospace series — Metallic materials — Test method — Micrographic determination of content of non-metallic inclusions*<sup>1)</sup>

EN 3874, *Aerospace series — Test methods for metallic materials — Constant amplitude force-controlled low cycle fatigue testing*<sup>1)</sup>

EN 3987, *Aerospace series — Test method for metallic materials — Constant amplitude force-controlled high cycle fatigue testing*<sup>1)</sup>

EN 3988, *Aerospace series — Test methods for metallic materials — Constant amplitude strain-controlled low cycle fatigue testing*<sup>1)</sup>

EN 4050-1, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 1: General requirements*<sup>1)</sup>

EN 4050-4, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 4: Acceptance criteria*<sup>1)</sup>

EN 4258, *Aerospace series — Metallic materials — General organization of standardization — Links between types of EN standards and their use*

EN 4259, *Aerospace series — Metallic materials — Definition of general terms*<sup>1)</sup>

EN 9100, *Quality Management Systems — Requirements for Aviation, Space and Defence Organizations*

EN 9133, *Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts*

EN 10027-1, *Designation systems for steels — Part 1: Steel names*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10079, *Definition of steel products*

AMS 2315, *Determination of Delta Ferrite Content*<sup>2)</sup>

AMS 2750, *Pyrometry*<sup>2)</sup>

---

1) Published as ASD-STAN Prestandard at the date of publication of this standard by Aerospace and Defence Industries Association of Europe-Standardization (ASD-STAN), ([www.asd-stan.org](http://www.asd-stan.org)).

2) Published by: SAE National (US) Society of Automotive Engineers <http://www.sae.org/>

ASTM A604, *Standard Practice for Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets* <sup>3)</sup>

ASTM E709, *Standard Guide for Magnetic Particle Testing* <sup>3)</sup>

ASTM E1444, *Standard Practice for Magnetic Particle Testing* <sup>3)</sup>

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 4259 apply. For definitions specific to steel, see EN 10079.

### 4 Wording of order

The order shall clearly indicate:

- quantities to be supplied;
- dates of delivery;
- material standard number;
- delivery condition and metallurgical code of products;
- dimensions and tolerances or reference to an appropriate dimensional standard;
- product designation, when required;
- forwarding address;
- nature and type of packing, if required;
- surface protection, if appropriate;
- definition and frequency of any special tests and their retest procedures, if required.

### 5 Health and safety

Products in the delivery condition shall fulfil the health and safety laws of the area of the country when and where it is to be delivered.

A product safety data sheet shall be available.

### 6 Technical requirements

#### 6.1 General

The product shall be manufactured in accordance with the requirements of the relevant material standard and the applicable requirements of this specification. A manufacturing schedule shall be established and applied in accordance with EN 2078.

---

3) Published by: ASTM National (US) American Society for Testing and Materials <http://www.astm.org/>

Product shall satisfy the requirements of the material standard and/or order and shall be free from irregularities prejudicial to the subsequent manufacture or use of this product.

Notwithstanding previous acceptance complying with this material standard, any product that is found, at a later stage, to contain such defects shall be rejected.

Unless otherwise specified, the requirements in Tables 1 and 2 shall apply in conjunction with those of the relevant material standard. Table 1 relates to lines 1 to 29 (inclusive) of the material standard and Table 2 relates to lines 30 onwards in which the subline format is also used. Lines 2 to 98 may also be opened in line 100 if the material standard details specific qualification requirements. If a specific line number is not shown in Tables 1 and 2, the requirement is stated in the material standard and/or order.

The requirements of the order and/or material standard shall over-ride the requirements of the technical specification.

## **6.2 Qualification requirements**

Qualification requirements when invoked by the material standard and/or order are detailed in Tables 1 and 2. Unless otherwise agreed between the manufacturer and purchaser the qualification phase shall be run on the first 3 batches, coming from at least 2 casts.

## **6.3 Release requirements**

### **6.3.1 Release tests**

Release testing shall be the responsibility of the manufacturer.

The purchaser reserves the right to perform any of the inspections and/or tests required by the material standard and/or order.

The test samples shall be representative of the product.

When required on the order, the manufacturer shall inform the purchaser of the planned dates for extraction of samples and release testing in order that these operations may be witnessed.

Tables 1 and 2 detail the requirements for each line of the material standard. Unless otherwise specifically requested by the purchaser, a particular inspection and/or test for release shall be carried out if corresponding acceptance criteria and/or values are stated in the applicable material standard, but see also in 6.3.5.

### **6.3.2 Retests**

If any requirement is not met, retests shall be carried out under the following conditions unless otherwise stated in the material standard or order.

If the test procedure or test piece preparation is faulty, testing shall be re-applied at the original frequency after rectification of the original cause of failure, on a test sample located near the first one.

When failure cannot be attributed to faulty testing, or test piece preparation, further test samples shall be selected at twice the original frequency from the product, one of which shall be that on which the original results were obtained unless already withdrawn by the manufacturer after suitable identification of the cause of failure. If all retest results are satisfactory, the batch shall be accepted. If one or more tests are unsatisfactory, the batch shall be:

- rejected, or
- 100 % retested and the conforming products accepted, or

- partially or fully re-heat treated if heat treatment can rectify the cause of the failure and tested as a completely new batch except for chemical composition and cleanness inspection. The reheat treatment shall be stated on the release test certificate.

For cleanness inspection, if the material fails the requirement the product may be cut back before retesting.

### **6.3.3 Rejection**

Any failure to meet the requirements of the material standard shall be cause for rejection.

### **6.3.4 Special tests**

Special tests may be required by the purchaser. In such cases, the nature of the test, method, frequency and technical requirements shall be specified on the order or inspection schedule and shall be mutually agreed by the manufacturer and purchaser.

### **6.3.5 Capability clause**

Where the capability clause is invoked and where sufficient statistical evidence exists, the test need not be carried out (unless specifically requested by the purchaser).

However, this in no way reduces the obligations of the manufacturer to fulfil the requirements. If subsequent testing indicates that the product does not comply with the requirements, the batch shall be rejected.

### **6.3.6 Statistical process control**

Reduction in the extent of release testing, other than that defined in 6.3.4 above, may be negotiated with the purchaser on the basis of appropriate statistical process control and/or statistical data.

### **6.3.7 Inspection and test report**

The manufacturer shall furnish, with each delivery, a report conforming to the requirements of EN 2078 stating the following:

- manufacturer's name and address and, if appropriate, identification of the plant;
- order number;
- material standard number;
- delivery condition and metallurgical code of the product;
- quantity and dimensions;
- manufacturing and inspection schedule reference;
- cast and batch number;
- batch and/or test samples heat treatment conditions;
- results of the tests and retests if any.

## **6.4 Traceability**

Each product shall be traceable to the cast, production batch and/or heat treatment batch at all stages of manufacture, testing and delivery.

Table 1 — Technical requirements for lines 1 to 29, where appropriate

| Material standard line reference |                      | Requirements   | Frequency of testing   |  |
|----------------------------------|----------------------|--|--|--|
| No.                              | Title                |  | Qualification  | Release  |
| 1                                | Material designation | EN 2032-1 and EN 10027-1 if applicable   | –  | –  |
| 2                                | Chemical composition | <p>The chemical composition of the alloy shall comply with requirements of the material standard.</p> <p>The samples taken for analysis shall be representative of the melt.</p> <p>The method of analysis shall be at the option of the manufacturer, but in cases of dispute, the reference method set out in the relevant EN or ISO standard shall be used. If no EN or ISO standard exists, a fundamental and agreed method of chemical analysis calibrated against accepted reference standards shall be used.</p> <p>In the case of remelted material, samples shall be taken from positions as follows:</p> <p>a) <i>Vacuum arc remelted (VAR) ingots</i>: the bottom of each ingot or ingot product.</p> <p>b) <i>Electroflux or electroslag remelted (ESR) ingots</i>: the top and bottom ends of each ingot or ingot product.</p> <p>An analysis shall be made of each sample and certificates of analysis shall be supplied to the purchaser. The elements to be determined shall be as required by the material standard or as agreed between the manufacturer and the purchaser.</p> <p>Elements not quoted in the material standard shall not be intentionally added to the alloy without the agreement of the purchaser, except for the purpose of finishing the heat (e.g. addition of deoxidant); reasonable precautions shall be taken to prevent their inclusion during manufacture. The purchaser, in agreement with the manufacturer, may set a limit to the amount of one or more such elements and may require the amount of such elements to be stated in the certificate of analysis.</p> <p>The specified ranges of chemical composition are based on cast analyses. Any subsequent analytical checks shall take into consideration the heterogeneity normal to the alloy.</p> <p>Additionally for remelted products, the samples shall be representative for the remelted ingot, taking into account any macro segregation.</p> | <p>a) 1 per cast in the case of air melted or vacuum induction melted product</p> <p>b) 2 per VAR or ESR ingot representing top and bottom positions</p> | <p>a) 1 per cast in the case of air melted or vacuum induction melted product</p> <p>b) 1 on one ingot or ingot product in case of VAR or ESR products</p> |
| 3                                | Method of melting    | <p><b>1 General</b></p> <p>The alloy shall be made by the process required by the material standard, unless otherwise agreed between the manufacturer and purchaser. If the material standard permits alternative processes, the manufacturer shall decide which of them shall be used unless the purchaser states a particular preference on his order. In all instances, the process by which the alloy was made shall be indicated on the release note.</p> <p><b>2 Consumable electrode remelted material</b></p> <p>2.1 Except as provided in 2.3 or 2.4 at no time during remelting shall material of any other composition or type be introduced into the melting chamber, i.e. starter material and electrode stub-ends shall be of the same composition as the material being remelted.</p>   | –  | –  |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (continued)

| Material standard line reference |                                  | Requirements  | Frequency of testing |         |
|----------------------------------|----------------------------------|---|----------------------|---------|
| No.                              | Title                            |   | Qualification        | Release |
| 3                                | Method of melting<br>(concluded) | <p><b>2.2</b> Whenever possible and except as provided in 2.3, weld material used to join electrodes together and to join the electrode to the stub-end shall be of the same composition as the material being remelted. If such weld material is not obtainable, material of a similar composition to, or compatible with, the material being remelted may be used at the discretion of the manufacturer, unless the purchaser indicates that his prior agreement is required.</p> <p><b>2.3</b> Alternatively to 2.1 and 2.2, for electro-flux and vacuum arc remelting, the stub and any weld material may be different from that being remelted, provided that the remelted material is not contaminated with material from the stub-ends or weld and that, for vacuum arc remelting, the stub welding takes place outside the furnace. Remelting shall be terminated not less than 20 mm from the electrode/stub interface and, after completion of the remelting cycle, the electrode/stub interface shall be examined to verify that the stub and weld are intact.</p> <p><b>2.4</b> For VAR or ESR remelting, material compatible with the composition of that being remelted shall be permitted to provide electrical contact to the furnace base plate, provided that the chemical composition of the melt is maintained.</p> | —                    | —       |
| 4.1                              | Form                             | Forging stock   | —                    | —       |
| 4.2                              | Method of production             | <p><b>Mechanical hot working:</b></p> <p>The manufacturer shall establish a procedure for mechanical hot working.</p> <p>This procedure shall define:</p> <ul style="list-style-type: none"> <li>— the homogenisation thermal cycle;</li> <li>— the thermo-mechanical working processes;</li> <li>— the manufacturing schedule for each process: the temperatures and durations of pre-heating; the temperature range for each working process; the dimensions of the products at each step and conditions for heat treatment between operations.</li> </ul> <p><b>Mechanical cold working (if any):</b></p> <p>The manufacturer shall establish a procedure for the mechanical cold working.</p> <p>This procedure shall define:</p> <ul style="list-style-type: none"> <li>— the mechanical working processes;</li> <li>— the manufacturing schedule for each process; the dimensions of the products at each step and heat treatment conditions between operations.</li> </ul> <p>Unless otherwise specified in the order or schedule, all forging stock shall be worked with a minimum cross-section ratio of 3:1.</p>  | —                    | —       |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (continued)

| Material standard line reference |                         | Requirements  | Frequency of testing |         |
|----------------------------------|-------------------------|---|----------------------|---------|
| No.                              | Title                   |   | Qualification        | Release |
| 4.3                              | Limit dimension(s)      | Minimum and/or maximum size of the product expressed as the nominal thickness $a$ , or nominal thicknesses for multi-legged/flanged sections, or as a nominal diameter, $D$ , of round bar or as equivalent diameter $D_e$ .  | —                    | —       |
| 5                                | Technical specification | Reference to this technical specification EN 4700-005. In cases of conflict, the requirements of the material standard shall take precedence over those of this technical specification.  | —                    | —       |
| 6.1                              | Delivery condition      | <p>Product shall be supplied in the delivery condition specified in this line in the material standard and/or as stated on the order.</p> <p><b>Marking:</b></p> <p>The method of marking used shall not cause corrosion, crack initiation, contamination or unacceptable deformation. The marking shall remain permanently visible after handling and contact with protective products.</p> <p>Each forging stock shall bear the following identification marking:</p> <ul style="list-style-type: none"> <li>— material standard number,</li> <li>— cast/ingot number,</li> <li>— batch number,</li> <li>— forging stock identification number, when required,</li> <li>— delivery condition if heat treatment is required by the order,</li> <li>— identification of manufacturer.</li> </ul> <p>Identification marking shall be:</p> <ul style="list-style-type: none"> <li>— hard stamped at least once on each length of forging stock <math>\geq 12,5</math> mm,</li> <li>— on a durable label for forging stock <math>&lt; 12,5</math> mm supplied in bundles.</li> </ul> <p><b>Packing:</b></p> <p>All necessary precautions shall be taken to prevent damage to the product, especially where the delivered surface finish shall be maintained.</p> <p>The packing shall be suitable for the type of transportation used.</p> <p>The exterior of the packing shall bear the following information:</p> <ul style="list-style-type: none"> <li>— name and address of recipient,</li> <li>— mass,</li> <li>— order number and sufficient information to enable the contents to be related to the relevant documentation.</li> </ul> | —                    | —       |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (continued)

| Material standard line reference |                                | Requirements   | Frequency of testing |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
|----------------------------------|--------------------------------|--|----------------------|---------------------|------|---------------------|-------------|----------|--------------|----|------|---|------------|----|------|---|-------------------|----|--------|-----|----------|----|--------|---|--------------|----|---|---|
|                                  |                                |  | Qualification        | Release             |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| No.                              | Title                          |  |                      |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 6.1                              | Delivery condition (concluded) | <b>Shipment:</b><br>The responsibility for shipping shall be detailed in a transport contract.   | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
|                                  | Heat treatment                 | Not applicable to the forging stock  | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 6.2                              | Delivery condition code        | See EN 2032-2.   | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 7                                | Use condition                  | The use condition treatment of the forging stock is the delivery condition.  | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
|                                  | Heat treatment                 | Not applicable to the forging stock  | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 8.1                              | Test sample(s)                 | This lines relates to test samples for the tests defined in lines 12 to 26.<br><br>Test samples may be worked before reference heat treatment in order to simulate the forging and/or to obtain a representative cross section.<br><br>Test samples and associated test pieces shall be marked in such a manner that their identity, with respect to the product is maintained.  | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 8.2                              | Test piece(s)                  | This line relates to test pieces for the tests defined in lines 12 to 26.<br><br>Test pieces shall be machined from the test samples taken in accordance with the requirements of line 8.1 of this technical specification.<br><br>Test piece type and dimensions shall be as specified for the appropriate test/line number in the material standard and/or this technical specification and/or test method.  | -                    | -                   |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| 8.3                              | Heat treatment                 | The samples or test pieces shall be subject to reference heat treatment in the same order as those specified in the material standard. For steels and HRA over 1 300 MPa, samples may be machined to size plus a grinding allowance prior to ageing or full heat treatment. Abbreviation and symbols used in the material standard are shown in the following table: all other terms are written in full.<br><br><table border="1"> <thead> <tr> <th>Term</th> <th>Abbreviation/Symbol</th> <th>Term</th> <th>Abbreviation/Symbol</th> </tr> </thead> <tbody> <tr> <td>temperature</td> <td><math>\theta</math></td> <td>water quench</td> <td>WQ</td> </tr> <tr> <td>time</td> <td>t</td> <td>oil quench</td> <td>OQ</td> </tr> <tr> <td>hour</td> <td>h</td> <td>forced air quench</td> <td>AQ</td> </tr> <tr> <td>minute</td> <td>min</td> <td>air cool</td> <td>AC</td> </tr> <tr> <td>second</td> <td>s</td> <td>furnace cool</td> <td>FC</td> </tr> </tbody> </table> | Term                 | Abbreviation/Symbol | Term | Abbreviation/Symbol | temperature | $\theta$ | water quench | WQ | time | t | oil quench | OQ | hour | h | forced air quench | AQ | minute | min | air cool | AC | second | s | furnace cool | FC | - | - |
| Term                             | Abbreviation/Symbol            | Term   | Abbreviation/Symbol  |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| temperature                      | $\theta$                       | water quench   | WQ                   |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| time                             | t                              | oil quench   | OQ                   |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| hour                             | h                              | forced air quench  | AQ                   |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| minute                           | min                            | air cool   | AC                   |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |
| second                           | s                              | furnace cool   | FC                   |                     |      |                     |             |          |              |    |      |   |            |    |      |   |                   |    |        |     |          |    |        |   |              |    |   |   |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (continued)

| Material standard line reference            |                                    | Requirements  | Frequency of testing  |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
|---|------------------------------------|---|---|-------------------------|------------------------|-----------|-------------------------------|----------|-------------------|--------------|-----------------------------|--------|----------------------------|------------|
|   |                                    |   | Qualification   | Release                 |                        |           |                               |          |                   |              |                             |        |                            |            |
| No.   | Title                              |   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 8.3   | Heat treatment<br>(concluded)      | AMS 2750 to be used unless otherwise agreed between customer and supplier.<br><br>The charge shall be maintained at the temperature specified, subject to the furnace tolerances in the following table, for the period stated in the material standard:<br><br><table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Selected temperatures<br/>°C</th> <th>Tolerances<br/>°C</th> </tr> </thead> <tbody> <tr> <td><math>\theta &lt; 750</math></td> <td><math>\pm 5</math></td> </tr> <tr> <td><math>750 \leq \theta \leq 1\,250</math></td> <td><math>\pm 10</math></td> </tr> <tr> <td><math>\theta &gt; 1\,250</math></td> <td><math>\pm 15</math></td> </tr> </tbody> </table><br>When the duration of the heat treatment is stated as a fixed value, the tolerance shall be: $(+20_0)\%$ . | Selected temperatures<br>°C   | Tolerances<br>°C        | $\theta < 750$         | $\pm 5$   | $750 \leq \theta \leq 1\,250$ | $\pm 10$ | $\theta > 1\,250$ | $\pm 15$     | -                           | -      |                            |            |
| Selected temperatures<br>°C                 | Tolerances<br>°C                   |   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $\theta < 750$                              | $\pm 5$                            |   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $750 \leq \theta \leq 1\,250$               | $\pm 10$                           |   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $\theta > 1\,250$                           | $\pm 15$                           |   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 9   | Dimensions concerned               | Nominal thickness, $a$ , nominal diameter, $D$ , or equivalent diameter $D_e$ of the product to which the properties, in lines 11 to 26 of the material standard, relate.   | -   | -                       |                        |           |                               |          |                   |              |                             |        |                            |            |
| 10  | Thickness of cladding on each face | Not used for steel and heat resisting alloys.   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 11  | Direction of test piece            | As specified in the material standard and relates to the direction of the test piece used for tensile, impact and creep testing.<br><br>When the material standard specifies mechanical properties in the longitudinal direction only, it is permissible to release material testing in the transverse direction, provided the test results are conform to the longitudinal direction requirements.   | -   | -                       |                        |           |                               |          |                   |              |                             |        |                            |            |
| Tensile test                                |                                    | Lines 12 to 16  | -   | -                       |                        |           |                               |          |                   |              |                             |        |                            |            |
| 12  | Temperature                        | $\theta$ °C   | As specified in the material standard and relates to the temperature at which the tensile tests is carried out. |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 13  | Proof stress                       | $R_{p0.2}$ MPa  | 2 specimens per batch<br><br>1 specimen per batch   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 14  | Strength                           | $R_m$ MPa   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 15  | Elongation                         | A %   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| 16  | Reduction of area                  | Z %   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
|   |                                    | The tensile test specimen location and direction within the product shall be in accordance with the following table:<br><br><table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Minor transverse dimension of product<br/>mm</th> <th>Direction of test piece</th> <th>Location of test piece</th> </tr> </thead> <tbody> <tr> <td><math>\leq 25</math></td> <td>Longitudinal</td> <td>Centre</td> </tr> <tr> <td><math>25 &lt; D \leq 75</math></td> <td>Longitudinal</td> <td>at 12,5 mm from the surface</td> </tr> <tr> <td><math>&gt; 75</math></td> <td>Longitudinal or transverse</td> <td>Mid radius</td> </tr> </tbody> </table>  | Minor transverse dimension of product<br>mm   | Direction of test piece | Location of test piece | $\leq 25$ | Longitudinal                  | Centre   | $25 < D \leq 75$  | Longitudinal | at 12,5 mm from the surface | $> 75$ | Longitudinal or transverse | Mid radius |
| Minor transverse dimension of product<br>mm | Direction of test piece            | Location of test piece  |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $\leq 25$                                   | Longitudinal                       | Centre  |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $25 < D \leq 75$                            | Longitudinal                       | at 12,5 mm from the surface   |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |
| $> 75$                                      | Longitudinal or transverse         | Mid radius  |   |                         |                        |           |                               |          |                   |              |                             |        |                            |            |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (continued)

| Material standard line reference            |                            | Requirements   | Frequency of testing                        |                         |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
|---|----------------------------|--|---|-------------------------|------------------------|------|--------------|--------|-------------|--------------|-----------------------------|------|----------------------------|------------|-----------------------------|----------------------------|
| No.   | Title                      |  | Qualification                               | Release                 |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| 17  | Hardness                   | Where required by the material specification, test in accordance with EN ISO 6506-1 (Brinell) or EN ISO 6508-1 (Rockwell) or ISO 6507-1 (Vickers), as appropriate.<br><br>NOTE There is no perfect correlation between hardness and tensile strength values. In case of dispute, the tensile strength value is mandatory; in that case the hardness value become an indicative value.  | 1 specimen per batch                        | 1 specimen per batch    |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| 18  | Shear strength             | Not normally used for this product.  | –   | –                       |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| 19  | Bending                    | Not used for this product.   | –   | –                       |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| 20  | Impact strength            | <p>Test in accordance with EN 10045-1 (Charpy V or U notch) or EN 2003-2 (Izod) as required by the material standard.</p> <p>The test specimen location and direction shall be in accordance with the following table:</p> <table border="1"> <thead> <tr> <th>Minor transverse dimension of product<br/>mm</th> <th>Direction of test piece</th> <th>Location of test piece</th> </tr> </thead> <tbody> <tr> <td>≤ 25</td> <td>Longitudinal</td> <td>Centre</td> </tr> <tr> <td>25 &lt; D ≤ 75</td> <td>Longitudinal</td> <td>at 12,5 mm from the surface</td> </tr> <tr> <td>&gt; 75</td> <td>Longitudinal or transverse</td> <td>Mid radius</td> </tr> </tbody> </table> <p>The notch shall be towards the centre of the product.</p> <p>The tests shall be carried out on products of diameter greater than or equal to 16 mm or of thickness greater than or equal to 12 mm.</p> | Minor transverse dimension of product<br>mm | Direction of test piece | Location of test piece | ≤ 25 | Longitudinal | Centre | 25 < D ≤ 75 | Longitudinal | at 12,5 mm from the surface | > 75 | Longitudinal or transverse | Mid radius | 2 sets of 3 tests per batch | 1 set of 3 tests per batch |
| Minor transverse dimension of product<br>mm | Direction of test piece    | Location of test piece   |   |                         |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| ≤ 25  | Longitudinal               | Centre   |   |                         |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| 25 < D ≤ 75                                 | Longitudinal               | at 12,5 mm from the surface  |   |                         |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |
| > 75  | Longitudinal or transverse | Mid radius   |   |                         |                        |      |              |        |             |              |                             |      |                            |            |                             |                            |

continued

Table 1 — Technical requirements for lines 1 to 29, where appropriate (concluded)

| Material standard line reference           |                            |  |     | Requirements  | Frequency of testing                       |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
|--|----------------------------|--|-----|---|--|-------------------------|------------------------|-----------|--------------|--------|------------------|--------------|-----------------------------|--------|----------------------------|------------|--|--|
| No.  | Title                      |  |     |   | Qualification                              | Release                 |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| Creep parameters                           |                            |  |     | Lines 21-26   | -  | -                       |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 21   | Temperature                | $\theta$   | °C  | As specified in the material standard and relates to the temperature at which the creep and/or stress rupture tests are carried out.  | -  | -                       |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 22   | Time                       |  | h   |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 23   | Stress                     | $\sigma_b$   | MPa | Test in accordance with EN 2002-005.<br><br>The test piece definition shall be one of those indicated in EN 2002-005, unless otherwise agreed.<br><br>The test specimen location and direction shall be in accordance with the following table:<br><br>NOTE A load greater than the specified load may be applied in order to limit the time of the test at the condition that the time satisfy the requirement. No change of the load is allowed during the test.                          | 2 specimens per batch                      | 1 specimen per batch    |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 24   | Elongation                 | a  | %   |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 25   | Rupture stress             | $\sigma_R$   | MPa |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 26   | Elongation at rupture      | A  | %   |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
|  |                            |  |     | <table border="1"> <thead> <tr> <th>Minor transverse dimension of product (mm)</th> <th>Direction of test piece</th> <th>Location of test piece</th> </tr> </thead> <tbody> <tr> <td><math>\leq 25</math></td> <td>Longitudinal</td> <td>Centre</td> </tr> <tr> <td><math>25 &lt; D \leq 75</math></td> <td>Longitudinal</td> <td>at 12,5 mm from the surface</td> </tr> <tr> <td><math>&gt; 75</math></td> <td>Longitudinal or transverse</td> <td>Mid radius</td> </tr> </tbody> </table> | Minor transverse dimension of product (mm) | Direction of test piece | Location of test piece | $\leq 25$ | Longitudinal | Centre | $25 < D \leq 75$ | Longitudinal | at 12,5 mm from the surface | $> 75$ | Longitudinal or transverse | Mid radius |  |  |
| Minor transverse dimension of product (mm) | Direction of test piece    | Location of test piece   |     |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| $\leq 25$                                  | Longitudinal               | Centre   |     |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| $25 < D \leq 75$                           | Longitudinal               | at 12,5 mm from the surface  |     |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| $> 75$                                     | Longitudinal or transverse | Mid radius   |     |   |  |                         |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 27   | Notes                      | List of indices appearing on page 4 of the material standard which relate to normative and/or interpretative notes which are subsequently explained in line 98 of the material standard. |     |   | -  | -                       |                        |           |              |        |                  |              |                             |        |                            |            |  |  |
| 29   | Reference heat treatment   | When required, reference heat treatment is applied to the test samples, see line 8.3.  |     |   | -  | -                       |                        |           |              |        |                  |              |                             |        |                            |            |  |  |

Table 2 — Technical requirements for lines 30 onwards, where appropriate

| 30                                     |   | Microstructure (heat resisting alloys) |                        |
|--|---|--|------------------------|
| Test method                            | 1 | EN 2950                                |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>                   | <b>Release testing</b> |
|  |   | 1 per batch                            | 1 per batch            |
| Sample type                            | 3 | See EN 2950.                           |                        |
| Test piece definition                  | 4 | See EN 2950.                           |                        |
| Heat treatment condition of test piece | 5 | See material standard.                 |                        |
| Testing condition                      | 6 | See EN 2950.                           |                        |
| Acceptance criteria                    | 7 | See material standard.                 |                        |

| 30                                     |   | Microstructure ( $\delta$ Ferrite for steels) |                        |
|--|---|---|------------------------|
| Test method                            | 1 | AMS 2315 (for $\delta$ ferrite)               |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>                          | <b>Release testing</b> |
|  |   | 1 cast  | 1 cast                 |
| Sample type                            | 3 | See AMS 2315.                                 |                        |
| Test piece definition                  | 4 | See AMS 2315.                                 |                        |
| Heat treatment condition of test piece | 5 | Use condition.                                |                        |
| Testing condition                      | 6 | See AMS 2315.                                 |                        |
| Acceptance criteria                    | 7 | See material standard.                        |                        |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (continued)

| 31                                     |   | Jominy hardenability test |                        |
|--|---|---------------------------|------------------------|
| Test method                            | 1 | EN ISO 642                |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>      | <b>Release testing</b> |
|  |   | 1 per cast                | 1 per cast             |
| Sample type                            | 3 | -                         |                        |
| Test piece definition                  | 4 | See EN ISO 642            |                        |
| Heat treatment condition of test piece | 5 | See material standard.    |                        |
| Testing condition                      | 6 | See EN ISO 642            |                        |
| Acceptance criteria                    | 7 | See material standard.    |                        |

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

| 38                                     |   | Intergranular corrosion  |                                  |
|--|---|--|----------------------------------|
| Test method                            | 1 | EN ISO 3651-1 or EN ISO 3651-2   |                                  |
| Frequency of testing                   | 2 | <b>Qualification</b>   | <b>Release testing</b>           |
|  |   | 1 per batch  | The "capability clause" applies. |
| Sample type                            | 3 | -  |                                  |
| Test piece definition                  | 4 | See EN ISO 3651-1 or EN ISO 3651-2   |                                  |
| Heat treatment condition of test piece | 5 | Use condition unless otherwise specified.  |                                  |
| Testing condition                      | 6 | See EN ISO 3651-1 or EN ISO 3651-2   |                                  |
| Acceptance criteria                    | 7 | See EN ISO 3651-2, or for EN ISO 3651-1 to be agreed between manufacturer and purchaser. |                                  |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (continued)

| 44                                     |   | External defects  |                        |
|--|---|---|------------------------|
| Test method                            | 1 | Visual inspection or equivalent   |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>  | <b>Release testing</b> |
|  |   | <i>Each product 100 %</i>   | Each product 100 %     |
| Sample type                            | 3 | -   |                        |
| Test piece definition                  | 4 | After final surface finishing   |                        |
| Heat treatment condition of test piece | 5 | Delivery condition  |                        |
| Testing condition                      | 6 | -   |                        |
| Acceptance criteria                    | 7 | <p>Forging stock shall be clean and free from harmful defects (such as cracks, pits, score marks, rolled or forged in debris).</p> <p>Machined forging stock may be tested in accordance with ASTM E 709 and ASTM E 1444 for magnetic steels and EN 2002-16 or equivalent method agreed between the manufacturer and the purchaser for non-magnetic steels and heat resisting alloys.</p> <p>Local dressing may be carried out by the manufacturer provided the dimensions of the product remain within the tolerance limits. It shall be carried out under the conditions agreed between the manufacturer and the purchaser.</p> |                        |

| 46   |                         | Fatigue   |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
|--|-------------------------|---|------------------------|--|-------------------------|------------------------|-----------|--------------|--------|------------------|--------------|-----------------------------|--------|--------------|------------|
| Test method                                | 1                       | EN 3874, 3987 or 3988 as appropriate  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Frequency of testing                       | 2                       | <b>Qualification</b>  | <b>Release testing</b> |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
|  |                         | <i>1 per batch</i>  | Not normally used      |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Sample type                                | 3                       | <p>Test specimen orientation and location shall be in accordance with:</p> <table border="1"> <thead> <tr> <th>Minor transverse dimension of product (mm)</th> <th>Direction of test piece</th> <th>Location of test piece</th> </tr> </thead> <tbody> <tr> <td><math>\leq 25</math></td> <td>Longitudinal</td> <td>Centre</td> </tr> <tr> <td><math>25 &lt; D \leq 75</math></td> <td>Longitudinal</td> <td>at 12,5 mm from the surface</td> </tr> <tr> <td><math>&gt; 75</math></td> <td>Longitudinal</td> <td>Mid radius</td> </tr> </tbody> </table> |                        | Minor transverse dimension of product (mm) | Direction of test piece | Location of test piece | $\leq 25$ | Longitudinal | Centre | $25 < D \leq 75$ | Longitudinal | at 12,5 mm from the surface | $> 75$ | Longitudinal | Mid radius |
| Minor transverse dimension of product (mm) | Direction of test piece | Location of test piece  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| $\leq 25$                                  | Longitudinal            | Centre  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| $25 < D \leq 75$                           | Longitudinal            | at 12,5 mm from the surface   |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| $> 75$                                     | Longitudinal            | Mid radius  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Test piece definition                      | 4                       | See subline 1.  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Heat treatment condition of test piece     | 5                       | Use condition.  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Testing condition                          | 6                       | See material standard or as agreed between the manufacturer and purchaser.  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |
| Acceptance criteria                        | 7                       | See material standard.  |                        |  |                         |                        |           |              |        |                  |              |                             |        |              |            |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (continued)

| 50                                     | Inclusion content (steels)   |  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|--|------------------------------|--|----------------|------------------------------|--|-------------------------------|---|------------|-----------------------------------|-------------|---|------------------|---|------------------|---|----------|---|
| Test method                            | 1                            | EN 2951  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Frequency of testing                   | 2                            | <b>Qualification</b>   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  |                              | <i>Top, middle and bottom of ingot</i>   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  |                              | <b>Release testing</b>   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  |                              | Top and bottom ingot   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  |                              | Frequency as shown in the following table:   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  |                              | <table border="1"> <thead> <tr> <th>Melting method</th> <th>Number of ingots in the cast</th> <th>Minimum number of ingots to be samples</th> </tr> </thead> <tbody> <tr> <td>Consumable electrode remelted</td> <td>–</td> <td>Each ingot</td> </tr> <tr> <td rowspan="4">Air melted<br/>or<br/>vacuum melted</td> <td><math>N \leq 10</math></td> <td>2</td> </tr> <tr> <td><math>10 &lt; N \leq 25</math></td> <td>3</td> </tr> <tr> <td><math>25 &lt; N \leq 40</math></td> <td>4</td> </tr> <tr> <td><math>N &gt; 40</math></td> <td>5</td> </tr> </tbody> </table> | Melting method | Number of ingots in the cast | Minimum number of ingots to be samples | Consumable electrode remelted | – | Each ingot | Air melted<br>or<br>vacuum melted | $N \leq 10$ | 2 | $10 < N \leq 25$ | 3 | $25 < N \leq 40$ | 4 | $N > 40$ | 5 |
| Melting method                         | Number of ingots in the cast | Minimum number of ingots to be samples   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Consumable electrode remelted          | –                            | Each ingot   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Air melted<br>or<br>vacuum melted      | $N \leq 10$                  | 2  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  | $10 < N \leq 25$             | 3  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  | $25 < N \leq 40$             | 4  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
|  | $N > 40$                     | 5  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Sample type                            | 3                            | Samples shall be taken at the earliest convenient stage in manufacture following adequate working of the "as cast" structure and shall be in the form of transverse slices.  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Test piece definition                  | 4                            | See EN 2951.   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Heat treatment condition of test piece | 5                            | –  |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Testing condition                      | 6                            | See EN 2951.   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |
| Acceptance criteria                    | 7                            | See material standard.   |                |                              |  |                               |   |            |                                   |             |   |                  |   |                  |   |          |   |

| 51                                     | Macrostructure |   |
|--|----------------|---|
| Test method                            | 1              | EN 2950 (HRA) or ASTM A604 (steels)   |
| Frequency of testing                   | 2              | <b>Qualification</b>  |
|  |                | <i>2 from each final ingot corresponding to top and bottom of ingot</i>                             |
|  |                | <b>Release testing</b>  |
|  |                | 1 from each cast for air melted forging stock<br>1 from each final ingot for remelted forging stock |
| Sample type                            | 3              | Transverse slice shall be taken at a convenient stage of manufacture.                               |
| Test piece definition                  | 4              | See EN 2950 or ASTM A604.   |
| Heat treatment condition of test piece | 5              | Delivery condition  |
| Testing condition                      | 6              | See EN 2950 or ASTM A604.   |
| Acceptance criteria                    | 7              | Samples shall be free from unsoundness, seams and detrimental segregation.                          |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (continued)

| 59                                     |   | Carburization and decarburization   |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|--|---|---|----------------------------------|--|---|---------------------------------|------------|---------------------------------------|--------------------|---|------|-------------------------|---|------|-------------------------|-----|------|--------------------------|-----|------|------------------|-----|---|---------------------------------------|---------------------------|--|--|
| Test method                            | 1   | EN ISO 3887   |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Frequency of testing                   | 2   | <b>Qualification</b>  | <b>Release testing</b>           |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|  |   | <i>1 per batch</i>  | The "capability clause" applied. |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Sample type                            | 3   | All gauge   |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Test piece definition                  | 4   | See EN ISO 3887.  |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Heat treatment condition of test piece | 5   | Delivery condition  |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Testing condition                      | 6   | See EN ISO 3887.  |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| Acceptance criteria                    | 7   | <p>Unless otherwise specified by the material standard or order, the material shall be free from carburization. Decarburization may be present within the limits given in the following table:</p> <table border="1"> <thead> <tr> <th></th> <th>Diameter (<i>D</i>) or thickness (<i>a</i>)<br/>mm</th> <th>Max. decarburization depth<br/>%</th> <th>Max.<br/>mm</th> </tr> </thead> <tbody> <tr> <td rowspan="5"><b>Non machined<br/>Forging stock</b></td> <td><math>D</math> or <math>a \leq 10</math></td> <td>4</td> <td>0,40</td> </tr> <tr> <td><math>10 &lt; D</math> or <math>a \leq 25</math></td> <td>3</td> <td>0,75</td> </tr> <tr> <td><math>25 &lt; D</math> or <math>a \leq 60</math></td> <td>2,0</td> <td>1,20</td> </tr> <tr> <td><math>60 &lt; D</math> or <math>a \leq 100</math></td> <td>1,5</td> <td>1,50</td> </tr> <tr> <td><math>D</math> or <math>a &gt; 100</math></td> <td>1,5</td> <td>–</td> </tr> <tr> <td><b>Machined bar<br/>Forging stock</b></td> <td colspan="3">Free from decarburization</td> </tr> </tbody> </table> |                                  |  | Diameter ( <i>D</i> ) or thickness ( <i>a</i> )<br>mm | Max. decarburization depth<br>% | Max.<br>mm | <b>Non machined<br/>Forging stock</b> | $D$ or $a \leq 10$ | 4 | 0,40 | $10 < D$ or $a \leq 25$ | 3 | 0,75 | $25 < D$ or $a \leq 60$ | 2,0 | 1,20 | $60 < D$ or $a \leq 100$ | 1,5 | 1,50 | $D$ or $a > 100$ | 1,5 | – | <b>Machined bar<br/>Forging stock</b> | Free from decarburization |  |  |
|  | Diameter ( <i>D</i> ) or thickness ( <i>a</i> )<br>mm | Max. decarburization depth<br>%   | Max.<br>mm                       |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| <b>Non machined<br/>Forging stock</b>  | $D$ or $a \leq 10$                                    | 4   | 0,40                             |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|  | $10 < D$ or $a \leq 25$                               | 3   | 0,75                             |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|  | $25 < D$ or $a \leq 60$                               | 2,0   | 1,20                             |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|  | $60 < D$ or $a \leq 100$                              | 1,5   | 1,50                             |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
|  | $D$ or $a > 100$                                      | 1,5   | –                                |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |
| <b>Machined bar<br/>Forging stock</b>  | Free from decarburization                             |   |                                  |  |   |                                 |            |                                       |                    |   |      |                         |   |      |                         |     |      |                          |     |      |                  |     |   |                                       |                           |  |  |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (continued)

| 61                                     |   | Internal defects   |                        |
|--|---|--|------------------------|
| Test method                            | 1 | EN 4050-1  |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>   | <b>Release testing</b> |
|  |   | <i>Each product 100 %</i>  | Each product 100 %     |
| Sample type                            | 3 | Products with diameter or minor sectional dimension > 100 mm shall be tested in the delivery condition. Products with diameter or minor sectional dimension ≤ 100 mm may be ultrasonically tested at an intermediate stage of manufacture. |                        |
| Test piece definition                  | 4 | -  |                        |
| Heat treatment condition of test piece | 5 | Depending from the stage of manufacture while the test is release  |                        |
| Testing condition                      | 6 | -  |                        |
| Acceptance criteria                    | 7 | See EN 4050-4 and material standard  |                        |

| 82                                     |   | Batch uniformity  |                        |
|--|---|---|------------------------|
| Test method                            | 1 | The method used shall be at the discretion of the manufacturer.                   |                        |
| Frequency of testing                   | 2 | <b>Qualification</b>  | <b>Release testing</b> |
|  |   | <i>Each product 100 %</i>   | Each product 100 %     |
| Sample type                            | 3 | See subline 1.  |                        |
| Test piece definition                  | 4 | -   |                        |
| Heat treatment condition of test piece | 5 | Delivery condition  |                        |
| Testing condition                      | 6 | The product shall be tested at final inspection.                                  |                        |
| Acceptance criteria                    | 7 | The manufacturer has to guarantee that all the products belong to the same batch. |                        |

Table 2 — Technical requirements for lines 30 onwards, where appropriate (*concluded*)

| 95                                     | Marking inspection |  |
|--|--------------------|--|
| Test method                            | 1                  | Visual inspection  |
| Frequency of testing                   | 2                  | <b>Qualification</b>   |
|  |                    | <b>Release testing</b>   |
|  |                    | Sufficient to certify compliance   |
| Sample type                            | 3                  | -  |
| Test piece definition                  | 4                  | -  |
| Heat treatment condition of test piece | 5                  | -  |
| Testing condition                      | 6                  | -  |
| Acceptance criteria                    | 7                  | The requirements of line 6.1 of this technical specification shall be met. |

| 96                                     | Dimensional inspection |  |
|--|------------------------|--|
| Test method                            | 1                      | Measuring equipment and procedures suitable for the tolerances shall be used.                                |
| Frequency of testing                   | 2                      | <b>Qualification</b>   |
|  |                        | <b>Release testing</b>   |
|  |                        | Sufficient to certify compliance   |
| Sample type                            | 3                      | -  |
| Test piece definition                  | 4                      | -  |
| Heat treatment condition of test piece | 5                      | -  |
| Testing condition                      | 6                      | -  |
| Acceptance criteria                    | 7                      | Dimensions and tolerances shall conform to the requirements of the dimensional standard stated on the order. |

|    |       |   |   |
|----|-------|---|---|
| 98 | Notes | - | Normative and/or interpretive notes appearing on pages 4 and 5 of the material standard |
|----|-------|---|---|

|    |             |   |  |
|----|-------------|---|--|
| 99 | Typical use | - | This line is not normally completed for steel and heat resisting alloys. |
|----|-------------|---|--|

|     |               |   |   |
|-----|---------------|---|---|
| 100 | Qualification | - | For approval of the manufacturer's quality systems, see EN 9100.<br>For product qualification, see EN 9133. |
|-----|---------------|---|---|



# British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

## About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards-based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

## Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at [bsigroup.com/standards](http://bsigroup.com/standards) or contacting our Customer Services team or Knowledge Centre.

## Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at [bsigroup.com/shop](http://bsigroup.com/shop), where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

## Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to [bsigroup.com/subscriptions](http://bsigroup.com/subscriptions).

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

**PLUS** is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit [bsigroup.com/shop](http://bsigroup.com/shop).

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email [bsmusales@bsigroup.com](mailto:bsmusales@bsigroup.com).

## BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

## Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

## Copyright

All the data, software and documentation set out in all British Standards and other BSI publications are the property of and copyrighted by BSI, or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI. Details and advice can be obtained from the Copyright & Licensing Department.

## Useful Contacts:

### Customer Services

**Tel:** +44 845 086 9001

**Email (orders):** [orders@bsigroup.com](mailto:orders@bsigroup.com)

**Email (enquiries):** [cservices@bsigroup.com](mailto:cservices@bsigroup.com)

### Subscriptions

**Tel:** +44 845 086 9001

**Email:** [subscriptions@bsigroup.com](mailto:subscriptions@bsigroup.com)

### Knowledge Centre

**Tel:** +44 20 8996 7004

**Email:** [knowledgecentre@bsigroup.com](mailto:knowledgecentre@bsigroup.com)

### Copyright & Licensing

**Tel:** +44 20 8996 7070

**Email:** [copyright@bsigroup.com](mailto:copyright@bsigroup.com)