BS EN 4700-005:2010

BSI Standards Publication

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

Part 005: Forging stock

National foreword

This British Standard is the UK implementation of EN 4700-005:2010.

The UK participation in its preparation was entrusted to Technical Committee ACE/61/-/48, Heat Resisting Alloys for Aerospace Purposes.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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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of an identical text or by endorsement, at the latest by March 2011, and conflicting national standards shall be withdrawn at the latest by March 2011.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* [1)]

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* [1)]

EN 3874, *Aerospace series — Test methods for metallic materials — Constant amplitude force-controlled low cycle fatigue testing* [1)]

EN 3987, *Aerospace series — Test method for metallic materials — Constant amplitude force-controlled high cycle fatigue testing* [1)]

EN 3988, *Aerospace series — Test methods for metallic materials — Constant amplitude strain-controlled low cycle fatigue testing* [1)]

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

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

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* [1)]

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* [2)]

AMS 2750, *Pyrometry* [2)]

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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).

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* 3)

ASTM E709, *Standard Guide for Magnetic Particle Testing* 3)

ASTM E1444, *Standard Practice for Magnetic Particle Testing* 3)

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	The chemical composition of the alloy shall comply with requirements of the material standard. The samples taken for analysis shall be representative of the melt. 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. In the case of remelted material, samples shall be taken from positions as follows: a) *Vacuum arc remelted (VAR) ingots*: the bottom of each ingot or ingot product. b) *Electroflux or electroslag remelted (ESR) ingots*: the top and bottom ends of each ingot or ingot product. 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. 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. 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. Additionally for remelted products, the samples shall be representative for the remelted ingot, taking into account any macro segregation.	*a) 1 per cast in the case of air melted or vacuum induction melted product* *b) 2 per VAR or ESR ingot representing top and bottom positions*	*a) 1 per cast in the case of air melted or vacuum induction melted product* *b) 1 on one ingot or ingot product in case of VAR or ESR products*
3	Method of melting	**1 General** 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. **2 Consumable electrode remelted material** **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.	–	–

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			
3	Method of melting *(concluded)*	**2.2** 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. **2.3** 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. **2.4** 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.	–	–
4.1	Form	Forging stock	–	–
4.2	Method of production	**Mechanical hot working:** The manufacturer shall establish a procedure for mechanical hot working. This procedure shall define: — the homogenisation thermal cycle; — the thermo-mechanical working processes; — 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. **Mechanical cold working (if any):** The manufacturer shall establish a procedure for the mechanical cold working. This procedure shall define: — the mechanical working processes; — the manufacturing schedule for each process; the dimensions of the products at each step and heat treatment conditions between operations. Unless otherwise specified in the order or schedule, all forging stock shall be worked with a minimum cross-section ratio of 3:1.	–	–

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			
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	Product shall be supplied in the delivery condition specified in this line in the material standard and/or as stated on the order. **Marking:** 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. Each forging stock shall bear the following identification marking: — material standard number, — cast/ingot number, — batch number, — forging stock identification number, when required, — delivery condition if heat treatment is required by the order, — identification of manufacturer. Identification marking shall be: — hard stamped at least once on each length of forging stock ≥ 12,5 mm, — on a durable label for forging stock < 12,5 mm supplied in bundles. **Packing:** All necessary precautions shall be taken to prevent damage to the product, especially where the delivered surface finish shall be maintained. The packing shall be suitable for the type of transportation used. The exterior of the packing shall bear the following information: — name and address of recipient, — mass, — order number and sufficient information to enable the contents to be related to the relevant documentation.	–	–

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
6.1	Delivery condition *(concluded)*	**Shipment:** 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. Test samples may be worked before reference heat treatment in order to simulate the forging and/or to obtain a representative cross section. 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. Test pieces shall be machined from the test samples taken in accordance with the requirements of line 8.1 of this technical specification. 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.	–	–

Term	Abbreviation/Symbol	Term	Abbreviation/Symbol
temperature	θ	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	
No.	Title				*Qualification*	Release
8.3	Heat treatment *(concluded)*			AMS 2750 to be used unless otherwise agreed between customer and supplier. 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: **Selected temperatures °C** / **Tolerances °C** $\theta < 750$ / ± 5 $750 \leq \theta \leq 1\,250$ / ± 10 $\theta > 1\,250$ / ± 15 When the duration of the heat treatment is stated as a fixed value, the tolerance shall be: $(^{+\,20}_{0})$ %.	–	–
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. 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	θ	°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	Tensile testing shall be carried out in accordance with EN 2002-001 for testing at ambient temperature and EN 2002-002 for testing at elevated temperature. EN ISO 6892-1 and EN ISO 6892-2 are also applicable subject to agreement between customer and supplier on the test method (A or B method). The tensile test specimen location and direction within the product shall be in accordance with the following table: **Minor transverse dimension of product mm** / **Direction of test piece** / **Location of test piece** ≤ 25 / Longitudinal / Centre $25 < D \leq 75$ / Longitudinal / at 12,5 mm from the surface > 75 / Longitudinal or transverse / Mid radius	*2 specimens per batch*	1 specimen per batch
14	Strength	R_m	MPa			
15	Elongation	A	%			
16	Reduction of area	Z	%			

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. 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	Test in accordance with EN 10045-1 (Charpy V or U notch) or EN 2003-2 (Izod) as required by the material standard. The test specimen location and direction shall be in accordance with the following table: **Minor transverse dimension of product** 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 The notch shall be towards the centre of the product. 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.	*2 sets of 3 tests per batch*	1 set of 3 tests per batch

continued

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

<table>
<tr><th colspan="4">Material standard line reference</th><th rowspan="2">Requirements</th><th colspan="2">Frequency of testing</th></tr>
<tr><th>No.</th><th colspan="3">Title</th><th>Qualification</th><th>Release</th></tr>
<tr><td colspan="4">Creep parameters</td><td>Lines 21-26</td><td>–</td><td>–</td></tr>
<tr><td>21</td><td>Temperature</td><td>θ</td><td>°C</td><td rowspan="2">As specified in the material standard and relates to the temperature at which the creep and/or stress rupture tests are carried out.</td><td>–</td><td>–</td></tr>
<tr><td>22</td><td>Time</td><td></td><td>h</td><td></td><td></td></tr>
<tr><td>23</td><td>Stress</td><td>σ_a</td><td>MPa</td><td rowspan="4">Test in accordance with EN 2002-005.
The test piece definition shall be one of those indicated in EN 2002-005, unless otherwise agreed.
The test specimen location and direction shall be in accordance with the following table:
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.
<table><tr><th>Minor transverse dimension of product (mm)</th><th>Direction of test piece</th><th>Location of test piece</th></tr><tr><td>≤ 25</td><td>Longitudinal</td><td>Centre</td></tr><tr><td>25 < D ≤ 75</td><td>Longitudinal</td><td>at 12,5 mm from the surface</td></tr><tr><td>> 75</td><td>Longitudinal or transverse</td><td>Mid radius</td></tr></table></td><td rowspan="4">2 specimens per batch</td><td rowspan="4">1 specimen per batch</td></tr>
<tr><td>24</td><td>Elongation</td><td>a</td><td>%</td></tr>
<tr><td>25</td><td>Rupture stress</td><td>σ_R</td><td>MPa</td></tr>
<tr><td>26</td><td>Elongation at rupture</td><td>A</td><td>%</td></tr>
<tr><td>27</td><td colspan="3">Notes</td><td>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.</td><td>–</td><td>–</td></tr>
<tr><td>29</td><td colspan="3">Reference heat treatment</td><td>When required, reference heat treatment is applied to the test samples, see line 8.3.</td><td>–</td><td>–</td></tr>
</table>

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

30		**Microstructure (heat resisting alloys)**	
Test method	1	EN 2950	
Frequency of testing	2	***Qualification***	**Release testing**
		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 (δ Ferrite for steels)**	
Test method	1	AMS 2315 (for δ ferrite)	
Frequency of testing	2	***Qualification***	**Release testing**
		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	***Qualification***	**Release testing**
		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	***Qualification***	**Release testing**
		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	***Qualification***	**Release testing**
		Each product 100 %	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	Forging stock shall be clean and free from harmful defects (such as cracks, pits, score marks, rolled or forged in debris). 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. 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.	

46	**Fatigue**		
Test method	1	EN 3874, 3987 or 3988 as appropriate	
Frequency of testing	2	***Qualification***	**Release testing**
		1 per batch	Not normally used
Sample type	3	Test specimen orientation and location shall be in accordance with:	

Minor transverse dimension of product (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	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)*

<table>
<tr><td>50</td><td colspan="3">Inclusion content (steels)</td></tr>
<tr><td>Test method</td><td>1</td><td colspan="2">EN 2951</td></tr>
<tr><td rowspan="4">Frequency of testing</td><td rowspan="4">2</td><td>Qualification</td><td>Release testing</td></tr>
<tr><td>Top, middle and bottom of ingot</td><td>Top and bottom ingot</td></tr>
<tr><td colspan="2">Frequency as shown in the following table:
<table>
<tr><th>Melting method</th><th>Number of ingots in the cast</th><th>Minimum number of ingots to be samples</th></tr>
<tr><td>Consumable electrode remelted</td><td>–</td><td>Each ingot</td></tr>
<tr><td rowspan="4">Air melted
or
vacuum melted</td><td>N ≤ 10</td><td>2</td></tr>
<tr><td>10 < N ≤ 25</td><td>3</td></tr>
<tr><td>25 < N ≤ 40</td><td>4</td></tr>
<tr><td>N > 40</td><td>5</td></tr>
</table></td></tr>
<tr><td>Sample type</td><td>3</td><td colspan="2">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.</td></tr>
<tr><td>Test piece definition</td><td>4</td><td colspan="2">See EN 2951.</td></tr>
<tr><td>Heat treatment condition of test piece</td><td>5</td><td colspan="2">–</td></tr>
<tr><td>Testing condition</td><td>6</td><td colspan="2">See EN 2951.</td></tr>
<tr><td>Acceptance criteria</td><td>7</td><td colspan="2">See material standard.</td></tr>
</table>

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

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

<table>
<tr><td>59</td><td colspan="3">Carburization and decarburization</td></tr>
<tr><td>Test method</td><td>1</td><td colspan="2">EN ISO 3887</td></tr>
<tr><td rowspan="2">Frequency of testing</td><td rowspan="2">2</td><td>Qualification</td><td>Release testing</td></tr>
<tr><td>1 per batch</td><td>The “capability clause” applied.</td></tr>
<tr><td>Sample type</td><td>3</td><td colspan="2">All gauge</td></tr>
<tr><td>Test piece definition</td><td>4</td><td colspan="2">See EN ISO 3887.</td></tr>
<tr><td>Heat treatment condition of test piece</td><td>5</td><td colspan="2">Delivery condition</td></tr>
<tr><td>Testing condition</td><td>6</td><td colspan="2">See EN ISO 3887.</td></tr>
<tr><td>Acceptance criteria</td><td>7</td><td colspan="2">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:
<table>
<tr><th></th><th>Diameter (D) or thickness (a)
mm</th><th>Max. decarburization depth
%</th><th>Max.
mm</th></tr>
<tr><td rowspan="5">Non machined Forging stock</td><td>D or a ≤ 10</td><td>4</td><td>0,40</td></tr>
<tr><td>10 < D or a ≤ 25</td><td>3</td><td>0,75</td></tr>
<tr><td>25 < D or a ≤ 60</td><td>2,0</td><td>1,20</td></tr>
<tr><td>60 < D or a ≤ 100</td><td>1,5</td><td>1,50</td></tr>
<tr><td>D or a > 100</td><td>1,5</td><td>–</td></tr>
<tr><td>Machined bar Forging stock</td><td colspan="3">Free from decarburization</td></tr>
</table></td></tr>
</table>

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

61	**Internal defects**		
Test method	1	EN 4050-1	
Frequency of testing	2	***Qualification***	**Release testing**
		Each product 100 %	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	***Qualification***	**Release testing**
		Each product 100 %	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	***Qualification***	**Release testing**
		Each length	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	***Qualification***	**Release testing**
		Each product	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. For product qualification, see EN 9133.

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