BS EN 10294-2:2012

BSI Standards Publication

Hollow bars for machining — Technical delivery conditions

Part 2: Stainless steels with specified machinability properties

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National foreword

This British Standard is the UK implementation of EN 10294-2:2012.

The UK participation in its preparation was entrusted to Technical Committee ISE/110, Steel Tubes, and Iron and Steel Fittings.

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.

ISBN 978 0 580 63805 3

ICS 77.140.75

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 February 2012.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10294-2

February 2012

ICS 77.140.75

English Version

Hollow bars for machining - Technical delivery conditions - Part 2: Stainless steels with specified machinability properties

Barres creuses pour usinage - Conditions techniques de livraison - Partie 2: Aciers inoxydables à usinabilité spécifiée

Stahlrohre für die spanende Bearbeitung (Drehteilrohre) - Technische Lieferbedingungen - Teil 2: Nichtrostende Stähle mit spezifizierten Zerspanungseigenschaften

This European Standard was approved by CEN on 16 December 2011.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 10294-2:2012) has been prepared by Technical Committee ECISS/TC 110 “Steel tubes, and iron and steel fittings”, the secretariat of which is held by UNI.

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of an identical text or by endorsement, at the latest by August 2012, and conflicting national standards shall be withdrawn at the latest by August 2012.

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.

This document differs from ISO 2938, *Hollow bars for machining.*

EN 10294 consists of the following parts, under the general title *Hollow bars for machining — Technical delivery conditions*:

— Part 1: Non alloy and alloy steels;

— Part 2: Stainless steels with specified machinability properties.

Another European Standard series covering tubes for mechanical and general engineering purposes are:

— EN 10297, *Seamless circular steel tubes for mechanical and general engineering purposes - Technical delivery conditions*

— EN 10296, *Welded circular steel tubes for mechanical and general engineering purposes - Technical delivery conditions*.

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, Turkey and the United Kingdom.

1 Scope

This part of EN 10294 specifies the technical delivery conditions for seamless hollow bars made of austenitic (including creep resisting steels) and austenitic-ferritic (duplex) stainless steels, with specified machinability properties, intended for the manufacture of engineering components by machining.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10020, *Definition and classification of grades of steel*

EN 10021, *General technical delivery conditions for steel products*

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

EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

EN 10052, *Vocabulary of heat treatment terms for ferrous products*

EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

EN 10168, *Steel products — Inspection documents — List of information and description*

EN 10204, *Metallic products — Types of inspection documents*

CEN/TR 10261, *Iron and steel — Review of available methods of chemical analysis*

EN 10266, *Steel tubes, fittings and structural hollow sections — Symbols and definitions of terms for use in product standards*

EN ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (ISO 377)*

EN ISO 2566-2, *Steel — Conversion of elongation values — Part 2: Austenitic steels (ISO 2566-2)*

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 sulphuric acid (ISO 3651-2)*

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

EN ISO 10893-10, *Non-destructive testing of steel tubes — Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-10)*

ISO 3685, *Tool-life testing with single-point turning tools*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 10021, EN 10052 and EN 10266 and the following apply.

3.1
hollow bar
circular hollow product for machining made by a seamless tube manufacturing process or by drilling a bore into a rolled or forged bar

3.2
guaranteed cutting speed
lowest cutting speed guaranteed by the manufacturer to obtain a specified minimum tool-life time with a fixed set of machining parameters for a certain steel grade

3.3
centring on the outside diameter
first chucking is made on the outside diameter and machining is performed on the outside surface and/or on the inside surface

3.4
centring on the inside diameter
first chucking is made on the inside diameter and machining is performed on the outside surface and/or on the inside surface

4 Symbols

In addition to (or deviating from) the symbols defined in EN 10266 the following symbols apply:

D Outside diameter;

d Inside diameter;

$D_{(e)}$ Maximum achievable outside diameter when centring on the outside diameter;

$d_{(e)}$ Minimum achievable inside diameter when centring on the outside diameter;

$D_{(i)}$ Maximum achievable outside diameter when centring on the inside diameter;

$d_{(i)}$ Minimum achievable inside diameter when centring on the inside diameter;

T_N Nominal wall thickness, calculated as the half difference between the nominal outside diameter D and the nominal inside diameter d;

v_c (Velocity cutting) Cutting speed.

5 Classification and designation

5.1 Classification

According to the classification system in EN 10020 and to their structure, the steel grades in this European Standard are classified as:

— austenitic stainless steels (corrosion resisting or creep resisting steels);

— austenitic-ferritic (duplex) stainless steels.

For more details see EN 10088-1.

5.2 Designation

For hollow bars covered by this part of this European Standard the steel designation consists of:

— the number of this part of this European Standard (EN 10294-2);

plus either:

— the steel name in accordance with EN 10027-1;

or:

— the steel number allocated in accordance with EN 10027-2.

6 Information to be supplied by the purchaser

6.1 Mandatory information

The following information shall be supplied by the purchaser at the time of enquiry and order:

a) quantity (mass or total length or number);

b) term "hollow bar";

c) hollow bar size code (outside diameter and inside diameter);

d) reference to this European Standard (EN 10294-2);

e) steel designation (steel name or steel number) (see 5.2);

f) mechanical properties for tubes with wall thicknesses T_N > 50 mm.

6.2 Options

A number of options are specified in this European Standard and these are listed below. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the hollow bars shall be supplied in accordance with the basic specification (see 6.1).

a) product analysis (see 8.2.2);

b) corrosion resistance (see 8.4);

c) specify the machinability with reference to the Taylor method (specification of constants α and C) (see 8.5);

d) special requirements on surface condition, either outside or inside, as specified by the purchaser (see 8.6.1);

e) non-destructive testing (see 8.6.2);

f) other dimensional requirements (see 8.9.1);

g) exact lengths (see 8.9.3).

6.3 Example of an order

50 tonnes of hollow bars, 140 mm outside and 90 mm inside diameter, in accordance with EN 10294-2, made of steel grade 1.4307 (X2CrNi18-9):

50 t hollow bars – 140 X 90 – EN 10294-2 – 1.4307

or

50 t hollow bars – 140 X 90 – EN 10294-2 – X2CrNi18-9

7 Manufacturing process

7.1 Material making process

The steels covered by this European Standard are characterized by their suitability for machining (see 8.5). The material making process is left at the discretion of the manufacturer provided all requirements defined in Clause 8 can be fulfilled with the material produced.

7.2 Manufacturing and delivery conditions

7.2.1 Manufacturing

The hollow bars shall be made by a seamless process or by drilling from round bars. At the discretion of the manufacturer the hollow bars may be hot finished or cold finished. The terms “hot finished“ and “cold finished“ apply to the condition of the hollow bar before it is heat treated in accordance with 7.2.2.

7.2.2 Delivery conditions

The hollow bars shall be supplied in the solution annealed condition over their full length in either:

— reference heat treatment conditions;

— solution annealed condition obtained directly by extrusion and subsequent rapid cooling provided the mechanical properties, corrosion resistance and other properties are in accordance with this European Standard. All specified mechanical properties shall be met even after a subsequent reference heat treatment.

8 Requirements

8.1 General

The hollow bars, when supplied in the delivery condition in 7.2.2 and inspected in accordance with Clause 9, Clause 10 and Clause 11, shall comply with the requirements of this part of this European standard.

In addition, the general technical delivery requirements specified in EN 10021 shall apply.

8.2 Chemical composition

8.2.1 Cast analysis

The cast analysis reported by the material manufacturer shall apply and comply with the requirements of Tables 1 and 2.

8.2.2 Product analysis

In case of dispute the permissible deviations of a product analysis from the limits of cast analysis specified in Tables 1 and 2 are given in Table 3.

Option a: *Product analysis shall be supplied.*

NOTE When welding hollow bars produced according to this European Standard, account shall be taken of the fact that the behaviour of the steel during and after welding is dependent not only on the steel, but also on the material thickness and the conditions of preparing for and carrying out welding.

Table 1 — Chemical composition (cast analysis)[a] of austenitic stainless steels in % by mass

Steel grade		C max	Si max	Mn max	P max	S	N max	Cr	Mo	Ni	Others
Steel name	Steel number										
X2CrNi19-11	1.4306	0,030	1,00	2,00	0,040	0,015-0,030	0,10	17,0-19,0	-	10,0-12,0	-
X2CrNi18-9	1.4307	0,030	1,00	2,00	0,040	0,015-0,030	0,10	17,5-19,5	-	8,0-10,5	-
X5CrNi18-10	1.4301	0,07	1,00	2,00	0,040	0,015-0,030	0,10	17,5-19,5	-	8,0-10,5	-
X8CrNiS18-9	1.4305	0,10	1,00	2,00	0,040	0,15-0,35	0,10	17,0-19,0	-	8,0-10,0	Cu ≤ 1.00
X2CrNiMo17-12-2	1.4404	0,030	1,00	2,00	0,040	0,015-0,030	0,10	16,5-18,5	2,00-2,50	10,0-13,0	-
X5CrNiMo17-12-2	1.4401	0,07	1,00	2,00	0,040	0,015-0,030	0,10	16,5-18,5	2,00-2,50	10,0-13,0	-
X6CrNiMoTi17-12-2	1.4571	0,08	1,00	2,00	0,040	0,015-0,030	-	16,5-18,5	2,00-2,50	10,5-13,5	Ti 5xC-0.70
X2CrNiMo18-14-3	1.4435	0,030	1,00	2,00	0,040	0,015-0,030	0,10	17,0-19,0	2,50-3,00	12,5-15,0	-

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

Table 2 — Chemical composition (cast analysis)[a] of austenitic-ferritic stainless steels in % by mass

Steel grade		C max	Si max	Mn max	P max	S max	N	Cr	Mo	Ni
Steel name	Steel number									
X3CrNiMoN27-5-2	1.4460	0,05	1,00	2,00	0,035	0,015	0,05-0,20	25,0-28,0	1,30-2,00	4,5-6,5
X2CrNiMoN22-5-3	1.4462	0,030	1,00	2,00	0,035	0,015	0,10-0,22	21,0-23,0	2,50-3,5	4,5-6,5

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

Table 3 — Permissible deviations of the product analysis from specified limits on cast analysis given in Tables 1 and 2

Element	Limiting value for the cast analysis according to tables 1 and 2 % by mass	Permissible deviation of the product analysis[a] % by mass
Carbon	≤ 0,030	+ 0,005
	> 0,030 ≤ 0,10	± 0,01
Silicon	≤ 1,00	± 0,05
Manganese	≤ 2,00	+ 0,04
Phosphorus	≤ 0,015	± 0,003
	> 0,015 ≤ 0,045	± 0,005
Sulphur	≤ 0,030	+ 0,003
	> 0,030 ≤ 0,35	± 0,005
Nitrogen	≤ 0,22	± 0,01
Chromium	≥ 16,5 ≤ 20,0	± 0,20
	>20,0 ≤ 28,0	± 0,25
Molybdenum	> 1,30 ≤ 1,75	± 0,05
	> 1,75 ≤ 3,5	± 0,10
Nickel	> 4,5 ≤ 5,0	± 0,07
	> 5,0 ≤ 10,0	± 0,10
	> 10,0 ≤ 20,0	± 0,15
	> 20,0 ≤ 35,0	± 0,20

[a] If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or to fall short of the permissible minimum value, but not both for one cast.

8.3 Mechanical properties

8.3.1 The mechanical properties at room temperature shall conform to the requirements of Tables 4 and 5.

Table 4 — Mechanical properties of austenitic corrosion resisting steels in the solution annealed condition

Steel grade		Proof strength	Proof strength	Tensile strength	Elongation[a] A min (%)		Reference heat treatment conditions		Resistance to intergranular corrosion	
Name	Number	$R_{p0,2}$ min MPa	$R_{p1,0}$ min MPa	R_m MPa	l	t	Solution temperature[b]	Cooling in[c]	d	Method in EN ISO 3651-2
X2CrNi19-11	1.4306	180	215	460-680	40	35	1000-1100	w,a	yes	A
X2CrNi18-9	1.4307	180	215	460-680	40	35	1000-1100	w,a	yes	A
X5CrNi18-10	1.4301	195	225	500-700	40	35	1000-1100	w,a	yes[e]	A
X8CrNiS18-9	1.4305	190	225	500-700	35	30	1000-1100	w,a	no	-
X2CrNiMo17-12-2	1.4404	190	225	490-690	40	30	1020-1120	w,a	yes	A
X5CrNiMo17-12-2	1.4401	200	235	500-700	40	30	1020-1120	w,a	yes[e]	A
X6CrNiMoTi17-12-2	1.4571	190	225	490-690	35	30	1020-1120	w,a	yes	A
X2CrNiMo18-14-3	1.4435	190	225	490-690	40	30	1020-1120	w,a	yes	A

a l = longitudinal t = transverse

b The maximum temperatures are for guidance only.

c w = water a = air; cooling sufficiently rapidly.

d When tested according to EN ISO 3651-2 (Appropriate method A or B or C as indicated).

e In delivery condition (Normally not fulfilled in the sensitized condition).

Table 5 — Mechanical properties of austenitic–ferritic stainless steels in the solution annealed condition

Steel grade		Proof strength	Tensile strength	Elongation[a] A min (%)		Reference heat treatment conditions		Resistance to intergranular corrosion	
Name	Number	$R_{p0,2}$ min MPa	R_m MPa	l	t	Solution temperature[b]	Cooling in[c]	d	Method in EN ISO 3651-2
X3CrNiMoN27-5-2	1.4460	460	620-880	20	20	1050-1100	w,a	yes	A
X2CrNiMoN22-5-3	1.4462	450	640-880	22	22	1020-1100	w,a	yes	B

[a] l = longitudinal t = transverse

[b] The maximum temperatures are for guidance only.

[c] w = water a = air; cooling sufficiently rapidly.

[d] When tested according to EN ISO 3651-2 (Appropriate method A or B or C as indicated).

For wall thicknesses T_N > 50 mm, the mechanical properties shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

8.4 Corrosion resistance

The information given in Tables 4 and 5 refer to the resistance of the steels to intergranular corrosion when tested in accordance with EN ISO 3651-2 to the indicated method A or B or C.

Guideline values for the limit temperature for susceptibility to intergranular corrosion are indicated in Tables 4 and 5.

Option b: *A test for the verification of resistance to intergranular corrosion is specified.*

If other specific corrosion tests are required, they shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

8.5 Machinability

8.5.1 General

The machinability of a material is characterised by the number of parts produced in a certain time, i.e. productivity, and the surfaces and tolerances that can be achieved during that operation. The machining operations are made in two principal steps, semi-roughing followed by finishing. In order to achieve as high productivity as possible the tool-life should be in the area of 10 min to 20 min depending on combination of cost of production, material, and tools. Due to this the cutting speed should be kept at as a high level as possible and at a guaranteed minimum level.

NOTE The productivity is limited by many factors, e.g. power, chip formation, tool-life and surface quality. To achieve a problem-free production a predictable tool-life is desired together with good chip breaking performance. The cutting data chosen should be chosen to minimise the production cost and at the same time consider surface quality and tolerances. The machining operations are made in two principal steps, semi-roughing followed by finishing. Semi-roughing is used to form the part to near-net shape and where high productivity is important. Finishing is used to form the part to finished shape and where surface quality and close dimensional tolerance are limiting the productivity.

To achieve a high productivity in machining the way to fulfil the requirement of tool life, is to guarantee a certain lowest level of machinability as per the general requirements of this standard which is "Guaranteed cutting speeds" as expressed in 8.5.2 and in Annex A.

Unless Option c is specified, the hollow bars are delivered only to a "Guaranteed cutting speed" as expressed in 8.5.2.

Option c: *Machinability with reference to the Taylor method.*

The general requirements in 8.5.2 shall be completed by additional machinability properties based on the Taylor method

The test shall be carried out in accordance with ISO 3685 (applicable constants α and C shall be quantified).

The purpose of this option is to offer an additional method to characterize the machinability of a steel grade by obtaining a determined tool wear as a function of the cutting speed.

This representation is usually called “Taylor method” and results shall be given as a Taylor curve expressing the tool life or the time corresponding to 0,15 mm or 0,30 mm flank wear (time in minutes) as a function of the cutting speed (speed in m/min).

The test shall be carried out without the use of any lubricant.

8.5.2 Guaranteed cutting speeds (semi-roughing and finishing)

In Tables 6 and 7 there are two columns for the two types of operations; semi-roughing and finishing. The cutting speeds stated in the tables are the minimum cutting speed to achieve 15 minutes of tool-life for the austenitic grades and 10 minutes of tool-life for the austenitic-ferritic grades.

The machining data are to be established in accordance with Annex A.

Table 6 — Machining data for austenitic grades

Steel grade		Guaranteed cutting speeds (tool-life 15 minutes)	
Name	Number	v_c, semi-roughing m/min	v_c, finishing m/min
X2CrNi19-11	1.4306	190	240
X2CrNi18-9	1.4307	190	240
X5CrNi18-10	1.4301	190	240
X8CrNiS18-9	1.4305	350	450
X2CrNiMo17-12-2	1.4404	190	240
X5CrNiMo17-12-2	1.4401	190	240
X6CrNiMoTi17-12-2	1.4571	180	230
X2CrNiMo18-14-3	1.4435	180	230

Table 7 — Machining data for austenitic-ferritic grades

Steel grade		Guaranteed cutting speeds (tool-life 10 minutes)	
Name	Number	v_c, semi-roughing m/min	v_c, finishing m/min
X3CrNiMoN27-5-2	1.4460	150	200
X2CrNiMoN22-5-3	1.4462	110	180

8.6 Appearance and soundness

8.6.1 Appearance

The surface condition of the hollow bars shall be such that imperfections requiring further investigation with respect to depth can be detected by visual inspection.

Surface imperfections which would impair the specified dimensions after final machining shall be considered defects and the hollow bars shall be free from them.

It shall be permissible to dress surface imperfections provided that only grinding or machining is used for rectification and that the dimensions after final machining are not impaired. All dressed areas shall blend smoothly into the contour of the hollow bar.

Option d: *Special requirements for either the outside or the inside surface shall apply as specified by the purchaser.*

8.6.2 Soundness

The hollow bars shall be sound and free from internal defects that preclude their intended use.

Option e: *The hollow bars shall be submitted to a non-destructive testing for the detection of longitudinal imperfections according to 11.6.*

8.7 Straightness

The deviation from straightness of any hollow bar length L shall not exceed 0,0015 L, however not exceeding 2 mm per metre length.

8.8 Preparation of ends

Hollow bars shall be delivered with square cut ends. The ends shall be free from burrs that may be harmful during handling.

8.9 Dimensions, masses and tolerances

8.9.1 Outside diameter and inside diameter

Hollow bars shall be ordered by outside diameter *D* and inside diameter d. Preferred outside diameters *D* and inside diameters *d* are given in Table 8.

Option f: *Other dimensional requirements that are different to those in Table 8 may be agreed between purchaser and manufacturer at the time of enquiry and order.*

8.9.2 Mass

For the calculation of mass per unit length, in case of dimensions different from of those in Table 8, the density values given in e.g. EN 10088-1 shall be used.

8.9.3 Lengths

Unless Option g is specified, the hollow bars shall be delivered in random lengths. The delivery range shall be agreed at the time of enquiry and order.

Option g: *The hollow bars shall be delivered in exact lengths and the length shall be specified at the time of enquiry and order. The tolerances on these lengths shall conform to 8.9.4.2.*

Table 8 — Preferred dimensions and mass per unit length

Outside diameter mm	Inside diameter mm	Average weight[a] kg/m	Final component sizes[b]			
			Centring on the outside diameter		Centring on the inside diameter	
			$D_{(e)}$ mm	$d_{(e)}$ mm	$D_{(i)}$ mm	$d_{(i)}$ mm
32	20	4,2	31,0	21,9	30,1	21,0
	16	5,1	31,0	18,0	30,0	17,0
36	25	4,5	35,0	26,9	34,1	26,0
	20	5,9	35,0	22,0	34,0	21,0
	16	6,8	35,0	18,1	33,9	17,0
40	28	5,5	39,0	29,9	38,1	29,0
	25	6,5	39,0	27,0	38,0	26,0
	20	7,8	39,0	22,1	37,9	21,0
45	32	6,7	44,0	33,9	43,1	33,0
	28	8,2	44,0	30,0	43,0	29,0
	20	10,5	44,0	22,2	42,8	21,0
50	36	8,0	49,0	38,0	48,0	37,0
	32	9,7	49,0	34,1	47,9	33,0
	25	12,1	49,0	27,2	47,8	26,0
56	40	10,2	55,0	42,0	54,0	41,0
	36	12,1	55,0	38,1	53,9	37,0
	28	15,2	55,0	30,3	53,7	29,0
63	50	9,9	62,0	51,9	61,1	51,0
	45	12,2	62,0	47,0	61,0	46,0
	40	15,4	62,0	42,2	60,8	41,0
	36	17,3	62,0	38,3	60,7	37,0
	32	19,0	62,0	34,4	60,6	33,0
71	56	12,9	69,9	58,0	68,9	57,0
	45	19,6	69,9	47,3	68,6	46,0
	40	22,3	69,9	42,4	68,5	41,0
	36	24,1	69,9	38,5	68,4	37,0
75	60	13,7	73,8	62,0	72,8	61,0
	50	21,1	73,8	52,2	72,6	51,0
	40	26,0	73,8	42,5	72,3	41,0
80	63	16,4	78,8	65,0	77,8	64,0
	50	25,3	78,8	52,4	77,4	51,0
	45	28,3	78,8	47,5	77,3	46,0
	49	30,9	78,8	42,6	77,2	41,0

Table 8 *(continued)*

Outside diameter mm	Inside diameter mm	Average weight[a] kg/m	Final component sizes[b]			
			Centring on the outside diameter		Centring on the inside diameter	
			$D_{(e)}$ mm	$d_{(e)}$ mm	$D_{(i)}$ mm	$d_{(i)}$ mm
85	67	18,5	83,7	69,1	82,6	68,0
	55	26,8	83,7	57,4	82,3	56,0
	45	33,5	83,7	47,6	82,1	46,0
90	71	20,6	88,6	73,1	87,6	72,1
	63	27,1	88,6	65,3	87,3	64,0
	56	32,3	88,6	58,5	87,1	57,0
	50	36,1	88,6	52,6	87,0	51,0
95	67	29,9	93,5	69,3	92,2	68,0
	50	42,1	93,5	52,7	91,8	51,0
100	80	24,4	98,5	82,3	97,4	81,2
	71	32,7	98,5	73,4	97,2	72,1
	63	39,2	98,5	65,5	97,0	64,0
	56	42,3	98,5	58,7	96,8	57,0
106	80	32,3	104,4	82,5	103,1	81,2
	71	40,6	104,4	73,5	103,0	72,1
	63	47,1	104,4	65,7	102,7	64,0
	56	52,1	104,4	58,9	102,5	57,0
112	90	30,2	110,3	92,5	109,2	91,4
	80	40,6	110,3	82,6	108,9	81,2
	71	48,8	110,3	73,7	108,7	72,1
	63	55,3	110,3	65,8	108,5	64,0
118	90	39,0	116,2	92,7	114,9	91,4
	80	49,4	116,2	82,8	114,6	81,2
	71	57,6	116,2	73,8	114,5	72,1
	63	64,2	116,2	66,0	114,2	64,0
125	100	38,3	123,1	102,7	121,9	101,5
	90	49,8	123,1	92,8	121,7	91,4
	80	82,9	123,1	82,9	121,4	81,2
	71	74,0	123,1	74,0	121,2	72,1
132	106	42,0	130,0	108,8	128,8	107,6
	90	61,1	130,0	93,0	128,4	91,4
	80	71,5	130,0	83,1	128,1	81,2
	71	79,7	130,0	74,2	127,9	72,1

Table 8 *(continued)*

Outside diameter mm	Inside diameter mm	Average weight[a] kg/m	Final component sizes[b]			
			Centring on the outside diameter		Centring on the inside diameter	
			$D_{(e)}$ mm	$d_{(e)}$ mm	$D_{(i)}$ mm	$d_{(i)}$ mm
140	112	47,8	137,9	115,0	136,6	113,7
	100	63,3	137,9	103,1	136,3	101,5
	90	74,9	137,9	93,2	136,1	91,4
	80	85,2	137,9	83,3	135,8	81,2
150	125	47,4	147,7	128,1	146,5	126,9
	106	74,2	147,7	109,3	146,0	107,6
	95	87,7	147,7	98,4	145,7	96,4
	80	103	147,7	83,6	145,3	81,2
160	132	56,2	157,6	135,3	156,3	134,0
	122	71,6	157,6	125,4	156,0	123,8
	112	85,8	157,6	115,5	155,8	113,7
	90	113	157,6	94,0	155,2	91,4
170	140	63,8	167,4	143,5	166,0	142,1
	130	80,2	167,4	133,6	165,8	132,0
	128	80,8	167,4	131,6	165,7	130,0
	118	98,4	167,4	121,7	165,5	119,8
	106	115	167,4	109,8	165,2	107,6
	100	122	167,4	103,9	165,0	101,5
180	150	68,4	177,3	153,6	176,0	152,3
	140	86,1	177,3	143,7	175,7	142,1
	125	110	177,3	128,9	175,3	126,9
	100	144	177,3	104,1	174,7	101,5
190	160	73,0	187,1	163,8	185,7	162,4
	150	91,9	187,1	153,9	185,5	152,3
	140	110	187,1	144,0	185,3	142,1
	132	123	187,1	136,0	185,1	134,0
200	160	97,6	197,0	164,0	195,4	162,4
	150	117	197,0	154,1	195,2	152,3
	140	134	197,0	144,2	194,9	142,1
212	170	109	208,8	174,2	207,2	172,6
	130	182	208,8	134,6	206,2	132,0
224	180	121	220,6	184,4	218,9	182,7
	140	199	220,6	144,8	217,9	142,1

Table 8 *(concluded)*

Outside diameter mm	Inside diameter mm	Average weight[a] kg/m	Final component sizes[b]			
			Centring on the outside diameter		Centring on the inside diameter	
			$D_{(e)}$ mm	$d_{(e)}$ mm	$D_{(i)}$ mm	$d_{(i)}$ mm
236	190	133	232,4	194,6	230,7	192,9
	150	216	232,4	155,0	229,7	152,3
250	200	153	246,2	204,9	244,3	203,0
275	200	247	270,6	205,5	268,4	203,1
300	200	340	295,5	206,1	292,4	203,1
340	200	507	334,9	207,1	330,8	203,1
380	230	609	374,3	237,8	369,5	233,5
400	300	478	394,0	307,6	390,9	304,5
420	300	585	413,7	308,6	410,1	304,5

a Based on density.

b The values indicated are valid for lengths less than 2,5 times the outside diameter.

8.9.4 Tolerances

8.9.4.1 Tolerances on diameter

The tolerances on diameter are given in Table 9.

Table 9 — Tolerances on outer and inner diameter

Dimensions in mm

Outer diameter	Tolerance on outer diameter	Inner diameter	Tolerance on inner diameter
D< 50	+ 1 0	d < 50	0 - 1
D ≥ 50	+ 0,02D 0	d ≥ 50	0 - 0,02d

8.9.4.2 Exact lengths

The tolerances for exact lengths are given in Table 10.

Table 10 — Tolerances on exact lengths

Dimensions in mm

Length L	Tolerance on exact length
L ≤ 6 000	+ 5 0
L > 6 000	+ 10 0

8.9.5 Dimensions achievable after machining

The manufacturer shall indicate at the time of enquiry and order the clean turned sizes which can be machined without non clean-up surface from each hollow bar size,

for centring on the outside diameter D i.e.:

- maximum achievable outside diameter $D_{(e)}$;
- minimum achievable inside diameter $d_{(e)}$.

— or for centring on the inside diameter d i.e.:

- maximum achievable outside diameter $D_{(i)}$;
- minimum achievable inside diameter $d_{(i)}$.

The maximum length of the machined component for which these values are achievable is lower than or equal to 2,5 times the outside diameter *D.*

NOTE When subsequent heat treatment has to be carried out at any stage of the processing of the products after delivery, dimensional variations may happen which may affect the final clean turned sizes. In this case, the purchaser should contact the manufacturer before ordering for further advice.

9 Inspection

9.1 Type of inspection

The compliance with the requirements of the order, for hollow bars in accordance with this part of this European standard, shall be verified by specific inspection.

9.2 Inspection documents

9.2.1 Types of inspection documents

An inspection certificate 3.1 in accordance with EN 10204 shall be issued.

9.2.2 Content of inspection documents

The content of the inspection document shall be in accordance with EN 10168 as shown below.

In all type of inspection documents a statement on the conformity of the products delivered with the requirements of the order shall be included.

The inspection certificate shall contain the following codes and information:

— A – commercial transactions and parties involved;

— B – description of products to which the inspection document applies;

— C01-C02 – location of the samples and direction of the test pieces;

— C10-C13 – tensile test;

— C71-C92 – chemical composition of the cast analysis (product analysis if applicable);

— D01 – marking and identification, surface appearance and dimensional properties;

— D02 – machining data;

— Z – validation.

9.3 Summary of inspection and testing

Inspection and testing shall be carried out as stated in Table 11.

Table 11 — Summary of inspection and testing

Type of inspection or test		Frequency of tests	Reference
Mandatory	Cast analysis	One per cast	11.1
	Tensile test	One per test unit	11.2
	Dimensional inspection	Each tube	11.3
	Visual examination	Each tube	11.4
Optional	Product analysis	One per cast	11.1
	Intergranular corrosion test	One per test unit	11.5
	NDT for the detection of longitudinal imperfections	Each tube	11.6

10 Sampling

10.1 Test unit

A test unit shall comprise hollow bars of the same size, the same steel grade, the same cast, the same manufacturing process and, if applicable, the same heat treatment condition.

A test unit shall comprise a maximum of 100 random manufacturing lengths.

10.1.1 Number of samples per test unit

One sample hollow bar shall be taken from each test unit.

10.2 Preparation of samples and test pieces

10.2.1 General

Samples and test pieces shall be taken at the hollow bar ends in accordance with the requirements of EN ISO 377.

10.2.2 Test piece for the tensile test

The test piece for the tensile test shall be taken, at the manufacturer's option, either in the longitudinal direction or in the transverse direction, in accordance with the requirements of EN ISO 6892-1.

10.2.3 Test piece for the intergranular corrosion test

The test pieces for the intergranular corrosion test shall be prepared according to EN ISO 3651-2.

11 Test methods

11.1 Chemical analysis

The elements to be determined and reported shall be those specified in Tables 1 and 2. The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In case of dispute the method used shall be agreed between the manufacturer and the purchaser at the time of enquiry and order taking into account CEN/TR 10261.

11.2 Tensile test

The test shall be carried out at room temperature in accordance with EN ISO 6892-1, and the following shall be determined:

— the tensile strength (R_m);

— the 0,2 % and the 1,0 % proof strength (respectively $R_{p0,2}$ and $R_{p1,0}$);

— the percentage elongation after fracture with a reference to a gauge length (L_0) of 5, 65 $\sqrt{S_0}$.

If a non proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length $L_0 = 5, 65 \sqrt{S_0}$ using the conversion tables in ISO 2566-1.

11.3 Dimensional inspection

The specified dimensions, including straightness, shall be verified for compliance with the requirements of 8.7 and 8.9.

11.4 Visual examination

Tubes shall be visually examined for compliance with the requirements of 8.6.1.

11.5 Intergranular corrosion test

The intergranular corrosion test shall be carried out according to EN ISO 3651-2.

11.6 Non-destructive test

Each hollow bar shall be subjected to ultrasonic testing for the detection of longitudinal imperfections, according to EN ISO 10893-10, to acceptance level U2, sub-category C.

Regions at the hollow bar ends not automatically tested shall either be subjected to manual/semi-automatic ultrasonic testing according to EN ISO 10893-10 to acceptance level U2, sub-category C or be cropped off.

11.7 Machining data

A method for establishing machining data is given in Annex A.

11.8 Retests, sorting and reprocessing

For retest, sorting and reprocessing, the requirements of EN 10021 shall apply.

12 Marking

Unless otherwise agreed each hollow bar shall be indelibly marked continuously over the hollow bar length on one line parallel to the hollow bar axis.

For hollow bars with outside diameter smaller than 45 mm, the marking on the product may be replaced by a marking on a tag securely attached to the bundle or box.

The marking shall include the following information:

— the manufacturer's name or trade mark;

— the hollow bar size;

— the number of this European standard;

— the steel name or the steel number;

— a heat or code number;

— the mark of the inspection representative;

— an identification number (e.g. order item number) which permits the correlation of the product or delivery unit to the related document.

13 Temporary corrosion protection

The hollow bars shall be delivered without temporary corrosion protection unless otherwise agreed.

Annex A
(normative)

Method for establishing machining data

A.1 General

This Annex specifies a method and the parameters which shall be used when determining the machinability of a steel grade.

The purpose of this test is to determine the life duration of a tool used for machining a steel grade under predetermined testing conditions.

The test shall be carried out in accordance with ISO 3685.

The hollow bar to be tested shall be pre-machined in connection to the testing. The machining shall be carried out on the external surface of the hollow bar.

All parameters used during the test shall be reported.

A.2 Hollow bar sizes

The preferred sizes (after pre-machining) to be used for the hollow bar to be machined are:

- outside diameter between 90 mm and 150 mm;
- wall thickness: greater than 10 mm;
- length: between 500 mm and 1000 mm.

A.3 Machining parameters

The machining parameters shall be:

- tool rake angle: -6°;
- clearance angle: +6°;
- tool: coated cemented carbide valid for machining of stainless steel;
- feed, semi-roughing: 0,25 mm - 0,35 mm/rev;
- feed, finishing: 0,08 mm - 0,12 mm/rev;
- depth of cut, semi-roughing: 2 mm - 3 mm;
- depth of cut, finishing: 0,5 mm - 1 mm;
- nose radius, semi-roughing: 0,8 mm - 1,2 mm;

— nose radius, finishing: 0,4 mm - 0,8 mm;

— entrance angle: 90° ± 15°;

— tool geometry: shape in accordance with ISO 3685;

— cutting fluid: shall be applied;

— clamping of the material shall be stable to achieve stable cutting conditions.

Clamping of the material shall be performed at both ends for length-to-diameter ratio > 1,5 and preferable at both ends when the ratio is > 1.

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