

# Seamless precision steel tubes

## Technical delivery conditions

**DIN**  
**2391**  
Part 2

ICS 23.040.10

Supersedes July 1981 edition.

Descriptors: Tube, steel tube, precision tube, technical delivery conditions.

Nahtlose Präzisionsstahlrohre (mit besonderer Maßgenauigkeit); technische Lieferbedingungen

*In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.*

Dimensions in mm

### 1 Scope and field of application

**1.1** This standard specifies technical delivery conditions for cold finished seamless precision steel tubes of the dimensions listed in DIN 2391 Part 1, which are made from the steel grades listed in clause 4.

Such tubes are mainly used where accuracy to size and, possibly, a small wall thickness, a particular surface condition and specific mechanical properties are required.

**1.2** This standard does not cover:

- seamless circular unalloyed steel tubes subject to special requirements (cf. DIN 1629);
- high performance seamless circular unalloyed steel tubes (cf. DIN 1630);
- seamless circular steel tubes for structural steelwork (cf. DIN 17121);
- seamless circular fine grain steel tubes for structural steelwork (cf. DIN 17124);
- seamless circular tubes made from steel with low-temperature toughness (cf. DIN 17173);
- seamless tubes made from steel with elevated temperature properties (cf. DIN 17175);
- seamless circular fine grain steel tubes subject to special requirements (cf. DIN 17179);
- seamless circular tubes made from steel for quenching and tempering (cf. DIN 17204);
- seamless circular austenitic stainless steel tubes subject to special requirements (cf. DIN 17458);
- steel pipes for conveying combustible liquids and gases (cf. DIN 17172).

Subject to agreement, tubes of dimensions specified in DIN 2391 Part 1 and in compliance with one of the standards listed above may be ordered in quality grade C.

### 2 Quality grades

Tubes shall be supplied in the following quality grades:

for precision steel tubes, that do not require an inspection certificate and thus are not subject to special requirements, grade A;

for precision steel tubes subject to special requirements, grade C.

In accordance with the stated demands of the purchaser, such special requirements and the relevant test methods shall be the subject of agreement. Table 10 lists possible additional requirements (for grade C).

### 3 Order details and options

The following information shall be supplied by the purchaser:

- a) the quantity, in metres;
- b) a reference to this standard;
- c) the quality grade;
- d) the steel grade;
- e) the final supply condition;
- f) the outside and inside diameters, or, where relevant, the outside diameter and wall thickness or inside diameter and wall thickness;
- g) the type of tube length to be supplied;
- h) any inspection document agreed upon.

Designation for 1000 m seamless precision steel tubes, made of St 35 steel, normalized (NBK) as specified in DIN 2391 Part 1, of quality grade C, with an outside diameter,  $D$ , of 100 mm and an inside diameter,  $D_i$ , of 94 mm, in exact lengths of 4000 mm, with type 3.1.B inspection certificate as specified in DIN 50049:

1000 m tube DIN 2391 - C - St 35 NBK -  
100 × ID 94 × 4000 - 3.1.B

Continued on pages 2 to 8.

Unless otherwise specified, tubes shall be supplied in quality grade A and in lengths as specified in subclause 9.3.

#### 4 Materials

The tubes shall be manufactured from electric steel or basic oxygen steel, the melting and casting processes being at the discretion of the manufacturer.

The steel shall be cast as killed steel. Table 1 lists relevant steel grades.

#### 5 Chemical composition

##### 5.1 Ladle analysis

The chemical composition of the steels dealt with in this standard shall be as specified in table 2. Small departures from these specifications are permissible if they do not impair the performance of the steel.

##### 5.2 Product analysis

When a product analysis is carried out on finished tubes, the permitted deviations given in table 3 shall apply to the ladle analysis specified in table 2.

Table 1: Steel grades

Quality grade	Steel grade		Previous designation used in Germany
	as in DIN EN 10027 Part 1	as in DIN EN 10027 Part 2	
A	S215GSiT	1.0211	St 30 Si
	S215GAlT	1.0212	St 30 Al
	S235G2T	1.0308	St 35
	S255GT	1.0408	St 45
	S355GT	1.0580	St 52
C	All grades as for quality grade A, and any other steel grades.		

Table 2: Chemical composition of steel grades shown on ladle analysis

Steel grade		Chemical composition, as a percentage by mass				
Symbol	Material number	C max.	Si max.	Mn	P max.	S max.
St 30 Si	1.0211	0,10	0,30	≤ 0,55	0,025	0,025
St 30 Al	1.0212	0,10	0,05	≤ 0,55	0,025	0,025
St 35	1.0308	0,17	0,35	≥ 0,40	0,025	0,025
St 45	1.0408	0,21	0,35	≥ 0,40	0,025	0,025
St 52	1.0580	0,22	0,55	≤ 1,60	0,025	0,025

The following alloying elements may be added: Nb: ≤ 0,03 %; Ti: ≤ 0,03 %; V: ≤ 0,05 %; Nb + Ti + V: ≤ 0,05 %.

Table 3: Permitted deviations of the product analysis from the specified ladle analysis

Element	Permitted deviation from the specified limits of the ladle analysis, as a percentage by mass
C	+0,02
Si	+0,03
Mn	+0,06 or -0,06
P	+0,005
S	+0,005
Nb	+0,01
Ti	+0,01
V	+0,02

## 6 Final supply conditions

Tubes are to be supplied in one of the conditions specified in table 4.

## 7 Mechanical properties

7.1 The mechanical properties are a function of the final supply condition (cf. table 4) and shall comply with table 5.

7.2 When tested as described in subclauses 10.2.2.2 and 10.2.2.3, tubes shall show no cracks.

7.3 In the case of steel grades and/or final supply conditions other than those specified in tables 2 and 4, the required mechanical properties shall be subject to agreement. Such tubes shall be supplied in quality grade C.

7.4 On the basis of their chemical composition and the way they have been processed, the steels listed in table 2 are to be regarded as weldable. It should, however, be noted that the mechanical properties of tubes in the BK, BKW or BKS condition are modified in the zone of the tube which has been subjected to heat (cf. DIN 8528 Part 1).

Table 4: Final supply conditions

Designation	Symbol	Description
Cold finished (hard)	BK	Tubes do not undergo heat treatment following the final cold forming and, thus, have a rather high resistance to deformation.
Cold finished (soft)	BKW	The final heat treatment is followed by cold drawing involving limited deformation. Appropriate further processing allows a certain degree of cold forming (e.g. bending, expanding).
Cold finished and stress-relieved	BKS	Heat treatment is applied following the last cold forming process. Subject to appropriate processing conditions, the increase in the residual stresses involved enables both forming and machining to a certain degree.
Annealed	GBK	The last cold forming process is followed by annealing in a controlled atmosphere.
Normalized	NBK	The last cold forming process is followed by annealing above the upper transformation point in a controlled atmosphere.

Table 5: Mechanical properties of tubes at ambient temperature

Final supply condition		Cold finished (hard) (BK) <sup>1)</sup>		Cold finished (soft) (BKW) <sup>1)</sup>		Cold finished and stress-relieved (BKS)			Annealed (GBK) <sup>1)</sup>		Normalized (NBK)		
Material designation	Material number	Min. tensile strength, $R_m$ , in N/mm <sup>2</sup>	Min. elongation at fracture, $A_5$ , as a percentage	Min. tensile strength, $R_m$ , in N/mm <sup>2</sup>	Min. elongation at fracture, $A_5$ , as a percentage	Min. tensile strength, $R_m$ , in N/mm <sup>2</sup>	Min. yield strength, $R_{eH}$ , in N/mm <sup>2</sup>	Min. elongation at fracture, $A_5$ , as a percentage	Min. tensile strength, $R_m$ , in N/mm <sup>2</sup>	Min. elongation at fracture, $A_5$ , as a percentage	Tensile strength, $R_m$ , in N/mm <sup>2</sup>	Min. yield strength, $R_{eH}$ , in N/mm <sup>2</sup>	Min. elongation at fracture, $A_5$ , as a percentage
St 30 Si	1.0211	430	8	380	12	380	280	16	280	30	290 to 420	215	30
St 30 Al	1.0212	430	8	380	12	380	280	16	280	30	290 to 420	215	30
St 35	1.0308	480	6	420	10	420	315	14	315	25	340 to 470	235	25
St 45	1.0408	580	5	520	8	520	375	12	390	21	440 to 570	255	21
St 52	1.0580	640	4	580	7	580	420	10	490	22	490 to 630	355	22

<sup>1)</sup> The yield strength for the annealed (GBK) condition shall be equal to at least 50% of the tensile strength. Depending on the extent of deformation, the yield strength of tubes supplied in the cold finished (hard) (BK) and cold finished (soft) (BKW) conditions, may come close to reaching the tensile strength. Calculations should be based on a minimum value of 80% of the tensile strength for the cold finished (hard) condition and of 70% for the cold finished (soft) condition.

<sup>2)</sup> For tubes with an outside diameter of up to 30 mm and a wall thickness up to 3 mm, the minimum yield strength may be 10 N/mm<sup>2</sup> lower.

## 8 Appearance

**8.1** Tubes shall have a smooth internal and external surface consistent with the cold working process. As a result, the arithmetical mean deviation of the profile,  $R_a$ , will be  $6,3 \mu\text{m}$  or less. Lower  $R_a$  values shall be subject to agreement for quality grade C tubes.

NOTE: For technical reasons, it is not always possible to obtain a smooth surface on tubes with an internal diameter of less than 15 mm.

**8.2** Slight surface imperfections such as scabs or gouges, resulting from the manufacturing process, are permitted provided the inner and outer diameters, after dressing, continue to meet the specified requirements. Scabs, laps or laminations are not permitted.

If freedom from imperfections is of particular significance, an appropriate non-destructive test method (such as eddy current or ultrasonic testing) shall be agreed (cf. subclause 10.2.2.8).

**8.3** As a result of cold working, tubes that have not undergone heat treatment, i.e. tubes in the BK or BKW condition, are generally covered by a lubricant or grease film on their inner and outer surfaces. An agreement shall be made concerning its removal.

Tubes that have undergone heat treatment, i.e. tubes in the BKS, GBK or NBK condition, may show signs of scorching, but shall be free of loose scale.

**8.4** Where, with regard to subsequent surface treatment (such as galvanizing), special requirements are to be met concerning the surface preparation grade of tubes, such requirements shall be agreed upon at the time of ordering.

**8.5** In compliance with commercial practice, the tubes shall be supplied with provisional corrosion protection. If a particular form of corrosion protection (e.g. galvanizing as specified in DIN 50960 Part 1), or none whatsoever, is requested, this shall be stated in the order.

## 9 Dimensions and limit deviations

### 9.1 Diameter and wall thicknesses

DIN 2391 Part 1 shall apply for the dimensions of seamless precision steel tubes.

If one of the limit deviations for the diameter is to be zero, the limit deviation for the wall thickness shall be equal to 10 % of the mean wall thickness calculated using the formula given in clause 2 of DIN 2391 Part 1.

### 9.2 Straightness

Tubes with an outside diameter exceeding 15 mm shall not deviate from straightness by more than 0,25 % of the total length. Tubes with a yield strength greater than  $500 \text{ N/mm}^2$  shall not deviate from straightness by more than 0,3 % of the total length. Localized deviations shall not exceed 3 mm/m and shall be measured as the distance between the tube surface and a chord linking two random points 1000 mm apart.

Tubes of exact lengths shall not deviate from straightness by more than 0,3 % of the tube length.

In compliance with commercial practice, tubes with an outside diameter of up to 15 mm shall be supplied straightened. As establishing the straightness of such tubes might prove to be difficult, the straightness measuring procedure shall be subject to agreement.

More stringent requirements regarding straightness shall be subject to agreement and shall apply for quality grade C tubes.

## 9.3 Lengths

Unless otherwise specified by the purchaser at the time of ordering, tubes shall be supplied as random lengths between 4 m and 7 m.

The number of tubes in lengths from 2 m to below 4 m shall not exceed 15 % of the quantity ordered and shall be supplied in separate bundles.

Cut lengths shall allow for deviations of  $\pm 500 \text{ mm}$  of the length ordered, short lengths of 2000 mm or more being supplied in separate bundles up to a maximum of 10 % of the quantity ordered.

Exact lengths are subject to the following limit deviations:

for lengths up to 500 mm:  $\begin{matrix} +2 \\ 0 \end{matrix} \text{ mm};$

for lengths above 500 mm up to 2000 mm:  $\begin{matrix} +3 \\ 0 \end{matrix} \text{ mm};$

for lengths above 2000 mm up to 5000 mm:  $\begin{matrix} +5 \\ 0 \end{matrix} \text{ mm};$

for lengths above 5000 up to 7000 mm:  $\begin{matrix} +10 \\ 0 \end{matrix} \text{ mm}.$

For lengths greater than 7000 mm, limit deviations shall be subject to agreement.

### 9.4 Tube ends

Tube ends shall be cut nominally square to the tube axis and shall be free from excessive burrs, as may result from the cutting process. Such burrs may cause a change in diameter, exceeding the limit deviations specified in DIN 2391 Part 1.

Agreement regarding the finishing of ends of tubes of exact length is mandatory.

### 9.5 Divergence between quantity ordered and consignment

Where tubes of exact length have been ordered, deficient supplies shall not be permitted. However, excess supplies shall be permissible in compliance with the specifications given in table 7.

Table 7: Excess supplies

Quantity ordered, in metres	Percentage deviation
Up to 500	+ 20
Above 500 up to 2000	+ 15
Above 2000	+ 10

## 10 Testing

### 10.1 Tubes to be supplied without inspection document (quality grade A)

As part of internal control, the manufacturer shall submit tubes to:

- a dimensional check;
- a surface inspection;
- a tensile test, as specified in DIN EN 10002 Part 1;
- a flattening test, as specified in DIN EN 10233;
- a drift expanding test, as specified in DIN EN 10234.

Flattening and drift expanding tests shall only be carried out on annealed or normalized tubes made of the steel grades listed in table 2 if testing does not adversely affect the tube diameter and wall thickness.

Subject to agreement, a type 2.2 inspection document in compliance with DIN 50049 shall be issued.

Additional tests shall be subject to agreement. They are relevant for quality grade C steels.

## 10.2 Tubes to be supplied with inspection document (quality grade C)

Should a DIN 50049 inspection certificate be required for quality grade C steel tubes, this shall be agreed upon at the time of ordering. The order shall state the type of document requested and the name the testing agency if the inspection is carried out by a third party.

Tubes shall be tested at the manufacturer's works. Production shall not be unduly disturbed if inspection is carried out by experts who are not employed by the manufacturer.

### 10.2.1 Scope of testing

Tubes shall be tested by batches. For details, see table 9. For the purpose of testing, tubes shall be divided according to steel grade, final supply condition and size, into batches each comprising 200 units. Remainders of up to 20 units may be distributed uniformly across the other batches, remainders ranging from 20 to 200 units and consignments of less than 200 units being considered a whole batch.

### 10.2.2 Procedure

All tests shall be carried out at ambient temperature.

#### 10.2.2.1 Tensile test

The tensile test shall be carried out as specified in DIN EN 10002 Part 1.

#### 10.2.2.2 Flattening test

The flattening test shall be carried out, as specified in DIN EN 10233, on annealed and normalized tubes, the wall thickness of which is less than 15% of the outside diameter. The test pieces or tube ends shall be flattened until a specified distance between platens,  $H$ , is reached. This distance, in mm, is to be calculated on the basis of the following equation:

$$H = \frac{(1+c) \cdot T}{c + \frac{T}{D}}$$

where

- $T$  is the wall thickness, in mm;
- $D$  is the outside diameter of the tube, in mm;
- $c$  is a constant, which is 0,09 for steel grades St 30 and St 35, and 0,07 for steel grades St 45 and St 52.

After testing, the samples shall be inspected for cracks.

Table 8: Percentage expansion

Steel grade	Final supply condition	Percentage expansion for a wall thickness, in mm, of	
		up to 4	above 4
St 30 Si	Normalized or annealed	20	15
St 30 Al		20	15
St 35		18	12
St 45		15	10
St 52		15	10

### 10.2.2.3 Drift expanding test

The drift expanding test shall be conducted until the maximum expansion specified in table 8 is reached. It shall be carried out, as described in DIN EN 10 234, on annealed and normalized tubes with a maximum outside diameter of 150 mm and a wall thickness of up to 9 mm.

After testing, the samples shall be inspected for cracks.

### 10.2.2.4 Measurement of surface roughness

The surface roughness shall be measured axially by using electric stylus instruments as specified in DIN 4768.

### 10.2.2.5 Dimensional check

The tube dimensions shall be measured with suitable techniques.

The type and scope of the dimensional checking of tubes of exact length shall be subject to agreement.

### 10.2.2.6 Surface inspection

The appearance of the outer and, if possible, inner tube surface shall be examined visually under appropriate lighting conditions by an inspector having normal vision. If so agreed, another method of checking the appearance may be used.

The type and scope of surface inspection of tubes of exact length shall be subject to agreement.

### 10.2.2.7 Leak tightness test

The tubes shall be tested for leak tightness by using appropriate non-destructive test methods (e.g. eddy current testing in accordance with *Stahl-Eisen-Prüfblatt* (Iron and steel testing specification) 1925)).

### 10.2.2.8 Non-destructive testing

If freedom from imperfections is of particular significance, eddy current testing as specified in PRP 02-74 may be carried out, primarily to detect transverse defects. The ultrasonic test, as specified in *Stahl-Eisen-Prüfblatt* 1915, is usually conducted to detect longitudinal defects.

## 10.2.3 Retests

**10.2.3.1** Tubes not satisfying the requirements when tested as specified in subclauses 10.2.2.1 to 10.2.2.3 shall be rejected. Two further tubes shall be taken from the batch concerned in place of the rejected sample tube and submitted for testing. If one of these two tubes does not fulfill the requirements, the entire batch shall be considered not to comply with the standard.

**10.2.3.2** If the defects or deficiencies established can be made good by means of heat treatment or other suitable measures, the supplier shall be given the opportunity to present a batch which was rejected for renewed acceptance inspection. If the test pieces still fail to satisfy the requirements, the entire batch shall be considered not to comply with the standard.

## 10.3 Inspection documents

The inspection documents to be issued shall comply with DIN 50049.

**Table 9: Scope of testing**

No.	Type of test or inspection	Cf. sub-clause	Scope of testing <sup>1)</sup>	Responsible for testing
1	Tensile test	10.2.2.1	One test piece, taken from one sample tube per batch.	Subject to agreement.
2	Flattening test	10.2.2.2	One test piece, taken at one end of sample tube specified under item No. 1.	Subject to agreement.
3	Drift expanding test	10.2.2.3	One test piece, taken at one end of sample tube specified under item No. 1.	Subject to agreement.
4	Measurement of surface roughness	10.2.2.4	If agreed upon, one test piece taken from one sample tube specified under item No. 1.	Manufacturer
5	Dimensional check	10.2.2.5	All tubes.	Subject to agreement.
6	Surface inspection	10.2.2.6	All tubes.	Subject to agreement.
7	Leak tightness test	10.2.2.7	If agreed, all tubes.	Manufacturer
8	Non-destructive test	10.2.2.8	If agreed, all tubes	Manufacturer

<sup>1)</sup> Applies to random lengths and multiples of cut and exact lengths.

## 11 Quality grade C

**Table 10: Special requirements (examples)**

Line	Special requirement	Features and/or technical delivery conditions
1	Steel grades other than specified in table 1.	As specified in DIN 1651, DIN EN 10025, DIN EN 10083 Parts 1 and 2, or DIN 17210.
2	Tubes for pipelines.	As specified in DIN 1629, DIN 1630, or DIN 2445 Part 2.
3	Other geometry and surface.	Tubes with an outside diameter smaller than 4 mm and greater than 260 mm, with a non-circular cross section, subject to other tolerances than those specified in DIN 2391 Part 1, other tolerance positions or special requirements regarding the surface condition, straightness and squareness of pipe ends.
4	Final supply condition other than specified in table 4.	Tempered; annealed to obtain specific microstructure.
5	Other mechanical properties.	Deviations regarding the mechanical properties specified in table 5.

## 12 Marking

A durable tag, containing the following information, shall be securely attached to each bundle:

- the manufacturer's mark;
- the relevant standard (technical delivery condition) and quality grade;
- steel grade, in compliance with table 1;
- the final supply condition, in accordance with table 4;
- the dimensions;
- the inspector's mark, where tubes are supplied with an inspection document.

Further markings shall be subject to agreement.

## 13 Bundling

The type of bundling shall be subject to agreement.

## 14 Complaints

Warranty claims may only be raised if based on the technical delivery conditions specified here or on any further agreement.

The purchaser shall give the supplier the opportunity of judging whether the complaint is justified, by submitting the tube objected to and samples of the other tubes supplied.

**Standards and documents referred to**

DIN 1629	Seamless, circular, unalloyed steel pipes subject to special requirements; technical delivery conditions
DIN 1630	High performance seamless, circular, unalloyed steel tubes; technical delivery conditions
DIN 1651	Free cutting steel; technical delivery conditions
DIN 2391 Part 1	Seamless precision steel tubes; dimensions
DIN 2445 Part 2	Seamless precision steel tubes subject to fatigue loading, rated for a pressure of 64 to 400 bar
DIN 4768	Determination of surface roughness parameters $R_a$ , $R_z$ , and $R_{max}$ using electric stylus instruments; concepts and measuring conditions
DIN 8528 Part 1	Weldability of metallic materials; concepts
DIN 17121	Seamless circular steel tubes for structural steelwork; technical delivery conditions
DIN 17124	Seamless circular fine grain steel tubes for structural steelwork; technical delivery conditions
DIN 17172	Steel pipes for conveying combustible liquids and gases; technical delivery conditions
DIN 17173	Seamless circular tubes made from steel with low temperature toughness; technical delivery conditions
DIN 17175	Seamless tubes with elevated temperature properties; technical delivery conditions
DIN 17179	Seamless circular fine grain steel tubes subject to special requirements; technical delivery conditions
DIN 17204	Seamless circular tubes made from steels for quenching and tempering; technical delivery conditions
DIN 17210	Case hardening steel, technical delivery conditions
DIN 17458	Seamless circular austenitic stainless steel tubes subject to special requirements; technical delivery conditions
DIN 50049	Inspection documents for the delivery of metallic products
DIN 50960 Part 1	Electroplated and chemically applied coatings; designation and information in technical documentation
DIN EN 10002 Part 1	Tensile testing of metallic materials; method of test at ambient temperature (including Amendment AC 1:1990)
DIN EN 10025	Hot rolled unalloyed structural steel products; technical delivery conditions (including Amendment A1:1993)
DIN EN 10027 Part 1	Designation systems for steel; steel names and principal symbols
DIN EN 10027 Part 2	Designation systems for steel; numerical system
DIN EN 10083 Part 1	Quenched and tempered steels; technical delivery conditions for special steels
DIN EN 10083 Part 2	Quenched and tempered steels; technical delivery conditions for unalloyed quality steels
DIN EN 10233	Metallic materials; tube; flattening test
DIN EN 10234	Metallic materials; tube; drift expanding test
Stahl-Eisen-Prüfblatt 1915**)	<i>Ultraschallprüfung auf Längsfehler von Rohren aus warmfesten Stählen</i> (Ultrasonic testing for longitudinal imperfections in steel tubes with elevated temperature properties)
Stahl-Eisen-Prüfblatt 1925**)	<i>Elektromagnetische Prüfung von Rohren zum Nachweis der Dichtheit</i> (Eddy current testing of tubes for leak tightness)
PRP 02-74*)	<i>Prüfblatt für die Wirbelstromprüfung von Präzisionsstahlrohren</i> (Specification regarding the eddy current testing of seamless precision steel tubes)

**Other relevant standard**

DIN EN 10021 General technical delivery conditions for steel and iron products

**Previous editions**

DIN 2391 Part 2: 1940-06, 1957-11, 1967-07, 1981-07.

\*) Obtainable from *Fachvereinigung Präzisionsrohrwerke e.V.* Postfach 30 03 64, D-40403 Düsseldorf.

\*\*\*) Obtainable from *Verlag Stahleisen mbH*, Postfach 10 51 64, D-40042 Düsseldorf.

## Amendments

In comparison with the July 1981 edition, this standard has been revised in form and substance and the following amendments made:

- a) Quality grade B has been dropped and grades A and C redefined.
- b) The outside diameter, the inside diameter and the wall thickness have been referred to as  $D$ ,  $D_i$ , and  $T$ , respectively, and the order details changed accordingly.
- c) The use of SM steel and unkilld casted steel is no longer specified for precision steel tubes.
- d) Grade C tubes may be made from other steels if these are suitable (cf. table 1).
- e) In table 2 the maximum permissible P and S contents were brought into line with the state of the art and the addition of further alloying elements specified.
- f) A table covering permitted deviations of the product analysis from the specified ladle analysis has been included (cf. table 3).
- g) The BKS 'cold formed and stress-relief annealed' condition has been included and the descriptions provided for the other final supply conditions amended.
- h) Mechanical properties of tubes in the BKS condition have been specified and the minimum values regarding the tensile strength for BK and BKW conditions increased.
- i) The specifications for surface appearance have been completely revised.
- j) With regard to deviations from straightness, a distinction has been made between localized deviations and deviations along the entire tube length.
- k) Random lengths have been limited to a range between 4 m and 7 m.
- l) The requirements for tube ends have been amended.
- m) Specifications regarding divergence between the quantity ordered and the actual consignment now apply to orders for exact lengths only.
- n) Leak tightness tests are no longer specified for quality grade A tubes. If delivery conditions require leak tightness, tubes shall be supplied in quality grade C.
- o) A table covering the scope of testing has been included (cf. table 9).
- p) The requirements regarding the performance of test pipes submitted to flattening and drift expanding tests have been amended.
- q) The procedures regarding surface roughness measurement, dimensional checks and surface inspections, as well as leak tightness tests and non-destructive testing have been altered.

## International Patent Classification

F 16 L 009/02  
G 01 B 021/30  
G 01 N 033/20

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