INTERNATIONAL STANDARD

ISO 13085

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Petroleum and natural gas industries — Aluminium alloy pipe for use as tubing for wells

Industries du pétrole et du gaz naturel — Tubes en alliage d'aluminium utilisés comme tubes de production dans les puits

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

Introduction

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a manufacturer from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the manufacturer should identify any variations from this International Standard and provide details.

This International Standard includes requirements of various natures. These are identified by the use of certain verbal forms:

— “shall” is used to indicate that a provision is mandatory;

— “should” is used to indicate that a provision is not mandatory, but recommended as good practice;

— “may” is used to indicate that a provision is optional.

Petroleum and natural gas industries — Aluminium alloy pipe for use as tubing for wells

1 Scope

This International Standard specifies the technical delivery condition, manufacturing process, material requirements, configuration and dimensions, and verification and inspection procedures for aluminium alloy pipes for use as tubing for wells in petroleum and natural gas industries.

2 Normative references

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

ISO 6892 (all parts), *Metallic materials — Tensile testing*

ISO 11961, *Petroleum and natural gas industries — Steel drill pipe*

ASTM G1, *Standard practice for preparing, cleaning, and evaluating corrosion test specimens*

ASTM G44, *Standard practice for exposure of metals and alloys by alternate immersion in neutral 3.5% sodium chloride solution*

NACE/TM 0177, *Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in hydrogen sulfide (H2S) environments*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
defect
imperfection of a size and/or population density greater than the acceptance criteria specified in this International Standard

3.1.2
heat
metal produced by a single cycle of a batch melting process

3.1.3
imperfection
discontinuity or irregularity in the product wall or on the product surface that is detectable by inspection methods outlined in this International Standard

Note 1 to entry: Imperfections are detected by methods outlined in this International Standard.

3.1.4
lot
those lengths of pipe with the same specified dimensions and grade which are heat treated as part of a continuous operation (or batch) and which are of a single heat or from different heats that are grouped according to a documented procedure which will ensure that the appropriate requirements of this International Standard are met

Note 1 to entry: The documented procedure will ensure that the requirements of this International Standard are met.

3.1.5
manufacturer
firm, company or corporation responsible for making and marking the product in accordance with the requirements of this International Standard

Note 1 to entry: Marking by the manufacturer warrants that the product conforms to this International Standard, and it is the manufacturer who is responsible for compliance with all of its applicable provisions.

3.1.6
pipe mill
firm, company or corporation that operates pipe-making facilities

3.1.7
seamless pipe
wrought tubular pipe product made without a welded seam, produced by a hot-forming process which can be followed by cold sizing or cold finishing to produce the desired shape, dimensions and properties

3.1.8
tubing
pipe placed within a well and serving to produce well fluids or to inject fluids

3.2 Symbols

D pipe body outside diameter

D_u outside diameter of upset end

d pipe body inside diameter

L_p pipe length (the distance between the pipe ends)

f test factor

m_1 mass of the specimen before the test

m_2 mass of the specimen after the test

p standard hydrostatic test pressure

S surface area of the specimen

t wall thickness of pipe body

b test time

t_u wall thickness of upset end

V_k corrosion rate

Y_{min} specified minimum yield strength for the pipe body

4 Information to be supplied by purchaser

4.1 In placing orders for aluminium alloy tubing, the purchaser shall specify the following on the purchase order:

a) reference to this International Standard (i.e. ISO 13085);

b) quantity;

c) tubing delivery condition (see 5.4);

d) outside diameter (see Table 3);

e) wall thickness (see Table 3);

f) material group (see Table 1);

g) length (see Table 2);

h) delivery date and shipping instruction;

i) inspection by purchaser (see Annex A).

4.2 The purchaser should also state on the purchase order requirements concerning the following stipulations, which are optional with the purchaser:

a) pipe coatings (see 7.9);

b) non-destructive inspection (see 10.4);

c) leak-proof test (see 8.4);

d) aluminium alloy name (see Table 1).

5 Process of manufacture and delivery condition

5.1 General

Tubing furnished to this International Standard shall be made by the seamless process.

5.2 Heat treatment

Tubing shall be heat treated by solution heat treatment followed by artificial or natural aging. The aluminium pipe shall not be subjected to cold working after the final heat treatment process, except for that which is incidental to normal straightening or threading operations.

The temperature and time requirements for the solution and aging heat treatment cycles shall be determined in accordance with the manufacturer's documented practice. Actual furnace temperatures and transfer timing shall be documented in order to verify that each heat treatment lot meets the manufacturer's documented requirements.

5.3 Traceability

The manufacturer shall establish and follow procedures for maintaining heat and/or lot identity until all required heat and/or lot tests have been performed and conformance with specification requirements has been verified.

5.4 Delivery condition

Aluminium alloy tubing shall be supplied as plain end pipe (with external or internal upsets but without threads).

6 Material requirements

6.1 Material groups

Aluminium alloy tubing after heat treatment shall conform to the requirements specified in Table 1. They are divided into four material groups:

a) **Group I**, without additional requirements for high strength or corrosion resistance;

b) **Group II**, with improved strength;

c) **Group III**, with high temperature mechanical properties;

d) **Group IV**, with improved corrosion resistance.

Table 1 — Material requirements for aluminium alloy tubing

Characteristic	Unit	Material group			
		I	II	III	IV
Alloy name		D16T	1953T1	AK4–1T1	1980T1
Yield strength, min (0,2 % offset method)	MPa	325	480	340	350
Tensile strength, min	MPa	460	530	410	400
Elongation, min	%	12	7	8	9
Operational temperature, max	°C	160	120	220	160
Corrosion rate in 3,5 % sodium chloride solution, max	g/(m^{2}h)	—	—	—	0,08
Corrosion in accordance with NACE (method B) solution (NACE/TM 0177)		—	No EC cracking	—	—
Mechanical testing shall be in accordance with ISO 6892. The NACE test requirement shall be stated on the purchase agreement. The NACE test is for quality control purposes only and does not qualify the material for any specific sour service application. It is the product user's responsibility to ensure that the product is suitable for the intended application.					
NOTE 1 It is permitted to use an alternative aluminium alloy system, as long as there is purchaser agreement and it conforms to the requirements of one of the four material group categories. NOTE 2 The mechanical properties of the alloys given in this table are for a test temperature of (20 ± 3) °C. NOTE 3 Maximum operational temperature is a material temperature that results in the minimum room temperature yield strength reduction by no more than 30 % at the exposure time of 500 h. See ISO 20312 for material yield strength reduction at other operating temperatures.					

6.2 Metallographic examination

Each heat treatment lot sample shall undergo metallographic examination. The macrostructure shall be homogeneous, without cracks, pits, laminations, shrinkage cavities, surface tears or sponginess. The microstructure shall not contain porosities or grain boundary eutectic melting resulting from solution heat treatment.

For terminology relating to microstructure examination, see ASTM B 917.

6.3 Chemical composition

Chemical analysis shall be undertaken on each heat. The manufacturer shall establish limits for chemical composition and shall confirm to the established limits.

6.4 Tensile properties

Product shall conform to the tensile requirements specified in Table 1.

The tensile properties of upset tubing, except elongation of the upset ends, shall comply with the requirements given for the pipe body. In case of dispute, the properties (except elongation) of the upset shall be determined from a tensile test specimen cut from the upset. A record of such tests shall be available to the purchaser.

7 Configuration and dimensions of pipes

7.1 Configuration

The configuration of the aluminium alloy tubing billet shall correspond to Figure 1.

Dimensions in millimetres

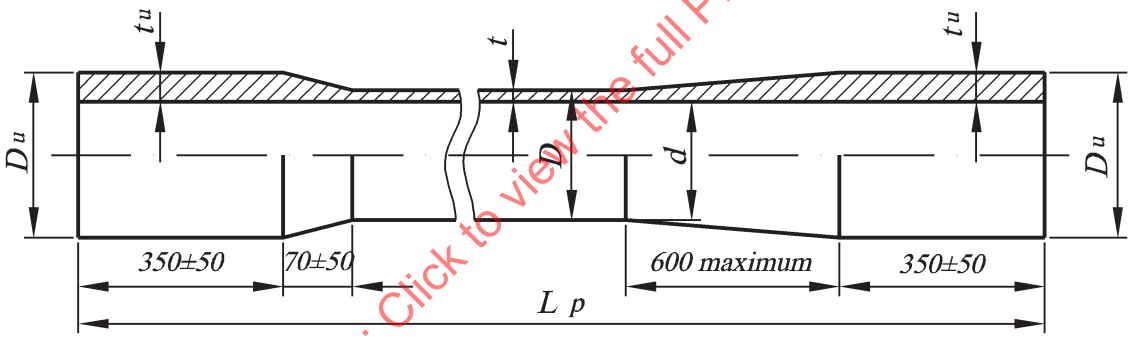


Figure 1 — Tubing billet (see Tables 2 and 3)

7.2 Length

Tubing length ranges shall comply with the requirements specified in Table 2 and Figure 1.

Table 2 — Tubing length

Dimensions in metres

Pipe condition at delivery	Range		
	1	2	3
L_p, tol. ± 0,25	5,50 to 7,92	8,50 to 10,36	11,58 to 13,72
NOTE Other pipe lengths can be ordered by agreement between the manufacturer and purchaser.			

7.3 Dimensions of pipes

The dimensions of the pipe body and upset ends, together with the tolerances, are given in Table 3. By agreement between the purchaser and manufacturer, this International Standard can also be applied to other pipe body and upset ends dimensions.

7.4 Design mass

Calculated mass of the plain pipe per unit length, mass increase of the upset ends are indicated in Table 3.

Table 3 — Tubing (see Figure 1)

Dimensions of pipe body mm				Mass kg		Dimensions of upset ends mm	
Outside diameter $D \pm 1\ \%$	Wall thickness t		Inside diameter d	1 m of the plain pipe body	Upset of both ends (increment)	Wall thickness $t_u \pm 10\ \%$	Outside diameter $D_u\ ^{+2}_{-1}$
		Tolerance					
74	8	±0,8	58	4,64	7,6	17,5	93
90	9	±0,9	72	6,4	9,1	19	110
102	9	±0,9	84	7,36	10,2	19	122
115	9	±0,9	97	10,68	13,2	20,5	138
While calculating mass, aluminium alloy density shall be taken equal to 2,8 g/cm^3. In case of using other density alloys, compensation factor shall be used.							

7.5 Upset run-out

At any place on the intermediate section between the upset end and the pipe body, a transverse groove or bulge is allowed, the height or depth of which may not increase or decrease the outside diameter by more than + 2,5 mm to – 2,5 mm of the nominal size, but the wall thickness shall not be less than the minimum specified wall thickness of the pipe body.

7.6 Straightness

Deviation from straightness or pipe maximum curvature excluding external upset ends and transition areas shall not exceed 0,2 % on length being checked (2 mm/m).

7.7 Ovality and eccentricity of pipes

The ovality and eccentricity of pipes shall be within the tolerances on outside diameter and wall thickness (see Table 3).

7.8 Drift requirements

Each tubing with external upset ends shall be tested full length with a cylindrical drift mandrel being 3,2 mm smaller in diameter than the inside diameter d of the pipe, and a length of 10 times the inside diameter.

7.9 Internal coating

By agreement between the manufacturer and purchaser, aluminium tubing may be given an internal coating.

8 Test methods

8.1 All tests and inspections in pipes shall be performed at the mill after heat treatment.

8.2 A minimum of 5 % of pipes from each lot shall be subjected to mechanical tests (but not less than two pipes). The types of tests shall be established in accordance with Table 1. If any of the test specimens representing a lot of pipes fail to conform to the requirements specified in Table 1, the manufacturer may retest double the number of specimens from this lot. If any of the specimens retested fails to conform to the specified requirements, the entire lot shall be rejected.

Evaluation of the tubing mechanical properties shall be carried out on specimens taken from the upset part of the pipe. The macrostructure check shall be made on macro sections representing 2 pipes from each lot.

NOTE The mechanical properties are invariably lower for the upset areas than for the pipe body.

8.3 Tensile testing shall be carried out in accordance with ISO 6892.

8.4 A leak-proof test shall be performed at the customer's request.

Each length of pipe shall hold without leakage hydrostatic pressure specified by Formula (1). The test conditions shall be held for not less than 5 s at full pressure.

The standard hydrostatic test pressure, p, shall be calculated using Formula (1), rounded to the nearest 0,5 MPa and limited to a maximum of 69,0 MPa:

$$p = \frac{2 \times f \times Y_{\min} \times t}{D} \tag{1}$$

where

f is a test factor: 0,8;

$Y_{\min}$ is the specified minimum yield strength for the pipe body, in mega Pascals;

D is the specified outside diameter, in millimetres;

t is the specified wall thickness, in millimetres.

NOTE Formula (1) for hydrostatic test pressure is applicable to both SI and USC units.

Lower test pressures may be allowed only for reasons of the physical limitations of the test equipment. The manufacturer shall have a documented design basis to enable the physical limits of the hydrostatic test equipment to be established. If the calculated test pressure (based on the outside diameter, thickness and grade) is greater than the physical capability of the hydrostatic test equipment, the manufacturer, upon agreement with the purchaser, shall use a test pressure equal to the physical capability of the test equipment.

However, the hydrostatic test capability may be less than 20,5 MPa only for those products where the calculated test pressure is less than 20,5 MPa.

Alternative test pressures shall be used when specified on the purchase agreement and when agreed by purchaser and manufacturer.

The manufacturer shall establish the leak proof testing method.

8.5 Tubing Group IV corrosion rate shall not exceed the value specified in Table 1, and shall be determined by the weight-loss method. This method is based on the estimation of the material mass loss per unit time per unit area in the test solution. A minimum of 2 % of tubing of each lot shall be subjected to the corrosion rate test, as described in Annex B.

8.6 Chemical composition shall be determined by any of the procedures commonly used for determining chemical composition, such as emission spectroscopy, X-ray emission, atomic absorption,

combustion techniques or wet analytical procedures. The calibration methods used shall be traceable to established standards

9 Measuring methods

9.1 Dimensional measurements shall be carried out on each joint of pipe.

9.2 The outside diameter of the pipe shall be measured by means of callipers, a snap gauge or any other acceptable means along the entire length of the pipe body in at least two perpendicular planes and shall be within the tolerances specified in Table 3.

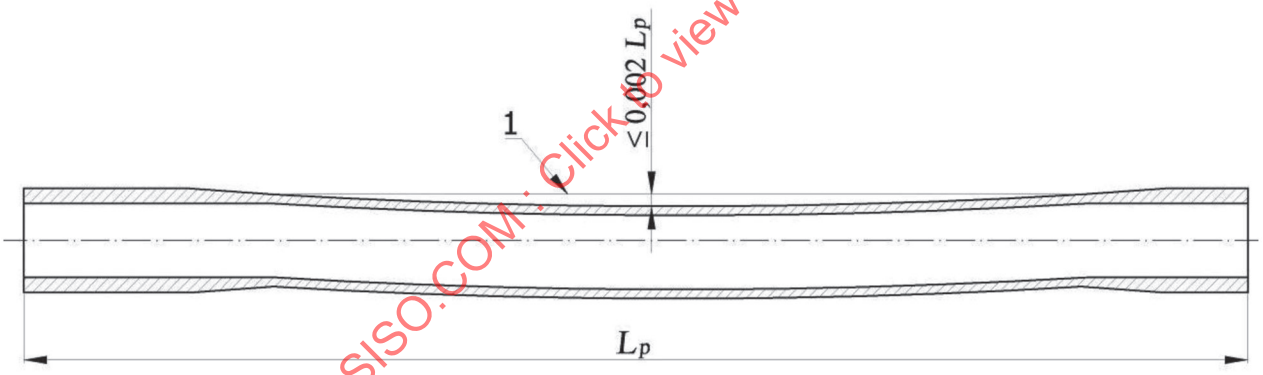
9.3 The outside diameter of the upset ends shall be measured in two perpendicular planes at a distance of 50 mm to 100 mm from the pipe end and shall be within the tolerances specified in Table 3.

9.4 Wall thickness shall be checked by a non-destructive testing method along the entire length of the pipe. The type of non-destructive method used shall be at the discretion of the manufacturer, but the manufacturer shall demonstrate that the accuracy of the method used is adequate to ensure the wall thickness meets the requirements specified in Table 3.

9.5 All pipes shall be visually examined. The straightness of questionably bent pipes or crooked extremities shall be verified using a straight-edge or taut string (wire) from one end of plain pipe to its other end (see Figure 2). The straight-edge shall be positioned to highlight the maximum deviation.

Deviation from the straight or chord height shall not exceed the requirements in 7.6.

The pipe straightness shall be measured with an accuracy of ±0,5 mm.



Key

1 taut string or wire

Figure 2 — Tubing straightness measurement

9.6 The accuracy of all measuring instruments used for acceptance/rejection shall be verified at least once every operating shift. Accuracy verification of rules, length measuring tapes and other non-adjustable measuring devices shall be defined as a visual check of markings legibility and the general wear of fixed reference points. The verification procedure of these working gauges shall be documented. The adjustable and non-adjustable designation utilized by the manufacturer shall be documented.

If measuring equipment, whose calibration or verification is required under the provisions of the specification, is subjected to unusual or severe conditions such as would make its accuracy questionable, calibration or verification shall be performed again before further use of the equipment.

10 Inspection

10.1 The outside and inside pipe surface shall be free of cavities, cracks, laminations, blisters, non-metallic inclusions and corrosion pits. Scratches, grooves, dents and mechanical damage are permitted provided that their depth remains within the limits of the tolerance for the outside diameter. Local traces of lubricant are also permitted.

10.2 The depth of a local imperfection on the outside pipe surface shall be determined by grinding or machining the defective area by a method that ensures visual inspection until the imperfection is completely removed. The depth of the imperfection shall not exceed the tolerance on pipe wall thickness (see Table 3).

10.3 Local hammering of defects on the pipe outside surface is not allowed.

10.4 Non-destructive inspection shall be by agreement between the manufacturer and purchaser. The three levels of non-destructive inspection are:

— PSL 1, no non-destructive inspection;

— PSL 2, non-destructive inspection of the transition zone only;

— PSL 3, full length body and transition zone ultrasonic inspection, according to ISO 11961 or a procedure agreed between purchaser and manufacturer.

11 Marking

11.1 Aluminium alloy tubing manufactured in accordance with this International Standard shall be marked by the manufacturer with a round bottomed die-stamp. The height of the marking shall be 10 mm and the depth shall be 0,3 mm to 0,7 mm. Pipes shall be die-stamped on the outside surface of the upset end, at a distance not exceeding 150 mm from the taper. Markings shall be placed longitudinally on the pin side of each pipe.

11.2 Pipe marking shall include the following information:

a) the manufacturer's name or trade mark;

b) number designation of this International Standard (ISO 13085), or alternatively, an identical national adoption of this international Standard if agreed;

c) the material group (see 6.1);

d) the size (specified outside diameter), in millimetres;

e) the specified wall thickness, in millimetres;

f) the serial number of the lot and identification number of the pipe in the lot.

12 Packaging, transport and storage

Aluminium alloy tubing may be shipped in bundles. The pipes in each bundle shall be of the same diameter, the same wall thickness, the same material group, and the same range length. Aluminium tubing should be electrically isolated from the ground during storage.

13 Documents

13.1 Certification

The manufacturer shall supply a certificate of compliance stating that the material has been manufactured, sampled, tested and inspected in accordance with this International Standard and has

been found to meet all the requirements. The manufacturer shall also supply the results of all non-destructive and destructive tests carried out.

13.2 Retention of records

Information for which the retention of records is required for this International Standard:

a) the country of manufacture;

b) the manufacturer's name or trade mark;

c) the material group and alloy name;

d) the pipe diameter, wall thickness and length;

e) the pipe length (total) and masses;

f) the results of any test;

g) the delivery completeness (when pipes are supplied with tool joint, the tool joint size and whether threads are left handed shall be indicated);

h) the number of the pipe lot;

i) the reference to this International Standard (i.e. ISO 13085);

j) heat treatment records.

Such records shall be retained by the manufacturer and shall be made available to the purchaser on request for a period of three years after the date of purchase from the manufacturer.

14 Delivery conditions

Aluminium alloy tubing shall be delivered in accordance with the requirements of this International Standard.

15 Minimum facility requirements for pipe mill

A pipe mill shall operate one or more pipe-making facilities capable of producing products as described in Clause 7. A pipe mill shall also have suitable equipment for, and be responsible for, weighing and marking pipe stock.

A pipe mill shall also have facilities for conducting all required tests and inspections. Alternatively, and at the option of the pipe mill, any of these tests or inspections may be provided by a subcontractor and may be located off-site. In the event that a subcontractor performs any of these services, the conduct of such inspections and tests shall be controlled and monitored by the pipe mill in accordance with a documented procedure.

