INTERNATIONAL STANDARD

ISO 15546

Third edition
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Petroleum and natural gas industries — Aluminium alloy drill pipe

Industries du pétrole et du gaz naturel — Tige de forage en alliage d'aluminium

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15546 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

This third edition cancels and replaces the second edition (ISO 15546:2007), which has been technically revised.

Introduction

Users of this International Standard need to be aware that further or differing requirements could 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 being particularly applicable where there is innovative or developing technology. Where an alternative is offered, the manufacturer will need to identify any variations from this International Standard and provide details.

This International Standard includes requirements of various nature. 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 drill pipe

1 Scope

This International Standard specifies the technical delivery conditions, manufacturing process, material requirements, configuration and dimensions, and verification and inspection procedures for aluminium alloy drill pipes with or without attached steel tool joints, for use in drilling and production operations in the petroleum and natural gas industries.

A typical drill pipe configuration is provided, showing main elements and lengths (see Figures 1 to 4). The main dimensions and masses of the grades of drill pipe are given in both SI units and USC units (see Annex A).

This International Standard does not consider performance properties.

NOTE 1 Reference can be made to ISO 10424-2 and ISO 27627 for the detailed requirements for the threading of drill pipe tool joints.

NOTE 2 Reference can be made to ISO 20312 for the performance properties of the drill pipe.

NOTE 3 Reference can be made to ISO 27627 for the "pipe body-tool joint" thread connection gauging.

2 Conformance

In this International Standard, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units.

Tables for data expressed in SI units are given in the body of this International Standard, whilst those expressed in USC units are given in Annex A. All figures in the body of this International Standard express data in both SI and USC units (the latter given in brackets), with the exception of Figure 11, which is reproduced as Figure A.1 using USC units. In the text, data in SI units are followed by data in USC units in brackets.

For a specific order item, it is intended that only one system of units be used, without combining data expressed in the other system.

Products manufactured to specifications expressed in either of these unit systems shall be considered equivalent and totally interchangeable. Consequently, compliance with the requirements of this International Standard as expressed in one system provides compliance with requirements expressed in the other system.

For data expressed in the SI system, a comma is used as the decimal separator and a space as the thousands separator. For data expressed in the USC system, a dot (on the line) is used as the decimal separator and a space as the thousands separator.

NOTE The procedures used to convert from SI units to USC units are given in Annex E.

3 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.

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

ISO 6506 (all parts), *Metallic materials — Brinell hardness test*

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 10424-2, *Petroleum and natural gas industries — Rotary drilling equipment — Part 2: Threading and gauging of rotary shouldered thread connections*

ISO 11130, *Corrosion of metals and alloys — Alternate immersion test in salt solution*

ISO 11960:—[1)], *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

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

ASTM B594-09, *Standard Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications*

ASTM G1, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens*

4 Terms, definitions and symbols

4.1 Terms and definitions

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

4.1.1
aluminium alloy drill pipe
aluminium alloy drill pipe body with threaded steel tool joints

4.1.2
aluminium alloy drill pipe body
aluminium alloy pipe formed by extrusion, including any upsets and protector thickening

4.1.3
box
tool joint part that has internal tool joint thread

4.1.4
corrosion
adverse chemical alteration or destruction of a metal by air, moisture or chemicals

4.1.5
defect
imperfection of sufficient magnitude to warrant rejection of the product based on the criteria of this International Standard

1) To be published. (Revision of ISO 11960:2004.)

4.1.6
gauge plane
imaginary plane, perpendicular to the thread axis of rotary shouldered connections, at which the pitch diameter at gauge point is measured

4.1.7
heat
metal melted with one continuous operation of one metal batch

4.1.8
imperfection
discontinuity in the product wall or on the product surface that can be detected by visual inspection or a non-destructive evaluation (NDE) method, as given in ISO 11960:—, Table C.42 or Table E.42

4.1.9
linear imperfection
imperfection which includes, but is not limited to, seams, laps, cracks, plug scores, cuts and gouges

NOTE See API STD 5T1 for terminology on imperfections.

4.1.10
lot
definite quantity of product manufactured under conditions that are considered uniform for the attribute being inspected

4.1.11
manufacturer
firm, company or corporation responsible for marking the product

NOTE 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.

4.1.12
pin
tool joint part that has external tool joint thread

4.1.13
pipe mill
firm, company or corporation that operates pipe-making facilities

4.1.14
plain pipe
part of aluminium alloy pipe body excluding upsets and protector thickening

4.1.15
room temperature
temperature between 5 °C and 50 °C

NOTE Between 41 °F and 122 °F.

4.1.16
seal gauge plane
imaginary plane, perpendicular to the thread axis of rotary shouldered connections, at which the seal estimated diameter is measured

4.1.17
tool joint
steel tool joint element for aluminium alloy drill pipes consisting of two parts (pin and box)

4.2 Symbols

D_{dp}	pipe body outside diameter
D_e	tool joint elevator bevel diameter
D_f	tool joint bevel diameter
D_{pe}	tool joint bevel diameter
D_{pt}	outside diameter of protector thickening
$D_{pt,min}$	outside diameter of protector thickening with lower limit of tolerance
D_{tj}	tool joint outside diameter
D_u	outside diameter of upset end
D_1	pipe end external bevel diameter
D_2	pipe end outside diameter in the end plane
D_3	pipe thread outside diameter in the end plane
D_4	pipe outside diameter in the seal estimated plane
d_b	tool joint box inside diameter
d_{dp}	pipe body inside diameter
d_p	tool joint pin inside diameter
d_u	inside diameter of the pipe upset
d_1	pipe thread inside diameter in the gauge plane
d_2	tool joint tapered bore diameter in the end plane
d_3	tool joint tapered bore diameter in the seal estimated plane
d_4	tool joint thread inside diameter in the gauge plane
d_5	tool joint thread inside diameter in the end plane
d_6	tool joint internal shoulder bevel diameter
f	hydrostatic pressure test factor
K	conversion coefficient
L_b	tool joint box length
L_{eu}	length of external upset end
L_{iu}	length of internal upset end

L_{pb}	tool joint pin outside diameter length
L_{pe}	pipe length without tool joint (the distance between the pipe ends)
L_{dp}	pipe length with tool joint (the distance between the tool joint box face and the pin shoulder)
L_1	length of external upset end transition zone
L_2	length of internal upset end transition zone
L_3	length of protector thickening transition zone
L_4	distance from tool joint end plane to inside shoulder face
L_5	distance between the pipe body end and the end of the external taper shoulder
M_b	cyclic bending moment
m_1	mass of the specimen before the test
m_2	mass of the specimen after the test
p	standard hydrostatic test pressure
$\sqrt{\text{Ra } x[y]}$	indicator of surface roughness, where x stands for values in 10^{-6} m and y stands for values in 10^{-6} in
S	surface area of the specimen
T_t	test time
t_{dp}	wall thickness of pipe body
t_u	wall thickness of upset end
V_k	corrosion rate
W_u	section modulus of pipe body upset area
Y_{min}	specified minimum yield strength of the pipe body
$\sqrt{y}$	indicator of surface roughness, where y stands for values in 10^{-6} in
σ	stress level

5 Information to be supplied when placing orders for drill pipe

5.1 Basic information

When placing orders for aluminium alloy drill pipe without threads, with threads but without tool joints, or with tool joints attached, the purchaser shall specify the following on the purchase order:

a) reference to this International Standard (i.e. ISO 15546);

b) quantity;

c) upset type (internal, external, with protector thickening) (see Tables 3 to 6 and Figures 1 to 4);

d) aluminium alloy drill pipe delivery condition (see 6.4 and Clause 15);

e) outside diameter of pipe body (see Tables 3 and 4);

f) wall thickness of pipe body (see Tables 3 and 4);

g) aluminium alloy name (see Table 1);

h) pipe range or special length and tolerance by agreement between purchaser and manufacturer (see 8.2, 8.3.3 and Table 2);

i) delivery date and shipping instruction;

j) inspection by purchaser (see Annex B);

k) variants of the tool joint elevator bevel, if ordered with tool joints or other special connection by agreement between purchaser and manufacturer (see Figure 8);

l) percentage of assembled pipes subject to hydrostatic testing (see 9.3).

5.2 Optional information

The purchaser should also state on the purchase order requirements concerning the following stipulations, which are at the option of the purchaser:

a) pipe coatings (see 8.10);

b) marking requirements (see Clause 12);

c) non-destructive inspection (see 11.2 and 11.3);

d) corrosion rate test for material Group IV (see Table 1);

e) test certificates (see 14.1).

6 Process of manufacturing and delivery condition

6.1 General

Aluminium alloy drill pipe body furnished to this International Standard shall be made by a seamless process.

6.2 Heat treatment

Aluminium alloy drill pipe bodies shall be heat treated by solution heat treatment followed by artificial or natural ageing. 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 ageing 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.

6.3 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. The procedures shall provide means for tracing tool joint and aluminium alloy drill pipe body to the relevant heat or lot and to the specified chemical, mechanical or other performed test result.

6.4 Delivery condition

Aluminium alloy drill pipes and aluminium alloy drill pipe bodies shall be supplied as:

a) plain end pipe (without threads);

b) threaded pipe (without tool joints);

c) with tool joints attached.

7 Material requirements

7.1 Material groups

Materials for aluminium alloy drill pipe bodies shall comply with the requirements specified in Table 1:

— Group I: aluminium alloy drill pipe body of base strength;

— Group II: aluminium alloy drill pipe body of high strength;

— Group III: aluminium alloy drill pipe body of elevated temperature resistance;

— Group IV: aluminium alloy drill pipe body of enhanced corrosion resistance.

Table 1 — Material requirements for aluminium alloy drill pipe bodies
(see Table A.1 for USC units)

Characteristics[a]	Unit	Material group			
		I	II	III	IV
Alloy name[b]	—	D16T	1953T1	AK4-1T1	1980T1
Minimum yield strength (0,2 % offset method)	MPa	325	480	340	350
Minimum tensile strength	MPa	460	530	410	400
Minimum elongation	%	12	7	8	9
Maximum operational temperature	°C	160	120	220	160
Maximum corrosion rate in 3,5 % sodium chloride solution	g/(m^{2}h)	—	—	—	0,08
It is permitted to use an alternative aluminium alloy, as long as there is purchaser agreement and this alloy conforms to the requirements of one of the four material group categories. Mechanical testing shall be made in accordance with ISO 6892. 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.					
[a] The mechanical properties of the alloys given in this table are for a test temperature of (20 ± 3) °C. [b] For chemical composition and properties of alloys, see References [9] and [11].					

7.2 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 B917.

7.3 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.

7.4 Steel tool joints

Material requirements for steel tool joints shall conform to ISO 11961.

8 Configuration and dimensions of pipes

8.1 Configuration

The configuration of the aluminium alloy drill pipe shall be in accordance with Figure 1 for pipes with internal upset ends, with Figure 2 for pipes with external upset ends, and with Figures 3 and 4 for pipes with protector thickening.

8.2 Length

Aluminium alloy drill pipe and aluminium alloy drill pipe body length ranges shall comply with the requirements specified in Table 2 and Figure 1.

Table 2 — Aluminium alloy drill pipe and aluminium alloy drill pipe body length (see Figure 1)
(see Table A.2 for USC units)

Dimensions in metres

Pipe delivery condition	Range		
	1	2	3
Aluminium alloy drill pipe, L_{dp}, tolerance ±0,25	6,20	9,10	11,80
Aluminium alloy drill pipe body, L_{pe}, tolerance ±0,25	5,80	8,70	11,40
Other pipe lengths can be ordered by agreement between manufacturer and purchaser.			

8.3 Dimensions of pipes and tool joints

8.3.1 Standard configuration

The configuration and dimensions of the pipe body and upset ends, together with the tolerances, shall be in accordance with the following tables and figures and/or with the purchase agreement:

— for pipes with external upset ends: Table 3 (see also Figure 5);

— for pipes with internal upset ends: Table 4 (see also Figure 6);

— for pipes with protector thickening: Tables 5 and 6 (see also Figure 7).

All dimensions shown without tolerances are related to the basis for design and are not subject to measurement to determine acceptance or rejection of product. Drill pipe dimensions that are not in this International Standard or in the purchase agreement are at the manufacturer's discretion.

8.3.2 Protector thickening dimensions

Aluminium drill pipe of range 1, as well as aluminium drill pipe with outside diameter 63 mm (2.52 in), may not be manufactured with protector thickenings.

Protector thickening shall be located in the middle of the pipe [tolerance ± 350 mm (13.78 in)].

The length of protector thickening transition zone, L_3, shall depend on the range of aluminium drill pipe, and shall be (1 000 ± 200) mm [(39.37 ± 7.87) in] for range 2, and (1 600 ± 250) mm [(62.99 ± 9.84) in] for range 3.

8.3.3 Alternative configurations

When specified in the purchase agreement, drill pipe shall be furnished in dimensional configurations not defined in this International Standard. In this case, dimensions, tolerances and markings shall be agreed between the purchaser and manufacturer. The drill pipe body and tool joint shall be modified in accordance with this agreement, but the drill pipe shall otherwise be manufactured in accordance with the requirements of this International Standard.

8.3.4 Tool joint dimensions

The dimensions for the tool joints shall be in accordance with Figure 8 and Table 8.

Rotary shouldered connections shall conform to requirements of ISO 10424-2. Right-hand thread connections shall be considered standard.

Other dimensions and designs of tool joints may be used by agreement between purchaser and manufacturer.

8.3.5 Pipe to tool joint connection dimensions

The thread dimensions of the tool joint (see Figure 9) are given in Table 8.

The thread dimensions for pipes (see Figure 10) are given in Table 9.

The dimensions of thread form are given in millimetres in Figure 11 (in inches in Figure A.1) for the tool joints (top of figure) and for the pipe (bottom of figure).

Other types of connections for assembling tool joints with pipe may be used by agreement between purchaser and manufacturer. In this case, the manufacturer shall have documented testing results to verify that this connection complies with the tensile, torque and pressure requirements of ISO 20312.

8.4 Design mass

The calculated mass of the plain pipe per unit length, the mass increase of the upset ends and protector thickening are indicated in Tables 3 to 6. The calculated mass of the tool joints is given in Table 7.