INTERNATIONAL STANDARD

ISO 13680

Second edition
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Petroleum and natural gas industries — Corrosion-resistant alloy seamless tubes for use as casing, tubing and coupling stock — Technical delivery conditions

Industries du pétrole et du gaz naturel — Tubes sans soudure en acier allié résistant à la corrosion utilisés comme tubes de cuvelage, tubes de production et tubes-ébauches pour manchons — Conditions techniques de livraison

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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 13680 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 5, *Casing, tubing and drill pipe*.

This second edition cancels and replaces the first edition (ISO 13680:2000), which has been technically revised, after the six-month overlap period. (It also incorporates the Technical corrigenda ISO 13680:2000/Cor.1:2002 and ISO 13680:2000/Cor.2:2004.)

It is the intent of ISO/TC 67 that the first and second editions of ISO 13680 both be applicable, at the option of the purchaser, for a period of six months from the first day of the calendar quarter immediately following the date of publication of this second edition, after which period the first edition will no longer be applicable.

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 vendor 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 vendor should 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 — Corrosion-resistant alloy seamless tubes for use as casing, tubing and coupling stock — Technical delivery conditions

WARNING — It is the purchaser's responsibility to specify the product specification level (PSL), corrosion-resistant alloy (CRA) group, category, grade, delivery conditions and any other requirements in addition to those specified herewith to ensure that the product is adequate for the intended service environment. ISO 15156 (all parts) or NACE MR0175/ISO 15156 should be considered when making specific requirements for H_2S containing environment (see Annex G).

1 Scope

This International Standard specifies the technical delivery conditions for corrosion-resistant alloy seamless tubulars for casing, tubing and coupling stock for two product specification levels:

— PSL-1, which is the basis of this International Standard;

— PSL-2, which provides additional requirements for a product that is intended to be both corrosion resistant and cracking resistant for the environments and qualification method specified in ISO 15156-3 and Annex G of this International Standard.

At the option of the manufacturer, PSL-2 products can be provided in lieu of PSL-1.

NOTE 1 The corrosion-resistant alloys included in this International Standard are special alloys in accordance with ISO 4948-1 and ISO 4948-2.

This International Standard is applicable to the following four groups of product:

a) group 1, which is comprised of stainless alloys with a martensitic or martensitic/ferritic structure;

b) group 2, which is comprised of stainless alloys with a ferritic-austenitic structure, such as duplex and super-duplex stainless alloy;

c) group 3, which is comprised of stainless alloys with an austenitic structure (iron base);

d) group 4, which is comprised of nickel-based alloys with an austenitic structure (nickel base).

This International Standard contains no provisions relating to the connection of individual lengths of pipe.

NOTE 2 The connection or joining method can influence the corrosion performance of the materials specified in this International Standard.

NOTE 3 It is necessary to recognize that not all PSL-1 categories and grades can be made cracking resistant per ISO 15156-3 and are, therefore, not included in PSL-2.

2 Conformance

2.1 Dual normative references

In the interests of world-wide application of this International Standard, ISO/TC 67 has decided, after detailed technical analysis, that certain of the normative documents listed in Clause 3 and prepared by ISO/TC 67 or another ISO Technical Committee are interchangeable in the context of the relevant requirement with the relevant document prepared by the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM) or the American National Standards Institute (ANSI). These latter documents are cited in the running text following the ISO reference and preceded by “or”, for example “ISO XXXX or API YYYY”.

Application of an alternative normative document cited in this manner can lead to technical results different from the use of the preceding ISO reference. However, both results are acceptable and these documents are thus considered interchangeable in practice.

2.2 Units of measurement

In this International Standard, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units. 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 SI units, a comma is used as the decimal separator and a space as the thousands separator.

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

In the text, data in SI units are followed by data in USC units in parentheses.

Separate tables for data expressed in SI units and USC units are given in Annex A and Annex C, respectively.

Figures are contained in Annex B and express data in both SI and USC units.

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 31-0, *Quantities and units — Part 0: General principles*

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

ISO 404, *Steel and steel products — General*

ISO 525, *Bonded abrasive products — General requirements*

ISO 783, *Metallic materials — Tensile testing at elevated temperature*

ISO 4885, *Ferrous products — Heat treatments — Vocabulary*

ISO 4948-1, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

ISO 4948-2, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 6929, *Steel products — Definitions and classification*

ISO 8501-1:2007, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 9303, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections*

ISO 9304, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Eddy current testing for the detection of imperfections*

ISO 9305, *Seamless steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of transverse imperfections*

ISO 9402, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections*

ISO 9598, *Seamless steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of transverse imperfections*

ISO 10124, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 10543, *Seamless and hot-stretch-reduced welded steel tubes for pressure purposes — Full peripheral ultrasonic thickness testing*

ISO 11484[1)], *Steel products — Employer's qualification system of non-destructive testing (NDT) personnel*

ISO 11496, *Seamless and welded steel tubes for pressure purposes — Ultrasonic testing of tube ends for the detection of laminar imperfections*

ISO 12095, *Seamless end welded steel tubes for pressure purposes — Liquid penetrant testing*

ISO 13665, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube body for the detection of surface imperfections*

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*

ISO 15156-3:2003, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion resistant alloys) and other alloys*

ISO 15156-3:2003/Cor 1:2005, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion resistant alloys) and other alloys — Technical Corrigendum 1*

ISO 15156-3:2003/Cor 2:2005, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion resistant alloys) and other alloys — Technical Corrigendum 2*

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1) To be published. (Revision of ISO 11484:1994)

ASNT SNT-TC-1A, *Recommended practice — Non-destructive Testing*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A604/A604M, *Standard Practice for Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets*

ASTM A941, *Terminology Relating to Steel, Stainless Steel, Related Alloys and Ferroalloys*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E21, *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E45, *Standard Test Methods for Determining the Inclusion Content of Steel*

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

ASTM E213, *Standard Practice for Ultrasonic Examination of Metal Pipe and Tubing*

ASTM E309, *Standard Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation*

ASTM E340, *Standard Test Method for Macroetching Metals and Alloys*

ASTM E381, *Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings*

ASTM E407, *Standard Practice for Microetching Metals and Alloys*

ASTM E562, *Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count*

ASTM E570, *Standard Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

NACE MR0175/ISO 15156-3, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion resistant alloys) and other alloys*

4 Terms, abbreviated terms, symbols and definitions

4.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 377, ISO 404, ISO 4885, ISO 4948-1, ISO 4948-2, ISO 6929, ISO 10474, ASTM A941 and the following apply.

4.1.1
casing
pipe intended to line the walls of a drilled well

4.1.2
cast
heat
material of the same category melted in the same manufacturing process at the same time sequence poured into multiple ingots or continuous strand cast

4.1.3
cold hardened
material condition where the mechanical properties are obtained by a cold finishing process not followed by heat treatment

NOTE 1 Cold finishing is a plastic deformation of material at a temperature below the recrystallization temperature such that permanent strain hardening occurs.

NOTE 2 The percentage of cold hardening depends on the specified strength level for each material grade, as shown in Table A.3 or Table C.3 for the cold hardened condition.

4.1.4
corrosion-resistant alloy
CRA
alloy intended to be resistant to general and localized corrosion and/or environmental cracking in environments that are corrosive to carbon and low-alloy steels

4.1.5
coupling stock
seamless thick-wall tubular product used for the manufacture of coupling blanks

4.1.6
defect
imperfection having sufficient magnitude to warrant rejection of the product based on the criteria defined in this International Standard

4.1.7
hot finished
material condition obtained by deforming metal plastically at such a temperature and strain rate that recrystallization takes place simultaneously with the deformation, thus preventing permanent strain hardening

4.1.8
imperfection
discontinuity on the product surface or in the product wall that can be detected by visual inspection or an NDE method outlined in this International Standard

4.1.9
label 1
dimensionless designation for the size or specified outside diameter that may be used when ordering pipe

4.1.10
label 2
dimensionless designation for the linear density that may be used when ordering pipe

NOTE Linear density is sometimes designated by the deprecated term “mass per unit length”.

4.1.11
linear imperfection
imperfection including, but not limited to, seams, laps, cracks, plug scores, cuts and gouges

4.1.12
manufacturer
firm, company or corporation that operates facilities for making seamless pipes for casing, tubing or coupling stock

4.1.13
pipe
plain end casing, tubing and pup joint as group

4.1.14
product
tubular product
pipe or coupling stock as applicable

4.1.15
pup joint
casing or tubing shorter than range 1

4.1.16
quench hardening
quenching
heat treatment requiring austenitization followed by cooling, under conditions such that austenite transforms into martensite

NOTE 1 Quench hardening is often followed by tempering.

NOTE 2 Adapted from ISO 4885.

4.1.17
solution annealing
heat treatment requiring heating to a suitable temperature, holding at that temperature long enough to cause one or more constituents to enter into solid solution, then cooling rapidly enough to hold such constituents in solution

4.1.18
tempering
heat treatment requiring heating, one or more times, to a specific temperature below the lower critical temperature and holding at that temperature

NOTE 1 Tempering is often preceded by quench hardening.

NOTE 2 Adapted from ISO 4885.

4.1.19
test lot
lot
unit formed by products from the same heat, with the same specified outside diameter and wall thickness, the same grade, the same manufacturing process, the same final heat-treatment conditions, the same cold hardening parameters and in the range length as defined in Table A.16 and Table C.16

NOTE The maximum number of products in a test lot is found on Table A.21 and Table C.21.

4.1.20
tubing
pipe placed in a well to produce or inject fluids

4.2 Symbols

A cross-sectional area of the tensile test specimen, expressed in square millimetres (square inches) based on specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 10 mm^2 (0.01 in^2), or 490 mm^2 (0.75 in^2), whichever is smaller

C_V Charpy V-notch energy requirement, expressed in Joules (foot pounds)

D outside diameter of the product, expressed in millimetres (inches)

d inside diameter of the product, expressed in millimetres (inches)

e minimum elongation in 50,8 mm (2.0 in) gauge length, expressed in percent

f factor (for hydrostatic test): 0,8 (0.8) for all grades and sizes

m mass

p hydrostatic test pressure, expressed in megapascals (thousand pounds per square inch)

R_m tensile strength, expressed in megapascals (thousand pounds per square inch)

$R_{p0,2}$ yield strength (0,2 % non-proportional elongation), expressed in megapascals (thousand pounds per square inch)

t wall thickness of the product, expressed in millimetres (inches)

w_x percent mass fraction of element, x

$Y_{S,min}$ minimum specified yield strength, expressed in megapascals (thousand pounds per square inch)

$Y_{S,max}$ maximum specified yield strength, expressed in megapascals (thousand pounds per square inch)

4.3 Abbreviated terms

AOD argon oxygen decarburization

CH cold hardened

EMI electromagnetic inspection

ESR electro-slag remelting

HF hot-finished

HRC Rockwell hardness C-scale

L+T longitudinal plus transverse

MT magnetic-particle inspection

NA not applicable

NDE non-destructive examination

PRE pitting-resistance equivalent number

PSL product specification level

QT quenched and tempered

SA solution-annealed

UT ultrasonic testing

VAD vacuum arc degassing

VAR vacuum arc remelting

VIM vacuum induction melting

VOD vacuum oxygen decarburization

5 Information to be supplied by the purchaser

WARNING — It is the purchaser's responsibility to specify the PSL, CRA group, category, grade, delivery conditions and any other requirements in addition to those specified herewith to ensure that the product is adequate for the intended service environment. ISO 15156 (all parts) or NACE MR0175/ISO 15156 should be considered when making specific requirements for H_2S containing environment (see Annex G).

5.1 The purchaser shall state the following minimum information, as applicable, in the enquiry and purchase agreement:

Requirement		Reference
a)	Quantity of product	—
b)	Product designation: coupling stock or plain end casing or tubing or upset product	For upset product, upset drawing and drift dimension shall be supplied by the purchaser
c)	Reference to this International Standard	—
d)	Material category/grade	Table A.2 or Table C.2 and Table A.3 or Table C.3
e)	Label 1 and Label 2 or specified outside diameter and specified wall thickness	Table A.15 or Table C.15 or as specified in purchase agreement
f)	Coupling stock dimensions, mm (in)	as specified in purchase agreement
g)	Length range	8.2; Table A.16 or Table C.16 or as specified in purchase agreement
h)	Length for coupling stock	as specified in purchase agreement
i)	Critical thickness for impact testing of coupling stock	7.4.2
j)	Tolerances on outside diameter, wall thickness and mass of coupling stock	8.3.1
k)	Inspection by the purchaser	Annex D

5.2 The purchaser shall also state on the purchase agreement the requirements, where applicable, concerning the following stipulations, which are at the purchaser's option; if PSL-2 is not specified, the product will be supplied according to the requirements of PSL-1:

Requirement		Reference
a)	Chemical composition	7.1
b)	Mechanical properties at elevated temperature	7.2
c)	PSL-2	Annex G
d)	Impact test temperature if lower than –10 °C (14 °F)	7.4.6
e)	Special surface condition	7.10
f)	Second outside surface NDE method for group 1 materials	9.16.9
g)	Chromium depletion	9.3.3
h)	Surface protection for group 1 materials	12
i)	Hydrostatic test	7.12 and 9.14
j)	Corrosion testing	7.8
k)	Ferrite content for material 13-1-0	7.9.1
l)	Alternate drift mandrel	8.3.4
m)	End sizing by cold expansion	6.3.2
n)	Additional marking that is consistent with 11.1	11.1
o)	Surface protection	12.2
p)	For UNS N06975, $c_{Mo} + c_W \geqslant 6$ % mass fraction	Table A.28 or Table C.28

6 Manufacturing process

6.1 Manufacturing of corrosion-resistant alloys

The alloys covered by this International Standard shall be made by the basic oxygen process or the electric furnace process or blast furnace (group 1 only) followed by further refining operations such as AOD, VOD, VAR, ESR, VIM and VAD.

6.2 Product manufacturing process

Product manufacturing processes, starting material and heat treatment or cold hardened conditions are listed in Table A.1 or Table C.1.

Group 1 pipes and group 2 solution-annealed pipes shall be full-length heat-treated after any upsetting.

The manufacturer shall apply a process control plan that precludes the occurrence of phenomenon that can create surface effects (e.g. chromium depletion below 12,0 % for groups 2, 3 and 4) on products where heat treatment is part of the manufacturing process, which can affect the corrosion resistance.

For group 2, the product shall be in the

a) solution-annealed and liquid-quenched condition, or

b) solution-annealed and liquid-quenched and cold hardened condition.

6.3 Pipe end sizing

6.3.1 Group 1 pipe may be end-sized such as swaging or expanding after final heat treatment for purposes of threading. When end sizing such as swaging or expanding exceeds 3 % plastic strain, group 1 pipe either shall be stress relieved at suitable temperature or shall be full-length heat-treated in accordance with a documented procedure.

When the manufacturer has demonstrated and documented that the swaging process has not detrimentally affected the corrosion properties, by agreement between the purchaser and manufacturer, group 1 pipe may be cold swaged exceeding 3 % plastic strain without subsequent heat treatment.

If end sizing is performed before final full-length heat treatment, stress relief is not required.

6.3.2 For groups 2, 3 and 4 pipe, end sizing by cold swaging or cold expansion for purpose of threading is allowed. However, end sizing by cold expansion shall be only by agreement between purchaser and manufacturer.

NOTE 1 It is very difficult to stress relieve duplex stainless steels without causing sigma-phase formation.

NOTE 2 End sizing can detrimentally influence the corrosion performance of the materials specified in this International Standard.

6.4 Straightening

For group 1 martensitic material and for group 2 material delivered in the solution-annealed condition, the pipe shall not be subjected to either tensile or expansion cold-working, except for that which is incidental to normal straightening operations, and to no more than 3 % plastic strain, after the final heat treatment operation.

Group 1 pipes shall be hot-rotary straightened, when necessary, after heat treatment, at 400 °C (750 °F) minimum at the end of rotary straightening unless a higher minimum temperature is specified in the purchase agreement. If hot rotary straightening is not possible, the pipe may be cold rotary straightened, provided it is then stress-relieved at 510 °C (950 °F) or higher.

Light gag-press straightening shall be permitted, providing that the plastic strain does not exceed 3 %.