

Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells

The European Standard EN ISO 11960:2001 has the status of a
British Standard

ICS 75.180.01

National foreword

This British Standard is the official English language version of EN ISO 11960:2001, including Technical Corrigendum March 2003. It is identical with ISO 11960:2001. It supersedes BS EN ISO 11960:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PSE/17, Materials and Equipment for Petroleum and Natural Gas Industries, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 21 December 2001

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English version

Petroleum and natural gas industries - Steel pipes for use as
casing or tubing for wells (ISO 11960:2001)

Industries du pétrole et du gaz naturel - Tubes d'acier
utilisés comme cuvelage ou tubes de production dans les
puits (ISO 11960:2001)

Erdöl- und Erdgasindustrien - Stahlrohre zur Verwendung
als Futter- oder Steigrohre für Bohrungen (ISO
11960:2001)

This European Standard was approved by CEN on 1 October 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN ISO 11960:2001) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2002, and conflicting national standards shall be withdrawn at the latest by April 2002.

This document supersedes EN ISO 11960:1998.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 11960:2001 has been approved by CEN as EN ISO 11960:2001 without any modifications.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

INTERNATIONAL STANDARD

ISO
11960

Second edition
2001-10-01

Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells

*Industries du pétrole et du gaz naturel — Tubes d'acier utilisés comme
cuvelage ou tubes de production dans les puits*



Reference number
ISO 11960:2001(E)

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11960 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 5, *Casing, tubing and drill pipe*.

This second edition replaces the first edition (ISO 11960:1996) which has been technically revised. It is the intent of TC 67 that the first and second editions of ISO 11960 both be applicable, at the user's option, for a period of six months after the date of publication of this second edition, after which the first edition will no longer be applicable.

Annexes A to E form a normative part of this International Standard. Annexes F and G are for information only.

Introduction

This International Standard is based on API 5CT (Specification for Casing and Tubing).

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 — Steel pipes for use as casing or tubing for wells

1 Scope

1.1 This International Standard specifies the technical delivery conditions for steel pipes (casing, tubing, plain end casing liners and pup-joints) and accessories. This International Standard is applicable to the following connections in accordance with ISO 10422 or API Spec 5B:

- short round thread casing (STC);
- long round thread casing (LC);
- buttress thread casing (BC);
- extreme-line casing (XC);
- non-upset tubing (NU);
- external upset tubing (EU);
- integral joint tubing (IJ).

For such connections, this International Standard specifies the technical delivery conditions for couplings and thread protection.

For pipes covered by this International Standard, the sizes, masses, wall thicknesses, grades and applicable end finish are listed in Tables C.1 to C.3 and Tables E.1 to E.3.

This International Standard may also be applied to tubulars with connections not covered by ISO/API standards.

1.2 The four groups of products to which this International Standard is applicable include the following grades of pipe:

- Group 1: All casing and tubing in Grades H, J, K and N;
- Group 2: All casing and tubing in Grades C, L, M and T;
- Group 3: All casing and tubing in Grade P;
- Group 4: All casing in Grade Q.

1.3 Casing sizes larger than Label 1: 4-1/2 but smaller than Label 1: 10-3/4 may be specified by the purchaser to be used in tubing service, see Tables C.1, C.24, C.30 and C.31 or Tables E.1, E.24, E.30 and E.31.

1.4 Supplementary requirements that may optionally be agreed between purchaser and manufacturer, for non-destructive examination, coupling blanks, upset casing, electric-welded casing, impact testing, seal ring couplings and certificates are given in annex A.

1.5 This International Standard is not applicable to threading requirements.

NOTE Dimensional requirements on threads and thread gauges, stipulations on gauging practice, gauge specifications, as well as instruments and methods for inspection of threads are given in ISO 10422 or API Spec 5B. Connections machined to either of these specifications are the same for practical purposes and are totally interchangeable.

2 Conformance

2.1 Normative references

In the interests of worldwide 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 other 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 will lead to the same results as the use of the preceding ISO reference. 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 the SI, 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.

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

2.3 Tables and figures

Separate tables for data expressed in SI units and USC units are given in annex C and annex E respectively. For a specific order item, only one unit system shall be used.

Figures are contained in annex D and express data in both SI and USC units.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 643, *Steels — Micrographic determination of the ferritic or austenitic grain size*

ISO 6506-1, *Metallic materials — Brinell Hardness test — Part 1: Test method*

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 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile/compression testing machines — Verification and calibration of the force-measuring system*

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 9764, *Electric resistance and induction welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal imperfections*

ISO 10400, *Petroleum and natural gas industries — Formulae and calculation for casing, tubing, drill pipe and line pipe properties*

ISO 10422, *Petroleum and natural gas industries — Threading, gauging and thread inspection of casing, tubing and line pipe threads — Specification*

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

ISO 11484, *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel*

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

ISO 13678, *Petroleum and natural gas industries — Evaluation and testing of thread compounds for use with casing, tubing and line pipe*

ISO/TR 9769, *Steel and iron — Review of available methods of analysis*

ANSI-ASNT SNT-TC-1A:1984, *Personnel qualifications and certification in non-destructive testing*

ANSI-NACE TM0177:1996, *Laboratory testing of metals for resistance to sulfide stress cracking at ambient temperature in H₂S environment*

API Bul 5C2, *Bulletin on performance properties of casing, tubing and drill pipe*

API Bul 5C3, *Bulletin on formulas and calculations for casing, tubing, drill pipe and line pipe properties (plus Supplement 1)*

API RP 5A3, *Bulletin on thread compounds for casing, tubing and line pipe*

API Spec 5B, *Specification for threading, gauging and thread inspection of casing, tubing and line pipe threads*

API Std 5T1, *Imperfection technology*

ASTM A370, *Standard test methods and definitions for mechanical testing of steel products*

ASTM A751, *Methods, practices and definitions for chemical analysis of steel products*

ASTM A941, *Terminology relating to steel, stainless steel, related alloys and ferro-alloys*

ASTM E4, *Practices for load verification of testing machines*

ASTM E10, *Standard method of test for Brinell hardness of metallic materials*

ASTM E18, *Standard methods of test for Rockwell hardness and Rockwell superficial hardness of metallic materials*

ASTM E23, *Standard test methods for notched bar impact testing of metallic materials*

ASTM E29, *Practice for using significant digits in test data to determine conformance with specifications*

ASTM E83, *Standard practice for verification and classification of extensometers*

ASTM E112, *Methods for determining average grain size*

ASTM E213, *Standard practice for ultrasonic examination of metal pipe and tubing*

ASTM E273, *Standard practice for ultrasonic examination of longitudinal welded pipe and tubing*

ASTM E309, *Standard practice for eddy-current examination of steel tubular products using magnetic saturation*

ASTM E570, *Standard practice for flux leakage examination of ferro-magnetic steel tubular products*

ASTM E709, *Standard practice for magnetic particle examination*

4 Terms, definitions, symbols and abbreviated terms

4.1 Terms and definitions

For the purposes of this International Standard, the terms and definitions in ASTM A941 for heat treatment operations and the following apply.

4.1.1

carload

quantity of pipe loaded on a railway car for shipment from the pipe-making facilities

4.1.2

casing

pipe run from the surface and intended to line the walls of a drilled well

4.1.3

casing and tubing accessory

one-piece tubular section used in a pipe string to provide mechanical and pressure integrity within the pipe string and facilitate the performance of some other function required of that pipe string

NOTE Examples of accessories are: crossover connectors, swages, nipples, flow couplings, blast joints, etc. Accessories exclude the other tubular products specifically defined in this International Standard or products included in other ISO (API) specifications.

4.1.4

connection

threaded assembly of tubular components

4.1.5**controlled cooling**

cooling from an elevated temperature in a pre-determined manner to avoid hardening, cracking or internal damage, or to produce a desired microstructure or mechanical properties

4.1.6**coupling**

internally threaded cylinder for joining two lengths of threaded pipe

4.1.7**coupling blank**

unthreaded material used to produce an individual coupling

4.1.8**coupling stock**

tubular used for the manufacture of coupling blanks

4.1.8**defect**

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

4.1.9**electric-welded pipe**

pipe having one longitudinal seam formed by electric-resistance or electric-induction welding, without the addition of filler metal, wherein the edges to be welded are mechanically pressed together and the heat for welding is generated by the resistance to flow of electric current

4.1.10**handling tight**

sufficiently tight that the coupling cannot be removed except by the use of a wrench

4.1.11**heat**

metal produced by a single cycle of a batch melting process

4.1.12**heat analysis**

chemical analysis representative of a heat as reported by the metal producer

4.1.13**imperfection**

discontinuity in the product wall or on the product surface that can be detected by a NDE method included in Table C.61 or Table E.61 of this International Standard

4.1.14**inspection**

process of measuring, examining, testing, gauging or otherwise comparing a unit of product with the applicable requirements

4.1.15**inspection lot**

definite quantity of product manufactured under conditions that are considered uniform for the attribute to be inspected

4.1.16**inspection lot sample**

one or more units of product selected from an inspection lot to represent that inspection lot

4.1.17

inspection lot size

number of units of product in an inspection lot

4.1.18

interrupted quenching

quenching in which the pipe being quenched is removed from the quenching medium while the pipe is at a temperature substantially higher than that of the quenching medium

4.1.19

ISO/API threads

threads as specified in ISO 10422 or API Spec 5B

4.1.20

label 1

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

4.1.21

label 2

dimensionless designation for the mass per unit length or wall thickness that may be used when ordering pipe

4.1.22

length

piece of pipe that may be plain-end, threaded, or threaded and coupled, that is in accordance with the range requirements in Table C.30 or Table E.30 of this International Standard

4.1.23

linear imperfection

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

NOTE See API Std 5T1.

4.1.24

manufacturer

one or more of the following, depending on the context: pipe mill; processor; threader; coupling manufacturer, pup-joint manufacturer; accessory manufacturer

NOTE See clause 14.

4.1.25

non-linear imperfection

imperfection which includes, but is not limited to, pits and round bottom die stamping

NOTE See API Std 5T1.

4.1.26

pipe

casing, tubing, plain-end casing liners and pup-joints as a group

4.1.27

pipe mill

firm, company or corporation that operates pipe-making facilities

4.1.28

plain-end casing liner

casing provided unthreaded and with a wall thickness often greater than that specified for J55

4.1.29

processor

firm, company or corporation that operates facilities capable of heat-treating pipe made by a pipe mill

4.1.30**product**

pipe, coupling, accessory, coupling stock or coupling blank, either individually or collectively as applicable

4.1.31**pup-joint**

casing, tubing or plain-end casing liner of length shorter than Range 1

4.1.32**purchaser**

party responsible for both the definition of requirements for a product order and for payment for that order

4.1.33**quench crack**

crack in steel resulting from stresses produced during the transformation from austenite to martensite

NOTE This transformation is accompanied by an increase in volume.

4.1.34**seamless pipe**

wrought steel tubular product made without a weld seam

NOTE It is manufactured by hot-working steel, and if necessary, by subsequently cold-working or heat-treating, or a combination of these operations, to produce the desired shape, dimensions and properties.

4.1.35**special end finish**

threads with thread form and features, manufacturing specifications, dimensions, connection make-up and performance properties which are beyond the scope of this International Standard

4.1.36**special processes**

final operations which are performed during pipe manufacturing that affect the attributes of product, except its chemistry and dimensions

NOTE These special processes are:

Manufacturing conditions	Special processes
Seamless, as-rolled	— Final re-heating practice and hot sizing or stretch-reducing. — If applicable, upsetting, coldfinishing. — Non-destructive examination
Seamless, heat-treated	— Heat treatment — Non-destructive examination
Electric-weld, as-rolled	— Sizing and seam welding — If applicable, seam heat treatment and upsetting — Non-destructive examination
Electric-weld, heat-treated	— Seam welding and full-body heat treatment — Non-destructive examination

4.1.37

thread protector

cap or insert used to protect threads and seals during handling, transportation and storage

4.1.38

tubing

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

4.1.39

upper critical temperature

A_{r3}

temperature at which austenite begins to transform to ferrite during cooling

4.2 Symbols and abbreviated terms

BC	buttress thread casing connection
C_V	Charpy V-notch impact test minimum absorbed energy
D	specified outside diameter for pipe
d	calculated inside diameter
EMI	electromagnetic inspection
EU	external upset tubing connection
EW	electric-welded process
HBW	Brinell hardness, when testing with a tungsten carbide ball
HBS	Brinell hardness, when testing with a steel ball
HRC	Rockwell hardness C-scale
ID	inside diameter
IJ	integral joint tubing connection
k	a constant used in the calculation of elongation
LC	long round thread casing connection
N	⟨heat-treat process⟩ full-length normalized
N&T	normalized and tempered
NDE	non-destructive examination
NU	non-upset tubing connection
OD	outside diameter
Q	quenched and tempered
S	seamless process
Sc	minimum acceptable result of the ANSI-NACE TM0177:1996 Method B test
SCC	special clearance coupling
SSCC	sulfide stress corrosion cracking

STC	short round thread casing connection
t	specified wall thickness
T&C	threaded and coupled
USC	United States customary (units)
UT	ultrasonic testing
W	specified outside diameter for ISO/API thread couplings other than special clearance couplings
W_C	specified outside diameter of special clearance couplings
XC	extreme line casing connection
$YS_{\min}$	specified minimum yield strength

5 Information to be supplied by the purchaser

5.1 Casing

5.1.1 When enquiring or placing orders for pipe to be manufactured in accordance with this International Standard, the purchaser shall specify the following:

Requirement	Reference
Standard	ISO 11960 or API 5CT
Quantity	
Type of pipe or couplings	
Casing:	
Threaded or plain-end	8.12
Type of connection: round (short or long), buttress, extreme-line threads, or other connection	8.12, Table C.1 or Table E.1
With or without couplings	8.12
Special clearance couplings	9.8, Tables C.1, C.36 or Tables E.1, E.36
Liners:	
Label 1 or specified outside diameter	8.12.1, Table C.2 or Table E.2
Label 2 or specified mass or wall thickness	Tables C.1, C.2 or Tables E.1, E.2
Grade and type where applicable	Tables C.1, C.2, C.5 or Tables E.1, E.2, E.5
Range length	8.6, Table C.30 or Table E.30
Seamless or electric-welded	6.1, Table C.4 or Table E.4
Critical thickness for special end-finish couplings, stock or blanks	7.6.6
Critical thickness for special end-finish accessories	7.6.6
Wall thickness verification of special end-finish accessories	10.13.4
Delivery date and shipping instructions	
Inspection by purchaser	Annex B

5.1.2 The purchaser should also state on the purchase agreement his requirements concerning the following stipulations, which are at the purchaser's option:

Requirement	Reference
Heat treatment	6.2
Lower alternative impact test temperature	7.3.7
Casing jointers	8.7

Alternative drifting requirements	8.10
Casing with couplings detached	8.14
Coupling make-up (other than power-tight)	8.14
Coupling blanks	9.2, A.3 (SR9)
Seal ring couplings	9.11, A.7 (SR13)
Heat and supplementary analyses	10.3
Additional markings	11
Pipe coatings	12.1
Material certification	13.2, A.8 (SR15)

5.1.3 The following may be agreed between purchaser and manufacturer:

Requirement	Reference
Cold rotary straightening - Q125 Grade	6.3
Statistical impact testing	7.3.8, A.6 (SR12)
Impact of Group 1 non-heat-treated pipe	7.5.1, A.9 (SR16)
Sulfide stress cracking test - C90 and T95 Grade	7.14
Length of accessories	8.6
Thread and storage compound	8.14
Waiving NDE of Group 1 couplings in Grades H40, J55 and K55	9.14.3
Coupling thread plating - Q125 Grade only	9.17
Additional hardness testing - Grades M65 and L80	10.6.2
Additional hardness testing - C90 and T95 Grade	10.6.4
Reduced section tensile specimens - Q125 Grade	10.4.6
Hydrostatic pressure test for handling-tight make-up, accessories and Group 4 pup-joints	10.12.2
Alternative hydrostatic test pressures	10.12.3
Plain-end Q125 casing hydrostatic testing	10.12.2
Non-destructive examination	10.15, A.1 (SR1), A.2 (SR2), A.4 (SR10) and A.5 (SR11)
Marking requirements	11.1
Thread protectors	12.2
Coupling blanks - Q125 Grade only	A.3 (SR9)
Upset casing - Q125 Grade only	A.4 (SR10)
Electric-weld casing - P110 and Q125 Grade	A.5 (SR11)
Alternative <i>F</i> factor in SR 12 - Q125 Grade	A.6 (SR12.2)
Special end-finish for casing, couplings, pup-joints or accessories	8.12.8, 9.13.2
Quality assurance requirements	
Special wall thickness for Grades C90, T95 and Q125	8.2

5.2 Tubing

5.2.1 When enquiring or placing orders for pipe to be manufactured in accordance with this International Standard, the purchaser shall specify the following:

Requirement	Reference
Standard	ISO 11960 or API 5CT
Quantity	
Type of pipe or couplings	
Tubing:	
Non-upset, external-upset or integral joint	Table C.3 or Table E.3
Threaded, plain-end, or other connection	8.12
With or without couplings	8.12
Special bevel couplings	9.12, Tables C.3, C.37 and C.38 or Tables E.3, E.37 and E.38

Special clearance couplings	9.8, Tables C.3, C.38 or Tables E.3 and E.38
Label 1 or specified outside diameter	Table C.3 or Table E.3
Label 2 or specified mass or wall thickness	Table C.3 or Table E.3
Grade and type, where applicable	Table C.3 or Table E.3, Table C.5 or Table E.5
Range length	8.6, Table C.30 or Table E.30
Seamless or electric-welded	6.1, Table C.4 or Table E.4
Critical thickness for special end-finish couplings, stock or blanks	7.4.6
Critical thickness for accessory material	7.6.6
Wall thickness verification of special end-finish accessories	10.13.4
Delivery date and shipping instructions	
Inspection by purchaser	Annex B

5.2.2 The purchaser should also state on the purchase agreement his requirements concerning the following stipulations, which are at the purchaser's option:

Requirement	Reference
Heat treatment	6.2
Upset length — Standard or extended	8.11.6
Rounded nose	8.12.4
Coupling make-up (other than power-tight)	8.14
Tubing with couplings detached	8.14
Seal ring couplings	9.11, A.7 (SR13)
Heat and supplementary analyses	10.3
Additional markings	11
Pipe coatings	12.1
Material certification	13.2, A.8 (SR15)

5.2.3 The following may be agreed between purchaser and manufacturer:

Requirement	Reference
Statistical impact testing	7.3.8, A.6 (SR12)
Impact testing of Group 1 pipe	7.5.1, A.9 (SR16)
Sulfide stress cracking test — C90 and T95 Grade	7.14
Length of accessories	8.6
Thread and storage compound	8.14
Special end-finish for tubing, couplings or accessories	8.12.8, 9.13.3
Waiving NDE of Group1 couplings in Grades H40, J55 and K55	9.14.3
Additional hardness testing — Grades M65 and L80	10.6.2
Additional hardness testing — C90 and T95 Grade	10.6.4
Hydrostatic pressure test for handling-tight make-up and pup-joints	10.12.2
Alternative hydrostatic test pressures	10.12.3
Non-destructive examination	10.15, A.1 (SR1), A.2 (SR2), A.4 (SR10) and A.5 (SR11)
Marking requirements	11.1
Thread protectors	12.2
Electric-weld tubing — Grade P110	A.5 (SR11)
Special end-finish tubing, couplings, pup-joints and accessories	8.12.8, 9.13.3
Quality assurance requirements	
Special wall thickness for Grades C90 and T95	8.2
Casing used for tubing	8.2, Table C.30 or Table E.30

6 Process of manufacture

6.1 General

The various grades and groups of pipe furnished to this International Standard shall be made to a fine-grain practice. Steel made to a fine-grain practice contains one or more grain-refining elements, such as aluminium, niobium (columbium), vanadium or titanium in amounts intended to result in the steel having a fine austenitic grain size.

Pipe furnished to this International Standard shall be made by the seamless or electric-weld process as shown in Table C.4 or Table E.4 and as specified on the purchase agreement. Pup-joints shall be made from standard casing or tubing or by machining thick-wall casing, tubing or bar stock. Couplings shall be manufactured by one of the processes listed in 9.3 or 9.4. Cold-drawn tubular products without appropriate heat treatment are not acceptable.

Casing and tubing accessories shall be seamless and made from standard casing or tubing, or by machining thick-wall casing, tubing or mechanical tubes, or bar stock or hot forgings.

Electric-welded Grade P110 pipe and Grade Q125 casing shall be provided only when the supplementary requirement in A.5 (SR11) is specified on the purchase agreement.

Grade Q125 upset casing shall be provided only when the supplementary requirement in A.4 (SR10) is specified on the purchase agreement.

6.2 Heat treatment

6.2.1 General

Product shall be heat-treated in accordance with a documented procedure as stipulated in Table C.4 or Table E.4 for the particular grade and type specified on the purchase agreement. Heat-treated upset pipe shall be heat-treated full length after upsetting. Product requiring heat treatment shall be heat-treated the full length. Individually heat-treated coupling blanks are acceptable. All pipe processed through a hot-stretch mill (i.e. stretch-reduced) shall be considered normalized, provided the exit temperature is above the upper critical temperature (A_{r3}) for the steel being processed, and the pipe is air-cooled.

The weld seam of electric-welded pipe shall be heat-treated after welding to a minimum temperature of 540 °C (1 000 °F) or processed in such a manner that no untempered martensite remains.

6.2.2 Group 1

Grade N80 Type 1 product shall be normalized or, at the manufacturer's option, shall be normalized and tempered. Grade N80Q product shall be quenched and tempered (including the interrupted quenching followed by controlled cooling method) full length. Grade J55 and K55 casing and Grade J55 tubing shall be heat-treated if so specified on the purchase agreement.

6.2.3 Group 2

When requested by the purchaser, the manufacturer shall produce evidence to show that the tempering practice will result in the pipe attaining the minimum tempering temperature.

Grade L80 13Cr may be subject to embrittlement when tempered below 620 °C (1 150 °F). When all product meets the requirements in 7.3, 7.4.5, 7.5.3 and 10.7, no further precautions are necessary.

NOTE In this International Standard when the symbol L80 is used alone it covers Grades L80 Type 1, L80 9Cr and L80 13Cr.

6.2.4 Groups 3 and 4

Product furnished to this International Standard shall be quenched and tempered.

6.3 Straightening

6.3.1 Groups 1 and 3

No specific methods are required.

6.3.2 Grades M65 and L80

Grades M65 and L80 shall not be subjected to cold working after the final heat treatment, except for that which is incidental to normal straightening operations. Grades M65 and L80 pipe rotary-straightened at temperatures less than 480 °C (900 °F) shall not contain roll marks that exceed the maximum hardness specified in Table C.6 or Table E.6; however:

- Roll marks that are not detectable by feel and have no measurable surface deformation are acceptable without further evaluation;
- Roll marks that are not more severe than those previously evaluated and verified by the manufacturer in a documented procedure not to exceed the maximum hardness specified in Table C.6 or Table E.6 are acceptable without further evaluation.
- Pipe with severe roll marks shall be either rejected or stress-relieved at 480 °C (900 °F) minimum.

6.3.3 Grade C95

Grade C95 pipe shall be subjected to no tensile or expansion cold-working, except that which is incidental to normal straightening operations, and to no more than 3 % compressive cold-working, after the final tempering operation.

6.3.4 Grades C90 and T95

Grades C90 and T95 pipe may be subjected to cold rotary-straightening if, subsequent to the cold rotary-straightening operation, the pipe is heated to a minimum temperature of 480 °C (900 °F) for stress-relieving. When necessary, light gag-straightening for Grades C90 and T95 shall be permitted.

6.3.5 Grade Q125

Gag-press straightening or hot rotary-straightening at 400 °C (750 °F) minimum at the end of rotary-straightening (unless a higher minimum temperature is specified on the purchase agreement) is acceptable. 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. Pipe may be cold rotary-straightened without subsequent stress-relieving only by agreement between purchaser and manufacturer.

6.4 Traceability

6.4.1 General

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

6.4.2 Serialization of Grades C90, T95 and Q125

The serial number shall be marked on products as specified below. It is the responsibility of the manufacturer to maintain the identification of material until it is received by the purchaser.

Each length of pipe shall be uniquely numbered so that test data can be related to individual lengths. In addition, when supplementary requirement A.6 (SR12) is specified, the number shall identify the sequence in which the lengths were tempered in order to allow re-test in accordance with A.6.3 (SR12.3).

Each tube length of coupling, pup-joint or accessory material shall be uniquely numbered so that test data can be related to individual lengths. When cut from material that has been heat-treated full length, the pieces shall be marked with the serial number of the full length piece. When heat-treated in coupling blank or individual lengths, each heat-treat lot (see 10.2.3) shall be uniquely numbered. Additionally, when coupling, pup-joint or accessory material in coupling blank or individual lengths is heat-treated as a unit in a continuous process-run, the pieces within the lot shall be sequentially numbered in the order in which they are heat-treated.

7 Material requirements

7.1 Chemical composition

Product shall conform to the requirements specified in Table C.5 or Table E.5 for the grade and type specified.

7.2 Tensile properties

7.2.1 General

Product shall conform to the tensile requirements specified in Table C.6 or Table E.6.

The tensile properties of upset casing and 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.

7.2.2 Elongation — All groups

The minimum elongation shall be that determined by the following equation:

$$e = k \times \frac{A^{0,2}}{U^{0,9}}$$

where

e is the minimum gauge length extension in 50,8 mm (2.0 in) in percent rounded to the nearest 0,5 % below 10 % and to the nearest unit percent for 10 % and larger;

k is a constant: 1 944 (625 000);

A is the cross-sectional area of the tensile test specimen in square millimetres (square inches), based on specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 10 mm² (0.01 in²), or 490 mm² (0.75 in²) whichever is smaller.

U is the minimum specified tensile strength, in megapascals (pounds per square inch).

The minimum elongation for both round-bar tensile specimens [8,9 mm (0.350 in) diameter with 35,6 mm (1.40 in) gauge length, and 12,7 mm (0.500 in) diameter with 50,8 mm (2.0 in) gauge length] shall be determined with an area A of 130 mm² (0.20 in²)

Table C.7 or Table E.7 gives minimum elongation values for various sizes of tensile specimens and for various grades.

7.2.3 Yield strength

The yield strength shall be the tensile stress required to produce the elongation under load specified in Table C.6 or Table E.6 as determined by an extensometer.

7.3 Charpy V-notch test properties — General requirements

7.3.1 Evaluation of test results

A test shall consist of a set of three specimens taken from one location from a single tubular product length. The average value of the three impact specimens shall equal or exceed the absorbed energy requirement specified in 7.4, 7.5 and 7.6. In addition, not more than one impact specimen shall exhibit an absorbed energy below the absorbed energy requirement, and in no case shall an individual impact specimen exhibit an absorbed energy below two-thirds of the absorbed energy requirement.

7.3.2 Critical thickness

The absorbed energy requirements are based on the critical thickness. The critical thickness for couplings with ISO/API threads is the thickness at the root of the thread at the middle of the coupling, based on the specified coupling diameter and the specified thread dimensions. The critical thickness for all couplings with ISO/API threads is provided in Table C.8 or Table E.8. For pipe, the critical thickness is the specified wall thickness. For other applications, the critical thickness shall be determined as specified in 7.6.6.

7.3.3 Specimen size and orientation

When the use of full-size (10 mm × 10 mm) transverse test specimens is not possible, the largest possible sub-size transverse test specimen listed in Table C.9 or Table E.9 shall be used. When it is not possible (or allowed in accordance with 7.3.6) to test using any of these transverse test specimens, the largest possible longitudinal test specimen listed in Table C.9 or Table E.9 shall be used.

When testing EW pipe using a transverse test specimen, the weld line shall be positioned at the notch in the Charpy test specimen.

When the outside diameter or wall thickness precludes the machining of longitudinal impact test specimens ½-size or larger, the pipe need not be tested; however, the manufacturer shall use a chemical composition and processing that is documented and demonstrated to result in impact-energy absorption meeting or exceeding the minimum specified requirement.

7.3.4 Hierarchy of test specimens

The hierarchy of test specimen orientation and size is specified in Table C.10 or Table E.10.

7.3.5 Alternative size impact test specimens

At the manufacturer's option, impact test specimens of an alternative size, listed in Table C.9 or Table E.9, may be used in lieu of the minimum size specified in Tables C.11 through C.16, C.21, C.22 and Tables E.11 through E.16, E.21 and E.22. However, the alternative test specimen selected shall be higher on the hierarchy table (Table C.10 or Table E.10) than the specified size, and the absorbed energy requirement shall be adjusted consistent with the orientation and size of the impact specimen.

7.3.6 Sub-size test specimens

The minimum Charpy V-notch absorbed energy requirement for sub-size test specimens shall be that specified for a full-size test specimen multiplied by the reduction factor in Table C.9 or Table E.9; however, in no event shall a sub-size test specimen be used if the reduced absorbed energy requirement is less than 11 J (8 ft-lb).

7.3.7 Test temperature

The test temperature shall be 0 °C (32 °F) for all groups except Group 1, Grades J55 and K55. Grades J55 and K55 shall be tested at 21 °C (70 °F). An alternative lower test temperature may be specified on the purchase agreement or selected by the manufacturer for any grade. The tolerance on the test temperature shall be ± 3 °C (± 5 °F).

A reduction in test temperature may be required for Grades J55 and K55 when sub-size specimens are used. The amount of test temperature reduction depends on the critical thickness of the connection and the size of the impact test specimen. The test temperature reduction specified in Table C.11 or Table E.11 shall be used when applicable.

7.3.8 Statistical impact testing

By agreement between purchaser and manufacturer, the supplementary requirements for statistical impact testing in A.6 (SR 12) shall apply.

7.3.9 Reference information

ISO 10400 or API Bul 5C3 includes reference information on fracture mechanics and equations and tables used in preparing impact requirements.

7.4 Charpy V-notch (CVN) — Absorbed energy requirements for coupling stock, coupling blanks and couplings

7.4.1 General

Coupling stock suitable for more than one type of connection may be qualified by a test to demonstrate conformance to the most stringent requirements. The test specimen orientation and size shall be the highest possible listed on the hierarchy in Table C.10 or Table E.10 and the absorbed energy requirement shall equal or exceed the applicable requirements.

7.4.2 Grade H40

There is no mandatory CVN impact energy requirement.

NOTE See A.9 (SR16) for optional CVN requirements.

7.4.3 Grades J55 and K55 for ISO/API threads

The minimum full-size transverse absorbed energy requirement C_V is 20 J (15 ft-lb). The minimum full-size longitudinal absorbed energy requirement C_V is 27 J (20 ft-lb). The impact specimen orientation, minimum size, minimum absorbed energy requirement (that is, adjusted for the size of specimen indicated), and test temperature reduction (as applicable) for couplings are provided in Table C.11 or Table E.11.

7.4.4 Grade M65 for ISO/API threads

There are no Grade M65 couplings. Grade L80 Type 1 couplings shall be used on Grade M65 pipe.

7.4.5 Grades N80 Type 1 and N80Q, Groups 2 (except M65), 3 and 4 for ISO/API threads

7.4.5.1 The impact specimen orientation, minimum size, and minimum absorbed energy requirement C_V (i.e. adjusted for the specimen size indicated) for couplings are provided in Tables C.12 to C.16 or Tables E.12 to E.16.

7.4.5.2 For SI units, the minimum absorbed energy requirements C_V for full-size test specimens are calculated based on the equations given in a) and b) below, where:

$YS_{\max}$ is the specified maximum yield strength, in megapascals, for the grade evaluated;

t is the critical wall thickness, in millimetres, based on the specified dimensions for couplings.

a) Transverse requirement

The minimum full-size transverse absorbed energy requirement, C_V , in joules, shall be as specified in Table C.17 for various critical wall thicknesses based on the following:

$$C_V = YS_{\max} \cdot (0,001\,18\,t + 0,012\,59) \text{ or } 20 \text{ J, whichever is greater.}$$

b) Longitudinal requirement

The minimum full-size absorbed energy requirement, C_V , in joules, shall be as specified in Table C.18 for various critical wall thicknesses based on the following:

$$C_V = YS_{\max} \cdot (0,002\,36\,t + 0,025\,18) \text{ or } 41 \text{ J, whichever is greater.}$$

7.4.5.3 For USC units, the minimum absorbed energy requirements, C_V , for full-size test specimens are calculated based on the equations given in a) and b) below, where:

$YS_{\max}$ is the specified maximum yield strength, in thousand pounds per square inch (ksi), for the grade evaluated,

t is the critical wall thickness, in inches, based on the specified dimensions for couplings.

a) Transverse requirement

The minimum full-size transverse C_V absorbed energy requirement, in foot-pounds, shall be as specified in Table E.17 for various critical wall thicknesses based on the following:

$$C_V \text{ (foot-pounds)} = YS_{\max} \cdot (0.152\,t + 0.064) \text{ or } 15 \text{ ft}\cdot\text{lb, whichever is greater.}$$

b) Longitudinal requirement

The minimum full-size absorbed energy requirement, C_V , in foot-pounds, shall be as specified in Table E.18 for various critical wall thicknesses based on the following:

$$C_V \text{ (foot-pounds)} = YS_{\max} \cdot (0.304\,t + 0.128) \text{ or } 30 \text{ ft}\cdot\text{lb, whichever is greater.}$$

7.4.6 Special end-finish

The critical thickness shall be as specified in 7.6.6. The absorbed energy requirements in 7.4.1 to 7.4.5 shall apply.

7.5 Charpy V-notch — Absorbed energy requirements for pipe

7.5.1 Grades H40, J55, K55 and N80 Type 1

There is no mandatory CVN impact requirement.

NOTE See A.9 (SR16) for optional CVN impact energy requirements.

7.5.2 Grade M65

The minimum full-size transverse absorbed energy requirement shall be 20 J (15 ft·lb). The minimum full-size longitudinal absorbed energy requirement shall be 41 J (30 ft·lb).

7.5.3 Grades N80Q, L80, C90, C95, T95 and P110

7.5.3.1 The minimum absorbed energy requirement for full-size test specimens for pipe is provided in Tables C.19 and C.20 or Tables E.19 and E.20.

7.5.3.2 For SI units, the requirements are calculated based on the equations given in a) and b) below, where:

YS_{min} is the specified minimum yield strength, in megapascals;

t is the specified wall thickness, in millimetres.

a) Transverse requirement:

$$C_V \text{ (joules)} = YS_{min} \cdot (0,001\,18\,t + 0,012\,59) \quad \text{or } 20 \text{ J, whichever is greater, for Grade P110}$$

or 14 J, whichever is greater, for other grades

b) Longitudinal requirement:

$$C_V \text{ (joules)} = YS_{min} \cdot (0,002\,36\,t + 0,025\,18) \quad \text{or } 41 \text{ J, whichever is greater, for Grade P110}$$

or 27 J, whichever is greater, for other grades

7.5.3.3 For USC units the requirements are calculated based on the equations given in a) and b) below, where:

YS_{min} is the specified minimum yield strength, in thousand pounds per square inch (ksi)

t is the specified wall thickness, in inches

a) Transverse requirement:

$$C_V \text{ (foot-pounds)} = YS_{min} \cdot (0.152\,t + 0.064) \quad \text{or } 15 \text{ ft}\cdot\text{lb, whichever is greater, for Grade P110}$$

or 10 ft·lb, whichever is greater, for other grades

b) Longitudinal requirement:

$$C_V \text{ (foot-pounds)} = YS_{min} \cdot (0.304\,t + 0.128) \quad \text{or } 30 \text{ ft}\cdot\text{lb, whichever is greater, for Grade P110}$$

or 20 ft·lb, whichever is greater, for other grades

7.5.4 Grade Q125

7.5.4.1 The minimum absorbed energy requirement for full-size test specimens for pipe is provided in Tables C.19 and C.20 or Tables E.19 and E.20.

7.5.4.2 For SI units, the requirements are calculated based on the equations given in a) and b) below, where:

YS_{max} is the specified maximum yield strength, in megapascals (1 034 MPa);

t is the specified wall thickness, in millimetres.

a) Transverse requirement:

$$C_V = YS_{max} \cdot (0,001\,18\,t + 0,012\,59) \quad \text{or } 20 \text{ J whichever is greater}$$

b) Longitudinal requirement:

$$C_V = YS_{\max} \cdot (0,002\,36\,t + 0,025\,18) \quad \text{or } 41\,\text{J whichever is greater}$$

7.5.4.3 For USC units, the requirements are calculated in based on the equations given in a) and b) below, where:

$YS_{\max}$ is the specified maximum yield strength, in thousand pounds per square inch (125 ksi);

t is the specified wall thickness, in inches.

a) Transverse requirement:

$$C_V \text{ (foot-pounds)} = YS_{\max} \cdot (0.152\,t + 0.064) \quad \text{or } 15\,\text{ft}\cdot\text{lb, whichever is greater}$$

b) Longitudinal requirement:

$$C_V \text{ (foot-pounds)} = YS_{\max} \cdot (0.304\,t + 0.128) \quad \text{or } 30\,\text{ft}\cdot\text{lb, whichever is greater}$$

7.5.5 Test specimen

Table C.21 or Table E.21 for transverse specimens and Table C.22 or Table E.22 for longitudinal specimens provide the calculated wall thickness required to machine full-size, $\frac{3}{4}$ -size, and $\frac{1}{2}$ -size impact test specimens. The impact test specimen size that shall be selected from these tables is the largest impact test specimen having a calculated wall thickness that is less than the specified wall thickness for the pipe tested.

7.5.6 Testing conditions

For Grade M65 and Grade Q125 pipe, impact testing in accordance with 10.7 is mandatory. For all other grades except Grades H40, J55, K55 and N80 Type 1 (which have no mandatory impact requirements for pipe) compliance with the requirements of 7.5.3 may be qualified by a documented procedure in lieu of testing, at the manufacturer's option, unless A.9 (SR16) is specified on the purchase agreement, in which case testing is mandatory as specified in 10.7. Pipe qualified by a documented procedure that fails to show conformance to the specified impact energy requirements after shipment shall be rejected.

7.6 Charpy V-notch test — Absorbed energy requirements for casing and tubing accessories

7.6.1 Accessories — General

If the accessory has an ISO/API internally threaded connection, the minimum impact energy requirement for the accessory shall not be less than the requirement for that particular connection.

7.6.2 Accessories with internal ISO/API threads except integral joint tubing connections and extreme-line casing connections

The requirements in 7.4.1 to 7.4.5 apply.

7.6.3 Accessories with internal special end finish tapered interference-type threads

The requirements in 7.4.6 apply.

7.6.4 Accessories with external threads

The requirements in 7.5 apply.

7.6.5 Accessories with both integral joint tubing connections and extreme line casing connections, and also internal special end finish connections that do not have thread interference

By agreement between the manufacturer and purchaser, the provisions of A.9 (SR16) shall apply.

7.6.6 Critical thickness for accessory material

If not specified on the purchase agreement, the critical thickness for determining the impact energy requirements shall be based on the thickness of the cross-section of the accessory that has the lowest t/D ratio, where D is the specified outside diameter and t is the calculated wall thickness at that section.

For an accessory with ISO/API internal threads, the critical thickness for these ISO/API threads is shown in Table C.8 or Table E.8, and D is the specified outside diameter of the connection as specified in 9.6 and 9.8.

For special end finish connections, the critical thickness for externally threaded members is the specified pipe body thickness, while for internally threaded members it is the calculated thickness of the internally threaded member at the plane of the small end of the pin (when the connection is made up power-tight).

7.7 Hardness maxima

7.7.1 Group 2 — Casing, tubing, couplings, pup-joints and accessories

a) Grades M65 and L80 all types

For each tensile specimen required, a hardness specimen (ring or block) shall be removed from the product from the location shown in Figure D.10 and described in the notes of the figure. The hardness survey specimen shall be prepared and tested in accordance with the requirements of 10.6. The hardness values obtained shall comply with the requirements given in Table C.6 or Table E.6.

b) Grades C90 and T95

Any hardness value (see Figure D.11) not exceeding 25,4 HRC is acceptable. If any hardness reading exceeds 27,0 HRC, the piece shall be rejected. Hardness values falling between these limits require re-test. Hardness tests shall be taken on each ring or blocks in accordance with Figure D.11 to provide three hardness values in one quadrant for non-upset pipe and in each of four quadrants for upset pipe.

7.7.2 Grade Q125 — Casing, couplings, pup-joints and accessories

There are no upper or lower hardness limits for these products.

7.8 Hardness variation — Grades C90, T95 and Q125

Material shall conform to the hardness variation requirements of Table C.6 or Table E.6, where hardness variation is defined as the difference between any two hardness values within one quadrant. This criterion shall not apply between specimens.

7.9 Process control — Grades C90, T95 and Q125

All individually heat-treated coupling blanks, pup-joints or accessories shall be surface hardness-tested to verify process control. For grades C90 and T95, the hardness test results shall be used in the selection of the pieces for through-wall hardness testing (see 10.6.5). The hardness test results need not be provided by the manufacturer or processor unless specified on the purchase agreement.

7.10 Hardenability — Minimum percentage martensite for quenched and tempered products

7.10.1 Grades C90 and T95

A full body as-quenched sample shall be taken to characterize the hardening response for a particular size, mass, chemistry and austenitize-and-quench combination. Hardness values shall equal or exceed the hardness corresponding to 90 % minimum martensite as determined by the following equation:

$$\text{HRC}_{\min} = 58 \times (\% \text{ carbon}) + 27$$

NOTE The above equation was derived from data in [2]. Based on these data, the above equation is valid from 0,15 % carbon to 0,50 % carbon.

7.10.2 All grades except Grades C90 and T95

A full body as-quenched sample shall be taken as part of a documented procedure to confirm sufficient hardening for each size, mass, chemistry and austenitize-and-quench combination. To be in compliance with this International Standard, hardness values (see 10.6.8) taken during the documentation procedure shall equal or exceed the hardness corresponding to 50 % minimum martensite as determined by the following equation:

$$\text{HRC}_{\min} = 52 \times (\% \text{ carbon}) + 21$$

7.11 Grain size — Grades C90 and T95

Prior austenitic grain size shall be ASTM 5 or finer (determined in accordance with ISO 643 or ASTM E112).

7.12 Surface condition — Grades L80 9Cr and L80 13Cr

The internal surface of the pipe shall be free from scale after the final heat treatment.

7.13 Flattening — Electric-welded pipe

All products that are produced by the electric-weld process of manufacture shall comply with the flattening requirements shown in Table C.23 or Table E.23.

7.14 Sulfide stress corrosion cracking (SSCC) test — Grades C90 and T95

7.14.1 Test and re-test requirements

For each heat, manufacturers shall demonstrate that the product meets or exceeds the minimum SSCC threshold using one of the ANSI-NACE TM0177-96 test methods given below. If the purchaser requires an SSCC threshold higher than the minimum, or requires a specific test method from the list below, agreement shall be reached between purchaser and manufacturer. For Methods A and D, sub-size or alternative specimens shall only be used following agreement with the purchaser. When Method D sub-size or alternative specimens are required, acceptance criteria shall be agreed between the purchaser and manufacturer.

The details of a manufacturer's qualification, frequency of sulfide stress cracking testing, re-test procedures and testing practices should be addressed by the purchaser and the manufacturer prior to placing or accepting a purchase order.

7.14.2 Minimum SSCC threshold values

a) ANSI-NACE TM0177-96 Method A, Smooth tensile

Full-size (6,35 mm [0.250 in] diameter) specimen:	80 % of $Y_{S_{min}}$	496 MPa (72 000 psi) for C90 524 MPa (76 000 psi) for T95
Sub-size (3,81 mm [0.150 in] diameter) specimen:	72 % of $Y_{S_{min}}$	447 MPa (64 800 psi) for C90 472 MPa (68 400 psi) for T95

b) ANSI-NACE TM0177-96 Method B, Bent beam

Sc (12.0) for C90

Sc (12.6) for T95

NOTE The requirement for Method B is only stated in USC units, based on current industry convention.

c) ANSI-NACE TM0177-96 Method D, DCB

Mean value of $33,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($30,0 \text{ ksi}\sqrt{\text{in}}$) with a minimum of at least three valid test specimens for Grades C 90 and T95. All valid test results shall be included when calculating the mean value.

A standard test specimen thickness of 9,53 mm (0.375 in) shall be used.

No valid test specimen shall have a value less than $30,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($27,0 \text{ ksi}\sqrt{\text{in}}$).

Either non-pre-cracked or fatigue pre-cracked specimens may be used. If fatigue pre-cracking of specimens is employed, the maximum stress intensity factor during pre-cracking shall not exceed $30,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($27,0 \text{ ksi}\sqrt{\text{in}}$).

The arm displacement shall be 0,70 mm to 0,80 mm (0.028 in to 0.032 in).

7.14.3 Test temperature

The test solution shall be maintained at $24 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$ ($75 \text{ }^{\circ}\text{F} \pm 5 \text{ }^{\circ}\text{F}$).

7.14.4 Test solution

For the purposes of this International Standard, ANSI-NACE TM0177-96 Test Solution A shall be used. To prevent conflict arising from future revisions, the properties of the test solution shall be:

a) for Test Methods A and D:

- The test solution shall have a pH in the range 2,6 to 2,8 before contacting the test specimen.
- The test solution shall have 5,0 % mass fraction sodium chloride and 0,5 % mass fraction glacial acetic acid dissolved in distilled or de-ionized water.
- The test solution shall be saturated with hydrogen sulfide (H_2S) as described in ANSI-NACE TM0177-96.

b) for Test Method B:

- The test solution shall have a pH in the range 2,6 to 2,8 before contacting the test specimen.
- The test solution shall have 0,5 % mass fraction glacial acetic acid dissolved in distilled or de-ionized water.
- The test solution shall be saturated with H_2S as described in ANSI-NACE TM0177-96.

8 Dimensions, masses, tolerances, pipe ends and defects

8.1 Labels and sizes

In the dimensional tables in this International Standard, pipe is designated by labels, and by size (outside diameter). The outside diameter size of external-upset pipe is the outside diameter of the body of the pipe, not the upset portion.

8.2 Dimensions and masses

Pipe shall be furnished in the sizes, wall thicknesses and masses (as shown in Tables C.24 to C.29 inclusive or Tables E.24 to E.29 inclusive) as specified on the purchase agreement except Grades C90, T95 and Q125 which may be furnished in other sizes, masses and wall thickness as agreed between purchaser and manufacturer. 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.

Casing sizes larger than Label 1: 4-1/2 but smaller than Label 1: 10-3/4 may be specified by the purchaser to be used in tubing service, see Tables C.1, C.24, C.30 and C.31 or Tables E.1, E.24, E.30 and E.31.

The accuracy of all measuring equipment used for acceptance or rejection, except ring-and-plug thread gauges and weighing devices, shall be verified at least every operating shift.

Verifying the accuracy of measuring devices such as snap gauges and drift mandrels shall consist of inspection for wear and conformance to specified dimensions. Verifying the accuracy of rules, length-measuring tapes and other non-adjustable measuring devices shall consist of a visual check for the legibility of markings and general wear of fixed reference points. The adjustable and non-adjustable designations of measuring devices utilized by the manufacturer shall be documented.

The verification procedure for working ring-and-plug thread gauges shall be documented. The accuracy of all weighing devices shall be verified at periods not to exceed those required by the manufacturer's documented procedure in accordance with National Institute of Standards and Technology (NIST) standards or equivalent regulations in the country of manufacture of products made to this International Standard.

If measuring equipment whose calibration or verification is required under the provisions of this International Standard is subjected to unusual or severe conditions sufficient to make its accuracy questionable, re-calibration or re-verification shall be performed before further use of the equipment.

8.3 Diameter

8.3.1 Measurement and design

a) Using SI units

For measurement of diameter, an accuracy of one decimal place shall be used for sizes larger than Label 1: 6-5/8. In this International Standard two decimal places are used for design purposes to ensure interchangeability.

b) Using USC units

The diameter shall be rounded to three decimal places.

8.3.2 Requirements

The outside diameter shall be within the tolerances specified in 8.11.1. For threaded pipe, the outside diameter at the threaded ends shall be such that the thread length, L_4 , and the full-crest thread length, L_C , are within the tolerances and dimensions specified in ISO 10422 or API Spec 5B. For pipe furnished non-upset and plain-end and which is specified on the purchase agreement for the manufacture of pup-joints, the non-upset plain-end tolerances shall apply to the full length.

8.4 Wall thickness

The wall thickness at any place shall not be less than the tabulated thickness, t , minus the permissible under-tolerance specified in 8.11.2.

8.5 Mass

The masses determined as described in 10.13.7 shall conform to the calculated masses as specified herein (or adjusted calculated masses) for the end finish specified on the purchase agreement, within the tolerances stipulated in 8.11.3. Calculated masses shall be determined in accordance with the following formula:

$$m_L = (m_{pe} \times L) + e_m$$

where

m_L is the calculated mass of a piece of pipe of length L , in kilograms (pounds);

m_{pe} is the plain-end mass, in kilograms per metre (pounds per foot);

L is the length of pipe, including end-finish in metres (feet), as defined in 8.6;

e_m is the mass gain or loss due to end-finishing, in kilograms (pounds). For plain-end non-upset pipe, $e_m = 0$.

NOTE The densities of martensitic chromium steels (L80 Types 9Cr and 13Cr) are less than those of carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0,989 may be used.

8.6 Length

Casing, tubing, plain end liners, and pup-joints shall be furnished in lengths conforming to Table C.30 or Table E.30. The length of accessories, except couplings, shall be as agreed between purchaser and manufacturer.

The length of each finished pipe shall be determined for conformance to length requirements. Length determination shall be in metres and hundredths of a metre (feet and tenths of a foot).

The accuracy of length-measuring devices for lengths of pipe less than 30 m (100 ft) shall be $\pm 0,03$ m (± 0.1 ft).

8.7 Casing jointers

If so specified on the purchase agreement, for round thread casing only, jointers (two pieces coupled to make a standard length) may be furnished to a maximum of 5 % of the order; but no length used in making a jointer shall be less than 1,52 m (5.0 ft).

8.8 Height and trim of electric-weld flash

8.8.1 Trimming electric-weld flash

The outside flash of electric-welded pipe shall be trimmed to an essentially flush condition.

It shall be the aim of the manufacturer to provide an inside surface at the weld of electric-weld pipe that is:

- a) reasonably close to flush after trimming; and
- b) contains no jagged edges from the original weld flash.

It may be desirable for the manufacturer to provide an inside surface at the trimmed weld with a slight groove in order to meet this aim. The inside flash of electric-welded pipe shall be trimmed as given in 8.8.2 and 8.8.3.

8.8.2 Groups 1 and 2

The height of the inside weld flash shall not exceed 1,14 mm (0.045 in) for casing or 0,38 mm (0.015 in) for tubing, measured from the inside surface adjacent to the flash.

The depth of groove resulting from removal of the inside flash shall not be greater than the amount listed below for the various wall thicknesses. Depth of groove is the difference between the wall thickness measured approximately 25 mm (1 in) from the weld line and the remaining wall under the groove.

Wall thickness	Maximum depth of trim
3,84 mm to 7,64 mm (0.151 in to 0.301 in)	0,38 mm (0.015 in)
$\geq 7,64$ mm (0.301 in)	0,05

8.8.3 Groups 3 and 4

No inside flash height shall be permitted. The groove on the inside weld surface shall not exceed a depth of 0,38 mm (0.015 in) and shall not contain sharp corners that would interfere with ultrasonic inspection.

8.8.4 Disposition

Pipe with weld flash exceeding the limits specified in 8.8.2 or 8.8.3, as applicable, shall be either rejected or repaired by grinding.

8.9 Straightness

Deviation from straight, or chord height, shall not exceed either of the following:

- 0,2 % of the total length of the pipe measured from one end of the pipe to the other end for pipes Label 1: 4-1/2 and larger;
- 3,18 mm (1/8 in) maximum drop in the 1,83 m (6.0 ft) length at each end. See Figures D.14 and D.15.

8.10 Drift requirements

Each length of casing and tubing either finished or unfinished shall be drift tested throughout its entire length (see Table C.31 or Table E.31). Casing and tubing threaded by an entity other than the pipe manufacturer shall also be drift tested for a distance of 0,6 m (24 in) from the coupled end on casing and 1,1 m (42 in) from the coupled end on tubing.

Casing sizes larger than Label 1: 4-1/2 but smaller than Label 1: 10-3/4 specified by the purchaser to be used in tubing service shall be drift tested with drift mandrels as indicated hereafter and marked as specified in clause 11.

NOTE See ISO 10400 or API Bul 5C3 for the joint strength of casing used in tubing service.

Label 1	Mandrel length	Mandrel diameter
$> 4\text{-}1/2$ to $\leq 8\text{-}5/8$	1 067 mm (42.0 in)	$d - 3,18$ mm ($d - 1/8$ in)
$> 8\text{-}5/8$ to $< 10\text{-}3/4$	1 067 mm (42.0 in)	$d - 3,97$ mm ($d - 5/32$ in)

When specified by the purchaser as "alternative drift casing", casing in the sizes and masses in Table C.32 or Table E.32 shall be tested with the alternative drift mandrels as shown. Pipe which is drifted with the alternative drift mandrels shall be marked as described in clause 11.

8.11 Tolerances on dimensions and masses

8.11.1 Outside diameter, D

The following tolerances apply to the outside diameter, D , of pipe:

Label 1	Tolerance on outside diameter, D
$< 4\text{-}1/2$	$\pm 0,79 \text{ mm } (\pm 0.031 \text{ in})$
$\geq 4\text{-}1/2$	$+ 1 \% D \text{ to } - 0,5 \% D$

For upset pipe, the following tolerances apply to the outside diameter of the pipe body immediately behind the upset for a distance of approximately 127 mm (5.0 in) for sizes Label 1: 5-1/2 and smaller, and a distance approximately equal to the outside diameter for sizes larger than Label 1: 5-1/2. Measurements shall be made with callipers or snap gauges.

Label 1	Tolerances behind m_{eu} or L_0
$\leq 3\text{-}1/2$	$+ 2,38 \text{ mm to } - 0,79 \text{ mm } (+ 3/32 \text{ in to } - 1/32 \text{ in})$
$> 3\text{-}1/2 \text{ to } \leq 5$	$+ 2,78 \text{ mm to } - 0,75 \% D (+ 7/64 \text{ in to } - 0.75 \% D)$
$> 5 \text{ to } \leq 8\text{-}5/8$	$+ 3,18 \text{ mm to } - 0,75 \% D (+ 1/8 \text{ in to } - 0.75 \% D)$
$> 8\text{-}5/8$	$+ 3,97 \text{ mm to } - 0,75 \% D (+ 5/32 \text{ in to } - 0.75 \% D)$

For Label 1: 2-3/8 and larger external-upset tubing the following tolerances shall apply to the outside diameter at distance L_a (see Figure D.5) from the end of the pipe.

The measurements shall be made with snap gauges or callipers. Changes in diameter between L_a and L_b shall be smooth and gradual. Pipe body OD tolerances do not apply for a distance of L_b from the end of the pipe.

Label 1	Tolerances
$\geq 2\text{-}3/8 \text{ to } \leq 3\text{-}1/2$	$+ 2,38 \text{ mm to } - 0,79 \text{ mm } (+ 3/32 \text{ in to } - 1/32 \text{ in})$
$> 3\text{-}1/2 \text{ to } \leq 4$	$+ 2,78 \text{ mm to } - 0,79 \text{ mm } (+ 7/64 \text{ in to } - 1/32 \text{ in})$
> 4	$+ 2,78 \text{ mm to } - 0,75 \% D (+ 7/64 \text{ in to } - 0.75 \% D)$

8.11.2 Wall thickness, t

Tolerance $- 12,5 \%$

8.11.3 Mass

Amount

Single lengths

Carload 18 144 kg (40 000 lb) or more

Carload less than 18 144 kg (40 000 lb)

Order items 18 144 kg (40 000 lb) or more

Order items less than 18 144 kg (40 000 lb)

Tolerance

$+ 6,5 \% \text{ to } - 3,5 \%$

$- 1,75 \%$

$- 3,5 \%$

$- 1,75 \%$

$- 3,5 \%$

8.11.4 Inside diameter, d

Inside diameter, d , is governed by the outside diameter and mass tolerances.

8.11.5 Upset dimensions

Tolerances on upset dimensions are given in Tables C.26, C.27 and C.28 or Tables E.26, E.27 and E.28.

8.11.6 Extended length upsets

External upset tubing may be ordered with extended length upsets (L_{el}) as agreed between purchaser and manufacturer. A minimum of 95 % of the number of joints (both ends) shall meet the L_{el} with the remaining balance meeting L_{eu} requirements, unless otherwise agreed between purchaser and manufacturer.

8.12 Pipe ends

8.12.1 Unfinished pipe

Unfinished pipe is pipe furnished unthreaded, either upset or non-upset, but in compliance with all requirements of this International Standard for a particular grade, and shall be identified by the UF symbol in addition to the other marking requirements. See 11.5.2.

8.12.2 Casing with ISO/API threads

Unless otherwise stated on the purchase agreement, casing shall be furnished threaded and coupled, 8-round long or short thread as applicable. If specified on the purchase agreement, casing shall be furnished with one of the following end finishes:

- 8-round thread without coupling;
- Buttress thread with coupling;
- Buttress thread without coupling;
- Extreme-line thread.

Additionally, seal ring configuration in accordance with A.7 (SR13) may be ordered.

If long-thread Grade H40, J55 or K55 casing in accordance with Table C.24 or Table E.24 is desired, the purchaser shall so specify on the purchase agreement. Otherwise short-thread casing in accordance with Table C.24 or Table E.24 shall be furnished.

Liners shall be furnished with square-cut plain ends, with all burrs removed from both inside and outside edges.

8.12.3 Tubing with ISO/API threads

Unless otherwise stated on the purchase agreement, tubing shall be threaded and coupled. If specified on the purchase agreement, tubing shall be furnished with any of the following end finishes:

- threaded ends without coupling;
- integral joint.

Additionally, seal ring configuration according to A.7 (SR13) may be ordered.

8.12.4 Rounded nose

In lieu of the conventional corner breaks on the threaded ends of tubing, the "round" or "bullet-nose" end may be supplied at the manufacturer's option or may be specified by the purchaser. The modified end shall be rounded to provide for coatable service, and the radius transition shall be smooth with no sharp corners, burrs, or slivers on the ID or OD chamfer surfaces. See Figure D.6 for an illustration and dimensions. It is recognized that the dimensions in Figure D.6 are recommended values but are not subject to measurement to determine acceptance or rejection of the product.

8.12.5 Pup-joints and accessories

Pup-joints and accessories shall be furnished with threaded ends without couplings unless otherwise specified.

8.12.6 Threading

Pipe threads, gauging practice and thread inspection shall conform to the requirements of ISO 10422 or API Spec 5B. Pipe ends shall not be rounded out by hammering to secure conformance with threading requirements.

8.12.7 Workmanship of ends

The inside and outside edges of the ends of all pipe shall be free of burrs. The threads of martensitic chromium alloys have shown a tendency toward adhesive wear, or galling during make-up and breakout. Their galling resistance may be improved by surface preparations which are beyond the scope of this International Standard.

8.12.8 Special end finish

Pipe with end finish not specified in this International Standard may be furnished if so specified in the purchase agreement. This pipe shall have the body of the pipe manufactured in accordance with the requirements of this International Standard and shall be marked with the symbol "SF" as specified in 11.5.2.

Completed couplings and completed accessories with end finish not specified in this International Standard may be furnished if so specified in the purchase agreement. These items shall be manufactured in accordance with the requirements of this International Standard, except for end finish and dimensions, and shall be marked with the symbol "SF" as specified in 11.5.2.

8.13 Defects

All pipe and accessories shall be free from defects as listed hereafter:

- a) any quench crack;
- b) any surface-breaking imperfection which is proven to reduce the net effective wall thickness below 87,5 % of the specified wall thickness;
- c) when NDE (except visual) is specified by this International Standard [see 10.15, A.1 (SR1) and clause A.2 (SR2)] or specified on the purchase agreement, any non-surface-breaking imperfection detected that, when outlined on the outside surface, has an area greater than 260 mm² (0.40 in²);
- d) any non-surface-breaking weld seam imperfection within 1,6 mm (1/16 in) of either side of the weld line that is proven to reduce the net effective wall thickness below 87,5 % of the specified wall thickness;
- e) any linear imperfection on the outside or inside surface, of any orientation, with a depth greater than tabulated in Table C.33 or Table E.33;
- f) any surface breaking pipe upset imperfection, of any orientation, with a depth greater than tabulated in Table C.34 or Table E.34;

- g) on the internal upset configuration on all upset products, any sharp corner or drastic change of section that would cause a 90° hook-type tool to hang up.

The manufacturer, based on knowledge of the production process and the requirements of clause 10, shall apply a process control plan that will ensure that the above requirements are fulfilled.

8.14 Coupling make-up and thread protection

8.14.1 Groups 1, 2 and 3

All casing couplings and regular tubing couplings shall be screwed onto the pipe power-tight, except that they shall be screwed on handling-tight (see Note 1 below) or shipped separately if so specified on the purchase agreement. Special-clearance tubing couplings shall be screwed onto the pipe handling-tight, except that they shall be shipped separately if so specified on the purchase agreement.

A thread compound shall be applied to cover the full surface on the engaged thread of either the coupling or pipe before making up the joint. Application on both coupling and pipe may be agreed between purchaser and manufacturer. Unless otherwise specified by the purchaser, the thread compound shall conform to ISO 13678 or API RP 5A3. When pipe is furnished threaded and coupled, the field end and the coupling shall be provided with thread protectors. When pipe is furnished threaded, but without couplings attached, each end shall be provided with a thread protector. Thread protectors shall conform to the requirements of 12.2. All exposed threads shall be coated with thread compound. A storage compound of distinct colour may be substituted for this thread compound on all exposed threads. The compound shall be applied to a surface that is clean and reasonably free of moisture and cutting fluids.

NOTE 1 The purpose of making up couplings handling-tight is to facilitate removal of the couplings for cleaning and inspecting threads and applying fresh thread compound before using the pipe. This procedure has been found to result in less chance for thread leakage, because mill-applied couplings made up power-tight, although leakproof at the time of make-up, may not always remain so after transportation, handling and use.

NOTE 2 Martensitic chromium steels are sensitive to galling. Special precautions may be necessary for thread surface treatment and/or lubrication to minimize galling during hydrostatic testing (plug application and removal).

8.14.2 Group 4

All requirements for Group 4 are the same as that shown in 8.14.1, except that ISO 10422 or API Spec 5B casing couplings shall be shipped separately unless power-tight make-up is specified on the purchase agreement.

9 Couplings

9.1 General requirements

Couplings for pipe conforming to this International Standard shall be seamless, be of the same grade and type as the pipe and be given the same heat treatment as the pipe except as provided in 9.2 and 9.3.

When couplings are electroplated, the electroplating process should be controlled to minimize hydrogen absorption.

9.2 Alternative grades or heat treatments

9.2.1 When heat treatment is not stipulated on the purchase agreement, Grade H40 pipe shall be furnished with Grade H40, J55, or K55 couplings which are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

9.2.2 When heat treatment is not stipulated on the purchase agreement, Grade J55 pipe shall be furnished with Grade J55 or K55 couplings which are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

9.2.3 When heat treatment is not stipulated on the purchase agreement, Grade K55 pipe shall be furnished with Grade K55 couplings which are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

9.2.4 Grade J55 EUE tubing shall be furnished with L80 Type 1 special clearance couplings when specified on the purchase agreement.

9.2.5 Grade J55 and K55 buttress casing shall be furnished with L80 Type 1 couplings when specified on the purchase agreement.

9.2.6 Grade M65 products shall be furnished with L80 couplings.

9.2.7 Normalized Grade N80 Type 1 pipe shall be furnished with either Grade N80 Type 1 or Grade N80Q couplings.

9.2.8 Normalized and tempered Grade N80 Type 1 pipe shall be furnished with either normalized and tempered Grade N80 Type 1 or Grade N80Q couplings.

9.2.9 Grade N80 EUE tubing shall be furnished with P110 special clearance couplings when specified on the purchase agreement.

9.2.10 Grade N80 buttress casing shall be furnished with P110 couplings when specified on the purchase agreement.

9.2.11 Grade P110 buttress casing shall be furnished with Q125 couplings when specified on the purchase agreement.

9.3 Process of manufacture — Groups 1, 2 and 3

9.3.1 Seamless pipe and hot forging

Couplings made from seamless pipe as defined in 4.1 or hot forgings shall be heat-treated as required in 6.2.

9.3.2 Sub-critical forging

Grade J55 and K55 couplings made by sub-critical forging shall be stress-relieved or, at the option of the manufacturer, normalized or normalized and tempered. Grade N80 Type 1 couplings shall be normalized and tempered or, at the option of the manufacturer, quenched and tempered. For Groups 2 and 3 couplings shall be heat-treated as specified in 6.2 for the particular grade and type.

9.3.3 Centrifugal casting

Couplings made by centrifugal casting shall be cast in a rotating mould, shall be given a homogenizing heat treatment (as specified in ASTM A941) prior to the final treatment, and shall be fully machined on all surfaces. All grades of centrifugal cast couplings shall be either normalized and tempered or quenched and tempered at the option of the manufacturer.

9.4 Process of manufacture — Grade Q125

Grade Q125 couplings shall be made from seamless coupling stock using the same requirements and quality control provisions as Grade Q125 casing manufactured to this International Standard (see clauses 6 and 7). Couplings and coupling blanks shall be cut from coupling stock. See A.3 (SR9) for optional requirements for coupling blanks.

9.5 Mechanical properties

Couplings shall conform to the mechanical requirements specified in clauses 7 and 10, including the frequency of testing, re-test provision, etc. A record of these tests shall be open to inspection by the purchaser.

9.6 Dimensions and tolerances

9.6.1 Groups 1, 2 and 3

Couplings shall conform to the dimensions and tolerances shown in Tables C.35 to C.38 or Tables E.35 to E.38. Unless otherwise specified on the purchase agreement, threaded and coupled casing and tubing shall be furnished with regular couplings.

9.6.2 Group 4

Couplings may be machined on the complete outside surface in addition to the inside surface. Dimensions shall be as specified on the purchase agreement unless standard ISO/API couplings are ordered, in which case the dimension shall be as shown in Tables C.35 and C.36 or Tables E.35 and E.36.

The purchaser should recognize that ISO/API threaded couplings with the regular outside diameter may not have a leak resistance as high as the internal yield pressure rating of the pipe body, due to inadequate bearing pressure between the coupling and pin.

9.7 Regular couplings

Regular couplings have diameters (W) as shown in Tables C.35 to C.38 or Tables E.35 to E.38. The inside and outside edges of the bearing face shall be rounded or broken, but shall not materially reduce the width of the bearing face (dimension b) so that enough thickness is left to safely support the mass of the pipe on the elevator. The ends of couplings shall be faced true at right angles to the axis.

9.8 Special-clearance couplings — Groups 1, 2 and 3

Special clearance (reduced outside diameter W_c) couplings for buttress casing and external upset tubing shall be furnished when specified in the purchase agreement. Special-clearance couplings shall conform to the dimensions (except b) and tolerances given in Tables C.36 and C.38 or Tables E.36 and E.38. See clause 11 for marking and colour identification. Unless otherwise specified, special-clearance tubing couplings shall be bevelled on both ends.

9.9 Combination couplings

Combination couplings with different types of thread of the same specified size shall be furnished when specified on the purchase agreement. The minimum length and minimum outside diameter of combination couplings shall be sufficient to accommodate the specified size and type of threads.

9.10 Reducing couplings

9.10.1 Groups 1, 2 and 3

Reducing couplings are used to connect two pipes of different diameter with the same or different types of thread on the two ends, and shall be furnished when specified on the purchase agreement. The minimum length and minimum diameter of reducing coupling shall be sufficient to accommodate the specified size and type of threads.

9.10.2 Grade Q125

Reducing couplings are not allowed.

9.11 Seal-ring couplings

Seal-ring couplings conforming to the requirements of A.7 (SR13) shall be furnished when specified on the purchase agreement.

9.12 Special-bevel couplings — Groups 1, 2 and 3

Special-bevel couplings conforming to the requirements of Tables C.37 and C.38 or Table E.37 and E.38 shall be furnished for non-upset and external-upset tubing when specified on the purchase agreement. Unless otherwise specified, special-bevel couplings shall be bevelled 20° on both ends.

9.13 Threading

9.13.1 General requirements

Coupling threads, gauging practice, and thread inspection shall conform to the requirements of ISO 10422 or API Spec 5B. Couplings shall not be expanded to provide the required taper for threads for couplings with ISO/API threads.

9.13.2 Casing couplings — All groups

Casing couplings shall be furnished with one of the following end finishes, as specified on the purchase agreement:

- a) long or short 8-round thread;
- b) buttress — regular, special bevel or special clearance;
- c) seal ring configuration A.7 (SR13);
- d) special end-finish.

9.13.3 Tubing couplings — Groups 1, 2, and 3

Tubing couplings shall be furnished with one of the following end finishes as specified on the purchase agreement:

- a) 8- or 10-round thread for upset tubing — regular, special bevel, or special clearance;
- b) 8- or 10-round thread for non-upset tubing — regular or special bevel;
- c) seal ring configuration A.7 (SR13);
- d) special end finish.

9.14 Surface inspection

9.14.1 All finished couplings shall be free on the inside from all imperfections that break the continuity of the thread.

9.14.2 All couplings shall be inspected on the outside and inside surfaces after finish machining and before any inside or outside surface plating, using the wet fluorescent magnetic particle method in accordance with ISO 13665 or ASTM E709 with a circumferentially oriented magnetic field for the detection of longitudinal surface imperfections, or by other non-destructive method of equal sensitivity as demonstrated to the purchaser. Records according to 10.15.4 shall be maintained.

9.14.3 By agreement between purchaser and manufacturer, NDE of Grades H40, J55 and K55 couplings may be waived. However, in this case, the couplings shall be inspected visually on the outside and inside surfaces after finish machining and before plating and shall be free from all visible seams, cracks and porosity. See Table C.67 or Table E.67 for marking requirements.

NOTE Visible seams or cracks are those that can be seen without the aid of magnetic particle inspection, dye penetrant or other non-destructive methods of inspection.

9.14.4 To ensure adequate plating or coating, the threaded surfaces of all couplings shall be visually inspected after plating or coating.

9.14.5 All finished couplings shall be free of imperfections, with the exception of those external imperfections given in Table C.39 or Table E.39 which are disclosed by inspection in accordance with 9.14.2 or 9.14.3.

9.14.6 All imperfections of any depth, revealed during inspection at the manufacturing facility, except as allowed in Table C.39 or Table E.39, shall be removed. For Grades J55 and K55 coupling material that is impact-tested at or below 0 °C (32 °F) that demonstrates a shear area greater than 80 % and exceeds the minimum absorbed energy requirements, and Grade N80 and Groups 2, 3 and 4 coupling material shall not be rejected for imperfections less than 5 % of the critical wall thickness if detected on subsequent re-inspection outside the manufacturer's facility. The critical thickness is defined in 7.3.2.

9.15 Measurement of imperfections

The depth of imperfection shall be measured from the normal surface or contour of the coupling extended over the imperfection. The outside diameter of the finished coupling shall be measured across the finished surface or contour of the coupling (that is, the initial surface or grind contour resulting from the removal of an imperfection or defect). The outside diameter shall not be measured at the base of an acceptable pit.

9.16 Repair and removal of imperfections and defects

Repair welding is not permitted. Non-permissible imperfections defined in 9.14.5 shall be removed. Permissible imperfections, see Table C.39 or Table E.39, may be removed or reduced by machining or grinding on the outer surface, provided the outside diameter of the finished coupling is within the tolerances when measured at the point from where the defect was removed, or the coupling shall be rejected. The machining or grinding shall be approximately blended into the outer contour of the coupling.

After removal of the defect, the affected zone shall be re-inspected by the same inspection method at the same sensitivity used to perform the initial inspection or by a different inspection method of equal or greater sensitivity.

9.17 Thread surface treatment — Grade Q125

Thread surface treatment shall be as specified on the purchase agreement.

9.18 Couplings and coupling blank protection — Grade Q125

All loose couplings and all coupling blanks that have been machined to their final outside diameter shall be boxed to prevent contact with one another during shipment. All other coupling blanks shall be boxed to prevent nicks and gouges that will not be removed by subsequent machining. Boxes shall be manufactured from wood and designed to be easily handled by forklift. Boxes shall be limited to 1,22 m (4.0 ft) in width to facilitate truck transport.

10 Inspection and testing

10.1 Test equipment

The manufacturer shall determine the appropriate calibration frequency in order to be able to certify that all products conform to the requirements of this International Standard.

If test or measuring equipment, whose calibration or verification is required under the provisions of this International Standard, is subjected to unusual or severe conditions which make its accuracy questionable, re-calibration or re-verification shall be performed before further use of the equipment.

10.2 Lot definition for testing of mechanical properties

10.2.1 Groups 1, 2 (Grades M65, L80 Type 1, and C95 only) and 3 — Pipe except pup-joints heat-treated after cutting to blank or individual length

For the purposes of testing the mechanical properties of the above pipe, a lot is defined as all those lengths of pipe with the same specified dimension and grade which are either as rolled or heat-treated as part of the continuous operation (or batch), and are from a single heat of steel; 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.

10.2.2 Grades L80 9Cr, L80 13Cr, C90, T95 and Q125 — Pipe except pup-joints heat-treated after cutting to blank or individual length

For the purposes of testing the mechanical properties of the above pipe, a lot is defined as all those lengths of pipe with the same specified dimensions and grade from the same heat of steel which are heat-treated as part of a continuous operation (or batch).

10.2.3 Coupling blanks, pup-joints or accessories heat-treated after cutting to blank or individual length

For the purposes of testing the mechanical properties, a lot of coupling blanks, pup-joints or accessories heat-treated after cutting to blank or individual lengths is defined as that group of pieces with the same specified dimensions and grade from the same heat of steel which has been

- a) batch heat-treated concurrently in the same heat treating furnace unit or
- b) heat-treated in sequential loads to the same cycle without interruption in an integral quench furnace unit equipped with a recording controller to provide documentation of heat treating control through the run or
- c) individually heat-treated as a unit in a continuous process run within eight hours or less of continuous operation.

In addition, for Grades C90, T95 and Q125, a lot shall not exceed 30 couplings, pup-joints or accessories for Label 1: 9-5/8 and larger casing, or 50 couplings, pup-joints or accessories for smaller sizes of individually heat-treated pieces.

10.3 Testing of chemical composition

10.3.1 Couplings, pup-joints and accessories

For couplings, pup-joints and accessories the analyses requested shall be furnished by the steel manufacturer or processor and shall be taken from material in tubular or bar form.

10.3.2 Heat analyses

For Groups 1, 2 and 3, when requested by the purchaser, the manufacturer shall furnish a report giving the heat analysis of each heat of steel used in the manufacture of pipe and couplings furnished on the purchase agreement. In addition the purchaser, upon request, shall be furnished the results of quantitative analyses of other elements used by the manufacturer to control mechanical properties.

For Grade Q125, the manufacturer shall furnish a report giving the heat analysis of each heat of steel used in the manufacture of pipe and couplings furnished on the purchase agreement. The report shall include quantitative analyses of other elements used by the manufacturer to control mechanical properties.

10.3.3 Product analyses

Two tubular products from each heat used shall be analysed for product analyses. Product analyses shall be made by the manufacturer on the finished tubular product. For electric-welded products, the chemical analysis may be determined on samples of skelp.

Product analyses shall include the results of quantitative determinations of all elements listed in Table C.5 or Table E.5 plus any other elements used by the manufacturer to control mechanical properties.

For Groups 1, 2 and 3, the product analyses shall be available to the purchaser on request.

For Group 4, the product analyses shall be provided to the purchaser.

10.3.4 Test method

Chemical analysis 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. In case of conflict, chemical analyses shall be made in accordance with ISO/TR 9769 or ASTM A751.

10.3.5 Re-check of product analyses — All groups

If the product analyses of both lengths of tubular product representing the heat fail to conform to the specified requirements, at the manufacturer's option either the heat shall stand rejected or all the remaining lengths in the heat shall be tested individually for conformance to the specified requirements. If only one of two samples fails, at the manufacturer's option either the heat shall stand rejected or two re-check product analyses shall be made on two additional lengths from the same heat. If both re-check product analyses conform to the requirements, the heat shall be accepted except for the length represented by the initial analysis which failed. If one or both of the re-check product analyses fail, at the manufacturer's option the entire heat shall be rejected or each of the remaining lengths shall be tested individually. In the individual testing of the remaining lengths in any heat, analyses for only the rejecting element or elements need be determined. Samples for re-check product analyses shall be taken in the same manner as specified for product analysis samples. The results of all re-check product analyses shall be provided to the purchaser when specified on the purchase agreement.

10.4 Tensile tests

10.4.1 Stress-relief temperature

For the purpose of tensile test frequency, stress-relief of tempered products shall not be considered "heat treatment" provided the stress-relief temperature is at least 56 °C (100 °F) below the final tempering temperature.

10.4.2 Heat-control tensile tests — Groups 1, 2 and 3

One tensile test shall be made as a control on each heat of steel used by the manufacturer for the production of pipe under this International Standard. For electric-welded pipe, these tensile tests shall be made on either the skelp or the finished pipe, at the option of the manufacturer.

A heat-control test made on a length of pipe may also be considered as a product test for the lot being tested.

10.4.3 Frequency of testing and location of test specimen — Casing and tubing

The frequency of testing for casing and tubing of all groups is defined in Table C.40 or Table E.40.

The lengths for testing shall be selected at random and, when more than one test is required, the selection procedures shall provide samples representing the start and end of the heat-treat cycle (as applicable) and alternative ends. When more than one test is required, the test specimens shall be from different lengths, except for upset pipe the test specimens may be taken from both ends of one length.

10.4.4 Frequency of testing and test specimen location — Couplings, pup-joints and accessories

The frequency of testing is defined for couplings in Table C.41 or Table E.41 and for pup-joints and accessories in Table C.42 or Table E.42.

For Group 1, Group 2 (except Grades C90 and T95) and Group 3, the test specimens from bar stock shall be taken from a location corresponding to the mid-wall of the finished products for accessories.

For Group 2 (Grades C90 and T95) and Group 4, tensile test specimens for coupling, pup-joint or accessory material heat-treated in tube length shall be removed from locations shown in Figure D.10.

No test is required for pup-joints or accessories manufactured from a length of casing, tubing or coupling stock, provided that it has been previously tested and conforms to requirements and there is no subsequent heat treatment.

A heat-control test may also be considered as a product test for the lot being tested.

10.4.5 Test specimens — General

Pipe-body tensile test specimens shall be either full-section specimens, strip specimens or round bar specimens, as shown in Figure D.9, at the option of the manufacturer. Strip specimens from seamless pipe shall be taken from any location about the pipe circumference at the option of the manufacturer. Round bar specimens shall be taken from the mid-wall. Strip specimens and round bar specimens from welded pipe shall be taken approximately 90° from the weld, or, at the option of the manufacturer, from the skelp parallel to the direction of rolling and approximately midway between the edge and the centre. Tensile test specimens for heat-treated pipe shall be removed from pipe subsequent to final heat treatment on the production line.

All strip specimens shall be approximately 38 mm (1.500 in) wide in the gauge length if suitable curved-face testing grips are used, or if the ends of the specimen are machined or cold-flattened to reduce the curvature in the grip area; otherwise they shall be approximately 19 mm (0.750 in) wide for pipe smaller than Label 1: 4, approximately 25 mm (1.000 in) wide for pipe from Label 1: 4 up to and including Label 1: 7-5/8, and approximately 38 mm (1.500 in) wide for pipe larger than Label 1: 7-5/8.

All pipe-body tensile specimens shall represent the full wall thickness of the pipe from which the specimen was cut, except for round bar tensile specimens, and shall be tested without flattening. When round bar specimens are used, the 12,7 mm (0.500 in) diameter round bar specimens shall be used when the pipe size allows, and the 8,9 mm (0.350 in) diameter round bar specimen shall be used for other sizes. For pipe sizes too small to allow a 8,9 mm (0.350 in) specimen, round bar tensile specimens are not permitted.

When elongation is recorded or reported, the record or report shall show the nominal width of the test specimen when strip specimens are used, the diameter and gauge length when round bar specimens are used or shall state when full section specimens are used.

10.4.6 Test specimens — Additional requirements for couplings, pup-joints and accessories — Grade Q125

In addition to the requirements in 10.4.5, longitudinal tensile test specimens shall be removed from coupling, pup-joint or accessory material and individually heat-treated coupling blanks, pup-joints or accessories subsequent to final heat treatment. Tensile test specimens shall be either strip specimens or, if the wall thickness of the tubular is over 19,1 mm (0.750 in), a round specimen 12,7 mm (0.500 in) in diameter may be used as shown in Figure D.9.

Round specimens may be used for coupling stock at the option of the manufacturer. Tensile test specimens for coupling, pup-joint or accessory material heat-treated in coupling blank or individual lengths shall be removed from the piece as illustrated in Figure D.10. Reduced-section strip specimens may be used by agreement between purchaser and manufacturer.

10.4.7 Test method

Tensile properties shall be determined by tests on longitudinal specimens conforming to the requirements of 10.4.5, ISO 6892 or ASTM A370, and 10.4.6 for the Q125 products covered therein. Tensile tests shall be made with the specimens at room temperature. The strain rate during tensile testing shall be in accordance with the requirements of ISO 6892 or ASTM A370.

Tensile test machines shall have been calibrated within the 15 months preceding any test in accordance with the procedures of ISO 7500-1 or ASTM E4. Extensometers shall be calibrated within 15 months preceding any test in accordance with the procedures of ASTM E83. Records retention shall be in accordance with 13.5.

10.4.8 Invalidation of tests

If any tensile specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted. When the elongation of any tensile specimen is less than that specified, if any part of the fracture is outside the middle third of the gauge length as indicated by scribe scratches on the specimen before testing, a re-test shall be allowed.

10.4.9 Re-tests — All products except couplings, coupling stock, pup-joints or accessory materials in Grades C90, T95 and Q125

If a tensile test representing a lot fails to conform to the specified requirements, the manufacturer may elect to make re-tests on three additional lengths from the same lot.

If all of the re-tests conform to the requirements, the lot shall be accepted, excepting the failed length.

If more than one of the original test specimens fails or one or more of the re-test specimens fails to conform to the specified requirements, the manufacturer may elect to test each of the remaining lengths in the lot. Specimens for re-tests shall be taken in the same manner as specified in 10.4.5 and 10.4.6. For Grades M65, L80 and C95 the tensile re-test specimens shall be taken from the same end as the original test specimen.

Rejected lots may be re-heat-treated and re-tested as new lots.

10.4.10 Re-tests — Couplings, coupling stock, pup-joints or accessory materials in Grades C90, T95 and Q125

For material heat-treated in tube lengths, if a tensile specimen fails to conform to the specified requirements, the manufacturer shall either make tests on both ends of the tube in question or reject the length. No other additional testing shall be allowed to qualify a length of coupling, pup-joint or accessory material. Both test results shall conform to the specified requirements or the length shall be rejected. Rejected lengths may be re-heat-treated and re-tested.

For material heat-treated in coupling blank or individual product lengths, if a tensile specimen fails to conform to the specified requirements, the manufacturer shall either re-heat treat that lot in question or make three additional tests from the lot in question. If one or more of them fails, the lot shall be rejected. The manufacturer may elect to re-heat treat and re-test the lot.

10.5 Flattening test

10.5.1 General requirement for testing

Flattening tests shall be made for all welded pipe with D/t ratios as shown in Table C.23 or Table E.23.

In the following subclauses 10.5.2 to 10.5.7, the 0° position shall have the weld contacting the parallel plate (defined as 12 o'clock or 6 o'clock). The 90° position shall have the weld positioned at 3 o'clock or 9 o'clock.

10.5.2 Frequency of testing

The frequency of testing shall be in accordance with Table C.43 or Table E.43.

10.5.3 Test specimens

Test specimens shall be rings or crop ends not less than 63,5 mm (2½ in) long.

On pipe cut from multiple lengths of a coil, the test on one end of one piece shall represent a test on the adjacent end of the next piece of pipe. If the pipe is to be upset, the test specimen shall be taken from the tube prior to upsetting.

The test specimens may be cut before heat treating and given the same type heat treatment as the pipe represented. If lot testing is used, precaution shall be taken so that the test specimens can be identified with respect to the length of pipe from which they are cut. Each heat in each lot shall be subjected to a flattening test.

For electric-welded pipe that is full-body normalized, including pipe that is processed through a hot-stretch mill in accordance with the requirements in 6.2.1, flattening test specimens shall be obtained either prior to or after such treatment at the option of the manufacturer.

10.5.4 Test method for Group 1 — Non-full-body heat-treated pipe

Test specimens shall be flattened between parallel plates. From each pair of flattening test specimens, one shall be flattened with the weld located in the 90° position and the other with the weld located in the 0° position. Test specimens shall be flattened until opposite walls of the pipe meet. No cracks or breaks shall occur anywhere in the specimen until the distance between the plates is less than that specified in Table C.23 or Table E.23; nor shall evidence of poor texture, incomplete fusion in the weld, laminations, burnt metal or extruded metal develop during the entire flattening process.

10.5.5 Test method for Groups 1 and 2 — Full-body heat-treated pipe

Test specimens shall be flattened between parallel plates with the weld at the point of maximum bending; and, at the discretion of the inspector, separate flattening tests shall also be made with the weld located 90° from the point of maximum bending. Test specimens shall be flattened until opposite walls of the pipe meet. No cracks or breaks shall occur anywhere in the specimen until the distance between the plates is less than that specified in Table C.23 or Table E.23; nor shall evidence of poor texture, incomplete fusion in the weld, laminations, burnt metal or extruded metal develop during the entire flattening process.

10.5.6 Test method for Grade P110 pipe and Grade Q125 casing

The supplementary requirements in A.5 (SR11) shall apply.

10.5.7 Re-tests

If either test specimen representing a single length of pipe fails to meet the requirements specified, the manufacturer may elect to make additional tests on specimens cut from the same end of the same length of pipe, until the requirements are met, except that the finished pipe shall not be shorter than 80 % of its length after the initial cropping. If any test specimen from a length of pipe representing a lot fails to conform to the requirements specified, the manufacturer may elect to repeat the tests on specimens cut from two additional lengths of pipe from the same lot. If such specimens conform to the specified requirements, all the lengths in the lot shall be accepted except the length initially selected for the test. If any of the re-test specimens fails to pass the specified requirements, the manufacturer may elect to test specimens cut from the individual lengths remaining in the lot. Specimens for re-tests shall be taken in the same manner as specified in 10.5.3. At the option of the manufacturer, any lot of pipe may be re-heat-treated and tested as a new lot.

10.6 Hardness test

10.6.1 Sampling — Heat control tests — Grades M65 and L80

Each heat control tensile test specimen shall be hardness-tested to verify conformance to hardness requirements.

10.6.2 Sampling and test specimen location — Grades M65 and L80

On pipe, coupling stock and accessory material, hardness testing shall be carried out at the same frequency as tensile testing for each of these products. Additional hardness testing of the outside surface and through-wall hardness testing of upsets may be carried out as agreed between purchaser and manufacturer. Test procedures for this additional testing shall be as agreed between purchaser and manufacturer.