

DIN EN ISO 11960

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Ersatz für
DIN EN ISO 11960:2005-07

**Erdöl- und Erdgasindustrie –
Stahlrohre zur Verwendung als Futter- oder Steigrohre für Bohrungen
(ISO 11960:2011);
Englische Fassung EN ISO 11960:2011, nur auf CD-ROM**

Petroleum and natural gas industries –
Steel pipes for use as casing or tubing for wells (ISO 11960:2011);
English version EN ISO 11960:2011, only on CD-ROM

Industries du pétrole et du gaz naturel –
Tubes d'acier utilisés comme cuvelage ou tubes de production dans les puits
(ISO 11960:2011);
Version anglaise EN ISO 11960:2011, seulement en CD-ROM

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Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

Nationales Vorwort

Dieses Dokument (EN ISO 11960:2011) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum and natural gas industries“, Subcommittee SC 5 „Casing, tubing and drill pipe“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-05 AK „Futter-, Steig- und Bohrröhre – Spiegelausschuss zu ISO/TC 67/SC 5“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) des DIN Deutsches Institut für Normung e. V. mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO Norm.

Dieses Dokument enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „ft“, „ft · lb“, „in (inch)“, „ksi“, „lb (pound)“, „ppm“, „psi (psig)“ und „r/min“, die in Deutschland nicht zugelassen sind. Es wird jedoch ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung
°F	°C	°C = (5/9) (°F-32)
ft	m	1 ft = 0,304 8 m
ft · lb	Nm	1 ft · lb = 1,35 Nm
in (inch)	mm	1 in = 25,4 mm
ksi	MPa	1 ksi = 6,894 757 MPa
lb (pound)	kg	1 lb = 0,453 592 37 kg
ppm	mg/kg	1 ppm = 1 mg/kg
psi (psig)	kPa	1 psi = 6,894 757 kPa
r/min	min ⁻¹	1 r/min = 1 min ⁻¹

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 643	siehe	DIN EN ISO 643
ISO 6506-1	siehe	DIN EN ISO 6506-1
ISO 6506-2	siehe	DIN EN ISO 6506-2
ISO 6508-1	siehe	DIN EN ISO 6508-1
ISO 6508-2	siehe	DIN EN ISO 6508-2
ISO 6892	siehe	DIN EN ISO 6892-1
ISO 7500-1	siehe	DIN EN ISO 7500-1
ISO 8501-1	siehe	DIN EN ISO 8501-1
ISO 9303	siehe	DIN EN ISO 10893-10
ISO 9304	siehe	DIN EN ISO 10893-2
ISO 9305	siehe	DIN EN ISO 10893-10

ISO 9402	siehe	DIN EN ISO 10893-3
ISO 9513	siehe	DIN EN ISO 9513
ISO 9598	siehe	DIN EN ISO 10893-3
ISO/TR 10400	siehe	DIN SPEC 91040 (DIN CEN ISO/TR 10400)
ISO 13665	siehe	DIN EN ISO 10893-5
ISO 15156-2	siehe	DIN EN ISO 15156-2
ISO/IEC 17011	siehe	DIN EN ISO/IEC 17011
ISO/IEC 17025	siehe	DIN EN ISO/IEC 17025

Änderungen

Gegenüber DIN EN ISO 11960:2005-07 wurden folgende Änderungen vorgenommen:

- a) der Anwendungsbereich wurde insbesondere im Hinblick auf Werkstoffe für Zubehör und auf den Werkstoff der Güte C110 erweitert;
- b) der Abschnitt 4.1 „Begriffe“ wurde erweitert;
- c) der normative Anhang K „Modification of the hydrogen sulfide titration procedures in ANSI-NACE TM0284-2003“ wurde ergänzt;
- d) der informative Anhang L „Technical changes from the previous edition“ unter Berücksichtigung der technischen Änderungen im Hinblick auf die vorherige Normausgabe wurde ergänzt.

Frühere Ausgaben

DIN EN ISO 11960: 1998-04, 2003-06, 2005-07

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benennung der folgenden Begriffe, Symbole und Abkürzungen sind identisch mit der Benennung in der Englischen Fassung

4.1 Begriffe

Für die Anwendung dieses Dokuments gelten die Begriffe nach ASTM A941 für Arbeitsabläufe für die Wärmebehandlung und die folgenden Begriffe.

4.1.1

Zubehörteil-Grundelement

nahtlose Futter- oder Steigrohre, nahtlose dickwandige Rohre oder Drehteilrohre, Stangenmaterial oder Warmschmiedeteile, die für die Herstellung von Zubehörteilen verwendet werden

4.1.2

API-Gewinde

Gewinde entsprechend den Festlegungen in API Spec 5B

4.1.3

Lichtbogenzündstelle

örtlich begrenzter Punkt, an dem die Oberfläche geschmolzen ist, verursacht durch die Bildung eines Lichtbogens zwischen einer Elektrode oder Erdung (Erde) und der Produktoberfläche

ANMERKUNG Kontaktmarken, das sind unterbrochene Marken neben der Bindenaht des EW-Rohrs, die aus dem elektrischen Kontakt zwischen den Elektroden, die den Schweißstrom liefern, und der Oberfläche des Rohres entstehen, bzw. Kontaktmarken, die durch die Anwendung eines Spektrometers zur Ermittlung der chemischen Zusammensetzung des Stahls entstehen, sind keine Lichtbogenzündstellen.

4.1.4

Wagenladung

Waggonladung

Menge des auf ein Schienenfahrzeug verladenen Produktes für den Abtransport von den Produktionseinrichtungen

4.1.5

Futterrohr

Rohrleitung von der Oberfläche, die zum Ausfüttern der Wände einer Bohrung vorgesehen ist

4.1.6

Verbindung

aus rohrförmigen Bauteilen bestehende Baugruppe mit Gewinde

4.1.7

geregeltes Abkühlen

Abkühlen von einer erhöhten Temperatur auf eine zuvor festgelegte Art und Weise zur Vermeidung von Aushärten, Rissbildung oder innerer Beschädigung oder um eine gewünschte Mikrostruktur oder mechanische Eigenschaften zu erzeugen

4.1.8**Muffe**

Zylinder mit Innengewinde zum Verbinden von zwei Rohrlängen mit Gewinde

4.1.9**Muffenrohling**

Grundelement ohne Gewinde, das zur Herstellung einer individuellen Muffe verwendet wird

4.1.10**Muffen-Grundelement**

dickwandiges nahtloses Rohr, das zur Herstellung von Muffenrohlingen verwendet wird

ANMERKUNG Der Hauptunterschied zwischen Muffen-Grundelementen und Muffenvorrohren besteht darin, dass bei Muffen-Grundelementen keine vorgeschriebenen Anforderungen an zerstörungsfreie Prüfungen (siehe 10.15) bestehen. Vorgeschriebene Anforderungen an die zerstörungsfreie Prüfung von fertig bearbeiteten Muffen siehe Abschnitt 9.

4.1.11**Muffenvorrohr**

Muffen-Grundelement, das die Anforderungen an das Muffenvorrohr erfüllt

4.1.12**Fehler**

Unregelmäßigkeit, deren Ausmaß ausreichend dafür ist, dass, beruhend auf den in dieser Internationalen Norm festgelegten Kriterien, ein Zurückweisen des Produktes gerechtfertigt ist

4.1.13**elektrisch geschweißtes Rohr**

Rohr mit einer Längsnaht, die durch elektrisches Widerstandsschweißen oder Induktionsschweißen, ohne das Hinzufügen von Schweißzusätzen geformt ist, wobei die zu schweißenden Kanten mechanisch zusammengedrückt sind und die Wärme zum Schweißen durch den Durchgangswiderstand des elektrischen Stroms erzeugt wird

4.1.14**Gesamtquerschnitt**

vollständiger Querschnitt des Produkts

4.1.15**Gesamtlänge**

vollständige Länge des Produkts (von einem zum anderen Ende)

4.1.16**für die Handhabung fest angezogen**

ausreichend fest angezogen, so dass die Muffe nicht entfernt werden kann, außer es wird ein Schraubenschlüssel verwendet

4.1.17**Schmelze**

Metall, das während eines Schmelzprozesses einer Charge durch einen einzigen Arbeitsgang erzeugt wird

4.1.18**Analyse der Schmelze**

für eine Schmelze repräsentative chemische Analyse, wie vom Metallhersteller angegeben

4.1.19**Unregelmäßigkeit**

Diskontinuität in der Wand des Produktes oder auf der Oberfläche des Produktes, die durch ein in Tabelle C.42 oder Tabelle E.42 dieser Internationalen Norm enthaltenes Verfahren der zerstörungsfreien Prüfung nachgewiesen werden kann

4.1.20

Prüfung

Vermessungs-, Untersuchungs-, Prüf- oder Messvorgang oder ein auf andere Art und Weise durchgeführter Vorgang des Vergleichens einer Produkteinheit mit den geltenden Anforderungen

4.1.21

Prüflos

Los

festgelegte Menge eines Produktes, das unter Bedingungen hergestellt wurde, die für die zu untersuchende Merkmalseigenschaft als einheitlich angesehen werden

4.1.22

Prüflosprobe

eine oder mehrere Einheit(en) eines aus einem Prüflos ausgewählten Produktes, mit dem dieses Prüflos repräsentiert wird

4.1.23

Prüflosumfang

Anzahl von Produkteinheiten in einem Prüflos

4.1.24

unterbrochenes Abschrecken

Abschrecken, bei dem das Produkt, das abgeschreckt wird, aus dem Abschreckmittel entfernt wird, wobei die Temperatur des Produktes wesentlich höher als die des Abschreckmittels ist

4.1.25

Label 1

dimensionslose Bezeichnung für die Größe oder für den festgelegten Außendurchmesser, die bei der Bestellung eines Rohres verwendet werden kann

4.1.26

Label 2

dimensionslose Bezeichnung für die Masse je Längeneinheit, die bei der Bestellung eines Rohres verwendet werden kann

4.1.27

Länge

Rohrstück, das möglicherweise glatte Enden, Gewinde oder Gewinde und Muffen aufweist und das die in Tabelle C.27 oder Tabelle E.27 dieser Internationalen Norm enthaltenen Anforderungen bezüglich des Längenbereichs erfüllt

4.1.28

linear verlaufende Unregelmäßigkeit

Unregelmäßigkeit, die Nähte, Überlappungen, Risse, Kerben, Schnitte und Rillen umfasst, aber nicht darauf beschränkt ist

ANMERKUNG Siehe API Std 5T1.

4.1.29

Hersteller

in Abhängigkeit vom Kontext eines oder mehrere der folgenden Unternehmen: Rohrwerk; Verarbeiter; Gewin-
deschneider; Hersteller von Muffen, Hersteller von Passstangen; Hersteller von Zubehörteilen

ANMERKUNG Siehe Abschnitt 14.

4.1.30**nicht linear verlaufende Unregelmäßigkeit**

Unregelmäßigkeit, die Vertiefungen und beim Prägen erzeugte Dellen umfasst, aber nicht darauf beschränkt ist

ANMERKUNG Siehe API Std 5T1.

4.1.31**Rohr**

Futterrohre, Steigrohre und Passstangen als eine Gruppe

4.1.32**Rohrwerk**

Firma, Betrieb oder Unternehmen, in der/dem Einrichtungen betrieben werden, mit denen Rohre hergestellt werden

4.1.33**Rohr mit glatten Enden**

Rohr, entweder angestaucht oder nicht angestaucht, ohne Gewinde

4.1.34**Verarbeiter**

Firma, Betrieb oder Unternehmen, in der/dem Einrichtungen betrieben werden, mit denen die in einem Rohrwerk hergestellten Produkte einer Wärmebehandlung unterzogen werden können

4.1.35**Produkt**

Rohr, Muffe, Muffenvorrohr, Muffen-Grundelement, Muffenrohling oder Zubehörteil-Grundelement, entweder einzeln oder zusammen, wie jeweils zutreffend

4.1.36**Produkt-Prüfblock**

Prüfblock, der dem Produkt, dem Prüfkörper für die Zugprüfung oder dem Prüfkörper für die Prüfung der Härtetiefe entnommen wurde

4.1.37**Passstange**

Futter- oder Steigrohr, das eine geringere Länge als der Längenbereich 1 aufweist, siehe Tabelle C.27 oder Tabelle E.27

4.1.38**Passstangen-Grundelement**

genormtes Futter- oder Steigrohr, dickwandige Rohre oder Drehteilrohre oder Stangenmaterial, das/die für die Herstellung von Passstangen verwendet wird/werden

4.1.39**Käufer**

Partei, die sowohl für die Festlegung von Anforderungen an eine Produktbestellung als auch für die Bezahlung dieser Bestellung verantwortlich ist

4.1.40**Härteriss**

Riss im Stahl, der durch Spannungen entsteht, die während der Umwandlung von Austenit zu Martensit erzeugt werden

ANMERKUNG Bei dieser Umwandlung erhöht sich gleichzeitig das Volumen.

4.1.41

nahtloses Rohr

röhrenförmiges Produkt aus Schweißstahl, das ohne eine Schweißnaht gefertigt wurde

ANMERKUNG Um die gewünschte Form, die gewünschten Maße und Eigenschaften zu erhalten, erfolgt die Herstellung durch Warmformgebung von Stahl und erforderlichenfalls durch anschließendes Kaltumformen oder Wärmebehandlung oder durch eine Kombination aus diesen Arbeitsschritten.

4.1.42

Röhrenstreifen

warmgewalzter Stahlstreifen, der zur Herstellung von EW-Rohren verwendet wird

4.1.43

spezielle Endverarbeitung

Gewinde mit Gewindeform und -merkmalen, Herstellerspezifikationen, Abmessungen, Verbindungsausführung und Leistungseigenschaften, die außerhalb des Anwendungsbereiches dieser Internationalen Norm liegen

4.1.44

genormter Prüfblock

Prüfblock, der hinsichtlich einer mittleren Härtezahl zertifiziert wurde und der für die Verifizierung der Leistungsfähigkeit von für die Härteprüfung angewendeten Maschinen verwendet wird

4.1.45

Gewindeschützer

Kappe oder Einsatz, die/der während der Handhabung, des Transports und der Lagerung zum Schutz von Gewinden und Dichtungen verwendet wird

4.1.46

Steigrohr

in eine Bohrung eingesetztes Rohr zum Fördern oder Einspritzen von Flüssigkeiten

4.1.47

obere kritische Temperatur

A_{r3}

Temperatur, bei der Austenit anfängt, sich während des Abkühlens in Ferrit umzuwandeln

4.2 Symbole und Abkürzungen

BC	API Spec 5B, Futterrohrverbindung mit Sägen(profil)gewinde
B_f	maximaler Durchmesser der Auflagefläche
CS	Muffenvorrohr
C_V	beim Kerbschlagbiegeversuch nach Charpy mit V-Kerbe geringste verbrauchte Schlagarbeit
CVN	beim Kerbschlagbiegeversuch nach Charpy erzeugte V-Kerbe
D	für das Rohr festgelegter Außendurchmesser
d	berechneter Innendurchmesser
EMI	elektromagnetische Prüfung
EU	API Spec 5B, außen angestauchte Steigrohrverbindung
EW	elektrisches Schweißverfahren

HBW	Brinellhärte bei Prüfung mit einer Kugel aus Wolframcarbid
HRC	Rockwell-Härte, Skale C
ID	Innendurchmesser
IJ	API Spec 5B, Steigrohrverbindung mit Integralverbinder
k	bei der Berechnung der Dehnung angewendete Konstante
LC	API Spec 5B, Futterrohrverbindung mit langem rundem Gewinde
N	〈Wärmebehandlungsverfahren〉 über den Gesamtquerschnitt und die gesamte Länge normalgeglüht
N&T	normalgeglüht und angelassen
NDE	zerstörungsfreie Prüfung
NIST	nationales Standardisierungsinstitut der USA (National Institute of Standards and Technology)
NU	API Spec 5B, nicht angestauchte Steigrohrverbindung
OD	Außendurchmesser
PE	gewindeloses Rohr, entweder angestaucht oder nicht angestaucht
PSL	Herstellungsstufe
Q	abgeschreckt und angelassen
RC	normale Muffe
S	nahtlose Fertigung (wenn nicht auf das chemische Element Schwefel verwiesen wird)
Sc	bei Prüfung nach ANSI-NACE TM0177-2005, Verfahren B, kleinstes erhaltenes zulässiges Ergebnis
SCC	Muffe mit speziellem Spiel
SSC	schwefelinduzierte Spannungsrissbildung
SC	API Spec 5B, Futterrohrverbindung mit kurzem rundem Gewinde
SR	zusätzliche Anforderung
SF	spezielle Endverarbeitung
t	festgelegte Wanddicke
T&C	mit Gewinde und Muffe
USC	angloamerikanisches Maßsystem
UT	Ultraschallprüfung
W	für normale Muffen mit API-Gewinden festgelegter Außendurchmesser
W_c	für Muffen mit speziellem Spiel und mit API-Gewinden festgelegter Außendurchmesser
$YS_{\max}$	festgelegte maximale Fließgrenze
$YS_{\min}$	festgelegte Mindestfließgrenze

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN SPEC 91040 (DIN CEN ISO/TR 10400), *Erdöl- und Erdgasindustrie — Formeln und Berechnungen der Eigenschaften von Futterrohren, Steigrohren, Bohrgestängen und Leitungsrohren*

DIN EN ISO 643, *Stahl — Mikrophotographische Bestimmung der scheinbaren Korngröße*

DIN EN ISO 6506-1, *Metallische Werkstoffe — Härteprüfung nach Brinell — Teil 1: Prüfverfahren*

DIN EN ISO 6506-2, *Metallische Werkstoffe — Härteprüfung nach Brinell — Teil 2: Prüfung und Kalibrierung der Prüfmaschinen*

DIN EN ISO 6508-1, *Metallische Werkstoffe — Härteprüfung nach Rockwell — Teil 1: Prüfverfahren (Skalen A, B, C, D, E, F, G, H, K, N, T)*

DIN EN ISO 6508-2, *Metallische Werkstoffe — Härteprüfung nach Rockwell — Teil 2: Prüfung und Kalibrierung der Prüfmaschinen (Skalen A, B, C, D, E, F, G, H, K, N, T)*

DIN EN ISO 6892-1, *Metallische Werkstoffe — Zugversuch — Prüfverfahren bei Raumtemperatur*

DIN EN ISO 7500-1, *Metallische Werkstoffe — Prüfung von statischen einachsigen Prüfmaschinen — Teil 1: Zug- und Druckprüfmaschinen — Prüfung und Kalibrierung der Kraftmesseinrichtung*

DIN EN ISO 8501-1, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 1: Rostgrade und Oberflächenvorbereitungsgrade von unbeschichteten Stahloberflächen und Stahloberflächen nach ganzflächigem Entfernen vorhandener Beschichtungen*

DIN EN ISO 9513, *Metallische Werkstoffe — Kalibrierung von Längenänderungs-Messeinrichtungen für die Prüfung mit einachsiger Beanspruchung*

DIN EN 10246-12, *Zerstörungsfreie Prüfung von Stahlrohren — Teil 12: Magnetpulverprüfung nahtloser und geschweißter ferromagnetischer Stahlrohre zum Nachweis von Oberflächenfehlern*

DIN EN ISO 10893-2, *Zerstörungsfreie Prüfung von Stahlrohren — Teil 2: Automatisierte Wirbelstromprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) Stahlrohre zum Nachweis von Unvollkommenheiten*

DIN EN ISO 10893-3, *Zerstörungsfreie Prüfung von Stahlrohren — Teil 3: Automatisierte Streuflussprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) ferromagnetischer Stahlrohre über den gesamten Rohrumfang zum Nachweis von Unvollkommenheiten in Längs- und/oder Querrichtung*

DIN EN ISO 10893-5, *Zerstörungsfreie Prüfung von Stahlrohren — Teil 5: Magnetpulverprüfung nahtloser und geschweißter ferromagnetischer Stahlrohre zum Nachweis von Oberflächenunvollkommenheiten*

DIN EN ISO 10893-10, *Zerstörungsfreie Prüfung von Stahlrohren — Teil 10: Automatisierte Ultraschallprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) Stahlrohre über den gesamten Rohrumfang zum Nachweis von Unvollkommenheiten in Längs- und/oder Querrichtung*

DIN EN ISO 15156-2, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H₂S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 2: Gegen Rissbildung beständige unlegierte und niedriglegierte Stähle und Gusseisen*

DIN EN ISO/IEC 17011, *Konformitätsbewertung — Allgemeine Anforderungen an Akkreditierungsstellen, die Konformitätsbewertungsstellen akkreditieren*

DIN EN ISO/IEC 17025, *Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien*

English Version

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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 CEN-CENELEC 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 CEN-CENELEC Management Centre has the same status as the official versions.

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Foreword

This document (EN ISO 11960:2011) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical 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 December 2011, and conflicting national standards shall be withdrawn at the latest by December 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 11960:2004.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 11960:2011 has been approved by CEN as a EN ISO 11960:2011 without any modification.

Introduction

This International Standard is based on API Spec 5CT.

Users of this International Standard are advised that further or differing requirements can 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 can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, it is advisable that the vendor 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.

Details of the major changes (additions, modifications and deletions) agreed by the committee, and which affect the performance of the products or the technical requirements applicable to the products, are provided for information in Annex L. While efforts have been made to ensure the accuracy of the changes indicated, the user of this International Standard is advised to consider the total technical content and not only the changes identified. *The user is ultimately responsible for recognising any differences between this edition and the previous edition of this International Standard. ISO expressly disclaims any liability or responsibility for loss or damage resulting from inappropriate use of this International Standard on the basis of any inaccuracy in the changes identified.*

1 Scope

1.1 This International Standard specifies the technical delivery conditions for steel pipes (casing, tubing and pup joints), coupling stock, coupling material and accessory material and establishes requirements for three Product Specification Levels (PSL-1, PSL-2, PSL-3). The requirements for PSL-1 are the basis of this International Standard. The requirements that define different levels of standard technical requirements for PSL-2 and PSL-3, for all Grades except H-40, L-80 9Cr and C110, are contained in Annex H.

For pipes covered by this International Standard, the sizes, masses and wall thicknesses as well as grades and applicable end-finishes are listed in Tables C.1 and C.2 and Tables E.1 and E.2.

By agreement between the purchaser and manufacturer, this International Standard can also be applied to other plain-end pipe sizes and wall thicknesses.

This International Standard is applicable to the following connections in accordance with API Spec 5B:

- short round thread casing (SC);
- long round thread casing (LC);
- buttress thread casing (BC);
- non-upset tubing (NU);
- external upset tubing (EU);
- integral tubing connections (IJ).

For such connections, this International Standard specifies the technical delivery conditions for couplings and thread protection. Supplementary requirements that can optionally be agreed for enhanced leak resistance connections (LC) are given in A.11 SR22.

This International Standard can 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, N and R;
- 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 can be specified by the purchaser to be used in tubing service, see Tables C.1, C.23, C.27 and C.28 or Tables E.1, E.23, E.27 and E.28.

1.4 Supplementary requirements that can optionally be agreed between purchaser and manufacturer for non-destructive examination, fully machined coupling blanks, upset casing, electric-welded casing, tubing and pup joints, impact testing, seal ring couplings, test certificates, tensile testing and sulfide stress cracking testing 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 API Spec 5B.

2 Conformance

2.1 Dual referencing of normative references

In the interests of world-wide application of this International Standard, ISO/TC 67 has decided, after detailed technical analysis, that certain of the normative documents listed in Clause 3 and prepared by ISO/TC 67 or 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 technical results different from the use of the preceding ISO reference. However, both results are acceptable and these documents are thus considered interchangeable in practice.

2.2 Units of measurement

In this International Standard, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units. For a specific order item, it is intended that only one system of units be used, without combining data expressed in the other system.

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

For data expressed in 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 parentheses.

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

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

3 Normative references

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

ISO 80000-1, *Quantities and units — Part 1: General*

ISO 643, *Steels — Micrographic determination of the apparent grain size*

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

ISO 6506-2, *Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines*

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 6508-2, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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

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

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

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

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

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

ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing*

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

ISO/TR 10400, *Petroleum and natural gas industries — Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing*

ISO 11484, *Steel products — Employer's qualification system for 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, line pipe and drill stem elements*

ISO 15156-2, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons*

ISO/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ANSI/NACE TM0177-2005, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments*

ANSI/NACE TM0284-2003, *Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

ANSI/NACE MR0175/ISO 15156, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

API RP 5A3, *Recommended Practice on Thread Compounds for Casing, Tubing, Line Pipe, and Drill Stem Elements*

API TR 5C3, *Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing*

API Spec 5B, *Specification for Threading, Gauging and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

ASNT SNT-TC-1A, *Recommended Practice No. SNT-TC-1A — Non-Destructive Testing*

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

ASTM A751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

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

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM E4, *Standard Practices for Force Verification of Testing Machines*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

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

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

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

ASTM E83, *Standard Practice for Verification and Classification of Extensometer Systems*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

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

ASTM E273, *Standard Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing*

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

ASTM E543, *Standard Practice for Agencies Performing Nondestructive Testing*

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

IADC/SPE 11396, B.A. Dale, M.C. Moyer, T.W. Sampson, *A Test Program for the Evaluation of Oilfield Thread Protectors*, IADC/SPE Drilling Conference, New Orleans, LA, 20-23 February 1983

MIL-STD-810c, *Military Environmental Test Methods*, 10 March 1975

4 Terms, definitions, symbols and abbreviated terms

4.1 Terms and definitions

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

4.1.1

accessory material

seamless casing or tubing, or seamless thick-walled tubes or mechanical tubes, or bar stock or hot forgings used for the manufacture of accessories

4.1.2

API threads

threads as specified in API Spec 5B

4.1.3

arc burn

localised point of surface melting caused by arcing between an electrode or ground (earth) and the product surface

NOTE Contact marks, which are intermittent marks adjacent to the weld line of EW pipe resulting from electrical contact between the electrodes supplying the welding current and the pipe surface, or contact marks resulting from the use of a spectrometer for the detection of steel chemical composition, are not arc burns.

4.1.4

carload

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

4.1.5

casing

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

4.1.6

connection

threaded assembly of tubular components

4.1.7

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

4.1.8

coupling

internally threaded cylinder for joining two lengths of threaded pipe

4.1.9

coupling blank

unthreaded material used to produce an individual coupling

4.1.10

coupling material

thick-walled seamless tube used to manufacture coupling blanks

NOTE The main difference between coupling material and coupling stock is that coupling material has no mandatory NDE inspection requirements (see 10.15). See Clause 9 for mandatory NDE requirements for finished couplings.

4.1.11

coupling stock

coupling material that meets the coupling stock requirements

4.1.12

defect

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

4.1.13

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

4.1.14

full-body

complete cross-section of the product

4.1.15

full-length

complete length of the product (end-to-end)

4.1.16

handling tight

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

4.1.17

heat

metal produced by a single cycle of a batch melting process

4.1.18

heat analysis

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

4.1.19

imperfection

discontinuity in the product wall or on the product surface that can be detected by a NDE method included in Table C.42 or Table E.42 of this International Standard

4.1.20

inspection

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

4.1.21

inspection lot

lot

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

4.1.22

inspection lot sample

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

4.1.23

inspection lot size

number of units of product in an inspection lot

4.1.24

interrupted quenching

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

4.1.25

label 1

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

4.1.26

label 2

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

4.1.27

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.27 or Table E.27 of this International Standard

4.1.28

linear imperfection

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

NOTE See API Std 5T1.

4.1.29

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.

4.1.30

non-linear imperfection

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

NOTE See API Std 5T1.

4.1.31

pipe

casing, tubing and pup joints as a group

4.1.32

pipe mill

firm, company or corporation that operates pipe-making facilities

4.1.33

plain-end pipe

pipe, either upset or non-upset, furnished without threads

4.1.34

processor

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

4.1.35

product

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

4.1.36

product test block

test block removed from the product, the tensile test specimen or through-wall hardness test ring

4.1.37

pup joint

casing or tubing of length shorter than Range 1, see Table C.27 or Table E.27

4.1.38

pup-joint material

standard casing or tubing, or thick-wall tubes or mechanical tubes, or bar stock used for the manufacture of pup joints

4.1.39

purchaser

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

4.1.40

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.

4.1.41

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.

4.1.42

skelp

hot-rolled steel strip used for manufacturing EW pipe

4.1.43

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

4.1.44

standardised test block

test block, certified to a mean hardness number, used for the verification of the performance of hardness testing machines

4.1.45

thread protector

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

4.1.46

tubing

pipe placed in a well to produce or inject fluids

4.1.47

upper critical temperature

A_{r3}
temperature at which austenite begins to transform to ferrite during cooling

4.2 Symbols and abbreviated terms

BC	API Spec 5B buttress thread casing connection
B_f	maximum bearing face diameter
CS	coupling stock
C_V	Charpy V-notch impact test minimum absorbed energy
CVN	Charpy V-notch
D	specified outside diameter for pipe
d	calculated inside diameter
EMI	electromagnetic inspection
EU	API Spec 5B external upset tubing connection
EW	electric-welded process
HBW	Brinell hardness, when testing with a tungsten carbide ball
HRC	Rockwell hardness C-scale
ID	inside diameter
IJ	API Spec 5B integral tubing connection
k	a constant used in the calculation of elongation
LC	API Spec 5B long round thread casing connection
N	〈heat-treat process〉 full-body, full-length normalised
N&T	normalised and tempered
NDE	non-destructive examination
NIST	National Institute of Standards and Technology
NU	API Spec 5B non-upset tubing connection
OD	outside diameter
PE	unthreaded pipe either upset or non-upset
PSL	product specification level
Q	quenched and tempered
RC	regular coupling
S	seamless process (when not referencing the chemical element sulfur)
Sc	minimum acceptable result of the ANSI-NACE TM0177-2005 Method B test
SCC	special clearance coupling
SSC	sulfide stress cracking
SC	API Spec 5B short round thread casing connection
SR	supplementary requirement
SF	special end finishing

t	specified wall thickness
T&C	threaded and coupled
USC	United States customary (units)
UT	ultrasonic testing
W	specified outside diameter for regular couplings with API threads
W_c	specified outside diameter of special clearance couplings with API threads
$YS_{\max}$	specified maximum yield strength
$YS_{\min}$	specified minimum yield strength

5 Information to be supplied by the purchaser

5.1 Grades C90, T95 and C110

The purchaser should refer to ISO 15156-2 or ANSI-NACE MR0175/ISO 15156-2 for guidance on the usage of Grades C90, T95 and C110. Particular attention should be given to the application of Grade C110 in ISO 15156-2 or ANSI-NACE MR0175/ISO 15156-2 SSC Regions 2 or 3, as this material is not suitable for all sour (hydrogen sulfide-containing) service applications.

NOTE The SSC test is for quality control purposes only and does not qualify the material for any specific sour service application. It is the product user's responsibility to ensure that the product is suitable for the intended application.

5.2 Casing

5.2.1 When enquiring or placing orders for pipe 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	8.12.1, Table C.1 or Table E.1
Type of connection: SC, LC or BC	8.12.2, Table C.1 or Table E.1
or other connection	
With or without couplings	8.12.2, Table C.1 or Table E.1
Special clearance couplings – BC	9.6, Tables C.1, C.33 or Tables E.1, E.33
Special clearance couplings with special bevel – BC	9.6
Label 1 or specified outside diameter	Table C.1 or Table E.1
Label 2 or specified mass or wall thickness	Table C.1 or Table E.1
Grade and type where applicable	Tables C.1, C.4 or Tables E.1, E.4
Range length	8.6, Table C.27 or Table E.27
Seamless or electric-welded	6.1, Table C.3 or Table E.3
Critical thickness for special end-finish couplings, stock or blanks	7.6.6
Delivery date and shipping instructions	
Inspection by purchaser	Annex B

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

Requirement	Reference
Heat treatment	6.2, Table C.3 or Table E.3
Lower alternative impact test temperature	7.3.7
Impact testing for Group 1 Grades N80 type Q and R95, Group 2 (except M65) and Group 3	7.5.6, A.10 SR16
Impact testing for Group 1 Grades H40, J55, K55, N80 type 1	7.5.1, A.10 SR16
Casing jointers – SC and LC	8.7
Alternative drifting requirements	8.10
Casing with couplings detached	8.14
Coupling make-up (other than power-tight)	8.14
Coupling grade	9.2
Seal ring couplings	9.9, A.8 SR13
Heat and supplementary analyses	10.3
Additional markings	11
Pipe coatings	12.1
Material certification	13.2, A.9 SR15
Product Specification Level (PSL-2 or PSL-3)	Annex H
Alternative grades or heat treatments of coupling	9.2
Statistical tensile test - Grades C90, T95, C110	A.12 SR38
Combination couplings	9.7
Reducing couplings - Groups 1, 2 and 3	9.8

5.2.3 The following may be agreed between purchaser and manufacturer:

Requirement	Reference
Upset – Grade C110	6.1
Cold rotary straightening - Grade Q125	6.3.6
Statistical tensile testing	7.2.4, A.12 SR38
Statistical impact testing	7.3.8, A.7 SR12
Impact of Group 1 non-heat-treated pipe	7.5.1, A.10 SR16
Sulfide stress cracking test - Grades C90 and T95	7.14
Sulfide stress cracking test and test solution – Grade C110	7.14, A.13 SR39
Thread and storage compound	8.14
Waiving NDE of Group 1 couplings in Grades H40, J55 and K55	9.12.3
Coupling thread surface treatment - Grade Q125 only	9.15
Reduced section tensile specimens – Grade Q125	10.4.6
Additional hardness testing	10.6.2
Alternative hydrostatic test pressures	10.12.3
Plain-end Grade Q125 casing hydrostatic testing	10.12.2
Non-destructive examination	10.15, A.2 SR1, A.3 SR2, A.5 SR10 and A.6 SR11
Marking requirements	11
Thread protectors	12.2
Coupling blanks – Grade Q125 only	9.4.2, A.4 SR9
Upset casing – Grade Q125 only	A.5 SR10
Electric-weld casing and pup joints – Grades P110 and Q125	A.6 SR11
Alternative F factor for statistical impact testing	A.7.2 SR12.2
Special end-finish for casing, couplings or pup joints	8.12.6, 9.11.2
Special size and wall thickness – plain-end pipe	8.2
Enhanced leak resistance LC connections	A.11 SR22

5.3 Tubing

5.3.1 When enquiring or placing orders for pipe 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.2 or Table E.2
Threaded, plain-end, or other connection	8.12
With or without couplings	8.12
Regular couplings with special bevel – NU, EU	9.10, Tables C.24, C.34 and C.35 or Tables E.24, E.34 and E.35
Special clearance couplings – EU	9.6, Tables C.24, C.35 or Tables E.24 and E.35
Label 1 or specified outside diameter	Table C.2 or Table E.2
Label 2 or specified mass or wall thickness	Table C.2 or Table E.2
Grade and type, where applicable	Table C.2 or Table E.2, Table C.4 or Table E.4
Range length	8.6, Table C.27 or Table E.27
Seamless or electric-welded	6.1, Table C.3 or Table E.3
Critical thickness for special end-finish couplings	7.4.6
Critical thickness for accessory material	7.6.6
Delivery date and shipping instructions	
Inspection by purchaser	Annex B

5.3.2 The purchaser shall also state on the purchase agreement the requirements, where applicable, concerning the following stipulations, which are at the purchaser's option:

Requirement	Reference
Heat treatment	6.2, Table C.3 or Table E.3
Lower alternative impact test temperature	7.3.7
Impact testing for Group 1 Grades N80 type Q and R95, Group 2 (except M65) and Group 3	7.5.6, A.10 SR16
Impact testing for Group 1 Grades H40, J55, N80 type 1	7.5.1, A.10 SR16
Alternative drift requirements	8.10
Extended length upset	8.11.6
Rounded nose for EU	8.12.3
Coupling make-up (other than power-tight)	8.14
Tubing with couplings detached	8.14
Coupling grade	9.2
Alternative grades or heat treatments of coupling	9.2
Combination couplings	9.7
Reducing couplings — Groups 1, 2 and 3	9.8
Seal ring couplings	9.9, A.8 SR13
Heat and supplementary analyses	10.3
Additional hardness testing	10.6.2
Additional markings	11
Pipe coatings	12.1
Material certification	13.2, A.9 SR15
Product Specification Level (PSL-2 or PSL-3)	Annex H

5.3.3 The following may be agreed between purchaser and manufacturer:

Requirement	Reference
Statistical tensile test	7.2.4, A.12 SR38
Statistical impact testing	7.3.8, A.7 SR12
Impact testing of Group 1 non-heat-treated pipe	7.5.1, A.10 SR16
Sulfide stress cracking test — Grades C90 and T95	7.14
Extended length upsets — EU	8.11.6
Upset length — regular or extended	8.11.6
Thread and storage compound	8.14
Special end-finish for tubing, couplings or pup-joints	8.12.6, 9.11.3
Waiving NDE of Group 1 couplings in Grades H40, J55 and K55	9.12.3
Additional hardness testing	10.6.2
Alternative hydrostatic test pressures	10.12.3
Non-destructive examination	10.15, A.2 SR1, A.3 SR2, A.5 SR10 and A.6 SR11
Marking requirements	11
Thread protectors	12.2
Electric-weld tubing and pup joints — Grade P110	A.6 SR11
Special size and wall thickness	8.2
Casing used for tubing	8.2, Table C.27 or Table E.27

5.4 Coupling stock, coupling material and accessory material

5.4.1 When enquiring or placing orders for coupling stock, coupling material or accessory material manufactured in accordance with this International Standard, the purchaser shall specify the following:

Requirement	Reference
Standard	ISO 11960 or API 5CT
Quantity	
Kind of product: coupling stock, coupling material or accessory material	
Outside diameter and tolerances	8.2
Wall thickness and tolerances	8.2
Straightness tolerance	8.9.2
Length	8.6
Grade and type, where applicable	Tables C.3 & C.4 or Tables E.3 & E.4
Impact requirements or critical thickness	7.4
Inspection by purchaser	Annex B
Critical thickness for special end-finish accessory material	7.6.6
Wall thickness verification of special end-finish accessory material	10.13.4
Delivery date and shipping instructions	

5.4.2 The purchaser shall also state on the purchase agreement the requirements, where applicable, concerning the following stipulations, which are at the purchaser's option:

Requirement	Reference
Heat treatment	6.2, Table C.3 or Table E.3
Statistical tensile testing	7.2.4, A.12 SR38
Statistical impact testing	7.3.8, A.7 SR12
Impact testing	7.5.3, A.10 SR16
Sulfide stress cracking test — Grades C90 and T95	7.14
Sulfide stress cracking test and test solution — Grade C110	7.14, A.13 SR39
Heat and supplementary analyses	10.3
Additional markings	11
Material certification	13.2, 13.3, A.9 SR15
Product Specification Level (PSL-2 or PSL-3)	Annex H

6 Process of manufacture

6.1 General

The product 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.3 or Table E.3 and as specified on the purchase agreement. Pup joints shall be made from the materials listed in 4.1.37. Material for couplings, coupling stock and coupling material shall be manufactured by the seamless process. Cold-drawn tubular products without appropriate heat treatment are not acceptable.

Accessory material for casing and tubing shall be seamless unless otherwise specified on the purchase agreement.

Electric-welded Grade P110 pipe and Grade Q125 casing shall be provided only when the supplementary requirement in A.6 SR11 is specified on the purchase agreement.

Grade C110 shall not be upset unless agreed between the purchaser and manufacturer.

Grade Q125 upset casing shall be provided only when the supplementary requirement in A.5 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.3 or Table E.3 for the particular grade and type specified on the purchase agreement. Heat-treated upset pipe shall be heat-treated full-body, full-length after upsetting. Product requiring heat treatment shall be heat-treated full-body, full-length. Heat-treated upset product shall be heat-treated full-body, full-length after upsetting. Individually heat-treated coupling blanks are acceptable. All pipe processed through a hot-stretch mill (i.e. stretch-reduced) shall be considered normalised, 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 (except H40)

For Grades J55 and K55 product the heat treatment (see Table C.3 or Table E.3) is at the manufacturer's option unless a specific type of treatment, consistent with Table C.3 footnote b or Table E.3 footnote b, is specified on the purchase agreement.

Grade N80 Type 1 product shall be normalised or, at the manufacturer's option, shall be normalised and tempered. Grade N80Q product shall be quenched and tempered.

Grade R95 shall be quenched and tempered.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

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.

6.3 Straightening

6.3.1 Groups 1 (except Grade R95) and 3

No specific methods are required.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

6.3.2 Grade R95

Grade R95 product 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.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

6.3.3 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 product rotary-straightened at temperatures less than 480 °C (900 °F) shall not contain roll marks that exceed the maximum hardness specified in Table C.5 or Table E.5; 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.5 or Table E.5 are acceptable without further evaluation;
- product with severe roll marks shall be either rejected or stress-relieved at 480 °C (900 °F) minimum.

6.3.4 Grades C90 and T95

Grades C90 and T95 product 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.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

6.3.5 Grade C110

Product, when necessary, shall be either cold rotary straightened followed by stress relief at 30 °C to 55 °C (50 °F to 100 °F) below the final specified tempering temperature, or hot rotary straightened with an exit temperature not more than 165 °C (300 °F) below the final specified tempering temperature. When necessary, light gag straightening shall be permitted.

6.3.6 Grade Q125

Gag-press straightening or hot rotary-straightening at 400 °C (750 °F) minimum at the end of rotary-straightening is acceptable (unless a higher minimum temperature is specified on the purchase agreement). If hot rotary-straightening is not possible, the product may be cold rotary-straightened provided it is then stress-relieved at 510 °C (950 °F) or higher. Product 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, C110 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.7 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.7.3 SR12.3.

Each length of coupling stock, coupling material, coupling blank, 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-body, 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 blanks, or pup joints or accessory material in individual lengths, are 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.

6.5 Processes requiring validation

Final operations performed during product manufacturing that affect attribute compliance as required in this International Standard (except chemical composition and dimensions) shall have their processes validated.

Those processes requiring validation are:

- for seamless, as-rolled pipe: final reheating practice and hot sizing or stretch-reducing. If applicable, upsetting, cold-working;
- for seamless, heat-treated pipe: heat treatment;
- for electric-welded, as-rolled pipe: sizing and seam welding. If applicable, seam heat treatment and upsetting;
- for electric-welded, heat-treated pipe: seam welding and full-body, full-length heat treatment.

7 Material requirements

7.1 Chemical composition

Product shall conform to the requirements specified in Table C.4 or Table E.4 for the grade and type specified.

For Grade C110 the manufacturer shall inform the purchaser at the time of inquiry of the minimum and maximum concentrations for all elements intentionally added to each heat, regardless of the purpose of the addition.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

7.2 Tensile properties

7.2.1 General

Product shall conform to the tensile requirements specified in Table C.5 or Table E.5.

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, e , expressed in percent, is calculated as given by Equation (1):

$$e = k \times \frac{A^{0,2}}{U^{0,9}} \quad (1)$$

where

- e is the minimum gauge length extension in 50,8 mm (2.0 in), expressed in percent, rounded to the nearest 0,5 % below 10 % and to the nearest unit percent for 10 % and larger;
- k is a constant: 1 942,57 (625 000);
- A is the cross-sectional area of the tensile test specimen, expressed in square millimetres (square inches), based on specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 10 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 using an area A of 130 mm² (0.20 in²).

Table C.6 or Table E.6 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.5 or Table E.5 as determined by an extensometer.

Additional requirements for PSL-3 products are specified in Annex H.

7.2.4 Statistical tensile testing – Grades C90, T95 and C110

By agreement between purchaser and manufacturer the supplementary requirements for statistical tensile testing of Grades C90, T95 and C110 in A.12 (SR38) shall apply.

7.3 Charpy V-notch test — 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.

For Grade C110 either:

- a) the minimum shear area shall be 75 %, in accordance with ASTM E23 or
- b) the manufacturer may use a documented procedure (taking into account, as a minimum, variations in chemical composition, diameter and wall thickness) together with the impact test results to demonstrate that the upper shelf behaviour is achieved.

If the minimum shear area is less than 75 % or if the requirements of b) are not met, then either the material shall be rejected or a transition curve shall be made to demonstrate that the product is on the upper shelf at the specified test temperature (either the standard test temperature or a reduced test temperature specified by the purchaser).

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

7.3.2 Critical thickness

The absorbed energy requirements are based on the critical thickness. The critical thickness for couplings with 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 API threads is provided in Table C.7 or Table E.7. 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.

For coupling stock, coupling materials and accessory materials where the critical thickness is not specified in the purchaser agreement, the critical thickness shall be the specified wall thickness.

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.8 or Table E.8 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.8 or Table E.8 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 product 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 which meets or exceeds the minimum specified requirement.

7.3.4 Hierarchy of test specimens

The hierarchy of test specimen orientation and size is specified in Table C.9 or Table E.9.

7.3.5 Alternative size impact test specimens

At the manufacturer's option, impact test specimens of an alternative size, listed in Table C.8 or Table E.8, may be used in lieu of the minimum size specified in Tables C.10 to C.15, C.20, C.21 and Tables E.10 to E.15, E.20 and E.21. However, the alternative test specimen selected shall be higher on the hierarchy table (Table C.9 or Table E.9) 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 CVN 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.8 or Table E.8; 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.10 or Table E.10 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.7 SR12 shall apply.

7.3.9 Reference information

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

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

7.4.1 General

Coupling stock, coupling material and coupling blanks 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.9 or Table E.9 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.10 SR16 for optional CVN requirements.

7.4.3 Grades J55 and K55 for 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.10 or Table E.10.

7.4.4 Grade M65 for 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, N80Q and R95, Groups 2 (except Grades M65 and C110), 3 and 4 for API threads

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.11 to C.15 or Tables E.11 to E.15.

The minimum absorbed energy requirements, C_V , for full-size test specimens are calculated based on the equations below, where:

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

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

Unit system	Transverse requirement C_V	Longitudinal requirement C_V
SI units, joules	$YS_{\max} \cdot (0,001\ 18 \cdot t + 0,012\ 59)$ or 20 J, whichever is greater (Table C.16)	$YS_{\max} \cdot (0,002\ 36 \cdot t + 0,025\ 18)$ or 41 J, whichever is greater (Table C.17)
USC units, foot-pounds	$YS_{\max} \cdot (0.152 \cdot t + 0.064)$ or 15 ft-lb whichever is greater (Table E.16)	$YS_{\max} \cdot (0.304 \cdot t + 0.128)$ or 30 ft-lb, whichever is greater (Table E.17)

NOTE Tables for requirements for Grade C110 couplings with API threads are not included since these threads are not standardised for this grade.

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.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

NOTE See A.10 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, R95, L80, C90, T95 and P110

The minimum absorbed energy requirement, C_V , for full-size test specimens is provided in Tables C.18 and C.19 or Tables E.18 and E.19.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

The requirements are calculated based on the equations given below, where:

- YS_{min} is the specified minimum yield strength, in megapascals (thousand pounds per square inch);
 t is the specified wall thickness, in millimetres (inches).

Unit system and grade	Transverse requirement C_V	Longitudinal requirement C_V
SI units, joules Grades N80Q, R95, L80, C90, T95	$YS_{min} \cdot (0,001\ 18 \cdot t + 0,012\ 59)$ or 14 J, whichever is greater (Table C.18)	$YS_{min} \cdot (0,002\ 36 \cdot t + 0,025\ 18)$ or 27 J, whichever is greater (Table C.19)
SI units, joules Grade P110	$YS_{min} \cdot (0,001\ 18 \cdot t + 0,012\ 59)$ or 20 J, whichever is greater (Table C.18)	$YS_{min} \cdot (0,002\ 36 \cdot t + 0,025\ 18)$ or 41 J, whichever is greater (Table C.19)
USC units, foot pounds Grades N80Q, R95, L80, C90, T95	$YS_{min} \cdot (0.152 \cdot t + 0.064)$ or 10 ft-lb, whichever is greater (Table E.18)	$YS_{min} \cdot (0.304 \cdot t + 0.128)$ or 20 ft-lb, whichever is greater (Table E.19)
USC units, foot pounds Grade P110	$YS_{min} \cdot (0.152 \cdot t + 0.064)$ or 15 ft-lb, whichever is greater (Table E.18)	$YS_{min} \cdot (0.304 \cdot t + 0.128)$ or 30 ft-lb, whichever is greater (Table E.19)

7.5.4 Grades C110 and Q125

The minimum absorbed energy requirement for full-size test specimens is provided in Tables C.18 and C.19 or Tables E.18 and E.19.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

The requirements are calculated based on the equations given below where:

- YS_{max} is the specified maximum yield strength, in megapascals (thousand pounds per square inch);
 t is the specified wall thickness, in millimetres (inches).

Unit system	Transverse requirement C_V	Longitudinal requirement C_V
SI units, joules Grades C110 and Q125	$YS_{max} \cdot (0,001\ 18 \cdot t + 0,012\ 59)$ or 20 J whichever is greater (Table C.18)	$YS_{max} \cdot (0,002\ 36 \cdot t + 0,025\ 18)$ or 41 J whichever is greater (Table C.19)
USC units, foot pounds Grades C110 and Q125	$YS_{max} \cdot (0.152 \cdot t + 0.064)$ or 15 ft-lb whichever is greater (Table E.18)	$YS_{max} \cdot (0.304 \cdot t + 0.128)$ or 30 ft-lb, whichever is greater (Table E.19)

7.5.5 Test specimen

Table C.20 or Table E.20 for transverse specimens and Table C.21 or Table E.21 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 Grades M65, C110 and 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.10 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 — Absorbed energy requirements for accessory material

7.6.1 Accessory material — General

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

7.6.2 Accessory material for accessories with internal API threads except integral tubing connections

The requirements in 7.4.1 to 7.4.5 apply.

7.6.3 Accessory material for accessories with internal special end-finish tapered interference-type threads

The requirements in 7.4.6 apply.

7.6.4 Accessory material for accessories with external threads

The requirements in 7.5 apply.

7.6.5 Accessory material for accessories with either integral tubing connections or internal special end-finish connections that do not have thread interference

By agreement between the manufacturer and purchaser, the provisions of A.10 SR16 shall apply.

7.6.6 Critical thickness for accessory material and special end-finish 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 API internal threads, the critical thickness for these API threads is shown in Table C.7 or Table E.7, and D is the specified outside diameter of the connection as specified in 9.4 and 9.6.
- 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 Maximum hardness

7.7.1 Group 2 — All product

- a) Grades M65, L80 all types, C90, T95 and C110 – Through-wall hardness

The hardness numbers and/or mean hardness numbers obtained shall comply with the requirements in Table C.5 or Table E.5.

- b) Grades C90, T95 and C110 — Surface hardness (only if required in accordance with 10.6)

For Grades C90 and T95, if the Brinell or Rockwell C-scale hardness number does not exceed 255 HBW or 25,4 HRC respectively, then the length or piece is acceptable. If any of the hardness numbers are over 255 HBW or 25,4 HRC two additional indentations may be made in the immediate area. If either of the second test hardness numbers exceeds 255 HBW or 25,4 HRC the length or piece shall be rejected.

For Grade C110 upset product and individually heat treated coupling blanks, pup joints or accessory material, if the Brinell or Rockwell C-scale hardness number does not exceed 286 HBW or 30 HRC respectively then the piece is acceptable. If any of the hardness numbers are over 286 HBW or 30 HRC two additional indentations may be made in the immediate area. If either of the second test hardness numbers exceeds 286 HBW or 30 HRC the piece shall be rejected.

- c) Grades C90, T95 and C110 — Through-wall hardness

For Grades C90 and T95, any mean hardness number not exceeding 25,4 HRC is acceptable. If any hardness number from a single indentation exceeds 27,0 HRC, the length or piece shall be rejected. Products with mean hardness numbers between 25,4 HRC and 27,0 HRC shall be retested.

For Grade C110, any mean hardness number not exceeding 30 HRC is acceptable. If any hardness number from a single indentation exceeds 32 HRC the length or piece shall be rejected. Products with mean hardness numbers between 30 HRC and 32 HRC shall be retested.

- d) Grades C90 and T95 — Alternative maximum hardness requirements

By agreement between the purchaser and manufacturer, the maximum mean hardness numbers may be altered from those stated above, based on sulfide stress corrosion cracking tests specified in 7.14.

7.7.2 Grade Q125 — All products

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

7.8 Hardness variation — Grades C90, T95, C110 and Q125

Material shall conform to the hardness variation requirements of Table C.5 or Table E.5. Hardness variation is defined as the difference between any two mean hardness numbers within one quadrant. This criterion shall not apply between specimens.

7.9 Process control — Grades C90, T95, C110 and Q125

All individually heat-treated coupling blanks, pup joints or accessory material shall be surface hardness tested to verify process control. For Grades C90, T95 and C110, the surface hardness test results shall be used in the selection of the pieces for through-wall hardness testing. The process-control 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

For each size, mass, chemical composition and austenitise-and-quench combination, a through-wall hardness test shall be made on products after quenching and prior to tempering for each production run to characterise the hardening response. These tests shall be made on the body of products or, in the case of upset products or accessory material, shall be made in the upset or design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to a minimum of 90 % martensite, as determined by Equation 2:

$$\text{HRC}_{\min} = 58 \times (\% \text{ carbon}) + 27 \quad (2)$$

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

Additional requirements for PSL-3 products are specified in Annex H.

7.10.2 Grade C110

For each size, mass, chemical composition and austenitise-and-quench combination, a through-wall hardness test shall be made after quenching and prior to tempering for each production run. These tests shall be made on the body of products or, in the case of accessory material, shall be made in the design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to 95 % minimum martensite as determined by Equation 3:

$$\text{HRC}_{\min} = 59 \times (\% \text{ carbon}) + 29 \quad (3)$$

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

For pipe, coupling blanks, coupling material and coupling stock with a wall thickness of 30 mm (1.181 in) or larger, an alternative requirement may be used by agreement between manufacturer and purchaser.

7.10.3 All grades except Grades C90, T95 and C110

For each size, mass, chemical composition and austenitise-and-quench combination, a through-wall hardness test shall be made after quenching and prior to tempering as part of a documented procedure to confirm sufficient hardening. These tests shall be made on the body of products or, in the case of upset products or accessory material, shall be made in the upset or design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to a minimum of 50 % martensite, as determined by Equation 4:

$$\text{HRC}_{\min} = 52 \times (\% \text{ carbon}) + 21 \quad (4)$$

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

7.11 Grain size — Grades C90, T95 and C110

Prior austenitic grain size shall be ASTM 5 or finer for Grades C90 and T95 and ASTM 6 or finer for Grade C110 (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.

Additional requirements for PSL-2 and PSL-3 products are specified in Annex H.

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.22 or Table E.22.

7.14 Sulfide stress cracking test — Grades C90, T95 and C110

7.14.1 General guidance

The purchaser should refer to ISO 15156-2 or ANSI-NACE MR0175/ISO 15156-2 for guidance on the usage of Grades C90, T95 and C110. Particular attention should be given to the application of Grade C110 in ISO 15156-2 or ANSI-NACE MR0175/ISO 15156-2 SSC Regions 2 or 3, as this material is not suitable for all sour (hydrogen sulfide-containing) service applications.

NOTE The SSC test is for quality control purposes only and does not qualify the material for any specific sour service application. It is the product user's responsibility to ensure that the product is suitable for the intended application.

7.14.2 Test and re-test requirements

a) Grades C90 and T95: for each lot, as specified by 10.2, manufacturers shall demonstrate that the product meets or exceeds the minimum SSC requirement using one of the ANSI-NACE TM0177-2005 test methods given in 7.14.5. If the purchaser requires an SSC requirement higher than the minimum, or requires a specific test method from the list below, agreement shall be reached between purchaser and manufacturer.

Additional requirements for PSL-3 products are specified in Annex H.

b) Grade C110: for each lot, as defined in 10.2, manufacturers shall demonstrate that the product meets or exceeds the minimum SSC requirement using ANSI-NACE TM0177-2005 test Method A or test Method D as given in 7.14.5. If the purchaser requires an SSC requirement higher than the minimum or requires a specific test method, agreement shall be reached between the purchaser and manufacturer.

c) For Method A full size tensile test specimens shall be used except where sub-size tensile specimens are required because of product size constraints.

d) For Method D, a full size DCB specimen shall be used except where sub-size DCB specimens are required because of product size constraints. When Method D sub-size or alternative specimens are required, acceptance criteria shall be agreed between the purchaser and manufacturer.

e) When not specified in this International Standard, the details of the manufacturer's qualification, frequency of sulfide stress-cracking testing, retest procedures and testing practices should be addressed by the purchaser and manufacturer prior to placing or accepting a purchase agreement.

7.14.3 Test sample selection and location

Where possible, based on product size and type of test specimen required, the SSC test specimens shall be taken from a length, end and location (outside-wall, midwall, inside-wall based on through wall hardness tests, see Figure D.10) selected using one of the following criteria:

- a) for all test methods, for Grades C90 and T95 a mean hardness of 24,4 HRC or higher or for Grade C110 a mean hardness of 29 HRC or higher, or
- b) for all test methods, the highest mean hardness number based on preliminary hardness testing with a minimum of five lengths per lot and a frequency of not less than one length per 20 spaced uniformly in the sequence of the lot, or

NOTE Preliminary hardness testing is intended to capture 5% of the required hardness tests in order to expedite SSC testing. These lengths are part of the pipe required to be tested in 7.7.1.

- c) for all test methods, specimens shall be taken from product representing the highest mean hardness for a particular lot, or
- d) for all test methods, when agreed by the purchaser, the manufacturer may use randomly selected test specimens provided prior documented validation test results or previous qualification of the manufacturing procedure (according to ISO 15156-2 or ANSI-NACE MR0175/ISO 15156-2) confirm that the manufacturing procedure results in products that meet the SSC requirements of this International Standard.

Hardness data obtained on the SSC test specimens shall be for information only.

7.14.4 Test solution for Grades C90, T95 and C110

For the purposes of this International Standard, ANSI-NACE TM0177:2005 Test Solution A shall be used.

See A.13 (SR39) for use of an alternative test solution in an additional informative test.

7.14.5 Minimum SSC requirements

- a) ANSI-NACE TM0177-2005 Method A, Smooth tensile

Full-size (6,35 mm [0.250 in] diameter) specimen	80 % of YS_{min}	496 MPa (72 000 psi) for C90
		524 MPa (76 000 psi) for T95
	85 % of YS_{min}	644 MPa (93 500 psi) for C110
Sub-size (3,81 mm [0.150 in] diameter) specimen	72 % of YS_{min}	447 MPa (64 800 psi) for C90
		472 MPa (68 400 psi) for T95
	76 % of YS_{min}	576 MPa (83 600 psi) for C110

- b) ANSI-NACE TM0177-2005 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. There is no Method B requirement for Grade C110.

- c) ANSI-NACE TM0177-2005 Method D, DCB

A mean value of $33,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($30.0 \text{ ksi}\cdot\text{in}^{1/2}$) with a minimum of at least three valid test specimens for Grades C90 and T95 or a mean value of $26,3 \text{ MPa}\cdot\text{m}^{1/2}$ ($24.0 \text{ ksi}\cdot\text{in}^{1/2}$) with a minimum of at least three valid test specimens for Grade C110.

All valid test results shall be included when calculating the mean value.

No valid test specimen shall have a value less than:

$30,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($27.0 \text{ ksi}\cdot\text{in}^{1/2}$) for Grades C90 and T95 or
 $23,1 \text{ MPa}\cdot\text{m}^{1/2}$ ($21.0 \text{ ksi}\cdot\text{in}^{1/2}$) for Grade C110.

A standard test specimen thickness of 9,53 mm (0.375 in) shall be used except as allowed by 7.14.2.d.

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:

$30,0 \text{ MPa}\cdot\text{m}^{1/2}$ ($27.0 \text{ ksi}\cdot\text{in}^{1/2}$) for Grades C90 and T95 or
 $20,7 \text{ MPa}\cdot\text{m}^{1/2}$ ($18.6 \text{ ksi}\cdot\text{in}^{1/2}$) for Grade C110.