Polski Komitet Normalizacyjny

POPRAWKA do POLSKIEJ NORMY

ICS 75.180.01;

PN-EN ISO 15156-3:2004/AC

Maj 2006

Wprowadza
EN ISO 15156-3:2003/AC:2006, IDT
ISO 15156-3:2003/AC1:2005, IDT
ISO 15156-3:2003/AC2:2005, IDT

Zastępuje

Dotyczy
PN-EN ISO 15156-3:2004 (U)

Przemysł naftowy, petrochemiczny i gazowniczy -- Materiały stosowane przy eksploatacji ropy i gazu w środowisku zawierającym H2S -- Część 3: Stopy CRA (odporne na korozję) odporne na pękanie i inne stopy

Na wniosek Komitetu Technicznego nr 31
ds. Górnictwa Nafty i Gazu
poprawka do normy europejskiej EN ISO 15156-3:2003/AC:2006 Petroleum, petrochemical and natural gas industries -- Materials for use in H2S-containing environments in oil and gas production -- Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys (ISO 15156-3:2003)
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EUROPEAN STANDARD

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EN ISO 15156-3:2003/AC

March 2006
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English version
Version Française
Deutsche Fassung

Petroleum, petrochemical and natural gas industries - Materials for use in H2S-containing environments in oil and gas production - Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys (ISO 15156-3:2003/Cor.1:2005 and ISO 15156-3:2003/Cor.2:2005)

Industries du pétrole, pétrochimiques et du gaz naturel - Matériaux pour utilisation dans des environnements contenant de l'hydrogène sulfuré (H2S) dans la production de pétrole et de gaz - Partie 3: ARC (alliages résistants à la corrosion) et autres alliages résistants à la fissuration (ISO 15156-3:2003/Cor.1:2005 et ISO 15156-3:2003/Cor.2:2005)

Erdöl- und Erdgasindustrie - Werkstoffe für den Einsatz in H2S-haltiger Umgebung bei der Öl- und Gasgewinnung - Teil 3: Hochlegierte Stähle (CRAs) und andere Legierungen (ISO 15156-3:2003/Cor.1:2005 und ISO 15156-3:2003/Cor.2:2005)

This corrigendum becomes effective on 1 March 2006 for incorporation in the three official language versions of the EN.

Ce corrigendum prendra effet le 1 mars 2006 pour incorporation dans les trois versions linguistiques officielles de la EN.

Die Berichtigung tritt am 1.März 2006 zur Einarbeitung in die drei offiziellen Sprachfassungen der EN in Kraft.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No.:EN ISO 15156-3:2003/AC:2006 D/E/F

English version

Endorsement Notice

The text of ISO 15156-3:2003/Cor.1:2005 and ISO 15156-3:2003/Cor.2:2005 has been approved by CEN as a European Corrigendum without any modifications.

Version française

Notice d'entérinement

Le texte de l'ISO 15156-3:2003/Cor.1:2005 et de l'ISO 15156-3:2003/Cor.2:2005 a été approuvé par le CEN comme Corrigendum européen sans aucune modification.

INTERNATIONAL STANDARD ISO 15156-3:2003
TECHNICAL CORRIGENDUM 1

Published 2005-02-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production —

Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys

TECHNICAL CORRIGENDUM 1

Industries du pétrole et du gaz naturel — Matériaux pour utilisation dans des environnements contenant de l'hydrogène sulfuré (H_2S) dans la production de pétrole et de gaz —

Partie 3: ARC (alliages résistants à la corrosion) et autres alliages résistants à la fissuration

RECTIFICATIF TECHNIQUE 1

Technical Corrigendum 1 to ISO 15156-3:2003 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

Page 59, D.2:

Replace D.2 with the following:

These tables provide a link between the UNS numbers used in the tables of Annex A and the chemical compositions of the alloys to which they refer. Document users are encouraged to consult Reference [19] where they will find a written description of each alloy, its chemical composition, common trade names and cross references to other industry specifications.

ICS 75.180.01 **Ref. No. ISO 15156-3:2003/Cor.1:2005(E)**

Published in Switzerland

Pages 60 to 70, Tables D.1 to D.12:

Delete column 2.

Page 72:

Amend Reference [19] to read as follows:

[19] SAE - ASTM, *Metals and Alloys in the Unified Numbering System* 6)

Add footnote 6:

6) Available from ASTM online, as searchable CD and in printed form.

INTERNATIONAL STANDARD ISO 15156-3:2003
TECHNICAL CORRIGENDUM 2

Published 2005-09-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production —

Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys

TECHNICAL CORRIGENDUM 2

Industries du pétrole et du gaz naturel — Matériaux pour utilisation dans des environnements contenant de l'hydrogène sulfuré (H_2S) dans la production de pétrole et de gaz —

Partie 3: ARC (alliages résistants à la corrosion) et autres alliages résistants à la fissuration

RECTIFICATIF TECHNIQUE 2

Technical Corrigendum 2 to ISO 15156-3 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries.*

Page iii, Contents:

Replace the title for Annex A with the following:

Annex A (normative) **Environmental cracking-resistant CRAs and other alloys (including Table A.1 — Guide to the use of the materials selection tables of Annex A)**

ICS 75.180.01 **Ref. No. ISO 15156-3:2003/Cor.2:2005(E)**

Published in Switzerland

Page 2, Table 1 — List of equipment:

Replace Table 1 with the following:

Table 1— List of equipment

ISO 15156-3 is applicable to materials used for the following equipment	Permitted exclusions
Drilling, well construction and well-servicing equipment	Equipment only exposed to drilling fluids of controlled composition[a] Drill bits Blowout Preventer (BOP) shear blades[b] Drilling riser systems Work strings Wireline and wireline equipment[c] Surface and intermediate casing
Wells, including subsurface equipment, gas lift equipment, wellheads and christmas trees	Sucker rod pumps and sucker rods[d] Electric submersible pumps Other artificial lift equipment Slips
Flowlines, gathering lines, field facilities and field processing plants	Crude oil storage and handling facilities operating at a total absolute pressure below 0,45 MPa (65 psi)
Water-handling equipment	Water-handling facilities operating at a total absolute pressure below 0,45 MPa (65 psi) Water injection and water disposal equipment[e]
Natural gas treatment plants	—
Transportation pipelines for liquids, gases and multiphase fluids	Lines handling gas prepared for general commercial and domestic use
For all equipment above	Components loaded only in compression

[a] See ISO 15156-2:2003, A.2.3.2.3 for more information.

[b] See ISO 15156-2:2003, A.2.3.2.1 for more information.

[c] Wireline lubricators and lubricator connecting devices are not permitted exclusions.

[d] For sucker rod pumps and sucker rods, reference can be made to NACE MR0176.

[e] For water injection and water disposal, reference can be made to NACE RP0475.

Page 7, 6.2.2.2.2 Hardness testing methods for welding procedure qualification:

Replace 6.2.2.2.2 with the following:

Hardness testing for welding procedure qualification shall be carried out using Vickers HV 10 or HV 5 methods in accordance with ISO 6507-1 or the Rockwell 15N method in accordance with ISO 6508-1.

NOTE For the purposes of this provision, ASTM E 92 is equivalent to ISO 6507-1 and ASTM E 18 is equivalent to ISO 6508-1.

The use of other methods shall require explicit user approval.

Page 7, 6.2.2.2.3 Hardness surveys for welding procedure qualification:

Replace 6.2.2.2.3 with the following:

Hardness surveys for butt welds, fillet welds, repair and partial penetration welds and overlay welds shall be carried out as described in 7.3.3.3 of ISO 15156-2:2003.

Page 10, Annex A:

Replace the title for Annex A with the following:

Annex A (normative) **Environmental cracking-resistant CRAs and other alloys (including Table A.1 — Guide to the use of the materials selection tables of Annex A)**

Page 13, Table A.1 — Guide to the use of the materials selection tables of Annex A:
Replace Table A.1 with the following:

Table A.1 — Guide to the use of the materials selection tables of Annex A

Equipment or components	Material selection table numbers for various materials groups									
	Austenitic stainless steel (see A.2)	**Highly-alloyed austenitic stainless steels** (see A.3)	**Solid-solution nickel-based alloys** (see A.4)	**Ferritic stainless steels** (see A.5)	**Matensitic stainless steels** (see A.6)	**Duplex stainless steels** (see A.7)	**Precipitation-hardened stainless steels** (see A.8)	**Precipitation-hardened nickel-based alloys** (see A.9)	**Cobalt-based alloys** (see A.10)	**Titanium and tantalum** (see A.11)
Any equipment or component	A.2	A.8	A.13, A.14	A.17	A.18	A.24	A.26	A.31, A.32, A.33	A.38	A.41, A.42
Additional materials selection tables for casing, tubing and downhole equipment										
Downhole tubular components	—	A.9	—	—	A.19	A.25	—	—	—	—
Packers and other subsurface equipment	—	A.9	—	—	A.20, A.21	A.25	A.27	—	—	—
Gas lift equipment	A.7	A.10	A.16	—	—	—	—	A.37	—	—
Injection tubing and equipment	A.7	—	—	—	—	—	—	—	—	—
Downhole control line tubing and downhole screens	A.7	A.11	—	—	—	—	—	—	—	—
Additional materials selection tables for wellheads, christmas trees, valves, chokes and level controllers										
Wellhead and tree components (with various specified exclusions)	—	—	A.13	—	A.23	—	A.27	A.34	—	—
Valve and choke components (with various specified exclusions)	—	—	—	—	A.23	—	A.27	A.34	—	—
Shafts, stems and pins	A.3	—	—	—	—	—	—	—	—	—
Non-pressure-containing internal-valve, pressure-regulator, and level-controller components	—	—	—	—	—	—	A.28	A.35	—	—
Additional materials selection tables for process plant										
Compressor components	A.6	—	—	—	A.22	—	A.30	—	—	—
Additional materials selection tables for other equipment										
Instrumentation and control devices	A.6	—	—	—	—	—	—	—	—	—
Instrument tubing and associated compression fittings, surface control line tubing and surface screens	A.4	A.11	—	—	—	—	—	—	—	—
Springs	—	—	—	—	—	—	—	A.36	A.39	—
Diaphragms, pressure measuring devices and pressure seals	—	—	—	—	—	—	—	—	A.40	—
Seal rings and gaskets	A.5	—	—	—	—	—	—	—	—	—
Snap rings	—	—	—	—	—	—	A.29	—	—	—
Bearing pins	—	—	A.15	—	—	—	—	—	—	—
Miscellaneous equipment as named in the tables (including hardware (e.g. set screws, etc.), downhole and surface temporary-service tool applications)	A.7	—	A.16	—	—	—	A.28	A.35	—	—

Page 14, Table A.2 — Environmental and materials limits for austenitic stainless steels used for any equipment or components:

Replace Table A.2 with the following:

Table A.2 — Environmental and materials limits for austenitic stainless steels used for any equipment or components

Materials type/ Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Any equipment or components						
Austenitic stainless steel from materials type described in A.2	60 (140)	100 (15)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
	See remarks	See remarks	50	See remarks	No	These materials have been used without restrictions on temperature, p_{H_2S}, or *in situ* pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.
S20910	66 (150)	100 (15)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
Any equipment or components in oil and gas processing and injection facilities in operations after separation						
Austenitic stainless steel from materials type described in A.2	See remarks	See remarks	50	See remarks	No	These materials have been used without restrictions on temperature, p_{H_2S}, or *in situ* pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.

These materials shall also

— be in the solution-annealed and quenched, or annealed and thermally-stabilized heat-treatment condition;

— be free of cold work intended to enhance their mechanical properties; and

— have a maximum hardness of 22 HRC.

However, S20910 is acceptable in the annealed or hot-rolled (hot/cold-worked) condition at a maximum hardness of 35 HRC.

A limit on the martensite content of these austenitic stainless steels should be considered.

Page 16, Table A.6 — Environmental and materials limits for austenitic stainless steels used in compressors and instrumentation and control devices:

Replace Table A.6 with the following:

Table A.6 — Environmental and materials limits for austenitic stainless steels used in compressors and instrumentation and control devices

Materials type	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Compressors						
Austenitic stainless steel from materials type described in A.2	See remarks	See remarks	See remarks	See remarks	NDS [a]	Any combinations of temperature, p_{H_2S}, chloride concentration and *in situ* pH occurring in production environments are acceptable.
Instrumentation and control devices[b]						
Austenitic stainless steel from materials type described in A.2	See remarks	See remarks	See remarks	See remarks	NDS [a]	These materials have been used for these components without restriction on temperature, p_{H_2S}, Cl^-, or *in situ* pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.
For these applications, these materials shall also — be in the solution-annealed and quenched, or annealed and stabilized heat-treatment condition; — be free of cold work intended to enhance their mechanical properties; and — have a maximum hardness of 22 HRC. A limit on the martensite content of these austenitic stainless steels should be considered.						
[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment. [b] Instrumentation and control devices include but are not limited to diaphragms, pressure measuring devices and pressure seals						

Page 18, Table A.8 — Environmental and materials limits for highly-alloyed austenitic stainless steels used for any equipment or components:

Replace Table A.8 with the following:

Table A.8 — Environmental and materials limits for highly-alloyed austenitic stainless steels used for any equipment or components

Materials types/ Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Any equipment or components						
Materials type 3a and 3b	60 (140)	100 (15)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
Materials type 3a and 3b	See remarks	See remarks	50	See remarks	No	These materials have been used without restrictions on temperature, p_{H_2S}, or in situ pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.
Materials type 3b	121 (250)	700 (100)	5 000	See remarks	No	The *in situ* pH values occurring in production environments are acceptable.
	149 (300)	310 (45)	5 000	See remarks	No	
	171 (340)	100 (15)	5 000	See remarks	No	
N08926	121 (250)	700 (100)	60 700	$\geqslant$ 3,5, see also remarks	No	pH estimated from laboratory test conditions. UNS N08926 is material type 3b tested to higher limits of chloride concentration than apply for the materials type as a whole.
J95370	150 (302)	700	90 000	See remarks	No	The *in situ* pH values occurring in production environments are acceptable.
J93254	See remarks	See remarks	See remarks	See remarks	No	Any combinations of temperature, p_{H_2S}, chloride concentration and *in situ* pH occurring in production environments are acceptable.
Any equipment or components in oil and gas processing and injection facilities in operations after separation						
Materials type 3a and 3b	See remarks	See remarks	50	See remarks	No	These materials have been used without restrictions on temperature, p_{H_2S}, or *in situ* pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.

These materials shall also comply with the following.

— Materials type 3a shall be highly-alloyed austenitic stainless steel with (Ni + 2Mo) > 30 (where Mo has a minimum value of 2 %).

— Materials type 3b shall be highly-alloyed austenitic stainless steel with $F_{PREN} > 40$.

— Materials types 3a and 3b (including N08926) shall be in the solution-annealed condition.

— Cast UNS J93254 (CK3McuN, cast 254SMO) in accordance with ASTM A 351, A 743 or A 744 shall be in the cast, solution heat-treated condition and shall have a maximum hardness of 100 HRB.

— Cast J95370 shall be in the solution heat-treated and water-quenched condition and shall have a maximum hardness of 94 HRB.

Page 22, Table A.13 — Environmental and materials limits for solid-solution nickel-based alloys used in any equipment or component:

Replace Table A.13 with the following:

Table A.13 — Environmental and materials limits for solid-solution nickel-based alloys used in any equipment or component

Materials types/ Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Annealed alloys of types 4a and 4b	See remarks	See remarks	See remarks	See remarks	Yes	Any combinations of temperature, p_{H_2S}, chloride concentration and *in situ* pH occurring in production environments are acceptable.
N04400, N04405	See remarks	See remarks	See remarks	See remarks	NDS[a]	
Wrought or cast solid-solution nickel-based products made from alloys of types 4a and 4b shall be in the solution-annealed or annealed condition. UNS N04400 and UNS N04405 shall have a maximum hardness of 35 HRC. Wellhead and christmas tree components shall also be in accordance with ISO 10423.						
[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.						

Page 23, Table A.14 — Environmental and materials limits for annealed and cold-worked, solid-solution nickel-based alloys used as any equipment or component:

Replace Table A.14 with the following:

Table A.14 — Environmental and materials limits for annealed and cold-worked, solid-solution nickel-based alloys used as any equipment or component

Materials types	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Cold-worked alloys of types 4c, 4d and 4e	232 (450)	200 (30)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
	218 (425)	700 (100)	See remarks	See remarks	No	
	204 (400)	1000 (150)	See remarks	See remarks	No	
	177 (350)	1400 (200)	See remarks	See remarks	No	
	132 (270)	See remarks	See remarks	See remarks	Yes	Any combinations of hydrogen sulfide, chloride concentration and *in situ* pH in production environments are acceptable.
Cold-worked alloys of types 4d and 4e	218 (425)	2000 (300)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
	149 (300)	See remarks	See remarks	See remarks	Yes	Any combinations of hydrogen sulfide, chloride concentration and *in situ* pH in production environments are acceptable.
Cold-worked alloys of type 4e	232 (450)	7000 (1 000)	See remarks	See remarks	Yes	Any combinations of chloride concentration, in- situ pH occurring in production environments are acceptable.
	204 (400)	See remarks	See remarks	See remarks	Yes	Any combinations of hydrogen sulfide, chloride concentration and *in situ* pH in production environments are acceptable.

Wrought or cast solid-solution nickel-based products in these applications shall be in the annealed and cold-worked condition and shall meet all of the following.

a) The maximum hardness value for alloys in these applications shall be 40 HRC; and

b) The maximum yield strength of the alloys achieved by cold work shall be

- Type 4c: 1 034 MPa (150 ksi);
- Type 4d: 1 034 MPa (150 ksi);
- Type 4e: 1 240 MPa (180 ksi);

c) UNS 10276 (Type 4e) when used at a minimum temperature of 121°C (250°F) shall have a maximum hardness of 45 HRC

NOTE The limits of application of the materials types 4c, 4d and 4e in this table overlap.

Page 26, Table A.18 — Environmental and materials limits for martensitic stainless steels used for any equipment or components:

Replace Table A.18 with the following:

Table A.18 — Environmental and materials limits for martensitic stainless steels used for any equipment or components

Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
S41000, S41500, S42000, J91150, J91151, J91540, S42400	See remarks	10 (1,5)	See remarks	⩾ 3,5	NDS[a]	Any combinations of temperature and chloride concentration occurring in production environments are acceptable
S41425	See remarks	10 (1,5)	See remarks	⩾ 3,5	No	

These materials shall also comply with the following.

a) Cast or wrought alloys UNS S41000, J91150 (CA15), and J91151 (CA15M) shall have a maximum hardness of 22 HRC and shall be
   1) austenitized and quenched or air-cooled,
   2) tempered at 621°C (1 150°F) minimum, then cooled to ambient temperature, and
   3) tempered at 621°C (1 150°F) minimum, but lower than the first tempering temperature, then cooled to ambient temperature.

b) Low-carbon, martensitic stainless steels, either cast J91540 (CA6NM) or wrought S42400 or S41500 (F6NM), shall have a maximum hardness of 23 HRC and shall be
   1) austenitized at 1 010 °C (1 850 °F) minimum, then air- or oil-quenched to ambient temperature,
   2) tempered at 649 °C to 691 °C (1 200 °F to 1 275 °F), then air-cooled to ambient temperature, and
   3) tempered at 593 °C to 621 °C (1 100 °F to 1 150 °F), then air-cooled to ambient temperature.

c) Cast or wrought alloy UNS S42000 shall have a maximum hardness of 22 HRC and shall be in the quenched and tempered heat-treatment condition

d) Wrought low-carbon UNS S41425 martensitic stainless steel in the austenitized, quenched, and tempered condition shall have a maximum hardness of 28 HRC.

[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.

Page 27, Table A.19 — Environmental and materials limits for martensitic stainless steels used as downhole tubular components and for packers and other subsurface equipment:

Replace Table A.19 with the following:

Table A.19 — Environmental and materials limits for martensitic stainless steels used as downhole tubular components and for packers and other subsurface equipment

Specification/ Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
ISO 11960 L-80 Type 13 Cr, S41426, S42500	See remarks	10 (1,5)	See remarks	⩾ 3,5	NDS[a]	Any combinations of temperature and chloride concentration occurring in production environments are acceptable
S41429	See remarks	10 (1,5)	See remarks	⩾ 4,5	NDS[a]	

For these applications, these materials shall also comply with the following.

a) UNS S41426 tubular components shall be quenched and tempered to maximum 27 HRC and maximum yield strength 724 MPa (105 ksi).

b UNS S42500 (15 Cr) tubing and casing is acceptable as Grade 80 [SMYS 556 MPa (80 ksi)] only and shall be in the quenched and double-tempered condition, with a maximum hardness of 22 HRC. The quench and double-temper process shall be as follows:

1) austenitize at minimum 900 °C (1 652 °F), then air- or oil-quench;

2) temper at minimum 730 °C (1 346 °F), then cool to ambient temperature; and

3) temper at minimum 620 °C (1 148 °F), then cool to ambient temperature.

c) UNS S41429 tubular components shall be quenched and tempered or normalised and tempered to a maximum hardness of 27 HRC and a maximum yield strength of 827 MPa (120 ksi).

[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.

Page 29, Table A.22 — Environmental and materials limits for martensitic stainless steels used as compressor components:

Replace Table A.22 with the following:

Table A.22 — Environmental and materials limits for martensitic stainless steels used as compressor components

Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant ?	Remarks
S41000, S41500, S42400, J91150, J91151, J91540	See remarks	See remarks	See remarks	See remarks	NDS[a]	Any combinations of temperature, p_{H_2S}, chloride concentration and *in situ* pH occurring in production environments are acceptable.
For these applications, these materials shall also comply with the following. a) Cast or wrought alloys UNS S41000, J91150 (CA15), and J91151 (CA15M) shall have 22 HRC maximum hardness if used for compressor components and shall be 1) austenitized and quenched or air-cooled, 2) tempered at 621 °C (1 150 °F) minimum, then cooled to ambient temperature, and 3) tempered at 621 °C (1 150 °F) minimum, but lower than the first tempering temperature, then cooled to ambient temperature. b) Low-carbon, martensitic stainless steels, either cast J91540 (CA6NM) or wrought S42400 or S41500 (F6NM), shall have a maximum hardness of 23 HRC and shall be 4) austenitized at 1 010 °C (1 850 °F) minimum, then air- or oil-quenched to ambient temperature, 5) tempered at 649 °C to 690 °C (1 200 °F to 1 275 °F), then air-cooled to ambient temperature, and 6) tempered at 593 °C to 621 °C (1 100 °F to 1 150 °F), then air-cooled to ambient temperature. c) If used for impellers, cast or wrought alloys UNS S41000, J91150 (CA15) and J91151 (CA15M), cast J91540 (CA6NM) and wrought S42400 or S41500 (F6NM) shall exhibit a threshold stress $\geqslant$ 95 % of actual yield strength in the anticipated service environment.						
[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.						

Page 30, Table A.23 — Environmental and materials limits for martensitic stainless steels used as wellhead and tree components and valve and choke components (excluding casing and tubing hangers and valve stems):

Replace Table A.23 with the following:

Table A.23 — Environmental and materials limits for martensitic stainless steels used as wellhead and tree components and valve and choke components (excluding casing and tubing hangers and valve stems)

Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
S41000, S41500, S42000, J91150, J91151, J91540, S42400	See remarks	See remarks	See remarks	$\geqslant$ 3,5	NDS[a]	Any combinations of temperature, p_{H_2S} and chloride concentration occurring in production environments are acceptable.

For these applications, these materials shall also comply with the following:

a) Cast or wrought alloys UNS S41000, J91150 (CA15), and J91151 (CA15M), shall have 22 HRC maximum hardness and shall be
   1) austenitized and quenched or air-cooled,
   2) tempered at 620 °C (1 150 °F) minimum, then cooled to ambient temperature, and
   3) tempered at 620 °C (1 150 °F) minimum, but lower than the first tempering temperature, then cooled to ambient temperature.

b) Low-carbon, martensitic stainless steels either cast J91540 (CA6NM) or wrought S42400 or S41500 (F6NM) shall have 23 HRC maximum hardness and shall be:
   1) austenitized at 1 010 °C (1 850 °F) minimum, then air- or oil-quenched to ambient temperature;
   2) tempered at 648 °C to 690 °C (1 200 °F to 1 275 °F), then air-cooled to ambient temperature; and
   3) tempered at 593 °C to 620 °C (1 100 °F to 1 150 °F), then air-cooled to ambient temperature.

c) Cast or wrought alloy UNS S42000 shall have a maximum hardness of 22 HRC and shall be in the quenched and tempered heat-treatment condition.

[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.

Page 30, A.6.3 Welding of martensitic stainless steels of this materials group:

Replace A.6.3 with the following:

The requirements for the cracking-resistance properties of welds shall apply (see 6.2.2).

The hardness of the HAZ after welding shall not exceed the maximum hardness allowed for the base metal, and the hardness of the weld metal shall not exceed the maximum hardness limit of the respective alloy used for the welding consumable.

Martensitic stainless steels welded with nominally matching consumables shall meet the following requirements.

Weldments in martensitic stainless steels shall undergo a PWHT at 621 °C (1 150 °F) minimum and shall comply with (6.2.2.2)

Weldments in the low-carbon martensitic stainless steels [cast J91540 (CA6NM) or wrought S42400 or S41500 (F6NM)] shall undergo a single- or double-cycle PWHT after first being cooled to 25 °C (77 °F), as follows.

— Single-cycle PWHT shall be at 580 °C to 621 °C (1 075 °F to 1 150 °F).

— Double-cycle PWHT shall be at 671 °C to 691 °C (1 240 °F to 1 275 °F), then cooled to 25 °C (77 °F) or less, then heated to 580 °C to 621 °C (1 075 °F to 1 150 °F).

Page 31, Table A.24 — Environmental and materials limits for duplex stainless steels used for any equipment or component:

Replace Table A.24 with the following:

Table A.24 — Environmental and materials limits for duplex stainless steels used for any equipment or component

Materials type/individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
Any equipment or components						
$30 \leqslant F_{PREN} \leqslant 40$, Mo $\geqslant$ 1,5 %	232 (450)	10 (1,5)	See remarks	See remarks	NDS[a]	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable
S31803 (HIP)	232 (450)	10 (1,5)	See remarks	See remarks	No	
$40 < F_{PREN} \leqslant 45$	232 (450)	20 (3)	See remarks	See remarks	NDS[a]	
Any equipment or components in oil and gas processing and injection facilities in operations after separation						
$30 \leqslant F_{PREN} \leqslant 40$, Mo $\geqslant$ 1,5 %	See remarks	See remarks	50	See remarks	NDS[a]	These materials have been used without restrictions on temperature, p_{H_2S}, or *in situ* pH in production environments. No limits on individual parameters are set but some combinations of the values of these parameters might not be acceptable.
$40 < F_{PREN} \leqslant 45$	See remarks	See remarks		See remarks	NDS[a]	

Wrought and cast duplex stainless steels shall

— be solution-annealed and liquid-quenched,

— have a ferrite content (volume fraction) of between 35 % and 65 %, and

— not have undergone ageing heat-treatments.

Hot isostatic pressure-produced (HIP) [18] duplex stainless steel UNS S31803 ($30 \leqslant F_{PREN} \leqslant 40$, Mo $\geqslant$ 1,5 %) shall have a maximum hardness of 25 HRC and shall

— be in the solution-annealed and water-quenched condition,

— have a ferrite content (volume fraction) of between 35 % and 65 %, and

— not have undergone ageing heat-treatments.

NOTE Higher values of F_{PREN} provide higher corrosion resistance, however they also lead to increased risk of sigma- and alpha-prime phase formation, in the materials' ferrite phase, during manufacture, depending on product thickness and achievable quench rate. The ranges of F_{PREN} quoted are typical of those found to minimize the problem of sigma- and alpha- prime phase formation.

[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.

Page 37 Table A.31 — Environmental and materials limits for precipitation-hardened nickel-based alloys (I) used for any equipment or component:

Replace Table A.31 with the following:

Table A.31 — Environmental and materials limits for precipitation-hardened nickel-based alloys (I) used for any equipment or component

Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
N07031, N07048, N07773 and N09777 (wrought) N07718 (cast), N09925 (cast)	232 (450)	200 (30)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
	204 (400)	1 400 (200)	See remarks	See remarks	No	
	149 (300)	2 700 (400)	See remarks	See remarks	No	
N07031, N07048, N07773 and N09777 (wrought)	135 (275)	See remarks	See remarks	See remarks	Yes	Any combinations of hydrogen sulfide, chloride concentration and *in situ* pH in production environments are acceptable.
N09925 (cast)	135 (275)	See remarks	See remarks	See remarks	NDS[a]	
N07718 (cast)	135 (275)	See remarks	See remarks	See remarks	NDS[a]	
N07924 (wrought)	175 (347)	3 500 (500)	121 300	$\geqslant$ 3,5, see also remarks	No	pH estimated from laboratory test conditions.

These materials shall also comply with the following.

a) Wrought UNS N07031 shall be in either of the following conditions:

   1) solution-annealed to a maximum hardness of 35 HRC;

   2) solution-annealed and aged at 760 °C to 871 °C (1 400 °F to 1 600 °F) for a maximum of 4 h to a maximum hardness of 40 HRC.

b) Wrought UNS N07048, wrought UNS N07773 and wrought UNS N09777 shall have a maximum hardness of 40 HRC and shall be in the solution-annealed and aged condition.

c) Wrought UNS N07924 shall be in the solution-annealed and aged condition at a maximum hardness of 35 HRC

d) Cast UNS N09925 shall be in the solution-annealed and aged condition at a maximum hardness of 35 HRC.

e) Cast UNS N07718 shall be in the solution-annealed and aged condition at a maximum hardness of 40 HRC.

[a] No data submitted to ascertain whether these materials are acceptable for service in the presence of elemental sulfur in the environment.

Page 39, Table A.33 — Environmental and materials limits for precipitation-hardened nickel-based alloys (III) used for any equipment or component:

Replace Table A.33 with the following:

Table A.33 — Environmental and materials limits for precipitation-hardened nickel-based alloys (III) used for any equipment or component

Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, p_{H_2S} max. kPa (psi)	Chloride conc. max. mg/l	pH	Sulfur-resistant?	Remarks
N07626 (powder metal)	232 (450)	1 000 (150)	See remarks	See remarks	No	Any combinations of chloride concentration and *in situ* pH occurring in production environments are acceptable.
N07716, N07725 (wrought)	220 (425)	2 000 (300)	See remarks	See remarks	Yes	
N07626 (powder metal)	204 (400)	4 100 (600)	See remarks	See remarks	No	
N07716, N07725 (wrought)	204 (400)	4 100 (600)	See remarks	See remarks	Yes	
N07626 (powder metal) N07716, N07725 (wrought)		See remarks	See remarks	See remarks	Yes	Any combinations of hydrogen sulfide, chloride concentration and *in situ* pH in production environments are acceptable.

These materials shall also comply with the following.

a) UNS N07626, totally dense hot-compacted by a powder metallurgy process, shall have a maximum hardness of 40 HRC and a maximum tensile strength of 1 380 MPa (200 ksi) and shall be either

   — solution-annealed [927 °C (1 700 °F) minimum] and aged [538 °C to 816 °C (1 000 °F to 1 500 °F)], or

   — direct-aged [538 °C to 816 °C (1 000 °F to 1 500 °F)].

b) Wrought UNS N07716 and wrought UNS N07725 shall have a maximum hardness of HRC 43 and shall be in the solution-annealed and aged condition.

c) Wrought UNS N07716 and wrought UNS N07725 in the solution-annealed and aged condition may also be used at a maximum hardness of 44 HRC in the absence of elemental sulfur and subject to the other environmental limits shown for the maximum temperature of 204 °C (400 °F).

Page 46, A.13.2.1 Wear-resistant alloys used for sintered, cast or wrought components:

Replace A.13.2.1 with the following:

Environmental cracking resistance of alloys specifically designed to provide wear-resistant components is not specified in ISO 15156 (all parts). No production limits for temperature, pH_2S, Cl, and *in situ* pH have been established.

Some materials used for wear-resistant applications can be brittle. Environmental cracking can occur if these materials are subject to tension. Components made from these materials are normally loaded only in compression.

Page 46, A.13.2.2 Hard-facing materials:

Replace A.13.2.2 with the following:

Hard-facing may be used.

Environmental cracking resistance of alloys or surface layers specifically designed to provide hard-facing is not specified in ISO 15156 (all parts). No production limits for temperature, pH_2S, Cl, and *in situ* pH have been established.

Some materials used for hard-facing applications can be brittle. Environmental cracking of the hard facing can occur if these materials are subject to tension.

Unless the user can demonstrate and document the likely long-term in-service integrity of the hard-facing materials, the base material after application of the hard-facing material shall comply with ISO 15156-2 or this part of ISO 15156, as applicable.

Page 72 Bibliography

Add the following:

[20] NACE RP0475, *Selection of Metallic Materials to Be Used in All Phases of Water Handling for Injection into Oil-Bearing Formations*

[21] ASTM E 18, *Test Method for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*

[22] ASTM E 92, *Test Method for Vickers Hardness of Metallic Materials*