روز دوازدهم جلسه دوم -

الزامات سرویس ترش

1. NACE MR0175 / ISO 15156

بالادستی - upstream و تاسیسات شیرین سازی گاز - حفاری - سرچاهی

- Cl - CO2 - محیط ترش $P_{H_2S} > 0.05$ psi

2- NACE MR0103 / ISO - 17945

پایین دستی - CO2↓ - Cl↓ - جوشهای سختگیرانه تر - تعریف دقیق تر از سرویس ترش

مقدمه:

اولین ویرایش استاندارد NACE ← 1975

MR 0175 → 01 → ویرایش اول

↓ 75 → 1975

matl Requirement

MR0103 → 01 → اول

03 → 2003

< 2003 → بالادستی - پایین دستی   MR0175
oilfield   Refinery

≥ 2003 <
oilfield → MR0175 - ISO 15156
Refinery → MR0103 - ISO 17945

EAC - NACE MR0175   الزامات سرویس

مکانیزمهای تخریبی :

1- SSC : Sulfide Stress Cracking - ترک تنشی سولفیدی

- تنش کششی : اعمالی - پسماند (کارسرد - جوشکاری)   EAC-

- wet $H_2S + H_2O$

- CS - LA - CRA ←

- EFC 16-17   + { MR0175 / MR0103 -

- NACE 1F192

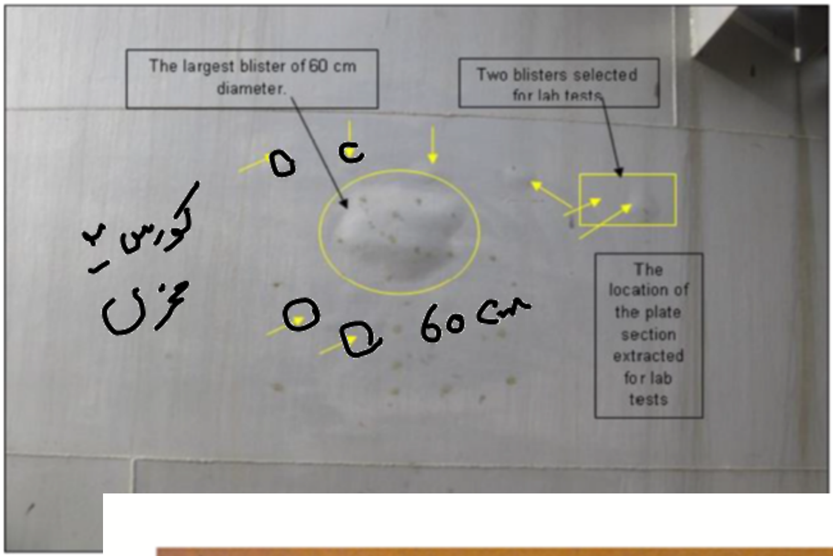
+ API publ 939B

۲: HIC : ترک‌های القائی هیدروژنی Hydrogen Induced cracking → NACE TM 0284

$H^{\cdot} + H^{\cdot} \rightarrow H_2$

- Wet H_2S

- Flat Roll _ ناخالصی: وجود Lamination



- معمولاً همراه با تاول هیدروژنی

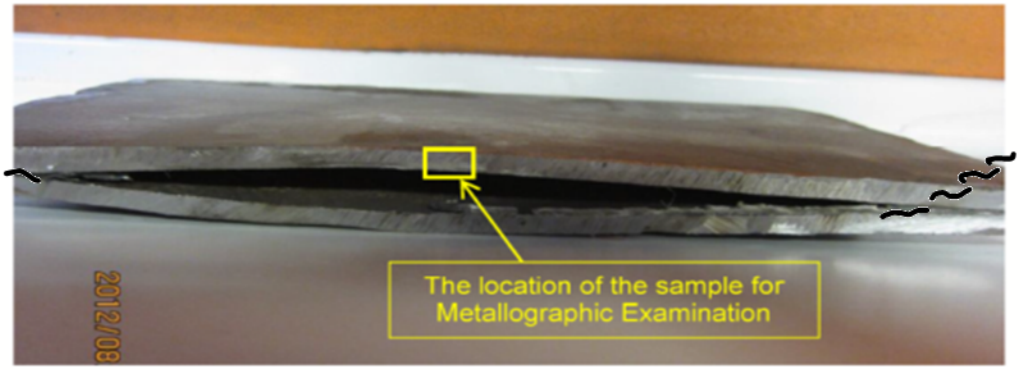
- نیازی به تنش ندارد. (اعمالی - پسماند)

- سختی فولاد بی‌تاثیر است. ///

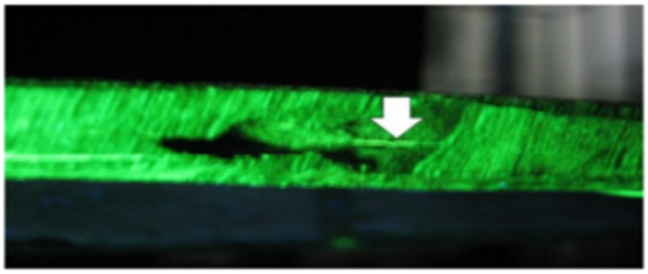
API 571

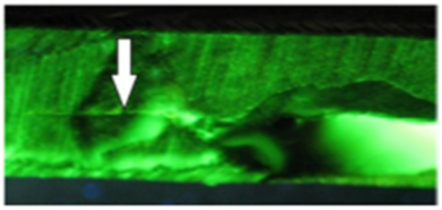
- PWHT بی‌تاثیر است.

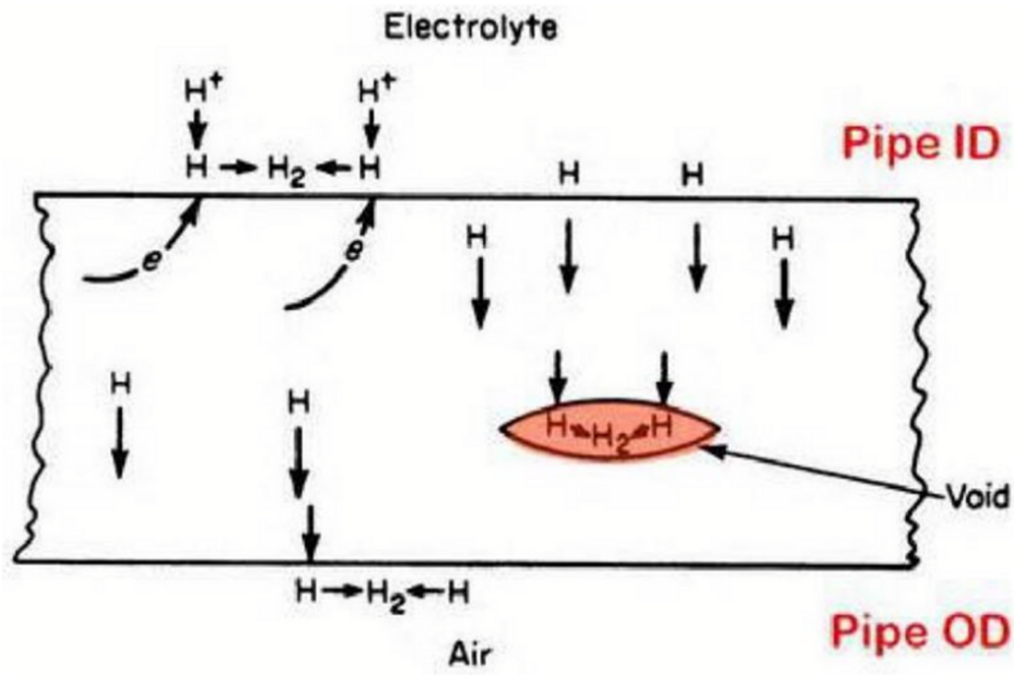
تاول HIC

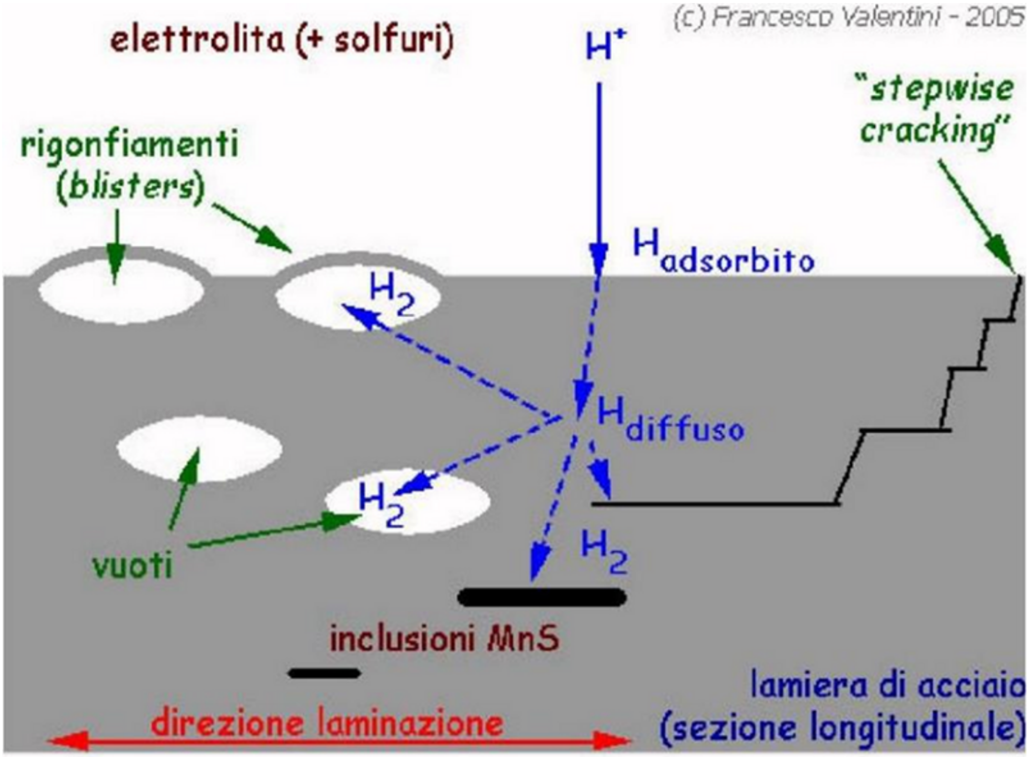


HIC






Electrolyte
H^+
H^+
$H \rightarrow H_2 \leftarrow H$
Pipe ID
H
H
e
e
H
H
H
H
$H \rightarrow H_2 \leftarrow H$
Void
$H \rightarrow H_2 \leftarrow H$
Pipe OD
Air


(c) Francesco Valentini - 2005
elettrolita (+ solfuri)
H^+
"stepwise cracking"
rigonfiamenti (blisters)
$H_{adsorbito}$
H_2
$H_{diffuso}$
H_2
H_2
vuoti
inclusioni MnS
lamiera di acciaio (sezione longitudinale)
direzione laminazione

above 200 °F (95 °C)], they can subsequently crack when cooled back down to ambient.

g) Microstructure. API 571 ناخالصی تورق

1. Blistering and HIC are strongly affected by the presence of inclusions and laminations, which provide sites for diffusing hydrogen to accumulate.

   — Flat, elongated manganese sulfide (MnS) inclusions produced by ordinary steel plate rolling practices are particularly detrimental. However, steel chemical composition and manufacturing methods can be tailored to produce HIC-resistant steels. (See Reference 6.)

   — Improving steel cleanliness and processing to minimize blistering and HIC damage may still leave the steel susceptible to SOHIC.

2. HIC is often found in so-called “dirty” steels with high levels of inclusions or other internal discontinuities from the steel-making process.

c) HIC-resistant steels can be used to minimize the susceptibility to blistering and HIC damage. Detailed materials and fabrication guidance can be found in Reference 6.

d) PWHT can help minimize susceptibility to SOHIC.

e) PWHT will not prevent blistering or HIC, because they are not initiated by stress and usually occur away from and not associated with welds.

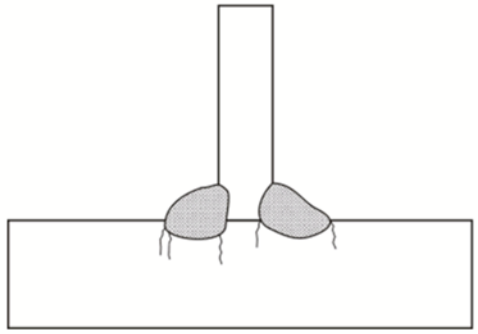
f) SSC in welds can generally be prevented by limiting the hardness of carbon steel welds and HAZs to 200 HB maximum. Similar, but slightly higher, maximum hardness limits are normally applied to Cr-Mo steels for which high hardness is prevented by using preheat, PWHT, and welding procedure control.

stress oriented HIC : SOHIC ۳

SCC + HIC تلفیق

Hydrogen Induced Stress Cracking HISC

منبع هیدروژنی: حفاظت کاتدی - فولادهای دوفاز - داپلکس - سوپرداپلکس



Schematic of SOHIC damage at a fillet weld that is usually a combination of SSC and SOHIC.

- تنش
- سختی فلز
- PWHT
- MR0175 / MR0103 → SSC

MR0103 / MR0175 مقایسه

تفاوت های MR0103/MR0175

۱- حوزه کاربری

MR0175 → upstream

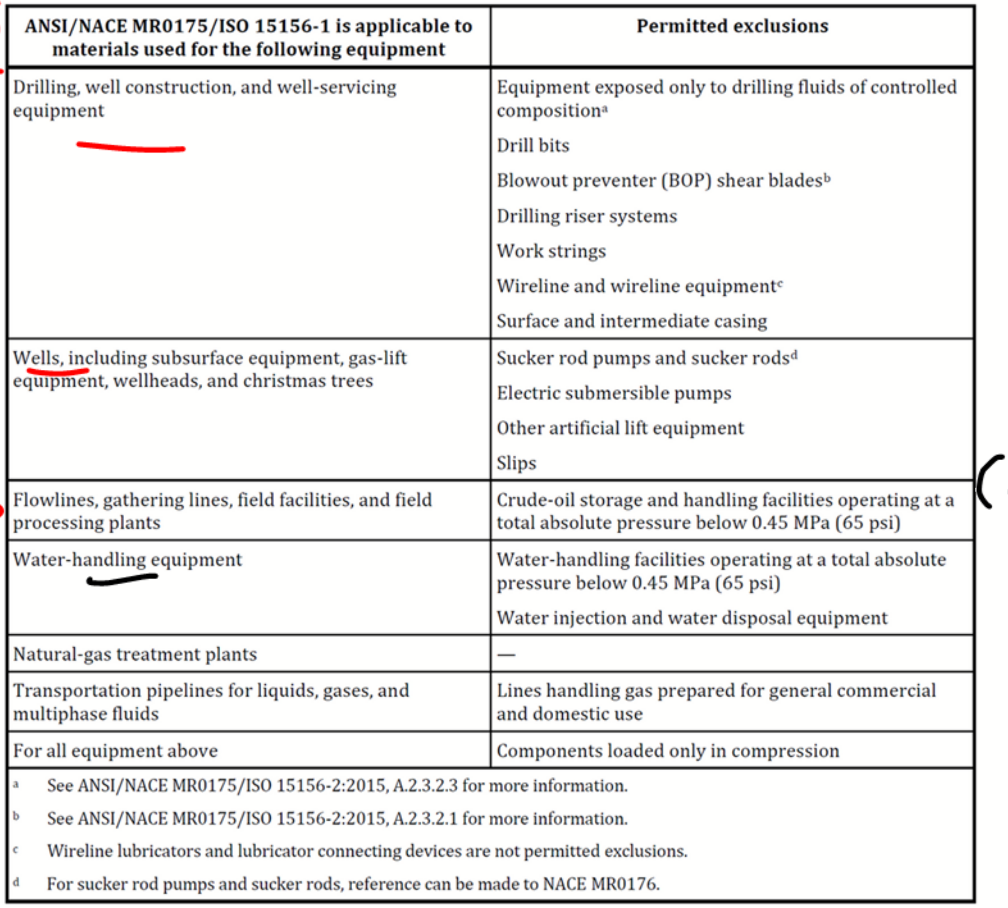
- تاسیسات سرچاهی
- حفاری
- بالادستی
- پالایشگاه های گاز - شیرین سازی
- خط لوله انتقال (مشابه شیرین سازی)

SPGC ← POGC

- تاسیسات لخته گیر

slag catch

Table 1 — List of equipment



ANSI/NACE MR0175/ISO 15156-1 is applicable to materials used for the following equipment	Permitted exclusions
Drilling, well construction, and well-servicing equipment	Equipment exposed only 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
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 ANSI/NACE MR0175/ISO 15156-2:2015, A.2.3.2.3 for more information.

[b] See ANSI/NACE MR0175/ISO 15156-2:2015, 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.

۲. تعریفِ سرویسِ ترش :

MR0175 : $P_{H_2S} > .05\ psi$

↳

$$P_{H_2S} = m_{H_2S} \times P_{tot}$$

⇐ محاسبات استوکیومتری : براساس جرم مولکولی H2S و ترکیب ← تبدیل به ppm وزنی

MR0103 : $f(\underline{\underline{pH}} - ppmw^{H_2S} - HCN + P_{H_2S})$

تعریف سرویس ترش دقیق‌تر

1- $ppmw\ H_2S > \underline{\underline{50}}\ ppmw$ + آب

2- $\underline{pH} < 4$ - آب + $H_2S > 1\ ppmw$

3- $pH > 7.6$ - $HCN > 20\ ppmw + H_2S$ + آب

4- $P_{H_2S} > .05\ psi$

۳- سختگیری : MR0103 ← جوشکاری سختگیرانه تر

متالورژی و نکات NACE MR0175

6 Evaluation and definition of service conditions to enable material selection

6.1 Before selecting or qualifying materials using ANSI/NACE MR0175/ISO 15156-2 or ANSI/NACE MR0175/ISO 15156-3, the user of the equipment shall define, evaluate, and document the service conditions to which materials can be exposed for each application. The defined conditions shall include both intended exposures and unintended exposures that can result from the failure of primary containment or protection methods. Particular attention shall be paid to the quantification of those factors known to affect the susceptibility of materials to cracking caused by H_2S.

Factors, other than material properties, known to affect the susceptibility of metallic materials to cracking in H_2S service include H_2S partial pressure, *in situ* pH, the concentration of dissolved chloride or other halide, the presence of elemental sulfur or other oxidant, temperature, galvanic effects, mechanical stress, and time of exposure to contact with a liquid water phase.

6.2 The documented service conditions shall be used for one or more of the following purposes:

a) to provide the basis for selection of SSC/SCC-resistant materials from existing lists and tables (see Clause 7);

b) to provide the basis for qualification and selection based upon documented field experience (see 8.2);

c) to define the laboratory test requirements to qualify a material for H_2S service with respect to one or more of SSC, SCC, HIC, SOHIC, SZC, and/or galvanically induced HSC (see 8.3);

d) to provide the basis for the reassessment of the suitability of existing alloys of construction, using Clause 7, 8.2, and/or 8.3, in the event of changes to the actual or intended service conditions.

فصل 7 ← پیش تأیید شده - انکس A

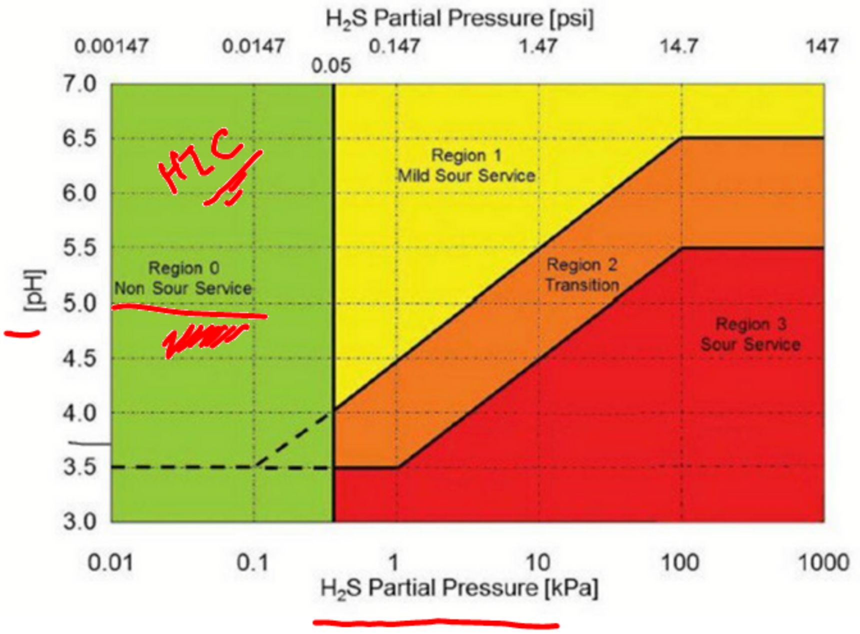
بند 8.2 ← تجربیات ثبت شده

بند 8.3 ← تست آزمایشگاهی

متالورژی MR0175 انتخاب متریال و الزامات

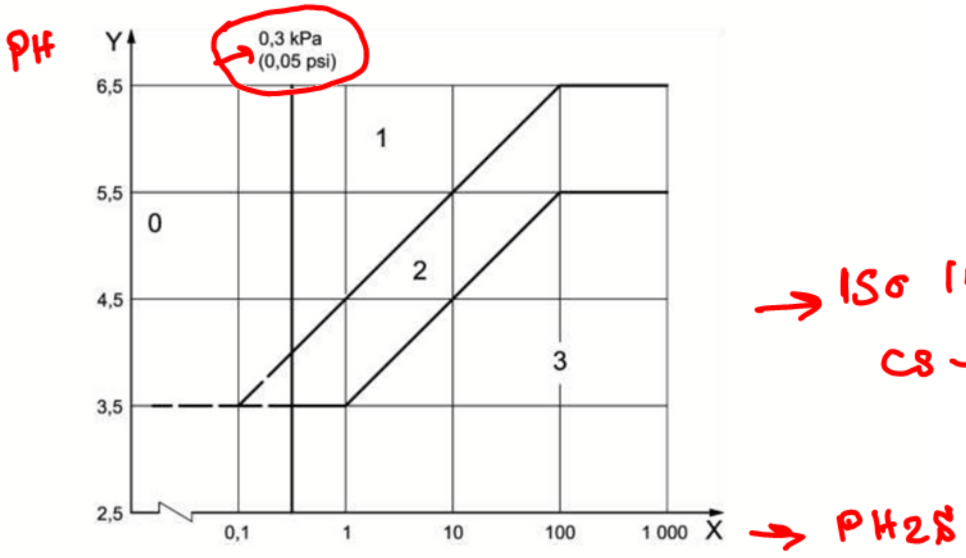
ISO 15156-2 - MR0175 تعریف رژیم سرویس در

CS LA



7.2.1.2 SSC regions of environmental severity

The severity of the sour environment, determined in accordance with ANSI/NACE MR0175/ISO 15156-1, with respect to the SSC of a carbon or low-alloy steel shall be assessed using Figure 1. In defining the severity of the H_2S-containing environment, the possibility of exposure to unbuffered, condensed aqueous phases of low pH during upset operating conditions or downtime, or to acids used for well stimulation and/or the backflow of stimulation acid after reaction should be considered.



Key

X H_2S partial pressure, expressed in kilopascals

Y *in situ* pH

0 region 0

1 SSC region 1

2 SSC region 2

3 SSC region 3

NOTE 1 The discontinuities in the figure below 0.3 kPa (0.05 psi) and above 1 MPa (150 psi) partial pressure H_2S reflect uncertainty with respect to the measurement of H_2S partial pressure (low H_2S) and the steel's performance outside these limits (for both low and high H_2S).

7.2.1.3 Region 0 — For p_{H_2S} < 0.3 kPa (0.05 psi)

Normally, no precautions are required for the selection of steels for use under these conditions. Nevertheless, a number of factors, as follows, that can affect a steel's performance in this region should be considered.

- Steels that are highly susceptible to SSC and HSC can crack.
- Steel's physical and metallurgical properties affect its inherent resistance to SSC and HSC; see Clause 6.
- Very high-strength steels can suffer HSC in aqueous environments without H_2S. Above about 965 MPa (140 ksi) yield strength, attention should be given to steel composition and processing to ensure that these steels do not exhibit SSC or HSC in region 0 environments.
- Stress concentrations increase the risk of cracking.

7.2.1.4 SSC regions 1, 2 and 3

Referring to the regions of severity of the exposure as defined in Figure 1, steels for region 1 may be selected using A.2, A.3 or A.4; steels for region 2 may be selected using A.2 or A.3; and steels for region 3 may be selected using A.2.

In the absence of suitable choices from Annex A, carbon and low-alloy steels may be tested and qualified for use under specific sour-service conditions or for use throughout a given SSC region. Testing and qualification shall be in accordance with ANSI/NACE MR0175/ISO 15156-1 and Annex B.

Documented field experience may also be used as the basis for material selection for a specific sour-service application; see ANSI/NACE MR0175/ISO 15156-1.

الزامات ناحیه ۰: 🔑

۱- PH2S <0.05 psi : شرط لازم ولی کافی نیست عوامل تاثیرگذار:

۱- تمرکز تنش ۲- محیط ۳- متالورژی فلز ۴- فلزات به شدت مستحکم

الزامات نواحی ۱و۲و۳: ← الزامات NACE

ISO 15156-1 کلی - جدول حوزه‌های کاربری

ISO 15156-2 - CS/LA رژیم سرویس

ISO 15156-3 - CRA

MR0175 ③ پارت

ISO 15156-2 پارت ۲

متریال‌های پیش تأیید شده - الزامات جوش . صلاحیت؟

International Standard

ANSI/NACE MR0175/ISO 15156-2:2015

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

Part 2:

Cracking-resistant carbon and low-alloy steels, and the use of cast irons

متدولوژی الزامات انتخاب متریال ← بند 7 / بند 8

→ Annex

MR0175 →

Div1 U-2

- وظیفه user / owner ← تحقیق ترش بودن سرویس یا خیر

+ فاکتورهای تاثیرگذار بر روی محیط ترش

← ۳ ناحیه تقسیم بندی - 0 ایمن - 1،2،3

ISO 15156-2

6 Factors affecting the behaviour of carbon and low alloy steels in H_2S-containing environments

The behaviour of carbon and low-alloy steels in H_2S-containing environments is affected by comple interactions of parameters, including the following:

a) chemical composition, method of manufacture, product form, strength, hardness of the material and its local variations, amount of cold work, heat-treatment condition, microstructure, microstructural uniformity, grain size and cleanliness of the material;

b) H_2S partial pressure or equivalent concentration in the water phase;

c) chloride ion concentration in the water phase;

d) acidity (pH) of the water phase;

e) presence of sulfur or other oxidants;

f) exposure to non-production fluids;

g) exposure temperature;

h) total tensile stress (applied plus residual);

i) exposure time.

These factors shall be considered when using this part of ANSI/NACE MR0175/ISO 15156 for the selection of materials suitable for environments containing H_2S in oil and gas production systems.

user /owner

فاکتورهای تاثیرگذار در رفتار CS/LA در سرویس ترش :

① - ترکیب شیمیایی - روش تولید - سختی - استحکام - میزان کارسرد - عملیات حرارتی - ریزساختار - اندازه دانه و تمیزی متریال

② P_{H_2S}

③ Cl^-

④ PH

۵- عناصر گوگردی

۶ سیالات غیرفرآیندی

۷ دما

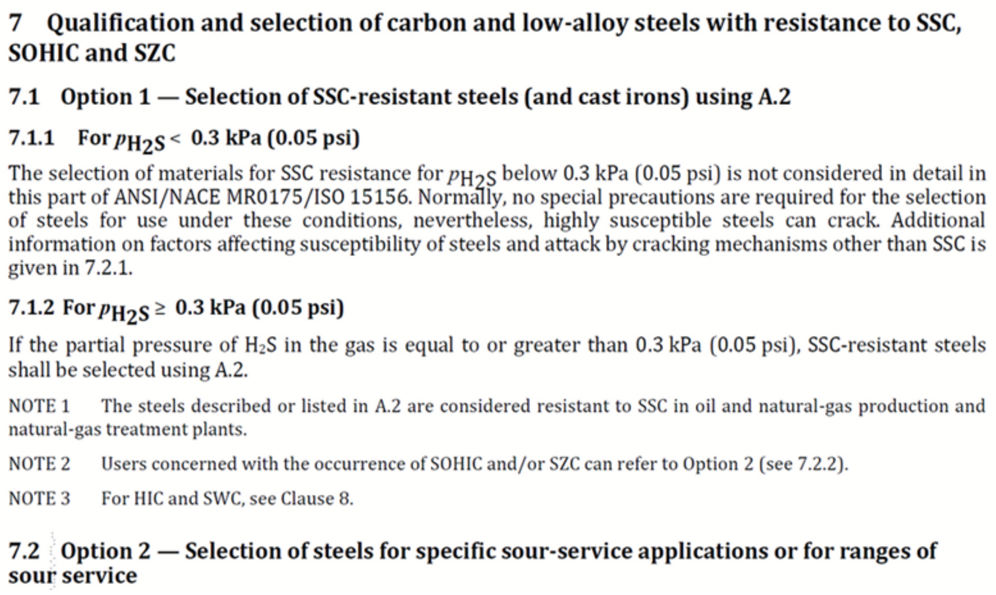
۸- تنش کششی

۹ زمان

بند 7 - ISO 15156-2

S

انکس A



7 Qualification and selection of carbon and low-alloy steels with resistance to SSC, SOHIC and SZC

7.1 Option 1 — Selection of SSC-resistant steels (and cast irons) using A.2

7.1.1 For $p_{H_2S} <$ 0.3 kPa (0.05 psi)

The selection of materials for SSC resistance for p_{H_2S} below 0.3 kPa (0.05 psi) is not considered in detail in this part of ANSI/NACE MR0175/ISO 15156. Normally, no special precautions are required for the selection of steels for use under these conditions, nevertheless, highly susceptible steels can crack. Additional information on factors affecting susceptibility of steels and attack by cracking mechanisms other than SSC is given in 7.2.1.

7.1.2 For $p_{H_2S} \geq$ 0.3 kPa (0.05 psi)

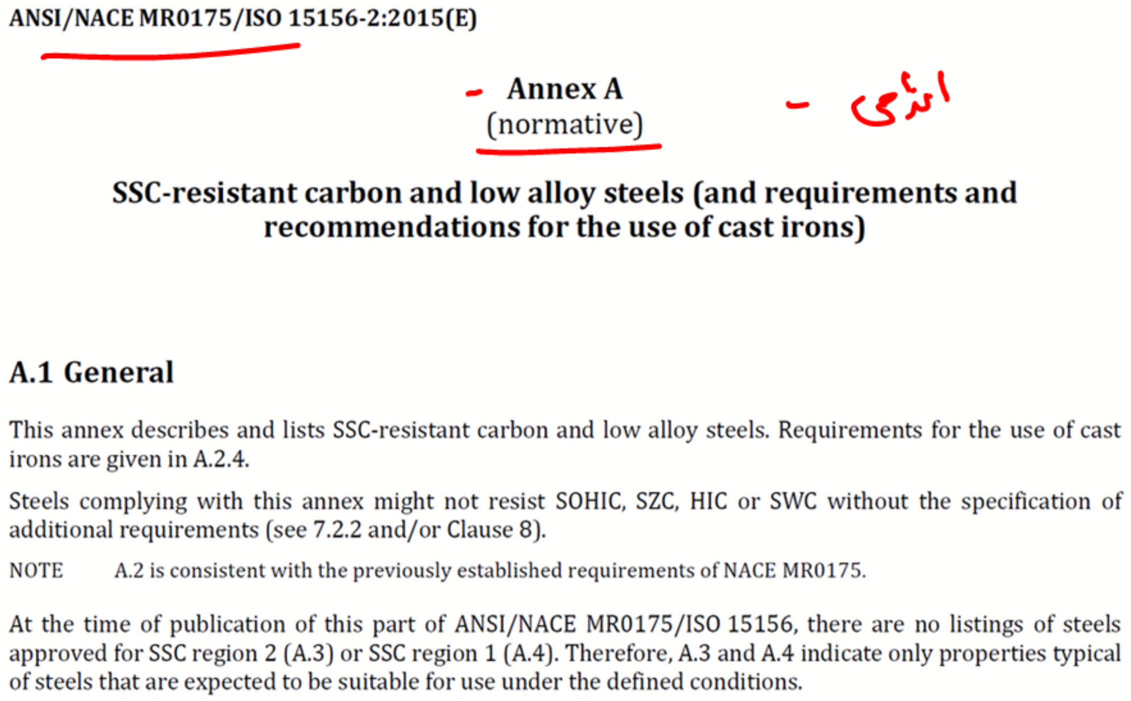
If the partial pressure of H_2S in the gas is equal to or greater than 0.3 kPa (0.05 psi), SSC-resistant steels shall be selected using A.2.

NOTE 1 The steels described or listed in A.2 are considered resistant to SSC in oil and natural-gas production and natural-gas treatment plants.

NOTE 2 Users concerned with the occurrence of SOHIC and/or SZC can refer to Option 2 (see 7.2.2).

NOTE 3 For HIC and SWC, see Clause 8.

7.2 Option 2 — Selection of steels for specific sour-service applications or for ranges of sour service



ANSI/NACE MR0175/ISO 15156-2:2015(E)

- Annex A
(normative)

الزامی -

SSC-resistant carbon and low alloy steels (and requirements and recommendations for the use of cast irons)

A.1 General

This annex describes and lists SSC-resistant carbon and low alloy steels. Requirements for the use of cast irons are given in A.2.4.

Steels complying with this annex might not resist SOHIC, SZC, HIC or SWC without the specification of additional requirements (see 7.2.2 and/or Clause 8).

NOTE A.2 is consistent with the previously established requirements of NACE MR0175.

At the time of publication of this part of ANSI/NACE MR0175/ISO 15156, there are no listings of steels approved for SSC region 2 (A.3) or SSC region 1 (A.4). Therefore, A.3 and A.4 indicate only properties typical of steels that are expected to be suitable for use under the defined conditions.

A.2 SSC-resistant carbon and low-alloy steels and the use of cast irons

A.2.1 General requirements for carbon and low alloy steels

A.2.1.1 General

Carbon and low-alloy steels shall comply with A.2.1.2 through A.2.1.9.

Carbon and low-alloy steels, products and components that comply with A.2 are, with stated exceptions, qualified in accordance with this part of ANSI/NACE MR0175/ISO 15156 without further SSC testing. Nevertheless, any SSC testing that forms part of a materials manufacturing specification shall be carried out successfully and the results reported.

The majority of steels that comply with the general requirements of A.2 are not individually listed; however, for convenience, some examples of such steels are listed in Table A.2, Table A.3 and Table A.4.

NOTE 1 The carbon and low-alloy steels described/listed previously in NACE MR0175 (all revisions) were identified by extensive correlations of field failures/successes and laboratory data. The hardness limit of HRC 22 applied to most carbon and low-alloy steels is based on correlations of heat treatment, chemical composition, hardness and failure experience. The higher hardness limits for the chromium-molybdenum steels are based on similar considerations.

NOTE 2 It can be possible to qualify a carbon or low alloy steel not described or listed in the text or tables of A.2 for use in specific sour service applications or for a range of sour service in accordance with Option 2 (7.2).

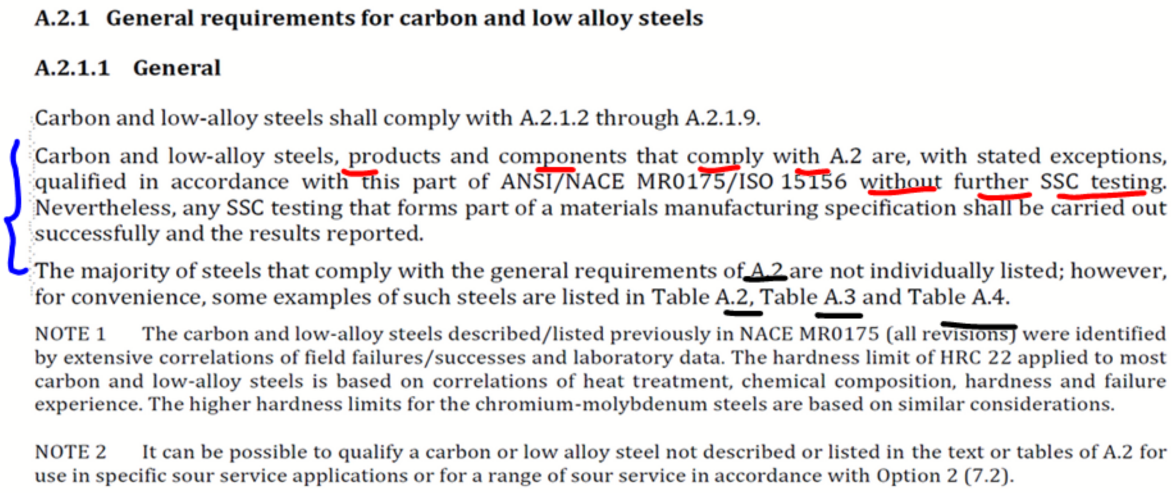
روال انکس A :

A2.1 → General Requirement

A2.2 → product form
A2.2.1 → General
A2.2.2 - pipe - plate - Fittings

A2.3 → equipment
A2.3.2 blowout
A2.3.3 - Compressors

A2.4 → Cast Iron



A.2.1 General requirements for carbon and low alloy steels

A.2.1.1 General

Carbon and low-alloy steels shall comply with A.2.1.2 through A.2.1.9.

Carbon and low-alloy steels, products and components that comply with A.2 are, with stated exceptions, qualified in accordance with this part of ANSI/NACE MR0175/ISO 15156 without further SSC testing. Nevertheless, any SSC testing that forms part of a materials manufacturing specification shall be carried out successfully and the results reported.

The majority of steels that comply with the general requirements of A.2 are not individually listed; however, for convenience, some examples of such steels are listed in Table A.2, Table A.3 and Table A.4.

NOTE 1 The carbon and low-alloy steels described/listed previously in NACE MR0175 (all revisions) were identified by extensive correlations of field failures/successes and laboratory data. The hardness limit of HRC 22 applied to most carbon and low-alloy steels is based on correlations of heat treatment, chemical composition, hardness and failure experience. The higher hardness limits for the chromium-molybdenum steels are based on similar considerations.

NOTE 2 It can be possible to qualify a carbon or low alloy steel not described or listed in the text or tables of A.2 for use in specific sour service applications or for a range of sour service in accordance with Option 2 (7.2).

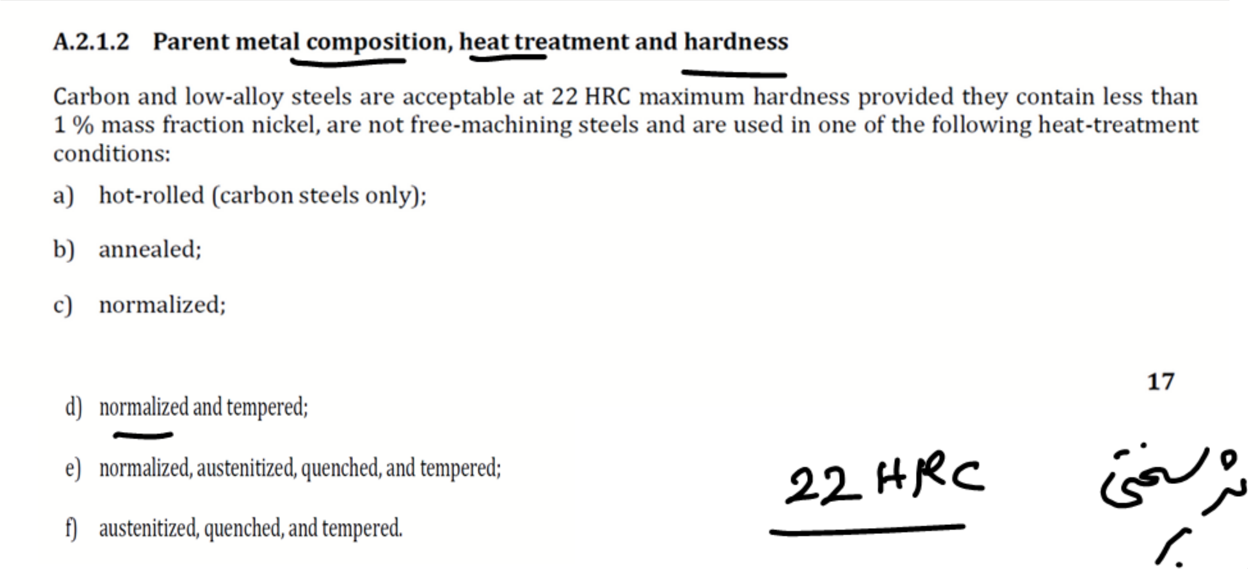
نکته A2.1 : الزامات کلی

- در صورت رعایت الزامات A.2 نیازی به پاس کردن الزامات تستی که ذکر شده نمی‌باشد.

- اگر الزام متریال با تست در کارخانه موفقیت آمیز پاس شده باشد ، نیازی به تست مجدد نیست.

- جداول کاربردی انکس A

A.2.1.2 - الزامات فلز پایه : ترکیب ـ عملیات حرارتی و سختی



A.2.1.2 Parent metal composition, heat treatment and hardness

Carbon and low-alloy steels are acceptable at 22 HRC maximum hardness provided they contain less than 1 % mass fraction nickel, are not free-machining steels and are used in one of the following heat-treatment conditions:

a) hot-rolled (carbon steels only);

b) annealed;

c) normalized;

17

d) normalized and tempered;

e) normalized, austenitized, quenched, and tempered;

f) austenitized, quenched, and tempered.

- حداکثر سختی 22 HRC
- درصد نیکل Ni < 1 %
- یکی از عملیات حرارتی: آنیل - نرماله - N+T - (N+A+QT)
(A+Q+T)
-

نقاط سختی سنجی
- میانگین گیری ✓
- پرتابل ←

- API 577 - ISO 16859-1
2 μm   Ra ≤ 7 μm
Ra ≤

A2.1.3 محدودیتهای CS :

A.2.1.3 Carbon steels acceptable with revised or additional restrictions

In addition to the restrictions of A.2.1.2, some carbon steels are acceptable subject to the following revised or additional restrictions.

a) Forgings produced in accordance with ASTM A105 are acceptable if the hardness does not exceed 187 HBW.

b) Wrought pipe fittings to ASTM A234, grades WPB and WPC are acceptable if the hardness does not exceed 197 HBW.

① فورج - A105 187 HBW (... N+T + W) %Ni < 1%

② متریال کارشده - A234 - WPB WPC · سختی کمتر 197 HBW

A2.1.4 - الزامات جوشکاری

★

- جدول سختی - جوش - HAZ - جدول A1

A.2.1.4 Welding

Welding and weld-hardness determinations shall be performed in accordance with 7.3.3.

Acceptable maximum hardness values for carbon steel, carbon manganese steel and low alloy steel welds are given in Table A.1.

As-welded carbon steels, carbon-manganese steels and low-alloy steels that comply with the hardness requirements of Table A.1 do not require post-weld heat treatment.

Tubular products with an SMYS not exceeding 360 MPa (52 ksi) and listed in Table A.2 are acceptable in the as-welded condition. For these products, hardness testing of welding procedures may be waived if agreed by the equipment user.

Some tubular products with an SMYS exceeding 360 MPa (52 ksi) (see A.2.2.2) may be acceptable in the as-welded condition if suitable qualified welding procedures are used. The conditions in Table A.1 shall be met.

Carbon steel, carbon manganese and low-alloy steel weldments that do not comply with other paragraphs of this subclause shall be post weld heat treated after welding. The heat treatment temperature and its duration shall be chosen to ensure that the maximum weld zone hardness, determined in accordance with 7.3, shall be 250 HV or, subject to the restrictions described in 7.3.3, 22 HRC.

A minimum post weld heat treatment temperature of 620 °C (1 150 °F) shall be used for low alloy steels.

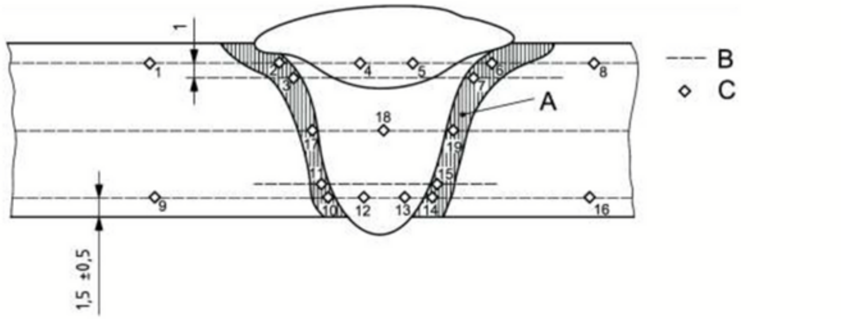
The acceptability of any effects on mechanical properties, other than hardness, caused by the chosen heat treatment and its duration shall be subject to the approval of the equipment user.

Welding consumables and procedures that produce a deposit containing more than 1 % mass fraction nickel are acceptable after successful weld SSC qualification by testing in accordance with Annex B.

! روش سختی سنجی و مواقع سختی سنجی مطابق بند 7.3.3

ANSI/NACE MR0175/ISO 15156-2:2015(E)

Dimensions in millimetres



Key

A weld heat-affected zone (visible after etching)

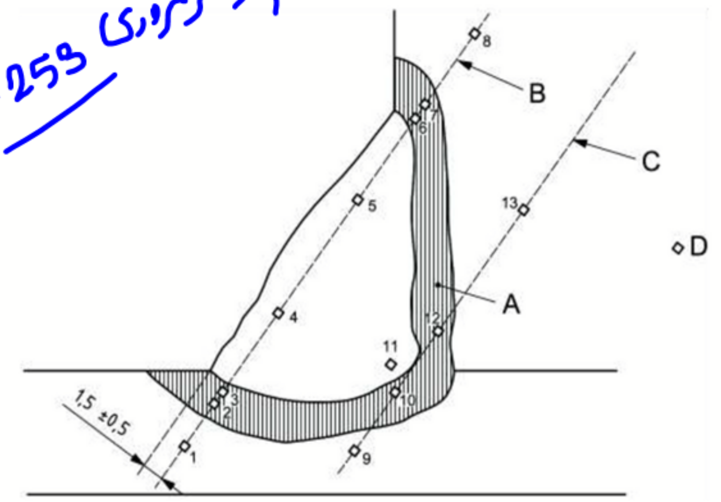
B lines of survey

C hardness impressions: Impressions 2, 3, 6, 7, 10, 11, 14, 15, 17 and 19 should be entirely within the heat-affected zone and located as close as possible to the fusion boundary between the weld metal and the heat-affected zone

The top line of survey should be positioned so that impressions 2 and 6 coincide with the heat-affected zone of the final run or change of profile of the fusion line associated with the final run.

PQR
مجدد QW-407.1 → حذف یا جایگزینی
QW-253 متغیر ضروری PWHT

Dimensions in millimetres



تمپربید
هاف بید بیشتر از نرمش B.W است

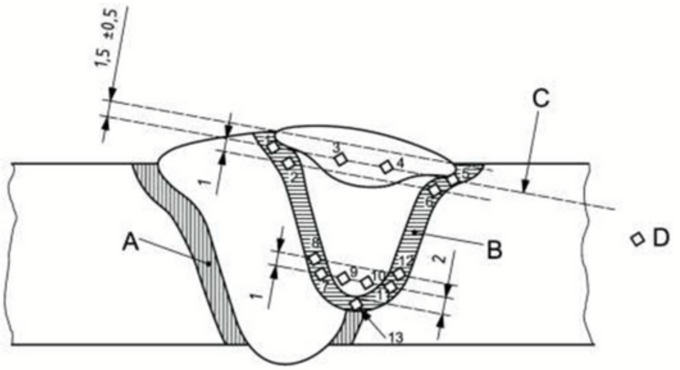
نکته بسیار مهم:
کنترل سختی ← PWHT
روش هاف بید، تمپربید ←

API 939B : بوشه - جایگزینی
تمپربید بی اثر است
ی

⟹ بوشه ⟹ PWHT

API 939B : جوشهای تعمیری ← PWHT توصیه می شود.

Dimensions in millimetres



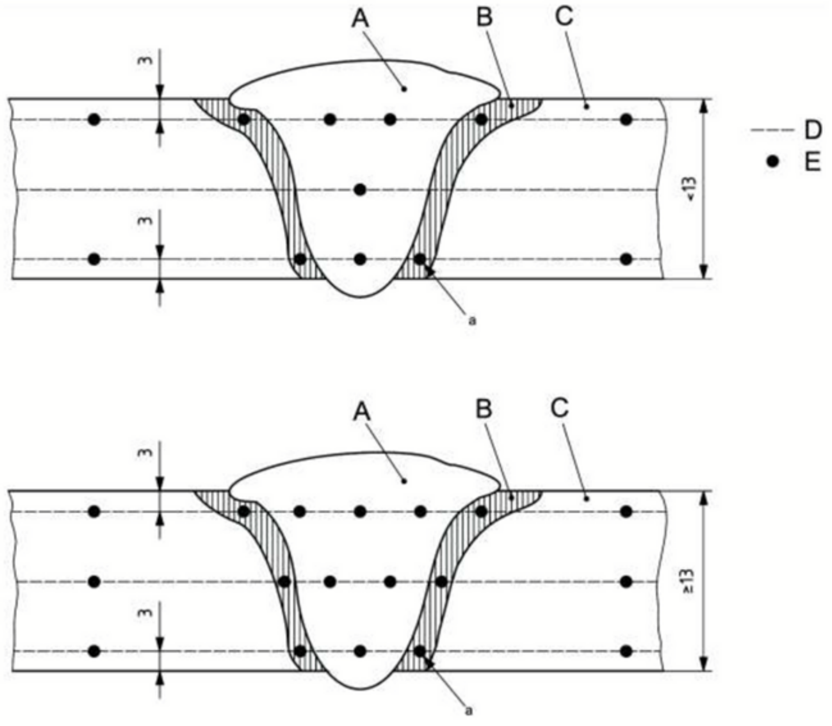
Key

A	original weld heat-affected zone
B	repair-weld heat-affected zone
C	parallel lines of survey
D	hardness impressions: Impressions in the heat-affected zone should be located as close as possible to the fusion boundary

The top line of survey should be positioned so that the heat-affected zone impressions coincide with the heat-affected zone of the final run or change in profile of the cap of fusion line associated with the final run.

Figure 4 — Repair and partial penetration welds

Dimensions in millimetres



راکول
ی
ویکرز معادل

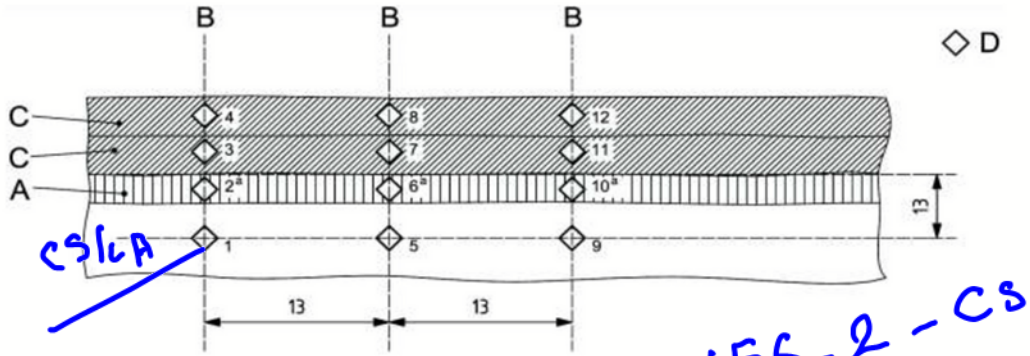
E 140

Key

A	weld
B	weld heat-affected zone (visible after etching)
C	parent metal
D	lines of survey
E	hardness impressions: Impressions in the weld heat-affected zone should be located within 2 mm of the fusion boundary

Figure 5 — Butt weld survey method for Rockwell hardness measurements

Dimensions in millimetres



CS/LA

ISO 15156-2 - CS/LA

Key

A	weld heat-affected zone (visible after etching)
B	lines of hardness survey indentations 1 to 12
C	layer of weld overlay (visible after etching)
D	hardness impressions

The Rockwell C hardness measurement method may be used subject to the requirements of 7.3.3.2. HRC hardness impressions in the HAZ shall be located within 2 mm of the fusion boundary.

[a] Using the Vickers or Rockwell 15N measurement methods, hardness impressions 2, 6 and 10 should be entirely within the heat-affected zone and located as close as possible to, but no more than 1 mm from, the fusion boundary between the weld overlay and HAZ.

Figure 6 — Weld overlay

ادامه

A2.1.4 الزامات جوش

A.2.1.4 Welding

Welding and weld-hardness determinations shall be performed in accordance with 7.3.3.

Acceptable maximum hardness values for carbon steel, carbon manganese steel and low alloy steel welds are given in Table A.1.

As-welded carbon steels, carbon-manganese steels and low-alloy steels that comply with the hardness requirements of Table A.1 do not require post-weld heat treatment.

Tubular products with an SMYS not exceeding 360 MPa (52 ksi) and listed in Table A.2 are acceptable in the as-welded condition. For these products, hardness testing of welding procedures may be waived if agreed by the equipment user.

Some tubular products with an SMYS exceeding 360 MPa (52 ksi) (see A.2.2.2) may be acceptable in the as-welded condition if suitable qualified welding procedures are used. The conditions in Table A.1 shall be met.

Carbon steel, carbon manganese and low-alloy steel weldments that do not comply with other paragraphs of this subclause shall be post weld heat treated after welding. The heat treatment temperature and its duration shall be chosen to ensure that the maximum weld zone hardness, determined in accordance with 7.3, shall be 250 HV or, subject to the restrictions described in 7.3.3, 22 HRC.

A minimum post weld heat treatment temperature of 620 °C (1 150 °F) shall be used for low alloy steels.

The acceptability of any effects on mechanical properties, other than hardness, caused by the chosen heat treatment and its duration shall be subject to the approval of the equipment user.

Welding consumables and procedures that produce a deposit containing more than 1 % mass fraction nickel are acceptable after successful weld SSC qualification by testing in accordance with Annex B.

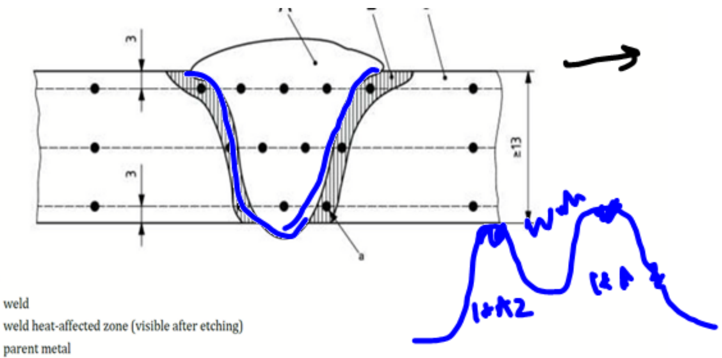
جدول A.1 - MR0175-2 . حداکثر سختی جوش

Table A.1 — Maximum acceptable hardness values for carbon steel, carbon-manganese steel and low-alloy steel welds

Hardness test methods	Hardness test locations for welding procedure qualification	Maximum acceptable hardness
Vickers HV 10 or HV 5 or Rockwell HR 15N	Weld root: Base metal, HAZ and weld root metal as shown in Figure 2, Figure 3 or Figure 4	250 HV 70.6 HR 15N
	Base metal and HAZ for weld overlays as shown in Figure 6; see also A.2.1.5 b)	250 HV 70.6 HR 15N
	Weld cap: Base metal, HAZ and weld metal of unexposed weld cap as shown in Figure 2 or Figure 4	275 HV[a] 73.0 HR 15N
Rockwell HRC; see 7.3.3.2	As shown in Figure 5	22 HRC
	Base metal and HAZ for weld overlays as shown in Figure 6; see also A.2.1.5 b)	22 HRC

[a] The maximum shall be 250 HV or 70.6 HR 15N unless all three of the following conditions are met:

- equipment user agrees the alternative weld cap hardness limit;
- parent material(s) are over 9 mm thick;
- weld cap is not exposed directly to the sour environment.



Key

A weld

B weld heat-affected zone (visible after etching)

C parent metal

D lines of survey

E hardness impressions: Impressions in the weld heat-affected zone should be located within 2 mm of the fusion boundary

Figure 5 — Butt weld survey method for Rockwell hardness measurements

روش پرتابل - HRC -

ISO 16859-1

ناحیه - HAZ

API 577 - 0.2mm

[illegible] خط ذوب

نکته: اگر با عملیات جوشکاری از حداکثر سختی ذکر شده، تجاوز نکنند ⟸ نیازی به PWHT نمی‌باشد.

① توجه: معمولاً برای ضخامت‌های <32mm می‌توان با جوشکاری مناسب از حداکثر سختی ذکر شده تجاوز نکرد.

② اگر مقادیر سختی جدول A1 رعایت نشود ⟵ تنش زدایی ⟵ 620°C

DN1 - B31.3 P1 - 595°C

595 ~ 650°C

③ استاندارد NACE MR0175 الزام آور جهت PWHT نمی باشد.

④ سختی شرط لازم هست ولی شرط کافی نمی باشد.

⑤ برای محصولات بشکل لوله که SMYS ≤ 52 ksi جدول A2

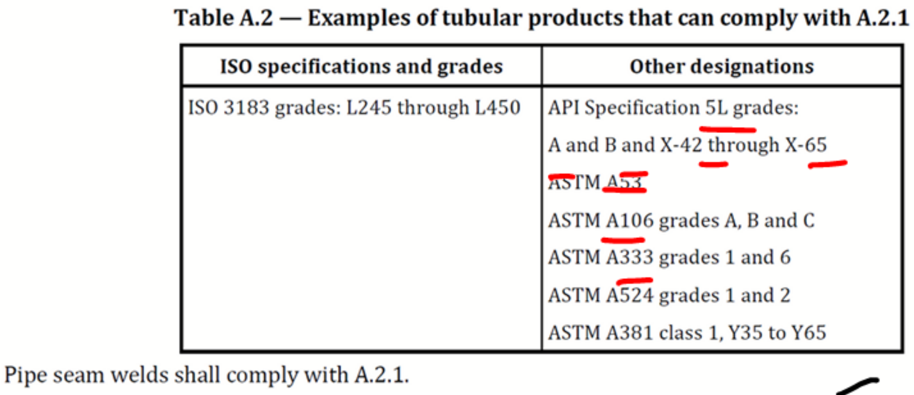


Table A.2 — Examples of tubular products that can comply with A.2.1

ISO specifications and grades	Other designations
ISO 3183 grades: L245 through L450	API Specification 5L grades: A and B and X-42 through X-65 ASTM A53 ASTM A106 grades A, B and C ASTM A333 grades 1 and 6 ASTM A524 grades 1 and 2 ASTM A381 class 1, Y35 to Y65

Pipe seam welds shall comply with A.2.1.

⑥ درصد نیکل در جوش تولیدی کمتر از ۱٪ باشد. و بالاتر از ۱٪ اگر تست SSC را مطابق انکس B3 پاس نماید.

⇐ جوش نهایی ملاک است نه متریال مصرفی

ANO

روز سیزدهم _ جلسه اول

PFHT - Cold Forming   A2.1.6 _ عملیات کار سرد:

Div1 - UG-79
B31.3 → B31P
} Fiber elongation

$R_o = \infty$

%Fe
- vessel
  - shell - cylinderical
    $\%Fe = \frac{50t}{R_f}\left(1 - \overset{0}{\frac{R_f}{R_o}}\right)$
  - Head - spherical
    $\%Fe = \frac{75t}{R_f}\left(1 - \frac{R_f}{R_o}\right)$
- pipe
  $\%Fe = \frac{100r}{R}$
  r → شعاع لوله
  R → شعاع خم

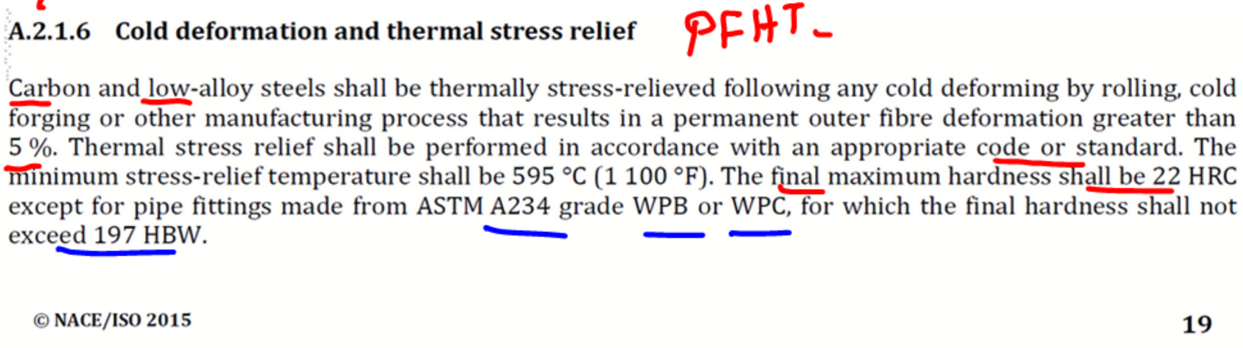
B31.3 → 332 → P1 ~ P6   %Fe > 50%

Div1 - UCS-79
- P1 - %Fe > 40% - PFHT _ UCS-56
- lethal - %Fe > 5% ← سرویس های H2S
- P-1 _ tube { مبدل → No PFHT
  2019   t < 19mm

MR0175-2

3

سیال ترش: ← %Fe > 5%



A.2.1.6 Cold deformation and thermal stress relief

Carbon and low-alloy steels shall be thermally stress-relieved following any cold deforming by rolling, cold forging or other manufacturing process that results in a permanent outer fibre deformation greater than 5 %. Thermal stress relief shall be performed in accordance with an appropriate code or standard. The minimum stress-relief temperature shall be 595 °C (1 100 °F). The final maximum hardness shall be 22 HRC except for pipe fittings made from ASTM A234 grade WPB or WPC, for which the final hardness shall not exceed 197 HBW.

© NACE/ISO 2015 19

PFHT-

Wet H2S → %Fe > 5% → PFHT → applicable code

→ UCS-56
→ 331.1.1
} → Min Hold Tem = 595°C → Hardness 22 HRC

A234 WPB-WPC < 197 HBW

نکات :

Q1 - t = 50mm → t > 38mm PWHT ✓ - UCS-56 ✓✓✓

%5 < %Fe < 40% ✗

Wet H2S → PFHT > 5% → PWHT - UCS-56

سیال سمی → UW-2a → PWHT

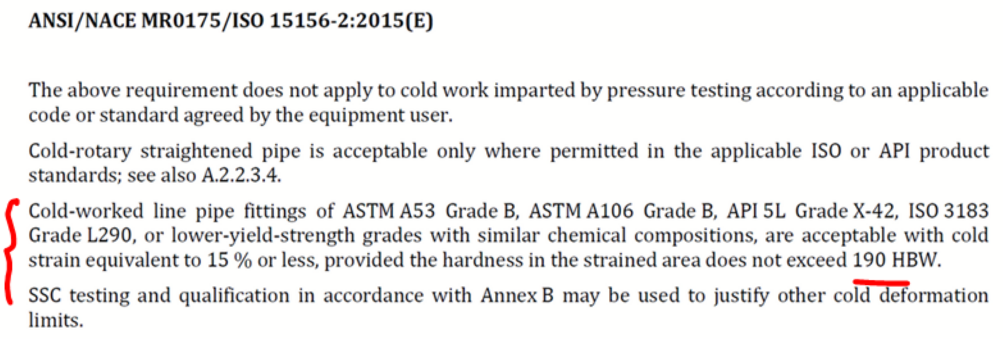
نکته: حالت PFHT همزمان PWHT ناشی از ضخامت / سیال سمی را نیز کاور می کند.

PFHT ← بعد جوشکاری

البته MR0175 تا میزان %Fe ~15% را نیز جزء مصالح تحت

سرد در شرایط خاص ترش نموده است.

A2.1.6



ANSI/NACE MR0175/ISO 15156-2:2015(E)

The above requirement does not apply to cold work imparted by pressure testing according to an applicable code or standard agreed by the equipment user.

Cold-rotary straightened pipe is acceptable only where permitted in the applicable ISO or API product standards; see also A.2.2.3.4.

Cold-worked line pipe fittings of ASTM A53 Grade B, ASTM A106 Grade B, API 5L Grade X-42, ISO 3183 Grade L290, or lower-yield-strength grades with similar chemical compositions, are acceptable with cold strain equivalent to 15 % or less, provided the hardness in the strained area does not exceed 190 HBW.

SSC testing and qualification in accordance with Annex B may be used to justify other cold deformation limits.

A53 Gr.B / API 5L-X42 - B $\leq 15\%$ ~ 190 HBW

نکات مهم در MR0175:

! آیا سختی 22 HRC به عنوان معیار انطباق MR0175 است؟ خیر

② آیا ناحیه صفر Region 0 ($P_{H_2S} < 0.05$ psi) به عنوان ناحیه ایمن محسوب می‌شود؟ خیر

③ آیا هرجا H2S بود باید سراغ MR0175 برویم؟ خیر - MR0103

SP0296

TM0284

EFC 16, 17

SP0472

P1 - MR0103

④ آیا الزامات استاندارد ISO 15156 یا MR0175 یکسان است؟ بله

⑤ آیا صرفاً دیدن گواهی برای تائید شدن مطابق NACE کفایت می‌کند؟ خیر

⑥ آیا همه جوشها نیاز به PWHT دارد؟ خیر

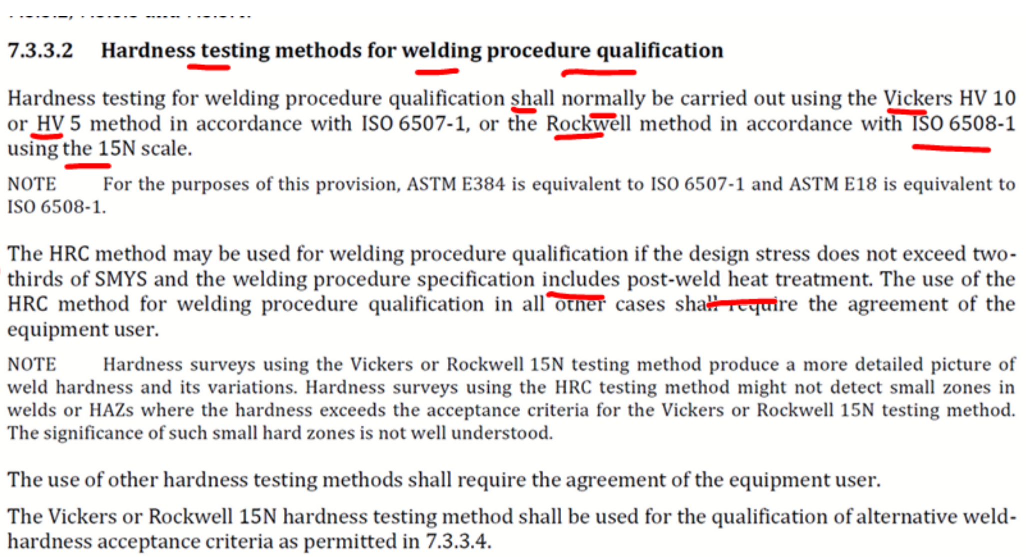
⑦ آیا از متریال استوک قبل 2003 می‌توانیم بدون تائید استفاده نمائیم (بر اساس Clause 7 ؟ خیر

⑧ آیا می‌توان از سختی سنج پرتابل استفاده نمود؟ Leeb

بله - البته با رعایت شرایط

۱- ISO 16859-1 و حداکثر زبری میانگین $Ra < 2\ \mu m$

۲- رعایت الزامات بند 7.3.3.2



7.3.3.2 Hardness testing methods for welding procedure qualification

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

NOTE For the purposes of this provision, ASTM E384 is equivalent to ISO 6507-1 and ASTM E18 is equivalent to ISO 6508-1.

The HRC method may be used for welding procedure qualification if the design stress does not exceed two-thirds of SMYS and the welding procedure specification includes post-weld heat treatment. The use of the HRC method for welding procedure qualification in all other cases shall require the agreement of the equipment user.

HRC بشرط PWHT

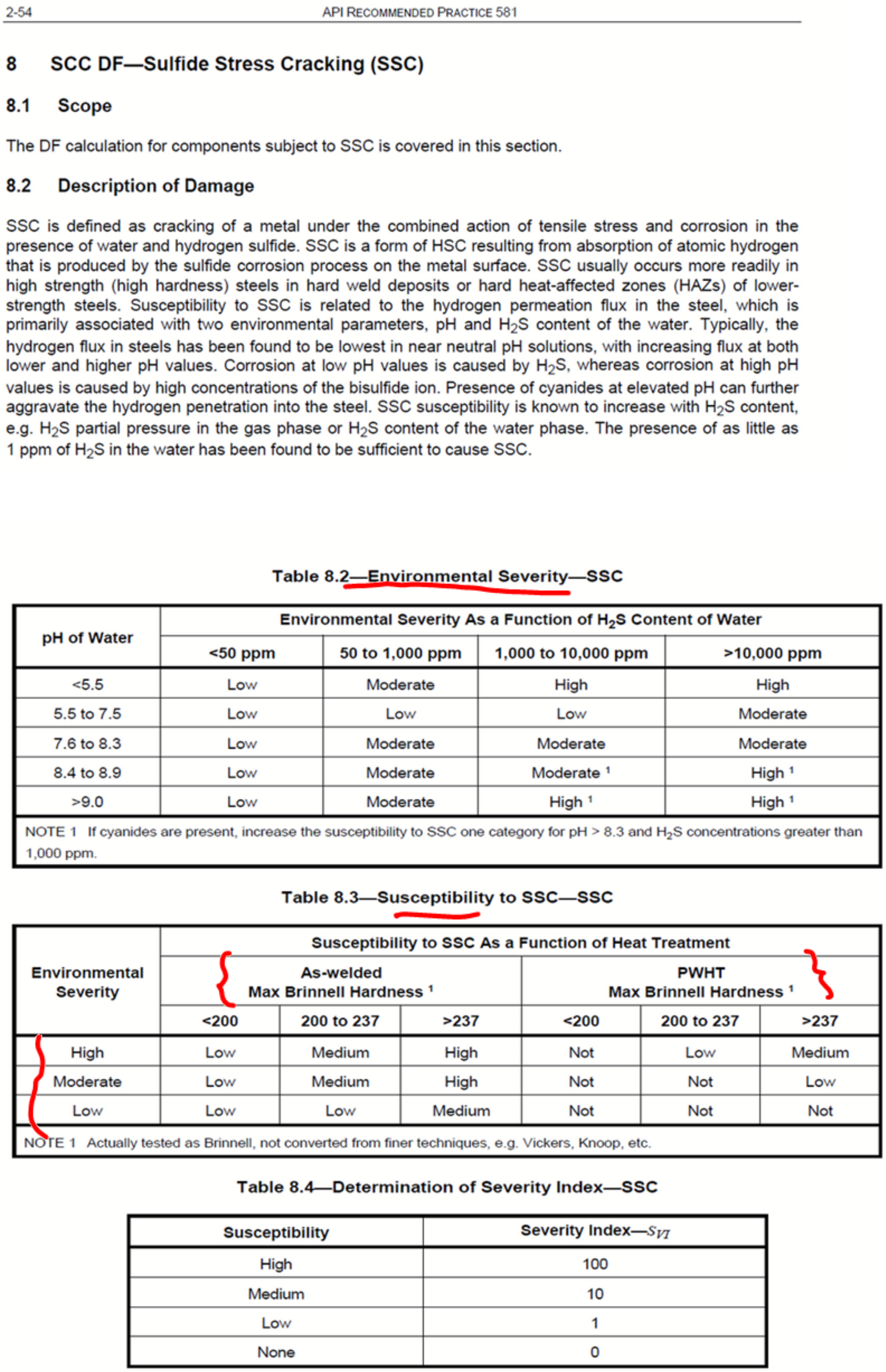
NOTE Hardness surveys using the Vickers or Rockwell 15N testing method produce a more detailed picture of weld hardness and its variations. Hardness surveys using the HRC testing method might not detect small zones in welds or HAZs where the hardness exceeds the acceptance criteria for the Vickers or Rockwell 15N testing method. The significance of such small hard zones is not well understood.

The use of other hardness testing methods shall require the agreement of the equipment user.

The Vickers or Rockwell 15N hardness testing method shall be used for the qualification of alternative weld-hardness acceptance criteria as permitted in 7.3.3.4.

API 581

معیار ارزیابی محیط و احتمالات مربوطه:



8 SCC DF—Sulfide Stress Cracking (SSC)

8.1 Scope

The DF calculation for components subject to SSC is covered in this section.

8.2 Description of Damage

SSC is defined as cracking of a metal under the combined action of tensile stress and corrosion in the presence of water and hydrogen sulfide. SSC is a form of HSC resulting from absorption of atomic hydrogen that is produced by the sulfide corrosion process on the metal surface. SSC usually occurs more readily in high strength (high hardness) steels in hard weld deposits or hard heat-affected zones (HAZs) of lower-strength steels. Susceptibility to SSC is related to the hydrogen permeation flux in the steel, which is primarily associated with two environmental parameters, pH and H_2S content of the water. Typically, the hydrogen flux in steels has been found to be lowest in near neutral pH solutions, with increasing flux at both lower and higher pH values. Corrosion at low pH values is caused by H_2S, whereas corrosion at high pH values is caused by high concentrations of the bisulfide ion. Presence of cyanides at elevated pH can further aggravate the hydrogen penetration into the steel. SSC susceptibility is known to increase with H_2S content, e.g. H_2S partial pressure in the gas phase or H_2S content of the water phase. The presence of as little as 1 ppm of H_2S in the water has been found to be sufficient to cause SSC.

Table 8.2—Environmental Severity—SSC

pH of Water	Environmental Severity As a Function of H_2S Content of Water			
	<50 ppm	50 to 1,000 ppm	1,000 to 10,000 ppm	>10,000 ppm
<5.5	Low	Moderate	High	High
5.5 to 7.5	Low	Low	Low	Moderate
7.6 to 8.3	Low	Moderate	Moderate	Moderate
8.4 to 8.9	Low	Moderate	Moderate [1]	High [1]
>9.0	Low	Moderate	High [1]	High [1]

NOTE 1 If cyanides are present, increase the susceptibility to SSC one category for pH > 8.3 and H_2S concentrations greater than 1,000 ppm.

Table 8.3—Susceptibility to SSC—SSC

Environmental Severity	Susceptibility to SSC As a Function of Heat Treatment					
	As-welded Max Brinnell Hardness [1]			PWHT Max Brinnell Hardness [1]		
	<200	200 to 237	>237	<200	200 to 237	>237
High	Low	Medium	High	Not	Low	Medium
Moderate	Low	Medium	High	Not	Not	Low
Low	Low	Low	Medium	Not	Not	Not

NOTE 1 Actually tested as Brinnell, not converted from finer techniques, e.g. Vickers, Knoop, etc.

Table 8.4—Determination of Severity Index—SSC

Susceptibility	Severity Index—S_{VI}
High	100
Medium	10
Low	1
None	0

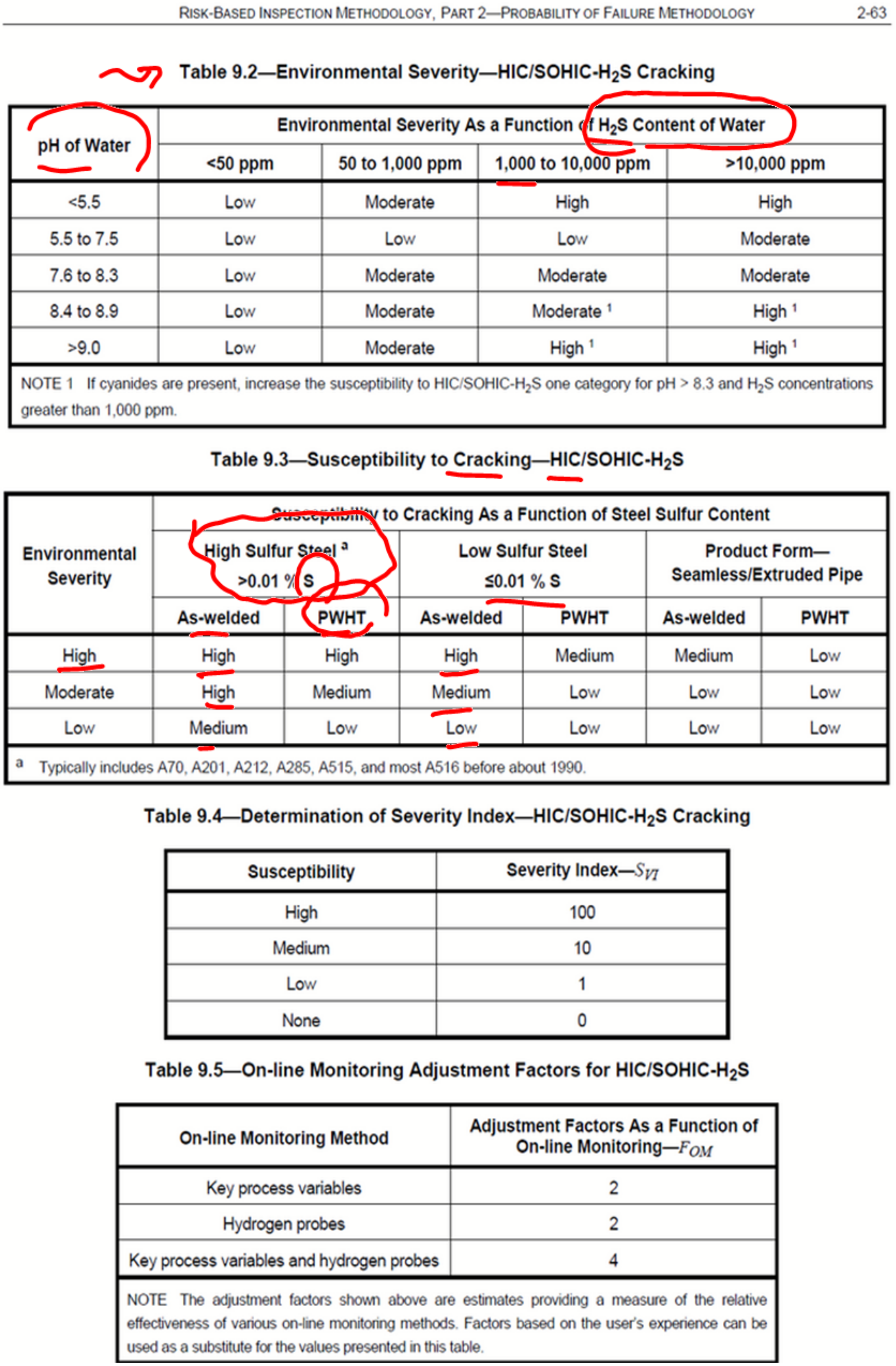


Table 9.2—Environmental Severity—HIC/SOHIC-H_2S Cracking

pH of Water	Environmental Severity As a Function of H_2S Content of Water			
	<50 ppm	50 to 1,000 ppm	1,000 to 10,000 ppm	>10,000 ppm
<5.5	Low	Moderate	High	High
5.5 to 7.5	Low	Low	Low	Moderate
7.6 to 8.3	Low	Moderate	Moderate	Moderate
8.4 to 8.9	Low	Moderate	Moderate [1]	High [1]
>9.0	Low	Moderate	High [1]	High [1]

NOTE 1 If cyanides are present, increase the susceptibility to HIC/SOHIC-H_2S one category for pH > 8.3 and H_2S concentrations greater than 1,000 ppm.

Table 9.3—Susceptibility to Cracking—HIC/SOHIC-H_2S

Environmental Severity	Susceptibility to Cracking As a Function of Steel Sulfur Content					
	High Sulfur Steel [a] >0.01 % S		Low Sulfur Steel ≤0.01 % S		Product Form—Seamless/Extruded Pipe	
	As-welded	PWHT	As-welded	PWHT	As-welded	PWHT
High	High	High	High	Medium	Medium	Low
Moderate	High	Medium	Medium	Low	Low	Low
Low	Medium	Low	Low	Low	Low	Low

[a] Typically includes A70, A201, A212, A285, A515, and most A516 before about 1990.

Table 9.4—Determination of Severity Index—HIC/SOHIC-H_2S Cracking

Susceptibility	Severity Index—S_{VI}
High	100
Medium	10
Low	1
None	0

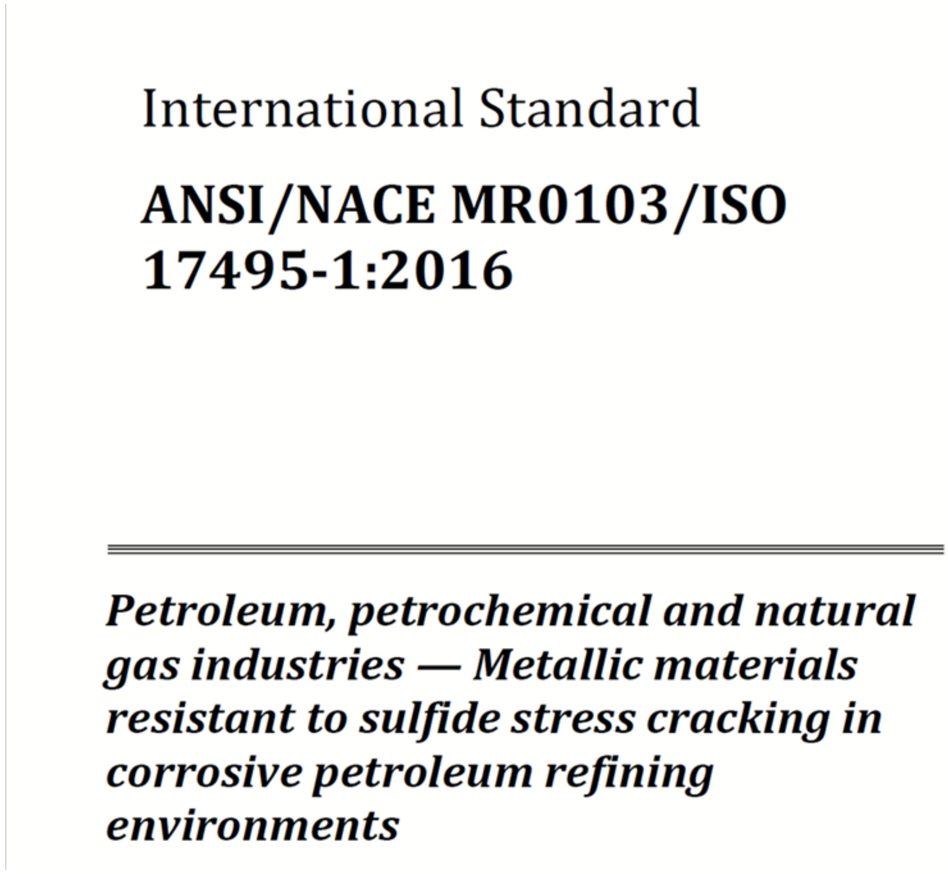
Table 9.5—On-line Monitoring Adjustment Factors for HIC/SOHIC-H_2S

On-line Monitoring Method	Adjustment Factors As a Function of On-line Monitoring—F_{OM}
Key process variables	2
Hydrogen probes	2
Key process variables and hydrogen probes	4

NOTE The adjustment factors shown above are estimates providing a measure of the relative effectiveness of various on-line monitoring methods. Factors based on the user's experience can be used as a substitute for the values presented in this table.

روز سیزدهم جلسه دوم

NACE MR0103 الزامات استاندارد

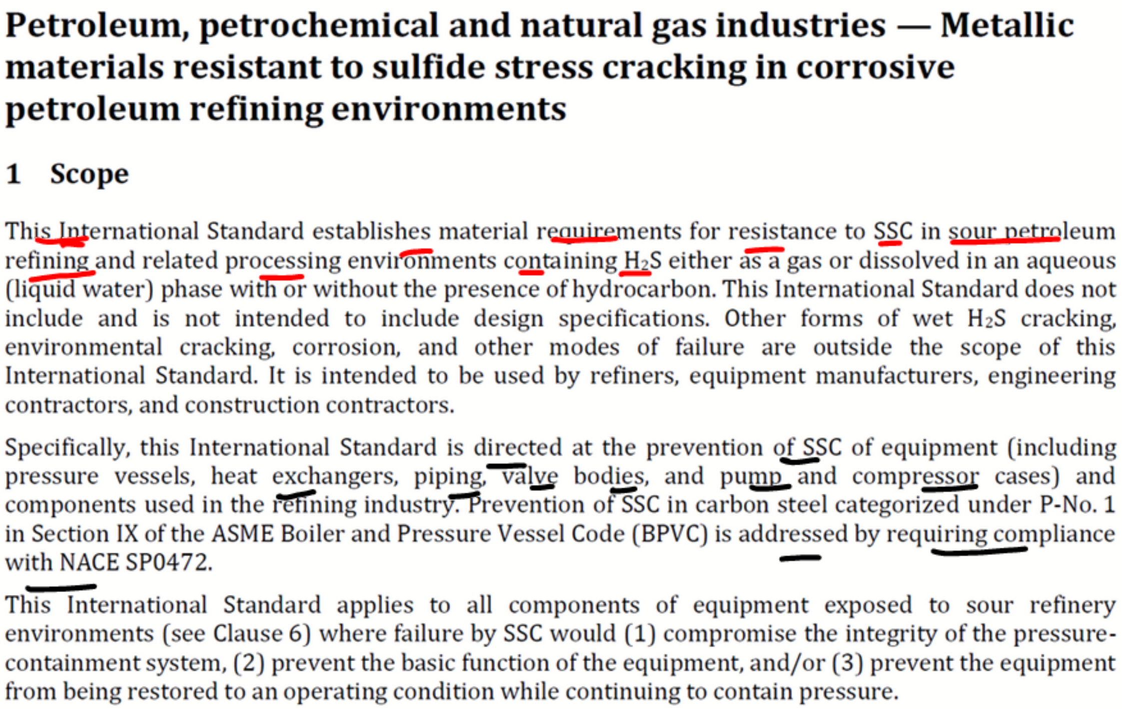


International Standard

ANSI/NACE MR0103/ISO 17495-1:2016

Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments

حیطه کاربری



Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments

1 Scope

This International Standard establishes material requirements for resistance to SSC in sour petroleum refining and related processing environments containing H_2S either as a gas or dissolved in an aqueous (liquid water) phase with or without the presence of hydrocarbon. This International Standard does not include and is not intended to include design specifications. Other forms of wet H_2S cracking, environmental cracking, corrosion, and other modes of failure are outside the scope of this International Standard. It is intended to be used by refiners, equipment manufacturers, engineering contractors, and construction contractors.

Specifically, this International Standard is directed at the prevention of SSC of equipment (including pressure vessels, heat exchangers, piping, valve bodies, and pump and compressor cases) and components used in the refining industry. Prevention of SSC in carbon steel categorized under P-No. 1 in Section IX of the ASME Boiler and Pressure Vessel Code (BPVC) is addressed by requiring compliance with NACE SP0472.

This International Standard applies to all components of equipment exposed to sour refinery environments (see Clause 6) where failure by SSC would (1) compromise the integrity of the pressure-containment system, (2) prevent the basic function of the equipment, and/or (3) prevent the equipment from being restored to an operating condition while continuing to contain pressure.

۱- کاربرد پالایشی

۲- صرفاً SSC را بررسی می‌کند

NACE sp0472 ← P-1 ۳- برای

NACE sp0296

NACE Standard SP0296-2016
Item No. 21078

Approved March 2016

Detection, Repair, and Mitigation of Cracking in Refinery Equipment in Wet H_2S Environments

5 Responsibilities

5.1 Responsibilities of the end user

5.1.1 It is the responsibility of the end user (or the end user's agent) to determine the operating conditions and to specify when this International Standard applies.

شرایط فرآیند

کارفرما مسئولیت بهره‌برداری

5.2 Responsibility of the manufacturer

سازنده

The manufacturer is responsible for meeting the metallurgical requirements of this International Standard.

6.1 پارامترهای تاثیرگذار SSC :

6 Factors contributing to SSC

6.1 General parameters affecting SSC

SSC in refining equipment is affected by complex interactions of parameters including the following:

a) chemical composition, strength (as indicated by hardness), heat treatment, and microstructure of the material exposed to the sour environment;

b) total tensile stress present in the material (applied plus residual);

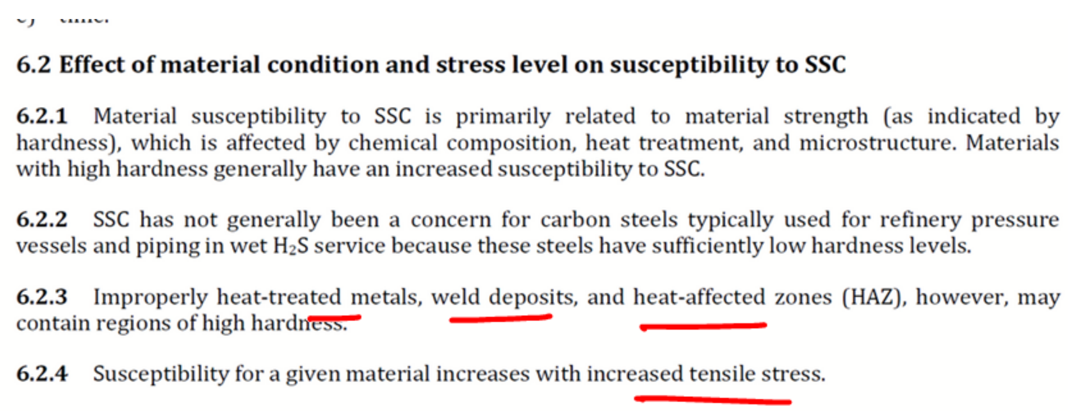
c) hydrogen flux generated in the material, which is a function of the environment (i.e. presence of an aqueous phase, H_2S concentration, pH, and other environmental parameters such as bisulfide ion concentration and presence of free cyanides);

d) temperature;

e) time.

- ترکیب شیمیایی - استحکام سختی - PWHT - ریزساختار
- میزان تنش ها - اعمالی - پسماند
- شار هیدروژنی
- سیانید
- pH
- دما
- زمان

6.2 - متریال و سطح تنش



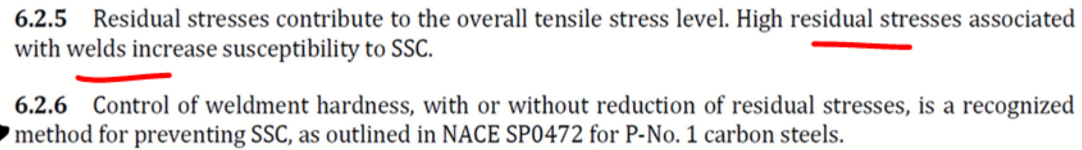
6.2 Effect of material condition and stress level on susceptibility to SSC

6.2.1 Material susceptibility to SSC is primarily related to material strength (as indicated by hardness), which is affected by chemical composition, heat treatment, and microstructure. Materials with high hardness generally have an increased susceptibility to SSC.

6.2.2 SSC has not generally been a concern for carbon steels typically used for refinery pressure vessels and piping in wet H_2S service because these steels have sufficiently low hardness levels.

6.2.3 Improperly heat-treated metals, weld deposits, and heat-affected zones (HAZ), however, may contain regions of high hardness.

6.2.4 Susceptibility for a given material increases with increased tensile stress.



6.2.5 Residual stresses contribute to the overall tensile stress level. High residual stresses associated with welds increase susceptibility to SSC.

6.2.6 Control of weldment hardness, with or without reduction of residual stresses, is a recognized method for preventing SSC, as outlined in NACE SP0472 for P-No. 1 carbon steels.

- حتی تنش پسماند برای ترک خوردگی تنشی SSC کافی خواهد بود.

- P1 - NACE SP 0472

6.2 قدرت نفوذ هیدروژن:

دو عامل اصلی تعیین کننده

PH

میزان سیانید ورودی

اسیدی A

عوامل Ar

pH - S رابطه

تعریف دقیق سرویس ترش برحسب pH و سولفید کل و ترکیبات سولفیدی

6.3 Effect of hydrogen permeation flux on SSC

6.3.1 Susceptibility to SSC is also related to the hydrogen permeation flux in the steel, which is primarily associated with two environmental parameters: pH and total sulfide content of the aqueous phase. In a closed system at equilibrium condition, dissolved hydrogen sulfide (H_2S_{aq}), bisulfide ion (HS^-), and sulfide ion (S^{2-}) (sometimes called "soluble sulfide") exist in an aqueous solution in different pH ranges.

% سولفید بودن در رابطه pH

6.3.2 The sulfide species plot exhibited in Figure A.1 shows their relative amounts present in an aqueous solution at 25 C (77°F) as a function of pH. At pH less than 6, H_2S_{aq} is the dominant (>90 % of total) sulfide specie present in the aqueous phase. At pH between 8 and 11, the dominant (>90 % of total) sulfide specie present in the aqueous phase is HS^-. At pH greater than 13, the dominant (>90 % of total) sulfide specie present in the aqueous phase is S^{2-}. At pH 7, the system contains 50 % H_2S_{aq}, 50 % HS^-, and virtually no S^{2-}. At pH 12, the system contains 50 % HS^-, 50 % S^{2-}, and virtually no H_2S_{aq}. The total sulfide content, therefore, refers to the total amount of all three sulfide species present in the aqueous phase (i.e. the sum of H_2S_{aq}, HS^-, and S^{2-}).

6.3.3 Typically, the hydrogen flux in steels has been found to be lowest in near-neutral pH solutions, with increasing flux at both lower and higher pH values. Corrosion at lower pH values is typically caused by H_2S_{aq}, whereas corrosion at higher pH values is typically caused by high concentrations of HS^-.

6.3.4 In many refinery sour water environments, the presence of dissolved ammonia (NH_3) increases the pH, thereby increasing the solubility of H_2S and resulting in a high HS^- concentration. At elevated pH, the presence of free cyanides, which include dissolved hydrogen cyanide (HCN_{aq}) and cyanide ion (CN^-), can further aggravate the degree of atomic hydrogen charging into the steel. Even though SSC susceptibility is known to increase with total sulfide content of the aqueous phase, the presence of as little as 1 ppmw total sulfide in the aqueous phase can cause SSC under conditions that promote aggressive hydrogen charging.

تعریف سرویس ترش از دیدگاه 103

عوامل SSC در CS

6.3.5 For carbon steel, some environmental conditions known to cause SSC are those containing an aqueous (liquid water) phase and either of the following:

a) >50 ppmw total sulfide content in the aqueous phase;

b) ≥1 ppmw total sulfide content in the aqueous phase and pH < 4;

c) ≥1 ppmw total sulfide content and ≥20 ppmw free cyanide in the aqueous phase, and pH > 7,6;

d) >0,3 kPa absolute (0,05 psia) partial pressure H_2S in the gas phase associated with the aqueous phase of a process.

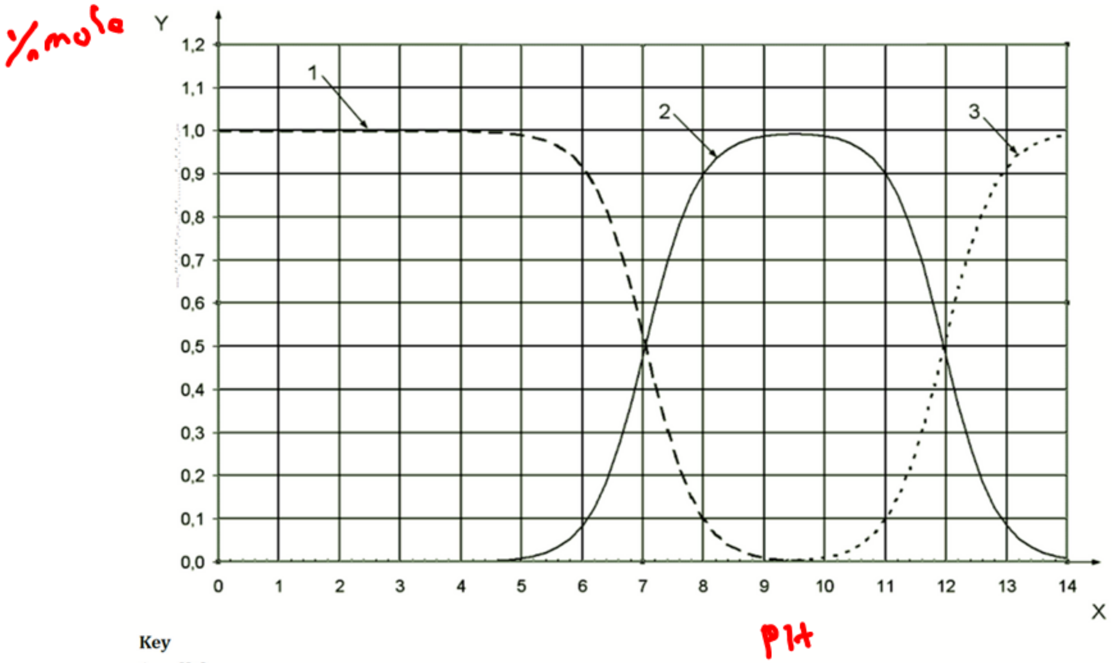
6.3.6 The high-pH sour environments differentiate refinery sour service from the oil and gas production sour environments covered by NACE MR0175/ISO 15156, because many wet sour streams in oil and gas production also contain carbon dioxide and, hence, exhibit a lower pH. Another major difference is that chloride ion concentrations tend to be significantly lower in refinery sour services than in oil production sour services.

اختلاف بین 103 و 175

pH↓ ← 175 ← CO_2

175 ← Cl^-

Cl^- عدم در نظر گرفتن اثر ← ↓ 103



Key

1	H_2S_{aq}
2	HS^-
3	S^{2-}
X	pH
Y	mole fraction of sulfur species

Figure A.1 — Sulfide species plot for closed system at 25 °C (77 °F)

نکته: نمودار فوق ترکیبات گوگردی ← ۳ ترکیب 1 و 2 و 3

← مقدار کل سولفید در این سیستم تعادلی ← مجموع سه جزء ← مثال PH=7

→

۶،۴ استاندارد

6.4 Effect of elevated temperature exposure on SSC

The hydrogen charging potential increases with increasing temperature provided the aqueous phase is not eliminated by the elevated temperature. Elevated temperature promotes dissociation of H_2S (thereby producing more monatomic hydrogen), and increases the diffusion rates of monatomic hydrogen in metals, thereby promoting hydrogen charging. However, cracking potential is maximized at near-ambient temperature. This distinction is important because metals can become charged during high-temperature exposure and subsequently crack during excursions to lower temperatures (such as during shutdowns).

بالا رفتن دما در محلول آبی ← قدرت نفوذ هیدروژن ↑ - دما بالا ← نفوذ H^+

تا قبل از حذف شدن محیط آبی ←

نکته: بیشترین ترک در محیط با د. محیط

6.5 - فاکتورهای تاثیرگذار بر دوره زمان تخریب

↑ ⇐ زمان ↓

- استحکام
- سطح تنش
- قدرت شارژ هیدروژنی

6.5 Factors affecting time to failure due to SSC

The time to failure decreases as material strength, total tensile stress, and environmental charging potential increase. Exposure time to cause SSC can be very short, if the other SSC factors favour susceptibility. Some susceptible equipment can fail even during short sour water excursions such as those encountered during equipment shutdowns.

⇐ تخمین زمان تخریب ← دشوار ← هرگونه تمهیدات ← هم اکنون ✓

PWHT

متدولوژی انتخاب متریال MR0103

شبیه MR0175 ← قدم اول - متریالهای پیش تایید شده ← clause 7

7 Materials included in this International Standard

7.1 Materials included in this International Standard are resistant to, but not necessarily immune to, SSC. Materials have been included based on their demonstrated resistance to SSC in field applications, in SSC laboratory testing, or both.

7.2 Listed materials do not all exhibit the same level of resistance to SSC. Standard laboratory SSC tests, such as those addressed in NACE Standard TM0177, are accelerated and severe tests. Materials that successfully pass these tests are generally more resistant to cracking in sour service than materials that fail the tests. Many alloys included in this International Standard perform satisfactorily in sour service even though they may crack in laboratory tests.

7.3 Improper design, processing, installation, or handling can cause resistant materials to become susceptible to SSC.

7.4 No effort has been made in this International Standard to rank materials based on their relative resistance to SSC. Selection of the appropriate material for a given application depends on a number of factors, including mechanical properties, corrosion resistance, and relative resistance to SSC, and is beyond the scope of this International Standard.

7.5 There are a number of instances where this International Standard specifically references the ASME BPVC. There are other instances where this International Standard references specific industry standards and/or designations for material grades, conditions, and testing requirements (e.g. ASTM, NACE, API, and UNS numbers). In these cases, the use of alternate "equivalent" standards, grade designations, condition designations, or testing methods shall only be permitted when approved by the end user. It is the responsibility of the agency requesting the substitution to provide to the end user sufficient information, data, etc. in order to prove "equivalency." If it is not clear that an alternate standard, grade designation, and/or condition designation is identical to the standard, grade

متدولوژی : متریال پیش تایید شده

تجارب مثبت به

تست آزمایشگاه خاص

TM 0177

متدولوژی

متریال جدید

این استاندارد در سطح لازم هست و هم کامل نمی‌باشد.

خواه غلطا و چه غیر استفاده ـــــ منجر به SSC روی متریال تایید شده گردد.

2E - ASME FFS

- Clause 8 - تست سختی سنجی

8 Hardness requirements

8.1 Hardness is related to tensile strength, a primary factor in SSC susceptibility. Because hardness testing is non-destructive and requires relatively minor component/specimen preparation compared with tensile testing, it is commonly used by manufacturers in production quality control and by users in field inspection. As such, a maximum allowable hardness is specified as a primary requirement for many of the materials in this International Standard.

8.2 Several different hardness scales are used in this International Standard. The most commonly used scales are Rockwell “C” (HRC), Rockwell “B” (HRBS), Brinell (HBW), and Vickers 49 N (5 kgf) or 98 N (10 kgf) (HV 5 or HV 10). Background information on these hardness scales and the logic behind the various references is provided in Annex B.

8.3 Hardness testing and reporting shall be performed in strict compliance with the methods described in the appropriate ASTM or ISO standards. Annex B lists the appropriate standards for the various test methods.

8.4 The standard test parameters (indenters, loads, and major-load dwell time) shall be used for all Rockwell hardness tests. The specimen temperature for Rockwell hardness testing shall be 10 °C to 35 °C (50 °F to 95 °F). No lubricant shall be used. Because Brinell hardness tests are only indicated for steel materials in this International Standard, all Brinell hardness tests shall be performed using 29,4 kN (3 000 kgf) load, a 10 mm indenter, and the standard dwell time of 10 s to 15 s.

8.5 In some cases, maximum allowable hardness values are provided in both HRC (or HRBS) and HBW. In those instances, either scale may be used.

8.6 When hardness requirements are stated in HBW, and testing using stationary Brinell hardness equipment is not viable, testing shall be performed using the comparison hardness test method (commonly, but incorrectly, referred to as portable Brinell hardness testing).

8.7 When applicable, the conversion tables in ASTM E140 or ISO 18265 shall be used for conversion of hardness values obtained by other test methods to HRC, HRBS, or HBW values. However, tables for many materials do not exist in those standards. The tables should be used only for materials that are specifically listed. Conversions may be performed based on empirical data for materials that are not covered when approved by the end user. When converted hardness values are used, they shall be reported in accordance with the requirements specified in ASTM E140 or ISO 18265.

8.8 Sufficient hardness tests shall be made to establish the actual hardness of the material being examined. Individual hardness readings exceeding the specified value shall be considered acceptable if the average of several readings taken within close proximity does not exceed the specified value and no individual reading exceeds the specified value by more than 2 HRC (or by more than 5 % in the case of HBW or HV 10).

8.9 Acceptance criteria for microhardness testing using Knoop or Vickers hardness test methods (see ASTM E384) are outside the scope of this International Standard. See Annex B for more information.

8.10 The use of portable hardness testing methods to verify compliance with the requirements of this International Standard is prohibited unless explicitly approved by the end user. The one exception that does not require end user approval is the use of comparison hardness testing in accordance with ASTM A833 to evaluate weld deposits as specified in NACE SP0472 (see Annex B).

۱- با توجه به دشواری های آزمون کشش و غیرمخرب بودن سختی سنجی و نیاز به ابعاد ریز کمتر ←
سختی سنجی ملاک اصلی این استاندارد جهت استحکام فلز پایه

Annex 2E.1 Table → ASME FFS

۲- سختی سنجی HRC–HB – معادل

۳- سختی سنجی پرتابل مجاز – E140 – تبدیل سختی ها استفاده شود.

۴- معیار سختی سنجی

میانگین : $avg \leq$ specified value

انفرادی :

$Individ \leq HRC_{spec} + 2$

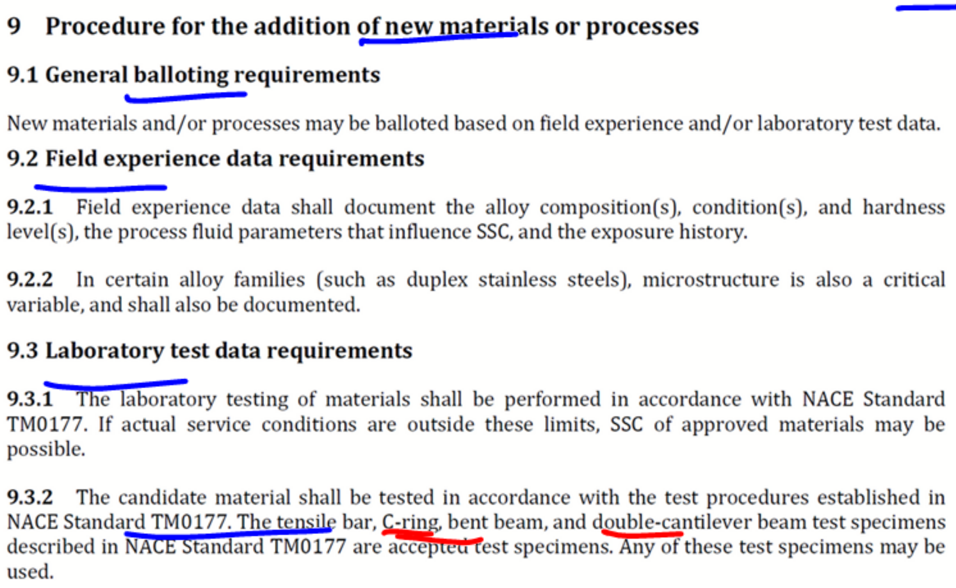
$Indiv \leq 1.05\ HBW / HV10$

۹۱ ← NACE SP0472 ← سختی سنجی پرتابل مجاز و مطابق
همین متالورژی

۹ - متدلوژی تأیید :

۱ - Field exp - تجربیات عملی

۲ - آزمایشگاهی TM0177



9 Procedure for the addition of new materials or processes

9.1 General balloting requirements

New materials and/or processes may be balloted based on field experience and/or laboratory test data.

9.2 Field experience data requirements

9.2.1 Field experience data shall document the alloy composition(s), condition(s), and hardness level(s), the process fluid parameters that influence SSC, and the exposure history.

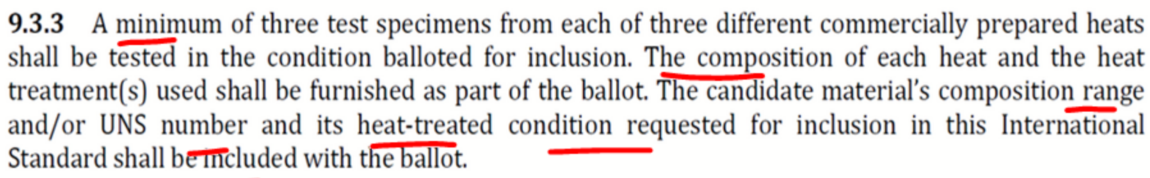
9.2.2 In certain alloy families (such as duplex stainless steels), microstructure is also a critical variable, and shall also be documented.

9.3 Laboratory test data requirements

9.3.1 The laboratory testing of materials shall be performed in accordance with NACE Standard TM0177. If actual service conditions are outside these limits, SSC of approved materials may be possible.

9.3.2 The candidate material shall be tested in accordance with the test procedures established in NACE Standard TM0177. The tensile bar, C-ring, bent beam, and double-cantilever beam test specimens described in NACE Standard TM0177 are accepted test specimens. Any of these test specimens may be used.

used.



9.3.3 A minimum of three test specimens from each of three different commercially prepared heats shall be tested in the condition balloted for inclusion. The composition of each heat and the heat treatment(s) used shall be furnished as part of the ballot. The candidate material's composition range and/or UNS number and its heat-treated condition requested for inclusion in this International Standard shall be included with the ballot.

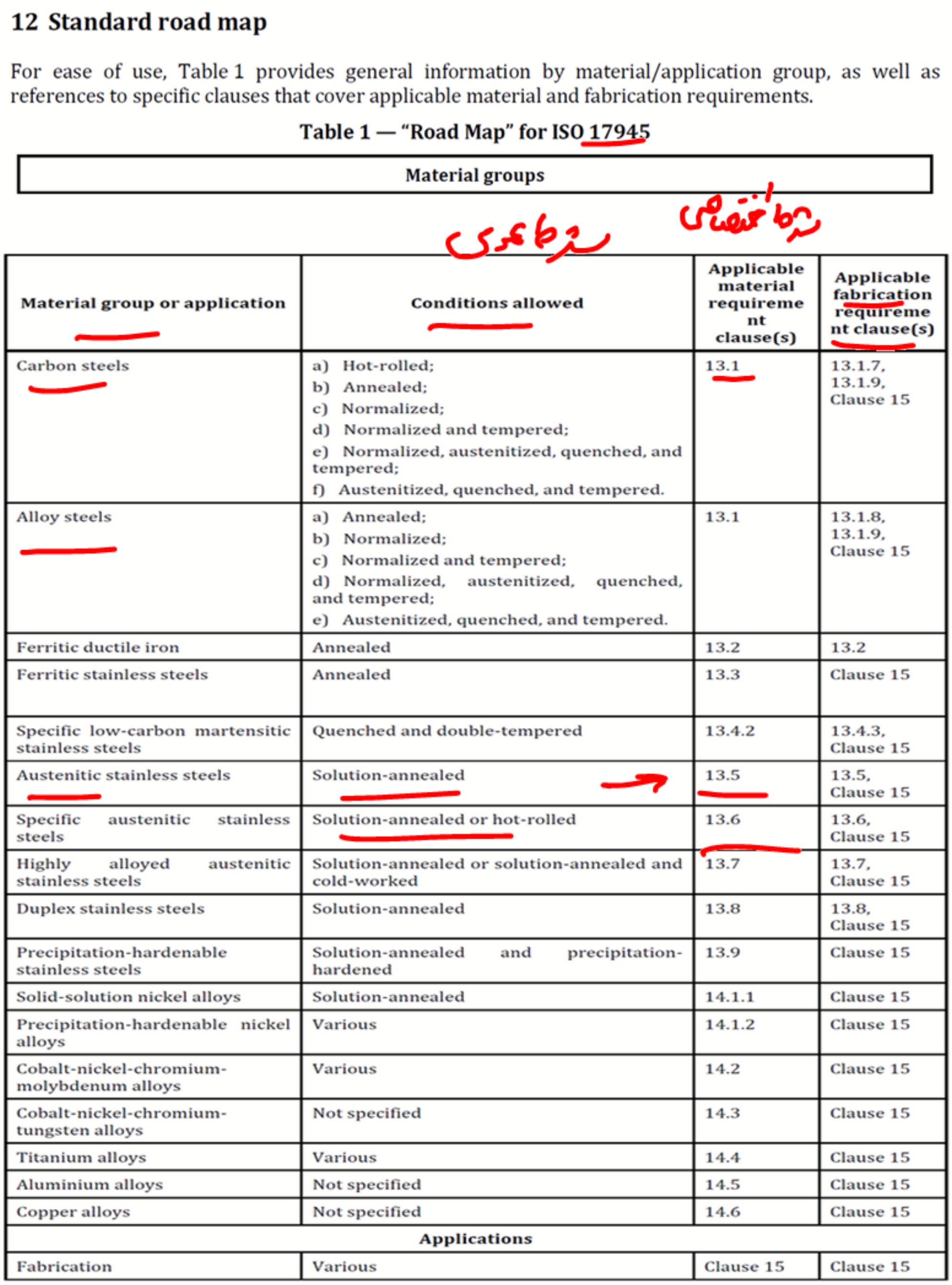
روش تأیید متریال جدید:

۱ - آزمایشگاهی TM0177

۱ C_Cring
۲ bent beam
۳ Double Cantlere beam

۲ - حداقل ۳ Heat از متریال باید تأیید شود.

۱۲ نقشه راه برای - MR0103



12 Standard road map

For ease of use, Table 1 provides general information by material/application group, as well as references to specific clauses that cover applicable material and fabrication requirements.

Table 1 — "Road Map" for ISO 17945

Material groups

شرط عمومی

شرط اختصاصی

Material group or application	Conditions allowed	Applicable material requirement clause(s)	Applicable fabrication requirement clause(s)
Carbon steels	a) Hot-rolled; b) Annealed; c) Normalized; d) Normalized and tempered; e) Normalized, austenitized, quenched, and tempered; f) Austenitized, quenched, and tempered.	13.1	13.1.7, 13.1.9, Clause 15
Alloy steels	a) Annealed; b) Normalized; c) Normalized and tempered; d) Normalized, austenitized, quenched, and tempered; e) Austenitized, quenched, and tempered.	13.1	13.1.8, 13.1.9, Clause 15
Ferritic ductile iron	Annealed	13.2	13.2
Ferritic stainless steels	Annealed	13.3	Clause 15
Specific low-carbon martensitic stainless steels	Quenched and double-tempered	13.4.2	13.4.3, Clause 15
Austenitic stainless steels	Solution-annealed	13.5	13.5, Clause 15
Specific austenitic stainless steels	Solution-annealed or hot-rolled	13.6	13.6, Clause 15
Highly alloyed austenitic stainless steels	Solution-annealed or solution-annealed and cold-worked	13.7	13.7, Clause 15
Duplex stainless steels	Solution-annealed	13.8	13.8, Clause 15
Precipitation-hardenable stainless steels	Solution-annealed and precipitation-hardened	13.9	Clause 15
Solid-solution nickel alloys	Solution-annealed	14.1.1	Clause 15
Precipitation-hardenable nickel alloys	Various	14.1.2	Clause 15
Cobalt-nickel-chromium-molybdenum alloys	Various	14.2	Clause 15
Cobalt-nickel-chromium-tungsten alloys	Not specified	14.3	Clause 15
Titanium alloys	Various	14.4	Clause 15
Aluminium alloys	Not specified	14.5	Clause 15
Copper alloys	Not specified	14.6	Clause 15
Applications			
Fabrication	Various	Clause 15	Clause 15

13 Ferrous materials

13.1 Carbon and alloy steels

13.1.1 Requirements for all carbon and alloy steels

شروط عمومی

Carbon and alloy steels shall require the following:

a) not contain intentional additions of elements such as lead, selenium, or sulfur to improve machinability;

صفر

b) meet the criteria of 13.1.6 through 13.1.9; →

c) be used in one of the following heat-treatment conditions:

  1) hot-rolled (carbon steels only);
  2) annealed;
  3) normalized;
  4) normalized and tempered;
  5) normalized, austenitized, quenched, and tempered;
  6) austenitized, quenched, and tempered.

NOTE There is no 1 % maximum nickel restriction for carbon steels and alloy steels.

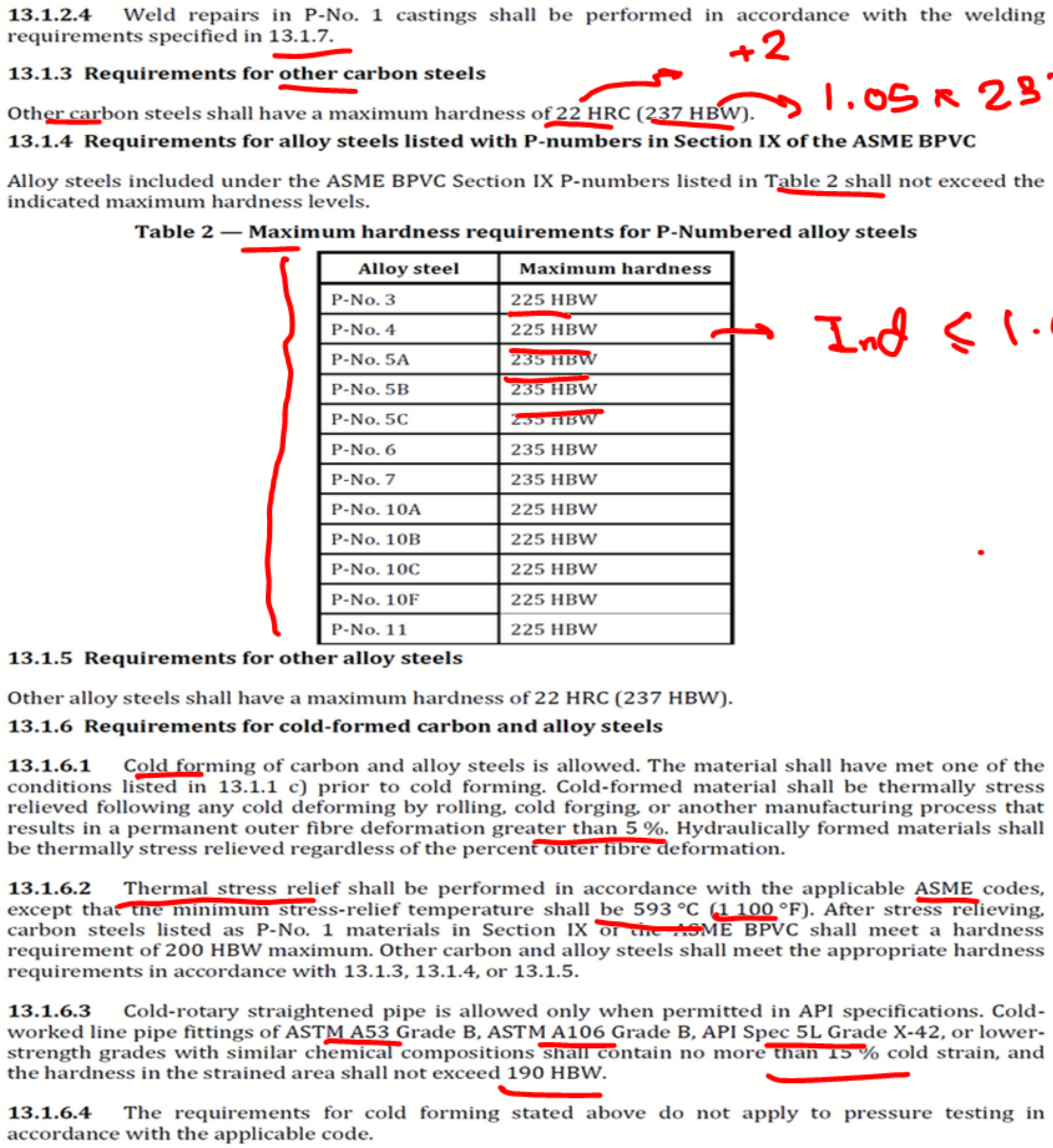
13.1.2 Requirements for carbon steels listed as P-No. 1 Group 1 or 2 in Section IX of the ASME BPVC

13.1.2.1 Carbon steels listed as P-No. 1 Group 1 or 2 materials in Section IX of the ASME BPVC shall meet one of the conditions listed in 13.1.1, c). Base-metal hardness controls are not required.

13.1.2.2 Welding of P-No. 1 carbon steels shall be controlled in accordance with 13.1.7 and 13.1.9.

13.1.2.3 Bends in P-No. 1 piping formed by heating to above the upper transformation temperature, A_{c3}, are allowed. The material shall have met one of the conditions listed in 13.1.1, c) prior to forming. The hardness in the bend area shall not exceed 225 HBW.

ASME B16.49



13.1.2.4 Weld repairs in P-No. 1 castings shall be performed in accordance with the welding requirements specified in 13.1.7.

13.1.3 Requirements for other carbon steels

+2

Other carbon steels shall have a maximum hardness of 22 HRC (237 HBW). → 1.05 × 237

13.1.4 Requirements for alloy steels listed with P-numbers in Section IX of the ASME BPVC

Alloy steels included under the ASME BPVC Section IX P-numbers listed in Table 2 shall not exceed the indicated maximum hardness levels.

Table 2 — Maximum hardness requirements for P-Numbered alloy steels

Alloy steel	Maximum hardness
P-No. 3	225 HBW
P-No. 4	225 HBW
P-No. 5A	235 HBW
P-No. 5B	235 HBW
P-No. 5C	235 HBW
P-No. 6	235 HBW
P-No. 7	235 HBW
P-No. 10A	225 HBW
P-No. 10B	225 HBW
P-No. 10C	225 HBW
P-No. 10F	225 HBW
P-No. 11	225 HBW

→ Ind ≤ 1.05 جدول

13.1.5 Requirements for other alloy steels

Other alloy steels shall have a maximum hardness of 22 HRC (237 HBW).

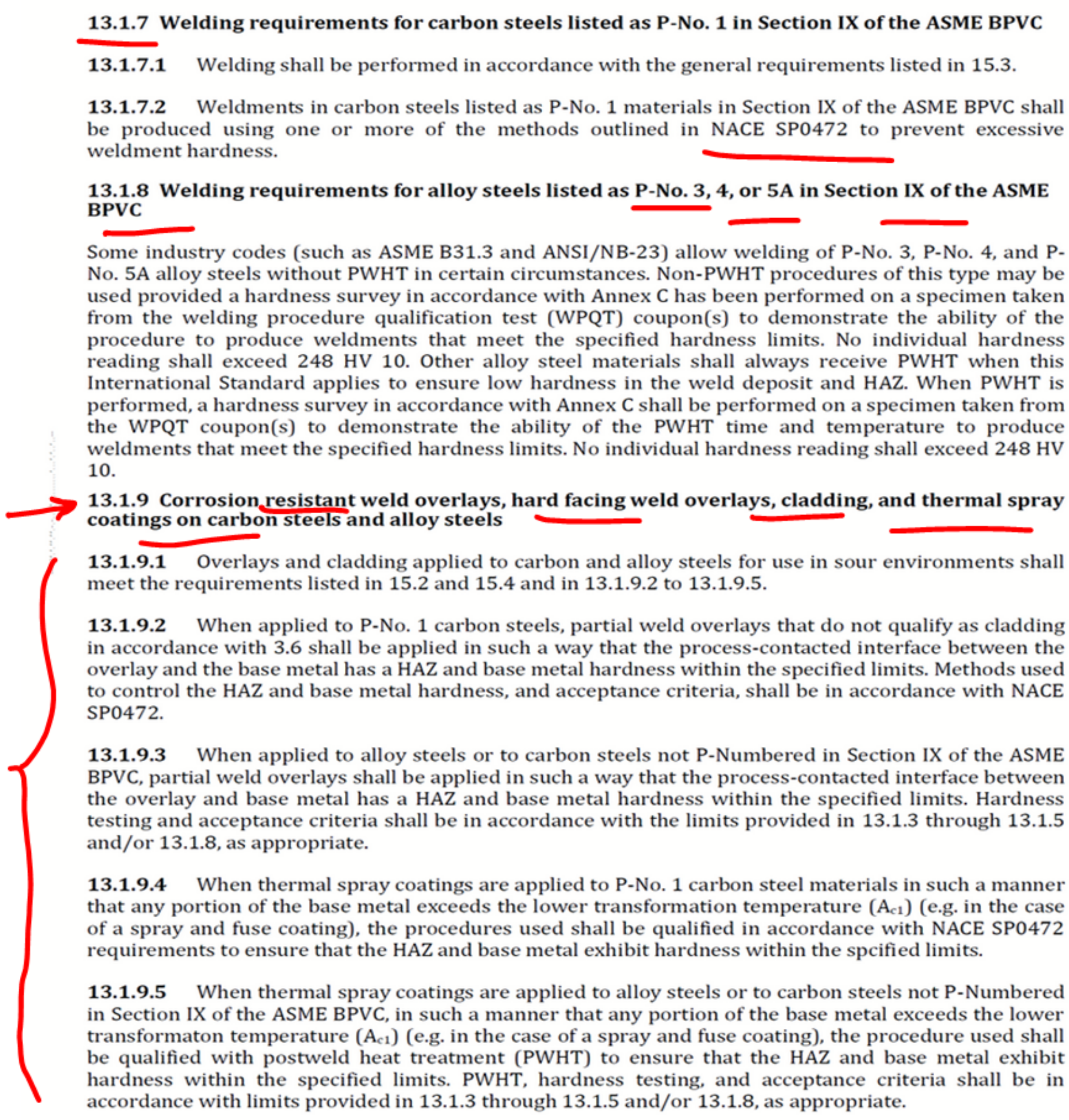
13.1.6 Requirements for cold-formed carbon and alloy steels

13.1.6.1 Cold forming of carbon and alloy steels is allowed. The material shall have met one of the conditions listed in 13.1.1 c) prior to cold forming. Cold-formed material shall be thermally stress relieved following any cold deforming by rolling, cold forging, or another manufacturing process that results in a permanent outer fibre deformation greater than 5 %. Hydraulically formed materials shall be thermally stress relieved regardless of the percent outer fibre deformation.

13.1.6.2 Thermal stress relief shall be performed in accordance with the applicable ASME codes, except that the minimum stress-relief temperature shall be 593 °C (1 100 °F). After stress relieving, carbon steels listed as P-No. 1 materials in Section IX of the ASME BPVC shall meet a hardness requirement of 200 HBW maximum. Other carbon and alloy steels shall meet the appropriate hardness requirements in accordance with 13.1.3, 13.1.4, or 13.1.5.

13.1.6.3 Cold-rotary straightened pipe is allowed only when permitted in API specifications. Cold-worked line pipe fittings of ASTM A53 Grade B, ASTM A106 Grade B, API Spec 5L Grade X-42, or lower-strength grades with similar chemical compositions shall contain no more than 15 % cold strain, and the hardness in the strained area shall not exceed 190 HBW.

13.1.6.4 The requirements for cold forming stated above do not apply to pressure testing in accordance with the applicable code.



13.1.7 Welding requirements for carbon steels listed as P-No. 1 in Section IX of the ASME BPVC

13.1.7.1 Welding shall be performed in accordance with the general requirements listed in 15.3.

13.1.7.2 Weldments in carbon steels listed as P-No. 1 materials in Section IX of the ASME BPVC shall be produced using one or more of the methods outlined in NACE SP0472 to prevent excessive weldment hardness.

13.1.8 Welding requirements for alloy steels listed as P-No. 3, 4, or 5A in Section IX of the ASME BPVC

Some industry codes (such as ASME B31.3 and ANSI/NB-23) allow welding of P-No. 3, P-No. 4, and P-No. 5A alloy steels without PWHT in certain circumstances. Non-PWHT procedures of this type may be used provided a hardness survey in accordance with Annex C has been performed on a specimen taken from the welding procedure qualification test (WPQT) coupon(s) to demonstrate the ability of the procedure to produce weldments that meet the specified hardness limits. No individual hardness reading shall exceed 248 HV 10. Other alloy steel materials shall always receive PWHT when this International Standard applies to ensure low hardness in the weld deposit and HAZ. When PWHT is performed, a hardness survey in accordance with Annex C shall be performed on a specimen taken from the WPQT coupon(s) to demonstrate the ability of the PWHT time and temperature to produce weldments that meet the specified hardness limits. No individual hardness reading shall exceed 248 HV 10.

13.1.9 Corrosion resistant weld overlays, hard facing weld overlays, cladding, and thermal spray coatings on carbon steels and alloy steels

13.1.9.1 Overlays and cladding applied to carbon and alloy steels for use in sour environments shall meet the requirements listed in 15.2 and 15.4 and in 13.1.9.2 to 13.1.9.5.

13.1.9.2 When applied to P-No. 1 carbon steels, partial weld overlays that do not qualify as cladding in accordance with 3.6 shall be applied in such a way that the process-contacted interface between the overlay and the base metal has a HAZ and base metal hardness within the specified limits. Methods used to control the HAZ and base metal hardness, and acceptance criteria, shall be in accordance with NACE SP0472.

13.1.9.3 When applied to alloy steels or to carbon steels not P-Numbered in Section IX of the ASME BPVC, partial weld overlays shall be applied in such a way that the process-contacted interface between the overlay and base metal has a HAZ and base metal hardness within the specified limits. Hardness testing and acceptance criteria shall be in accordance with the limits provided in 13.1.3 through 13.1.5 and/or 13.1.8, as appropriate.

13.1.9.4 When thermal spray coatings are applied to P-No. 1 carbon steel materials in such a manner that any portion of the base metal exceeds the lower transformation temperature (A_{c1}) (e.g. in the case of a spray and fuse coating), the procedures used shall be qualified in accordance with NACE SP0472 requirements to ensure that the HAZ and base metal exhibit hardness within the spcified limits.

13.1.9.5 When thermal spray coatings are applied to alloy steels or to carbon steels not P-Numbered in Section IX of the ASME BPVC, in such a manner that any portion of the base metal exceeds the lower transformaton temperature (A_{c1}) (e.g. in the case of a spray and fuse coating), the procedure used shall be qualified with postweld heat treatment (PWHT) to ensure that the HAZ and base metal exhibit hardness within the specified limits. PWHT, hardness testing, and acceptance criteria shall be in accordance with limits provided in 13.1.3 through 13.1.5 and/or 13.1.8, as appropriate.