

API Ballot 7235

API-AGA Joint Committee on Pipeline Welding

Revision Description	Proposed new Annex D, Welding of Pipelines and Related Facilities Affected by Hydrogen, for API Standard 1104, Edition 22
Sections Revised	Section 1 Scope Section 5.1 Procedure Qualification Section 8.2 Methods of Inspection Section 10.1 General Section A.1 General Section B.1 General *New* Annex D
Type of Ballot (Initial, Comment, Comment resolution (reference API ballot#), 1 st Re-ballot, 2 nd Re-ballot, etc.)	Comment-Only (no vote)
API Document Modified	API 1104 22 nd Edition, Addendum 1
Revision Key	Current API text = black Deletions = ~~red strikethrough~~ Additions = <u>underlined red</u>

Ballot Description: This “Comment-Only” ballot is on the proposed Annex D, Welding of Pipelines and Related Facilities Affected by Hydrogen, for a potential revision of API Standard 1104, Welding of Pipelines and Related Facilities, 22nd Edition. No voting options are available. The purpose of this ballot is to review and provide comments on the revised sections for API 1104, 22nd Edition. Be sure to examine the document carefully and thoroughly, also checking for accuracy with any cited references, cross references, descriptions, terminology, and values.

Section 1 (Scope): The section has been changed as indicated by the **red markup** below:

1 Scope

This standard covers the gas and arc welding of butt, branch, and fillet welds in carbon and low-alloy steel pipe and piping components used in the compression, pumping, and transmission of crude petroleum, petroleum products, fuel gases, carbon dioxide, nitrogen, and, where applicable, covers welding on distribution systems. It applies to both new construction and in-service welding. The welding may be done by a shielded metal arc welding, submerged arc welding, gas tungsten arc welding, gas metal arc welding, flux-cored arc welding, plasma arc welding, or oxyacetylene welding process, or by a combination of these processes using a manual, semiautomatic, or mechanized welding technique or a combination of these techniques. The welds may be produced by position or roll welding or by a combination of position and roll welding.

This standard also covers the procedures for radiographic, magnetic particle, liquid penetrant, and ultrasonic testing, as well as the acceptance standards to be applied to production welds tested to destruction or inspected by radiographic, magnetic particle, liquid penetrant, ultrasonic, and visual testing methods.

This standard includes annexes **covering addressing** alternative acceptance standards for girth welds (**Annex A**), in-service welding (**Annex B**), **and** guidelines for performing an engineering critical assessment (ECA) for offshore pipelines installed by reeling (**Annex C**), **and additional welding requirements for pipelines and related facilities used in the transportation of hydrogen or hydrogen-containing blends (Annex D).**

The values stated in either U.S. customary units (USC) or metric units (SI) are to be regarded separately as standard. Each system is to be used independently of the other, without combining values in any way.

The figures depicted in this standard are not drawn to scale.

It is intended that all work performed in accordance with this standard meets or exceeds the requirements of this standard.

While this standard is comprehensive, it may not address all issues that may arise. The absence of guidance or requirements is not to be considered prohibitive to a particular activity or approach that is based upon sound engineering judgment. For example, other industry standards, reliable engineering tests and analyses, or established industry practices may provide useful reference to establish sound engineering judgment.

Section 5.1: The section has been changed as indicated by the **red markup** below:

5.1 Procedure Qualification

This section shall apply to the qualification of welding procedures using manual welding and semiautomatic welding processes with filler metal additions.

When a welding procedure specification uses a combination of manual/semiautomatic and mechanized welding, the requirements of Section 5 and Section 12 shall apply to their portions of the welding procedure specification.

For welding of pipelines and related facilities used in the transportation of hydrogen or hydrogen-containing blends, the additional procedure qualification requirements of Annex D shall apply.

NOTE 1 Section 12 applies to the qualification of welding procedures using mechanized welding with filler metal additions.

Before production welding is started, a procedure qualification record shall be completed and a detailed welding procedure specification shall be written to demonstrate that sound welds with suitable mechanical properties (such as strength, ductility, and hardness) can be made by the procedure. The acceptance of the

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procedure qualification welds shall be determined by destructive testing in accordance with 5.6 or 5.8 as applicable.

NOTE 2 Multiple qualification weld reports may be combined to qualify a range of essential variables within one welding procedure specification. Similarly, a single qualification weld report can support multiple welding procedure specifications.

Section 8.2: The section has been changed as indicated by the *red markup* below:

8.2 Methods of Inspection

The NDT method used shall produce indications of imperfections that can be accurately interpreted and evaluated. The welds shall be evaluated on the basis of either Section 9 or, at the company's option, Annex A. *When Annex A is used, more extensive inspection to determine the imperfection size is required. Where Annex D applies, the additional acceptance requirements of D.3 shall also be satisfied.* For engineering critical assessment (ECA) of girth welds in offshore pipelines installed by reeling, see Annex C.

Destructive testing shall consist of the removal of completed welds, sectioning of the welds into specimens, and the examination of the specimens. The specimens shall be prepared in accordance with and shall meet the requirements of 6.5. The company shall have the right to accept or reject any weld that does not meet the requirements for the method by which it was inspected.

NOTE 1 The welder who makes a weld that fails to comply with the requirements may be disqualified from further work.

NOTE 2 Operators of nondestructive inspection equipment may be required to demonstrate the inspection procedure's capability to detect defects and the operator's ability to properly interpret the indications given by the equipment.

Trepanning methods of testing shall not be used.

Section 10.1: The section has been changed as indicated by the *red markup* below:

10 Repair and Removal of Weld Defects

10.1 General

Weld defects identified during visual inspection, nondestructive testing, or during the company's review of nondestructive testing results shall be repaired. *For welds subject to Annex D, the additional repair requirements of D.4 shall apply.*

The full length of the defect being repaired in a single repair area shall be removed and repaired as part of the repair weld process; intentional partial repair of a defect is prohibited. However, if part of the original defect remains after repair and the repair weld meets the acceptance criteria of Section 9, the repair weld shall be considered acceptable. New indications introduced by the repair weld shall be acceptable if the acceptance criteria is satisfied. Defects rejected by Annex A shall be repaired along the full length of the identified defect.

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*Section A.1: The section has been changed as indicated by the **red markup** below:*

A.1 General

...

This annex provides procedures to determine the maximum allowable imperfection sizes. It does not prevent the use of Section 9 for determining imperfection acceptance limits for any weld. Use of this annex is completely at the company's option.

For welds subject to Annex D, the additional requirements of D.3 shall also apply.

In this annex, the use of the phrase imperfection acceptance limits and other phrases containing the word imperfection is not intended to imply a defective condition or any lack of weld integrity. All welds contain certain features variously described as artifacts, imperfections, discontinuities, or flaws. These terms are widely accepted and used interchangeably. The primary purpose of this annex is to define, on the basis of a technical analysis, the effect of various types, sizes, and shapes of such anomalies on the suitability of the whole weld for a specific service.

...

*Section B.1: The section has been changed as indicated by the **red markup** below:*

B.1 General

...

An in-service pipeline or piping system that operates under such conditions that do not increase the weld cooling rate or increase the risk of hydrogen cracking when compared to the Section 5 procedure qualification conditions should be welded in accordance with that Section 5 welding procedure or Annex B.

For welds subject to Annex D, the additional requirements of D.5 shall also apply.

There are two primary concerns with welding onto in-service pipelines. The first concern is to avoid "burn-through," (defined in 3.1.6), where the welding arc causes the pipe wall to be breached. The second concern is for hydrogen cracking, since welds made in service cool at an accelerated rate as the result of the flowing contents' ability to remove heat from the pipe wall.

...

New Annex D: The following annex has been added, and the subsequent annex has been renumbered as Annex E:

Annex D **(normative)**

Welding of Pipelines and Related Facilities Affected by Hydrogen

D.1 General

D.1.1 Scope

This annex contains specific requirements for the welding of pipelines and related facilities used in the transportation of hydrogen or blends containing hydrogen.

This annex is applicable when the pipeline design requires welding to meet API 1104 with supplemental requirements for hydrogen, or when specified by the company.

The main body of this standard applies, with the additional requirements specified in this annex:

- Qualification of welding procedures shall be in accordance with Section 5 and D.2 for manual and semiautomatic processes, or Section 12 and D.2 for mechanized welding procedures.
- Qualification of welding procedures for alternate acceptance criteria shall be in accordance with Annex A and D.3.2.
- Qualification of repair welding shall be in accordance with Section 10 and D.4.
- Qualification of in-service welding shall be in accordance with Annex B and D.5.
- Acceptance standards shall be in accordance with Section 9 and D.3. Use of alternate acceptance criteria shall be qualified in accordance with Annex A and D.3.2.

D.2 Qualification of Welding Procedure Specifications

D.2.1 Butt, Branch and Fillet Welds

For all butt, branch and fillet welds, except as defined in D.2.2 and D.2.3, Category II welding procedures in accordance with Section 5 or Section 12 for both hardness and toughness are required. For branch and fillet welds, where CVN test specimens cannot be removed due to geometry, a butt groove test weld made using the parameters in the branch or fillet welding procedure, is required for CVN testing.

D.2.2 Seal Welds for Threaded Connections

Section 5 Category II welding procedures for hardness are required when seal (fillet) welds are used on threaded connections. Seal welds can be completed using either:

- a) An existing fillet weld procedure qualified to D.2.1.
- b) A seal weld mockup test with hardness testing only.

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D.2.3 Non-Structural External Attachments

Welding procedures for non-structural external attachment welds shall be qualified using a representative weld type. Section 5 Category II welding procedures for hardness are required. A weld procedure qualified to D.2.1 may be used for non-structural external attachments.

NOTE Structural attachments are outside the scope of this annex.

D.2.4 Cathodic Attachments

Procedures for cathodic corrosion protection attachments shall be qualified to appropriate standards and shall include hardness testing in accordance with this annex.

D.2.5 Postweld Heat Treatment (PWHT)

PWHT procedures shall be approved by the company.

NOTE PWHT procedures may be based on the guidance in AWS D10.10/D10.10M, ASME BPVC Section VIII Div.1, or ASME B31P.

PWHT of qualification test welds may be performed in a furnace or using simulated production PWHT of the entire weldment.

The following shall be specified in the WPS:

- a) Maximum heating and cooling rates.
- b) Number and location of thermocouples.
- c) Heating and cooling method.
- d) For quench and tempered steels, the maximum temperature shall be at least 45°F (25°C) below the tempering temperature of the materials being welded.

D.2.6 Additional Essential Variables

Section 5 and Section 12 welding procedures shall be qualified using the essential variables listed in Table 1 and Table 20, respectively, and the additional essential variables in this section.

D.2.6.1 Carbon Equivalent

An increase in carbon equivalent above either 0.02 CE_{Pcm} or 0.03 CE_{IW} of the material used for procedure qualification.

Carbon equivalent is calculated as CE_{Pcm} and/or CE_{IW} using equations (D.1) and (D.2) respectively. When both terms are listed on the WPS, the company shall define the applicability of each.

$$CE_{Pcm} = C + \frac{Si}{30} + \frac{(Mn+Cu+Cr)}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (D.1)$$

$$CE_{IW} = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Cu+Ni)}{15} \quad (D.2)$$

NOTE CE_{Pcm} is generally used for C ≤ 0.12%, and CE_{IW} is used for C > 0.12%. Carbon equivalent limit does not apply to welding consumables or deposited weld metal.

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D.2.6.2 Multipass to Single Pass

A change from a multiple-pass weld per side to single-pass weld per side, but not vice-versa.

D.2.6.3 Back Weld Pass(es)

- a) A change in sequence of the back weld pass(es) relative to the other welding passes.
- b) The addition of back weld pass(es), but not the omission (when the back weld is not required).

D.2.6.3 is not applicable to back weld repairs, which are covered in D.4.

D.2.6.4 Non-Fusing Root Backing

- a) The addition or deletion of non-fusing backing material for the root pass, e.g., copper or ceramic.
- b) The type of non-fusing backing.

D.2.6.5 Postweld Heat Treatment (PWHT)

- a) A change in PWHT temperature exceeding $\pm 45^{\circ}\text{F}$ (25°C) of that recorded during qualification.
- b) If a single PWHT hold time is qualified, a change in PWHT hold time of – 0 minutes to + 15 minutes of that recorded during qualification.
- c) When maximum and minimum PWHT hold times are qualified, the full range of hold times between these values is qualified.

NOTE The maximum aggregate PWHT hold time can include allowance for multiple PWHT cycles (e.g., when required for repair welding).

NOTE For quenched and tempered steels, the maximum PWHT temperature shall be at least 45°F (25°C) below the tempering temperature of the material used for qualification.

D.2.7 Supplemental PQR(s) to Support Previous WPS

A previously qualified WPS can be updated to meet the requirements of this annex with satisfactory supplemental PQR(s). The supplemental PQR(s) shall comply with this annex, and the updated WPS shall comply with this edition of API 1104.

D.2.8 Welding Procedure Qualification Testing

Qualification of welding procedures shall include the additional testing given in Table D.1 and defined in this section.

If the required number of test specimens cannot be removed from a single test weld, multiple test welds shall be performed using similar welding conditions, and the specimens shall evenly be distributed throughout all test welds.

Table D.1 - Type and Number of Test Specimens for Welding Procedure Qualification Test

Weld Type	Hardness	CVN (Set of 3 individual specimens)
Butt, branch ¹ , and fillet ¹ welds	One	Weld Metal and HAZ ²
External attachments and seal welds	One	Not required
¹ Except as specified in D.2.2 and D.2.3, when CVN test specimens cannot be removed due to geometry, a butt groove test weld is required. ² One set in the weld and one set in the HAZ for the base material being qualified.		

For PWHT procedures where maximum and minimum hold times are qualified, as per D.2.6.5 c), the qualification testing in Table D.1 shall be performed on welds produced at the maximum aggregate hold time, with an additional hardness test performed on welds produced at the minimum hold time.

D.2.8.1 Charpy V-Notch (CVN) Testing

D.2.8.1.1 Specimen Preparation

Testing shall be performed in accordance with ASTM E23. Two sets of three CVN specimens shall be removed from the 12 o'clock position unless specified otherwise by the company. One set shall be notched at the weld centerline, and the other set shall be notched in the HAZ of the base material being qualified as shown in Figure A.2. If multiple base materials are being qualified in a single weld, the HAZ on each side of the weld shall be tested.

When misalignment is present and/or the wall thickness is not sufficient to obtain full-sized CVN specimens, sub-sized CVN specimens may be used as defined in D.2.8.1.1 a) or b). The largest possible sub-sized CVN specimens shall be used.

- For materials of thickness equal to or greater than 10 mm (0.394 in.) full-sized CVN specimens should be used when possible. When the largest attainable CVN specimen has a thickness along the notch of at least 8 mm (0.315 in.), testing shall be conducted at a temperature in accordance with D.2.8.1.2 a). When the largest possible test specimen has a thickness along the notch less than 8 mm (0.315 in.), the test shall be conducted at a temperature in accordance with D.2.8.1.2 b).
- For materials with thickness less than 10 mm (0.394 in.), when the largest attainable CVN specimen has a thickness along the notch of at least 80% of the material thickness, testing shall be conducted at a temperature in accordance with D.2.8.1.2 a). When the largest attainable CVN specimen has a thickness along the notch of less than 80% of the material thickness, the CVN test temperature shall be in accordance with D.2.8.1.2 c).

D.2.8.1.2 Test Temperature

The CVN test temperature shall be according to the following:

- For full-size CVN specimens, or specimens that are at least 80% of the wall thickness, the testing temperature shall be 32°F (0°C) or the minimum design temperature, whichever is lower.

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- b) For sub-size CVN specimens defined in D.2.8.1.1 a), the CVN test temperature defined in D.2.8.1.2 a) shall be reduced in accordance with Table D.2.
- c) For sub-size CVN specimens defined in D.2.8.1.1 b), the CVN test temperature defined in D.2.8.1.2 a) shall be reduced in accordance with Table D.2 based on the temperature reduction between the pipe nominal wall thickness and the sub-size CVN specimen thickness.

Table D.2 – Temperature Adjustment for Sub-Sized Charpy V-Notch (CVN) Test Specimens

CVN Specimen thickness ¹		Temperature Reduction Below the Test Temperature Required for a Full-Sized Specimen	
mm	Inch	°C	°F
10	0.394	0	0
9	0.354	0	0
8	0.315	0	0
7.5 (3/4 size)	0.295	3	5
7	0.276	4	8
6.7 (2/3 size)	0.264	6	10
6	0.236	8	15
5 (1/2 size)	0.197	11	20
4	0.157	17	30
3.3 (1/3 size)	0.130	19	35
3	0.118	22	40
2.5 (1/4 size)	0.098	28	50
¹ Straight line interpolation for intermediate values is permitted.			

D.2.8.1.3 Acceptance Criteria

Unless otherwise specified by the company, the required full-sized equivalent minimum impact energy shall be:

- a) 30 ft-lb (40 J) for the average in each set of specimens (weld metal and/or HAZ), and
- b) 22 ft-lb (30 J) for each individual specimen in a set.

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NOTE Only one specimen in a set may be less than the average value of 30 ft-lb (40 J).

If sub-sized specimens are used, the required absorbed energy values shall be the required values for full-size test specimen multiplied by the ratio of the specified width of the sub-sized specimen to the specified width of the full-size specimen, with such derived values rounded to the nearest ft-lb (J).

D.2.8.1.4 Retesting

Retesting shall be permitted when:

- a) No more than one specimen in each set (weld metal and/or HAZ) has an impact energy less than 22 ft-lb (30 J), and
- b) The average impact energy from the set that contains the low individual value exceeds 30 ft-lb (40 J).

A set of three retest specimens shall be extracted from a location as close as possible to the location of the specimen that generated the low result.

The impact energy shall meet the requirements of D.2.8.1.3. If the requirements of D.2.8.1.3 are not met, retesting is not permitted, and the weld shall be rejected.

D.2.8.2 Fracture Toughness Testing in Hydrogen

When required in section D.3, or when specified by the company, fracture toughness testing of the weld metal and HAZ shall be performed on the qualification material in accordance with ANSI/CSA CHMC1 and ASTM E1820. Testing shall be performed in the test environment specified in ANSI/CSA CHMC1, or a gaseous hydrogen environment that conservatively represents the design conditions over the expected life. The user shall define what value of fracture toughness (e.g., J_{0-H} , J_{IC-H}) from the J-R curve is used for analysis.

A set of three specimens shall be taken in both the weld metal and HAZ, from the 12 o'clock position unless specified otherwise by the company.

Retesting may be permitted with company approval of a fracture toughness retesting plan. The retesting plan shall document why retesting was required and the actions taken.

When the design code permits the use of material equivalence, existing conservative fracture toughness data in hydrogen can be used in lieu of fracture toughness testing of the qualification material. The use of material equivalence shall be documented with justification.

D.2.8.3 Hardness Testing

D.2.8.3.1 Specimen Preparation and Hardness Testing

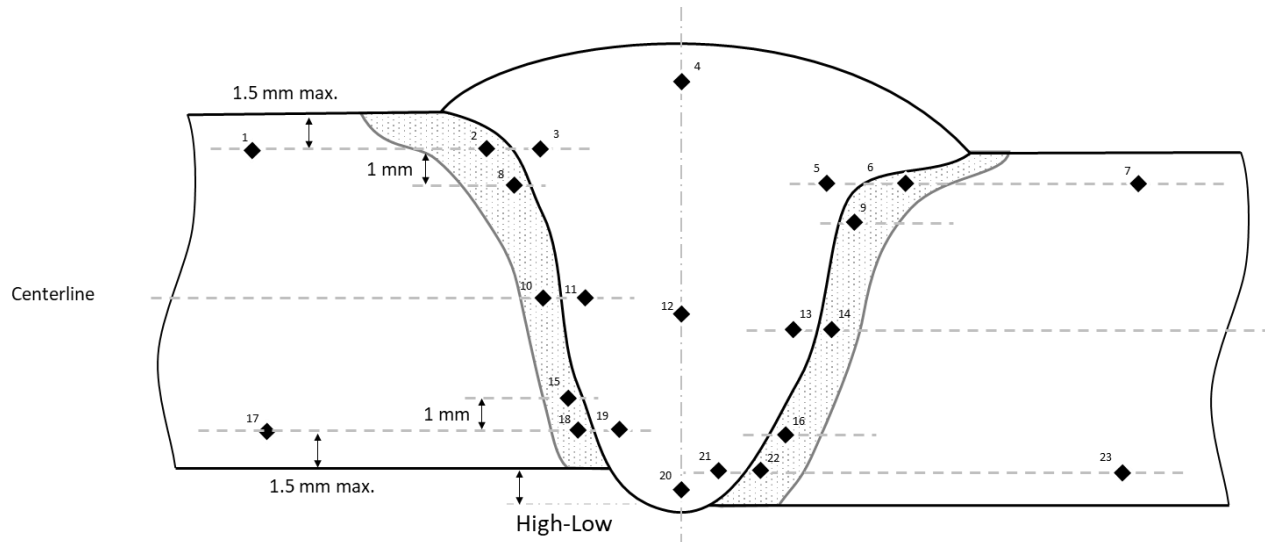
For butt welds, one macrosection shall be removed from the 3 o'clock position, unless a different position is specified by the company. For branch and fillet welds, the macrosection can be taken from any position.

Visual inspection of the macrosection shall be performed and the weld metal and HAZ shall be free of cracks. The use of optical devices is not necessary. For pin brazing, copper penetration shall not exceed 0.8 mm (1/32 in.), or as otherwise defined by the company.

Hardness testing shall be performed using a Vickers indenter with a 10-kg load. The number of indentations and their locations are shown in Figure D.1 through Figure D.4. Additional indent locations may be specified by the company.

All HAZ hardness indentations shall be entirely within the HAZ and located within 0.5 mm from the fusion line as shown in the example in Figure D.5.

NOTE In Figure D.2, Figure D.3, and Figure D.4, indentations 1 and 4 should be located near the weld toe/root to meet both the distance from the surface and from the fusion line.



NOTE High-low is a visual representation only. It is used to show the required location of the hardness indents either side of the welds when high-low exists. Indent 20 may be omitted or altered based on the weld geometry and available space.

Figure D.1 – Butt Groove Weld Hardness Indentation Locations

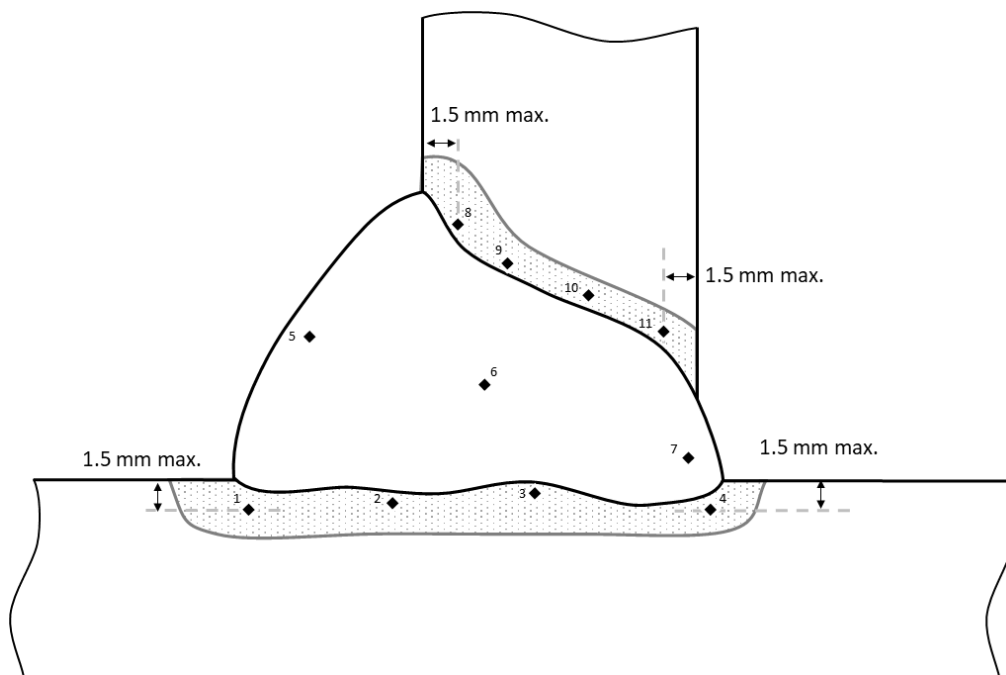


Figure D.2 – Branch Groove Weld Hardness Indentation Locations

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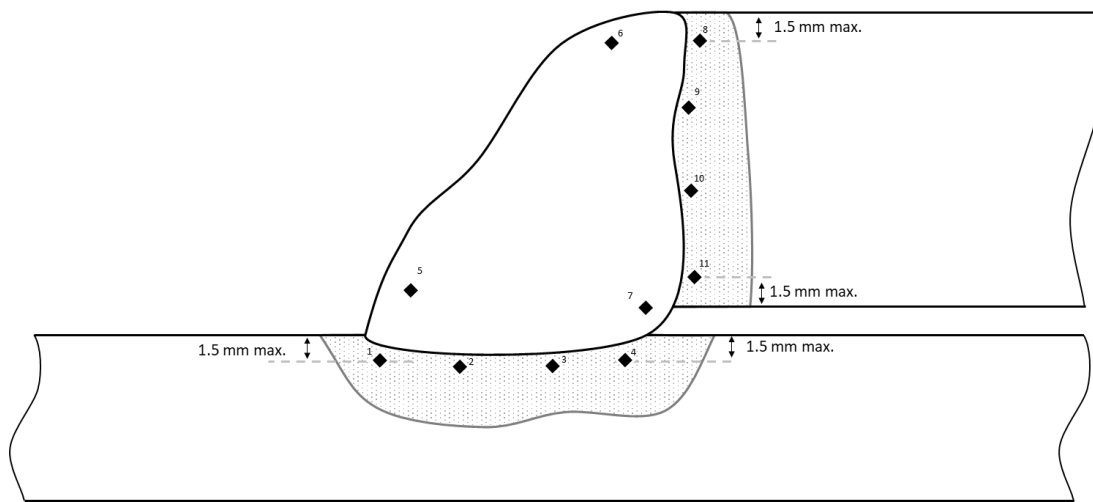


Figure D.3 – Fillet Weld Hardness Indentation Locations

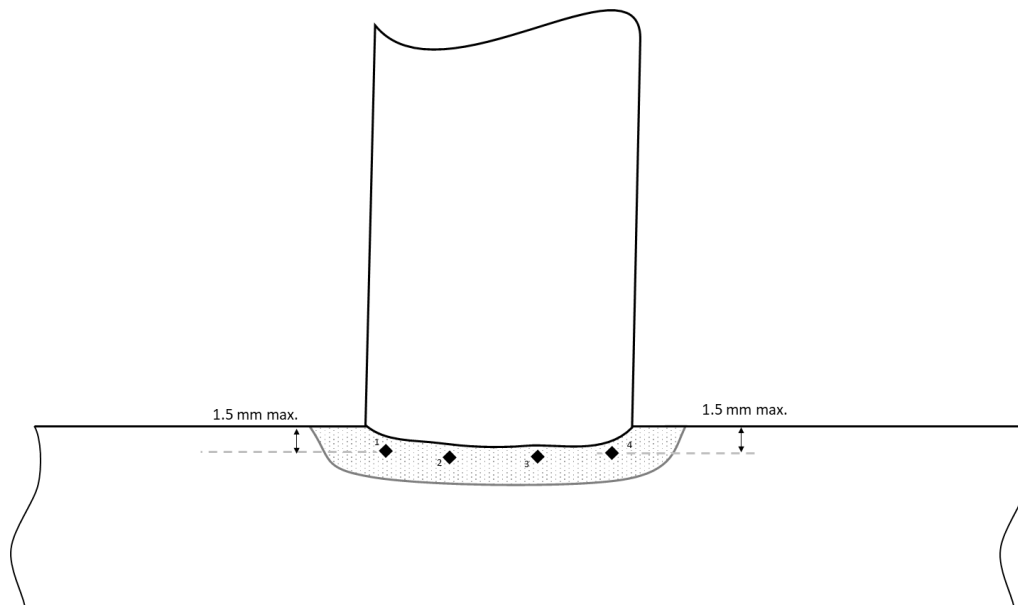
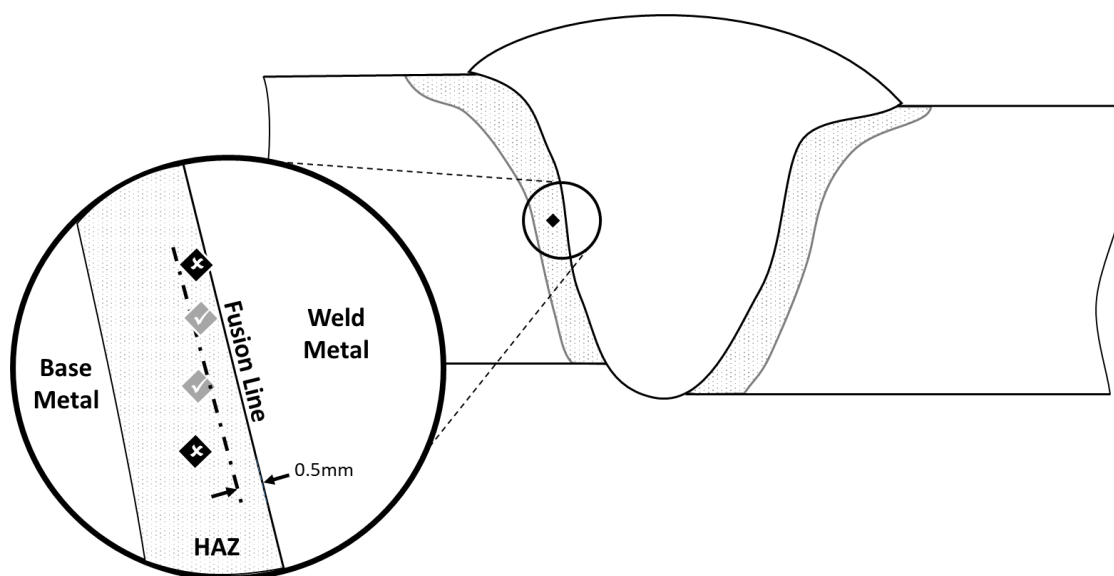


Figure D.4 – Cathodic Attachment Hardness Indentation Locations



NOTE Indents shall be located in the HAZ, within 0.5 mm of the fusion line. The indents shall not touch the fusion line.

Figure D.5 - Fusion Line Hardness Indentation Placement

D.2.8.3.2 Requirements

The maximum allowed hardness shall be as required by the design code or otherwise specified by the company.

D.2.8.3.3 Retesting

Retesting may be permitted with company approval of a hardness retesting procedure.

All retesting shall meet the requirements of D.2.8.3.2.

D.3 Acceptance Standards for NDT

D.3.1 Workmanship Acceptance Standards

Acceptance standards shall be in accordance with Section 9, except as permitted in D.3.2.

NOTE For pipelines that may experience axial tensile stress exceeding 50% SMYS, the user should consider validating that Section 9 acceptance criteria are appropriate.

D.3.2 Alternative Acceptance Standards

The use of this section is permitted when welding procedures are qualified in accordance with A.3 and D.2, except that the company may document deviations with technical justifications where conflicting or overlapping tests or essential variable requirements exist.

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The minimum CTOD value (in-air) for all six specimens (three weld metal and three HAZ) shall be 0.002 in (0.05 mm).

An ECA methodology document shall be prepared, including the appropriate ECA method, and submitted to the company for approval. The ECA shall use fracture toughness testing results in accordance with D.2.8.2. The ECA methods to determine maximum acceptable planar imperfection size in Section A.5, such as Option 1 and Option 2 may not be appropriate for hydrogen pipelines. Other ECA methods, for example Option 3 in Annex A or API 579, may be used.

D.3.3 Cracks

For both D.3.1 and D.3.2, any indications identified by any NDT method as cracks, including crater cracks or star cracks, are not acceptable.

NOTE Techniques optimized for detection, identification and sizing of planar flaws or crack-like features should be used.

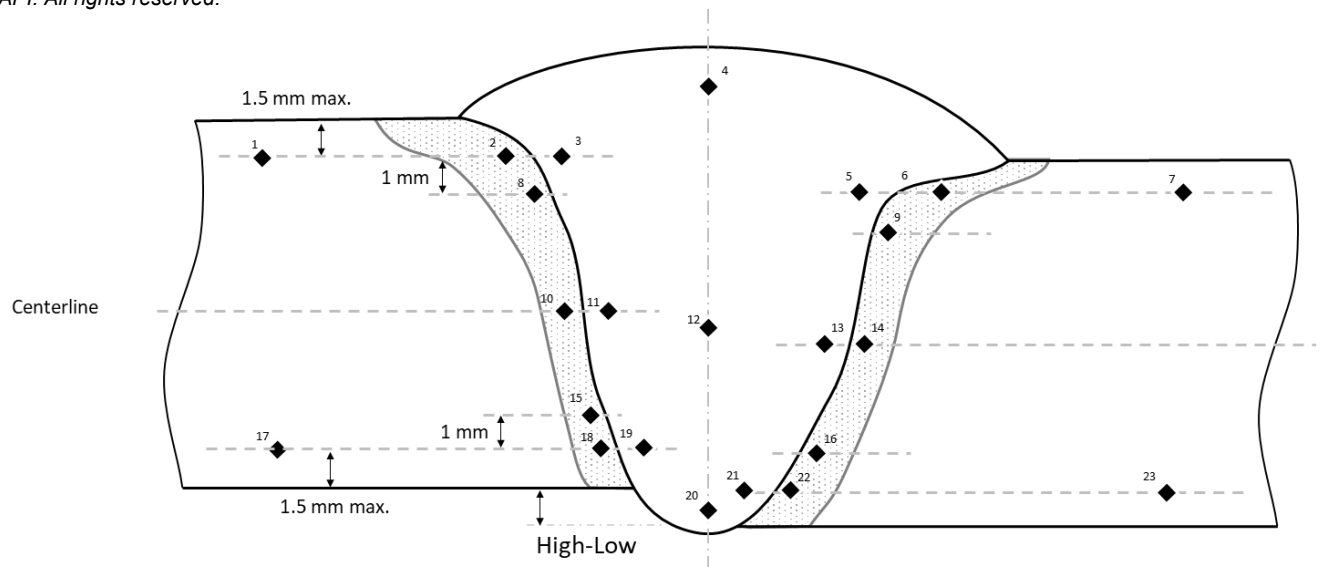
D.4 Repair of Welds

When authorized by the company, a single repair attempt may be made per area of a completed weld using the original welding procedure.

When using welding repair procedures qualified to this annex, the following alternative/additional requirements must be followed:

- a) A maximum of two welding repair attempts in the same area of a completed weld is permitted.
- b) Section 5 Category II welding procedures with testing, e.g. hardness and/or toughness, as required by the original welding procedure.
- c) Repair welding procedure qualifications shall be tested in accordance with Section 10 and this annex. The hardness indentations shall be located as given in Figure D.6 through Figure D.11 for the various repair options. Additional locations as specified by the company may be utilized.
- d) The same NDT method that identified the defect in the original weld shall be used to inspect the repair. The full circumference of the repaired weld shall be re-examined.
- e) The acceptance criteria shall be in accordance with D.3.

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NOTE High-low is a visual representation only. It is used to show the required location of the hardness indents either side of the welds when high-low exists. Indent 20 may be omitted or altered based on the weld geometry and available space.

Figure D.6 – Hardness Locations for Full-thickness Repair Procedure Qualifications

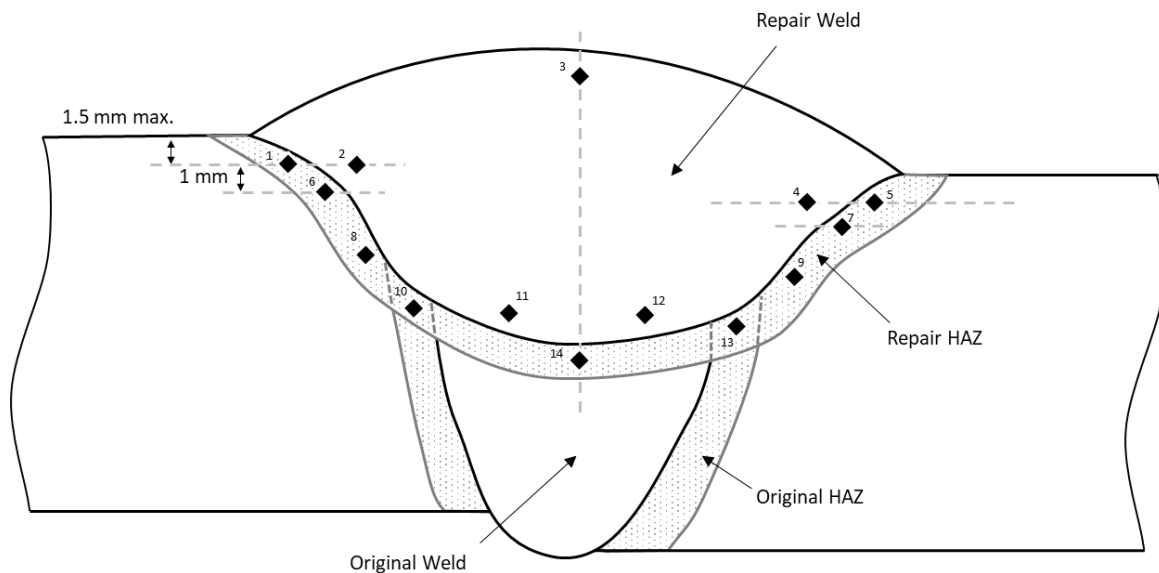


Figure D.7 – Hardness Locations for External Partial-thickness Repair Procedure Qualifications

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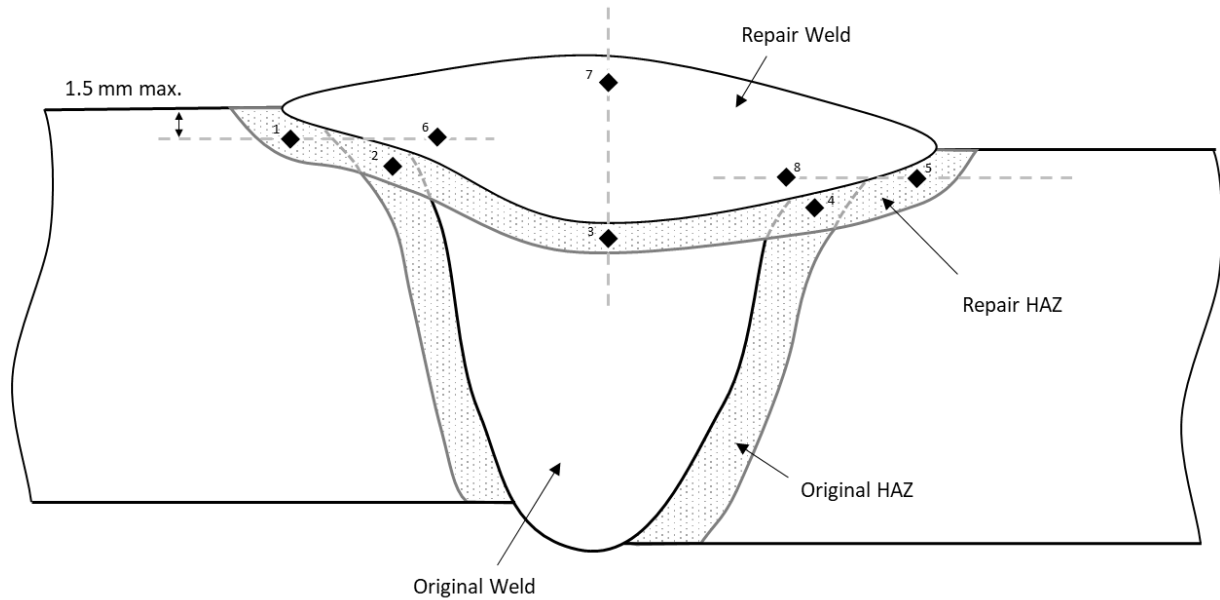


Figure D.8 – Hardness Locations for Cover Pass Repair Procedure Qualifications

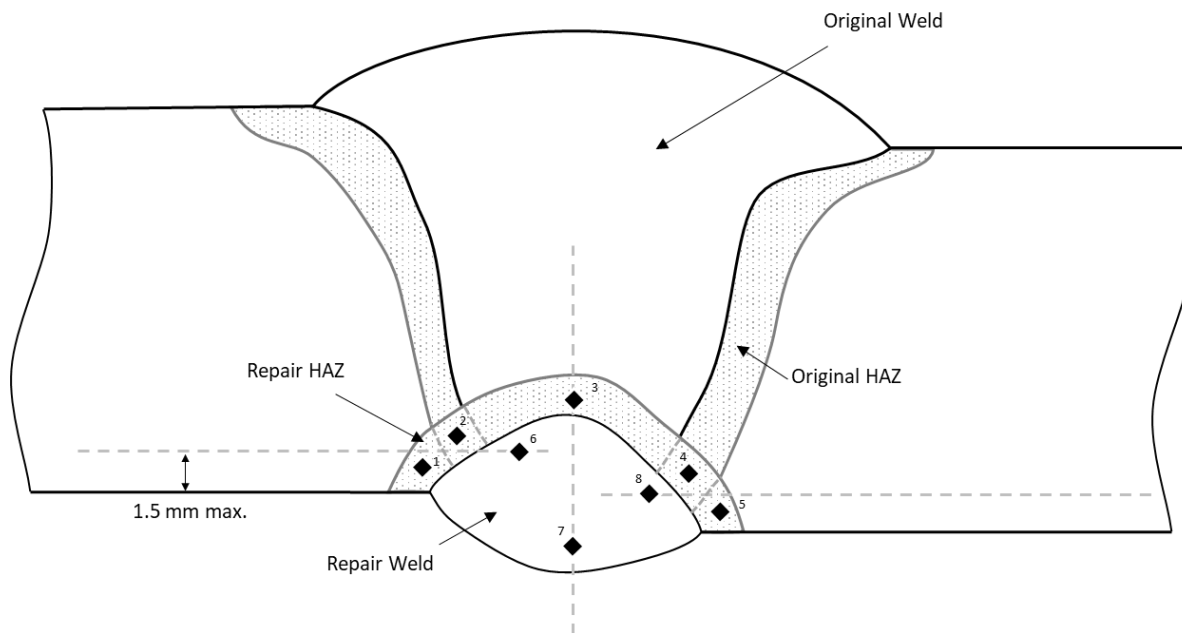


Figure D.9 – Hardness Locations for Back Weld Repair or Internal Partial-Thickness Repair Procedure Qualifications

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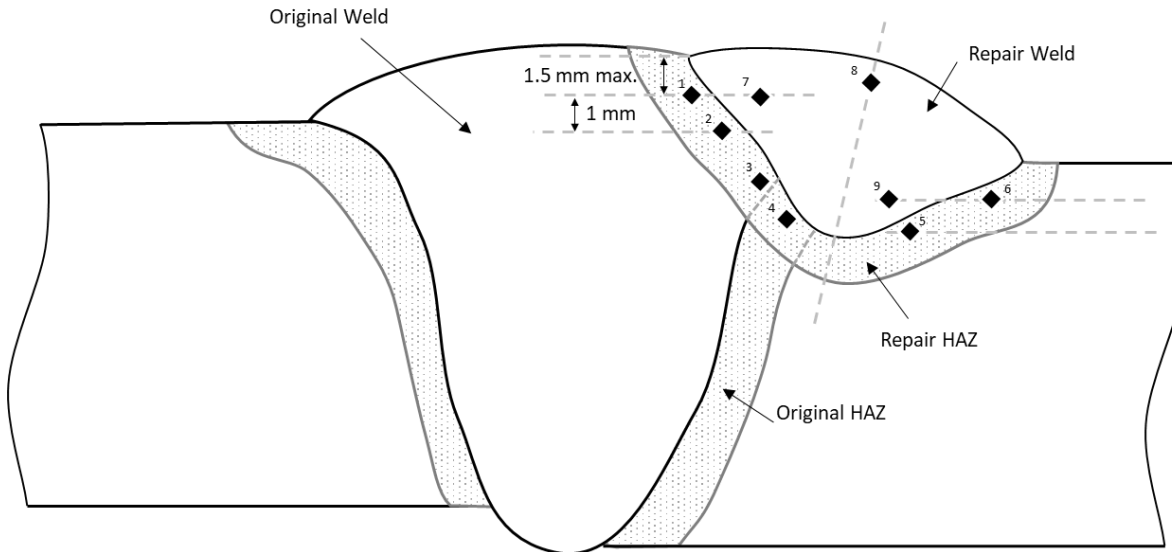


Figure D.10 – Hardness Locations for Cover Pass Repair at the Fusion Line Procedure Qualifications

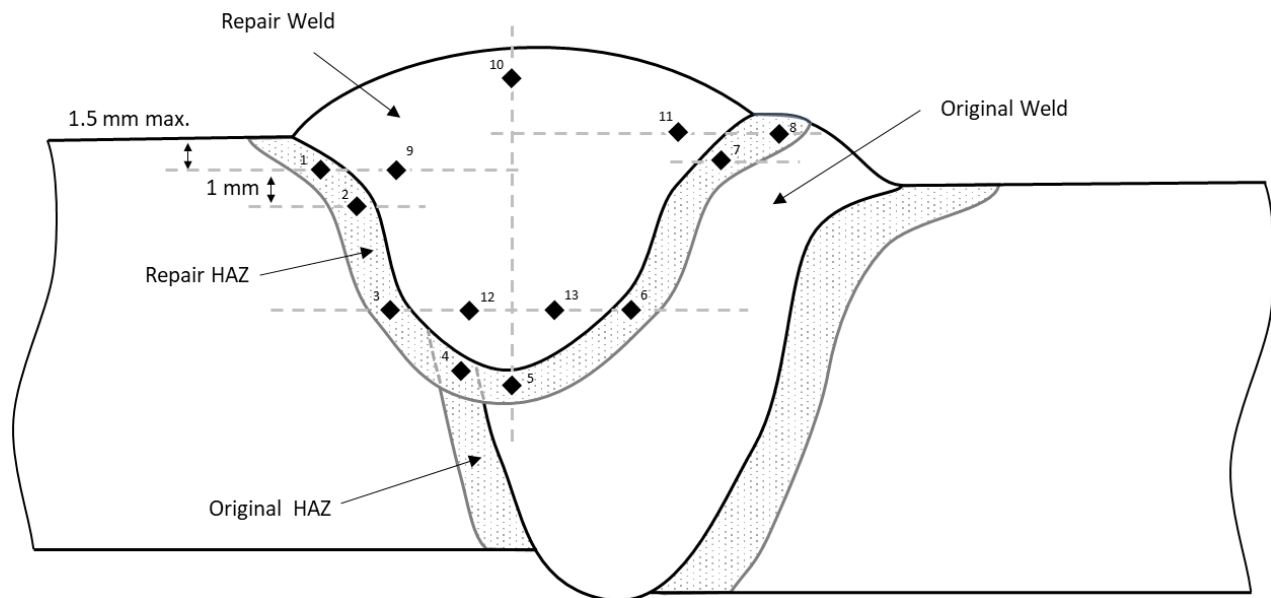


Figure D.11 – Hardness Locations for External Partial Repair at the Fusion Line Procedure Qualifications

D.5 In-Service Welding

In-service welding shall be in accordance with Annex B and the additional requirements given in this section.

D.5.1 Burn-Through

If a burn-through occurs during in-service welding onto a pipeline in hydrogen-service, the probability of an ignition of the pipeline products is generally higher than with products such as methane or other fuel gases.

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In addition to the guidance of Annex B, the user should consider industry guidance on best practices for in-service welding on pipelines containing hydrogen or hydrogen blends.

D.5.2 Filler Metal

Filler metal with a diffusible hydrogen classification of 5 ml/100g or less shall be used.

NOTE AWS electrode classifications with an H4R suffix (e.g. E7018 H4R) have a diffusible hydrogen classification less than 5 ml/100g.

D.5.3 Additional Essential Variables

Annex B welding procedures shall be qualified using the essential variables listed in Table B.1, with the following additional essential variables in this section.

D.5.3.1 Carbon Equivalent

The maximum increase in CE_{IIW} permitted in B.2.3.1.1 is 0.02 above that qualified.

NOTE The maximum carbon content should be stated on the welding procedure specification. Carbon content is not an essential variable, however the potential effects of applying the procedure to produce welds on materials with a higher carbon content should be considered.

D.5.3.2 Cap Passes

A change from a multiple pass cap to a single pass cap. For multiple pass cap welding procedures, a change from the final pass not contacting the pipeline or the appurtenance to the final pass contacting the pipeline or the appurtenance.

D.5.3.3 Heat Input

A decrease in the minimum heat input of the qualified heat input range.

D.5.3.4 Postweld Heat Treatment (PWHT)

The addition or deletion of PWHT or a change from the qualified time and temperature ranges specified in the procedure as defined in D.2.6.5.

D.5.4 Hardness Testing

The hardness indentation locations shall be as specified in D.2.8.3 for the weld joint being qualified, replacing the indentation locations specified in B.2.5.4.3.

The acceptable hardness values should comply with the lower of the hardness acceptance criteria in Table B.4 or Section D.2.8.3.2.

For PWHT procedures, hardness testing shall be performed on welds produced at the minimum hold time and the maximum aggregate hold time, if applicable.

D.5.5 Standards of Acceptability – NDT (Including Visual)

Acceptance criteria for in-service welds should comply with Section B.6, as modified by D.3.

D.5.6 Repair of Welds While In-Service

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In-service welding repair is only permitted in accordance with Section B.7 for new in-service welds, and when authorized by the company. In-service welding repair is not permitted for flaws or in-service degradation of construction welds.

When authorized by the company, a single repair attempt may be made per area using the original in-service welding procedure.

A second repair cycle in the same area is permitted if a repair procedure is qualified according to Annex B.7 and the requirements and D.5. The hardness requirements shall be specified by the company and may be different from D.5.4.