




NAVITEST Ltd.
NDT Laboratory
80-299 Gdańsk
Astronomów 5, Poland

Wydanie / Revision: 04
Data wydania / Issue date: 05.12.2024


NVT/VT/ASME
Badania wizualne złączy spawanych wg ASME
BPVC.V:2023 /
Visual examination of welded joints acc. to ASME
BPVC.V:2023

Lp. / Pos.	Data / Date	Punkty zmienione / Paragraphs changed	Krótki opis zmiany / Short comment	Podpis / Signature
1	05.12.2024	-	Lvl III approving person, minor editorial changes	

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1. Cel procedury

Procedura opisuje badanie wizualne złączy spawanych według ASME BPVC V:2023.

2. Zastosowanie

Procedura ma bezpośrednie zastosowanie do badań wizualnych bezpośrednich z wykorzystaniem prostych przyrządów optycznych (szkielec powiększających, lusterek itp.) dla których ścieżka optyczna do powierzchni podlegającej ocenie jest ciągła. W przypadku badań zdalnych wszystkie zasady ogólne tej procedury mają również zastosowanie z uwzględnieniem wszystkich warunków szczegółowych danego zadania badawczego.

3. Dokumenty odniesienia

ASME BPVC.V:2023 Boiler and pressure vessel code Nondestructive examination.

4. Personel badań nieniszczących

Personel badań nieniszczących musi posiadać kwalifikacje i certyfikaty zgodne z NVT/VT/ASME/WPSNT2020.

5. BHP

Podczas pracy, należy przestrzegać obowiązujących przepisów BHP.

Pracę należy wykonywać tylko w miejscu spełniającym warunki BHP. Zaleca się przestrzeganie wytycznych co do bezpieczeństwa dla każdego z użytych urządzeń.

6. Czas rozpoczęcia badania

Badania można rozpocząć po upływie 24 godzin od zakończenia czynności związanych ze spawaniem. W przypadku obiektów o grubości powyżej 40 mm lub ze specjalnych gatunków stali, badania można rozpocząć nie wcześniej niż 48 godzin.

7. Stan powierzchni do badań

Dobre wyniki są zazwyczaj uzyskiwane kiedy powierzchnia jest w oryginalnym, po procesowym, stanie dla złączy spawanych, powierzchni obrabianych, odlanych, czy odkutych. Niekiedy przygotowanie powierzchni przez szlifowanie może być konieczne, w przypadkach gdy nierówności powierzchni mogą zakrywać niezgodności.

Badana powierzchnia powinna być wolna od wszelkich powłok i innych zanieczyszczeń takich jak farba, smary, pozostałości spawalnicze, rozprysków, korozji itp.

8. Wykonanie badania

Badanie wizualne jest ogólnie wykorzystywane do wykrycia powierzchniowych lub spawalniczych niezgodności produktu lub spoiny, niewspółosiowości, niedoskonałości kształtu lub stwierdzenia wycieku itp.

1. Purpose of the procedure

This procedure describes visual examination of welded joints according to ASME BPVC V:2023.

2. Application

This procedure is strict forward applicable to direct visual examinations with simple viewing tools included (magnifying lens, mirrors etc.), for which the optical path to the surface under examination is continuous.

In case of remote examination techniques all general rules are applicable with all specific conditions of a designated examination task, taken into account.

3. Referenced documents

ASME BPVC.V:2023 Boiler and pressure vessel code Nondestructive examination.

4. NDT personnel

NDT personnel shall be qualified and certificated in accordance with NVT/VT/ASME/WPSNT2020.

5. HSE

During the work, binding health and safety regulations must be followed.

The work shall be performed only in a location that meets HSE conditions. It is recommended to follow the safety guidelines for each equipment used.

6. Time of testing

Testing shall begin minimum 24 hours after completion of all welding activities. In case of objects with thickness exceeding 40 mm, or of special steel grades, testing shall be commenced not sooner than 48 hours.


7. Inspection Area Surface Condition

Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as-forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask imperfections.

The inspection surface shall be free of all coating and other surface conditions, such as paint, grease, welding residues, spatter, corrosion, etc.

8. Execution of the examination

Visual examination is generally used to determine surface/welding imperfections of the element or weld, alignment, shape irregularities, or evidence of leaking etc.

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8.1. Aparatura badawcza

8.1.1. Przyrządy pomiarowe

Operator powinien posługiwać się pomocami pomiarowymi dedykowanymi do powierzonego zadania badawczego. Przykładem takiego wyposażenia są:

- Spoinomierze
- Taśma miernicza
- Suwmiarki
- Przymiary
- Mierniki natężenia światła
- Szkło powiększające
- WPiB do oględzin zdalnych
- Lusterka
- Inne.

Luksomierze kalibruje się co najmniej raz w roku lub każdorazowo, gdy były naprawiane. Jeżeli luksomierze nie były używane przez 1 rok lub dłużej, należy je poddać kalibracji przed użyciem.

(ASME V, Article 9, T-955)

8.1.2. Przyrządy pomocnicze

Oświetlacze, lusterka inspekcyjne, lupa, kreda, marker należy używać w zależności od potrzeb.

8.2. Metody przeprowadzania badań

8.2.1. Metoda bezpośrednia

Bezpośrednie badanie wizualne może być przeprowadzone, gdy odległość pomiędzy okiem a badaną powierzchnią jest mniejsza niż 600mm, a kąt obserwacji względem badanej powierzchni nie powinien być mniejszy niż 30 °.

Można użyć lusterek w celu polepszenia kąta obserwacji. Dopuszczalne jest także użycie szkieł powiększających.

Wymagane oświetlenie (naturalne lub sztuczne) badanej powierzchni, części, elementu, naczynia lub jego odcinka. Minimalne natężenie światła musi wynosić co najmniej 1076 lx. Natężenie światła, należy zmierzyć za pomocą luksomierza lub użyć zweryfikowanego źródła światła. Wymagana weryfikacja źródeł światła jest konieczna do zademonstrowania tylko raz, udokumentowana i przechowywana w aktach.

(ASME V, Article 9, T-952)

8.2.2. Badanie wizualne pośrednie

W niektórych przypadkach może być konieczne zastąpienie oględzin bezpośrednich badaniami pośrednimi. W badaniu pośrednim wizualnym można wykorzystywać pomoce wizualne, takie jak lustra, teleskopy, boroskopy, światłowody, kamery lub inne odpowiednie instrumenty. Takie systemy muszą mieć rozdzielczość i natężenie światła co najmniej równe temu, jakie są wymagane w bezpośrednim badaniu wizualnym (np., T-921.3; Section XI, Division 1, Tabela IWA-2211-1; ISO 12233; USAF 1951 tablica linii do pomiaru rozdzielczości)

(ASME V, Article 9, T-953)

8.1. Test equipment

8.1.1. Measurement equipment

The operator should use examination aids specific for his examination task. Examples of such equipment are:

- Welding gauges
- Measuring tape
- Calipers
- Fixed gauges
- Light meters
- Magnifying glass
- Remote visual aids
- Mirrors
- etc.

Light meters shall be calibrated at least once a year or whenever they have been repaired. If meters have not been in use for 1 year or more, they shall be calibrated before they are used.

(ASME V, Article 9, T-955)

8.1.2. Additional examination

Auxiliary illuminators, examination mirrors, magnifying glass, chalk, marker pen are to be used when necessary.

8.2. Methods of examination

8.2.1. Direct visual examination


Direct visual examination may usually be made when access is sufficient to place the eye within 600 mm of the surface to be examined and at an angle not less than 30 deg to the surface to be examined. Mirrors may be used to improve the angle of vision, and aids such as a magnifying lens may be used to assist examinations. Illumination (natural or supplemental white light) of the examination surface is required for the specific part, component, vessel, or section thereof being examined. The minimum light intensity shall be 1076 lx. The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the examination or a verified light source shall be used. Verification of light sources is required to be demonstrated only one time, documented, and maintained on file.

(ASME V, Article 9, T-952)

8.2.2. Remote visual examination

In some cases, remote visual examination may have to be substituted for direct examination. Remote visual examination may use visual aids such as mirrors, telescopes, borescopes, fiber optics, cameras, or other suitable instruments. Such systems shall have a resolution capability and light intensity at least equivalent to that obtainable by direct visual observation (e.g., T-921.3; Section XI, Division 1, Table IWA-2211-1; ISO 12233; USAF 1951 Resolution Target).

(ASME V, Article 9, T-953)

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8.3. Przeprowadzenie badania złączy spawanych

Wszystkie ukończone powierzchnie spoin należy poddać badaniom wizualnym na całej długości spoiny, chyba że określono inaczej.

Spoiny powinny być sprawdzane wymiarowo pod kątem zgodności z tolerancją rysunku, co najmniej jedno miejsce na spoinę. Miejsce spoiny wybrane do badania powinno być najmniej korzystne zgodnie z oceną wizualną.

Obszar inspekcji obejmuje spoinę i dostępny przyległy materiał podstawowy w odległości 1cala (25 mm) od krawędzi spoiny lub krawędzi materiału podstawowego, w zależności od tego, która z tych wartości jest mniejsza.

Grubość materiału powinna być grubość nominalna lub rzeczywista, jak określono na rysunku technicznym lub w specyfikacji materiału.

Gdzie to możliwe inspektor powinien poddać badaniu wizualnemu obydwie, dostępne strony złącza. Badania wizualne zdalne, jeżeli są wymagane i konieczne ze względu na odnośne przepisy, należy uzgodnić pomiędzy stronami przed rozpoczęciem projektu.

9. Ocena i kryteria akceptacji

Wyniki badań należy ocenić zgodnie z wymaganiami akceptacji konkretnej Sekcji Przepisów.

Do zaplanowania badań i sprawdzenia, czy przeprowadzono je zgodnie z wymaganiami, należy skorzystać z listy kontrolnej. Ta lista kontrolna określa minimalne wymagania dotyczące badań i nie wskazuje rzeczywistych badań jakie może przeprowadzić producent.

(ASME V, Article 9, T-980)

10. Raportowanie

10.1. Zapis oznaczeń

Wskazania dopuszczalne są rejestrowane w sposób określony w Odnósnym Przepisie odniesienia.

Należy rejestrować wskazania nieakceptowalne. Jako minimum, należy zarejestrować ich rodzaj (liniowy lub zaokrąglony), lokalizację oraz rozmiar.

10.2. Zapis z badań

Sprawozdanie z badań powinno zawierać następujące informacje:

- datę badania
- obowiązującą procedurę i jej rewizję
- zastosowaną technikę badania
- wyniki badania
- imię i nazwisko personelu badającego oraz, jeśli jest to wymagane przez odnośny Przepis, poziom kwalifikacji
- identyfikacja badanej części lub elementu

Po mimo, że wymiary/geometria itp. zostały zapisywane podczas wykonywania badań wizualnych aby umożliwić ocenę nie muszą być one zapisane każdorazowo przy badaniu lub sprawdzeniu wymiarów. Dokumentacja powinna obejmować wszystkie

8.3. Execution of examination of joint welds

All completed weld surfaces shall be visually inspected for the entire weld length, unless other specified.

Welds shall be dimensionally inspected for compliance to drawing tolerance a minimum of one place per weld in every three feet of weld. The weld location selected for examination shall be the least favorable as determined by visual examination.

The inspection area shall include the weld and the accessible adjacent base material for a distance of 1 inch (25 mm) from the toes of the weld or edge of the base metal, whichever is less.

Material thickness shall be the nominal or actual thickness as specified on the engineering drawing or material specification. Where possible the inspector shall visually inspect both, accessible sides of the joint. Remote access visual inspections, where necessary and required by the referencing Code Section, shall be agreed between parties before the start of the project.

9. Evaluation and acceptance criteria

All examinations shall be evaluated in terms of the acceptance standards of the referencing Code Section.

An examination checklist shall be used to plan visual examination and to verify that the required visual observations were performed. This checklist establishes minimum examination requirements and does not indicate the maximum examination which the Manufacturer may perform in process. (ASME V, Article 9, T-980)

10. Documentation

10.1. Recording of indications

Non rejectable indications shall be recorded as specified by the referencing Code Section.


Rejectable indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

10.2. Examination records

A written report of the examination shall contain the following information:

- the date of the examination
- procedure identification and revision used
- technique used
- results of the examination
- examination personnel identity, and, when required by the referencing Code Section, qualification level
- identification of the part or component examined

Even though dimensions, etc., were recorded in the process of visual examination to aid in the evaluation, there need not be documentation of each viewing or each dimensional check.

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inspekcje i kontrole wymiarowe określone w odnośnym Przepisie.

(ASME V, Article 9, T-991)

11. Załączniki

- Załącznik 1: Kryteria akceptacji wg ASME VIII Div1:2023 / ASME I:2023
- Załącznik 2: Kryteria akceptacji wg ASME IX Div1:2023
- Załącznik 3: Kryteria akceptacji wg ASME B31.1-2022
- Załącznik 4: Kryteria akceptacji wg ASME B31.3-2022

12. Uwagi do rewizji

W odniesieniu do poprzedniej wersji (główne zmiany):

- Cały dokument, wprowadzenie zmian ASME V:2023

Documentation shall include all observation and dimensional checks specified by the referencing Code Section.

(ASME V, Article 9, T-991)

11. Appendix

- Appendix 1: Acceptance criteria according to ASME VIII Div1:2023 / ASME I:2023
- Appendix 2: Acceptance criteria according to ASME IX Div1:2023
- Appendix 3: Acceptance criteria according to ASME B31.1-2022
- Appendix 4: Acceptance criteria according to ASME B31.3-2022

12. Remarks to revision

In relation to the previous version (major changes):

- Entire document, implementation of ASME V:2023 rules

Appendix 1

Acceptance Criteria according to ASME VIII Div1:2023 / Acceptance Criteria according to ASME I:2023

- The surfaces to be welded shall be clean and free of scale, rust, oil, grease, slag, detrimental oxides, and other deleterious foreign material. The method and extent of cleaning should be determined based on the material to be welded and the contaminants to be removed. When weld metal is to be deposited over a previously welded surface, all slag shall be removed by a roughing tool, chisel, chipping hammer, or other suitable means so as to prevent inclusion of impurities in the weld metal
- Cast surfaces to be welded shall be machined, chipped, or ground to remove foundry scale and to expose sound metal.

The requirements above are not intended to apply to any process of welding by which proper fusion and penetration are otherwise obtained and by which the weld remains free from defects

- Tack welds (if any) should be free of imperfections
- Preparation of the joint geometry should comply with the drawing documentation
- Alignment of sections at edges to be butt welded shall be such that the maximum offset is not greater than the applicable amount for the welded joint category (see UW-3) under consideration, as listed in Table UW-33. The section thickness t is the nominal thickness of the thinner section at the joint:

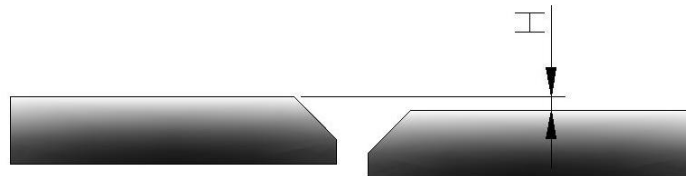


Figure 1 .Misalignment of section at edges to be welded

Table UW-33		
SI Units		
Section Thickness, mm	Joint Category	
	A	B, C, and D
Up to 13, incl.	$\frac{1}{4}t$	$\frac{1}{4}t$
Over 13 to 19, incl.	3 mm	$\frac{1}{4}t$
Over 19 to 38, incl.	3 mm	5 mm
Over 38 to 51, incl.	3 mm	$\frac{1}{8}t$
Over 51	Lesser of $\frac{1}{16}t$ or 10 mm	Lesser of $\frac{1}{8}t$ or 19 mm

Table 1. Alignment tolerances of section at edges to be welded

Any offset within the allowable tolerance provided above shall be faired at a three to one taper over the width of the finished weld, or if necessary, by adding additional weld metal beyond what would otherwise be the edge of the weld. Such additional weld metal buildup shall be subject to the requirements of UW-42

Welded joints

- **Butt welded** joints shall have complete penetration and full fusion.
- As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, and abrupt ridges and valleys to permit proper interpretation of radiographic and other required nondestructive examinations. If there is a question regarding the surface condition of the weld when interpreting a radiographic image, the image shall be compared to the actual weld surface for determination of acceptability

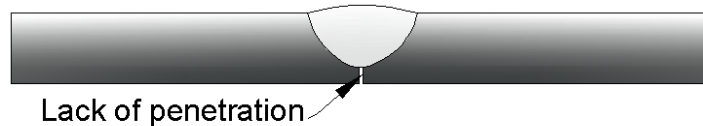


Figure 2. Lack of penetration

UW 35(c) A reduction in thickness due to the welding process, which includes undercut, is acceptable provided all of the following conditions are met:

- The reduction in thickness shall not reduce the material of the adjoining surfaces below the design thickness at any point
- The reduction in thickness shall not exceed 1/32 in. (1 mm) or 10% of the nominal thickness of the adjoining surface, whichever is less
- When a single-welded butt joint is made by using a backing strip which is left in place [Type No. (2) of Table UW-12], the requirement for reinforcement applies only to the side opposite the backing strip.

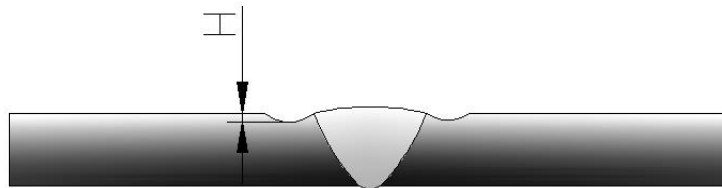


Figure 3. Reduction in thickness due to the welding process (undercuts)

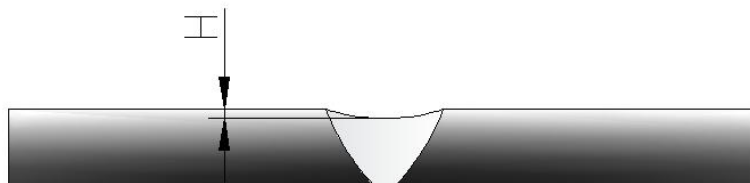


Figure 4. Reduction in thickness due to the welding process (face of weld concavity)

- To assure that the butt welded joints are completely filled so that the surface of the weld metal at any point does not fall below the surface of the adjoining base materials, weld metal may be added as reinforcement on each face of the weld. The thickness of the weld reinforcement on each face shall not exceed the following:

Material Nominal Thickness, mm	SI Units	
	Maximum Reinforcement, mm	
	Category B and C Butt Welds	Other Welds
Less than 2.4	2.5	0.8
2.4 to 4.8, incl.	3	1.5
Over 4.8 to 13, incl.	4	2.5
Over 13 to 25, incl.	5	2.5
Over 25 to 51, incl.	6	3
Over 51 to 76, incl.	6	4
Over 76 to 102, incl.	6	5.5
Over 102 to 127, incl.	6	6
Over 127	8	8

Table 2. Tolerances for weld reinforcement thickness

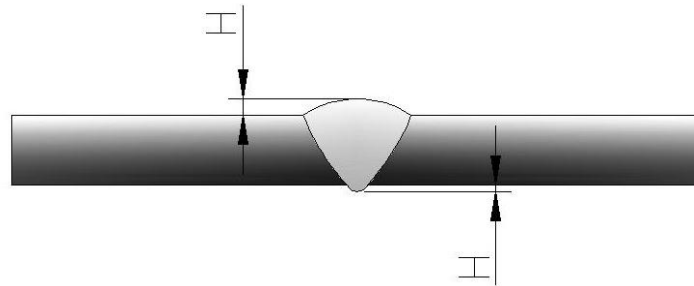


Figure 5. Weld reinforcement thickness

Fillet welds. In making fillet welds, the weld metal shall be deposited in such a way that fusion into the base metal at the root of the weld is secured.

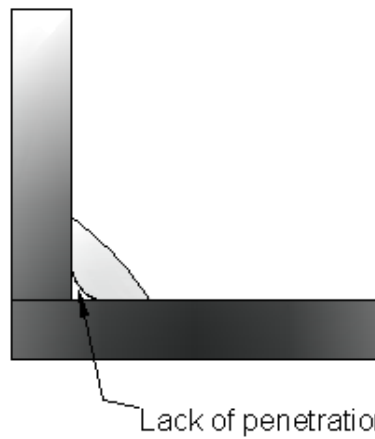


Figure 6. Example of lack of penetration

The reduction in thickness of the base metal due to welding process at the edges of the fillet weld shall meet the same requirements as for butt welds. [see UW-35(c)].

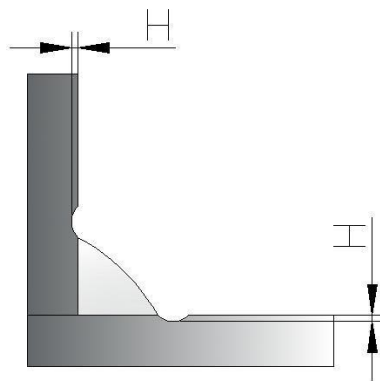



Figure 7. Reduction in thickness due to the welding process

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Appendix 2

Acceptance criteria according to ASME IX:2023

QW-193.1.1. (Tube-to-tubesheet)

- The accessible surfaces of the welds shall be examined visually with no magnification required. The welds shall show complete fusion and no evidence of burning through the tube wall, and shall be free from cracking or porosity.

QW-194 (Visual examination – performance)


- Performance test coupons shall show no cracks and complete joint penetration with complete fusion of weld metal and base metal.

QW-215.4 (Electron beam welding, laser beam welding and low-power density laser beam welding).

- The workmanship test coupon shall be acceptable when the weld and heat-affected zones of each cross section exhibit complete fusion and are free of cracks when visually examined at 10X magnification. Any indications 1/32 in. (0.8 mm) in length at the root of the weld may be disregarded. The depth of penetration of each cross section shall be measured to within 0.01 in. (0.3 mm) and shall meet the specified production requirements

QW-382.1 (Hard facing weld metal overlay, wear resistant, qualification test)

- The base metal shall be sectioned transversely to the direction of the hard-facing overlay. The two faces of the hard facing exposed by sectioning shall be polished and etched with a suitable etchant and shall be visually examined with 5X magnification for cracks in the base metal or the heat-affected zone, lack of fusion, or other linear defects. The overlay and base metal shall meet the requirements specified in the WPS. All exposed faces shall be examined. See Figure QW-462.5(b) for pipe and Figure QW-462.5(e) for plate

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Appendix 3

Acceptance criteria according to ASME B31.1-2022

Acceptance Standards. The following indications are unacceptable:

- cracks — external surface.
- undercut on the surface that is greater than 1/32 in. (0,8 mm) deep, or encroaches on the minimum required section thickness.
- undercut on the surface of longitudinal butt welds.
- weld reinforcement greater than specified in Table 127.4.2-1.
- lack of fusion on surface.
- incomplete penetration (applies only when inside surface is readily accessible).
- any other linear indications greater than 3/16 in. (5.0 mm) long.
- surface porosity with rounded indications having dimensions greater than 3/16 in. (5.0 mm) or four or more rounded indications separated by 1/16 in. (1,5 mm) or less edge to edge in any direction.
- arc strikes outside of the weld joint

Table 127.4.2-1 Reinforcement of Girth and Longitudinal Butt Welds

Thickness of Base Metal, in. (mm)	Maximum Thickness of Reinforcement for Design Temperature			
	>750°F (400°C)		≤750°F (400°C)	
	in.	mm	in.	mm
Up to 1/8 (3), incl.	1/16	1.5	3/32	2.5
Over 1/8 to 3/16 (3 to 5), incl.	1/16	1.5	1/8	3
Over 3/16 to 1/2 (5 to 13), incl.	1/16	1.5	5/32	4
Over 1/2 to 1 (13 to 25), incl.	3/32	2.5	3/16	5
Over 1 to 2 (25 to 50), incl.	1/8	3	1/4	6
Over 2 (50)	5/32	4	See Note (1)	See Note (2)

GENERAL NOTES:

- (a) For double-sided groove welds, the limitation on reinforcement given above shall apply separately to both inside and outside surfaces of the joint.
- (b) For single-sided groove welds with backing strips or bars that remain in place, the limitation on reinforcement given above shall apply to the outside surface. For single-sided groove welds without backing strips or bars that remain in place, the limits shall apply to the outside surface; they also apply to the inside surface when the inside surface is readily accessible.
- (c) The thickness of weld reinforcement shall be based on the thickness of the thinner of the materials being joined.
- (d) The weld reinforcement thicknesses shall be determined from the higher of the abutting surfaces involved.
- (e) Weld reinforcement may be removed if so desired.

NOTES:

- (1) The greater of 1/4 in. or 1/8 times the width of the weld in inches.
- (2) The greater of 6 mm or 1/8 times the width of the weld in millimeters.



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Appendix 4 Acceptance criteria according to ASME B31.3-2022

Table 341.3.2 Acceptance Criteria for Welds – Visual and Radiographic Examination

Criteria (A to M) for Types of Welds and for Service Conditions [Note (1)]										Weld Imperfection	Examination Methods	
Normal and Category M Fluid Service			Severe Cyclic Conditions			Category D Fluid Service					Visual	Radiography
Type of Weld			Type of Weld			Type of Weld						
Girth, Miter Groove & Branch Connection [Note (2)]	Longitudinal Groove [Note (3)]	Fillet [Note (4)]	Girth, Miter Groove & Branch Connection [Note (2)]	Longitudinal Groove [Note (3)]	Fillet [Note (4)]	Girth and Miter Groove	Longitudinal Groove [Note (3)]	Fillet [Note (4)]	Branch Connection [Note (2)]			
A	A	A	A	A	A	A	A	A	A	Crack	✓	✓
A	A	A	A	A	A	C	A	N/A	A	Lack of fusion	✓	✓
B	A	N/A	A	A	N/A	C	A	N/A	B	Incomplete penetration	✓	✓
E	E	N/A	D	D	N/A	N/A	N/A	N/A	N/A	Rounded Indications	...	✓
G	G	N/A	F	F	N/A	N/A	N/A	N/A	N/A	Elongated indications	...	✓
H	A	H	A	A	A	I	A	H	H	Undercutting	✓	✓
A	A	A	A	A	A	A	A	A	A	Surface porosity or exposed slag inclusion [Note (5)]	✓	...
N/A	N/A	N/A	J	J	J	N/A	N/A	N/A	N/A	Surface finish	✓	...
K	K	N/A	K	K	N/A	K	K	N/A	K	Concave surface, concave root, or burn-through	✓	✓
L	L	L	L	L	L	M	M	M	M	Weld reinforcement or internal protrusion	✓	...



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GENERAL NOTES:

- (a) Weld imperfections are evaluated by one or more of the types of examination methods given, as specified in paras. 341.4.1, 341.4.2, 341.4.3, and M341.4, or by the engineering design.
- (b) "N/A" indicates the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of weld.
- (c) Check (✓) indicates examination method generally used for evaluating this kind of weld imperfection.
- (d) Ellipsis (. .) indicates examination method not generally used for evaluating this kind of weld imperfection.



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Criterion Value Notes for Table 341.3.2

Symbol	Criterion Measure	Acceptable Value Limits [Note (6)]										
A	Extent of imperfection	Zero (no evident imperfection)										
B	Cumulative length of incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less										
C	Cumulative length of lack of fusion and incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less										
D	Size and distribution of rounded indications	See BPV Code, Section VIII, Division 1, Appendix 4 [Note (10)]										
E	Size and distribution of rounded indications	For $\bar{T}_w \leq 6 \text{ mm } (\frac{1}{4} \text{ in.})$, limit is same as D [Note (10)] For $\bar{T}_w > 6 \text{ mm } (\frac{1}{4} \text{ in.})$, limit is $1.5 \times D$ [Note (10)]										
F	Elongated indications Individual length Individual width Cumulative length	$\leq \bar{T}_w / 3$ $\leq 2.5 \text{ mm } (\frac{3}{32} \text{ in.})$ and $\leq \bar{T}_w / 3$ $\leq \bar{T}_w$ in any $12\bar{T}_w$ weld length [Note (10)]										
G	Elongated indications Individual length Individual width Cumulative length	$\leq 2\bar{T}_w$ $\leq 3 \text{ mm } (\frac{1}{8} \text{ in.})$ and $\leq \bar{T}_w / 2$ $\leq 4\bar{T}_w$ in any 150 mm (6 in.) weld length [Note (10)]										
H	Depth of undercut Cumulative length of internal and external undercut	$\leq 1 \text{ mm } (\frac{1}{32} \text{ in.})$ and $\leq \bar{T}_w / 4$ $\leq 38 \text{ mm } (1.5 \text{ in.})$ in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less										
I	Depth of undercut Cumulative length of internal and external undercut	$\leq 1.5 \text{ mm } (\frac{1}{16} \text{ in.})$ and $\leq \bar{T}_w / 4$ or $1 \text{ mm } (\frac{1}{32} \text{ in.})$ $\leq 38 \text{ mm } (1.5 \text{ in.})$ in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less										
J	Surface roughness	$\leq 12.5 \mu\text{m } (500 \mu\text{in.}) R_a$ in accordance with ASME B46.1										
K	Depth of surface concavity, root concavity, or burn-through	Total joint thickness, incl. weld reinf., $\geq \bar{T}_w$ [Notes (7) and (11)]										
L	Height of reinforcement or internal protrusion [Note (8)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (9). Weld metal shall merge smoothly into the component surfaces.	<table border="0"> <tr> <td>For \bar{T}_w, mm (in.)</td> <td>Height, mm (in.)</td> </tr> <tr> <td>$\leq 6 (\frac{1}{4})$</td> <td>$\leq 1.5 (\frac{1}{16})$</td> </tr> <tr> <td>$> 6 (\frac{1}{4}), \leq 13 (\frac{1}{2})$</td> <td>$\leq 3 (\frac{1}{8})$</td> </tr> <tr> <td>$> 13 (\frac{1}{2}), \leq 25 (1)$</td> <td>$\leq 4 (\frac{5}{32})$</td> </tr> <tr> <td>$> 25 (1)$</td> <td>$\leq 5 (\frac{3}{16})$</td> </tr> </table>	For \bar{T}_w , mm (in.)	Height, mm (in.)	$\leq 6 (\frac{1}{4})$	$\leq 1.5 (\frac{1}{16})$	$> 6 (\frac{1}{4}), \leq 13 (\frac{1}{2})$	$\leq 3 (\frac{1}{8})$	$> 13 (\frac{1}{2}), \leq 25 (1)$	$\leq 4 (\frac{5}{32})$	$> 25 (1)$	$\leq 5 (\frac{3}{16})$
For \bar{T}_w , mm (in.)	Height, mm (in.)											
$\leq 6 (\frac{1}{4})$	$\leq 1.5 (\frac{1}{16})$											
$> 6 (\frac{1}{4}), \leq 13 (\frac{1}{2})$	$\leq 3 (\frac{1}{8})$											
$> 13 (\frac{1}{2}), \leq 25 (1)$	$\leq 4 (\frac{5}{32})$											
$> 25 (1)$	$\leq 5 (\frac{3}{16})$											
M	Height of reinforcement or internal protrusion [Note (8)] as described in L. Note (9) does not apply.	Limit is twice the value applicable for L above										

Notes follow on next page



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Table 341.3.2 Acceptance Criteria for Welds – Visual and Radiographic Examination (Cont'd)

NOTES:

- (1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.
- (2) Branch connection weld includes pressure containing welds in branches and fabricated laps.
- (3) Longitudinal groove weld includes straight and spiral (helical) seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1, Table A-1M, or Table 326.1. Alternative Leak Test requires examination of these welds; see para. 345.9.
- (4) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.
- (5) These imperfections are evaluated only for welds ≤ 5 mm ($\frac{3}{16}$ in.) in nominal thickness.
- (6) Where two limiting values are separated by "and," the lesser of the values determines acceptance. Where two sets of values are separated by "or," the larger value is acceptable. \bar{T}_w is the nominal wall thickness of the thinner of two components joined by a butt weld.
- (7) For circumferential groove welded joints in pipe, tube, and headers made entirely without the addition of filler metal, external concavity shall not exceed the lesser of 1 mm ($\frac{1}{32}$ in.) or 10% of the joint nominal thickness. The contour of the concavity shall blend smoothly with the base metal. The total joint thickness, including any reinforcement, shall not be less than the minimum wall thickness, t_m .
- (8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat, Fig. 328.5.2A; internal protrusion does not apply.
- (9) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
 - (a) 1.5 mm ($\frac{1}{16}$ in.) for thickness ≤ 2 mm ($\frac{5}{64}$ in.)
 - (b) 2.5 mm ($\frac{3}{32}$ in.) for thickness > 2 mm and ≤ 6 mm ($\frac{1}{4}$ in.)For external reinforcement and for greater thicknesses, see the tabulation for symbol L.
- (10) Porosity and inclusions such as slag or tungsten are defined as rounded indications where the maximum length is three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density. Indications where the length is greater than three times the width are defined as elongated indications and may also be slag, porosity, or tungsten.
- (11) For radiography, acceptability may be determined by comparing the density of the image through the affected area to the density through the adjacent base metal (\bar{T}_w). If digital radiography is used, brightness comparison may be utilized. A density or brightness darker than the adjacent base metal is cause for rejection.

Fig. 341.3.2 Typical Weld Imperfections

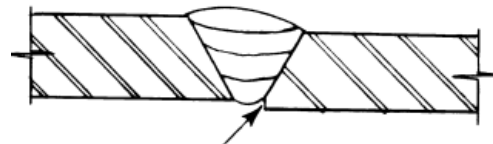


Lack of fusion between weld bead and base metal

(a) Side Wall Lack of Fusion

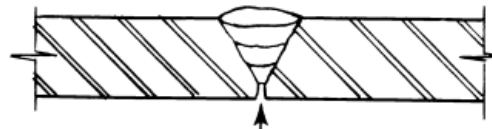


(b) Lack of Fusion Between Adjacent Passes



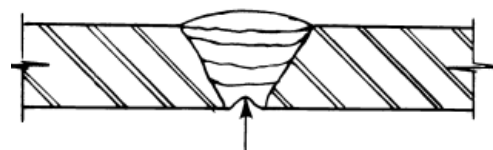
Incomplete filling at root on one side only

(c) Incomplete Penetration due to Internal Misalignment



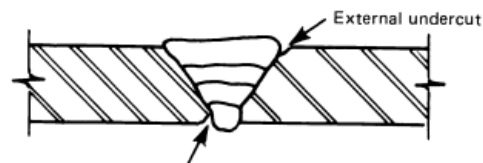
Incomplete filling at root

(d) Incomplete Penetration of Weld Groove



Root bead fused to both inside surfaces but center of root slightly below inside surface of pipe (not incomplete penetration)

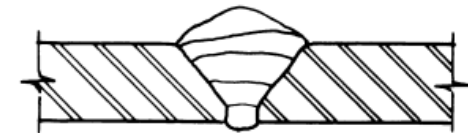
(e) Concave Root Surface (Suck-Up)



Internal undercut

External undercut

(f) Undercut



(g) Excess External Reinforcement