CHAPTER 5
FABRICATION, ASSEMBLY, AND ERECTION

PART MJ
MATERIALS JOINING

MJ-1 PURPOSE AND SCOPE

The purpose of this Part is to provide requirements for the joining of metallic and polymeric materials. This includes joining methods, welding procedure and performance qualifications, examination, inspection, testing, and acceptance criteria.

MJ-2 MATERIALS

MJ-2.1 Base Metals

MJ-2.1.1 Stainless Steels

(a) Austenitic Stainless Steels. Only the austenitic stainless steel grades listed in Table MM-2.1-1 or Table MM-2.1-3 may be used for welded components, except as permitted in MM-5.1.

Weld ends that are to be autogenously welded (without filler metal or consumable inserts) shall meet the requirements of MM-5.2.1.1.

However, a process component or tube of one of the above alloys with a sulfur content either below the lower limit or above the upper limit for sulfur in MM-5.2.1.1 may be used in a welded connection, provided all of the following conditions are met:

(1) Use of the process component or tube is agreed to by the owner/user.

(2) All welds on the component or tube are internally inspected and meet the requirements of MJ-8.4.

(b) Superaustenitic Stainless Steels. Only the superaustenitic stainless steel grades listed in Table MM-2.1-1 or Table MM-2.1-3 may be used for welded components, except as permitted in MM-5.1.

The superaustenitic stainless steels are prone to the precipitation of undesirable secondary intermetallic phases such as sigma and chi. The cautions of MM-5.2.3 shall be considered when welding superaustenitic stainless steels.

(c) Duplex Stainless Steels. Only the duplex stainless steel grades listed in Table MM-2.1-1 or Table MM-2.1-3 may be used for welded components, except as permitted in MM-5.1. The cautions of MM-5.2.3 shall be considered when welding duplex stainless steels.

MJ-2.1.2 Nickel Alloys. Only the nickel alloys listed in Table MM-2.1-2 or Table MM-2.1-3 may be used for welded components, except as permitted in MM-5.1.

MJ-2.1.3 Copper Alloys. Only the copper alloys listed in Table MM-2.1-4 may be used for brazed systems.

MJ-2.1.4 Other Metals. Other metals (e.g., titanium, tantalum, palladium, or gold, as used in instrumentation) may be joined, when specified by the owner/user.

MJ-2.2 Filler Metals

MJ-2.2.1 Stainless Steels. When filler metals are used, the matching filler metals listed in Tables MM-5.3-1 and MM-5.3-2 shall be used, except that higher alloy filler metals may be used when specified by the owner/user.

Austenitic stainless steel grades may be welded with or without filler metals. See MM-5.3 and MM-5.3.1 for further instructions.

Superaustenitic stainless steels may be welded with or without filler metals or consumable inserts. When welded autogenously (without filler metal or consumable inserts), postweld heat treatment in accordance with MM-5.4 is required. See MM-5.2.2, MM-5.3, and MM-5.3.2 for further instructions.

Duplex stainless steels may be welded with or without filler metals or consumable inserts. When welded autogenously, postweld heat treatment in accordance with MM-5.4 is required. Welding of duplex stainless steels generally results in an increase in the amount of ferrite in the microstructure, and, as a result, appropriate welding procedures should be selected. The balance of austenite and ferrite in the weld metal shall be maintained so that there is no less than 30% of the lesser phase. See MM-5.2.3, MM-5.3, and MM-5.3.2 for further instructions.

MJ-2.2.2 Nickel Alloys. When filler metals are used, the matching filler metals listed in Tables MM-5.3-1 and MM-5.3-2 shall be used, except that higher alloy filler metals may be used when specified by the owner/user.

Nickel alloys may be welded with or without filler metals. Postweld solution heat treatment is not required. See MM-5.3 for further instructions.

MJ-2.2.3 Copper Alloys. Brazing joint filler metals shall comply with Table MM-5.3.3-1. Copper-to-copper joints shall be brazed using copper-phosphorus or copper-phosphorus-silver brazing filler metal (BCuP series) without flux.

MJ-2.3 Nonmetallics

Joining of polymeric materials shall be performed in accordance with MJ-9. Joining of other nonmetallic materials shall be in accordance with procedures and processes recommended by the material manufacturer, and approved by the owner/user, using materials or compounds that are inert to the intended service.

MJ-3 JOINT DESIGN AND PREPARATION

MJ-3.1 General

All butt joints in which one or both weld faces are process contact surfaces shall have continuous complete weld joint penetration. This requirement exists for welds made from either one side or both sides of the weld joint. All weld joints shall have the process contact surfaces properly purged or protected for the prevention of discoloration or contamination. External attachments (e.g., lift lugs, dimple jackets, or ladder clips) shall have any discoloration of the process contact surface removed.

Welds attaching any connection that passes through the wall of a tank or vessel, or a branch connection on a pipe or tube system, in which one or both sides of the weld joint is a process contact surface, shall either be joined with a full penetration groove weld with a reinforcing fillet weld [similar to Figure SD-3.4.2-2, illustration (a)], or have at least one telltale hole provided if double fillet welded only [similar to Figure SD-3.4.2-2, illustration (b)]. A telltale hole is required on all lap, tee, corner, or edge joints that have one or both welds as a process contact surface and are not attached by full penetration welds. The telltale hole shall provide a path for process fluid or test media flow if the inner weld containment fails. Telltale holes are not required when all welds are on process contact surfaces [e.g., Figure SD-3.4.3-2, illustration (c) detail or similar]. The telltale hole shall be no larger than NPS $^1/_4$ in. (6 mm) and may be tapped for a preliminary compressed air and soapsuds test for tightness of inside welds. These telltale holes may be plugged when the vessel is in service. The plugging material used shall not be capable of sustaining pressure between the lapped surfaces.

Socket welding is not permitted in process stream systems or where CIP or SIP requirements are defined.

MJ-3.2 Pressure Vessels and Tanks

Weld joint designs shall be those permitted by ASME BPVC, Section VIII and shall comply with MJ-3.1.

MJ-3.3 Piping

Weld joint designs shall be those permitted by ASME B31.3 and shall comply with MJ-3.1.

MJ-3.4 Tubing

Weld joint designs for hygienic tubing and fittings shall be square butt joints. The tubing and fittings shall have ends prepared by machining or facing to provide a square end that meets the requirements of Tables DT-3-1 and DT-3-2. The butt weld joints shall be properly cleaned within $^1/_2$ in. (13 mm) of the joint area on the inside and outside surfaces prior to welding. Welding on tubing shall be done using automatic (or machine) welding techniques (such as orbital tube welding or lathe welding), except where size or space will not permit. In that case, manual welding can be performed, but it shall be agreed to by the owner/user and contractor.

MJ-3.5 Tube-Attachment Welds (19)

(a) Tube-attachment welds are those that

(1) make branch connections other than those used to fabricate the fittings described in Part DT

(2) attach tubes to other product forms

(3) attach nozzles to transfer panels

(4) attach a tube to any part of a hygienic system

(b) Tube-attachment welds not governed by this section include

(1) those governed by MJ-8.4

(2) tube-to-tubesheet welds that are governed by ASME BPVC, Section VIII, in addition to the visual examination requirements of Part SF and MJ-8.2

These welds may be performed manually, by machine, or by an automatic welding process. Joint designs shall comply with MJ-3.1. The weld joints for complete penetration welds shall be prepared by means compatible with hygienic service. The weld joints shall be properly cleaned within $^1/_2$ in. (13 mm) on the inside and outside surfaces, where accessible, prior to welding. Fillet welds, groove welds, or a combination of both may be used.

MJ-3.6 Brazed Joints

Joint design shall comply with the latest edition of NFPA 99.

MJ-4 JOINING PROCESSES AND PROCEDURES

MJ-4.1 Introduction

All welds, including tack welds, shall be made in accordance with a welding procedure qualified in accordance with MJ-5. All welders and welding operators, including those who make tack welds, shall be qualified per MJ-6.

MJ-4.2 Welds Finished After Welding

For pressure vessels, tanks, and piping and tubing systems where the process contact surface of the weld is to be finished after welding, the welding processes used shall be limited to the arc or high-energy beam (electron beam and laser beam) processes as defined in AWS A3.0. The owner/user and contractor shall agree that the welding process selected will provide the desired results.

MJ-4.3 Welds Used in the As-Welded Condition

For pressure vessels, tanks, and piping and tubing systems where the process contact surface of the weld is to be used as is, welding processes shall be limited to the inert-gas arc processes (such as gas tungsten-arc welding and plasma arc welding) or the high energy beam processes (such as electron beam or laser beam welding), as defined in AWS A3.0. Every effort shall be made to use an automatic or machine welding process. Autogenous welds, welds with filler wire, or welds with consumable inserts are acceptable provided they meet the requirements for all applicable codes. The owner/user and contractor shall agree that the welding process selected will provide the desired results.

MJ-4.4 Brazing

Joining of copper and copper alloy materials by brazing shall be in accordance with NFPA 99. All brazing procedures shall be qualified per MJ-5. All brazers shall be qualified per MJ-6.

MJ-5 PROCEDURE QUALIFICATIONS

MJ-5.1 Pressure Vessels and Tanks

Welding procedures for pressure vessels and tanks shall be qualified in accordance with ASME BPVC, Section VIII.

MJ-5.2 Piping

Welding procedures for piping systems shall be qualified in accordance with ASME B31.3.

MJ-5.3 Tubing

Welding procedures for hygienic tubing systems shall be qualified in accordance with ASME B31.3, with the following additions:

(a) A change in the type or nominal composition of the backing (purge) gas shall require requalification.

(b) If filler metal is used, a change from one AWS classification of filler metal to another, or to a proprietary filler metal, shall require requalification.

This includes qualification of procedures for welding of components to Part DT but does not apply to longitudinal welds on tubes made in accordance with a recognized standard.

MJ-5.4 Duplex Stainless Steels

In addition to the welding procedure specification test requirements of ASME BPVC, Section IX, the weld metal and heat-affected zones from qualification test coupons of duplex stainless steels shall meet the requirements of ASTM A923 Methods A and/or C.

MJ-5.5 Brazing

Brazing procedures for piping systems shall be qualified in accordance with NFPA 99.

MJ-6 PERFORMANCE QUALIFICATIONS

MJ-6.1 Pressure Vessels and Tanks

Welder and welding operator performance qualifications for pressure vessels and tanks shall be in accordance with ASME BPVC, Section VIII.

MJ-6.2 Piping

Welder and welding operator performance qualifications for piping systems shall be in accordance with ASME B31.3. When the piping is to be used for hygienic systems, the essential variables for welding operators in MJ-6.3 shall also apply.

MJ-6.3 Tubing (19)

Welder and welding operator performance qualifications for hygienic tubing systems shall be in accordance with ASME B31.3. This includes qualification of welders and welding operators who fabricate components in accordance with Part DT but not those who manufacture tubes in accordance with a recognized standard.

For the qualification of welding operators, the following essential variables also apply:

(a) welding of a joint using an edge preparation other than a square groove.

(b) the addition or deletion of solid backing.

(c) a change in the fit-up gap from that qualified.

(d) a change in pipe/tube diameter. See Table MJ-6.3-1.

(e) the addition or deletion of filler metal.

(f) the addition or deletion of consumable inserts.

(g) a change in the thickness of the deposited weld metal. See Table MJ-6.3-2.

(h) the addition or deletion of backing gas (purge gas).

Table MJ-6.3-1 Metallic Tube/Pipe Diameter Limits for Orbital GTAW Performance Qualification

Outside Diameter of Test Coupon		Outside Diameter Qualified			
		Minimum		Maximum	
in.	mm	in.	mm	in.	mm
≤1/2	≤13	None	None	1/2	13
>1/2 to 3 1/2	>13 to 89	>1/2	>13	3 1/2	89
>3 1/2	>89	>3 1/2	>89	Unlimited	Unlimited

(19) **Table MJ-6.3-2 Metallic Weld Thickness Limits for Orbital GTAW Performance Qualification**

Thickness of Test Coupon, T_w		Deposited Weld Thickness Qualified		
		Minimum		
in.	mm	in.	mm	Maximum
<1/16	<1.5	T_w	T_w	$2T_w$
1/16 ≤ t ≤ 3/8	1.5 ≤ t ≤ 10	1/16	1.5	$2T_w$
>3/8	>10	3/16	5	Unlimited

(i) a change in the current type or polarity.

(j) a change in the weld head type from open head to closed head or vice versa.

(k) a change from single-pass to multipass welding or vice versa, when using filler wire.

In addition, either the original ASME BPVC, Section IX qualification coupon or another tube-to-tube weld coupon made by that same welding operator shall be visually examined and shall meet all the requirements of Table MJ-8.4-1.

Any change in the variables listed in (a) through (k) requires welding of a new test coupon, for which only visual examination in accordance with Table MJ-8.4-1 is required. Compliance with the variables in this paragraph shall be documented.

MJ-6.4 Brazing

Brazer performance qualifications, for piping systems, shall be in accordance with NFPA 99 and shall be made under an internal purge and exhibit full joint penetration.

MJ-7 EXAMINATION, INSPECTION, AND TESTING

Owner/user, inspection contractor, and/or engineer shall agree to the types of examinations, inspections, and testing unless otherwise specified in the applicable code.

MJ-7.1 Examination Procedures

MJ-7.1.1 Pressure Vessels and Tanks. Examination procedures for pressure vessels and tanks shall be in accordance with ASME BPVC, Section VIII.

MJ-7.1.2 Piping. Examination procedures for piping systems shall be in accordance with ASME B31.3.

MJ-7.1.3 Tubing. Examination procedures for tubing systems shall be in accordance with ASME B31.3.

MJ-7.1.4 Tube Attachments. Examination procedures for tubing systems shall be performed in accordance with ASME B31.3.

MJ-7.1.5 Brazing. Examination procedures for brazed systems shall be in accordance with NFPA 99.

MJ-7.2 Personnel Requirements

MJ-7.2.1 Pressure Vessels and Tanks. Personnel performing examinations of pressure vessels and tanks designed to ASME BPVC, Section VIII shall meet the requirements of the appropriate section of that Code.

All inspectors shall be qualified in accordance with GR-4.1.

All Inspectors' Delegates shall meet the requirements of GR-4.2.

MJ-7.2.2 Piping. All examiners, inspectors, and Inspectors' Delegates shall be qualified in accordance with GR-4.

MJ-7.2.3 Tubing. All examiners, inspectors, and Inspectors' Delegates shall be qualified in accordance with GR-4.

MJ-7.2.4 Tube Attachments. All examiners, inspectors, and Inspectors' Delegates shall be qualified in accordance with GR-4.

MJ-7.2.5 Copper Tubing/Piping. All examiners, inspectors, and Inspectors' Delegates shall be qualified in accordance with GR-4.

MJ-7.2.6 Examination Personnel Eye Examination Requirements. Personnel performing examinations shall have eye examinations as follows:

(a) Near Vision Acuity. The individual shall have natural or corrected near distance acuity in at least one eye such that the individual is capable of reading a minimum of a Jaeger Number 2 or equivalent type and size letter at a distance designated on the chart but no less than 12 in. (305 mm). This test shall be administered initially and at least annually thereafter.

(b) Color Contrast. The individual shall demonstrate the capability of distinguishing and differentiating contrast among colors. This test shall be administered initially and, thereafter, at intervals not exceeding 3 yr.

These examinations shall be administered by an ophthalmologist, optometrist, medical doctor, registered nurse or nurse practitioner, certified physician assistant, or other ophthalmic medical personnel and shall include the state or province (or applicable jurisdictional) license number.

MJ-7.3 Examination, Inspection, and Testing Requirements

MJ-7.3.1 Pressure Vessels and Tanks

(a) Examination. Examinations shall be performed in accordance with the provisions of ASME BPVC, Section VIII. In addition, all welds having a process contact surface shall be visually examined by the fabricator.

(b) Inspection. In addition to the inspection required by ASME BPVC, Section VIII, the owner/user or inspection contractor shall perform inspection(s) necessary to ensure compliance with this Standard as well as any additional requirements of the owner/user's specification.

(c) Testing. In addition to the testing required by ASME BPVC, Section VIII, the owner/user or inspection contractor shall perform testing necessary to ensure compliance with this Standard as well as any additional requirements of the owner/user's specification.

MJ-7.3.2 Piping

(a) Examination. Examinations shall be performed in accordance with the provisions of the specified fluid service in ASME B31.3.

(b) Inspection. The owner/user, inspection contractor, and/or engineer shall agree to the minimum percentage of process contact welds to be selected for borescopic or direct visual inspection, and they shall inform the installation contractor. The inspection contractor shall submit an inspection plan to ensure that welds meet the acceptance criteria of this Part. This plan shall include borescopic or direct visual inspection of the process contact surfaces on at least 20% of the welds in each system installed. A representative sample of each welder's and/or welding operator's work (as applicable) shall be included.

The examination required for compliance with ASME B31.3 may be included in the minimum inspection percentage, provided those examinations were direct visual or borescopic and of the process contact surface.

(c) Testing. Leak testing of piping systems shall be performed in accordance with the specified fluid service requirements in ASME B31.3.

MJ-7.3.3 Tubing

(a) Examination. Examinations shall be performed in accordance with the provisions of the specified fluid service in ASME B31.3. The external surfaces of all welds shall be visually examined.

If ASME B31.3, High Purity Fluid Service (Chapter X), is specified, radiographic, ultrasonic, or in-process examination is not required unless specified by the owner/user.

(b) Inspection. The owner/user, inspection contractor, and/or engineer shall agree to the minimum percentage of process contact welds to be selected for borescopic or direct visual inspection, and they shall inform the installation contractor. The inspection contractor shall submit an inspection plan to ensure that welds meet the acceptance criteria of this Part. This plan shall include borescopic or direct visual inspection of the process contact surfaces on at least 20% of the welds in each system installed. A representative sample of each welder's and/or welding operator's (as applicable) work shall be included. There shall also be a plan for inspecting a representative sample of each welder's and/or welding operator's (as applicable) first shift of production. A procedure shall be submitted for inspecting blind welds. The random selection of accessible welds to be inspected shall be up to the owner/user's inspector's discretion.

The examination required for compliance with ASME B31.3 may be included in the minimum inspection percentage, provided those examinations were direct visual or borescopic and of the process contact surface.

(c) Testing. Leak testing of tubing systems shall be performed in accordance with the specified fluid service requirements in ASME B31.3.

MJ-7.3.4 Tube Attachments

(a) Examination. Examinations shall be performed in accordance with the provisions of the specified fluid service in ASME B31.3. The external surfaces of all welds shall be visually examined.

(b) Inspection. Visual inspection shall be performed on all process contact surfaces affected by the attachment welding.

(c) Testing. Testing shall be performed in conjunction with the system test.

MJ-7.3.5 Brazing

(a) Examination. Examinations shall be performed in accordance with NFPA 99.

(b) Inspection. The owner/user, inspection contractor, and/or engineer shall agree to the minimum percentage of brazed joints to be selected for direct visual inspection, and they shall inform the installation contractor. The inspection contractor shall submit an inspection plan to ensure that joints meet the acceptance criteria of this Part. A representative sample of each brazer's work shall be included.

(c) Testing. Leak testing of copper systems shall be performed in accordance with the specified fluid service requirements in ASME B31.3.

MJ-7.4 Records

See GR-5.

MJ-8 ACCEPTANCE CRITERIA

MJ-8.1 General

Welding for a sterile environment requires that the weld shall not result in a surface that will contribute to microbiological growth and contamination of the process fluid. The weld shall not have any discontinuities

such as cracks, voids, porosity, or joint misalignment that will promote contamination of the process fluid. All welding procedures shall be qualified to MJ-5.

MJ-8.2 Pressure Vessel and Tank Welds

Weld acceptance criteria for pressure vessels and tanks shall be in accordance with ASME BPVC, Section VIII, with the additional requirements of Table MJ-8.2-1.

MJ-8.3 Piping Welds

Weld acceptance criteria for piping shall be in accordance with the specified fluid service of ASME B31.3. The additional requirements of Table MJ-8.3-1 shall apply. See SD-3.1.1 for cautionary information if using pipe instead of tube for hygienic systems.

(19) MJ-8.4 Tubing Welds

Weld acceptance criteria (including borescopic acceptance criteria) for tubing and components shall be in accordance with Table MJ-8.4-1 (see also Figures MJ-8.4-1 through MJ-8.4-4). This includes welds on components but not longitudinal welds on tubes manufactured in accordance with a recognized standard. Welds performed in the fabrication of extruded branch outlets (such as tees) and reducers are exempt from the misalignment criteria.

Preproduction sample welds, when required, shall be submitted by the contractor to the owner/user to establish weld quality. The owner/user, contractor, and inspection contractor shall agree to the number and type of sample welds.

During construction, sample welds shall be made on a regular basis to verify that the equipment is operating properly and that the purging setup is adequate to prevent discoloration beyond the level agreed on by the owner/user and contractor. The owner/user and contractor shall agree to the frequency of sample welds. It is strongly recommended that these sample welds be made at the beginning of each work shift, whenever the purge source bottle is changed, and when the automatic or machine welding equipment is changed (such as when the orbital tube weld head is changed).

The sample welds described in the preceding paragraphs, and any associated welding machine printed records (e.g., welding parameter printouts directly from the welding machine or downloaded from a welding machine), if any, may be disposed of after written acceptance of the coupons by the owner, the owner's representative, or the inspector.

MJ-8.4.1 Sample Welds. Sample welds for tubing shall meet all the acceptance criteria of Table MJ-8.4-1. An internal bead width of 1.0 to 2.5 times the nominal wall thickness is required.

MJ-8.4.2 Rewelding. Rewelding (reflow) may be attempted one time only for the following defects:

(a) incomplete penetration (lack of penetration)

(b) incomplete fusion (lack of fusion)

(c) unconsumed tack welds that can be inspected on the process contact side

All rewelds shall either totally consume the original weld or overlap the original weld with no base metal between the welds.

MJ-8.5 Tube-Attachment Welds

The acceptance criteria for tube-attachment welds shall be in accordance with Table MJ-8.5-1 (see also Figure MJ-8.5-1).

MJ-8.5.1 Sample Welds. Sample welds are not required for tube-attachment welds or seal welds.

MJ-8.5.2 Rewelding. Rewelding is allowed, except for welds that are process contact surfaces, for which the rewelding restrictions of MJ-8.4.2 apply.

MJ-8.6 Brazed Joints

Brazed joint acceptance criteria shall be in accordance with NFPA 99.

MJ-9 JOINING OF POLYMERIC MATERIALS

MJ-9.1 General

Polymeric materials are described in Part PM. All joining techniques may not be available for all polymeric materials, nor are all methods acceptable for all processes. The selection of materials of construction and joining techniques is based on application requirements.

MJ-9.2 Weld Joint Design and Preparation

The weld surfaces to be joined shall be properly aligned. This may include planing or facing of the components. The weld surfaces shall be protected against adverse environmental influences, including excessive moisture, extreme temperature conditions, excessive drafts, and contamination sources (e.g., dirt, dust, oil, foreign material shavings).

MJ-9.2.1 Tubing and Piping. Joint designs for tubing, piping, and fittings shall be square butt joints. Joining surfaces shall have ends prepared by molding, cutting, machining, or facing to provide a square end that meets requirements for the applicable welding procedure specification (WPS).

Table MJ-8.2-1 Visual Examination Acceptance Criteria for Welds on Metallic Pressure Vessels and Tanks (19)

Discontinuities	Welds on Process Contact Surfaces			Welds on Non–Process Contact Surfaces	
	Welds Left in the As-Welded Condition	Prior to Postweld Finishing	After Postweld Finishing	Welds Left in the As-Welded Condition	After Postweld Finishing
Cracks	None	None	None	None	None
Lack of fusion	None	None	None	None	None
Incomplete penetration	None on process contact side; otherwise, see Note (1)	None on process contact side; otherwise, see Note (1)	None on process contact side; otherwise, see Note (1)	See Notes (1) and (2)	See Notes (1) and (2)
Porosity	None open to the surface; otherwise, see Note (1)	See Note (1)	See Table SF-2.2-1 for acceptance criteria for pits/porosity	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)
Inclusions [metallic (e.g., tungsten) or nonmetallic]	None open to the surface; otherwise, see Note (1)	See Note (1)	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)
Undercut	None	See Note (1)	None	See Note (1)	See Note (1)
Groove weld concavity	See Note (1)	See Note (1)	Maximum of 10% of the nominal wall thickness of thinner member	See Note (1)	See Note (1)
Fillet weld convexity	$1/16$ in. (1.5 mm) max.	Per applicable design and fabrication code	$1/32$ in. (0.8 mm) max.	See Note (1)	See Note (1)
Discoloration (heat-affected zone)	Heat-affected zone (HAZ) may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (3).	N/A	HAZ may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (3).	Per customer specification	Per customer specification
Discoloration (weld bead)	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (3).	N/A	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (3).	Per customer specification	Per customer specification
Oxide island	Oxide islands are permitted as long as they are adherent to the surface. Reflective color of oxide island is not cause for rejection. Alloy types are identified in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3.	N/A	None allowed	Oxide islands permitted	Oxide islands permitted
Reinforcement	See Note (1)	See Note (1)	$1/32$ in. (0.8 mm) max.	See Note (1)	See Note (1)
Tack welds	See Note (1)	N/A	N/A	See Note (1)	N/A
Arc strikes	None	N/A	None	None	None

Table MJ-8.2-1 Visual Examination Acceptance Criteria for Welds on Metallic Pressure Vessels and Tanks (Cont'd)

Discontinuities	Welds on Process Contact Surfaces			Welds on Non–Process Contact Surfaces	
	Welds Left in the As-Welded Condition	Prior to Postweld Finishing	After Postweld Finishing	Welds Left in the As-Welded Condition	After Postweld Finishing
Overlap	None	None	None	None	None
Weld bead width	N/A	N/A	N/A	N/A	N/A
Minimum fillet weld size	See Note (1)	See Note (1)	See Note (1)	See Note (1)	See Note (1)
Misalignment (mismatch)	See Note (1)	See Note (1)	See Note (1)	See Note (1)	See Note (1)

NOTES:
(1) The limits of ASME BPVC, Section VIII shall apply.
(2) Does not apply to insulation sheathing and similar welds.
(3) Welds on pressure vessels or tanks that have been in service may require unique criteria.

(19)

Table MJ-8.3-1 Visual Examination Acceptance Criteria for Welds on Metallic Pipe

Discontinuities	Welds on Process Contact Surfaces			Welds on Non–Process Contact Surfaces	
	Welds Left in the As-Welded Condition	Prior to Postweld Finishing	After Postweld Finishing	Welds Left in the As-Welded Condition	After Postweld Finishing
Cracks	None	None	None	None	None
Lack of fusion	None	None	None	None	None
Incomplete penetration	None	None on process contact side; otherwise, see Note (1)	None on process contact side; otherwise, see Note (1)	See Notes (1) and (2)	See Notes (1) and (2)
Porosity	None open to the surface; otherwise, see Note (1)	See Note (1)	See Table SF-2.2-1 for acceptance criteria for pits/porosity	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)
Inclusions [metallic (e.g., tungsten) or nonmetallic]	None open to the surface; otherwise, see Note (1)	See Note (1)	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)	None open to the surface; otherwise, see Note (1)
Undercut	None	See Note (1)	None	See Note (1)	See Note (1)
Concavity	See Note (1)	See Note (1)	See Note (1)	See Note (1)	See Note (1)
Fillet weld convexity	$1/16$ in. (1.5 mm) max.	See Note (1)	$1/32$ in. (0.8 mm) max.	See Note (1)	See Note (1)
Discoloration (heat-affected zone)	Heat-affected zone (HAZ) may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (3).	N/A [see Note (3)]	HAZ may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (3).	Per customer specification	Per customer specification

Table MJ-8.3-1 Visual Examination Acceptance Criteria for Welds on Metallic Pipe (Cont'd)

Discontinuities	Welds on Process Contact Surfaces			Welds on Non–Process Contact Surfaces	
	Welds Left in the As-Welded Condition	Prior to Postweld Finishing	After Postweld Finishing	Welds Left in the As-Welded Condition	After Postweld Finishing
Discoloration (weld bead)	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (3).	N/A [see Note (3)]	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (3).	Per customer specification	Per customer specification
Oxide island	Oxide islands are permitted as long as they are adherent to the surface. Reflective color of oxide island is not cause for rejection. Alloy types are identified in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3.	N/A	None allowed	Oxide islands permitted	Oxide islands permitted
Reinforcement	See Note (1)	See Note (1)	$\frac{1}{32}$ in. (0.8 mm) max.	See Note (1)	See Note (1)
Tack welds	Must be fully consumed by final weld bead	Must be fully consumed by final weld bead	Must be fully consumed by final weld bead	Per customer specification	Per customer specification
Arc strikes	None	None	None	None	None
Overlap	None	None	None	None	None
Weld bead width	N/A	N/A	N/A	N/A	N/A
Minimum fillet weld size	See Note (1)	See Note (1)	See Note (1)	See Note (1)	See Note (1)
Misalignment (mismatch)	See Notes (1) and (4)	See Notes (1) and (4)	See Notes (1) and (4)	See Notes (1) and (4)	See Notes (1) and (4)

NOTES:
(1) The limits of ASME B31.3 shall apply.
(2) Does not apply to insulation sheathing and similar welds.
(3) Special surface preparation may be needed to meet the criteria. Welds on piping that has been in service may require unique criteria.
(4) It is recognized that the I.D. misalignment is more relevant to hygienic design than O.D. misalignment. However, not all connections facilitate ready measurement of I.D. misalignment. For situations where compliance with O.D. misalignment criteria results in an I.D. misalignment that could affect drainability or cleanability, see Nonmandatory Appendix C for further details.

Table MJ-8.4-1 Visual Examination Acceptance Criteria for Groove Welds on Metallic Tube-to-Tube Butt Joints (19)

Discontinuities	Welds on Process Contact Surfaces	Welds on Non–Process Contact Surfaces
Cracks	None	None
Lack of fusion	None	None
Incomplete penetration	None [see Figure MJ-8.4-1, illustration (g)]	None [see Figure MJ-8.4-1, illustration (g)]
Porosity	None open to the surface; otherwise, see Note (1). If postweld finishing is performed, see Table SF-2.2-1 for acceptance criteria for pits/porosity.	None open to the surface; otherwise, see Note (1)
Inclusions [metallic (e.g., tungsten) or nonmetallic]	None open to the surface; otherwise, see Note (1)	See Note (1)
Undercut	None	See Note (1)
Concavity	10% T_w max. [see Figure MJ-8.4-1, illustration (d)]. However, O.D. and I.D. concavity shall be such that the wall thickness is not reduced below the minimum thickness required in DT-3 [see Note (2)].	10% T_w max. [see Figure MJ-8.4-1, illustration (c)] over entire circumference with up to 15% T_w permitted over a maximum of 25% of the circumference [see Note (2)]

Table MJ-8.4-1 Visual Examination Acceptance Criteria for Groove Welds on Metallic Tube-to-Tube Butt Joints (Cont'd)

Discontinuities	Welds on Process Contact Surfaces	Welds on Non–Process Contact Surfaces
Convexity	10% T_w max. [see Figure MJ-8.4-1, illustration (f)] [see Note (2)]	0.015 in. (0.38 mm) max. [see Figure MJ-8.4-1, illustration (e)] [see Note (2)]
Discoloration (heat-affected zone)	Heat-affected zone (HAZ) may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (3)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. See Note (3)
Discoloration (weld bead)	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (3)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. See Note (3)
Reinforcement	See convexity	See convexity
Tack welds	Must be fully consumed by final weld bead [see Note (4)]	Same as process contact side
Arc strikes	None	See Note (5)
Overlap	None	None
Weld bead width	No limit provided that complete joint penetration is achieved	If process contact surface cannot be examined (such as I.D. of a tube beyond the reach of remote vision equipment), then the non-process contact surface weld bead shall be straight and uniform around the entire weld circumference [see Figure MJ-8.4-4, illustration (a)]. The minimum weld bead width shall not be less than 50% of the maximum weld bead width [see Figure MJ-8.4-4, illustration (b)]. The maximum weld bead meander shall be 25% of the weld bead width, measured as a deviation from the weld centerline, as defined in Figure MJ-8.4-4, illustration (c).
Minimum throat	N/A	N/A
Misalignment (mismatch) [Notes (6), (7), and (8)]	N/A [see Note (6)]	15% T_w max. [see Figure MJ-8.4-1, illustration (b)], except that 4-in. tube may have a maximum of 0.015 in. (0.38 mm) misalignment on the O.D. and 6-in. tube may have a maximum of 0.030 in. (0.76 mm) misalignment on the O.D. Figure MJ-8.4-1, illustration (b) does not apply to 4-in. and 6-in. tube [see Notes (2) and (6)].
Oxide island	Oxide islands are permitted as long as they are adherent to the surface. Reflective color of oxide island is not cause for rejection. Alloy types are identified in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3.	Oxide islands permitted

GENERAL NOTE: Includes all product forms (e.g., tube, fittings, castings, forgings, and bar) whose final dimensions meet Part DT requirements.

NOTES:
(1) The limits of ASME B31.3 shall apply.
(2) T_w is the nominal wall thickness of the thinner of the two members being joined. Weld metal shall blend smoothly into base metal.
(3) Welds on tubing that has been in service may require unique criteria.
(4) Any weld that shows unconsumed tack welds on the non–process contact surface shall be examined on the process contact surface; otherwise it is rejected. If the weld cannot be examined on the process contact surface, rewelding per MJ-8.4.2 is not allowed. Rewelding per MJ-8.4.2 is allowed if the weld can be examined on the process contact surface after rewelding.
(5) Arc strikes on the non–process contact surface may be removed by mechanical polishing as long as the minimum design wall thickness is not compromised.
(6) Note that misalignment is controlled on the O.D. and is based on allowable O.D. dimensions and tolerances of fittings and tubing. The owner/user is cautioned that this can result in greater I.D. misalignment because this also takes into consideration the wall thickness dimensions and tolerances of fittings and tubing. However, there are no specified I.D. misalignment acceptance criteria.
(7) It is recognized that the I.D. misalignment is more relevant to hygienic design than O.D. misalignment. However, not all connections facilitate ready measurement of I.D. misalignment. For situations where compliance with O.D. misalignment criteria results in an I.D. misalignment that could affect drainability or cleanability, see Nonmandatory Appendix C for further details.
(8) Misalignment criteria do not apply in the fabrication of extruded branch outlets (such as tees) and reducers.

MJ-9.3 Joining Processes and Procedures

Tube and pipe systems composed of polymeric materials are joined by a variety of heat fusion welding methods, including beadless fusion, noncontact infrared (IR) fusion, contact butt fusion, and socket fusion. Fusion does not require solvents or glue to join material, and nothing is added or changed chemically between the two components being joined. Other joining methods may be used when agreed on by the owner/user. Joining of polymeric materials shall be performed in accordance with a documented WPS that is qualified in accordance with MJ-9.4. The owner/user, contractor, and manufacturer shall agree that the welding process selected will provide the desired results.

MJ-9.3.1 Beadless Welding. Beadless welding (a material-dependent process) shall be used where drainability is required (see Figure MJ-9.7.1-1) (reference SD-2.4.3).

MJ-9.3.1.1 Records. Weld equipment should monitor and record critical weld parameters such as heat, cool time, and temperature. If the equipment does not have monitoring or recording capabilities, weld data shall be recorded in welding protocols or on data carriers.

MJ-9.3.2 Noncontact IR and Contact Butt Fusion Welding. Noncontact infrared and contact butt fusion are not suitable joining processes for systems requiring drainability. Either may be acceptable for single-use applications. Refer to the WPS or manufacturer's written procedures.

MJ-9.3.3 Socket Fusion Welding. Socket fusion is not suitable for systems requiring drainability. Socket fusion may be acceptable for single-use applications where approved by the owner/user for the intended service. Refer to the WPS or manufacturer's written procedures.

MJ-9.4 Procedure Qualifications

Welding procedures shall be qualified in accordance with AWS B2.4. A WPS shall be provided for each polymeric material and process being used. Environmental condition recommendations shall be included in the WPS.

MJ-9.5 Performance Qualifications

Welder and welding operator performance qualifications shall be in accordance with AWS B2.4. The quality of polymeric weld joints depends on the qualification of the welders and welding operators, the suitability of the equipment used, environmental influences, and adherence to the applicable WPS. Welders and welding operators shall be trained and possess a valid qualification certificate from the manufacturer for the process and material being welded.

MJ-9.6 Examination, Inspection, and Testing

Examination, inspection, and testing criteria and methods are dictated by material type and joining method. The owner/user, inspection contractor, and/or engineer shall agree to the types of examinations, inspections, and testing unless otherwise specified in the applicable code.

MJ-9.6.1 Examination Procedures. Written visual examination procedures shall be used.

MJ-9.6.2 Personnel Requirements

MJ-9.6.2.1 Personnel Qualifications. All examiners, inspectors, and Inspectors' Delegates shall be qualified in accordance with GR-4 and shall be trained and possess a valid qualification certificate from the manufacturer for the process and material being welded.

MJ-9.6.2.2 Examination Personnel Eye Examination Requirements. Personnel performing examinations shall have eye examinations as follows:

(a) Near Vision Acuity. The individual shall have natural or corrected near distance acuity in at least one eye such that the individual is capable of reading a minimum of a Jaeger Number 2 or equivalent type and size letter at a distance designated on the chart but no less than 12 in. (305 mm). This test shall be administered initially and at least annually thereafter.

(b) Color Contrast. The individual shall demonstrate the capability of distinguishing and differentiating contrast among colors. This test shall be administered initially and, thereafter, at intervals not exceeding 3 yr.

These examinations shall be administered by an ophthalmologist, optometrist, medical doctor, registered nurse or nurse practitioner, certified physician assistant, or other ophthalmic medical personnel and shall include the state or province (or applicable jurisdictional) license number.

MJ-9.6.3 Examination, Inspection, and Testing Requirements

MJ-9.6.3.1 Examination. Examinations shall be performed in accordance with the provisions of the specified fluid service in ASME B31.3.

The external surfaces of all welds shall be visually examined. If ASME B31.3, High Purity Fluid Service (Chapter X), is specified, radiographic, ultrasonic, or in-process examination is not required unless specified by the owner/user.

Preproduction sample welds, when required, shall be submitted by the contractor to the owner/user to establish weld quality. The owner/user, contractor, and inspection contractor shall agree to the number and type of sample welds. During construction, sample welds shall be made on a regular basis to verify that the equipment is operating properly and that the setup is adequate to prevent discoloration beyond the level agreed on by

Figure MJ-8.4-1 Acceptable and Unacceptable Weld Profiles for Groove Welds on Metallic Tube-to-Tube Butt Joints

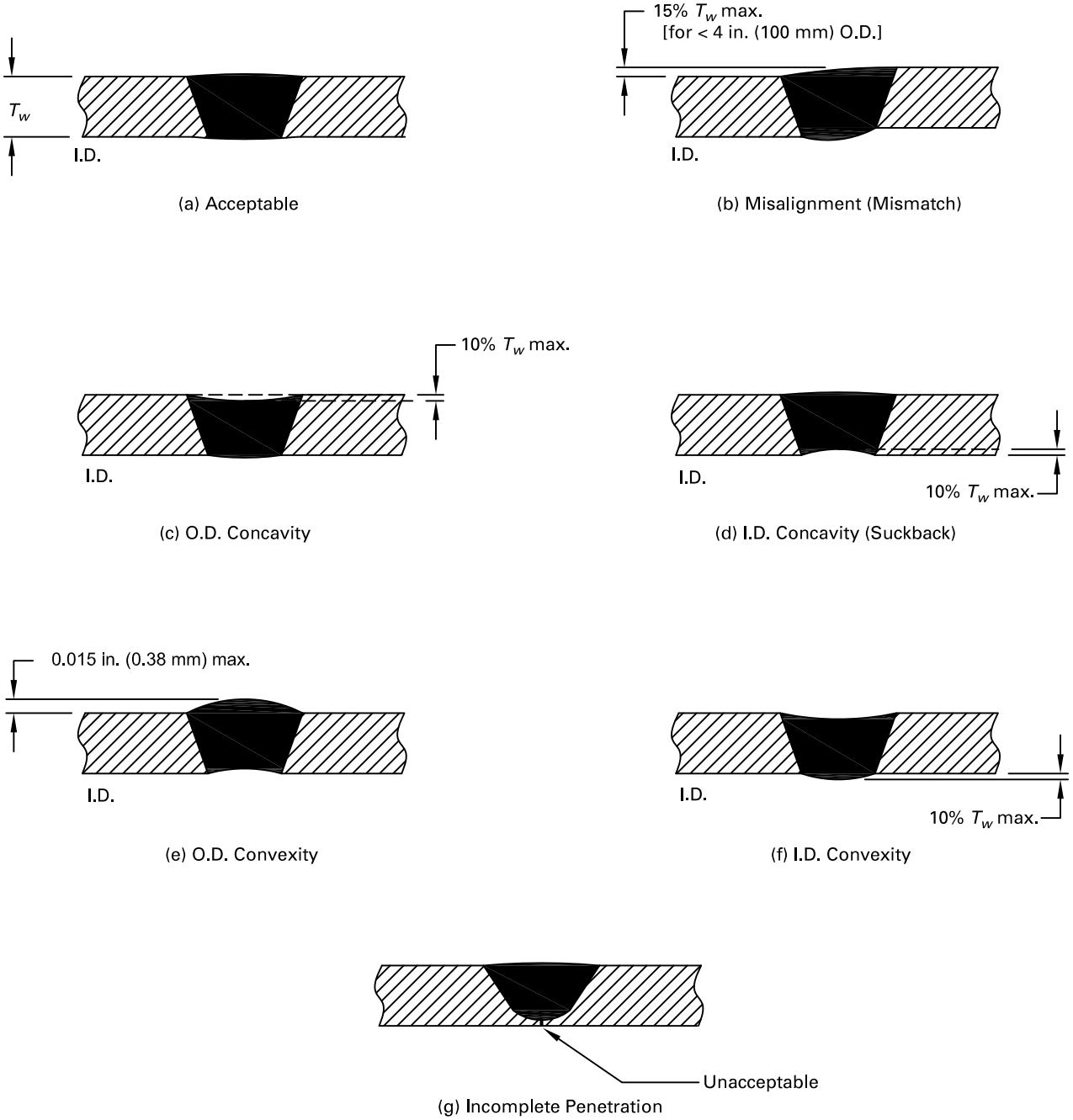
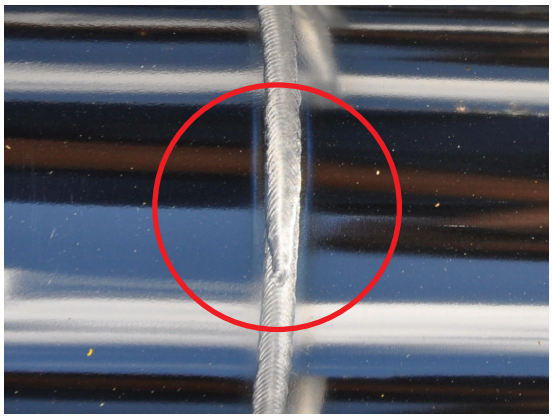
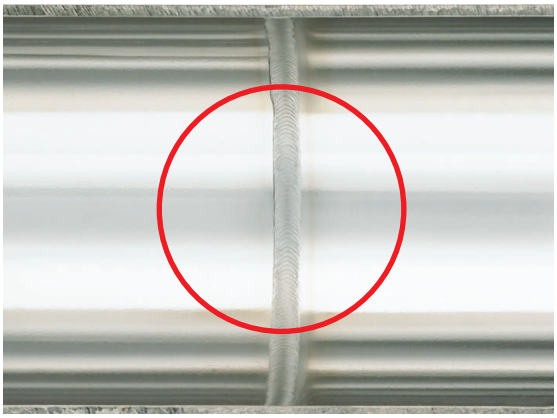


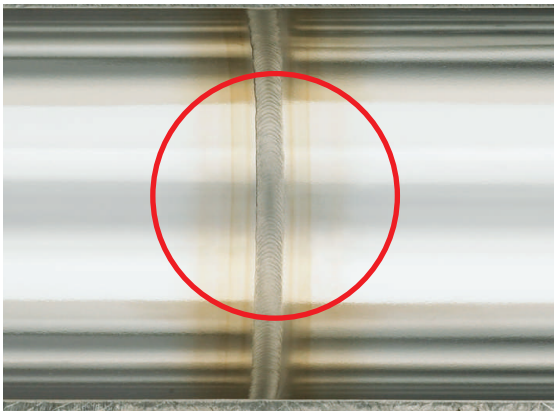
Figure MJ-8.4-2 Discoloration Acceptance Criteria for Welds and Heat-Affected Zones on Electropolished UNS S31603 Tubing



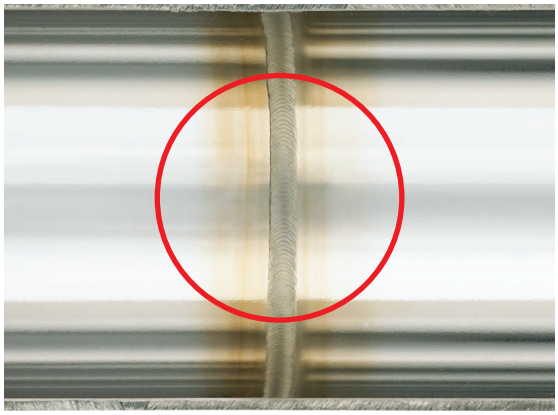
Sample #1a



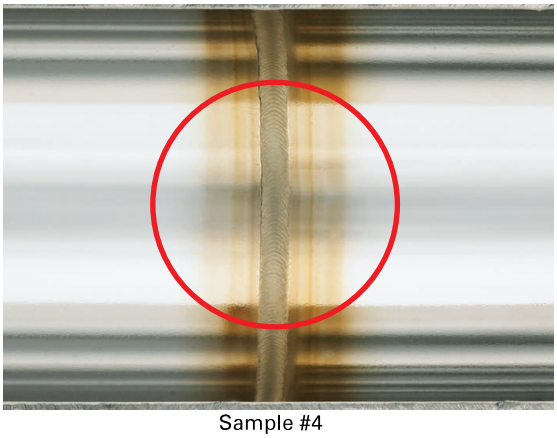
Sample #1b



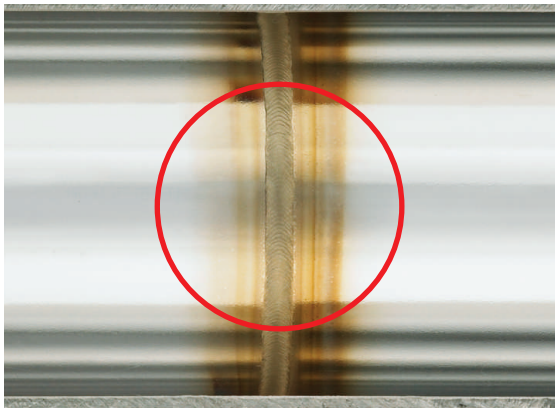
Sample #2



Sample #3



Sample #4



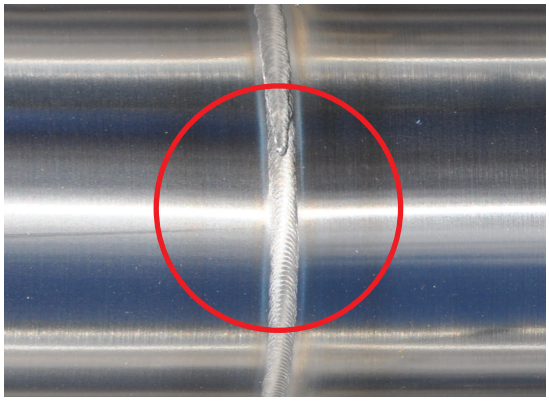
Sample #5

The weld beads shown in the above photographs are the weld beads on the I.D. of the tubing. The area for comparison in each photograph is the area inside the red circle. The weld bead shall have no discoloration. Weld heat-affected zones on electropolished UNS S31603 tubing with discoloration levels no worse than Samples #1 through #4 in the as-welded condition are acceptable. Heat-affected zone discoloration levels more severe than that shown in Sample #4 are unacceptable. Sample #5 shows unacceptable weld and heat-affected zone discoloration levels for comparison. The user is cautioned that the colors observed during direct visual examination or borescope examination will be different viewing directly down (90 deg) at the surface compared with viewing at a lower angle along the edges.

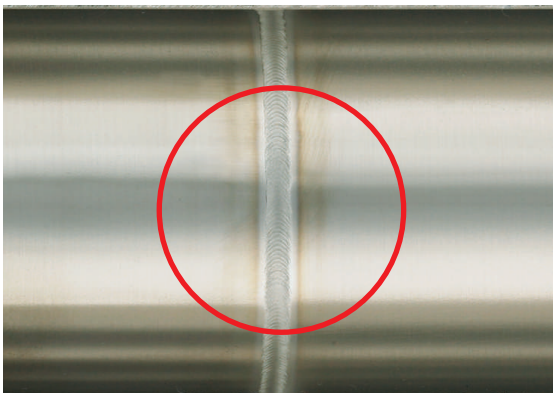
GENERAL NOTE: The user is cautioned that electronic versions or photocopies of these acceptance criteria shall not be used for evaluation of sample or production welds since subtle differences in color can influence weld acceptability. Nonmandatory Appendix N explains the technique by which these acceptance criteria were determined.

This figure is also available as a stand-alone document from ASME as ASME BPE-EP.

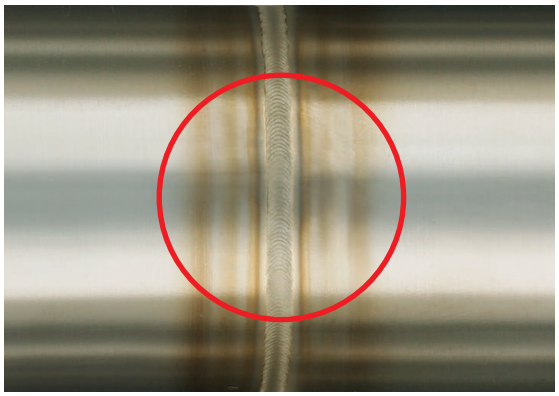
Figure MJ-8.4-3 Discoloration Acceptance Criteria for Welds and Heat-Affected Zones on Mechanically Polished UNS S31603 Tubing



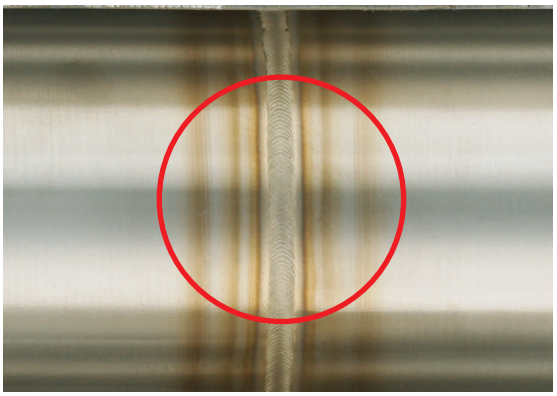
Sample #1a



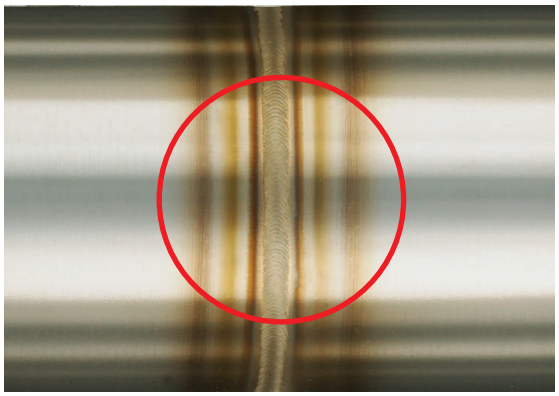
Sample #1b



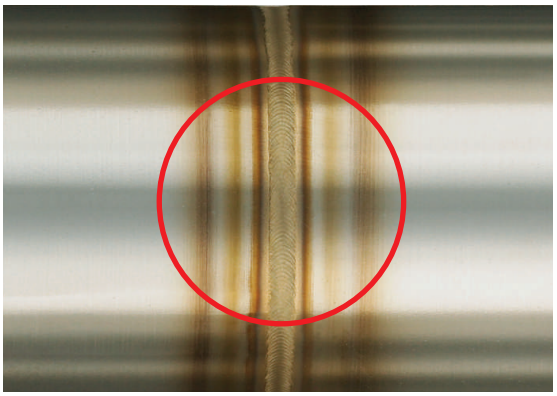
Sample #2



Sample #3



Sample #4



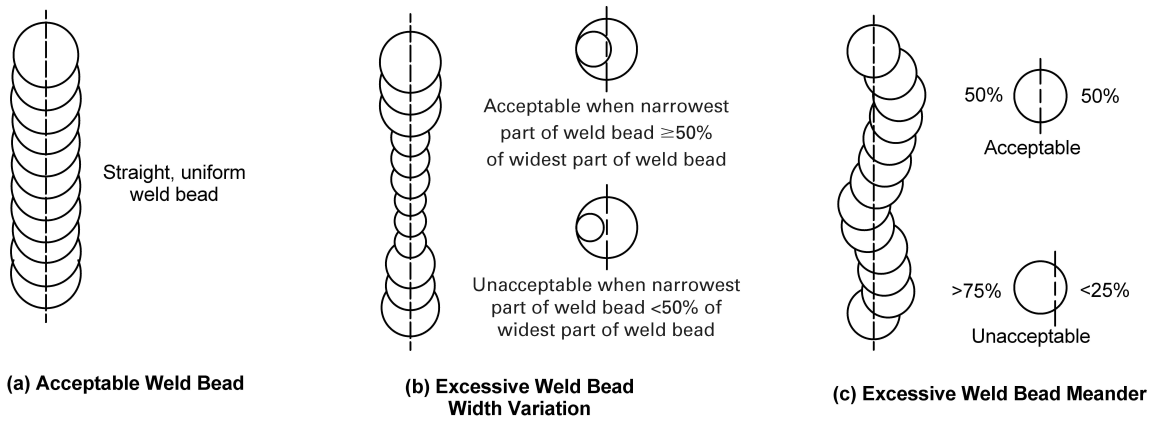
Sample #5

The weld beads shown in the above photographs are the weld beads on the I.D. of the tubing. The area for comparison in each photograph is the area inside the red circle. The weld bead shall have no discoloration. Weld heat-affected zones on mechanically polished UNS S31603 tubing with discoloration levels no worse than Samples #1 through #3 in the as-welded condition are acceptable. Heat-affected zone discoloration levels more severe than that shown in Sample #3 are unacceptable. Samples #4 and #5 show unacceptable weld and heat-affected zone discoloration levels for comparison. The user is cautioned that the colors observed during direct visual examination or borescope examination will be different viewing directly down (90 deg) at the surface compared with viewing at a lower angle along the edges.

GENERAL NOTE: The user is cautioned that electronic versions or photocopies of these acceptance criteria shall not be used for evaluation of sample or production welds since subtle differences in color can influence weld acceptability. Nonmandatory Appendix N explains the technique by which these acceptance criteria were determined.

This figure is also available as a stand-alone document from ASME as ASME BPE-MP.

(19) **Figure MJ-8.4-4 Acceptable and Unacceptable Metallic Weld Bead Width and Meander on Non–Process Contact Surfaces of Groove Welds on Tube-to-Tube Butt Joints**



(a) Acceptable Weld Bead

(b) Excessive Weld Bead Width Variation

(c) Excessive Weld Bead Meander

GENERAL NOTE:
Applies only to non-process contact surfaces and only if weld on process contact surface cannot be examined.

(19) **Table MJ-8.5-1 Visual Examination Acceptance Criteria for Metallic Tube-Attachment Welds**

Discontinuities	Groove Welds [Note (1)]		Fillet Welds	
	Welds on Process Contact Surfaces	Welds on Non-Process Contact Surfaces	Welds on Process Contact Surfaces	Welds on Non-Process Contact Surfaces
Cracks	None	None	None	None
Lack of fusion	None	None	None	None
Incomplete penetration	None	None	N/A	N/A [see Note (2)]
Porosity	None open to the surface; otherwise, see Note (3). If postweld finishing is performed, see Table SF-2.2-1 for acceptance criteria for pits/porosity.	None open to the surface; otherwise, see Note (3)	None open to the surface; otherwise, see Note (3). If postweld finishing is performed, see Table SF-2.2-1 for acceptance criteria for pits/porosity.	None open to the surface; otherwise, see Note (3)
Inclusions [metallic (e.g., tungsten) or nonmetallic]	None open to the surface	None open to the surface	None open to the surface	None open to the surface
Undercut	None	See Note (3)	None, see Note (4). [For autogenous fillet welds see Figure MJ-8.5-1, illustration (c)]	See Notes (3) and (5). [For autogenous fillet welds see Figure MJ-8.5-1, illustration (c)]
Concavity	10% T_w max. [see Figure MJ-8.4-1, illustrations (c) and (d)]. However, O.D. and I.D. concavity shall be such that the wall thickness is not reduced below the minimum thickness required in DT-3 [see Note (6)].	10% T_w [see Figure MJ-8.4-1, illustrations (c) and (d)] over entire circumference with up to 15% T_w permitted over a maximum of 25% of the circumference [see Note (6)]	N/A [see Figure MJ-8.5-1, illustrations (a) and (c), and Note (4)]	N/A [see Figure MJ-8.5-1, illustrations (a) and (c), and Note (5)]
Convexity	10% T_w max.	0.015 in. (0.38 mm) max. and Note (3)	10% T_w max. [see Figure MJ-8.5-1, illustration (b) and Note (6)]	N/A
Discoloration (heat-affected zone)	Heat-affected zone (HAZ) may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (7)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. See Note (7)	HAZ may be permitted to have light straw to light blue color (see Figures MJ-8.4-2 and MJ-8.4-3). Any discoloration present must be tightly adhering to the surface such that normal operations will not remove it. In any case, the HAZ shall have no evidence of rust, free iron, or sugaring. See Note (7)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. See Note (7)
Discoloration (weld bead)	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (7)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. This criterion	None allowed. This criterion does not apply to oxide islands visible on weld bead. See Note (7)	Discoloration level shall be agreed on between the owner/user and contractor. Postweld conditioning may be allowed to meet discoloration requirements at the discretion of the owner/user. This criterion

(19) **Table MJ-8.5-1 Visual Examination Acceptance Criteria for Metallic Tube-Attachment Welds (Cont'd)**

Discontinuities	Groove Welds [Note (1)]		Fillet Welds	
	Welds on Process Contact Surfaces	Welds on Non-Process Contact Surfaces	Welds on Process Contact Surfaces	Welds on Non-Process Contact Surfaces
		does not apply to oxide islands visible on weld bead. See Note (7)		does not apply to oxide islands visible on weld bead. See Note (7)
Oxide island	Oxide islands are permitted as long as they are adherent to the surface. Reflective color of oxide island is not cause for rejection. Alloy types are identified in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3.	Oxide islands permitted	Oxide islands are permitted as long as they are adherent to the surface. Reflective color of oxide island is not cause for rejection. Alloy types are identified in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3.	Oxide islands permitted
Reinforcement	See convexity	See convexity	N/A	N/A
Tack welds	Must be fully consumed by final weld bead; see Note (8)	Must be fully consumed by final weld bead; see Note (9)	Must be fully consumed by final weld bead; see Note (8)	Must be fully consumed by final weld bead; see Note (9)
Arc strikes	None	See Note (10)	None	See Note (10)
Overlap	None	None	None	None
Weld bead width	N/A	N/A	N/A	N/A
Minimum fillet weld size	N/A	N/A	Per client specification and Note (4). [For autogenous fillet welds see Figure MJ-8.5-1, illustration (c)]	Per client specification and Note (5). [For autogenous fillet welds see Figure MJ-8.5-1, illustration (c)]
Misalignment (mismatch)	N/A as long as other conditions are met	N/A as long as other conditions are met	N/A	N/A

GENERAL NOTE: Tube attachment welds include groove welds and fillet welds in various joint configurations, such as proximity stems on jumpers on transfer panels, transfer panel nozzles, and locator pins on sprayballs.

NOTES:

(1) Any weld where penetration is required into the joint.

(2) Penetration to the process contact surfaces is neither required nor prohibited. Welds that penetrate through to the process contact surface may exhibit intermittent penetration. Weld penetration through to the process contact surface shall meet all other process contact surface requirements of this Table.

(3) The limits of ASME B31.3 shall apply.

(4) For welds designated by the owner/user as autogenous fillet welds (seal welds), there is no minimum fillet weld size or throat. Concavity requirements are not applicable. Undercut in process contact surfaces shall not exceed the lesser of 0.015 in. or 15% T_w and shall have a smooth transition between weld and base metal.

(5) For welds designated by the owner/user as autogenous fillet welds (seal welds), there is no minimum fillet weld size or throat. Concavity and undercut requirements are not applicable.

(6) T_w is the nominal thickness of the thinner of the two members being joined. Weld metal shall blend smoothly into base metal.

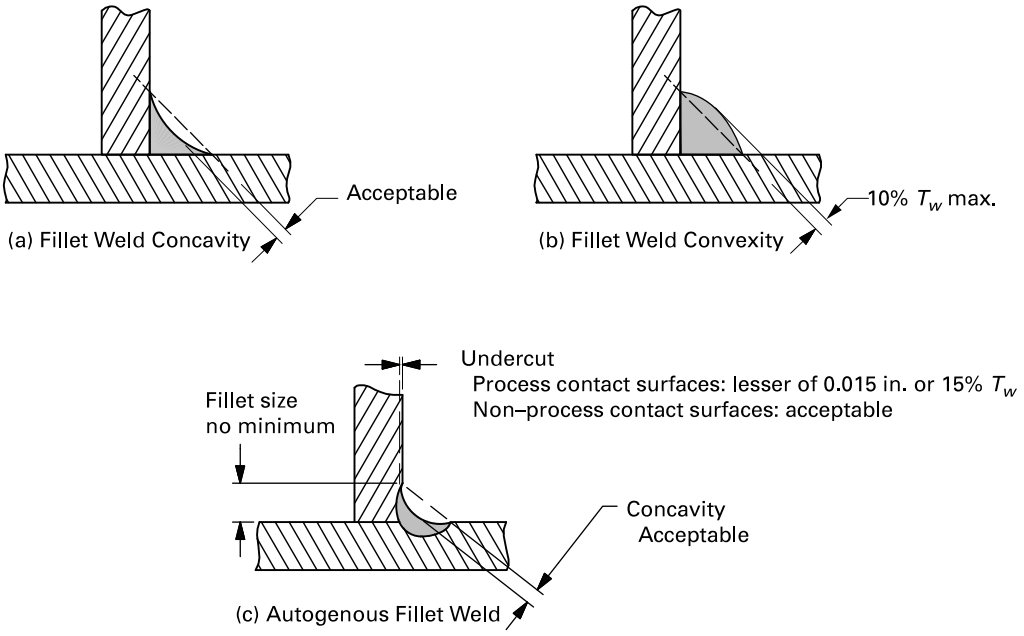
(7) Welds on tube attachments that have been in service may require unique criteria.

(8) Rewelding per MJ-8.5.2 is allowed.

(9) Any weld showing unconsumed tack weld(s) on the non-process contact surface can be rewelded per MJ-8.5.2 if the process contact surface can be reexamined. Otherwise, it is rejected.

(10) Arc strikes on the non-process contact surface may be removed by mechanical polishing as long as the minimum design wall thickness is not compromised.

Figure MJ-8.5-1 Acceptable Weld Profiles for Metallic Tube-Attachment Fillet Welds



the owner/user and contractor. The owner/user and contractor shall agree to the frequency of sample welds. It is strongly recommended that these sample welds be made at the beginning of each work shift and when changing the welder and/or welding operator (as applicable) and welding equipment.

The sample welds described in the preceding paragraphs, and any associated welding machine printed records (e.g., welding parameter printouts directly from the welding machine or downloaded from a welding machine), if any, may be disposed of after written acceptance of the coupons by the owner, the owner's representative, or the inspector.

MJ-9.6.3.2 Inspection. The owner/user, inspection contractor, and/or engineer shall agree to the minimum percentage of process contact welds to be selected for borescopic or direct visual inspection, and they shall inform the installation contractor. The inspection contractor shall submit an inspection plan to ensure that welds meet the acceptance criteria of this Part. This plan shall include borescopic or direct visual inspection of the process contact surfaces or visual inspection with light illumination of the weld cross sections on at least 20% of the welds in each system installed. A representative sample of each welder's and/or welding operator's (as applicable) work shall be included. There shall also be a plan for inspecting a representative sample of each welder's and/or welding operator's (as applicable) first shift of production. A procedure shall be submitted for inspecting blind welds. The random selection of accessible welds to be inspected shall be up to the owner/user's inspector's discretion.

The examination required for compliance with ASME B31.3 may be included in the minimum inspection percentage, provided those examinations were direct visual or borescopic and of the process contact surface.

MJ-9.6.3.3 Testing. Hydrostatic leak testing shall be performed in accordance with the specified fluid service requirements in ASME B31.3. Hydrostatic leak testing shall never exceed the manufacturer's rating of the system installed.

The use of pneumatic testing is not recommended on these systems.

MJ-9.6.4 Records. See GR-5.

MJ-9.7 Weld Acceptance Criteria

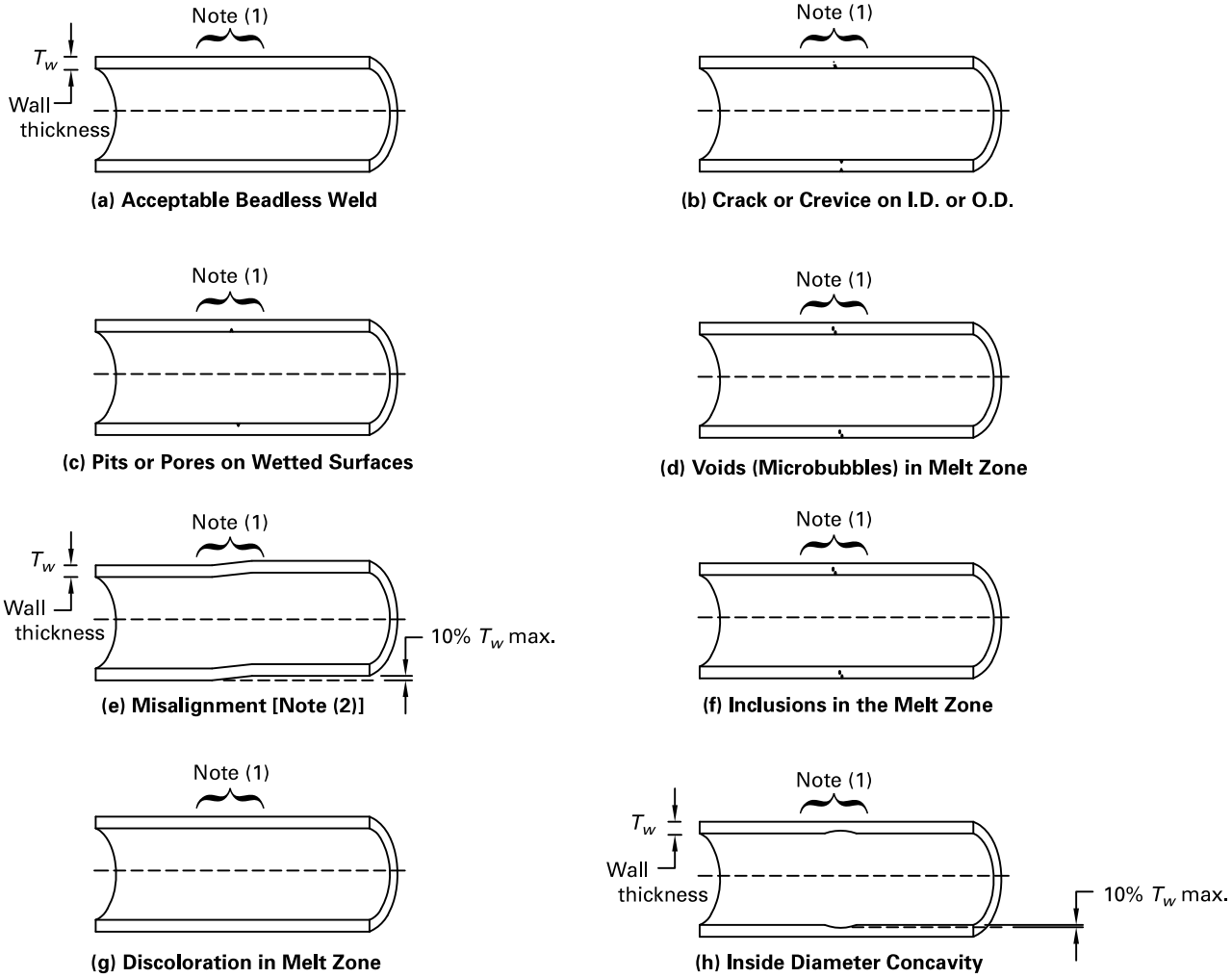
Common visual acceptance criteria include complete bonding of joining surface, straight and aligned joints, and exclusion of dirt and foreign substances in the weld zone.

MJ-9.7.1 Acceptance Criteria for Beadless Welds. An acceptable beadless weld is shown in Figure MJ-9.7.1-1, illustration (a). Weld acceptance criteria shall be in accordance with the following:

(a) Cracks and Crevices. Any crack or crevice would generally indicate lack of full penetration welds. Internal or external cracks or crevices shall not be permitted in the weld zone [see Figure MJ-9.7.1-1, illustration (b)].

(b) Pits and Pores. Pits and pores shall not be present in the weld zone on the interior surface [see Figure MJ-9.7.1-1, illustration (c)].

Figure MJ-9.7.1-1 Acceptable and Unacceptable Weld Profiles for Polymeric Beadless Welds



NOTES:
(1) Weld examination area: melt zone (area that was supported during fusion).
(2) Note that misalignment is controlled on the O.D. and is based on allowable O.D. dimensions and tolerances of fittings and piping. The owner/user is cautioned that this can result in greater I.D. misalignment because this also takes into consideration the wall thickness dimensions and tolerances of fittings and piping. However, there are no specified I.D. misalignment acceptance criteria.

(c) Voids. Voids or microbubbles in the weld zone are the result of molten material shrinking as it cools, leaving small voids, usually in the center of the weld, due to volume displacement. They are not uncommon in beadless welding, and their presence alone is not reason for rejection.

(1) The maximum single void diameter shall be 10% of nominal wall thickness.

(2) The maximum total for all void diameters in a given cross-sectional examination shall be 10% of nominal wall thickness [see Figure MJ-9.7.1-1, illustration (d)].

(d) Fit-Up and Mismatch. Components shall be aligned so as to prevent holdup that would contribute to contamination of the process fluid. The maximum misalignment is 10% of nominal wall thickness [see Figure MJ-9.7.1-1, illustration (e)]. It is not recommended to join components of different wall thicknesses.

(e) Inclusions. Any dark, visible inclusion(s) or speck(s) on the process contact surface of the weld zone are considered foreign materials and are not acceptable [see Figure MJ-9.7.1-1, illustration (f)].

(f) Discoloration. Slight discoloration in the weld zone is not uncommon in beadless welding. Slight discoloration would include up to a light "straw" color in the weld zone. Dark color on the surface or at the weld interface could indicate improper cleaning or joint preparation and is rejectable [see Figure MJ-9.7.1-1, illustration (g)].

(g) Concavity. Maximum inside diameter (I.D.) concavity shall be limited to 10% of the nominal wall thickness [see Figure MJ-9.7.1-1, illustration (h)].

MJ-9.7.2 Acceptance Criteria for Nonbeadless Welds. Acceptance criteria for nonbeadless welds in piping shall be in accordance with AWS G1.10M or DVS 2202-1.

MJ-9.7.3 Acceptance Criteria for Sample Welds. Sample welds shall meet all the acceptance criteria of MJ-9.7.1.

MJ-9.7.4 Rewelding. Rewelding is not allowed.

MJ-9.8 Documentation Requirements

The following documentation shall be presented to the owner/user or their designee, as a minimum:

(a) Welding Documentation. Welding procedure specifications (WPSs) used, their procedure qualification records (PQRs), and welder performance qualifications (WPQs)/performance qualification test records (PQTRs) and/or welding operator performance qualifications (WOPQs).

(b) Weld Maps. When required by the owner/user, weld maps of bioprocessing components, weld inspection logs of bioprocessing components (including type and date of inspection), and welder and/or welding operator identification of each weld shall be provided either on the weld map or on the inspection log.

Fusion equipment that electronically stores welding histories and serializes welds should be used. Welding history shall be turned over, in printed or electronic format, to the owner/user on completion of work and as part of the installation qualification (IQ) process.

(c) Materials. All molded fittings, molded valves, and extruded piping shall be intrinsically identified to provide, as a minimum, material of construction, lot number, and date of production to ensure traceability. Certificates of Compliance shall be provided for molded/extruded components not individually labeled.

(d) Testing Records. Other records (e.g., pressure test, surface finish) shall be provided as required by the owner/user.

MJ-10 DOCUMENTATION REQUIREMENTS

The requirements for metallic materials and weld documentation are listed in GR-5. For polymeric materials, see MJ-9.8.

MJ-11 PASSIVATION (19)

Refer to SF-2.4.

PART SF
PROCESS CONTACT SURFACE FINISHES

SF-1 PURPOSE AND SCOPE

The purpose of this Part is to provide process contact surface finish acceptance criteria for metallic and polymeric materials.

SF-2 METALLIC APPLICATIONS

SF-2.1 Applicable Systems

This Part shall be applicable to all systems designated by the owner/user or representative thereof.

Process contact surface requirements shall apply to all accessible and inaccessible areas of the systems that directly or indirectly come in contact with the designated product.

These systems shall include, but are not limited to, one or more of the following:

(a) USP water-for-injection (WFI)
(b) USP purified water
(c) USP pure steam
(d) other product/process contact surface systems

SF-2.2 Acceptance Criteria

Acceptance criteria, for common austenitic stainless steels as per Table MM-2.1-1, are listed in Tables SF-2.2-1 and SF-2.2-2. Acceptance criteria for other alloys as described in Part MM may differ and should be mutually agreed on by both the owner/user and supplier prior to ordering material. Visual comparison charts or samples may be used to define acceptable and/or unacceptable process contact surfaces.

(19) SF-2.3 Examination Techniques Employed in the Classification of Process Contact Surface Finishes

SF-2.3.1 General. Process contact surface finish examinations shall be made by one or more of the following methods:

(a) visual examination
(1) direct visual examination
(2) remote visual examination (e.g., videoscopes, borescopes)
(b) liquid penetrant testing
(c) surface roughness measurement device (profilometer)

Acceptance criteria for metallic process contact surface finishes are shown in Table SF-2.2-1.

Acceptance criteria for electropolished metallic process contact surface finishes shall meet requirements shown in Table SF-2.2-2 in addition to those shown in Table SF-2.2-1.

SF-2.3.2 Direct Visual Examination. Direct visual examinations should be performed with a light source having a color temperature between 5,000 K and 6,500 K. Illumination should be at least 500 lux at the surface to be examined. Personnel performing direct visual examinations shall meet the eye examination requirements of MJ-7.2.6. The size, shape, and contour of many process components (piping, vessels, valves, etc.) may limit the accessibility of direct visual examinations; however, direct visual examinations should be conducted with the eye at a distance of not more than 24 in. (600 mm) from the surface at an angle of not less than 30 deg.

SF-2.3.3 Remote Visual Examination. In some cases where areas subject to examination are inaccessible for direct visual examination, remote visual examination may be used. Such examination systems shall have a resolution capability at least equivalent to that obtainable by direct visual examination. Remote visual examination systems using cameras need particular attention paid to the following specific features:

(a) The observed colors may differ significantly from the actual colors due to the combined electronic data handling of camera, monitor, and software.
(b) Magnification level of viewed areas or objects should be verified. See ASTM A1015, para. 7, Calibration, for reference.
(c) Illumination typically is self-adjusted by the camera by changing readout time. Illumination requirements for direct visual examinations do not apply.

SF-2.4 Surface Condition (19)

The process contact surfaces of metallic materials listed in Tables MM-2.1-1, MM-2.1-2, and MM-2.1-3 shall be cleaned prior to being placed into service. The process contact surfaces of stainless steels listed in Tables MM-2.1-1 and MM-2.1-3 should be passivated after cleaning. Refer to Nonmandatory Appendix E for cleaning and passivating guidelines. Passivation of electropolished surfaces is not required unless the process contact surface has been

(19) **Table SF-2.2-1 Acceptance Criteria for Metallic Process Contact Surface Finishes**

Anomaly or Indication	Acceptance Criteria
Pits/porosity	If diameter <0.020 in. (0.51 mm) and bottom is shiny [Notes (1) and (2)]. Pits <0.003 in. (0.08 mm) diameter are irrelevant and acceptable.
Cluster of pits/porosity	No more than 4 pits per 0.5 in. (13 mm) × 0.5 in. (13 mm) inspection window. The cumulative total diameter of all relevant pits shall not exceed 0.040 in. (1.02 mm).
Dents	None accepted [Note (3)]
Finishing marks	If R_a max. is met
Welds	Welds used in the as-welded condition shall meet the requirements of MJ-8. Welds finished after welding shall be flush with the base metal, and concavity and convexity shall meet the requirements of MJ-8. Such finishing shall meet the R_a requirements of Table SF-2.4.1-1.
Nicks	None accepted
Scratches	For tubing, if cumulative length is <12.0 in. (305 mm) per 20 ft (6.1 m) tube length or prorated and if depth is <0.003 in. (0.08 mm) For fittings, valves, and other process components, if cumulative length is <0.25 in. (6.4 mm), depth <0.003 in. (0.08 mm), and R_a max. is met For vessels, if length <0.50 in. (13 mm) at 0.003 in. (0.08 mm) depth and if <3 per inspection window [Note (4)]
Surface cracks	None accepted
Surface inclusions	If R_a max. is met
Surface residuals	None accepted, visual inspection
Surface roughness (R_a)	See Table SF-2.4.1-1
Weld slag	For tubing, up to 3 per 20 ft (6.1 m) length or prorated, if <75% of the width of the weld bead For fittings, valves, vessels, and other process components, none accepted (as welded shall meet the requirements of MJ-8 and Table MJ-8.4-1)
Blistering	None accepted

GENERAL NOTE: This table covers surface finishes that are mechanically polished or any other finishing method that meets the R_a max.

NOTES:
(1) Black bottom pit of any depth is not acceptable.
(2) Pits in superaustenitic and nickel alloys may exceed this value. Acceptance criteria for pit size shall be established by agreement between owner/user and supplier. All other pit criteria remain the same.
(3) For vessels, dents in the area covered by and resulting from welding dimple heat transfer jackets are acceptable.
(4) An inspection window is defined as an area 4 in. × 4 in. (100 mm × 100 mm).

(19) **Table SF-2.2-2 Additional Acceptance Criteria for Electropolished Metallic Process Contact Surface Finishes**

Anomaly or Indication	Acceptance Criteria
Cloudiness	Acceptable if R_a max. is met
End grain effect	Acceptable if R_a max. is met
Fixture marks	Acceptable if electropolished
Haze	Acceptable if R_a max. is met
Interrupted electropolish	Acceptable if R_a max. is met
Orange peel	Acceptable if R_a max. is met
Stringer indication	Acceptable if R_a max. is met
Weld whitening	Acceptable if R_a max. is met
Variance in luster	Acceptable if R_a max. is met

altered (e.g., welded or mechanically polished) or exposed to external contamination after electropolishing. Specific passivation requirements shall be defined in the engineering design documents and/or specifications and shall be in accordance with SF-2.6.

SF-2.4.1 Surface Finishing. Process contact surfaces shall be finished using mechanical polishing, cold working, machining, or electropolishing in conformance with applicable sections of this Part.

Electropolished surfaces may have variances in luster that are acceptable, if the surface roughness values meet the requirements in Table SF-2.4.1-1. Mechanical buffing as a final polishing finish is unacceptable. All surfaces shall be clean. Cleanliness applies to finished components/equipment as produced and packaged by the manufacturer. Subsequent shipping, storage, handling, and/or installation may affect the cleanliness, and it will become a contractual issue between owner/user and manufacturer/service provider.

(19) **Table SF-2.4.1-1 R_a Readings for Metallic Process Contact Surfaces**

Surface Designation	Mechanically Polished [Note (1)] R_a Max. µin.	Mechanically Polished [Note (1)] R_a Max. µm
SF0	No finish requirement	No finish requirement
SF1	20	0.51
SF2	25	0.64
SF3	30	0.76
	Electropolished	
	R_a Max.	
	µin.	µm
SF4	15	0.38
SF5	20	0.51
SF6	25	0.64

GENERAL NOTES:
(a) All R_a readings are to be in accordance with ASME B46.1.
(b) All R_a readings are taken across the lay, wherever possible.
(c) No single R_a reading shall exceed the R_a max. value in this table.
(d) Other R_a readings are available if agreed on between the owner/user and supplier, not to exceed values in this table.

NOTE:
(1) Or any other finishing method that meets the R_a max.

SF-2.5 Electropolishing Procedure Qualification

Electropolishing service providers shall maintain and implement a quality assurance/control program for their electropolishing procedures. They shall also qualify their electropolishing method(s) in accordance with a written procedure. This procedure shall specify the acceptable ranges of the electropolishing essential variables.

Nonmandatory Appendix H has been provided as a guide.

Flash electropolishing shall not be acceptable. Spot electropolishing shall be acceptable if it meets the requirements in this section.

SF-2.6 Passivation Procedure

Passivation for this Part shall be limited to newly installed or newly modified sections of systems and components. Passivation shall be performed in accordance with an approved quality assurance/control program. The passivation method(s) including procedures for initial water flushing, chemical cleaning and degreasing, passivation, and final rinse(s) shall be qualified in accordance with a written procedure and documentation package. This procedure shall specify the acceptable ranges of the passivation essential variables. Nonmandatory Appendix E has been provided as a guide to passivation practices and evaluation of passivated surfaces. Spot passivation is permitted. The pickling process shall not be accepted as a substitute for passivation. There is no universally accepted nondestructive test for the presence of a passive layer.

For passivated process contact surfaces, the acceptance criteria in Table SF-2.6-1 apply in addition to Table SF-2.2-1 and/or Table SF-2.2-2, as applicable. Tests to ensure the presence of a passive layer shall be agreed to between the owner/user and contractor.

SF-2.7 Normative References

The following standards contain provisions that, through reference, specify terms, definitions, and parameters for the determination of surface texture (roughness, waviness, and primary profile) by profiling methods.

ASME B46.1, Surface Texture (Surface Roughness, Waviness, and Lay)
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

(19) **Table SF-2.6-1 Acceptance Criteria for Metallic Passivated Process Contact Surface Finishes**

Anomaly or Indication	Acceptance Criteria
Surface particles	No particles observed under visual inspection, without magnification, and using adequate room lighting
Stains	None accepted (weld discoloration to comply with appropriate table of MJ-8)
Visible construction debris	None accepted
Visible oils or organic compounds	None accepted

GENERAL NOTES:
(a) Surface condition shall meet Table SF-2.2-1 and/or Table SF-2.2-2, as applicable.
(b) Additional tests/acceptance criteria may be selected from Table E-5-1 in Nonmandatory Appendix E.

ISO 3274, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments
ISO 4287, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters
ISO 4288, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture
ISO 11562, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Metrological characteristics of phase correct filters
Publisher: International Organization for Standardization (ISO), Central Secretariat, Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland (www.iso.org)

SF-2.8 Rouge and Stainless Steel

Rouge is a naturally occurring phenomenon in existing stainless steel high-purity process systems (including water or pure steam). The degree to which it forms depends on

(a) the stainless steel material used for each component within the system

(b) how the system was fabricated (e.g., welding, surface finish, passivation treatment)

(c) what process conditions the system is exposed to (e.g., water purity, process chemicals, temperatures, pressures, mechanical stresses, flow velocities, and concentration of dissolved gases, such as oxygen or carbon dioxide)

(d) how the system is maintained

The presence of rouge in a system needs to be evaluated against its potential to affect the product, process, and/or long-term operation of the system. Nonmandatory Appendix D provides the methods to measure rouge in a system both in the process solution and on the actual process contact surface. It also suggests various fabrication and operation practices to minimize rouge formation and methods/techniques for its remediation. See the definition of rouge in GR-8.

For more information, refer to the ISPE Water and Steam Systems Baseline® Pharmaceutical Engineering Guide.

SF-3 POLYMERIC APPLICATIONS

SF-3.1 Applicable Systems

This section shall be applicable to all systems designated by the owner/user or representative thereof.

Process contact surface requirements shall apply to all accessible and inaccessible areas of the systems that directly or indirectly come in contact with the designated product.

These systems shall include process systems and clean utilities.

SF-3.2 Materials

The preferred materials of construction for these systems shall be as described in PM-2.

SF-3.3 Examination Techniques Employed in the Classification of Process Contact Surface Finishes (19)

Process contact surface finish examinations shall be made by one or more of the following methods:

(a) visual examination

(1) direct visual examination (e.g., illumination through pipe/tube wall)

(2) remote visual examination (e.g., videoscopes, borescopes)

(b) surface roughness measurement device: profilometer or other surface measurement devices

Acceptance criteria of polymeric process contact surface finishes are shown in Table SF-3.3-1.

Visual examination shall be performed under adequate room lighting. Additional lighting shall be used when appropriate to illuminate blind or darkened areas and to clarify questionable areas.

The same techniques shall be used for both examinations and inspections.

Table SF-3.3-1 Acceptance Criteria for Polymeric Process Contact Surface Finishes

Anomaly or Indication	Acceptance Criteria
Scratches	For rigid tubing/piping, if cumulative length is <12.0 in. (305 mm) per 20 ft (6.1 m) tube/pipe length or prorated and if depth <0.003 in. (0.08 mm) For other process components, surface finish must be agreed on by supplier and owner/user
Surface cracks	None accepted
Surface inclusions	None accepted
Surface roughness, R_a	See Table SF-3.4-1

GENERAL NOTE: All process contact surface finishes shall be defined by the owner/user and supplier using the criteria described in SF-1.

SF-3.4 Surface Condition

The following surface finishes of polymeric materials are available:

(a) piping/tubing and fittings
- *(1)* as molded
- *(2)* as extruded
- *(3)* as machined
- *(4)* as fabricated from molded, extruded, or machined components

(b) sheet, rod, and block
- *(1)* as molded
- *(2)* as extruded
- *(3)* as machined after molding or extrusion

These are generally used terms and may not be applicable in all cases. The final criteria shall be determined by the R_a values shown in Table SF-3.4-1.

Table SF-3.4-1 R_a Readings for Polymeric Process Contact Surfaces

Surface Designation	R_a max.	
	µin.	µm
SFP0	No finish requirement	No finish requirement
SFP1	15	0.38
SFP2	25	0.64
SFP3	30	0.76
SFP4	40	1.01
SFP5	50	1.27
SFP6	60	1.52

GENERAL NOTES:
(a) No single R_a reading shall exceed the R_a max. value in this table.
(b) Other R_a readings are available if agreed on between owner/user and supplier, not to exceed values in this table.