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MIL-B-7883B
20 February 1968

MILITARY SPECIFICATION

BRAZING OF STEELS, COPPER, COPPER ALLOYS, NICKEL ALLOYS, ALUMINUM AND ALUMINUM ALLOYS

This specification has been prepared by the Naval Air Systems Command based upon currently available technical information but it has not been approved for promulgation as a coordinated revision of MIL-B-7883B. It is subject to modification. However, pending its promulgation as a coordinated military specification, it may be used in acquisition.

1. SCOPE

1.1 Scope. This specification presents minimum fabrication and quality requirements for brazing steels, copper, copper alloys, nickel alloys, aluminum and aluminum alloys.

1.2 Classification.

1.2.1 Types of brazing.

Type I - Torch brazing.
Type II - Furnace brazing.
Type III - Induction brazing.
Type IV - Resistance brazing.
Type V - Dip brazing.

1.2.2 Joint quality. Quality of the braze joint shall be of the following grades, as specified on the applicable drawing:

Grade A Joints for critical fittings and structural applications which would primarily undergo high cycle vibration, high impact or shock, and/or high internal/external pressure.

Grade B Joints for non-critical fittings and non-critical structural applications which would primarily undergo moderate vibration, infrequent mild shock, and moderate internal/external pressure.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 93), Naval Air Engineering Center, Lakehurst NJ 08733-5100, by using the self-addressed Standardization Document Improvement Form (DD Form 1426) appearing at the end of this document or by letter.

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Grade C Joints for non-critical fittings and non-critical structural applications which would primarily undergo static loading, mild vibration, and infrequent shock.

1.2.2.1 Grade A shall apply to all joints where grade quality is not specified.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

O-F-499	Flux, Brazing, Silver Alloy, Low Melting Point
QQ-B-655	Brazing Alloys, Aluminum and Magnesium, Filler Metal
QQ-C-576	Copper Flat Products with Slit, Slit and Edge-Rolled, Sheared, Sawed or Machined Edges, (Plate, Bar, Sheet, and Strip)
QQ-R-571	Rods, Welding, Copper and Nickel Alloy

MILITARY

MIL-I-6866	Inspection, Penetrant
MIL-I-6870	Inspection Program Requirements, Nondestructive for Aircraft and Missile Materials and Parts
MIL-P-8853	Paste, Copper Brazing, Water Thinning
MIL-F-80082	Furnace, Heat-treating and Brazing, Electric, Controlled Atmosphere, Pusher and Conveyor Belt Types
MIL-F-80113	Furnace, Vacuum, Heat-treating And Brazing

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-453	Inspection, Radiographic
MIL-STD-1875	Ultrasonic Inspection, Requirements for

(Copies of specifications, standards, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of DODISS specified in the solicitation. Unless otherwise specified, the issue of documents not listed in the DODISS shall be the issue of the nongovernment document which is current on the date of the solicitation.

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	Symbols for Welding and Nondestructive Testing
AWS A3.0	Welding Terms and Definitions
AWS A5.8	Brazing Filler Metal

(Application for copies should be addressed to the American Welding Society, P.O. Box 351040, Miami FL 33135.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS 3410	Flux, Silver Brazing
AMS 3411	Flux, Silver Brazing, High Temperature
AMS 3412	Flux - Brazing, Aluminum
AMS 3415	Flux - Aluminum Dip Brazing, 1030°F (555°C) or Lower Liquidus
AMS 4184	Wire, Brazing - 10Si 4Cu
AMS 4185	Wire, Brazing - 12Si
AMS 4701	Wire - Copper, Annealed 99.95 (Cu + Ag)
AMS 4764	Brazing Filler Metal - Copper, 52.5Cu 38Mn 9.5Ni, 1615°-1700°F (880°-925°C) Solidus-Liquidus Range
AMS 4766	Brazing Filler Metal, Silver 85Ag 15Mn, 1760°-1780°F (960°-970°C) Solidus-Liquidus Range
AMS 4767	Brazing Filler Metal, Silver, 92.5Ag 7.2Cu 0.22Li, 1435°-1635°F (780°-890°C) Solidus-Liquidus Range
AMS 4768	Brazing Filler Metal - Silver, 35Ag 26Cu 21Zn 18Cd, 1125°-1295°F (605°-700°C) Solidus-Liquidus Range
AMS 4769	Brazing Filler Metal - Silver, 45Ag 24Cd 16Zn 15Cu, 1125°-1145°F (605°-620°C) Solidus-Liquidus Range

AMS 4770	Brazing Filler Metal - Silver, 50Ag 18Cd 16.5Zn 15.5Cu, 1160°-1175°F (625°-635°C) Solidus-Liquidus Range
AMS 4771	Brazing Filler Metal - Silver, 50Ag 16Cd 15.5Zn 15.5Cu 3.0Ni, 1170°-1270°F (630°-690°C) Solidus-Liquidus Range
AMS 4772	Brazing Filler Metal - Silver, 54Ag 40Cu 5.0Zn 1.0Ni 1325°-1575°F (720°-855°C) Solidus-Liquidus Range
AMS 4774	Brazing Filler Metal, Silver, 63Ag 28.5Cu 6.0Sn 2.5Ni, 1275°-1475°F (690°-800°C) Solidus-Liquidus Range
AMS 4775	Brazing Filler Metal, Nickel, 73Ni 4.5Si 14Cr 3.1B 4.5Fe, 1790°-1970°F (975°-1075°C) Solidus-Liquidus Range
AMS 4776	Brazing Filler Metal, Nickel 73Ni 4.5Si 14Cr 3.1B 4.5 Fe (Low Carbon) 1790°-1970°F (975°-1075°C) Solidus-Liquidus Range
AMS 4777	Brazing Filler Metal, Nickel, 82Ni 4.5Si 7.0Cr 3.1B 3.0 Fe 1780°-1830°F (970°-1000°C) Solidus-Liquidus Range
AMS 4778	Brazing Filler Metal, Nickel, 92Ni 4.5Si 3.1B, 1800°-1900°F (980°-1040°C) Solidus-Liquidus Range
AMS 4779	Brazing Filler Metal, Nickel, 94Ni 3.5Si 1.8B, 1800°-1950°F (980°-1065°C) Solidus-Liquidus Range
AMS 4780	Brazing Filler Metal, Manganese, 66Mn 16Ni 16Co 0.80B, 1770°-1875°F (965°-1025°C) Solidus-Liquidus Range
AMS 4782	Brazing Filler Metal, Nickel 7Ni 10Si 19Cr, 1975°-2075°F (1080°-1135°C) Solidus-Liquidus Range

(Application for copies should be addressed to SAE, 400 Commonwealth Drive, Warrendale PA 15096.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Material.

3.1.1 Filler metal. Filler metal shall conform to the documents referenced in 2.1 and 2.2, except that copper filler metal shall be deoxidized copper without residual deoxidizing agents (see 6.1.5).

3.1.2 Fluxes. Fluxes shall conform to the applicable specifications listed in 2.1 and 2.2. Fluxes shall be employed to promote wetting of the faying surfaces. Fluxes shall dissolve or remove any oxides and prevent additional oxidation of the filler metal and base metal. Fluxes may be applied in the form of powder, paste, vapor, gas or coating on filler rods.

3.1.3 Selection of brazing alloy/flux combinations. The brazing alloys and flux combination shall be selected in accordance with Tables I through IV.

3.2 Preparation of joints.

3.2.1 Cleaning. The mating surfaces and adjacent areas of all parts to be joined shall be thoroughly cleaned to remove all oil, grease, paint, dirt, scale, artifical oxide films, conversion coatings or any other foreign substances.

3.2.2 Deburring. Burrs shall be removed to permit proper fitting of parts and flow of filler metal.

3.2.3 Fit. The clearance between mating surfaces of steel parts, being furnace brazed, shall not exceed 0.001 inch for Grade A or 0.002 inch for Grades B and C. The clearance between mating surfaces when other methods are used shall not exceed 0.003 inch for Grade A or 0.006 for Grades B and C, except in areas of a joint where one or both mating surfaces are intentionally beveled. In fabrication of aluminum assemblies where sheet clad with brazing metal is employed, the joints shall make contact as the cladding material provides sufficient clearence.

3.2.4 Assembly of parts. Parts to be joined shall be held in position by jigs, clamps, supports or shall be self fixturing. Fixtures used to hold parts and assemblies in alignment during brazing shall be designed to allow expansion and contraction of the parts during heating and cooling, respectively. Jigs, fixtures and clamps shall be noncontaminating materials and should only involve point or line contact. When specified, staking, pinning, riveting, tack welding or spot welding may be used for positioning of parts, but shall not be located in areas subject to high stresses during service. Stop off materials may be used to restrict flow of filler metal where required.

3.2.5 Application of the filler metal. Sufficient brazing alloy in the form of wire, washers, sheet, powder with a residue free of chemical agents, or plated form shall be preplaced in close proximity to the joint, on one side only, in sufficient quantity to produce a satisfactory joint. Joints, having one end inaccessible to visual inspection, shall have the filler metal placed at the blind end prior to assembly, whenever it is practical to do so.

3.3 Methods.

3.3.1 Type I - Torch brazing. Depending on the temperature and the amount of heat required, fuels such as acetylene, propane, natural gas and hydrogen may be used with air, compressed air or oxygen. Parts shall be preheated with a neutral or slightly reducing flame to bring the entire joint uniformly to the liquidus temperature of the filler metal, but no higher than necessary to provide a satisfactory joint. Localized overheating shall be avoided. The filler metal shall be introduced at one edge of the interstice or in a groove provided for one of the mating surfaces, and shall flow by capillary action to fill the interstice.

3.3.2 Type II - Furnace brazing.

3.3.2.1 Equipment. Furnaces shall comply with the requirements of MIL-F-80082 or MIL-F-80113. Automatic temperature-controlling and recording devices, preferably of the potentiometer type, shall be provided to control furnace temperatures. Temperature variations within the brazing ranges shall not exceed 1 1/2 percent from the control point. Means shall be provided for controlling the furnace atmosphere. Dew point and composition of atmospheres shall be controlled to prevent oxidation or carburization of carbon steels, low alloy steel and stainless steels. In carbon and low alloy steels, decarburization shall not exceed a depth of 0.003 inch.

3.3.2.2 Procedure. Parts shall be assembled with proper fit in the joint areas and fixed in alignment as required. Flux may be used in addition to control of furnace atmosphere. Assemblies, cradled and racked, shall be placed in the furnace in such a manner that the atmosphere can reach all parts of the assemblies readily and bring the entire assembly to brazing temperature in the shortest possible time. Parts shall be held in the furnace until the filler metal has melted and formed the desired bonding. After brazing has been accomplished, assemblies shall be cooled in protective atmospheres to prevent oxidation, as required.

3.3.2.3 Grain refinement. Unless otherwise specified, carbon and low alloy steel parts which have been copper brazed or where Ni-Cr-Be-B-Si, Ni-Si-B, Ni-Cr-Si or Mn-Ni-Co-B filler metals are used shall be given a grain refinement heat treatment subsequent to brazing.

3.3.3 Type III - Induction brazing.

3.3.3.1 Equipment. Induction coils shall be of suitable design and construction so as to provide heating of the joint area. Coil design shall allow for corner effect on rectangular parts and surface irregularities which will be in the heat zone.

3.3.3.2 Procedure. The faying surfaces shall be coated with flux or enclosed in an appropriate atmosphere and the filler metal placed in position. The joint area shall be heated by placing within or near an appropriate induction coil.

3.3.4 Type IV - Resistance brazing.

3.3.4.1 Equipment. The current and electrode size shall be selected so that the heat distributed over the joint area is adequate to cause the filler metal to flow freely but does not cause overheating.

3.3.4.2 Procedure. Assembled parts shall be placed between electrodes and current passed through the assembly. Heating shall cease when the filler metal has formed fillets.

3.3.5 Type V - Dip brazing.

3.3.5.1 Equipment. An assembled joint shall be dipped in either a bath of molten filler metal covered with a layer of flux or a bath of molten flux with filler metal preplaced on the assembly. When the flux bath is used, it shall be free of metallic inpurities. The composition and quantity of the bath shall be adjusted as required. The operating temperature of the molten bath shall not exceed the liquidus temperature of the specified brazing alloy by more than 10°F and shall not vary more than ± 10°F.

3.3.5.2 Preheating. Assemblies shall be preheated in a suitable furnace and atmosphere to a temperature of 25 - 100°F below the solidus of the brazing alloy.

3.3.5.3 Procedure. The assembly shall be removed from the preheat furnace and immediately dipped into the molten bath at a uniform rate. Brazing times shall be established for the appropriate shape and cross section. Brazing is complete when the filler metal has flowed evenly into the joint. The assembly shall be removed at a rate which will not disturb the molten filler metal or allow defects to form (see 3.5).

3.4 Post brazing treatment.

3.4.1 Cooling. Assemblies shall be cooled after brazing to prevent cracks from forming and to minimize internal stresses and distortion.

3.4.2 Flux removal. Immediately after all thermal treatments, flux shall be removed by a method which does not affect surface finish or remove base metal/filler metal below tolerances.

3.4.3 Heat treatment of assemblies. After completion of the brazing operation, heat treatment shall be limited to temperatures below the solidification temperature of the respective brazing alloy. Heat treatment shall be in accordance with the applicable drawing.

3.4.4 Passivation of brazed assemblies. Assemblies that have been silver brazed shall not be given a nitric acid treatment for passivation. Copper or nickel brazing alloys with less than 7 percent chromium shall not be passivated.

3.5 Quality of joint.

3.5.1 Contour. The contour of an outside filler joint shall be of a uniform radius with a minimum amount of excess braze or flash over the adjacent surfaces.

3.5.2 External defects.

3.5.2.1 Surface porosity.

3.5.2.1.1 External porosity (pinholes). The maximum diameter permissible is 0.015 inch with a depth of not more than 10 percent of the braze depth. The total number of pinholes of maximum diameter permitted shall be one per linear inch of the joint, or one per joint when the joint length is less than 1.0 inch. Acceptance criteria for Type V joints shall be in accordance with Table V.

3.5.2.1.2 Concentrated surface porosity. An area of concentrated porosity which is less than 50 percent of the faying surface along its major axis is acceptable provided that the sum of the diameters of the pinholes in the area does not exceed 0.015 inch. Only one such concentrated area shall be permitted. Type V joints shall comply with the acceptance criteria of Table V.

3.5.2.1.3 Linear surface porosity. Linear porosity shall not exceed 3/16 inch and the sum of the diameters of the pinholes shall not exceed 0.015 inch. Type V joints shall comply with the acceptance criteria of Table V.

3.5.2.2 Cracks. Cracks are not acceptable regardless of location.

3.5.2.3 Blisters. Overheating of the base metal resulting in blisters on the surface of the base metal shall be cause for rejection.

3.5.2.4 Excess braze metal. Braze filler metal which may be in excess of that required for the joint is acceptable provided that it does not interfere with the function of the completed assembly.

3.5.2.5 Undercutting. Melting or erosion of the base metal on the outside surface adjacent to the brazed joint shall be limited to a maximum depth of 5 percent of the stock thickness and a maximum of 15 percent, cumulative, of the braze fillet length.

3.5.2.6 Unmelted braze alloy. The presence of unmelted brazing alloy in a joint is unacceptable and shall be cause for rejection.

3.5.2.7 Residual flux. No residual flux shall be permitted on the surface of a brazed joint or base metal.

3.5.2.8 External void. Acceptance of voids in the faying surface of Type V joints shall be in accordance with Table V.

3.5.2.9 Incomplete fusion. Table V contains acceptance criteria for incomplete fusion of Type V joints. Braze filler metal must have full penetration through the faying surface to the side opposite the incomplete fusion (see Figure 3).

3.5.2.10 Foreign material. The brazed joint shall be free of all foreign material.

3.5.3 Internal defects. Only Grade A shall be inspected for internal defects. Cracks are unacceptable. Internal void acceptance criteria shall be in accordance with Table VI for Type V joints.

3.5.3.1 Total aggregate area. The unbrazed area including trapped flux, scattered porosity, and voids shall not exceed 20 percent of the faying surface of the respective joint for aluminum and aluminum alloys and 15 percent for all other metals.

3.5.3.2 Maximum extent of a single defect. No single unbrazed joint shall exceed 20 percent of the overlap distance of the joint for aluminum and aluminum alloys and 15 percent for all other metals.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of section 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality comformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Sampling.

4.2.1 Lot size. For the purposes of sampling, a lot shall consist of all brazed parts of the same design or kind manufactured by the same process during one continuous period and submitted for acceptance at one time.

4.2.2 Sampling. A random sample shall be selected from each lot in accordance with MIL-STD-105, AQL of 2.5 percent defects.

4.3 Inspections. Inspection of brazed joints shall be performed at any assembly level where the joint is accessible for inspection. Brazed assemblies shall be inspected after all operations which may induce stresses in the brazed joint have been completed (i.e. machining, straightening, or heat treatment).

4.3.1 Visual inspection. Brazed joints shall be visually inspected to verify the requirements of 3.5.2. All indicated flaws shall be checked visually under ten power magnification for verification of the defect.

4.3.2 Penetrant inspection. Flourescent or visible dye penetrant in accordance with MIL-I-6866 may be used as inspection aids. Caution shall be exercised when using penetrant inspection as the media used may cause further processing problems.

4.3.3 Radiographic/ultrasonic inspection. Grade A joints shall be subject to either radiographic or ultrasonic inspection per MIL-STD-453 or MIL-STD-1875, respectively, to verify conformance to 3.5.3.

4.4 Flux removal test. A suitable test, such as the absence of a typical choride precipitate in a 5 percent aqueous solution of silver nitrate on the cleaned and rinsed part, may be used to determine that flux has been adequately removed.

4.5 Dimensional inspection. Samples from each lot shall be inspected to determine conformance to the dimensional tolerances of the appropriate specification or drawing.

4.6 Rejection. Brazed assemblies not conforming to the requirements of this specification shall be rejected.

4.7 Resubmitted lots. Lots found unacceptable may be resubmitted in accordance with MIL-STD-105.

4.7.1 Rework. Brazed assemblies may be reworked using such methods as re-dipping per this specification, torch brazing per this specification, fusion welding per the applicable specification, electron beam welding per the applicable specification, or any other welding or brazing method acceptable to the acquiring activity.

4.7.2 Repair. When rework of a brazed assembly is not possible using an approved method, it shall be referred to the acquiring activity for disposition.

5. PACKAGING

This section is not applicable to this specification.

6. NOTES

6.1 Base metal/filler metal combinations. Table IX is included for information purposes only.

6.2 Definitions. Unless otherwise specified as follows, terms shall be defined as per AWS A3.0.

6.2.1 Brazing symbols. The symbols used for identification shall be in accordance with AWS A2.4.

6.2.2 Joint faying surfaces. The cross sectional area between the pieces of base material being joined (see Figure 1).

6.2.3 Joint fillet. The formation of braze filler material formed at the juncture where pieces of base material are joined. It may appear on one or both ends of the joint faying surface (see Figure 1).

6.2.4 External void. An interuption in the joint filler material which extends through the joint faying surface (see figure 2).

6.2.5 Incomplete fusion. A recess in the joint filler material which only partially extends into the joint faying surface (see figure 3).

6.2.6 Internal void. An interuption in the joint filler metal which is confined to the interior of the joint faying surface and is not externally visible (see figure 4).

6.2.7 Surface porosity. May be manifested by round, smooth surfaced pinholes or pockets which are confined to the fillet of a brazed joint (see figure 5).

6.2.8 Filler alloy penetration. Extent to which the braze filler metal has flowed through the joint faying surface.

6.2.9 Crack. A discontinuity, surface or sub-surface, forming a sharply defined fissure whish is sufficient in extent to cause seperation or rupture of the joint (see Figure 6).

6.3 Subject term (key word) listing.

Aluminum
Aluminum alloys
Brazed joint
Brazing
Brazing, Dip
Brazing, Furnace
Brazing, Induction
Brazing, Resistance
Brazing, Torch
Copper
Copper alloys
Filler metal
Flux
Metal
Radiographic inspection
Ultrasonic inspection

6.4 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.4.1 Dip brazing (Type V) requirements. Acceptance criteria for Type V joints have been incorporated into this revision. The stated values should not be used for any of the other types of brazing covered by this document without prior approval from the acquiring activity.

Preparing Activity:
Navy - AS
(Project THJM-N246)

TABLE I. Filler Metal/Flux Combinations for Steels

Base Metal	Filler Metal Type	Filler Metal Specification	Flux Specification
Low Carbon Steel	Silver alloy	AWS A5.8, BAgMn AMS 4766	
		AWS A5.8, BAg-1 AMS 4769	O-F-499 AMS 3410
		AWS A5.8, BAg-1a AMS 4770	O-F-499 AMS 3410 AMS 3411
Low Alloy Steel		AWS A5.8, BAg-3 AMS 4771	AWS Type 3B O-F-499 AMS 3410 AMS 3411
		AWS A5.8, BAg-13 AMS 4772	AMS 3411
		AWS A5.8, BAg-19 AMS 4767	AMS 3411
Corrosion and Heat Resistant Steel	Copper	AWS A5.8, BCu-1 AMS 4701 MIL-P-8853	AWS Type 3B
		AWS A5.8, RBCuZn-A QQ-R-571	AMS 3411
	Cu-Mn-Ni	AMS 4764	
	Ni-Cr-Fe-B-Si	AWS A5.8, BNi-1 AMS 4775	AWS Type 3B
		AMS 4776	AWS Type 3B
		AWS A5.8, BNi-2 AMS 4777	AWS Type 3B
	Ni-Si-B	AWS A5.8, BNi-3 AMS 4778	AWS Type 3B
		AWS A5.8, BNi-4 AMS 4779	AWS Type 3B
	Ni-Cr-Si	AWS A5.8, BNi-5 AMS 4782	AWS Type 3B
	Mn-Ni-Co-B	AMS 4780	AWS Type 3B

TABLE II. Filler Metal/Flux Combinations for Aluminum and Aluminum Alloys

Base Metal	Filler Metal Classification		Other Specifications	Flux Specification
	AWS	Aluminum Assn.		
1100	BAlSi-2	4343	QQ-B-655	AMS 3415 1/ AMS 3412 2/
3003 3004 5005 6061 6062 6063 6951 A612 Cast C612 Cast	BAlSi-3	4145	QQ-B-655 AMS 4184	
	BAlSi-4	4047	QQ-B-655 AMS 4185	

NOTES: 1/ Flux for dip brazing.
2/ Flux for furnace or torch brazing.

TABLE III. Filler Metal/Flux Combinations for Copper and Copper Base Alloys

Base Metal	Filler Metal		Flux Specification
	Type	Specification	
Copper and Copper Base Alloys	Silver	AWS A5.8, BAg-1a AMS 4770	O-F-499 AWS Type 3A
		AWS A5.8, BAg-8 AWS A5.8, BAg-8a	
	Copper Phosporus	AWS A5.8, BCuP-3 1/ AWS A5.8, BCuP-5 1/	O-F-499 AWS Type 3A

NOTES: 1/ Use only for copper alloys with less than 10 percent nickel.

TABLE IV. Filler Metal/Flux Combinations for Brazing Nickel and Nickel Base Alloys

Base Metal	Filler Metal Type	Filler Metal Specification	Flux Specification
Nickel and Nickel Base Alloys	Silver	AWS A5.8, BAg-1 AMS 4769	O-F-499 AWS Type 3A AMS 3410 AMS 3411
		AWS A5.8, BAg-1a AMS 4770	
		AWS A5.8, BAg-2 AMS 4768	
		AWS A5.8, BAg-3 AMS 4771	
	Copper	AWS A5.8, BCu-1 QQ-C-576 QQ-R-571	AWS Type 3B
	Ni-Cr-Fe-B-Si	AWS A5.8, BNi-1 AMS 4775	AWS Type 3B
		AWS A5.8, BNi-1a AMS 4776	
		AWS A5.8, BNi-2 AMS 4777	
	Ni-Si-B	AWS A5.8, BNi-3 AWS A5.8, BNi-4 AMS 4778 AMS 4779	AWS Type 3B
	Ni-Cr-Si	AWS A5.8, BNi-5 AMS 4782	AWS Type 3A
	Mn-Ni-Co-B	AMS 4780	AWS Type 3A

TABLE V. Acceptance Criteria for Dip Brazed Joints.

Type of Defect	Grade A	Grade B	Grade C
External voids	U	U	See Table VII
Surface porosity	1/2/	A	A
Incomplete fusion	U	See Table VIII	See Table VIII

Notes:
U = Unacceptable.
A = Acceptable.
1/ Single porosity: No single pore may exceed 0.020 inch in diameter.
2/ Concentrated porosity: Accumulated total of diameters shall not exceed 0.050 inch in diameter in any three inches of braze.

TABLE VI. Acceptance Limits for Internal Voids in Dip Brazed Grade A Joints.1/

VOID WIDTH2/	MAXIMUM VOID LENGTH PER INCH OF JOINT3/
Void Width > W/2	0.400 inch
W/2 ≥ Void Width > W/3	0.600 inch
W/3 ≥ Void Width > W/4	0.800 inch
Void Width ≤ W/4	1.000 inch

NOTES: 1/ See Figure 4.
2/ Width (W) = width of faying surface.
3/ If indications in the braze joint vary in width such that the void width falls within two of the above ranges, the more stringent value shall apply.

TABLE VII. External Void Acceptance Criteria for Dip Brazed Joints.

Joint Length (L) (inch)	L ≤ 0.50 (inch)	0.50 < L ≤ 1.00 (inch)	L > 1.0 (inch)
Maximum acceptable cumulative void length	0.025	0.050	0.100 per inch of joint 1/

NOTES: 1/ With a minimum spacing of 2 inches between occurances where an occurance is either one isolated void or a group of voids. See Figure 7.

TABLE VIII. Incomplete Fusion Acceptance Criteria.[1/2/]

	Joint length(L) (inch)	Cumulative length for Lack of Braze	
		Case 1 [3/]	Case 2 [4/]
Braze filler alloy visible	L ≤ 0.50	0.125 inch max	0.125 inch max
	0.50 < L ≤ 1.00	0.250 inch max	0.250 inch max
	L > 1.00	0.250 inch max per inch	0.250 inch max per inch
Braze filler alloy not visible	L ≤ 0.50	0.050 inch max	[5/]
	0.50 < L ≤ 1.00	0.100 inch max	
	L > 1.00	0.100 inch max per inch	

Notes: 1/ Ten power magnification may be used as an aid to determine compliance.

2/ Where corrugated, clad material (e.g. fin stock) is brazed between two sheets, the brazed joints form at the lines of contact. Due to accumulation of design and process tolerances, some joints may be partially or completely missing. At one plate, the total number of lines contacts which may be partially or completely lack a braze joint shall not exceed twenty percent (20%) of the possible contacts. Where the total number of possible contacts is greater than twenty, no more than five percent (5%) of the adjacent contacts may totally lack braze joints. Where the total number of possible contacts is less than twenty, no two lines of contact which totally lack a braze joint shall be adjacent.

3/ Case 1 = Faying surface equal to the base material thickness, such as a tee or butt joint.

4/ Case 2 = Faying surface equal to the faying surface greater than the base material thickness, such as a lap joint.

5/ Incomplete fusion depth (see Figure 3) shall be inspected using one of the following methods:

Method A: Dimensional Inspection

$$\text{Allowable length of incomplete fusion} = \frac{\text{Width of faying surface X Void length (Table VIII)}}{\text{Depth of incomplete fusion}}$$

Method B: Functional Test

A functional test, such as a pressure test, may be performed in lieu of a dimensional inspection to verify the acceptability of the brazed joint.

TABLE IX. Base metal/filler metal combinations.

	Al & Al alloys	Mg & Mg alloys	Cu & Cu alloys	Carbon & low alloy steels	Cast iron	Stainless steels	Ni & Ni alloys	Ti & Ti alloys	Be, Zr, Vo, & alloys (reactive metals)	W, Mo, Ta, Cb & alloys (refractory metals)	Tool steels
Al & Al alloys	BAlSi										
Mg & Mg alloys	X	BMg									
Cu & Cu alloys	X	X	BAg, BAu, BCuP, RBCuZn								
Carbon & low alloy steels	BAlSi	X	BAg, BAu, RBCuZn	BAg, BAu, BCu, RBCuZn, BNi							
Cast iron	X	X	BAg, BAu, RBCuZn	BAg, RBCuZn	BAg, RBCuZn, BNi						
Stainless steel	BAlSi	X	BAg, BAu	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi					
Ni & Ni alloys	X	X	BAg, BAu, RBCuZn	BAg, BAu, BCu, RBCuZn, BNi	BAg, BCu, RBCuZn	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi				
Ti & Ti alloys	BAlSi	X	BAg	BAg	BAg	BAg	BAg	Y			
Be, Zr, V & alloys (reactive metals)	X BAlSi(Be)	X	BAg	BAg, BNi*	BAg, BNi*	BAg, BNi*	BAg, BNi*	Y	Y		
W, Mo, Ta, Cb & alloys (refractory metals)	X	X	BAg	BAg, BCu, BNi*	BAg, BCu, BNi*	BAg, BCu, BNi*	BAg, BCu, BNi*	Y	Y	Y	
Tool steels	X	X	BAg, BAu, RBCuZn, BNi	BAg, BAu, BCu, RBCuZn, BNi	BAg, BAu, RBCuZn, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, RBCuZn, BNi	X	X	X	BAg, BAu, BCu, RBCuZn, BNi

NOTE Refer to text for information on the specific compositions within each classification.
X — Not recommended; however, special techniques may be practicable for certain dissimilar metal combinations.
Y — Generalizations on these combinations cannot be made.
* — Special brazing filler metals are available and are used successfully for specific metal combinations.

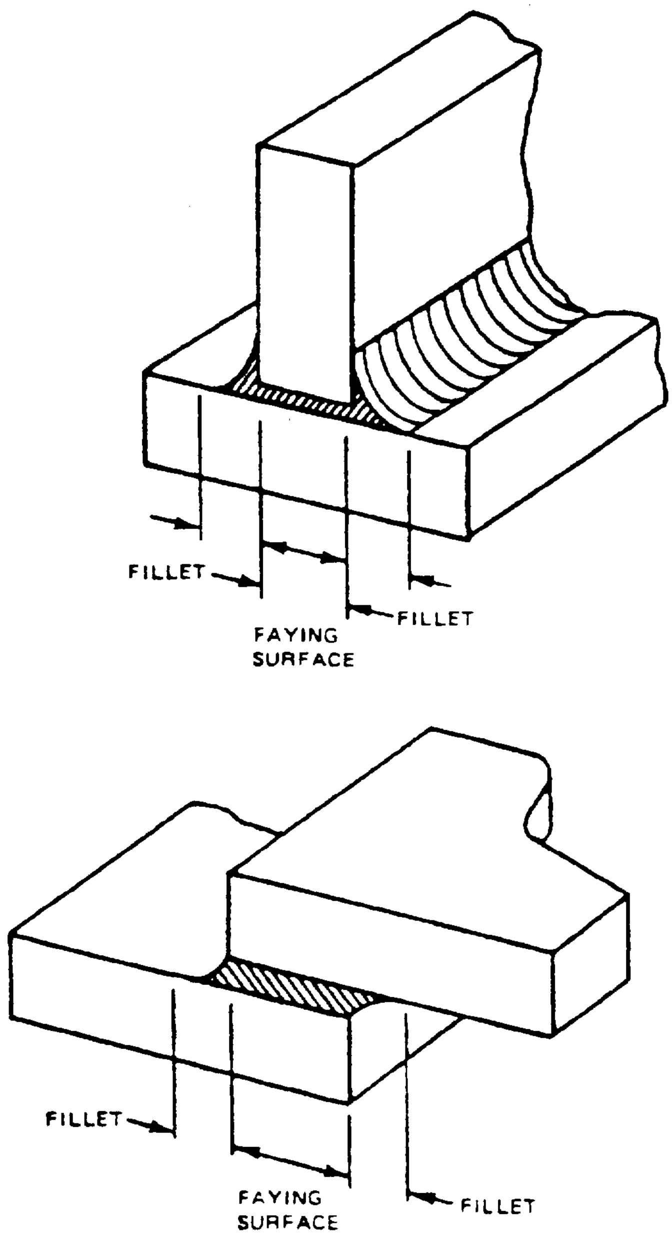


Figure 1. Typical Faying Surface and Fillet Configuration.

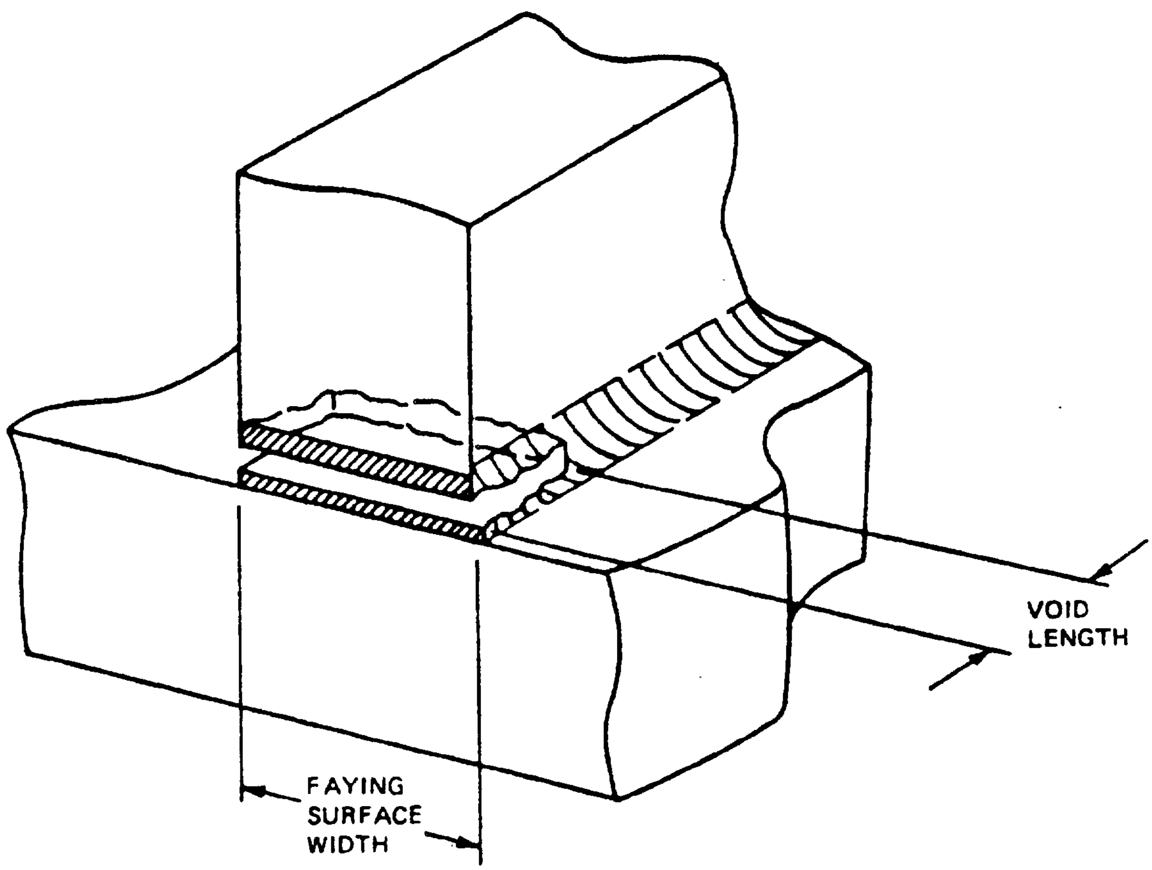


Figure 2. Cross-sectional View Through a Void in Faying Surface

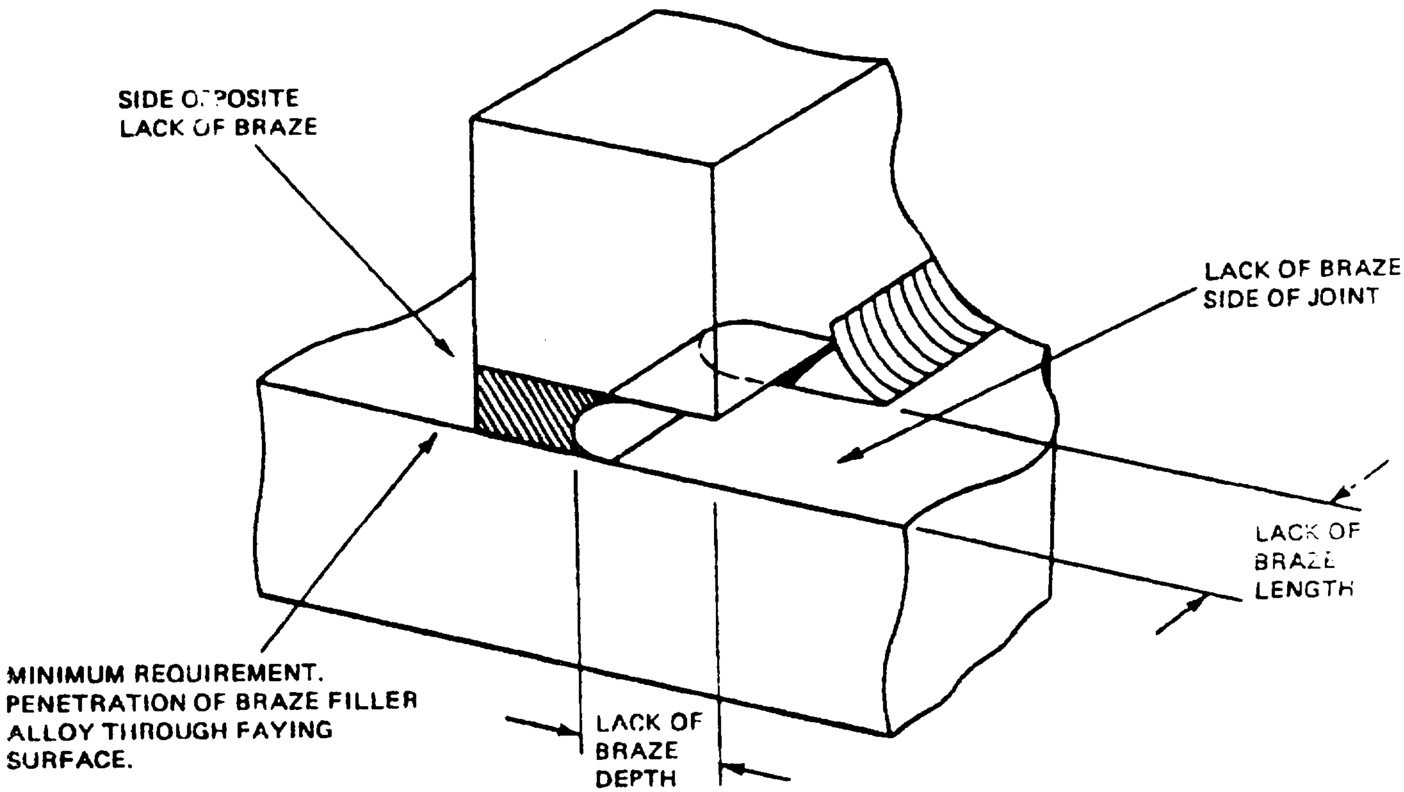
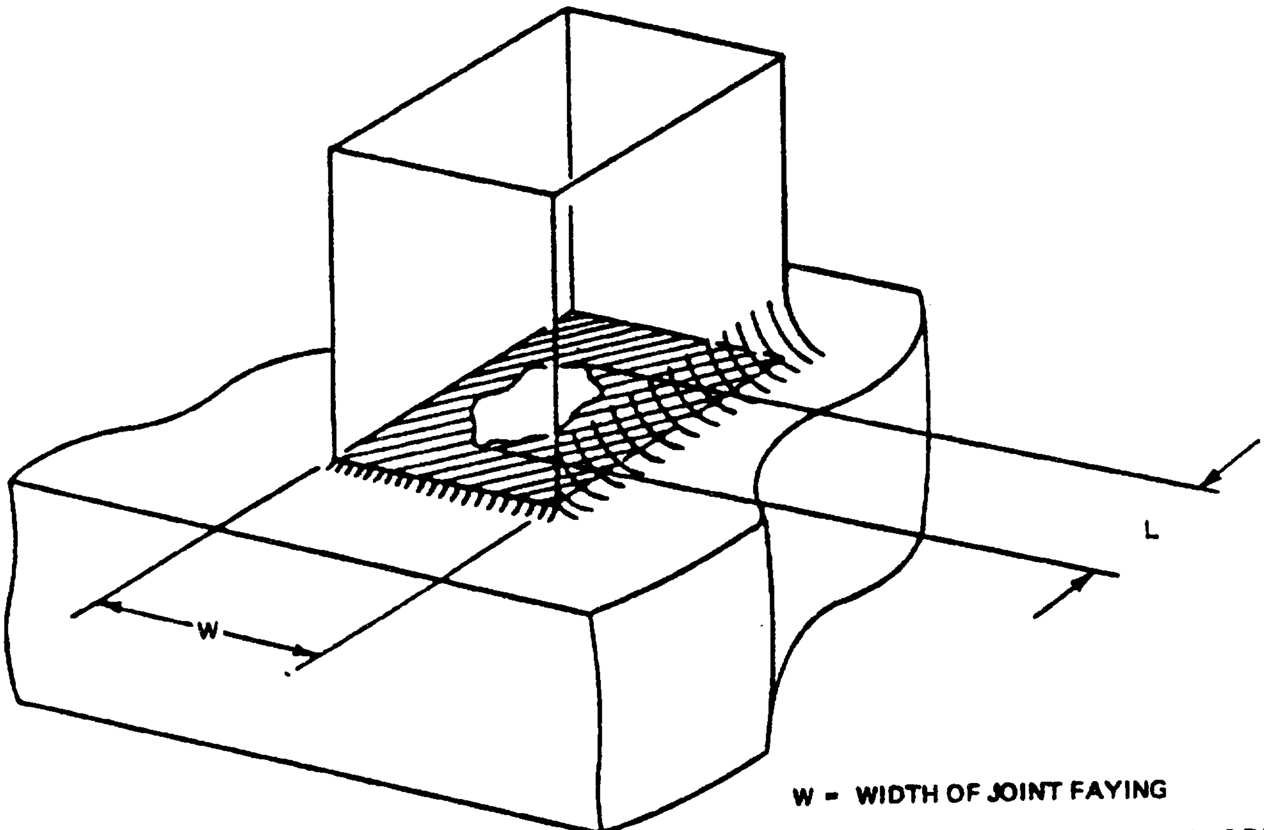


Figure 3. Cross-sectional View Through Lack of Braze.



W = WIDTH OF JOINT FAYING

L = ALLOWABLE VOID LENGTH AS DEFINED IN TABLE II. BASED ON RATIO OF MAXIMUM WIDTH OF VOID TO WIDTH OF JOINT FAYING SURFACE.

Figure 4. Internal voids.

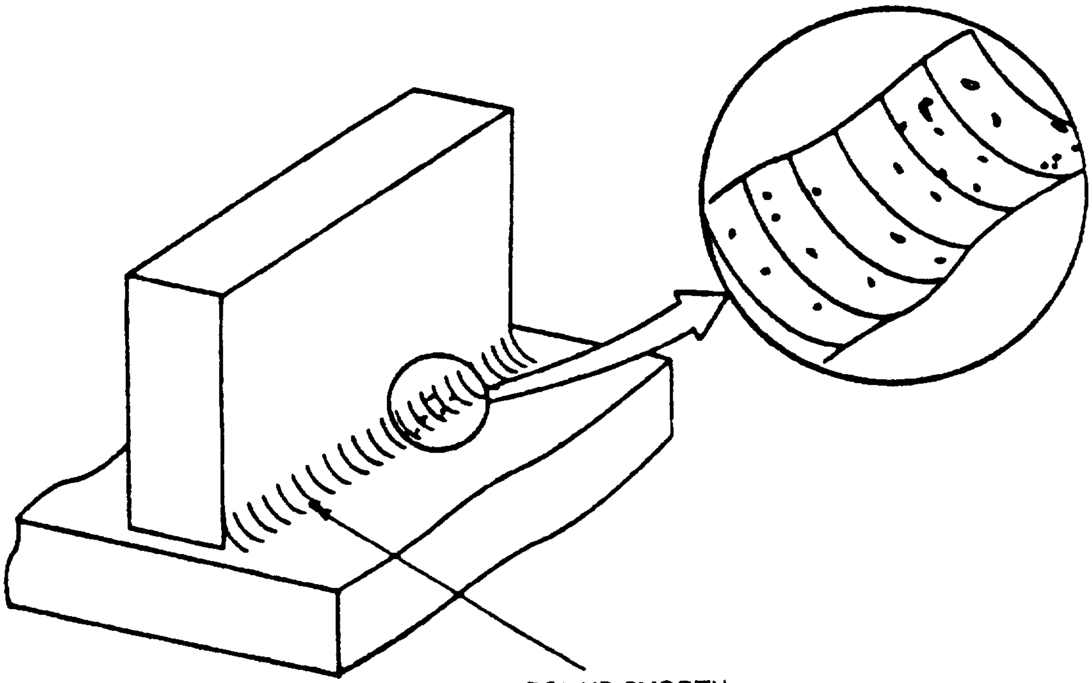


Figure 5. Surface Porosity.

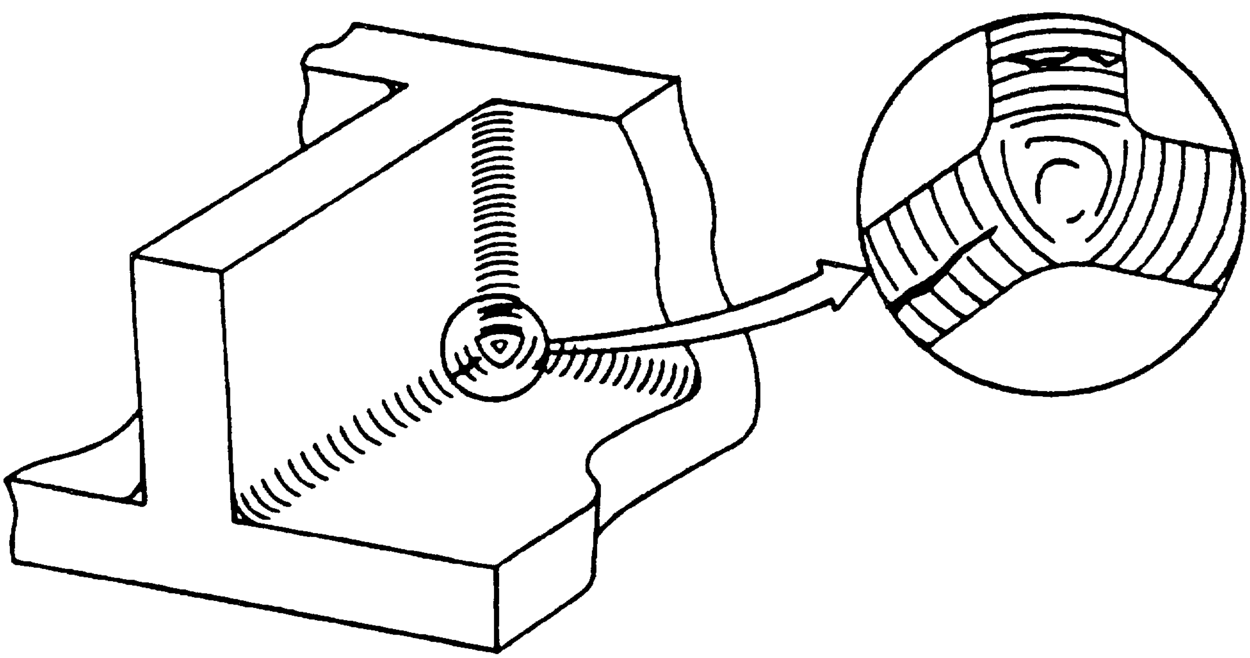


Figure 6. Cracks.

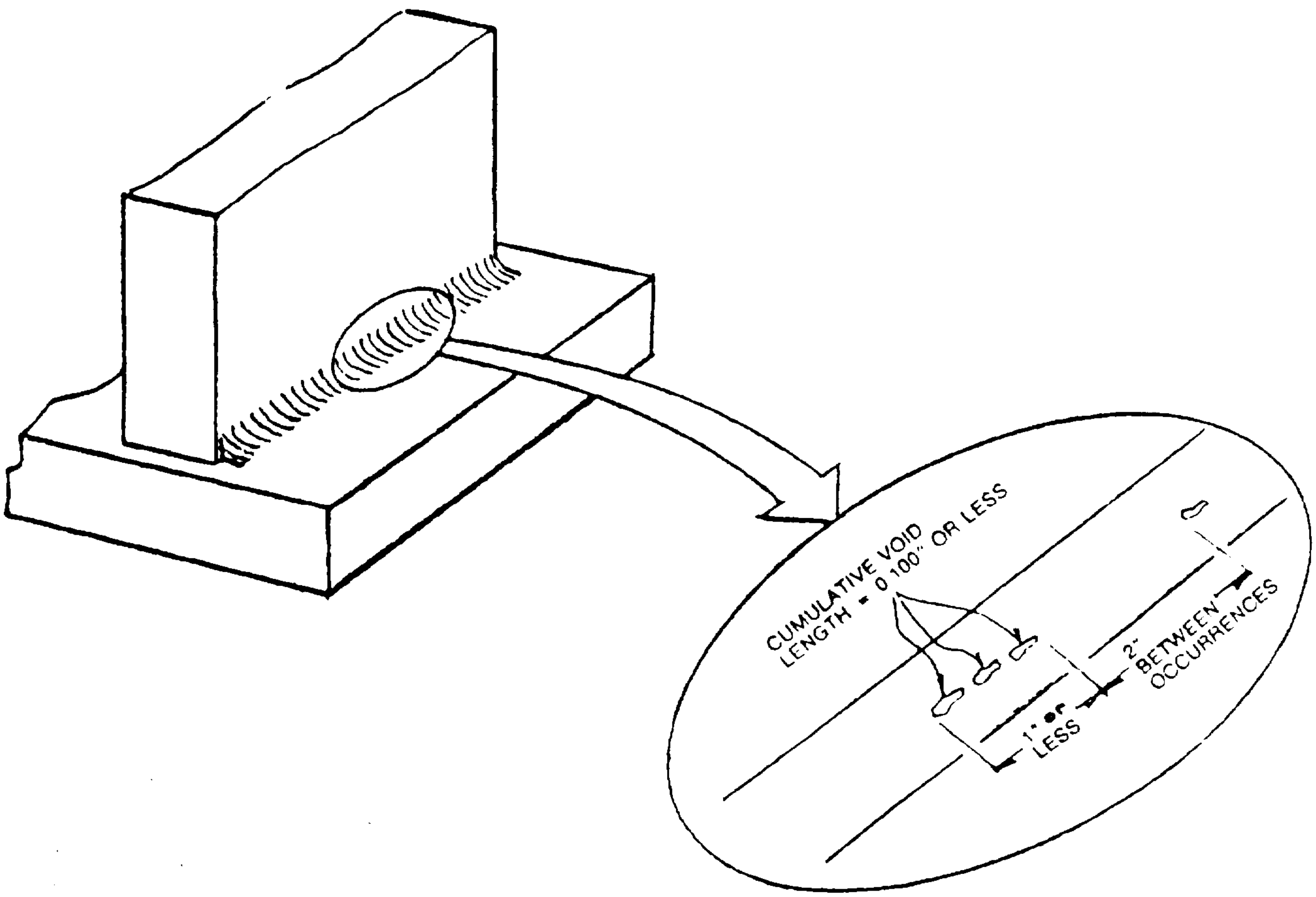


Figure 7. Acceptable Cumulative Void Length for a Joint > 1.00 inch.

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