

DOD-STD-1866
NOTICE 1
19 May 1988

MILITARY STANDARD

SOLDERING PROCESS GENERAL (NON-ELECTRICAL)

TO ALL HOLDERS OF DOD-STD-1866:

1. THE FOLLOWING PAGES OF DOD-STD-1866 HAVE BEEN REVISED AND SUPERSEDE THE PAGE LISTED:

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2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of DOD-STD-1866 will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

Custodians:

Army - AT
Air Force - 99

Preparing activity:

Army - AT

(Project SOLD-0028)

Review activities:

Army - MI, AR, AV
Navy - MC

User activities:

Army - ME
Navy - OS

AMSC N/A

AREA SOLD

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2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

- | | |
|-----------|---|
| A-A-50971 | - Soldering Iron, Non-Electric (Coppers). |
| A-A-51128 | - Torch, Kit Soldering (Propane Gas). |
| W-S-564 | - Soldering Gun. |
| W-S-570 | - Soldering Iron, Electric. |
| QQ-S-571 | - Solder; Tin-Alloy, Tin-Lead Alloy and Lead Alloy. |

MILITARY

- | | |
|-------------|---|
| MIL-M-3800 | - Metallizing Outfits (Wire-Gas), Guns and Accessories. |
| MIL-S-12204 | - Solder, Lead-Tin Alloy. |
| MIL-F-12784 | - Flux, Soldering (Stearine Compound IC-3). |
| MIL-F-14256 | - Flux, Soldering, Liquid (Rosin-Base). |
| MIL-S-45743 | - Soldering, Manual Type, High Reliability Electrical and Electronic Equipment. |
| MIL-S-46844 | - Solder Bath, Soldering of Printed Wiring. |
| MIL-S-46860 | - Soldering of Metal Ribbon Lead Materials to Solder Coated Terminals, Process. |

STANDARDS

FEDERAL

- | | |
|-------------|-------------------------|
| FED-STD-151 | - Metals: Test Methods. |
|-------------|-------------------------|

MILITARY

- | | |
|-------------|--|
| MIL-STD-105 | - Sampling Procedures and Tables for Inspection by Attributes. |
| MIL-STD-454 | - Standard General Requirements for Electronic Equipment. |
| MIL-STD-810 | - Environmental Test Methods and Engineering Guidelines. |

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(Copies of specifications and standards, 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 standard 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 the DODISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS-4750	- Solder - Tin-Lead 45 Sn-55 Pb.
AMS-4755	- Solder - Lead-Silver 94 Pb-5.5 Ag.
AMS-4756	- Solder - 97.5 Pb-1.5 Ag-1 Sn.

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B32	- Solder Metal.
ASTM B284	- Rosin Flux Core Solder.

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA, 19103.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

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5.4 Soldering methods.

5.4.1 Type I - Conduction soldering. Conduction soldering (soldering iron) shall be performed with soldering irons having copper bits which may be heated electrically, or by oil, coke or gas flame. Regardless of the type of iron used, the copper bit shall store and transmit heat from the source to the part being soldered, shall store and convey molten solder and shall withdraw surplus molten solder as required. Internally fired gas-flame-heated soldering irons may be used where electric power is not readily available, or where soldering is done automatically at high rates of speed. Electrically heated irons, often more convenient than gas-heated irons, should be used in manual high-speed repetitive operations, where light weight and ease of manipulation are desirable and open flames are objectionable. Selection of iron shall be such as to perform the necessary soldering operations with the greatest efficiency. For soldering process, electric soldering irons, conforming to W-S-570, soldering guns, conforming to W-S-564, or non-electric soldering irons, conforming to A-A-50971 may be used.

5.4.1.1 Procedure. The areas to be joined shall be heated above the liquidus temperature of the solder. To deliver maximum heat to the part, the copper bit of the soldering iron shall be applied at the correct angle. The flat side of the bit shall be applied to secure the maximum area of contact. Excessive time and temperature shall be avoided to prevent unreliable joints and damage to parts. If required, thermal shunts (heat sinks) shall be used for protection of parts. The parts to be joined shall be held together in such manner that parts shall not move in relation to one another during the soldering operation. The solder shall be applied to the joint and not to the soldering iron. The joint shall not be disturbed until the solder has completely solidified.

5.4.2 Type II - flame soldering. The selection of a gas or oil burning torch for soldering shall be controlled by the size, mass, and configuration of the assembly to be soldered. Time for performing the operation will also be a factor in equipment selection. Depending upon the temperature and amount of heat required, fuels such as acetylene, propane, butane, and natural gas, may be used in open air, or with compressed air or oxygen. Portability will be another factor in selection of a torch. For field work, a soldering torch kit, A-A-51128, using propane gas, may be used for torch soldering.

5.4.2.1 Procedure. Parts shall be preheated with a neutral or slightly reducing flame to bring the entire joint uniformly to the liquidus temperature of the solder, but no higher than necessary to provide a satisfactory joint. Localized overheating shall be avoided. The solder may 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.

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5.4.3 Type III - Dip soldering. Dip soldering shall be performed by immersing the assembled joint with preplaced solder metal in a bath of molten flux, by immersing the assembled joint into a flux solution and then into a bath of molten solder, or by dipping the parts into a bath of molten solder alloy covered with a layer of flux. Pots for the bath, either electrically heated or gas heated units, shall be of such capacity and construction as to allow production without appreciably lowering the temperature of the bath. The flux shall be of a type which has a stable flowability within the soldering temperature range, and processes satisfactory fluxing properties. The flux bath shall be free of metallic impurities.

5.4.3.1 Procedure. When required or specified (see 1.4), assemblies shall be preheated in a suitable furnace and atmosphere to a temperature of 25 to 100°F below the solidus temperature of the soldering alloy. Generally when a molten bath of solder is employed, no preheating is required. The assembly, together with jigs or fixtures, when used immediately upon removal from the preheat furnace, shall be dipped into the molten bath at a uniform rate so that the position of the prepared solder metal is not disturbed. Soldering times are dependent upon the shape and cross section of the assembly. Soldering is complete when the solder metal has flowed evenly into the joints. At this point, the assembly shall be removed slowly from the bath at a rate that will not cause loss of the molten solder metal. The composition and quantity of solder flux or molten solder shall be adjusted periodically. The operating temperature of the molten flux bath shall not exceed the liquidus temperature of the specified soldering alloy by more than 20°F.

5.4.4 Type IV - Resistance soldering. The transformer, electrode, and voltage/amperage controls shall be of sufficient size and capacity to provide adequate heat over an area large enough to permit free flow of the solder alloy over the area to be soldered, without overheating.

5.4.4.1 Procedure. Assembled parts shall then be placed between a ground and a moveable electrode, or between two moveable electrodes, and the current passed through the system. Heating of the joint is generated by contact with the electrodes, and the heat energy evolved is a direct product of the resistance of the work and the current passing through it ($Q = I^2 R$). Resistance soldering electrode bit generally cannot be turned; therefore, flux and solder must be in proper position before heating. Heating shall be discontinued as soon as the solder metal has flowed and formed fillets.

5.4.5 Type V - Oven and furnace soldering. Ovens and furnaces shall be of suitable design and size to maintain uniform constant temperature within the soldering area. Devices shall control the working temperature within one and one half percent of the temperature required for the item or items to be soldered. Ovens and furnaces shall be equipped with a means of controlling the atmosphere within the oven or furnace, as required, to prevent oxidation of the basis metals.

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5.4.5.1 Procedure. Parts shall be assembled with proper fit in alignment as required with proper clamping fixtures. Flux may be used in addition to control of oven or furnace atmosphere. Assemblies, cradled and racked, shall be placed in the oven or furnace in such manner that the atmosphere can reach all parts of the soldering assembly readily, and bring the entire assembly to soldering temperature in the shortest possible time. Parts shall be held in the oven or furnace until the filler metal has melted and formed the desired bond. After soldering has been accomplished, assemblies shall be cooled in protective atmosphere, as required, to prevent oxidation. The cooling of parts may be accelerated on removal from the oven or furnace by the use of an air blast on the hot parts, caution being taken to prevent warpage.

5.4.6 Type VI - Induction soldering. Induction coils shall be of such design and construction as to provide suitable heating of the joint areas. Coil design must allow for corner effects on rectangular parts, surface irregularities which must be in the heat zone, and for joining of dissimilar metals, particularly joints composed of both magnetic and non-magnetic components.

5.4.6.1 Procedure. The mating surfaces shall be coated with flux, either corrosive or noncorrosive, containing a minimum percentage of solvent in order to reduce the amount of volatile matter driven off during heating. Alternately, parts may be enclosed in a suitable atmosphere. The filler metal shall be placed in position and the joint heated by placing within, or near, a suitable induction heating coil.

5.4.7 Type VII - Ultrasonic soldering. Oscillators for generating electrical impulses, magnetostrictive transducers, shall be of such design and construction as to provide suitable cavitation erosion on the surface of the metal, permitting molten solder to wet the surface. The ultrasonic vibrations shall be transmitted from the laminated nickel core, which is used to reduce eddy currents, to the joint. A metal rod of suitable length, which connects the transducer to the soldering bit, shall be attached to the core so that maximum disturbance will result at the free end. The free end of the metal rod, which forms the soldering bit, shall be immersed in a small pool of molten solder that contacts the surface to be soldered. The metal rod shall then be moved across the surface of the base metal or joint so that ultrasonic vibrations break up the oxide on the surface, exposing the underlying metal to the wetting action of the molten solder.

5.4.7.1 Procedure. The area to be coated shall be heated to soldering temperature. A suitable quantity of solder shall then be melted on the surface to form a molten puddle. The end of the transducer rides over the surface. Two such solder-coated areas shall then be placed together and heated, until the solder coat melts and forms a bond.

5.4.8 Type VIII - Spray gun soldering. Spray guns shall be of suitable design and construction, so as to permit heating and spraying a continuous feed solid solder wire. Depending upon gun design, propane, acetylene, or natural gas with oxygen may be used for heating and spraying. Equipment shall be similar to that specified in MIL-M-3800.

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5.4.8.1 Procedure. Parts shall be assembled with proper fit and fixed in alignment as required. Using ordinary metal spraying techniques, the vast majority of solder is melted by the neutral flame of the gun. The solder should contact the part in a semi-liquid form. The balance of heat required, to melt the filler metal and bring the entire joint uniformly to the liquidus temperature of the solder for flowing, is to be supplied by the part.

5.4.9 Type IX - Wave soldering. Wave soldering equipment shall be of a suitable design and construction to permit an automatic application of solder. A continuous stream of solder shall be pumped up into the spout, forming a head of solder through which the work can be passed. The equipment and materials used shall pump a fresh amount of solder into the solder head at all times, so that dross will not accumulate on the solder surface or come in contact with the work. All flux and flux residues, which are wiped off the work and normally stay on top of the solder bath, shall be carried down with the wave into a special reservoir, where they shall not come in contact with any future work. Means shall be provided so that solder which is pumped out of the bottom of the solder container is always at the same temperature, and the solder reaching the head has no time to be cooled down by air drafts and other incidental side effects. The equipment shall be such that the temperature of the solder touching the work shall be uniform and can easily be controlled and maintained.

5.4.9.1 Procedure. Parts shall be fluxed by suitable application methods such as brushing, rolling, spraying, foaming, dipping or wave fluxing. The work shall then be passed through the equipment so that the molten solder and oil are pumped together to hit the work simultaneously and prevent rapid oxidation. Oil dispersion shall be smooth and evenly distributed, by injection where the velocity of the solder is greatest. It is important that preheating prior to soldering be performed, in order to give the flux enough temperature and time to clean and prepare the surfaces, because of the reduced time of the wave. After wave soldering has been accomplished, assemblies must be adequately post-treated to remove oil, whenever used in conjunction with this method.

5.5 Post-soldering treatment.

5.5.1 Cooling. Proper jiggling, assembly, or controlled cooling, shall be employed to prevent excessive deformation of the joint, or failure of the joint, during solidification of the solder. The cooling method may be varied to suit each individual application process.

5.5.2 Flux removal. Immediately after soldering and cooling, flux shall, or shall not, be removed depending upon the degree of corrosiveness. Fluxes conforming to MIL-F-14256, or those meeting the requirements of type R and RMA of QQ-S-571, having a rosin base do not generally require removal of the residue, except if appearance is a prime factor or if the joint areas is to be painted or otherwise coated. Fluxes conforming to O-F-506, identified as corrosive because of having a zinc chloride or other corrosive base, leave a.

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5.6.15 Maximum extent of a single defect. When specified, no single unsoldered area shall exceed 20 percent of the overlap distance of the joint for aluminum and aluminum alloys, and 15 percent in all other metals.

5.6.16 Resoldering. Resoldering of joints shall be avoided. If for any reason a satisfactory joint is not initially obtained, the joint shall be taken apart and the parts shall be cleaned. The entire soldering operation shall be repeated so that the quality standards for a resoldered joint shall be the same as for an original joint. Excessive solder, unmelted solder, lack of penetration, cold solder, and disturbed solder at the joints will require only reheating and reflowing of the solder.

5.6.17 Humidity test. When specified (see 1.4), soldered areas shall be tested for completeness of flux removal residue, and corrosive action on the materials involved, by the humidity test specified in method 507 of MIL-STD-810.

5.6.17.1 Test cabinet. The humidity test cabinet shall be lined with sheet metal, with soldered or welded joints, to form a vapor tight chamber. The walls shall be heavily insulated to minimize heat loss and condensation. Temperature and humidity controls shall be automatic, and shall be capable of maintaining a dry bulb temperature of $100 \pm 2^{\circ}\text{F}$ and a wet bulb temperature of $98 \pm 2^{\circ}\text{F}$. There shall not be more than 2°F temperature difference between any two points in the test area at anytime.

5.6.17.2 Procedure. Selected samples shall be placed in the humidity cabinet and exposed to the conditions specified in 5.6.17.1 for a period of 72 hours. The samples at the end of the test period shall be examined visually, or at a magnification of 4 X, to determine evidence of corrosion caused by contamination from flux residues or cleaning solutions.

5.7 Applications data. This standard is intended for use in the control of non-electric soldering processes as applied to various metals and alloys in manufacturing. These soldering procedures are used to obtain desired properties, such as leak tightness, pressure tightness, and heat conductivity within the limits of the respective materials. The solders required for the processes detailed in this standard, as structural materials, are weak when compared to the materials which they are generally used to join. To avoid depending upon the strength of the solder, joints for sheet metal structural assemblies should be so designed that surfaces to be soldered by the various methods will require the solder only to seal and stiffen the assembly.

5.7.1 Copper and copper alloys. Copper and copper alloys are soldered to form simple economical joints on equipment such as heat exchangers, automotive radiators, heating units, finned tubing, water lines, and flexible metal hose that requires leak tightness with good heat conductivity.

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5.7.2 Steels. Tin plated steel used for air ducts, amplifier frames, condensor and capacitor cans, air filters, and gas meter cases are often soldered by the dip soldering process. Terne steel is soldered for assembly into air cleaners, gasoline tanks, cans, radiator parts, oil pans, fire extinguisher bodies and burial caskets. Frames, tube covers, and chassis for electronic equipment, made of galvanized steel, are soldered for assembly. Stainless steel cans, pails and buckets are often soldered after spot welding or riveting to provide leak tight joints.

5.7.3 Nickel and nickel alloys. Nickel and nickel alloys are solderable. Application should be used only where resistance to corrosion is not an important factor. Solder can be used for sealing non-pressurized water containers, provided the strength of the joints is supplied by rivets, bolts, staking, lock seams, spot welds or other mechanical means. The soldering process should be limited to joints in sheet metal not more than 5/8 inch wide. Since the solders are weak compared to the basis nickel and nickel alloys, they should not be used for attaching fittings to nickel-copper fuel tanks or pressurized water containers. In the event soldering must be used for joining nickel and nickel alloys, only the corrosive fluxes (see 5.2.2), are recommended.

5.7.4 Lead and lead alloys. Lead pipe with soldered joints, or soldered copper fittings, are used to convey water underground, or in drainage and venting systems. Leaded sheathed cables for telephone, telegraph, and electrical power transmission conduit also require solder processing for joining purposes and waterproofing.

5.7.5 Aluminum and aluminum alloys. Tube fin assemblies and cellular assemblies for aluminum and aluminum alloys are joined by dip soldering.

5.7.6 Magnesium and magnesium alloys. Soldering processes are sometimes used for sealing of electronic components encased in tin, or copper plated magnesium alloy containers.

5.7.7 Cast iron. Soldering processes may be used for repair of broken or worn cast iron equipment. Surface cracks and depressions caused by inclusions of metal-mold reaction may be filled with solder, if the defects are superficial and application is not critical. Zinc chloride flux should be applied to the cast iron part prior to soldering application.

5.7.8 Cadmium-silver and cadmium-zinc solders. Cadmium-silver and cadmium-zinc solders have been used for the joining of aluminum and its alloys to itself, or to dissimilar metals, by processes detailed in this standard. These solders are extremely dangerous and are of a highly toxic nature. Overheating the solder during joining can vaporize the cadmium to produce highly dangerous and practically odorless fumes. Precautions must be taken for proper ventilation which may not be suitable or available, during soldering processes. Their use is not recommended as there are other materials,

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non-toxic in nature, that are available if soldering of aluminum is required. Also ultrasonic techniques for soldering (see 5.4.7) have been developed, and are being used commercially, which would not require the use of these toxic solder types.

5.7.9 Fluxes.

5.7.9.1 Noncorrosive. Noncorrosive, as used in 5.2.4 to classify fluxes of this type, is only a relative term. The noncorrosive fluxes are not as corrosive as the other fluxes listed, namely highly corrosive (see 5.2.2), or intermediate (see 5.2.3), but all fluxes must be corrosive in order to perform their function. In general, the amount of corrosion resulting from nonremoval of noncorrosive fluxes may not be harmful to the soldered part or article.

5.7.9.2 Chemical and reaction fluxes. Chemical and reaction fluxes are a special group of corrosive fluxes developed for soldering aluminum. A chemical flux is generally composed of an organic fluoboride (such as boron trifluoride monoethanolamine), a metal fluoborate (such as cadmium fluoborate), a vehicle (such as methyl alcohol), and a plasticizer (such as stearic acid). Modifiers such as zinc fluoride, zinc chloride, or ammonium chloride may also be incorporated into the formulation. Reaction fluxes usually are composed of zinc chloride, tin chloride, or combinations of other metallic halides and ammonium chloride.

5.7.10 For electrical and electronic soldering. This standard does not cover electrical and electronic soldering requirements, and applies to mechanical soldering only. For soldering of electrical and electronic connections, Requirement 5 of MIL-STD-454, MIL-S-45743, MIL-S-46844 or MIL-S-46860 should be used.

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6. NOTES

6.1 Subject term (key word) listing.

General Process of Soldering
Non-Electrical Soldering
Soldering
Soldering, Non-Electrical

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TABLE I. Tin-lead solders.

Nominal composition (percent)		Temperature (°F)			Specification classification			Application
Tin	Lead	Solidus	Liquidus	Pasty range	QQ-S-571	ASTM B32 ASTM B284	AMS	
5	95	586	594	76	Sn 5	5B	---	General purpose For coating and joining metals
10	90	514	570	56	-----	10B	---	
15	85	440	550	110	-----	15B	---	
20	80	361	531	170	Pb 80	20B	---	
25	75	361	511	150	-----	25A, 25B	---	Machine and torch soldering
30	70	361	491	130	Pb 70	30A, 30B	---	
35	65	361	477	116	Pb 65	35A, 35B	---	General purpose and wiping
40	60	361	460	99	Sn 40	40B 1/	---	
45	55	361	441	80	-----	45A, 45B	4750	Automobile radiator cores and roofing seams
50	50	361	421	60	Sn 50	50B 1/	---	
60	40	361 2/	374	13	Sn 60	60B 1/	---	Fine solder, general purpose
63	37	361 2/	361	0	Sn 63	63B 1/	---	
70	30	361 2/	378	17	Sn 70	70B 1/	---	Coating metals

1/ The "A" classification of these solders requires a lower antimony content than that specified in QQ-S-571.

2/ These solders should be considered as having practically no mechanical strength at 361°F.

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TABLE II. Tin-antimony lead solders.

Tin	Nominal Composition		Temperature °F			Specification classification		Application
	Antimony	Lead	Solidus	Liquidus	Pasty range	Q0-S-571	ASTM B32 ASTM B284	
20	1.0	79.0	363	517	154	Sn 20	20 C	Machine soldering and coating of metals, except on galvanized iron
25 30	1.3 1.6	73.7 68.4	364 364	504 482	140 118	- Sn 30	25 C 30 C	Torch and machine soldering, except on galvanized iron
35	1.8	63.2	365	470	105	Sn 35	35 C	Wiping and all uses, except on galvanized iron
40	2.0	58.0	365	448	83	-	40 C	General purpose, except on iron

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TABLE V. Fusible alloy solders. 1/

Nominal composition						Temperature (°F)			Application
Name	Tin	Lead	Anti-mony	Bis-muth	Cad-mium	Solidus	Liquidus	Pasty range	
Lipowitz	13.3	26.7	---	50	10	158	158	0	Where a soldering temperature below 360°F is required.
Bending (Wood's)	12.5	25	---	50	12.5	158	165	7	
Eutectic	---	40	---	52	8	197	197	0	
Eutectic	15.5	32	---	52.5	---	203	203	0	
Rose's	22	28	---	50	---	204	229	25	
Matrix	14.5	28.5	9	48	---	217	440	223	
Mold and pattern	---	44.5	---	55.5	---	255	255	0	

1/ No applicable specifications.

TABLE VI. Indium solders. 1/

Nominal composition					Temperature (°F)			Application
Tin	Indium	Bismuth	Lead	Cadmium	Solidus	Liquidus	Pasty range	
8.3	19.1	44.7	22.6	5.3	117	117	0	Special purposes
12	21	49	18	---	136	136	0	
12.8	4	48	25.6	9.6	142	149	7	
50	50	---	---	---	243	260	17	Glass to metal, or glass to glass soldering
48	52	---	---	---	243	243	0	

1/ No applicable specifications.

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