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SUPERSEDING
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MILITARY SPECIFICATION

SOLDERING PROCESS, GENERAL SPECIFICATION FOR

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope - This specification presents general fabrication and quality requirements for non-electrical assemblies of steel, coated steel, (tinned; terne; galvanized; electroplated with zinc, cadmium, or nickel; and clad) copper and copper alloys, lead and lead alloys, zinc and zinc alloys, nickel and nickel alloys, tin and tin alloys, aluminum and aluminum alloys, produced by soldering processes using solder filler metals having a lower melting point than the base metal. Filler metals used for making soldered joints have a flow temperature below 800° F (426° C). The filler metal is distributed between the joint surfaces usually by capillary action in closely fitted components and by gravity in cases of wide gaps (see 3.6).

1.2 Classification -

1.2.1 Soldering methods - Soldering methods shall be of the following types:

- Type I - Conduction (soldering iron) soldering
- Type II - Flame heat (torch or gas burner) soldering
- Type III - Dip soldering
- Type IV - Resistance soldering
- Type V - Oven or furnace soldering
- Type VI - Induction soldering
- Type VII - Ultrasonic soldering
- Type VIII - Spray gun soldering
- Type IX - Wave soldering

2. APPLICABLE DOCUMENTS

2.1 The following documents of issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein.

FSC - THJM

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SPECIFICATIONS

Federal

O-F-506	Flux, Soldering; Paste and Liquid
W-S-564	Soldering Gun
W-S-570	Soldering Iron, Electric
QQ-S-571	Solder; Tin-Alloy; Lead-Tin Alloy; and Lead Alloy
GGG-S-595	Soldering Iron; Non-electric (coppers)
GGG-T-570	Torch Kit, Soldering (propane gas)

Military

MIL-M-3800	Metallizing Outfits (Wire-gas), Guns and Accessories
MIL-I-6866	Inspection, Penetrant Method of
MIL-I-6870	Inspection Requirements, Nondestructive for Aircraft Materials and Parts
MIL-S-12204	Solder, Aluminum Alloy
MIL-F-12784	Flux Soldering (Stearine Compound IC-3)
MIL-F-14256	Flux, Soldering, Liquid (Rosin-base)

STANDARDS

Federal

Fed. Test Method Std. No. 151	Metals; Test Methods

Military

MIL-STD-105	Sampling Procecures and Tables for Inspection by Attributes
MIL-STD-454	Standard General Requirements for Electronic Equipment

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(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring 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 indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

Society of Automotive Engineers

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

(Applications for copies should be addressed to the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, N.Y. 10017.)

American Society for Testing and Materials

ASTM B32	Solder Metal
ASTM B284	Rosin Flux Cored Solder

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

3. REQUIREMENTS

3.1 Materials -

* 3.1.1 Solder metals- Unless otherwise specified by the procuring activity, solder metal shall conform to QQ-S-571, MIL-S-12204, ASTM B32, ASTM B284, AMS 4750, AMS 4755 or AMS 4756, as applicable. With the approval of the procuring activity, other solder metals may be used, provided the detailed requirements contained herein are complied with.

* 3.1.2 Fluxes - Unless otherwise specified by the procuring activity, fluxes shall conform to O-F-506, QQ-S-571, MIL-F-12784 or MIL-F-14256 as applicable. *Fluxes shall be employed as necessary to promote* wetting of the parent metal surfaces. The quantity of the flux or fluxes employed shall be no more than necessary to obtain satisfactorily soldered joints. Fluxes shall dissolve or remove any oxides and prevent additional oxidation of the solder metal and the base metal during heating. Fluxes may be applied in the form of paste, liquid, powder or as the

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core of solder filler metal. With approval of the procuring activity, other solder fluxes may be used, provided the flux or fluxes employed are no more active chemically than necessary to obtain satisfactorily soldered joints to comply with the detailed requirements contained herein.

* 3.1.3 Selection of solder alloys - Unless otherwise specified on drawings, solder alloys shall be selected in accordance with Tables I, II, III, IV, V, or VI as applicable.

* 3.1.3.1 Tin-lead solders - Selection of tin-lead solders (see Table I) shall depend upon types of metals to be joined. Tin-lead solders have good corrosion resistance to most of the common media. Fluxes of all types may be used with these solders. Treatment of flux residues with the tin-lead solders shall be dictated by flux used.

* 3.1.3.2 Tin-antimony-lead solders - The tin-antimony-lead solders (see Table II) shall not be used on aluminum and aluminum alloys, zinc and zinc alloys and galvanized (zinc-coated) steel, unless otherwise specified.

* 3.1.3.3 Tin-antimony, tin-silver, and lead-silver solders - Tin-antimony solders (see Table III) have a higher electrical conductivity than the tin-lead solders and shall be used where lead contamination must be avoided; such as food containing vessels. Tin-silver solders (see Table III), similiar to the tin-antimony, should be used for fine instrument work, as they are applied with a rosin flux. Lead-silver solders (see Table III) will readily wet steel and copper but their flow characteristics are very poor. The lead-silver solders shall be protected against humid atmosphere conditions in storage as they are susceptible to such corrosion conditions and may become unusable as solders. Zinc chloride base fluxes shall be used with the lead-silver solders as rosin fluxes are readily decomposed.

* 3.1.3.4 Tin-lead-zinc, tin-zinc, tin-zinc-aluminum and zinc-aluminum solders - The tin-lead-zinc, tin-zinc and tin-zinc-aluminum solders (see Table IV) should be used for the joining of aluminum. The tin-zinc solders, especially those with a zinc content of 20 to 30 percent, should be used to minimize the electrogalvanic corrosion of soldered joints. By increasing the zinc contents or with the addition of aluminum these solders will exhibit greater corrosion resistance; however greater application difficulty will be experienced because of the high liquidus temperature. Similarly zinc-aluminum solders, with high solidus temperatures, limit application where such solders may be used. The flux for the zinc-aluminum solder should be limited to the reaction type.

* 3.1.3.5 Fusible alloys - Where a soldering temperature below 360° F is required, fusible alloy low temperature solders (see Table V) shall be used. Fusible alloy solders should be used on heat treated surfaces where higher temperature solders would result in softening of parts, where adjacent material is temperature sensitive, in step soldering operations to avoid destroying nearby joints, or on temperature sensitive devices where failure of a soldered joint is required at low temperature.

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* 3.1.3.6 Indium solders - The indium solders (see Table VI) shall be used for special applications when specified. Lead-silver solder conforming to QQ-S-571, composition Ag 2.5, does not wet most metal well, but with the addition of 1 to 2 percent indium, the wetting properties of the lead-silver solder are improved. Lead-silver-indium solder shall be used where alkaline corrosion is a problem. Low melting indium solder containing bismuth should not require acid fluxes or precoating.

* 3.1.4 Selection of flux -

* 3.1.4.1 Types - Fluxes may be classified into three groups based upon the corrosive nature of residue. From these three groups, namely; highly corrosive, intermediate, and noncorrosive, good soldering practice requires the selection of the mildest flux that shall perform satisfactorily in a specific application (see 6.3.1).

* 3.1.4.1.1 Corrosive fluxes - Soldering flux conforming to O-F-506 is classified as a highly corrosive flux. This flux shall be used where conditions require a rapid and highly active fluxing, to be stable over various temperature ranges and when using the higher melting temperature solders. As the residue remains chemically active after soldering, the residue must be removed to prevent severe corrosion at the joint. Corrosive fluxes shall not be used in the soldering of closed containers such as thermostats or bellows.

* 3.1.4.1.2 Intermediate fluxes - Soldering flux conforming to MIL-F-12784 is classified as an intermediate flux. This flux shall be used in quick spot soldering operations where minimum controlled quantities may be applied and where sufficient heat can be applied to fully decompose or volatilize the corrosive constituents. Intermediate fluxes shall not be used where undecomposed flux may spread onto insulating sleeving, or in soldering closed systems where corrosive fumes may deposit on critical parts of the assembly. The flux should not be used with torch or flame heating due to the tendency to char, burn or volatilize when heated.

* 3.1.4.1.3 Noncorrosive fluxes - Soldering fluxes conforming to MIL-F-14256 and Types R, RMA and RA of QQ-S-571 are classified as noncorrosive flux. The noncorrosive or rosin flux, consisting of the resin and a suitable organic solvent, becomes protective at soldering temperatures. As the residue is hard, nonhygroscopic, does not cause corrosion, and is electrically nonconductive, it is mainly used for electrical and electronic systems. The plain noncorrosive flux has a slow fluxing action on anything but clean or precoated metal surfaces. Type W of MIL-F-14256 or Type R of QQ-S-571 shall be used for all critical applications of electronic parts. Type A of MIL-F-14256 or Types RMA and RA of QQ-S-571 shall be used for more active cleaning, as this flux contains a small amount of complex organic compounds which will increase the fluxing action without altering the noncorrosive nature of the residue.

* 3.2 Preparation of joints -

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TABLE I

TIN-LEAD SOLDERS

Nominal Composition		Temperature ° F			Specification Classification			Application
Tin	Lead	Solidus	Liquidus	Pasty Range	QQ-S-571	ASTM B32 (ASTM B284)	AMS	
5 10 15 20	95 90 85 80	518 514 2/ 440 2/ 361	594 570 550 531	76 56 110 170	Sn 5 ---- ---- Pb 80	5B 10B 15B 20B	-- -- -- --	General Purposes For coating and joining metals
25 30	75 70	361 361	511 491	150 130	---- Pb 70	25A, 25B 30A, 30B	-- --	Machine and torch soldering
35	65	361	477	116	Pb 65	35A, 35B	--	General purpose and wiping
40	60	361	460	99	Sn 40	40B 1/	--	Wiping for joining lead pipes and cable sheath
45	55	361	441	80	----	45A, 45B	4750	Automobile radiator cores and roofing seams
50	50	361	421	60	Sn 50	50B 1/	----	General purposes (most used)
60 63	40 37	361 361	374 361	13 0	Sn 60 Sn 63	60B 1/ 63B 1/	----	Fine solder. General purposes
70	30	361	378	17	Sn 70	70B 1/	----	Coating Metals

1/ The "A" classification of these solders requires a lower antimony content than 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

Nominal Composition			Temperature °F			Specification Classification		Application
Tin	Antimony	Lead	Solidus	Liquidus	Pasty Range	QQ-S-571	ASTM B32 (ASTM B284)	
20	1.0	79.0	363	517	154	Sn 20	20 C	Machine soldering and coating of metals, wiping, etc. -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 purposes except on iron

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TABLE III

TIN-ANTIMONY, TIN-SILVER, AND LEAD-SILVER SOLDERS

Nominal Composition				Temperature ° F			Specification Classification			Application
Tin	Antimony	Lead	Silver	Solidus	Liquidus	Pasty Range	QQ-S-571	ASTM B32 (ASTM B284)	AMS	
95	5	---	---	452	464	12	Sb 5	95 TA	---	Joints on copper; electrical plumbing and heating 1/
96.5 95	--- ---	--- ---	3.5 5.0	430 430	430 473	0 43	Sn 96 ---	96.5 TS ---	--- ---	Fine instrument work 2/
--- ---	--- ---	97.5 94.5	2.5 5.5	579 579	579 689	0 110	Ag 2.5 Ag 5.5	2.5 S ---	--- 4755	On copper, brass, and similar metal using torch heating. Susceptible to corrosion
1.0	---	97.5	1.5	588	588	0	Ag 1.5	1.5 S	4756	On copper, brass and similar metals using torch heating

1/ May be used for cryogenic purposes to -400° F (-240° C). Soldered joint has a tensile strength of 12,000 psi at -300° F (-184° C). However solders containing antimony should not be used in liquid oxygen environments because of its impact sensitivity in such environment.

2/ Soldered joint has a tensile strength of 10,610 psi at room temperature.

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TABLE IV

TIN-LEAD-ZINC, TIN-ZINC, TIN-ZINC-ALUMINUM AND ZINC-ALUMINUM SOLDERS

Nominal Composition				Temperature ° F			Specification Classification	Application
Tin	Lead	Zinc	Aluminum	Solidus	Liquidus	Pasty Range	MIL-S-12204	
34	63	3	---	335	500	165	Comp A	Aluminum joining
91	---	9	---	390	390	0	---	Aluminum joining, electrogalvanic corrosion can be minimized
85	---	15	---	390	445	55	Comp B	
80	---	20	---	390	518	128	Comp B	
70	---	30	---	390	592	202	Comp B	
60	---	40	---	390	645	255	Comp B	
50	---	50	---	390	675	285	Comp B	
30	---	70	---	390	708	318	---	
73-87	---	8-15	5-12	380	780-950	400-570	Comp C	Aluminum joining
---	---	95	5	720	720	0	---	High strength aluminum joints

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TABLE V

FUSIBLE ALLOY SOLDERS 1/

Name	Nominal Composition					Temperature ° F			Application
	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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* 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, pencil marking, drawing or cutting lubricant, dirt, scale, artificial oxide or rust film, and any other foreign substance. For the removal of oil or greases from surfaces, either solvent or alkaline degreasing shall be used. Vapor degreasing with solvents of the trichloroethylene types will leave the least residual film on the surface. Acid cleaning or pickling shall be used to remove rust, scale and oxide or sulfide from the parts to provide a chemically cleaned surface. When pickling treatment is used, articles shall be thoroughly washed in hot water and dried as quickly as possible to prevent subsequent corrosive action. Abrading by grit or shot blasting, mechanical grinding or sanding, filing, wire brushing or other mechanical methods may be used where effective. Shot or grit blasting should be preferable to sand blasting. Blast cleaning shall not be used with lead and lead alloys.

* 3.2.2 Deburring - Burrs shall be removed to permit proper fitting of parts and flow of metal using hand filing, scraper, shave hook or power-driven abrasives wheels or discs.

* 3.2.3 Precoating - Precoating should be used so that the soldering operation will be more rapid and uniform as well as to avoid the use of strong acid fluxes for assembly. Metals, such as aluminum, aluminum bronzes, highly alloyed steels and cast iron shall be precoated, unless otherwise specified. Steel, brass and copper should be precoated if the application warrents and when specified. To facilitate soldering, coatings of tin, copper, silver, cadmium, iron, nickel and alloys of tin-lead, tin-zinc and tin-copper shall be applied to basis metal surfaces. Precoating by electrodeposition, chemical conversion, or hot dipping shall be in accordance with the applicable specifications.

* 3.2.4 Joints -

3.2.4.1 Selection - The selection of a joint design for a specific application shall depend largely on the requirements of the assembly as well as heating method to be used, fabrication techniques prior to soldering, quantities to be soldered, as well as method of applying solder.

* 3.2.4.2 Joint design - Two basic types of joint design should be used for soldering, namely the lap joint and the butt joint. The lap joint should be used whenever possible as this joint offers the greatest possibility of obtaining joints in an assembly with the maximum strength. Butt joints should be limited to cross sectional area of one member. The butt joint must be free of defects to be efficient and should only be used where sealing is required.

* 3.2.5 Fit - Unless otherwise specified by the procuring activity, the clearance between mating surface of steel parts, being furnace soldered, shall not exceed 0.003 inch. The clearance between mating surfaces when other methods are

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used shall not exceed 0.006 inch, except in areas of a joint or joints where one or both mating surfaces are intentionally beveled or when precoated metals are used, in which case a clearance of 0.001 inch or less shall be required. In fabrication of aluminum assemblies where sheets, clad with soldering metal is employed, the joints shall make contact as the cladding material provides sufficient clearance. When a cladding material is not employed, parts shall be positioned and assembled so that the clearance between mating surface is 0.005 to 0.015 inch when a chemical flux is used and between 0.002 to 0.010 inch when a reaction flux is used, unless otherwise specified on drawing (see 6.3.2). Unless otherwise specified, joint clearance for copper and copper alloys shall be maintained from 0.003 to 0.005 inch.

* 3.2.6 Assembly of parts - Parts to be joined shall be held in position by jigs, clamps, supports or be self-fixturing. Fixtures used to hold parts and assemblies in alignment during soldering shall be designed to allow expansion of the parts during heating and contraction during cooling. Jigs, fixtures, and clamps shall be of noncontaminative materials and should only involve point or line contact. When authorized by the procuring activity, 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 in service. On closed assemblies, vent holes shall be located and drilled as specified. Stop-off materials may be used to restrict flow of solder metal when required.

* 3.2.7 Application of flux - Flux shall be applied to the surfaces to be soldered. The flux, used alone or from a flux cored solder, when heated, shall be fluid and effective in removing and excluding oxides and other impurities from the joint being soldered. The flux should allow lowering of the surface tension of the molten solder so that the solder will flow readily and adhere to the metal. The flux shall be readily displaced from the metal by the molten solder.

* 3.2.8 Application of solder metal - Sufficient soldering alloy, in the form of wire, shims, strip, powder with a residue free of chemical agents, or plated form (solder-flux paste), shall be preplaced or fed in close proximity to the joint, preferably on one side only, in sufficient quantity to produce a satisfactory joint. Joints having one end inaccessible to visual inspection, shall have the solder metal placed at the blind end prior to assembly, whenever it is practicable to do so.

* 3.3 Methods and procedures -

* 3.3.1 Type I - Conduction (soldering iron) soldering-

* 3.3.1.1 Equipment - Conduction soldering or soldering iron operation shall be performed with soldering irons having copper bits which may be heated electrically, by oil or coke, or by gas flame. Regardless of the types of irons used, the copper bit shall store and conduct heat from the source to the part being soldered,

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shall store and convey molten solder and shall withdraw the surplus molten solder. 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 GGG-S-595 may be used.

* 3.3.1.2 Procedure - The areas to be joined shall be heated above the liquidus temperature of the solder. To deliver the 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 in 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 a 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.

* 3.3.2 Type II - Flame heat (torch or gas burner) soldering -

* 3.3.2.1 Equipment - The selection of a torch or gas burner 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 for equipment selection. Depending upon the temperature and amount of heat required, fuels such as acetylene, propane, butane, and natural gas, may be used with air, compressed air or oxygen. Portability shall be another factor in selection of a torch. For field work, a soldering torch kit, GGG-T-570, using propane gas may be used for torch soldering.

* 3.3.2.2 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 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.

* 3.3.3 Type III - Dip Soldering -

* 3.3.3.1 Equipment - 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

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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 a type which has a stable flowability within the soldering temperature range, and possesses satisfactory fluxing properties. The flux bath shall be free of metallic impurities.

* 3.3.3.2 Preheating - When required or specified by the procuring activity, 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.

* 3.3.3.3 Procedure - 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.

* 3.3.4 Type IV - Resistance soldering -

* 3.3.4.1 Equipment - The current (low voltage with increasing amperage) from a heavy-duty variable transformer and electrode size shall be selected so that heat and pressure will be distributed over a large enough area to allow the solder alloy to flow freely, but not large enough to cause overheating.

* 3.3.4.2 Procedure - Assembled parts shall be placed between a ground and a movable electrode or between two movable 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.

* 3.3.5 Type V - Oven or furnace soldering -

* 3.3.5.1 Equipment - Ovens and furnaces shall be of suitable design and construction, heated by either gas or electricity, and shall provide uniform temperature within the working zone. Automatic temperature controlling and recording devices, preferably of the potentiometer type, shall be provided to satisfactorily control furnace temperature. Temperature variation within the soldering ranges shall be no

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greater than plus or minus one and one-half percent from the control point. Means shall be provided for controlling the oven or furnace atmosphere as required. A reducing atmosphere does not allow joints to be made without flux. An inert atmosphere will prevent further oxidation of the parts but a flux must be present to remove the oxide that is already present. All but the acid-type fluxes are subject to decomposition when maintained at elevated temperatures for extended time in furnace soldering. Dew point and composition of atmospheres shall be sufficiently controlled to prevent oxidation of carbon steel, low alloy steels, and stainless steels.

* 3.3.5.2 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 a 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 bonding. 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.

* 3.3.6 Type VI - Induction soldering -

* 3.3.6.1 Equipment - Induction coils shall be of suitable design and construction so 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.

* 3.3.6.2 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 or 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.

3.3.7 Type VII - Ultrasonic soldering -

* 3.3.7.1 Equipment - Oscillators for generating electrical impulses and magnetostrictive transducers shall be of suitable design and construction so as to provide suitable cavitation erosion on the surface of the metal to permit 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

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rod shall then be moved across the surface of the base metal or joint so that the ultrasonic vibrations break up the oxide on the surface exposing the underlying metal to the wetting action of the molten solder.

* 3.3.7.2 Procedure - The area to be coated shall be heated to the 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.

3.3.8 Type VIII - Spray gun soldering -

* 3.3.8.1 Equipment - 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. This equipment is similar to that detailed in MIL-M-3800.

* 3.3.8.2 Procedure - Parts shall be assembled with proper fit and fixed in alignment as required. Using ordinary metal spraying techniques, the vast majority of the 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.

3.3.9 Type IX - Wave soldering -

3.3.9.1 Equipment - Wave soldering equipment shall be of a suitable design and construction to permit an automatic application of the 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 in the equipment shall be capable of pumping a fresh amount of solder into the solder head at all times so that the 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 the 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.

* 3.3.9.2 Procedure - Parts shall be fluxed by suitable application methods such as brushing, rolling, spraying, foaming, dipping, wave fluxing, etc. The work shall then be passed through the equipment so that the molten solder and oil are

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pumped together to hit the work simultaneously and prevent rapid oxidation. Oil dispersion shall be smooth and evenly distributed by the injection where the velocity of the solder is greatest. It is of importance 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.

3.3.10 Other types - Other types of methods and procedures for soldering may be substituted for the specified types of soldering methods when approved by the procuring agency.

3.4 Post soldering treatment -

* 3.4.1 Cooling - Proper jigging, 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.

* 3.4.2 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 types R and RMA of QQ-S-561 having a rosin base do not generally require removal of the residue, except if appearance is a prime factor or if the joint area 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 fused residue. Flux residue shall be removed by a method which is not injurious to the surface finish and which will not remove parent metal and solder metal to below tolerances specified in the applicable drawings. A suitable test such as detailed in 4.4.5.1 or 4.4.5.2 may be used to determine that the flux has been adequately removed.

3.4.3 Passivation of soldered stainless steel assemblies - Unless specified in the applicable drawings or specifications, assemblies that have been soldered shall not be given a nitric acid treatment for passivation. Assemblies joined with the lead-tin, lead-antimony-tin, and lead-antimony solders are attacked by the passivation treatment, thus they shall not be passivated.

3.5 Quality of joint -

3.5.1 Workmanship - Soldered assemblies shall be processed in a careful and workmanlike manner. The soldering shall be free from scratches, roughness, sharp edges, dullness, looseness, blistering, foreign matter and other evidence of poor workmanship that will render the assemblies unsuitable for the purposes intended. Defects in quality of workmanship as detailed in 3.5.7 and the subparagraphs thereof shall be considered as failure at some point in the process and one in which the [illegible]t shall be rejected unless it can be repaired prior to final inspection.

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3.5.2 Appearance - A solder joint shall have a bright non-crystalline metallic appearance (the degree of brightness may vary with the solder used) with good adherence and shall be clean and smooth. Solder shall cover the joint and form a slight fillet between the terminal area and each side of the joint. The joined surfaces shall be covered with a coating of solder that leaves the general outline of the surfaces visible although the joint itself may be obscured.

3.5.3 Flow and wetting action - The solder connection shall indicate compatibility between the solder and the surfaces being joined by evidence of good flow and wetting action. Wetting and proper compatibility shall be achieved when the solder fillet feathers and thins out at the edges and bonds to the base material in those areas where sufficient joint area exists to allow solder spread. Solder fillets at cylindrical surfaces formed at a direction other than parallel with the cylinder axis shall form a fillet which blends to the cylindrical surface tangentially.

3.5.4 Line of demarcation - A line of demarcation where solder fillet blends to surfaces being joined shall be acceptable provided wetting as specified in 3.5.3 has been achieved.

3.5.5 Sharp projections - All sharp projections shall be removed.

3.5.6 Contour - The contour of an outside solder joint shall be of a uniform radius with a minimum amount of excess solder or flash over the adjacent surfaces.

3.5.7 External defects -

3.5.7.1 Porosity - This defect is the result of gases being expelled. It appears as small, round, smooth surfaced pockets on the surface of the solder metal. The presence of porosity is undesirable but is acceptable provided the number, depth, and area of concentration does not interfere with the function of the completed assembly, unless otherwise specified.

3.5.7.2 Blisters - This surface condition resulting from the overheating of the base metal shall be cause for rejection.

3.5.7.3 Residual flux - No residual flux shall be permitted on the surface of a soldered joint except those from organic-base fluxes where residues are non-corrosive or from rosin-base types (see 3.4.2), in which case the residual flux may be left in place unless removal is dictated by the applicable drawing or specification, or appearance, or the joint area is to be painted or otherwise coated.

3.5.7.4 Excessive solder alloy - Soldering metal in excess of that required for the joint is acceptable provided the excess solder metal does not interfere with the function of the completed assembly.

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3.5.7.5 Unmelted soldering alloy - The presence of unmelted soldering alloy in a joint is undesirable, and may be cause for rejection of the part. However it shall be acceptable for wide gap soldering when permitted by applicable drawings or specifications.

3.5.7.6 Penetration - Solder alloy must appear on all edges of a joint indicating proper flow through the joint. Lack of penetration shall be cause for rejection of the part.

* 3.5.7.7 Cold solder joint - The solder shall adhere smoothly to the parts being joined. The joint shall not be chalky in appearance, lacking metallic luster, nor shall it have a rough gritty, piled up surface. A cold solder joint shall be cause for rejection of the part as it may contain cracks due to solder not having flowed smoothly.

* 3.5.7.8 Disturbed solder joint - The solder connection shall not have an irregular, dull rough appearance cause by movement of the joint before the solder has fully solidified. This defect shall be cause for rejection as there will be a poor mechanical connection in which the parts forming the joint can move.

3.5.8 Internal defects - Internal defects in a soldered joint are undesirable and may be cause for rejection of the part. When specified in contract or purchase order, soldered parts shall be examined (see 4.4.4.2) for internal quality of joint.

3.5.8.1 Total aggregate area - When specified, the unsoldered 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.

* 3.5.8.2 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.

* 3.6 Quality of joint for electrical and electronic equipment -

* 3.6.1 General - Unless otherwise specified in applicable specification, contract or purchase order, the provisions of this specification shall not be applicable for soldered joints for electrical and electronic connections. The requirements for such joints shall be in accordance with Requirement 5 of MIL-STD-454.

3.7 Resoldering - Resoldering of joints shall be avoided. If for any reason a satisfactory joint is not initially obtained, the joint shall be taken apart, the parts shall be cleaned and the entire soldering operation repeated so that the quality standards for resoldered joint shall be the same as for an original joint. Excessive

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solder (see 3.5.7.4), unmelted soldering alloy (see 3.5.7.5), lack of penetration (see 3.5.7.6), cold solder (see 3.5.7.7) and disturbed solder (see 3.5.7.8) at the joints will require only reheating and reflowing of the solder.

4. QUALITY ASSURANCE PROVISIONS

* 4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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.

4.2 Sampling -

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

* 4.2.2 Sampling - A random sample shall be selected from each inspection lot in accordance with MIL-STD-105, Inspection Level II, Acceptable Quality Level 2.5 percent defects and subjected to the visual, dimensional, pressure-tightness, destructive and flux removal examinations specified.

* 4.3 Inspection and test - Inspection and test procedures shall be in accordance with the requirements of MIL-I-6870 and as specified herein.

4.4 Test methods -

* 4.4.1 Visual examination - Soldered joints shall be visually examined to determine the quality of the joint as specified in 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.5.5, 3.5.6, and 3.5.7. Fluorescent or dye penetrant, MIL-I-6866, procedures may be used as inspection aids. All indicated flaws shall be checked visually at 5 to 10 power magnification.

* 4.4.2 Dimensional inspection - Samples from each inspection lot, selected in accordance with 4.2.2, shall be inspected for compliance with dimensional requirements of applicable drawings and specifications.

* 4.4.3 Pressure tightness - Where gas or liquid tightness is required of a joint in accordance with the applicable drawings or specifications, the soldered assembly shall be tested at pressures greater than required service pressures, unless otherwise specified. Samples from each inspection lot shall be selected in accordance with 4.2.2. Joints shall be subject to pressure as specified by the applicable drawings, specifications, safety codes or purchase order.

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* 4.4.4 Destructive tests - When specified in the contract or purchase order, samples selected in accordance with 4.2.2 shall be inspected for compliance with physical stress property requirements of the applicable drawings or specifications.

* 4.4.4.1 Tension or shear - Tension or shear tests shall be determined in accordance with Method 211 of Fed. Test Method Std. No. 151.

* 4.4.4.2 Peel - The peel test may be used to determine compliance with the quality of lap joints as specified in 3.5.8. One part of the joint shall be firmly held in a vise while the other part is peeled away from the lap joint using pliers. The soldered area shall be checked visually at 5 to 10 power magnification to determine the general quality of joints.

* 4.4.5 Flux removal - Samples from each inspection lot, selected in accordance with 4.2.2, shall be inspected for compliance with 3.4.2 to determine completeness of flux residue removal.

* 4.4.5.1 Chloride containing flux residues - Soldered areas shall be tested for completeness of flux removal by leaching the area with a small quantity of distilled or deionized water. Industrial or tap water from pipe lines or conduits as used for processing tanks and vats shall not be used because of its impurities. To the leach, a few drops of nitric acid and a few drops of 5 percent silver nitrate solution shall be added. If a white precipitate is formed in an amount greater than that formed in an equal volume of standard sodium chloride solution (equivalent to 125 ppm as chloride) treated in a like manner, the flux removal is not complete.

4.4.5.1.1 Standard sodium chloride solution - Weigh 0.2060 ±0.005 grams of sodium chloride which has been dried for 2 hours at 225° F and dissolve in distilled water. Dilute to 1 liter at 70° F in a volumetric flask.

* 4.4.5.2 Humidity test - When specified in the contract or purchase order, soldered areas shall be tested for completeness of flux removal residue and corrosive action on the materials involved by the humidity or environmental cabinet test.

* 4.4.5.2.1 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 ±2° F and a wet bulb temperature of 98 ±2° F. There shall not be more than 2° F temperature difference between any two points in the test area at any time.

* 4.4.5.2.2 Procedure - Selected samples shall be placed in the humidity cabinet and exposed to the conditions stated in 4.4.5.2.1 for a period of 72 hours.

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Formation of or washing by condensate on the specimens shall not be permitted. 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 the flux residues or by the cleaning solutions.

* 4.5 Rejection - Soldered assemblies not conforming to the requirements of this specification shall be rejected.

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

5. PREPARATION FOR DELIVERY

5.1 The requirements of Section 5 are not applicable to this specification.

6. NOTES

* 6.1 Intended use - This specification is intended for use in the control of non-electrical soldering processes as applied to various metals and alloys in manufacturing and maintenance facilities for assemblies. Soldering procedures are used to obtain desired properities, 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 specification, as structrual materials, are weak when compared with the materials which they are generally used to join. To avoid depending upon the strength of solder, joints for 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.

* 6.1.1 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 and good heat conductivity.

* 6.1.2 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, chassis for electronic equipment 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.

6.1.3 Nickel and nickel alloys - Nickel and nickel alloys are solderable. Application should be limited where resistance corrosion is not an important factor. Solder can be used for sealing non-pressurized water containers provided the strength

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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 thick. 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 3.1.4.1.1) are recommended.

* 6.1.4 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 also require solder processing for joining purpose for water-proofing.

* 6.1.5 Aluminum and aluminum alloys - Tube fin assemblies and cellular assemblies of aluminum and aluminum alloys are joined by dip soldering.

* 6.1.6 Magnesium and magnesium alloys - Soldering processes are being used for sealing of electronic components encased in tin or copper plated magnesium alloy containers.

* 6.1.7 Cast iron - Soldering processes may be used for repair of broken or worn cast iron equipment. Surface cracks and depressions caused by inclusions or 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.

* 6.2 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 with dissimiliar metals by processes detailed in this specification. 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 during soldering processes which may not be suitable or available. Their use is not recommended as there are other materials, non-toxic in nature, that are available and covered by specifications if soldering of aluminum is required. Also ultrasonic techniques for soldering (see 3.3.7) have been developed and are being used commercially which would not require the use of these toxic solder types.

6.3 Fluxes -

6.3.1 Noncorrosive - Noncorrosive as used in 3.1.4.1.3 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 3.1.4.1.1) or intermediate (see 3.1.4.1.2), but all fluxes must be corrosive in order to perform their function. In general, the amount of corrosion resulting from nonremoval or of noncorrosive fluxes may not be harmful to the soldered part or article.

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6.3.2 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), 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 with other metallic halides and ammonium chloride.

* 6.4 Changes from previous issue - The margins of this specification are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

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