DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
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CRANE INDIANA 47522-5001

IN REPLY REFER TO:
NSWCCRANEINST 4855.18C
GXST
20 Sept 2011

NSWCCRANE INSTRUCTION 4855.18C

From: Commander

Subj: Soldering Technologies for Electronic Systems

Ref: (a) NAVSURFWARCENDIVCRANEINST 4855.1, Quality System
(b) EIA/IPC J-STD-00lE, Requirements for Soldered Electrical and Electronic Assemblies
(c) IPC J-STD-001ES, Space Applications Electronics Hardware Addendum
(d) IPC-A-610E, Acceptability of Electronic Assemblies
(e) IPC 7711/7721B, Rework, Repair and Modification of Electronic Assemblies
(f) IPC/WHMA-A-620A, Requirements and Acceptance for Cable and Wire Harness Assemblies
(g) IPC/JEDEC J-STD-609A, Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Pb-Free and Other Attributes
(h) NAVAIR 01-lA-23; NAVSEA SE004-AK-TRS-010/2M; MARINE CORPS TM 5895-45/1A; USAF T.O. 00-25-259, Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair
(i) NAVSEA TE000-AA-MAN-010/2M; NAVAIR SE-004-PQS-000, Certification MANUAL for Miniature/Microminiature (2M)/Module Test And Repair (MTR) Program
(j) COMNAVAIRFOR INSTRUCTION 4790.2A, The Naval Aviation Maintenance Program (NAMP)
(k) NAVSURFWARCENDIVCRANEINST 4855.10, Electrostatic Discharge (ESD) Control Program
(l) GEIA-STD-0006, Requirements for Using Solder Dip to Replace the Finish on Electronic Components
(m) GEIA-STD-0005-2, Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems

Encl: (1) Soldering Program Requirements
(2) Lead-Free Statement of Work Language

1. Purpose. To establish policy and requirements for soldering technologies used in the acquisition, production, sustainment, and deployment of systems containing electronics at Crane

Division, Naval Surface Warfare Center per reference (a). Additionally, this instruction with enclosures constitutes the Lead-Free Control Plan for NSWC Crane.

2. Cancellation. NSWCCRANEINST 4855.18B.

3. Scope. This instruction applies to systems containing electronics acquired, produced, sustained, or deployed by NSWC Crane and its detachments. This instruction ensures the continued quality, performance, reliability, and safety of these systems throughout their lifecycles. This instruction applies to developmental items and commercial-off-the-shelf (COTS) used in mission critical and/or safety of flight systems applications. This instruction does not apply to non-tactical/non-critical COTS or developmental items.

4. Policy

a. All acquisition, production, rework, and repair of electronic systems shall be accomplished in accordance with Class 3 specifications and procedures contained in references (b) through (f). Customer specified soldering requirements may be used provided the quality is not less than Class 3. Class 2 may be used where the equipment will operate in benign environments and performance degradation will not adversely affect critical missions. [In case of conflict, the order of precedence is this instruction, IPC J-STD-001ES, EIA/IPC J-STD-001E, IPC-610E, and then IPC 7711/7721B.]

b. The NSWC Crane Soldering Program Requirements [enclosure (1)] identifies the soldering processes authorized and describes how NSWC Crane intends to manage the quality and reliability ramifications of Lead-free soldering technologies.

c. The use of Lead-free soldering technologies in electronic systems requires approval from the cognizant Technical Authority and the Program Manager.

d. References (l) and (m) shall be used as part of the process for mitigating Tin whiskers when required.

e. All contracts for systems containing electronics shall cite reference (b) Class 3 (or Class 2, when appropriate) for soldering and reference (d) Class 3 (or Class 2) for quality inspection.

f. All contracts for mission critical and safety of flight military systems containing electronics shall also cite reference (c).

g. All contracts for rework/repair of military systems containing electronics shall cite reference (e) for processes and reference (b) Class 3 (or Class 2) for soldering.

h. All contracts shall require implementation of reference (g) to the extent practicable.

i. Operators and inspectors performing soldering operations or inspections shall be certified and shall receive re-certification per references (b) through (f) as applicable or as defined by customer requirements. The periodicity of the re-certification shall not exceed two years.

j. Operator and inspector personnel proficiency, soldering tools and equipment, and facilities shall meet the requirements set forth in enclosure (1).

k. Personnel and repair sites that are certified in the Navy 2M Repair Program, in accordance with customer quality requirements, shall continue to meet the requirements of references (h) and (i).

l. Personnel and repair sites that are aviation certified depots shall continue to meet the requirements of reference (j).

5. Action

a. Branch Managers will implement the soldering technologies policies of this instruction to ensure quality, performance, reliability, and safety of electronic systems are maintained.

b. Task Leaders and Chief Engineers will:

(1) Implement the soldering technologies policies of this instruction for all electronic systems acquired, produced, sustained, or deployed within their area of responsibility.

(2) Manage the risks inherent with Lead-free soldering technologies per enclosure (1), section 7.0, to ensure reliability and readiness are not driven below specified thresholds should the use of Lead-free become unavoidable.

(3) Incorporate the Lead-free Statement of Work (SOW) language of enclosure (2) in contracts for systems containing electronics.

(4) Use the Data Identification Description (DID), DI-MGMT-81772, when preparing the Contract Data Requirements List (CDRL) for acquisitions of electronic systems.

(5) Use the reference (g) marking requirements to the extent practical to ensure proper identification throughout the lifecycles of electronic systems.

(6) Use Defense Logistics Agency (DLA) or other trusted sources of supply for piece parts to the fullest extent practicable.

c. First-line Supervisors will:

(1) Use enclosure (1) to determine soldering requirements applicable to their work tasks. Ensure personnel performing and inspecting soldering operations have the proper and current certifications and that these requirements are identified in the Individual Development Plan (IDP).

(2) Ensure soldering systems are periodically checked as described in Section 6.2 of Enclosure (1).

(3) Ensure ESD protections of reference (k) are in place, where applicable.

(4) Ensure personnel performing and inspecting soldering operations have sufficient visual acuity to implement effectively this program.

d. Employee Development will provide assistance in securing training sources for meeting the training requirements as defined herein and shall maintain the training records and notify management of certification issues.

6. Records Management. Records created as a result of this instruction, regardless of media and format, shall be managed in accordance with SECNAV Manual 5210.1.

7. The Interconnect & Power Converter Support & Sustainment Branch (GXST) will maintain this instruction and manage its implementation.

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Soldering Program Requirements

1.0 INTRODUCTION

a. The quality and reliability of manufactured, modified, or repaired printed circuit boards, modules, cables, and harness assemblies is highly dependent upon the skill and competence of the person performing these tasks. Achieving successful results with the methods described herein is predicated on the use of properly equipped and trained personnel whose skills have been tested and certified to Command approved competency levels. The implementation of proper methods by unqualified personnel can result in impacts on the safety, quality, reliability, and performance of military electronics systems.

b. References (b) through (g) are commercial standards and guidelines which provide the requirements, processes, and procedures for manufacturing, modifying, repairing, and reworking printed circuit boards and printed circuit board assemblies; and describe materials, methods and acceptability criteria for producing quality soldering interconnections, assemblies, and printed circuit boards. Reference (b) divides electronic assemblies into three classes: Class 1-General Electronic Products, Class 2-Dedicated Service Electronic Products, and Class 3-High Performance Electronic Products. Class 3 consists of products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

c. Reference (h) is the Standard Maintenance Practices manual for the Navy Miniature/Microminiature (2M) Electronic Repair Program. This manual contains instructions to perform Organizational, Intermediate, and Depot level maintenance on electronic assemblies. Reference (i) is the Certification Manual for the Navy 2M Electronic Repair Program. This manual provides the certification/review criteria for all 2M technicians and sites under the auspices of the Navy 2M Repair Program.

d. The electronics industry has relied on Tin-Lead (SnPb) solder processes as the primary means of interconnection between electronic components, subassemblies, and devices. The

reliability of SnPb processes is well known, well studied, and well documented. The European Union's Restriction of Hazardous Substances (RoHS) directive, along with other international and domestic mandates to eliminate materials deemed hazardous has forced the electronics industry to adopt solders free of Lead (Pb). While military electronics are considered "out of scope" for these Pb-free imperatives, the reality is that the consumer market drives the electronics industry, not the military. To remain competitive, electronics companies and their suppliers worldwide must change to solders and materials compatible with these Pb-free mandates. Electronic components and assemblies for high reliability applications, such as the military, rely heavily on commercial entities for piece parts, circuit boards, assemblies, and equipment. The majority of manufacturers are in transition to Pb-free materials and finishes. As such, it is critical that appropriate risk management strategies for Pb-free be employed to minimize adverse impacts on the safety, quality, reliability, and performance of military electronics systems.

2.0 TERMS AND DEFINITIONS

Certified Inspectors	Personnel who have received formal training [references (d) and (f)] through a program taught by an IPC certified instructor. Periodic re-certification is required to maintain proficiency in inspection.
Certified Operators	Personnel who have received formal training [references (b), (c), (e), and/or (f)] through a program that is taught by an IPC certified instructor. Periodic re-certification is required to maintain proficiency in those processes.
Class 3 Electronics	Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life-support or other mission critical systems.

Class 2 Electronics	Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.
Commercial-Off-The-Shelf (COTS)	Commercially available products that can be purchased and integrated with little or no customization. COTS may apply to piece parts, components, assemblies, or systems/equipment manufactured to commercial standards and utilized by the military.
Defective Product	A product that, upon inspection, does not meet the requirements of the applicable drawings, specifications, or standards.
Electrostatic Protective Area (EPA)	An EPA may be a permanent workstation within a room or an entire shop. A protected area may also be portable and used in a field service situation.
Higher Pb-Free Processing Temperatures	Pb-free solders typically have melting points 30-40°C higher than Sn37Pb solder, require a longer dwell time to acquire fully liquidous state, and require changes to the flux properties needed. Greater potential for damage to the circuit boards and/or piece parts can exist. This requires a significant process change from the traditional SnPb methods. For systems designed and produced using Sn37Pb, a major concern in the switch to Pb-free solders is the impact higher reflow temperatures have on materials designed and qualified for Sn37Pb processing.
Mission Critical	A term applied to any condition, event, operation, process, or item, the failure of which may result in the inability to achieve successful mission completion or to maintain combat capability.

Modification	The revision of a product in order to satisfy compliance to new functional capability acceptance criteria. Modifications are usually required to incorporate design changes, which can be controlled by drawings, change orders, etc. Modifications should only be performed when specific authorization, prescribed details, and controlled documentation are presented.
Repair	The act of restoring defective products to functional capability without full compliance of the article with applicable drawings or specifications. Repairs are generally changes to an unacceptable end product to make it acceptable in accordance with original functional requirements.
Rework	A defined process to return a defective product to an acceptable status. The act of reprocessing non-complying articles, through the use of original or equivalent processing, in a manner that assures full compliance of the article with applicable drawings or specifications.
Safety of Flight	The property of a particular air system configuration to safely attain, sustain, and terminate flight within prescribed and accepted limits for injury/death to personnel and damage to equipment, property, and/or environment. The intent of safety-of-flight clearance is to show that the managing activity has completed appropriate risk management and the level of risk (hazards to system, personnel, property, equipment, and environment) has been appropriately identified and accepted prior to flight of the air system.

Solder Joint Integrity	Lead-free solder alloys are stiffer and less ductile (or more brittle) than Tin-Lead and are prone to fracturing. Insufficient data exist to validate whether Pb-free solders are reliable enough to sustain military hardware throughout the lifecycle of the system. There is no drop-in replacement for eutectic Sn37Pb solder and a multitude of Pb-free alloys is now available.
Tin Whiskers	Pure Tin (Sn) finishes have a propensity to form Tin Whiskers, which can result in electrical shorts and failures. Tin Whiskers are pure Tin crystal conductive filaments for which the contributing conditions for the formation of Tin Whiskers are known, but not well understood. The exact event or sequence of events that result in Tin Whisker growth is the subject of ongoing research. Driven by the transition to Pb-free products, Tin Whiskers pose major safety, reliability, and potential liability threats to all makers and users of high reliability electronics and associated hardware.

3.0 SYMBOLS AND ABBREVIATED TERMS

2M	Miniature/Microminiature Electronic Repair
COTS	Commercial-Off-the-Shelf
EPA	Electrostatic Protective Area
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Susceptibility
HSD	Hot Solder Dipping
Pb	Lead
Pb-free	Lead-free

RoHS	Restriction of Hazardous Substances
Sn	Tin
SnPb	Tin - Lead
Sn37Pb	63% Tin 37% Lead eutectic solder

4.0 EXTENDED REFERENCES

Links to the documents below are at public accessible Lead-free electronics site on the Defense Acquisition University (DAU) Acquisition Community Connection (ACC) website https://acc.dau.mil/leadfree.

Air Force Airworthiness Advisory AA-08-02	Lead-free Electronics
ANSI/ESD S20.20-2007	Electrostatic Discharge (ESD) Control Program
FAA AIR100-2011-120-003	Assessing the Reliability and Certification Procedures for Electrical and Electronic Equipment and Systems Using Lead-Free Solder and Lead-Free Finishes on Components
GEIA-STD-0005-1	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder
GEIA-STD-0005-3	Performance Testing for Aerospace and High Performance Electronics Containing Lead-Free Solder and Finishes
GEIA-HB-0005-1	Program Management/ Systems Engineering Guidelines for Managing the Transition to Lead-free Electronics
GEIA-HB-0005-2	Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder
JESD213	Common Test Method for Detecting Component Surface Finish Materials

LSA SOLD-08-02	Technical Guidance for Lead-Free Electronics
LSA SOLD-08-03	Technical Guidance for Rework-Repair of Lead-Free Electronics
LSA SOLD-08-07	Technical Guidance for Risk Management of Lead-Free Electronics
MDA-QS-003-PMAP-REV A	Missile Defense Agency Parts, Materials, And Processes Mission Assurance Plan (PMAP)
MIL-STD-1276	Leads For Electronic Component Parts
NASA Advisory NA-044	Parts advisory on Tin Whiskers
NASA Policy Directive NPD 8730.2C	NASA Parts Policy

5.0 OBJECTIVES

This instruction identifies NSWC Crane’s Program for Soldering Technologies. The instruction will be used in the acquisition, production, and sustainment of military electronic systems. The primary goal is to ensure the continued quality, performance, reliability, and safety of the electronic equipment and systems provided to the Warfighter given the commercial transition to Pb-free soldering technologies and the associated reliability consequences. The specific objectives of this document are:

- To meet the reliability and product lifecycle requirements of system specifications as well as the production of high reliability military (Class 3, or Class 2 when appropriate) electronic products

- To maintain control of the configurations of all systems, equipment, assemblies, and subassemblies, as required by the specific program

- To avoid, transfer, or mitigate the increased risk factors for military high-reliability electronics that the commercial transition to Pb-free products has introduced

- To introduce no additional limitations of use for the electronic assemblies procured, manufactured, refurbished, or repaired

- To assure repair, maintenance, and support activities comply with this strategy

- To apply the requirements of this instruction to all NSWC Crane electronic products, except as excluded in the Instruction's Scope paragraph

6.0 REQUIREMENTS

a. The solder processes authorized for use at NSWC Crane are described below. If the soldering requirements contained herein differ from what is called out in contracts, drawings, specifications, etc; the customer shall be informed of these requirements and the differences. Customer soldering requirements may be used if they meet or exceed Crane requirements identified herein.

b. All assembly and soldering including rework shall be performed by certified personnel such that the final product meets the requirements of references (b), (c), (e), and (f) where applicable.

c. Final inspection of all operations shall be done on all products. Only certified inspectors shall perform final inspection. Inspectors will inspect for acceptability to the requirements of the work performed. The inspector shall be a different person than the one who performs the operations.

d. Repair and rework operations shall be performed in accordance with reference (e).

e. Personnel and repair sites that are certified in the Navy 2M Repair Program, per customer requirements, shall continue 2M certification efforts in accordance with references (h) and (i).

f. Operations involving ESD sensitive items shall meet the requirements of reference (k).

g. These requirements may be waived when performing operations on documented prototype products unless used in mission critical and/or safety of flight systems applications. If any requirement is waived, all products made within the waiver shall be marked in a way that identifies that the product is for prototype use only.

6.1 Personnel Training and Certification Requirements

a. Certified Production Personnel. Personnel performing any soldering processes within the scope of this instruction shall be certified to the requirements of references (b), (c), and/or (f).

b. Certified Rework/Repair Personnel. Personnel performing rework and repair soldering processes shall be certified to the requirements of references (e) in addition to the requirements for Certified Production Personnel.

c. 2M Personnel. Personnel performing 2M soldering processes shall be certified to the requirements of reference (i).

d. Certified Inspectors. Personnel performing inspection of soldering processes within the scope of this instruction shall be certified to references (b) and (d).

e. ESD Awareness. Personnel performing any process that involves ESD sensitive products shall receive annual ESD Awareness Training [see reference (k)].

6.2 Equipment

a. General Requirements. To verify continuing satisfactory operation, soldering systems (soldering irons, soldering pots, and other types of soldering systems) shall be checked quarterly to verify applicable requirements identified below. The results of these checks shall be documented and maintained. A logbook or other means may be used for recording the results of the system checks. Each device or system shall have a unique identification. Soldering systems not meeting the requirements identified below are to be repaired or removed from service.

b. Safety. Use approved safety eyewear and other required personal protective equipment when working around energized soldering equipment.

c. Tools and Equipment. Tools and equipment shall be maintained such that no damage or degradation would be detrimental to the designed function of parts or assemblies.

d. Benchtop and Hand Soldering Systems. Soldering systems are to be tested in accordance with the manufacturer's procedures to verify compliance with the following applicable requirements:

(1) Temperature controlled soldering systems (at rest) shall be controlled within ±5°C [±9°F] of the idle tip temperature. Constant power output soldering systems shall be tested for peak power and meet the minimum requirements identified by the manufacturer.

(2) Operator selected or rated temperatures of soldering systems shall maintain an idle/standby temperature measured at the tip within ±5°C [±9°F] of the selected/rated temperature.

(3) Resistance between the tip of the soldering systems and the workstation common ground point shall not exceed 5 ohms.

(4) Tip transient voltages generated by the soldering system shall not exceed 2V peak. Note: AC and DC current leakage from heated tip to ground shall not create deleterious effects on equipment/components.

6.3 Facilities

Facilities within which soldering operations are performed shall meet the following minimum requirements:

a. General

(1) Cleanliness and ambient environments in all work areas shall be maintained at levels that prevent contamination or deterioration of soldering tools, materials, and surfaces to be soldered.

(2) Eating, drinking and/or use of tobacco products shall be prohibited in the work area.

b. Environmental Controls

(1) 18°-30°C [65°-80°F] temperature.

(2) 30%-70% relative humidity.

(3) Lighting is adequate for work being performed.

c. Moisture Controls. When applicable, effective controls shall be in place for handling of moisture sensitive components and boards.

d. Electrostatic Discharge (ESD) Protection. When applicable, ESD control program controls shall exist in the work

area and consist of the following minimum elements (see reference (k)):

(1) ESD benches and mats shall be tested quarterly unless continuous monitors are in use.

(2) ESD wrist straps shall be tested using an ESD wrist strap tester prior to each use unless connected to an ESD continuous monitor. In addition, ESD wrist straps shall be inspected for any excessive wear or damage prior to each use.

(3) The Electrostatic Protective Area (EPA) shall be clearly marked. (Bench displays ESD sign; floor area is taped or otherwise marked to show the EPA.)

(4) All personal grooming items, plastic articles, and other non-essential nonconductive materials shall be kept at least two feet away from the EPA and Electrostatic Discharge Susceptibility (ESDS) items.

(5) When transporting ESDS items out of an EPA all ESDS items including circuit cards must be protected by either a MIL-B-81705, Type III approved, sealable, static shielding bag or with other approved protective packaging materials. Provide an ESD barrier or complete the conductive layer of “black boxes” by placing conductive ESD caps or metal caps on all connectors.

7.0 SOLDERING TECHNOLOGIES PROCESSES

There are profound reliability risks inherent with using Pb-free soldering technologies in military electronic systems. The increased risk factors resulting from using Pb-free in military high-reliability electronics are Tin Whiskers, solder joint integrity, and increased processing temperatures. This section identifies the means to manage, limit, or control risks with negative impact to electronic systems using these four types of response strategies:

- **Avoid the Risk**—eliminate the threat or the possibility of having any impact

- **Mitigate the Risk**—reduce the probability of occurrence and/or reduce the impact if it does occur

- **Transfer the Risk**—shift responsibility to another party, (i.e. warranties)

- **Accept the Risk**—do nothing and deal with the impact should it occur

Table 1 describes how NSWC Crane will manage the risk of Pb-free using the risk response strategies identified above. The columns first categorize the solder, component, and board finish variables followed by the risk response strategy for each of the risk factors identified. Each column is named with a solder process identifier. For the risk response strategy blocks, the green (avoid) blocks denote no increased risk; the yellow (mitigate) show low to moderate increased risk; and the red (accept) blocks show moderate to high increased risk. Every effort should be made first to avoid the risk factor by eliminating it or its impact, followed by mitigating the probability of occurrence or reducing the impact of the risk factor, and finally, transferring the risk to another party. When there is no other viable or practical alternative, the risk factor will have to be accepted.

Table 1. Risk Management for Pb-free Soldering Technology

	SnPb	1	2	3	4	5	5a
Solder	Sn37Pb	Sn37Pb	Sn37Pb	Sn37Pb	Sn37Pb	Pb-free	Pb-free
Component Finish	>3%Pb	Non-Sn	HSD	Sn	Sn	Pb-free	Pb-free
Board Finish	>3%Pb	Non-Sn or >3%Pb	Non-Sn or >3%Pb	Non-Sn or >3%Pb	Sn	Pb-free	Pb-free
Tin Whiskers	**Avoids the risk**	**Avoids the risk**	**Mitigates the risk**	**Mitigates the risk**	**Mitigates the risk**	**Mitigates the risk**	**Accepts the risk**
Solder Joint Integrity	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Accepts the risk**	**Accepts the risk**
Processing Temperatures	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Accepts the risk**	**Accepts the risk**
Component Reliability	**Avoids the risk**	**Avoids the risk**	**Accepts the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**	**Avoids the risk**

One of the potential risk management techniques, hot solder dipping (HSD), creates an additional risk factor–**component reliability**. HSD reprocesses pure Sn component terminations by adding at least 3% Pb. Because HSD does reheat the component, there is potential for introducing latent defects.

All processes identified above in Table 1 shall be accomplished in accordance with Class 3 (or Class 2 when applicable)

specifications and procedures contained in references (b) through (f).

Of the seven processes identified above in Table 1, the standard and preferred soldering processes for all applications are:

- **SnPb process**—*Sn37Pb solder/SnPb board finish/SnPb component termination finishes*. The SnPb Process consists of the Sn37Pb solder alloy; the board finish contains a minimum of 3% Pb; and the component termination finishes contain a minimum of 3% Pb.

- **Process 1**—*Sn37Pb solder/non-Sn or SnPb board finish/non-Sn Pb-free component termination finishes*. Process 1 consists of the Sn37Pb solder alloy; the board finish is non-Sn or contains a minimum of 3% Pb; and/or the component termination finishes are non-Sn (e.g. Gold, Nickel Palladium, Nickel Palladium Gold).

Other soldering processes identified in Table 1, which can be used for assembly, rework, and repair albeit with increased risks due to Lead-free component termination and circuit board finishes are:

- **Process 2**—*Sn37Pb solder/non-Sn or SnPb board finish/reprocessed Pb-free Sn component termination finishes*. Process 2 consists of the Sn37Pb solder alloy; the board finish is non-Sn or contains a minimum of 3% Pb; and the component termination finishes are reprocessed [hot solder dipped (HSD)] per reference (l) to contain a minimum of 3% Pb. Because of potential reliability issues, the use of process 2 requires approval from the cognizant Technical Authority and the Program Manager. Process 2 mandates using Tin Whisker mitigation per reference (m)[i].

- **Process 3**—*Sn37Pb solder/non-Sn or SnPb board finish/pure Sn component termination finishes*. Process 3 consists of the Sn37Pb solder alloy; the board finish is non-Sn or contains a minimum of 3% Pb; and the component termination finishes are pure Sn. Because of potential reliability issues, the use of process 3 requires approval from the cognizant Technical Authority and the Program Manager. Process 3 mandates utilizing Tin Whisker mitigation per reference (m)[i].

- **Process 4**—*Sn37Pb solder/pure Sn board finish/pure Sn component termination finishes*. Process 4 consists of the Sn37Pb solder alloy with the board finish and the component termination finishes are pure Sn. Because of potential reliability issues, the use of process 4 requires approval from

the cognizant Technical Authority and the Program Manager. Process 4 mandates utilizing Tin Whisker mitigation per reference (m)[i].

Commercial-Off-The-Shelf (COTS) Equipment. The use of COTS equipment is being mandated as part of acquisition reform and is becoming increasingly prevalent in military electronic equipment and systems. In some cases, this equipment may be in mission critical systems and/or in safety of flight situations. COTS is more than likely to be Pb-free, as the commercial manufacturers are being forced to Pb-free to comply with RoHS and other legislative mandates. Special care must be taken to understand and address the reliability concerns that Pb-free presents for COTS equipment, as Pb-free is yet unproven in military environments. The same reliability concerns addressed herein apply to COTS used in military equipment especially for the use of COTS in mission critical and/or in safety of flight circumstances.

The remaining two processes identified above in Table 1 are reserved for COTS procurements where there is no viable alternative to Pb-free:

- **Process 5**—*Pb-free solder/board finish/component termination finishes*. Process 5 consists of no Pb in the solder alloy, the board finish, and the component termination finishes. Because of potential reliability issues, the use of process 5 requires written approval from the cognizant Technical Authority and the Program Manager. Process 5 mandates utilizing Tin Whisker mitigation per reference (m)[i].

- **Process 5a**—*Pb-free solder/board finish/component termination finishes*. Process 5a differs from process 5 in that there is no Tin Whisker mitigation. The use of process 5a requires written approval from the cognizant Technical Authority and the Program Manager.

8.0 CONCLUSION

Employment of the *NSWC Crane Soldering Program* described above will help to ensure that all military electronic systems will continue to meet the quality, performance, reliability, and safety requirements of the program specification lifecycle regardless of the soldering technology employed, Pb-free included. Pb-free electronics will affect the Military as long as the conversion of the commercial supply chain to Pb-free components, boards, and assemblies and COTS integration persist.

Managers of defense programs must be aware of the risks associated with use of Pb-free soldering technologies in order to control/manage the situation.

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[i] Per GEIA STD-0005-2, the following are methods for mitigating tin whiskers:

- Physical Barriers
- Choices of Underplating or Substrate Material
- Selection of Matte Tin
- Plating Process Considerations
    - Plating Baths
    - Hot Tin Dip
    - Reflowing, Fusing, Annealing
- Tin Thickness
- Material an Assembly Processing
- Solder Dip Tin-finished Surfaces
- Replating
- Pb Overplating
- Conformal Coating
- Foam Encapsulation
- Heat Treatments

Lead-Free
Statement of Work (SOW) Language
for Military Electronic Systems

The Contractor shall:

- Utilize the soldering process or processes per enclosure (1) of NSWCCRANE INSTRUCTION 4855.18C in the manufacture or procurement of electronic systems.

- Ensure piece parts being procured for assembly, rework, or repair are of the correct metallurgy intended [at least 3% Lead content by weight for Tin-Lead piece part terminations]. Use of Tin alloys for terminations and packaging finishes containing less than 3% Lead by weight must be approved by the procuring activity.

- Use Military Specifications and Standard Microcircuit Drawing Tin-Lead piece parts to the fullest extent practicable.

- Use DLA or other trusted agents as the source of supply for piece parts to the fullest extent practicable.

- Avoid the use of pure Tin (containing less than 3% Lead by weight) piece part termination finishes to the fullest extent practicable.

- Incorporate to the extent required by the Government, GEIA-STD-0006 “Requirements for Using Solder Dip to Replace the Finish on Electronic Components” (or equivalent) and GEIA-STD-0005-2 “Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems” (or equivalent) as part of a risk management process to mitigate Tin whiskers.

- Incorporate to the extent required by the Government, reballing of Lead-free Ball Grid Arrays with Tin-Lead solder balls as part of a risk management process to eliminate reliability concerns of Lead-free solder balls and to mitigate Tin whiskers.

- Implement IPC/JEDEC J-STD-609A “Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Pb-Free and Other Attributes” to ensure identification of the interconnect metallurgy throughout the lifecycle to the extent practical.