empfasis

A publication of the National Electronics Manufacturing Center of Excellence

End of Year Special Edition
(4th Quarter 2005)

ISO 9001-2000 Certified

American Competitiveness Institute
One International Plaza
Suite 600
Philadelphia, PA 19113
(610) 362-1200 • **FAX:** (610) 362-1290
HELPLINE: (610) 362-1320
WEBSITE: www.empf.org
www.aciusa.org

The EMPF is a U.S. Navy-sponsored National Electronics Manufacturing Center of Excellence focused on the development, application, and transfer of new electronics manufacturing technology by partnering with industry, academia, and government centers and laboratories in the U.S.

EMPF Director
Michael D. Frederickson
mfrederickson@aciusa.org

In This Issue

Improving Battery Logistics for the Warfighter

Today's warfighter is highly dependent upon many electronic devices for survival in the field. Those diverse electronic devices need power to work. Fortunately, battery technologies are one of the commodities in the field that supply that power. Unfortunately, those batteries are usually of custom form and fit, from multiple commercial sources, and the logistics involved in maintaining an adequate supply of custom batteries for the warfighter is extremely difficult. Each electronic device more than likely has a unique form and fit battery. The warfighter must carry enough spare batteries of each type necessary to complete the mission. This adds a significant amount of weight to the warfighter's provisions. Precious time is spent locating the right replacement battery on his/her person. Finally, dead batteries are not necessarily disposable, so the warfighter must maintain the dead battery "shells" until the next visit to a supply location.

A practical solution is to utilize commercial off-the-shelf (COTS) batteries. Ready availability around the world would shorten the supply chain. Today's COTS battery technologies are more advanced in their storage power capacity. They last longer and need less frequent replacement. Their form and fit has progressed as well.

Another option is to modify legacy custom battery enclosure "shells" to hold several COTS batteries ("AA", for example). These battery technologies are available today, around the world – easily supportable and readily accessible. This leads to a better outfitted warfighter with greater capabilities to complete missions.

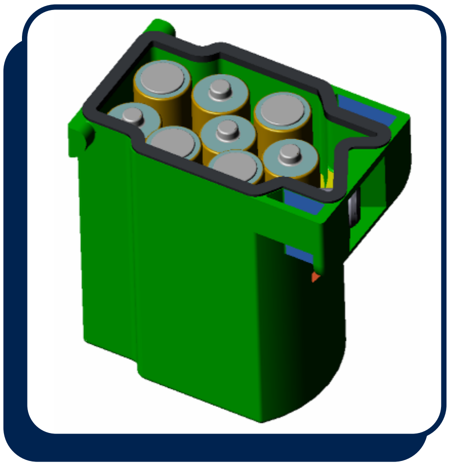

Figure 1-1 – AN/PRC-112 radio reusable battery case w/ "AA" batteries

The logistics burden of supplying power to the battlefield is growing and becoming more complex, due to the current lack of battery standardization and unification. A solution may be to utilize commercial-off-the-shelf (COTS) battery power sources. Standard-size alkaline, lithium (Li) ion or nickel-metal hydride (Ni-MH) batteries are readily available in traditional commercial outlets. Today's technology has made "D", "C", "AA", or "AAA" standard-size batteries viable options to traditional legacy power sources. They can provide the same or greater power capacities and are disposable.

continued on page 2

Improving Battery Logistics for the Warfighter

(continued from page 1)

The key to utilizing these resources is to research the form, fit, and function of each legacy power supply and engineer the COTS batteries to adapt as necessary. By matching system voltages and capacities to COTS equivalents, the legacy battery cases can then be adapted to hold COTS batteries and still physically fit within the existing system. The AN/PRC-112 hand-held radio, for example, uses a one-time use, disposable Lithium-type custom battery costing from $85 to more than $100 each. The EMPF reengineered and modified the existing battery case to hold eight (8) standard "AA" non-rechargeable Lithium-ion or rechargeable Ni-MH batteries, costing significantly less (Figure 1-1). The new battery casings are reusable. This redesign enables soldiers to support missions for longer durations.

The traditional method for the warfighter to replace used battery cells is to either discard or turn in the old cell at a supply location and get restocked, expending valuable time. Once a COTS adaptation is accomplished across all portable power systems, the time and materiel logistics burden to the warfighter can be reduced. The soldier will only need to carry COTS batteries, which are easily stocked, supplied, and disposed.

Primary batteries, particularly those made from lithium, can deliver up to eight times the watt-hour capacity of conventional rechargeable batteries; however, new rechargeable batteries using a lithium anode will also have higher capacity than the conventional rechargeable batteries. The logistics of primary batteries are simple, as portable energy can be made available at remote distribution points that are unmanned and have no electricity. Disposal is easy because little toxic material is used. Primaries are simple to store, as they require no maintenance, and a primary battery has a shelf life of 10 years; however, because they are single-use, the cost of the primary battery is about three times higher than that of a rechargeable one.

In contrast, lithium-based batteries are good for only two to three years, whether used or not. Cool storage at a 40 percent charge level prolongs longevity, though. Nickel-based batteries are good for five years and longer, but they require priming to regain performance after extended storage.

All of these factors must be taken into consideration when making final decisions on power supplies for the warfighter. A rechargeable battery pack saves costs in materials and saves the time expended going to and from the supply depot, but the soldier must have a readily available charging system in the field. On the other hand, disposable, non-rechargeable batteries can keep the warfighter in the field longer, with immediate replacements available (albeit a finite, depletable stock on hand). A combination of the two – rechargeable and disposable – may be the answer. The soldier can recharge the battery pack as often as is practical in the field when a charger becomes available. At others times, disposable batteries maintained in the soldier's uniform can be used. This would keep the warfighter mission-ready.

Stocking of rechargeable batteries requires significant maintenance, keeping track of the battery's state of health, cycle count, and age. Due to high self-discharge, nickel-based batteries exhibit a 10-20% self-discharge per month. This compares with 5-10% for lithium and lead-based batteries. Self-discharge increases at higher temperatures. "Smart" monitoring of effective battery power is a significant aspect for military use, but it is rarely available with primary batteries. While such implementations add to the cost of each battery, they reduce the total life cycle cost of the entire battery inventory.

The use of regenerable power is becoming critical for military missions. To aid the mission, the use of COTS battery technologies can only benefit the warfighter. Shortened lead times to replenishment, increased power capacity with the advent of newer technologies, and increased versatility will allow today's warfighter to manage more reliable, longer lasting electronic equipment. Disposability and interchangeability will only further streamline the logistics process. All of this technology is readily available to the warfighter today – now all we have to do is embrace it.

Author of article: *Chuck Thorpe* – Chuck is an Engineer at ACI. Comments or questions pertaining to this article can be sent to cthorpe@aciusa.org.

IPC-7711/7721
Rework, Repair, and Modification Training and Certification

Due to the increasing popularity of lead-free finishes, the EMPF is now offering the IPC-7711/7721 Rework, Repair, and Modification Training and Certification Program using both lead and lead-free printed circuit assemblies. The addition of a lead-free printed circuit assembly will accommodate companies that have converted to the use of lead-free alloys. The workmanship kits used in the course contain two fully-populated, mixed-technology board assemblies, one with a HASL finish, and the other with an ENIG finish.

The IPC-7711/7721 Application Specialist course consists of nine modules, covering the most commonly used procedures for board restoration. The modular approach to workforce training allows companies to select the appropriate amount of training for each individual employee.

The first module is a prerequisite for the rest of the course modules. In Module One, students learn how to interpret the procedures in terms of skill level, level of conformance, and product classification. This module also teaches students the basic considerations used to analyze rework and repair, tool and material considerations, auxiliary and primary heating methods, proper handling techniques (including basic ESD precautions), and basic cleaning procedures used in IPC-7711/7721. Students are required to pass a 20-question, open book exam with a minimum score of 70 percent.

Module Two of IPC-7711 covers the four most commonly used splicing procedures: mesh, wrap, hook, and lap. Students are required to demonstrate each of these procedures using both lead and lead-free solders.

During the remainder of the IPC-7711 Rework portion of the course, students learn how to correctly adjust preheat and reflow temperatures to avoid damage of both the circuit boards and the components. Demonstration of proficiency includes removal of a variety of through-hole and surface mount devices, including 16-leaded DIPs, and 20-mil pitch quad flat pacs. During the course, students are required to remove over 50 components from two PCBs. Once the boards are component-free and all pad areas and plated through-holes are cleaned up and free of solder, students are required to replace a variety of each component type. Students must assess their boards for damage using the acceptability criteria based on IPC-A-610.

The following modules can be selected for training in IPC-7711:

Module 2: Wire Splicing (5 hours)
Module 3: Through-Hole Technology (7 hours)
Module 4: Chips and MELFs (6 hours)
Module 5: SOIC and SOTs (6 hours)
Module 6: J-Lead and Gull Wing (8 hours)

During the IPC-7721 repair section, students must demonstrate proficiency in the replacement of traces, eyelets, and pads and in the installation of jumper wires. Another section of the repair course covers the replacement of laminate materials. Students will learn how to replace damaged laminate using the epoxy fill method. Conformal coating removal methods are included in IPC-7721 Repair Procedures. Participants learn how to correctly identify various conformal coatings, learn the preferred methods of removal for each type, and demonstrate proficiency using various removal techniques. The following modules can be selected for training in IPC-7721:

Module 7: PWB Circuit Repair (8 hours)
Module 8: Laminate Repair (6 hours)
Module 9: Conformal Coating (5 hours)

This course is ideal for individuals who possess strong reasoning capabilities and above average soldering skills. Successful training in rework and repair operation can usually be accomplished after 3 to 10 days of training. The entire IPC-7711/7721 course can be completed in nine days by personnel with above-average soldering skills.

The addition of the lead-free assembly will enable all types of manufacturers to obtain the necessary training for their workforce. With the 2006 lead-free implementation deadlines fast approaching, rework operators need to be properly trained for lead-free rework. Please contact the EMPF registrar at (610) 362-1320 for more details.

Author of article: *Tracy Clancy* – Tracy is a Technician/ Instructor at ACI. Comments or questions pertaining to this article can be sent to tclancy@aciusa.org.

Cleaning PCBs Exposed to High Humidity and Storm Damage

After hurricanes Katrina and Rita, many electronics manufacturers and suppliers with facilities in Louisiana, Texas, Mississippi, and Alabama had their work cut out for them. Many factories and warehouses were devastated by flood and wind damage. One might conclude that those inventories were lost and written off as losses to be replaced by insurance companies. But what became of the legacy electronics systems with components, boards, and layout drawings that are nearly irreplaceable? Manufacturers are now attempting to salvage these electronics assemblies. The ability to salvage these critical systems not only benefits the product owners but also impacts the U.S. and global economies, particularly in systems that are used to supply fuel, energy, communications, water, and food. The EMPF is assisting the recovery of such assemblies by providing a cleaning process for boards and assemblies exposed to the high humidity and storm damage of the harsh hurricane environments.

Recovery of economically or strategically important electronic hardware requires a stepwise approach:

1. Evaluation – A high-level decision which looks at the pros and cons of recovery vs. replacement.
2. Analysis of damage – Assess observable and potential damage: e.g., water logging, contamination, corrosion (using visual examination), chemical and physical analysis.
3. Damage mitigation approach – propose different methods to remove or eliminate damage.
4. Process of mitigation – for example, cleaning the circuit boards and drying.
5. Post-mitigation testing and documentation.

Hurricane exposure encompasses everything from extended high humidity to submersion in seawater. The exposure comes directly from damages to the storage and manufacturing facilities. Damage reports vary in severity from power loss and air conditioning failure (high-humidity) to structure failure (exposure to the salt atmosphere from hurricane environments) to tidal flooding (submersion in brine solution).

During the recent hurricanes, four feet of tidal floodwaters engulfed the facilities and much of the stock of electronic circuit boards. These floodwaters carried with them various forms of foreign matter that included sewage, oil, various forms of salts, and bacteria (Figure 2-1). Exposure to these elements results in board failures caused by corrosion and short circuits. Salt residue and unidentified contaminates, both visible and undetectable, coat the affected boards and components. To restore these boards to useful (though sometimes limited) operating condition, these assemblies must be cleaned of the harmful contaminates.

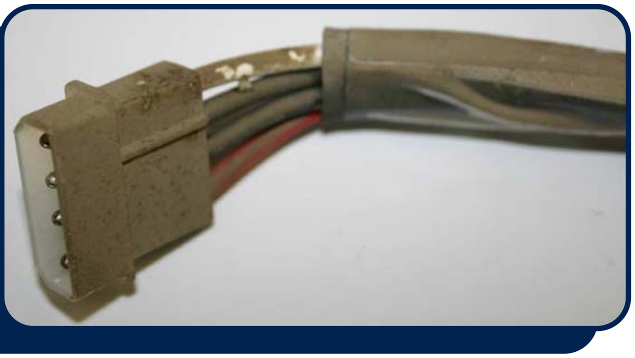
Figure 2-1 – Contaminated connector exposed to hurricane floodwaters.


Figure 2-2 – In-line cleaning operation used at the EMPF to recover boards affected by hurricane damage

Contaminates can be grouped into two categories – ionic and nonionic. The two most common failures due to ionic contamination are corrosion and dendrite growth. Both of these conditions can cause device failure. The most common sources of ionic contamination are flux, cleaning fluids (e.g., tap water), and plating chemistry residue (from the surface finish). In the case of the boards which the EMPF inspected, salt water posed the largest threat to the reliability of the assemblies. Ionic contamination can also result in dendrite growth, which in turn leads to short circuits.

Non-ionic contamination is not usually of great concern to most electronic device manufacturers, but this does not mean that it does not affect reliability. The most common failure modes due to non-ionic contamination are reduced solderability, lack of connectivity, and sensor malfunction. Since non-ionic contaminates are nonconductive, they can disrupt the flow of electricity through these connectors if they are present on an edge card connector or inside a socket.

continued on page 6

Ask the EMPF Helpline!

The EMPF Helpline received a call from a customer who had begun a lead-free pilot run. Upon removal from the reflow oven, the first set of soldered printed circuit boards (PCBs) were full of blisters.

The customer's board design had six layers, full ground, and power planes. The board was approximately 6" x 7" in size. It was not a high density board. The most difficult item to attach was a transformer. The reflow process temperature profile for the lead-free (Pb-free) solder assembly peaked at 250°C on the board itself. The substrate was made of FR-4 with a glass transition temperature of 170°C.

Initially, the customer considered that humidity was the cause of the blistering. To explore this possibility, one board was baked for 8 hours at 125°C. This was followed by reflow. Typically, this would bake out any moisture. Again, almost the same amount of blistering appeared (Figure 3-1). Next, after 3 months of storage, a PCB was reflowed at 250°C and a tiny blister appeared. The customer requested an analysis of the phenomenon and advice on correcting their process.

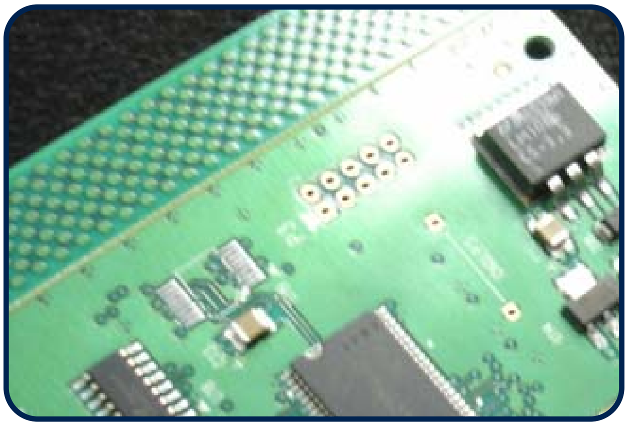
Figure 3-1 – Example of board delamination

Lead-free solders have a higher melting point than SnPb solders. Due to an increase in vapor pressure with increase in temperature, components are more sensitive to moisture which may have accumulated during fabrication. If left in the device, this moisture will vaporize at soldering temperature, leading to delamination, soldering voids, and device cracking. The process specifications used by the customer for peak temperatures (240 - 250°C) and the board bake out for 8 hours at 125°C are well within the limits established in IPC-HDBK-001 with amendment 1; *Handbook Guide to Supplement J-STD-001*. The bake out should remove water accumulated during the fabrication process and absorbed during storage. Extended bake out can degrade the PCB and component solderability.

A potential source of failure is the use of conventional FR-4, which may not withstand multiple lead-free reflow soldering temperatures of 250°C. Alternatively, high reliability FR-4 can tolerate the elevated soldering temperatures. The choice of laminate is determined by two critical temperature values. Traditionally, the glass transition temperature is the sole consideration in laminate selection. An equally important metric in determining the choice of laminates is the material decomposition temperature. This is defined as the temperature at which a weight change of 5% occurs. Degradation can occur with as little as a 2 to 3% weight change during thermal cycling; therefore, a high decomposition point is critical in providing reliability.

Another factor in selection is the resin system. Phenolic cure materials known as high reliability FR-4 have higher temperature resistance to support the 250°C peak soldering temperatures. Appropriate examples of other PCB laminate materials that are specifically developed for the higher lead-free soldering temperatures and also satisfy the material requirements are Polyclad Getek, Isola IS 415, and Nelco N4000-12.

The EMPF agreed with the customer's moisture testing procedures and results. Based on the EMPF's lead-free processing expertise, the EMPF concluded that the problem was not due to the customer's soldering process but due to improper bare board manufacture. This was likely due to the manufacturer's use of expired prepreg. Fabricating the board in an uncontrolled humid environment is also a potential source of blistering. This absorbed moisture and/or expired prepreg could prevent full resin curing during multi-layer PCB lamination steps.

Conclusions

Board manufacture-induced errors can give rise to blistering independent of processing. From a processing perspective, prior to initiating a lead-free trial run, first confirm that the board material can tolerate lead-free soldering temperatures. Some materials have been suggested to better support the higher temperatures required for lead-free assembly. High reliability FR-4 can be substituted for conventional FR-4, but beware that these substitutes may be more costly and reduce performance of the finished product.

Author of article: *John Butler, Ph.D.* – John is a Research Associate at ACI. Comments or questions pertaining to this article can be sent to jbutler@aciusa.org.

Cleaning PCBs Exposed to High Humidity and Storm Damage

(continued from page 4)

The EMPF has observed several problems with insulating films present on gold edge connectors. The good news is that most of the contaminates are soluble in water, and with the aid of surfactants, they can be removed with a well-executed cleaning process. Such a process must be well thought out and kept under extremely tight controls.

Before the affected boards and components are cleaned, a recovery plan is implemented. EMPF engineers meet with the board designers, quality assurance personnel, and manufacturing engineers, to discuss the details of the operation. An outline is formed with the steps required to conduct the cleaning and recovery operations based upon some critical considerations.

Severity of the exposure

The history of each board's storage and exposure conditions is evaluated. This includes an original date of manufacture, time in storage, storage location (e.g., in crates at the floor level, shelved above the water line, etc.), and any processing or recovery operations performed after exposure to extreme environments.

Product needs assessment

Each board set is prioritized by the end-use application (in some cases, the individual needs of specific facilities are considered) and availability of replacements. Systems that are more important to the individual facilities are evaluated first. These are the systems that are directly responsible for providing necessities like water, food, and fuel.

Cleaning process

The cleaning process is created using standard electronics manufacturing in-line cleaning equipment and materials as a base (Figure 2-2). Additional processes and materials are added to ensure removal of any atypical foreign matter to which the assemblies may have been exposed. Drying and baking time are also under consideration. Current guidelines for component and assembly drying and baking after cleaning and storage are targeted for surface mount packages designed and built within the past 15 years. They address moisture sensitive components that absorb water vapor from uncontrolled and controlled atmospheres. Because legacy electronics have been developed using older technology (1980s and earlier), compatibility issues exist with high-temperature baking, even in short duration. For example, some older dip packages are rated for operation at a maximum temperature of 60ºC. IPC J-STD-033 recommends baking some moisture sensitive surface mount components at 125ºC for up to 16 hours. Blindly following industry standards that are recommended for current technology would surely lead to component failure in the case of many older systems.

Development of a testing/validation system

Visual inspection and ionic cleanliness testing are used as a base for evaluating the effectiveness of the cleaning and drying operations. Although IPC J-STD-001 and IPC-A-610-D provide specifications for ionic cleanliness and visual inspection criteria, the age of the board and any add-on materials (markers, labels, etc.) will influence the results, possibly producing false readings. For example, the adhesive used for stick-on labels contains ionic residues that will give a false contamination reading. Careful scrutiny of inspection and cleanliness testing results is required.

Based upon these factors, multiple recovery plans were developed at the EMPF. The following is an example of a cleaning process developed to clean boards that have a mild level of exposure and have components which are compatible to an in-line hot water cleaning process. The performance of the components on these boards would not be affected by baking.

Example cleaning process for boards with mild level exposure and limited component sensitivity:

Receiving

Board lots are recorded; old storage bags and desiccants are disposed.

Compatibility assessment

Boards are inspected to ensure compatibility with the proposed cleaning process. This includes evaluating temperature ratings, moisture sensitivity, and board density.

Pre-wash

Particulate matter is removed by manually scrubbing the board with a coarse brush, using a deionized water and Kyzen Cybersolve solution.

Cleaning

Technical Devices NuClean PolySMT 318XL in-line aqueous cleaner is used for its efficiency and effectiveness. Extremely clean (17.5 Mega-ohm) deionized (DI) water is supplied to the cleaner. The DI supply water is heated to 130ºF. The assemblies are put through the cleaner with a conveyer speed of 2 feet per minute. Kyzen Aquanox A4520 cleaning fluid is used in the wash stages of the cleaning cycle. This cleaning agent is safe for use on yellow metals, aluminum, ferrous metals, composites, and various plastic materials (including Teflon and PVDF).

Inspection/validation

100% visual inspection for cleanliness is performed per IPC-A-610-D class 3 inspection criteria. Resistivity of Solvent Extract (ROSE) testing (Bulk Ionics) is also

continued on page 9

Cut here and save!

Tech Tips...

Vendor Qualification Checklist

Utilization of a vendor qualification checklist as part of your vendor qualification procedure is a simple way to ensure that design criteria and manufacturer capabilities are properly addressed. The vendor qualification checklist should include, but is not limited to, the following:

1. Company and site information

- Is the company ISO9000 certified?
- What is the company's organizational structure?
- Site description
- Manufacturing history
  This information may be needed to meet contractual obligations and to help justify the selection of a manufacturer. It should also provide chain of command and reporting structure, workforce capabilities, and facility size.

2. Accreditations and standards certifications

- Is the manufacturer certified for the type of board that is going to be produced?
- IPC Standards
- Mil Standards
- Industry accreditations and awards
  What product class is your end-product required to meet? Is the fabricator capable of manufacturing to that class, as set by specific standards?

3. Process and product capabilities

- Process capabilities
- Panel size limits
- Board size limits
- Line width and spacing capability
- Aspect ratios
- Hole size limit
- Lamination methods
- Surface finish types
- Data transmission requirements
- Process precision
  Along with manufacturing-specific information such as conductor forming method, plating method, and image transfer process.
- PWB Testing
- PWB test methods
- Number of nets and nodes
- Probe point pitch and accuracy
- Test percentage in single pass
- Grid density and probe accuracy
- Netlist capability
- Test equipment limits for voltage, impedance

4. Product capabilities

- Multilayer layer count limit
- Via technology
- Via fill, including board thickness and hole size limit
- Number of nets
- Rigid PWB
- Rigid/Flex PWB
- Flex PWB
- PWB Materials
  Note that a process used in one material may not be appropriate or possible in others. One needs to be very specific in certain circumstances, when special processes are needed or exotic materials are being used. Also, one needs to know if certain processes are outsourced if the shop does not have the capability in-house.

5. Equipment list

The equipment information included can be useful in verifying actual capability or in determining which supplier may be a better choice.

- Quality control methods
  What control methods do they use to maintain their processes, and do they have data to substantiate?
- Quality development
- Customer reference
  Speaking with someone else who has used a particular manufacturer and has applied similar processes can help one to avoid process pitfalls.
- Delivery schedule capability
  The realistic delivery capabilities, especially when complex and special processes are being utilized, can cause disastrous consequences if rushed.

Understanding the basics of PWB fabrication and the requirements of a particular design, in conjunction with a vendor qualification checklist, will ease the selection of a PWB fabricator and reduce the need for on-site audit or vendor qualification. For more information about developing an exhaustive vendor qualification checklist for your unique needs, please contact the EMPF Helpline at (610) 362-1320.

Author of article: *Ivers Keller* – Ivers is a Technician/ Instructor at ACI. Comments or questions pertaining to this article can be sent to ikeller@aciusa.org.

SEAL Delivery Vehicle (SDV) Battery Project

The new energy storage system – MK8 MOD1 SEAL Delivery Vehicle (SDV) – was one of more than one hundred projects reviewed at the recent Joint Defense Manufacturing Technology Panel (JDMTP). The technical review panel examined projects for many criteria, including “jointness”, or opportunities for teaming.

The JDMTP works to gain insight that will:

1. Aid the joint planning process
2. Identify progress in promoting jointness in project planning and execution
3. Identify Defense Technology Objectives and measure progress towards stated goals and objectives
4. Identify levels of effectiveness in program execution
5. Provide feedback to project engineers and JDMTP Principals

Technical issue

Navy SEALs currently need more than 36 hours to recharge the silver zinc (AgZn) energy storage system for the SDV, which does not support their mission turnaround time of 12 hours. To accomplish mission turnaround, they currently deploy with two to three AgZn battery sets to support each SDV, so that a fully charged battery system remains available. The primary insertion platform for the SDV is the Dry Deck Shelter (DDS) configured SSN. The DDS is an extremely cramped and humid environment for opening battery canisters during battery removal and installation. Additionally, the batteries have to be passed through numerous hatches and ladder-wells between the vehicle and the charging station. There are 24 battery trays per AgZn system, weighing 53 pounds each. Throughout the handling process, personnel must wear Personal Protective Equipment (PPE) and keep the batteries upright to protect from electrolyte exposure. AgZn batteries cannot be charged in place, and batteries must be fully charged prior to all missions. The current process involves over 46 man hours to charge, remove, and install over 2,500 pounds of AgZn batteries. The project’s primary goals are to retain mission turnaround time while increasing capability and safety at a decreased life cycle cost (Table 4-1).

Technical solution

The solution is to use lithium-ion battery technology. The lithium-ion energy system has a charge-in-place feature that requires less than 12 hours to recharge. This is possible because lithium-ion (Li-ion) technology can be driven at higher charge rates, whereas AgZn has no more than a C/20 charge rate. AgZn also requires a balance charge every cycle and gas handling.

Requirements	AgZn Baseline	Target	Requirements
Energy storage	60 kWh	75 kWh	104 kWh
Mission turn	36 hr	24 hr max	12-14 hr
Recharging	Removal	Charge-in-place	Charge-in-place
Single point failure	Single series string	Redundant parallel	10 parallel strings
Orientation	Sensitive	Insensitive	Insensitive

Table 4-1

Figure 4-1 – 36V 9 cell module with monitoring electronics

Figure 4-2 – 6061 T6 Aluminum underwater container for modules

The AgZn batteries have a rated capacity of 60 kWh. It is higher during initial discharges but lower towards the end of life. These batteries require a balance at every charge and teardown during deployments to support turnaround requirements. The Li-ion battery has an expected capacity of 100 kWh and a uniform fade rate. The AgZn energy system of the MK8 MOD1 SDV has single point failure, having only a single series string. This means that if one cell on the string shorts or opens, the boat will have no power.

continued on page 9

SEAL Delivery Vehicle (SDV) Battery Project

(continued from page 8)

In the event of string failure, the higher Li-ion cell voltage with 10 parallel strings facilitates a redundant capability to continue mission execution at a slightly reduced capability. The Li-ion cells are very low maintenance. The AgZn batteries require balancing every cycle, whereas, the Li-ion system only needs cell capacity balancing after 100 cycles. The Li-ion cells require no activation, clean-up, or purge, and the cells arrive activated and ready for charge.

Benefits

Following are the immediate tangible benefits of the new Li-ion technology:

1. Extended battery cycle-life – 17 times (plus) that of the existing AgZn battery
2. A one-time installation of a Li-ion battery system during Fiscal Year ’08/ ’09 matches ideally with the expected service-life of the MK8 MOD1 SDV (Fiscal Year ’15).
3. Elimination of separate storage areas for non-activated AgZn and electrolyte
4. Elimination of chilled areas for wet activated AgZn batteries
5. Reduced life cycle costs (mainly associated with maintenance)
6. Significant reduction in man hours.

Transition

The JDMTP considers the final customer and their involvement in transition planning, questioning whether funding sources have been identified for transition (i.e., qualification). The SDV teams are the final customer, and in-water testing is ongoing (November 2005 through November 2006) at NSWC Panama City. The prototype Li-ion system has been installed in the MK8 MOD1 SDV prototype and is undergoing rigorous evaluation. Transition to SDV Li-ion is a top priority of Naval Special Warfare (NSW), and it is a planned NSW POM ’08 submission to USSOCOM for possible acquisition during Fiscal Year ’08-’09, for a complete SDV fleet retrofit. The transition is a form, fit, and function replacement, which will be transparent to the user.

Jointness

The JDMTP categorizes a program based on whether it is jointly funded, whether it has implementations benefiting more than one service, or whether it is managed with joint decision-making. The project may also be of interest or potential benefit to more than one service. The SDV Battery Project is service-specific but has a technology that is beneficial to all of the services. Some other systems that Saft America, the vendor of the program, is working on include a Navy Unmanned Aerial Vehicle (UAV), the Army Improved Target Acquisition System (ITAS), and an Air Force Autonomous Underwater Vehicle (AUV). Any other system that requires a high energy density battery system will benefit. Information is being shared with other Navy activities such as NAVSEA, PEO LMW, PMS 403 (UUV). They are looking at what this program has accomplished, for possible integration into large diameter Unmanned Undersea Vehicles (UUVs) which are close to the size of the SDV.

Leveraging

Leveraging is an important aspect, and the ONR and USSOCOM (PMS-NSW) have each contributed to the program. Saft America has also contributed internal engineering dollars and hours towards the program. The project participants are USSOCOM, PMS NSW, NSWC Crane, NSWC Panama City, the EMPF, and Saft America.

Author of article: *Anthony Vigliotti* – Anthony is a Materials Engineer at ACI. Comments or questions pertaining to this article can be sent to avigliotti@aciusa.org.

Cleaning PCBs Exposed to High Humidity and Storm Damage

(continued from page 6)

performed in accordance with IPC J-STD-001. Assemblies pass the cleanliness inspection when they contain less than 1.56 micro grams/cm^2 of sodium chloride equivalent, unless otherwise noted. This specification applies mainly to assemblies. Components, connectors, wire harnesses, etc., are not required to meet this specification.

Drying/baking

Baking is performed in an air circulating oven or other thermal chamber at 60ºC for eight hours.

Shipping

Board lots are marked as “cleaned” and placed into new static resistant packaging with a desiccant to prevent moisture absorption.

The results have shown that execution of these cleaning processes can produce an effective revival for boards that would surely be rendered inoperable otherwise. The key to this successful effort has been well thought out planning, quick response, an efficient cleaning process, and the ability to validate board cleanliness.

Author of article: *Blaine Partee* – Blaine is an Engineer at ACI. Comments or questions pertaining to this article can be sent to bpartee@aciusa.org.

Manufacturer's Corner

JBC Advanced Series Soldering Irons

With the impending ban on lead-containing solder alloys and the industry already transitioning to lead-free, great attention has been given to implementation of lead-free technology in nearly every step of the electronics design and production process. The industry's main research organizations have plotted transition schemes, and production equipment manufacturers have shown the ability to adapt equipment to new lead-free alloys.

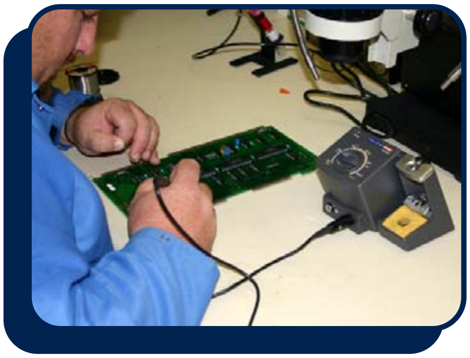

Figure 5-1 – JBC Advanced Series soldering iron in use at the EMPF

Figure 5-2 – JBC Advanced Series soldering iron

In the search for lead-free alternatives, few have chosen an alloy with a lower or similar melting point to standard SnPb (tin lead) solder. Alternative alloy selection is usually driven by the cost of the alloy, susceptibility to corrosion, and wetting characteristics. With the exception of solders containing Bismuth or Indium, most lead-free solders have a melting point of roughly 20-40ºC higher than eutectic SnPb (183ºC). Within their respective fields of application, and as far as limited experience has proven, these alternative alloys present generally acceptable characteristics in cost, availability, mechanical properties, and process compatibility, etc.

Nevertheless, these alternative alloys do not provide a ready-made solution. The wetting of standard lead-containing solder is still far superior to any of its alternatives. Because of this, more active flux must be used to compensate. In addition, higher lead-free solder melting temperatures drastically reduce the window between soldermelt and PCB/component damage. As a rule of thumb, temperature-sensitive components can withstand a maximum of 240ºC, which is dangerously close to the melting points of the alternative solders. In addition, a component can only be exposed to its maximum rated temperature for roughly 10 seconds.

In a standard SnPb solder procedure, the most common PCB base materials like FR3 and FR4 are under stress because of their low glass transition temperature of approximately Tg = 130ºC. A rapid process is necessary to avoid twisting, warping, outgassing, and delamination. Because of the increased cost of alternatives with a higher Tg, these standard base materials must also be used with lead-free solders. The stress on the materials will be significantly increased due to the higher lead-free solder melting temperatures.

All of these characteristics can combine to create drastically reduced lifespan for soldertips or cartridges in soldering irons and hot tweezers. There can also be a significant increase in scrapboard production if measures are not taken before changing to lead free solder alloys.

continued on page 11

Manufacturer's Corner

JBC Advanced Series Soldering Irons

(continued from page 10)

For hand soldering and rework, the many differences between the technologies lead to one specific conclusion – the process requires an iron with a superior temperature recovery and, therefore, the ability to maintain the selected tip temperature as closely as possible, even when the thermal load is significant. The initial warm-up time of the tip from room temperature to 350ºC can be used as an indicator of the iron's ability to recover.

A traditional iron with a warm-up time of 90 seconds is considered to have great inertia and slow reaction. It reacts slowly in two ways: 1) When the tip touches the solder joint, it transmits its heat to the joint and loses heat; 2) For the temperature sensor to make the power supply react to this change and correct the temperature, significant time is needed due to the bulky construction of the tip and the separation of the sensor and heating element. When the power supply reacts and the heating element begins warming up to correct the tip temperature, the inertia makes it impossible to do this in an acceptable time span.

By now, the solder tip's temperature will have dropped approximately 70ºC. If the starting temperature was chosen on the safe side (i.e., 320ºC), the iron will be at 250ºC – a temperature at which the soldering process is slow and cold solder joints are common. To prevent this from happening, the temperature will usually be set higher – up to 400ºC or even 450ºC. The lifespan of a soldering tip or cartridge depends directly on the temperatures it is exposed to. At these high temperatures, the solder tip or cartridge will have a drastically reduced lifespan. This boosts the cost of ownership of a soldering station to a critical level for any process, and to an outright unacceptable level for lead-free processes.

Fortunately, after decades of use, the traditional soldering iron has been improved upon. The average warm-up time has been reduced to roughly ten seconds for new irons. The Advanced Series by JBC features irons that heat up in only two seconds. An iron this quick enables low temperature soldering without the risk of cold solder joints. For lead-free hand soldering, it will provide sufficient heat to a solder joint by speeding up the soldering process, while also reducing twisting, warping, outgassing, and delamination of printed circuit boards (PCBs).

Another new feature of soldering irons is that they can be idled down to a "sleep" temperature after replacement into the holding stand. This saves the iron's cartridge from corrosion, because it will be at working temperature only when necessary. For a demonstration of the JBC Advanced Series soldering station, please contact Jeff Stong at (610) 362-1200, extension 224 or jstong@aciusa.org.

Author of article: *Jeff Stong* – Jeff is the Equipment Advisory Board Coordinator at ACI. Comments or questions pertaining to this article can be sent to jstong@aciusa.org.

The EMPFasis is converting from hard copy to digital format

In an effort to minimize the amount of paper that comes into your office, the EMPFasis is now available in digital format only. Be sure to visit http://www.empf.org/subscribe as soon as possible to sign up, so that you'll continue to receive the EMPFasis without interruption. Once signed up, you'll begin receiving the newsletter by email each month. Current and back issues will also continue to be available for download in PDF format at http://www.empf.org/empfasis.

EMLC Upcoming Course Schedule 2006

Skills

BGA Manufacturing, Inspection & Rework
January 30-31
February 22-23

Chip Scale Manufacturing
February 28 - March 2
June 27-29

Electronics Manufacturing

Boot Camp A
January 23-27
March 20-24

Boot Camp B
January 30 - February 3
March 27-31

Certifications

IPC J-STD-001 Instructor Certification
January 9-13
February 13-17

IPC-A-610 Instructor Certification
January 23-27
February 27 - March 3

IPC Challenge
January 11
March 22

WHMA-A-620 Wire Harness Manufacturing (Operator)
March 14-16
June 27-29

IPC-7711 Certified IPC Specialist (CIS) SMT Rework
March 6-10

J-STD-001 Instructor Recertification
January 12-13
February 23-24

IPC-A-610 Instructor Recertification
January 9-10
February 21-22

IPC-7711/7721 Certified IPC Specialist (CIS) SMT Rework and Circuit Repair
February 13-17
May 8-12

IPC-7721 Certified IPC Specialist (CIS) Circuit Repair
January 12-13
May 18-19

IPC-7721 Certified IPC Specialist (CIS) Repair and Modification of PCBs
February 7-10
May 2-5

Continuing Professional Advancement in Electronics Manufacturing

Lead-Free Manufacturing
January 17-18
February 23-24
March 14-15

Design for Manufacturability
January 19-20
February 8-9

Failure Analysis and Reliability Testing
January 18-20
March 7-9

For more information, please call (610) 362-1320 or e-mail: registrar@empf.org

For a complete course schedule, visit: http://www.empf.org/html/empfasis/emlcupcoming.pdf

issue: End of Year
Special Edition-05

Empfasis is a publication of the
American Competitiveness Institute and the EMPF
The EMPF is the U.S. Navy's National Center of Excellence dedicated to advancing the state-of-the-art in electronics and increasing domestic productivity in electronics manufacturing.

WEBSITE: www.empf.org
HELPLINE: (610) 362-1320
(610) 362-1200 • FAX: (610) 362-1290
Philadelphia, PA 19113
Suite 600
One International Plaza
American Competitiveness Institute