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BEST MANUFACTURING PRACTICES

REPORT OF SURVEY
CONDUCTED AT

GENERAL DYNAMICS
POMONA DIVISION
POMONA, CA

AUGUST 1986

BMP

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The purpose of the Best Manufacturing Practices (BMP) survey conducted at this facility was to identify their best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout the U.S. industrial base. The actual exchange of detailed data will be between contractors at their discretion. A company point of contact is listed in the report

The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

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GENERAL DYNAMICS

POMONA DIVISION

POMONA, CA

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I. INTRODUCTION

A. Scope

The purpose of the Best Manufacturing Practices (BMP) Review conducted at General Dynamics Pomona Division (GD) was to identify best practices, review manufacturing problems and document the results. The intent is to extend the use of high technology equipment and processes throughout industry. The ultimate goal is to strengthen the U.S. industrial base, solve manufacturing problems, improve quality and reliability, and reduce the cost of defense systems.

To accomplish this, a team of Navy engineers reviewed GD's Pomona Division to identify the most advanced manufacturing processes and techniques used in that facility. Manufacturing problems that had the potential of being industry wide problems were also reviewed and documented for further investigation in future BMP reviews. Demonstrated industry wide problems will be submitted to the Navy's Electronics Manufacturing Productivity Facility for investigation of alternatives to resolve the problems.

The review was conducted at the GD Pomona Division in Pomona, California on 12-15 August 1986 by a team of Navy personnel identified on page 2 of this report. GD Pomona is primarily engaged in the development and production of the Standard Missile and the Phalanx Close-In Weapon System. The Sparrow Missile, which is manufactured at Pomona's Camden, Arkansas facility, was not included in this review.

Based on the results of BMP reviews, a baseline is being established from which a data base will be developed to track best practices and manufacturing problems. The information gathered will be available for dissemination through an easily accessible central computer. The actual exchange of detailed data will be between contractors at their discretion.

The results of this review should not be used to rate GD Pomona among other defense electronics contractors. A contractor's willingness to participate in the BMP program and the results of a survey have no bearing on one contractor's performance over another. The documentation in this report and other BMP reports is not intended to be all inclusive of a contractor's best practices or problems. Only selected non-proprietary practices are reviewed and documented by the BMP survey team.

B. Review Process

This review was performed under the general survey plan guidelines established by The Department of the Navy. The review concentrated on three major functional areas: management, design engineering and manufacturing. GD Pomona identified potential best practices and potential industry wide problems. These practices and problems, and other areas of interest identified were discussed, reviewed and documented for dissemination throughout the U.S. industrial base.

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II. SUMMARY

The Best Manufacturing Practices Survey Team evaluated the management, design and manufacturing functions. Areas reviewed included the contractor's management policies and procedures, modernization plans, transition planning, design and production engineering, material procurement, receiving inspection, facilities, equipment, test equipment, quality assurance, material handling, inventory control, manufacturing technology and vendor selection and control.

The format for this survey consisted of formal briefings and discussions on best practices and problems. Time was spent on the factory floor reviewing practices, processes and equipment. In-depth discussions were conducted with GD Pomona personnel to document some of the practices and problems identified.

GD Pomona is in the initial phase of modernization. New equipment and processes are being installed and implemented in selected areas of the plant. In several areas, new methods have been identified but not yet installed into their operation.

Comprehensive programs have been implemented to more effectively manage vendor supplied parts and material, improve the quality of engineering and productivity, train both the professional and non-professional work force, and solicit employee participation in quality/productivity team efforts. GD Pomona has also taken steps to comply with the guidelines of DoD 4245.7M, "Transition From Development to Production" manual. This has resulted in improvements in design engineering and manufacturing.

GD Pomona has developed and is using an automatic axial lead solder coating system in a production mode. They have also applied the use of automated visual inspection systems in their operation. These automated features coupled with real time radiography, the use of robots, group technology and laser machining are positive steps toward modernization and improved quality and productivity.

A philosophy has been adopted by GD Pomona to become more automated in order to compete in the machining industry. A tour of its machining facility showed that GD Pomona is achieving that goal. Conventional/manual machines are being replaced by numerically controlled and computer numerically controlled machines and machining centers.

The best manufacturing practices and problems identified at GD Pomona will be evaluated and reviewed by the Navy team during future BMP surveys. Those practices identified as being among the best in the electronics industry will be documented in a central data base for dissemination throughout the industrial base. The industry wide problems will be investigated by the Navy in an effort to develop alternatives for their resolution.

III. BEST PRACTICES

The practices listed in this section are those identified by the Navy BMP survey team as having the potential of being among the best in the electronics industry. This judgment is based on experience from previous BMP surveys and expertise gained by team members through years of working relationships with industry.

A. Management

PRODUCTION QUALITY IMPROVEMENT PROGRAM

The Production Quality Improvement Program (PQIP) utilizes a team concept in addressing production problems. The teams are carefully structured, and the members are specially trained for the job. The first-line supervisor is usually the team leader. He/she organizes and leads the meetings, coordinates supporting resources, and is the spokesperson for the team at management presentations. The team leader is assisted by a "coach" who has been trained in group behavior and problem analysis techniques. Each PQIP team has been trained in quality improvement techniques and problem solving skills to effectively deal with production problems.

The primary input to the system is the "Top 10" Problem Parts Report, which is issued monthly in each cost center and gives the last six months' scrap and rework cost data for the center. The problems to investigate are taken from this report, which also shows the cost reduction goal and performance over a six-month period. In addition, each team monitors their cost center defects on a daily basis, with reduction goals established.

PRODUCTIVITY/QUALITY IMPROVEMENT PROGRAM

The Productivity/Quality Improvement Program (P/QIP) is a quality circles type program which is concerned specifically with improving administrative/white collar areas. There are currently eleven process teams. Each process team consists of a management team and four or five employee teams. The management teams consist of department heads and directors who have participated in two days of off-site training. The employee teams assist the management teams in the various phases of the projects. The teams look at the way the work flows through their area and the tasks that they perform. They question whether they are doing things right and doing the right things. They look at the ways they currently accomplish tasks and consider better ways to accomplish them.

A P/QIP study may look at whether a manual operation (e.g., making ledger entries) would be better done with a computer or whether cost analysts would work more efficiently if they were all located in the same area rather than scattered around the plant.

PRODUCT QUALITY VERIFICATION

Product Quality Verification (PQV) is a self imposed program developed to evaluate production quality, related processes and documentation through disassembly and workmanship assessment of accepted production. This program is similar to the Navy's Tear-Down Program, except that it is conducted by the contractor for his benefit.

The PQV team consists of representatives from the product program office, production engineering, quality assurance, and Navy Plant Representative Office (NAVPRO) quality assurance. The program quality representative is the team leader. A bonded, dedicated area with the required equipment is provided by the program office. PQV is currently implemented on the Standard Missile Program (twice a year) and on Phalanx (once a year). PQV finding are documented by the team and reviewed by the Program Quality Assurance Manager (PQAM) and the NAVPRO quality assurance counterpart. All findings classified as high mission impact are immediately reported to the PQAM, the NAVPRO QA, the Division Director of quality assurance, the product line director, and the program director. All other findings are reported at regularly scheduled meetings.

Corrective action statements are included in the final PQV report. Corrective actions are completed in a timely, effective and verifiable fashion. The PQAM has review and approval authority on corrective action responses. The hardware is reassembled, tested and accepted for delivery to the customer after the PQV is completed.

The entire PQV tear-down process is considered an internal effort with no outside reports to government agencies or officials, except as determined to be appropriate by individual GD program directors. The PQV concept has been implemented at the GD supplier/ subcontractor level with success. GD assists it's suppliers in developing similar programs appropriate for their product(s) and organizations.

CERTIFIED OPERATOR PROGRAM

The Certified Operator Program (COP) allows certified production employees who have a record of high quality and performance to inspect the operations they perform. The candidates are recommended by their supervisors and approved by Quality Control. They are selected based on their experience, performance, quality record, attendance, attitude, and required certification. The employees are trained both in the quality aspects of the operations they perform and in the techniques needed to inspect these operations.

Quality Control randomly selects samples of COP completed and self-inspected work on a scheduled basis to check on the operators' continued competent performance. COP operators are decertified and their stamps recalled if they fail to maintain high quality performance.

AUTOMATED CALIBRATION SYSTEM

GD is halfway through phase I of a five phase project whose goal is to implement an automated calibration system. The approach is to network an HP A900 host CPU to satellite systems. Following calibration systems development, one trial area will be used to close out phase I.

By mid-1987, the effectiveness of this system will be known. It is anticipated that the approach will prove to be effective. Multiyear savings should be substantial.

The configuration will allow for expansion and reconfiguration. The calibration systems controlled by the satellites will be equipped with test instruments which will have accuracies and ranges capable of calibrating most of the instruments from the respective workstations.

VOCATIONAL INDUSTRIAL CLUBS OF AMERICA

General Dynamics is actively involved in the "Vocational Industrial Clubs of America" (VICA) Program. This is an international program that has its U.S. headquarters in Leesburg, VA with branches in fifty states. This activity has been referred to as an "Industrial 4-H Club" with some justification. As with all corporations, GD participates in VICA in conjunction with high schools and junior colleges that have vocational school programs. The students become actively involved in various ways, the most visible of which is by participating in local/regional competitions and progressing to national and international competitions based on the individual "finishes" achieved. GD feels that the VICA involvement of individuals, along with their vocational schooling, does much toward instilling good personal traits and work habits in a person, which will make that person a better employee. GD has experienced that VICA membership helps to prepare the individual to enter the "mainstream of employment" with few problems or complications.

SPECIALIZED TRAINING AND CERTIFICATION

GD provides specialized training to insure that employees possess the skills to perform specialized tasks. The extensive training program covers just about everything. There are approximately 125 courses, which include shop skills and related subjects, safety, computer science, supervisory skills, oral and written communications, etc. Before working on hardware, GD requires that the employee be certified for the operation(s) to be performed. In some cases; e.g. soldering, certification of special training may be required by contract. Certification involves classroom/practical training and passing written/practical testing. There is a Process Certification Board, composed of representatives from Production, Quality Assurance, and Industrial Relations, which determines certification requirements.

B. Design

COMPUTER AIDED DESIGN (CAD)

GD uses computer aided design as an integral part of the design engineering process. Application areas include:

- o Mechanical Design and NC Programming
  - IBM 3083 mainframe
  - CATIA/CADAM software
- o Electronic Design
  - Xerox CAE workstations with digital simulation
  - Expert and Aquarius software
- o Circuit Card Packaging
  - VAX 11/780 mainframe
  - SCICARDS software
- o IC Design
  - Apollo Workstation
  - VLSI technology (VTI) software

Their approach to CAD is to specify and procure hardware and software systems that optimize the application areas. Thus, four different systems exist instead of one system. All four systems, however, are being networked together for transfer of data.

Through mechanical design and NC programming, NC programs can be checked out at the graphics workstation to a high degree of reliability before they are transferred to the NC machine. GD also has digital simulation capability through their electronic design equipment.

Processing guidelines are incorporated and design parameters/coordinates can be down-loaded to Excellon drilling machines and component insertion equipment using circuit card design packaging automation. GD has been very successful in using Apollo workstations to generate testing programs for IC design.

INTEGRATED CIRCUIT FABRICATION AND TEST

A semiconductor fabrication and test facility configured to supply fully tested Complementary Metal Oxide Semiconductors (CMOS) circuits has been established by Pomona Division. Processing capabilities in this facility include separate high-voltage (400 KeV) and medium circuit ion implantation; thermal processing, including diffusion, oxide growth, and annealing; low-pressure chemical vapor deposition and plasma-enhanced chemical vapor deposition; wet chemical and plasma etching, semiautomated photolithography capability including proximity exposure; and aluminum deposition. In process testing is performed using a computer-controlled parametric test system, while final wafer testing is done with an Accutest 7900 test station. With this system, circuits can be tested at speeds up to 50 MHz.

The IC fabrication and test facility performs its design on Apollo workstations using Very-Large-Scale-Integrated (VLSI) technology software. The IC testing is also derived from the same software. The facility staff is maintaining a current knowledge of developments in Very-High-Speed-Integrated-Circuit (VHSIC) technologies. Metal gate CMOS logic cell array devices have been fabricated and are being used in production. Development of a 3- to 5-micron silicon gate CMOS is currently underway to meet the density requirements of VLSI circuits.

C. Manufacturing

COMPONENT EVALUATION AND RELIABILITY TEST PROGRAM

The Component Evaluation and Reliability Test (CERT) Program was first implemented by GD Pomona in the mid 1960's for passive and active discrete electronic devices and microelectronic devices. In 1972 the program was augmented with a stress screening discipline.

The primary objective of CERT is to combine the aggregate experiences of four GD divisions into a unified force that identifies substandard material, provides global feedback and corrective action for responsible suppliers, and increases GD's overall quality of electronic components.

Devices received at a CERT center are tested in accordance with the requirements of the using division. The tests include:

- Temperature Cycling (25 cycles)
- Particle Impact Noise Detection (PIND)
- Electrical Testing
- Operational Life Testing
- Temperature Coefficent Testing

Substandard material is returned to the supplier.

The data resulting from all of the tests conducted is shared real time between each division on a computerized data communication network. CERT is used to flow-down lessons learned and provide assistance to suppliers. This program enhances supplier device quality through the sharing of data and periodic visits to supplier executive management.

ENGINEERING QUALITY IMPROVEMENT PROGRAM

An Engineering Quality Improvement Program was developed by GD Pomona to satisfy the need for engineering disciplines required for high quality products. Engineering disciplines were derived from DoD 4245.7M "Transition From Development to Production" design templates. These disciplines were further detailed in GD's "Engineering Management Instruction" and incorporated in the plans of each engineering development program. The application of these templates is the responsibility of the chief engineer of the program, who monitors their application and cost.

A training program was designed to give a broad background in engineering quality (derived from DoD 4225.7M). All engineers and management personnel participated in the program. Training was established at 20 hours per person. Although the seminars proceeded in many different directions, the main theme of designing with quality was maintained and determined beneficial. The success of the program has not been quantified; however, GD has launched similar training activities at its eight other defense production divisions.

REAL TIME PROCESS CONTROL OF AUTOMATED COPPER PLATING

GD is planning to replace its existing copper plating line with one which is pushing the state of the art. The system will be completely computer controlled. The operator will load the parts and then enter the part number into the computer, which will determine the optimum path (cycle time, current density) for the required bath conditions (copper content, pH, temperature). The computer will continuously monitor bath conditions in real time and effect automatic bath replenishment and temperature adjustment. Bath parameters will be maintained continuously within tighter limits, which should result in higher quality and more consistent coatings.

The system will include an in-line method for stripping the copper plating from the racks which carry the boards through the baths. The old method used nitric acid which released an environmentally unacceptable brown cloud of nitrogen oxides. The new method uses a sulfuric acid-hydrogen peroxide mixture which does not release hazardous volatiles. Another important aspect of the system is its environmental impact. The system will utilize non-sludging metal removal resulting in zero discharge. The effluent will be of better quality than the water entering the system.

The system will improve process controls and reduce support labor. It is expected to be installed in December 1987 and be operational in June 1988.

WATER BASE PHOTO RESIST MATERIAL

Dupont, the supplier of the photo etch resist material used in the production of copper clad printed wiring boards, has introduced a totally aqueous base material which has reduced chemical costs and waste water treatment requirements. The previous material (Riston 218R) needed butyl carbitol to remove the uncured resist, while the new materials (Riston 3813 for 1.3 mil resist and Riston 3620 for 2 mil resist) use baking soda to remove the uncured resist. Butyl carbitol required chemical treatment before it could be discharged into the environment. However, baking soda (sodium bicarbonate) is a mildly caustic, completely biodegradable material available in a low cost bulk form. It does not require chemical treatment before being discharged into the environment, saving the cost of this treatment.

The PWB shop is also planning to switch from Riston 210R to Riston 3113 for stripline or microwave boards (1 mil resist), which will make all processes totally aqueous.

REAL TIME RADIOGRAPHY OF INNER LAYERS OF FLEX-HARNESS

During the fabrication of multilayer printed wiring boards and flex harnesses, it is necessary to insure that breakout does not occur when drilling through-holes and that the layer-to-layer registration is compliant with the master drawing and MIL-P-55110. At present these requirements are verified by microsection, which may take up to two days to complete. For expediency and process control in manufacture of a PWB lot, GD Pomona has used the first article inspection technique to verify these parameters prior to building the entire lot. Their previous method utilized a radiographic film technique to examine the first article sample. This method required an inspection time of about 25 minutes and materials (film and chemicals) for each lot of PWBs manufactured.

GD Pomona has recently implemented the use of a new and improved method for accomplishing this task based on the use of a real-time x-ray imaging system. This system is located in the PWB fabrication area adjacent to the drilling equipment. First article samples are placed on the system for inspection and the real-time x-ray image is viewed on the system video monitor. Enhancement of gray scale levels with a color synthesizer built into the system allows the operator to discern between the various layers of the PWB for inspection purposes. The use of this system has eliminated material costs and reduced inspection times to three minutes per lot for the 140 to 160 lots per month manufactured at the GD Pomona facility. The system currently in use is manufactured by the X-Ray Instruments Division of Nicolet Instrument Corporation of Madison, WI, (608) 271-3333, and is their Model PC-1.

PARTS MEASUREMENT SYSTEM

GD Pomona has incorporated the use of non-contact measuring systems in several areas of production. The systems in use currently are a vast improvement over the previously used manual methods and have resulted in cost savings in labor as well as an increase in product yields of up to 30%.

The Model 1200 system by View Engineering of Semi Valley, CA, (805) 522-8439, is used to measure piece part dimensions using a menu driven computer based control unit in conjunction with a video processor to make measurements with 20 millionths of an inch accuracy in an average time of about 105 milliseconds. This method replaced a manual method using a hand comparator and microscope which took on the average of 20 minutes per part to perform an inspection and reduced the inspection time to about 15 seconds per part. Although the system was initially procured for harness and PWB inspection, applications of this method continue to expand. The system is interfaceable with CAE systems via one IEEE-488 and four RB-232C interfaces.

Inspection of PWB artwork for dimensional characteristics and flaws is accomplished using a combination of units by Operations Technology Incorporated. An image of the artwork is projected onto a screen using their model Optek-102. Flaws in the emulsion are readily identified by an inspector. Dimensional characteristics of the artwork are measured from the projected image using their model CM-80 coordinate measuring digital readout. Since the incorporation of this system, overall quality yields have improved by about 30% due to virtual elimination of circuit problems resulting from defective artwork. This has resulted in cost savings from a corresponding reduction in labor and scrap.

AUTOMATIC AXIAL LEAD SOLDER COATING SYSTEM

GD Pomona has designed and developed a system which solder coats axial lead parts. The significant thing is that these parts are on reels. Simply, the approach is to load the reel, strip tape off the bottom lead, pre-clean and flux the leads, pre-tin, final clean and reload the reel. This reel is then moved to another system which aligns, spaces and retapes the pre-tinned leads. The reel is inverted, and loaded on the axial lead solder coating system. The opposite lead is then "pre-tinned" aligned and retaped. This machine will process 4,000 parts per hour.

The solder coating system has reduced labor and increased quality and reliability. Using this system, three operators on two shifts solder coated 1.1 million components in less than one month. To solder-coat this number of components by hand, using the old manual method, would have required 22 operators on two shifts. GD Pomona has licensed Unique Industries of Sun Valley, California to produce and market a similar automatic axial solder coating system.

MICROELECTRONICS 80-PIN EXPRESS LINE

In another area of automation/modernization, GD Pomona has identified and construction has started on the installation of a product line designated to handle the hybrid microelectronic assemblies in the 80-pin configuration. This line will utilize an automatic die attach system and an automatic wire bonder along with manual assembly support equipment. A video inspection station will provide real time feedback of visual quality to the pick-and-place station. The operation of this line will be in a semi "just-in-time". mode, with limited work-in-process and minimum throughput time, and will utilize multifunction operators. The success of this line will determine whether the plans to establish a 19-pin and a 43-pin line are implemented.

The BMP survey team has not observed a just-in-time operation of this magnitude in the microelectronics industry.

LEAD STRAIGHTENING

Insertion of DIP's using automated equipment is driven by the quality of the lead straightness which is severely affected by handling, such as occurs during pre-tinning operations. GD has applied the use of automatic straightening equipment prior to automatic insertion of DIP's. Use of this equipment minimizes problems with bent leads causing components not to insert. First time yields from auto insertion has increased significantly.

AUTOMATED INSPECTION

There are several examples of equipment that GD Pomona has installed in the PWB fabrication area with the purpose of reducing costs. Labor and material input have been reduced substantially by changing from manual to automatic inspection techniques.

The Automatic Non-Contact Dimensional Inspection System, View-1200, manufactured by View Engineering of Semi Valley, California, replaced three pieces of equipment and reduced inspection time from 20-25 minutes per part to 15 seconds per part. Payback time was eight months. This system is used to measure critical dimensions on printed wiring boards; e.g., hole-to-hole and trace-to-trace registration and separation, to 40 millionths of an inch accuracy. This is accomplished with an embedded computer which computes dimensions based on input from a camera and comparison to pre-selected values for the accept/reject decision. The computer controls the entire operation and can be programmed from CAD data.

The semi-automated registration validation system, Optek 102, manufactured by Operations Technology, Inc. of Blairstown, New Jersey, replaced a highly fatiguing manual inspection operation and resulted in an increase of 25% in overall quality. The system is used to inspect artwork for defects and registration prior to use based on image projection at 25X or 50X magnification. Savings have resulted from labor and scrap reduction by elimination of circuit problem after PCB fabrication.

A third area of automated inspection is in the microelectronics hybrid area and uses the Synthetic Vision Systems TFI-4000 Hybrid Substrate Inspection System. The TFI-4000 is capable of detecting process failure or drift before hundreds of flawed circuits are produced.

ROBOTIC SOLDER MASKS

GD Pomona uses a Chad Robotic Solder Masking System to apply latex-type mask material to their PWB's. Other than manual loading and unloading of the PWB's, the system was completely automatic. Data used for X-Y coordinates was directly down-loaded from their CAD system. Modifications made to the system include a frame on which the PWB is supported. The necessity for such a frame came as a result of bending and deflection of the PWB experiences when using the Chad Supplied frame. GD Pomona developed a frame to support the

PWB uniformly throughout it's entire surface. A modification in the planning stage is to replace the mask material reservoir, which is currently under the machine and fed to the end-effect via a long tube, with a top-mount smaller reservoir closer to the end-effect. The advantage to this is less waste when masking in very small lots. A problem associated with the robotic solder masking system is the lack of consistency in the viscosity of mask material by the supplier.

GROUP TECHNOLOGY

GD Pomona makes excellent use of Group Technology (GT) in at least one area. They have set up a GT cell for all rotational parts under 3/4 inch in diameter. The cell consists of two milling machines (one vertical and one horizontal), sixteen screw machines, three chuckers and eight drill presses. Total floor space is approximately 4,000 square feet. Typical batch sizes are 100 to 2,000 parts.

It is significant to note that while the average realization factors for the entire machining area is 65-70%, the GT cell achieves 100-120% realization. Obviously, this represents a substantial improvement.

LASER MACHINING

The LASERDYNE 780 Machining Center was purchased to eliminate the problems encountered in (KEVLAR) launch tube machining such as fraying, delaminating, degradation of surface integrity, and long cycle times. Since then the system has been used for a variety of parts made from stainless steel, rubber, foam, KAPTON, aluminum, cobalt, and others.

The easily programmable system is quick, accurate and does not suffer from tool wear. Like most programmable systems, it brings GD Pomona capabilities that they weren't anticipating, such as the ability to quickly produce small quantities of washers, shims, and a variety of intricate shapes used by manufacturing engineering. But the truly impressive result of the system is its capability of producing a variety of intricate shapes from a wide range of different materials.

IV. PROBLEM AREAS

The problems discussed below were identified by GD Pomona as having the potential of being industry wide problems. The BMP survey team will collect more data on these problems from other contractors and government agencies. This data will be reviewed and those manufacturing problems considered to have an industry wide impact will be referred to the Electronics Manufacturing Productivity Facility, China Lake, California for research and resolution. Some of the problem areas may lead to the establishment of a government/industry ad hoc group to evaluate the concern and propose alternative solutions.

BONDING OF MYLAR LAYERS DURING FLEX CIRCUIT FABRICATION

There has been a continual industry wide problem with delamination of multilayer flex circuits during assembly. The processes and materials utilized in this operation have not been perfected to withstand the high temperatures used during solder operations. The resins used in the bonding adhesive systems are not controlled during formulation to the extent required for use as adhesives for bonding mylar layers and are sensitive to water absorption which causes delamination during solder operations. More research and development in this area is needed in order to more adequately define the requirements of adhesive systems.

MIL-P-55110 INSPECTION REQUIREMENTS

The mil spec requirements for PWB manufacturing are based on antiquated techniques of inspection for layer registration. Destructive microsectioning of board samples or coupons supposedly representing board lot characteristics are required for verification of various master drawing dimensions and Mil-P-55110 requirements. This method is time consuming, labor intensive, and makes use of a considerable amount of materials. By its nature, it cannot be used as a real-time process control procedure. This method, however, is the only method recognized and therefore must be used by any manufacturer listed on QPL-55110.

The use of automated inspection techniques, such as the Nicolet Model PC-1 real-time x-ray imaging system, should be allowed by Mil-P-55110. This would result in higher quality product at a lower cost.

VENDOR QUALITY CONTROL

There is an industry-wide concern about vendor quality control. Problems range from part marking permanency to age control. GD Pomona has developed guidelines to assist vendors in providing better quality assurance. As with other companies, there are some success stories, but the problem is still there. A better job of standardizing and flowing down requirements needs to be considered.

COMPONENT SOLDERABILITY

Four companies have been reviewed by the BMP survey team, and all four have identified component solderability as a problem. Each company is doing something different to address the concern depending on the type and volume of piece parts used.

GD Pomona uses a large number of axial lead components in their production operation. Until recently, they pre-tinned these parts using a labor intensive manual process similar to that used by many manufacturers. They have now developed an automated tinning system, discussed on page 11, to control solderability and reduce labor input.

Automated pre-tinning at the prime contractor level is only an interim solution. The solderability problem needs to be addressed at the vendor level to truly be resolved. However, automated equipment/processes such as the one developed by GD Pomona are a step in the right direction and something that may be employed by the vendor.

V. CONCLUSIONS

Based on the results of this BMP survey, it is apparent that GD Pomona is making strides to modernize their facility and make improvements in the management of both material and human resources. Automation seems to be a major ingredient in their formula for modernization. The BMP team observed the utilization of equipment and practices that they considered among the best in the electronics industry. Many potential best practices were also in the stages of planning or early implementation.

A large part of GD Pomona's business is in the machining area. Much of this operation has been automated reducing the need for a large number of machines and labor input. Cells of robotic material handling and machining operations have been implemented and future improvements are underway.

The Pomona Division has been successful in selected areas of productivity improvements. They are a leader in the electronics industry for pre-tinning axial lead components reel-to-reel. Several companies have been working on a method to automate this process, but GD is the only company the team is aware of that has developed automated equipment and a process that is being used in a production mode. This automated process has substantially reduced labor input while increasing quality and reliability.

The problems discussed at GD Pomona are not uncommon to the other companies surveyed. Most prime contractors are concerned about vendor quality, especially solderability of component leads. This problem is what motivated GD to invest in the development of automatic pre-tinning of axial lead components. Several new problems were also identified and discussed at GD Pomona.

As more surveys and discussions are conducted, all of the problems identified in this report and those identified in previous BMP reports will be reviewed and data will be collected to document the magnitude of the problem. Resolution of these problems may come from another company's efforts (best practice) or from research by a government activity such as the Electronics Manufacturing Productivity Facility in China Lake, California. By forming a collective government/industry position with documentation on issues and problems identified, and establishing a data base of the best practices used in industry, the chances of resolution are increased significantly.