DEPARTMENT OF THE NAVY
OFFICE OF THE ASSISTANT SECRETARY
(SHIPBUILDING AND LOGISTICS)
WASHINGTON, D.C.

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# BEST MANUFACTURING PRACTICES



REPORT OF SURVEY
CONDUCTED AT

## HONEYWELL INC.
## UNDERSEAS SYSTEMS DIVISION
## HOPKINS, MN



JANUARY 1986



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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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BEST MANUFACTURING PRACTICES

REVIEW

JANUARY 1986



HONEYWELL INC.

UNDERSEAS SYSTEMS DIVISION

HOPKINS, MN



STATEMENT "A" per Adrenne Gould
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DEPARTMENT OF THE NAVY

WASHINGTON, DC

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# I. INTRODUCTION

## A. Scope

The purpose of the Best Manufacturing Practices (BMP) Review conducted at Honeywell Inc. 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 and managers reviewed Honeywell's Underseas Systems 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 Electronic Manufacturing Productivity Facility for investigation of alternatives to resolve the problem.

The review was conducted at the Underseas Systems Division (USD) in Hopkins, Minnesota, on 21-24 January 1986 by a team of Navy personnel identified on page 2 of this report. USD is primarily engaged in the development and production of torpedoes. They have been manufacturing the Navy's lightweight, antisubmarine MK 46 torpedo since 1965 and are currently developing the MK 50 lightweight torpedo.

Based on the results of these 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.

## 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. The team observed practices and equipment used in these areas. Honeywell gave a general overview briefing of each functional area and identified their best practices and potential industry wide problems they are experiencing. These practices and problems, and other areas of interest identified were followed up by an on the factory floor review and individual meetings between Navy team members and Honeywell personnel.

The Navy team documented potential best practices which will be investigated and compared with the rest of industry. Manufacturing problems encountered by Honeywell USD were also discussed and are documented in this report.

## C. BMP REVIEW TEAM

| Team Member | Agency | Team Role |
| --- | --- | --- |
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# II. SUMMARY

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

The format for the survey consisted of a general overview of the functional areas highlighting best practices and problem areas and a plant tour on the first day. The next two days were spent reviewing in detail those areas identified. Time was spent on the factory floor reviewing practices, processes and equipment. In-depth discussions were also conducted with Honeywell personnel to document some of the practices and problems identified. Several of the Navy team members visited off site support facilities such as the Electronic Test Center which inspects all incoming vendor material.

Honeywell USD discussed their policy of keeping the lines of communication open within the division and with their suppliers and customers. Internally, USD uses various methods to communicate to their employees including briefings, bulletins and video monitors. Several systems are in place for employees to inform management of production problems, i.e. employee teams and the defect reduction program. USD has improved their communication with their vendors through their Material Quality Improvement Program, and the customer is kept informed by bi-annual reports on factory performance.

A very effective transition plan has been developed by USD. It follows the guidelines of DoD 4245.7-M, Transition from Development to Production Manual. The transition plan requires a close interface between design and production engineers from beginning to end of a project. It also requires establishment of a vendor base during the program development phase. Another unique feature of the plan is the tracking of risks against predicted values.

Honeywell maintains an Electronic Test Center (ETC) to rescreen, qualify and characterize incoming material. The center has an automated tracking, storage and retrieval system. Bar codes are used to track the product throughout the ETC. Quality concerns are discussed with vendors by knowledgeable ETC personnel giving the center another added value.

Several useful manufacturing aides have been developed by USD. They include a computerized process instruction tool, an overhead air ionization system, automated tinning process and improved printed wiring board assembly equipment. These manufacturing aides improve output, quality and the performance of operators. They also reduce defects and their related rework problem.

Dedicated facilities and equipment are maintained to analyze failures. Laboratories are equipped with similar test stations to those used on the factory floor. This allows a failure to be recreated, isolated and analyzed for the cause. Critical and repeat failures are studied and discussed by engineering, design, and quality and reliability personnel. These discussions often lead to process changes, design reviews or workmanship improvements.

USD dedicates a lot of effort to manufacturing detail and improving operator processes. This is driven by managements desire to reduce defects and improve quality and reliability of their product. The Navy team found that this has lead to the development and utilization of many positive practices at USD which have the potential of being best manufacturing practices.

The manufacturing problems identified by USD were vendor and specification related. Vendor problems appear to be common throughout the electronic industry. Engineering changes and specification tailoring were also identified as a constraint to manufacturing that can result in increased cost and poor quality.

The best manufacturing practices and problems identified at Honeywell USD will be evaluated and reviewed by the Navy team during future BMP surveys. Those practices identified as being 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. DISCUSSION

A more detailed discussion of the areas reviewed follows:

### A. Management

#### COMPANY COMMUNICATION POLICY

Communication is a key to successful management of any organization. Honeywell maintains a practice of clearly communicating to all personnel whether technical or business-related. Management believes employees want to do a good job and the more they know about what is expected of them the more motivated they became. Varied forms of communication are used including stand up briefings, one-on-one conversations, articles in the company newsletter, and video monitors and teleprompters.

The communication process is a two way street. Production workers are often aware of problems and impedances to quality that the supervisor may not be aware of. Quality, manufacturing, design and other teams meet on a regular basis to discuss problems and solutions.

One unique method of communicating to the employee is through the State of the Place presentation given to all employees quarterly by the Director of Production. This presentation helps to keep the employees involved making them feel like an important part of the company.

## RECEIVING INSPECTION (ELECTRONIC TEST CENTER)

Honeywell Corporation maintains three strategically located Electronic Test Centers (ETC). The ETC located in New Hope, MN serves the entire twin cities area, along with other divisions involved in military production. The facility supports 20 contracts spread out among 12 Honeywell Divisions.

All material is received directly at the ETC where it is logged into the automated tracking system and then stored in an automated storage and retrieval system. Bar codes are used to track the product throughout the ETC. Each lot is assigned a process traveler which specifies the precise testing requirements for that material.

The primary services performed at the ETC are:

- Rescreening
- New component qualification
- Characterization (primarily for design engineering)
- Back end processing (post package testing/processing)

Rescreening functions performed involve temperature cycling/ thermal shock, hermeticity, destructive physical analysis, external visual, and functional electrical tests. The Electronic Test Center has the capability to electrically test the components at room, hot and cold temperatures. The extensive use of automatic handlers allow many of the device types (i.e. integrated circuits) to be screened 100% at each temperature, cost effectively.

A secondary benefit of the ETC is in dealing with vendors. Once vendors understand that the ETC personnel are knowledgable professionals supported by state of the art equipment, the vendors become more cooperative in responding to Honeywell's quality concerns.

## MATERIAL QUALITY IMPROVEMENT PROGRAM

Recognizing the need for good communication between the prime and its vendors, Honeywell established a Material Quality Improvement Program (MQIP). The main purpose of MQIP is to increase the awareness of each other's needs and problems. This approach has proven to be beneficial to both USD and its suppliers.

MQIP is a two part program directed at increasing the quality of the product and reducing the cost of quality. One is the Piece Part Quality Improvement Program (PPQIP), the other is the Major Supplier Quality Improvement Program (MSQIP). The PPQIP has resulted in visits to 55 of the key MK 46 torpedo suppliers, to date. The MSQIP will involve USD's major suppliers (five

Honeywell divisions and three other contractors). Some of the program's objective are: defect reduction, on time delivery, elimination of repeat problems, to involve as many suppliers as possible, to improve communication, and to establish a permanent process for material improvement versus quick fixes. In an effort to improve purchase documentation, USD has consolidated all technical requirements on a separate document in lieu of having them scattered throughout the purchase order.

What has really made the program work is the use of USD management/technical commodity teams that visit suppliers to inform them of the use of their part(s), the end item it supports, problems that failures can cause, and why specification requirements are important. This has opened the door to better communication and a willingness to work together to reduce problems. The team effort can be considered a training program that is capable of offering technical assistance to vendors.

Some of the MQIP goals are: 100% defect free material, 100% on time delivery, 48 hours issuance of return material authorization, single designated contact at the vendor and development of monitoring points at vendors.

The MQIP program is in its early stages, but has been received well by vendors. USD is in the process of developing a suppliers reporting system to manage vendor participation and to report yields, trends, and defect data.

## TRANSITION FROM DEVELOPMENT TO PRODUCTION

Honeywell USD has implemented a Design to Production Transition Plan that makes it a leader among the government contractors. As a result of difficulties that USD encountered in MK 46 transition, the transition to production process was baselined into the MK 50 Torpedo program. Planning started with the the technical assessment phase in 1976. USD brought the design and production personnel together at the very outset of the program. Consequently, the exchange of production requirements relative to design requirements was an ongoing process.

Production engineers were involved in building the first four prototypes. Subsequent torpedo "builds" incorporated an increasing level of production processes. Requirements for corrective actions were then fed back to the designer and incorporated into the design to make the torpedo more producible.

USD has incorporated the suggested philosophy of DoD 4245.7M, Transition from Development to Production Manual. It recommends that production methods, equipment, and personnel be integrated into "hands on" fabrication of the program as early as possible. Low rate initial production torpedoes are being built using production tools and test equipment and the "final" processes are certified. USD management is thoroughly committed to the implementation and discipline maintenance of a design to transition plan. This managerial commitment is demonstrated by the fact that designers are told that their jobs do not end until the torpedo (project) is in full production and production engineers are told that their jobs start with the initial design.

A similar process is used in the development of vendors. Initial vendor contacts were made during advanced development. During full scale development, vendor contracts were being developed to allow for the planning necessary for a smooth transition from design to production. The development of the vendor base is thereby demonstrated during low rate initial production.

USD uses baselined charts to track risks against predicted values. "Alert zones" are established which trigger reports to management when the observed values deviate from established limits. An innovation is the tracking of unit costs per torpedo during development. This allows USD to have a cost factor of the torpedo throughout the entire program. USD has implemented a detailed transition plan that has resulted in efficient transition of all phases of a program.

## QUALITY CONTROL (DEFECT REDUCTION PROGRAM)

USD has developed a well defined Defect Reduction Program called the Willoughby System, that identifies, analyzes, corrects, tracks, and follows up defects throughout the factory. Formats and goals are always being improved to maintain the lowest possible Defects Per Unit (DPU) performance possible.

The purpose of the defect reduction program is to regularly review key factory operations, spot problems early and allocate resources to assure ultimate product quality. Goals of the defect reduction program are established at the beginning of each year. Teams consisting of a production engineer, quality engineer, and factory representative are assigned to each problem.

The teams review the DPU levels, rework hours and associated test results. Factory operations are analyzed, necessary resources are allocated, solutions are formulated and implemented, and effectiveness to DPU levels is monitored. The Honeywell team meets weekly with quality management, factory management, and factory supervision to present the status of these problem areas. The presence of management and supervision provides a check for proper allocation of resources for problem solutions. This increases the ownership of the problem and provides a complete communication loop.

The Willoughby System and DPU tracking places the highest priority on "product quality" --- ahead of schedule and cost. This emphasis on quality has received total commitment by Honeywell top management.

Advantages of the Willoughby System are:

- o Provides a communications tool between management and the customer
- o Defines factory performance accurately
- o Allows cross communications between quality engineers, production engineers and factory supervisors
- o Permits problem solving in a timely manner
- o The weekly format promotes a disciplined review of factory performance

The Willoughby system has greatly impacted the MK 46 DPU levels and continues to receive full support by Honeywell management. The system will be further applied to the new MK 50 torpedo system when it reaches the factory floor.

The defect reduction program includes:

- o A monthly report to Willoughby's office
- o Meeting with Navy personnel approximately twice a year for production conferences
- o Once a year visit to Willoughby's office by USD's Vice President and General Manager and the Product Assurance Director to present the previous year's results and next year's goals

## EMPLOYEE TEAM CONCEPT

Honeywell USD has an employee product team concept in-place. The purpose of the team is to be a quick reaction, or sustained, group to examine/solve problems that occur at the subassembly level. A team is assigned to each sub-assembly, i.e., control group, guidance unit, and final assembly.

The result is a pyramid effect of reaction teams. The intent is to "umbrella" the torpedo with problem solving teams. These teams are formed to solve only technical problems and they do not become involved or concerned with problems that are primarily cost or schedule. Each team has as a minimum, a production engineer and a quality engineer. One of the team members is designated the Team Captain by the USD Product Assurance Director and the Production Director. The Team Captain is responsible for the performance of the team. Management supports the team concept by making USD resources available to the team as needed. The team members are dedicated to that activity and have no other USD responsibilities as long as they remain on that particular team or are reassigned. This demonstrates the high level of priority

USD has attached to the team concept, and the importance in which it is held by USD. The team reports its progress, or status on problems, at weekly management meetings - or on call, if required. The team concept works for Honeywell USD.

## TRAINING

The Honeywell USD learning center is a well run production operator training and certification facility having some rather unique functions and capabilities. It is staffed with seven professional instructors and a supervisor, and is housed in a modern, spacious and well equipped facility. All new production operators are provided with 40 to 60 hours of training in produc- tion operations, certifying them in basic soldering to MIL-STD- 454H and WS 6536 requirements. To graduate, each trainee must build an operating radio, pass written tests and demonstrate ability to meet workmanship standards. Inspectors receive an additional 12 hours in factory procedures, defect detection, accept/reject documentation and rework ticket preparation. More than 400 operators have been trained in one year.

The center also provides training in special production processes such as electrostatic discharge (ESD) control procedures, LUMA induction soldering of connectors, epoxy application to secure components to PWBs, automatic sequencing and insertion machine operation and subassembly stress screening. These courses run about 20 hours each, have well structured lesson plans and utilize commercially available and Honeywell produced slides and video tapes, and one-on-one instruction. Training stations have computer terminal process and visual aids and work place setups like those in the production areas. In some training, actual production parts are used. Another function of the learning center is to support production engineering in the development and evaluation of new products, processes and equipment in such areas as soldering equipment, hand tools, ergonomics/human factors engineering design and evaluation of work stations, and try out and debugging of new equipment. The facility, but not the staff, is also used for computer training of engineering and secretarial personnel. Engineering personnel also receive basic soldering training.

## B. Manufacturing

## PROCESS INSTRUCTION TOOL

The Process Instruction Tool (PIT) is a computer-assisted manufacturing aid which provides graphically presented process instructions for the factory workers to perform their given operation as well as for production engineers to define the desired process using graphical aids and animation. PIT which operates on Apple II & IIe microcomputers employs graphics software and the BASIC programming language to develop these process instructions. A graphics file tool and user friendly software facilities allow process engineers to describe the process instruction using animation, color codes, etc. to present the factory worker with a step by step instruction for performing their function. Each factory worker can enter the process desired and view the instruction on a color monitor located at their workstation. Typical instructions involve several frames of graphics each which provide the operator with location information and operation instruction for performing each step of their assembly function. All process instructions are stored on a CORVUS disk system to which all of the Apple computers are linked. Using the PIT provides greater understanding of each instruction, reduces time required in reviewing process instructions, and significantly reduces the amount of paper in the factory.

## AIR IONIZATION (ESD CONTROL)

Honeywell currently uses costly 40% Relative Humidity (R.H.) for Electrostatic Discharge (ESD) control on the factory floor. Installation has begun on an air ionization system which performs the same function better and at lower cost. The air will be at 15 to 25% R.H. when this system is operational.

The system will control static electricity in the work area by flooding the room with both positive and negative ions generated by overhead wires suspended from the ceiling. The ions will dissipate the static charge that may be present on parts, machinery, or employees.

The lower humidity environment will reduce the moisture absorbed by parts, components, etc., which could cause problems later, and provides a more comfortable environment for the employees.

## JUST-IN-TIME PROGRAM

Honeywell USD has initiated a Just-In-Time (JIT) program to have the right material at the right place at the right time. As part of this program they have developed a JIT cell for the MK 46 Fire Control unit. The cell consists of four workstations. Boards come in from the automatic insertion area in batches of approximately 60. In the JIT cell, they are processed at the rate of 6 per day. The system is based on the fact that no more than 6 units are started each day and that the product is pulled through the line.

The primary advantages of JIT are:

- o Drastically reduced inventory levels
- o Simplified scheduling
- o Reduced floor space and material handling
- o Production problems are immediately highlighted and resolved, leading to improved quality

Honeywell is introducing an additional line for the 15 Volt Regulator unit in the same area. Though JIT is primarily a pilot project, it is fully operational on the MK 46 Fire Control and 15 Volt Regulator.

## AUTOMATED TINNING OF COMPONENTS

Honeywell engineers have developed the AUTOTIN system which is manufactured and marketed under license by TEKCOM Corporation of Eden Prairie, MN. AUTOTIN, which is currently in the prototype stage, will be able to handle axial lead components on tape. The components will be fed through a cleaning, soldering, drying station and onto a take-up reel at rates of 8,000-25,000 per hour.

At these rates, AUTOTIN has a great deal of potential. It would be most effectively utilized by the component manufacturers who will have a fast and effective method of pre-tinning all of their components prior to shipment.

A major drawback in the AUTOTIN process is the requirement for an organic acid (OA) flux. The current MILSPEC prohibits the use of OA flux. However, Honeywell is attempting to have tne MILSPEC changed.

## WAVE SOLDERING

A wave solder system has many variables that must be controlled in order to produce non-defective assemblies. These variables are difficult to monitor and control through human resources and some of the variables need to be changed to optimize the process for various PCBs going through a wave solder system.

An Electrovert Century 2000S system is utilized by Honeywell. Salient features include:

- o 18" wide conveyor
- o Pyrometers monitor board temperatures as it passes through preheaters
- o IBM computer for control, monitoring and storage of parameters
- o Less than 10 minutes for stabilization

The preheaters, conveyor width and speed and wave height are the variables altered from board to board. All other variables are monitored/controlled but maintained fixed. The second preheater temperature is based on the PWB board type. Temperature of the board is normally set to 200°F.

The system has not yet been totally perfected, but the plan is to make it simple to use and release it to the factory operators. Although this system is an "off-the-shelf" equipment, it's full potential cannot be realized to the degree that Honeywell has, without further refining the equipment.

## COMPONENT LEAD FORMING (WORK INSTRUCTIONS)

Component lead forming setup information is provided to the operator via an on-line computer terminal and printer. The operator enters the part and assembly numbers and a configuration code from the stock issue ticket accompanying the parts to be formed. The printer outputs a lead forming data sheet which displays a formed part sketch and setup information such as cut and form tool number, style of formed components, lead extension length, and hole span dimension. The operator uses these data to select preset tooling or to dial-in cut and form information into such axial component forming machines as the MARK V Component Lead Former, GDP, GF8, Heller 116A, and others. Set up information is entered into the computer by the process engineer as assembly processes are written. Because the same part and configuration may be used several times on one board or throughout a product, production economies are also realized because of the resulting lead forming data base.

## PRINTED WIRING BOARD ASSEMBLY

Two, three and four lead components and DIPs are quickly and accurately assembled to PWBs, leads cut off and clinched using the DYNA/CAM 1800 series machine which is manufactured by DynaPert division of the Emhart Corporation of Beverly, MA. Lead diameters of .015" to about .035" are accommodated. Lead center-to-center dimensions are limited to about 1.2" on a single cut but larger dimensions can be done on multiple cuts. Component orientation is limited to "X" and "Y" positions.

The equipment consists of a table mounted holding fixture behind which is the X-Y table and cutting/crimping head; and a material carousel bin containing several trays of eight compartments each. After the PWB is loaded into the holding fixture, the program start button is pressed to zero the head to the reference position. Depression of a foot pedal operates the cut off and form tool and indexes the head to the next programmed board location and simultaneously presents the next component to the operator at the carousel window. A white light located on the head shines through the PWB hole into which the component is to be inserted. If polarity orientation is required a flashing red light indicates the hole for the positive lead. The operator inserts the component into the indicated position. The operating head cuts the leads to length and crimps them to the board at about a 45 degree angle; tight enough to prevent motion during soldering. The cut off height is less than .060". The X-Y positioning of the head is done by a program down loaded from a computer or a program generated on the Dynacam. Carousel trays are loaded in the kitting area using kitting sheets generated by the process engineer which specify component location and sequence in the trays.

The system not only assures accurate component selection and placement but is considerably faster then manual insertion and crimping methods. It is particularly useful on long cycle operations or infrequently built assemblies as learning component location is eliminated. The 1981 cost of the equipment including carousel and some software was about $25,000.

## CABLE/HARNESS WIRING

Instead of visually scanning a wire bundle to find the right wire, the T&B QS200S Cable Scan System permits "finger scanning" and provides a beep confirming correct wire selection. This process is speedier and more error-free than visual selection alone. The system is primarily used for marrying cable harnesses to PWBs where mass wire terminations are involved.

Two other commercially available systems are used in conjunction with cable scan for this operation; the Ragen position indicator which indicates wire termination points by projecting a light beam from an overhead projector on the spot, and the Honeywell developed Process Instruction Tool (PIT) which provides colored visual aids and work instructions on a computer terminal. Each wiring step on all three pieces of equipment is simultaneously advanced by depressing a foot pedal.

When the connector end of the cable being married is connected to the cable scan and the operator is electrically connected to the system by a wrist band, a low voltage signal passes through the operators hand, through the properly selected wire and to the cable scan console activating a beeper. A lead number display on the console is keyed to the PIT display and the Ragen projector.

The system facilitates learning, substantially reduces miswiring, and speeds production. It is particularly useful on long cycle operations and infrequently produced assemblies. All three pieces of equipment are driven by a single program prepared for the Ragen.

## FAILURE ANALYSIS

When a system or subsystem fails a test it is sent to the Failure Analysis Laboratory for cause identification. The laboratory is chartered to support production but provides an independent analysis of failures to determine the root cause, i.e., design deficiencies, production errors (process, workmanship) and piece part problems. One of the first things done at the laboratory is to recreate the failure. The laboratory has test and environmental equipment similar to that in the factory to perform this task. The most important operation of the laboratory is to isolate the problem and analyze the cause. Trends in workmanship and part problems are studied and discussed with quality, design, manufacturing and reliability engineers. These discussions can lead to process changes, design revisions or simply informing an operator of a workmanship problem. Whatever the action, the result is a closed loop system to take corrective actions to reduce future failures.

A meeting is chaired each week by reliability with engineering, design, quality and production to review the more critical failures of that week. If a problem identified by this group cannot be resolved, it is elevated to management for action. In an effort to keep the process closed loop, system/subsystem failures are coordinated with the parts failure analysis laboratory and the electronics test center, and workmanship problems are coordinated with the factory supervisors.

## PARTS ANALYSIS LABORATORY

Honeywell is equipped with a Parts Analysis Laboratory which services not only Honeywell but also other companies. This is attributed to Honeywell's insistence on high quality, reliable products. The laboratory has the capability to test and evaluate failed parts to determine cause, test and evaluate samples from new lots of parts to expose weaknesses, work with suppliers to resolve problems, develop and evaluate screens to sift out bad parts and provide detailed information from a computerized data base.

Honeywell has found that part failure at any stage in the design or production process can be a serious problem if not solved quickly. Their staff has the experience and sophisticated equipment to identify problems. The laboratory can determine what went wrong and what needs to be changed. This often leads to a modification in the specification, design or vendor's processes.

## IV. BEST PRACTICES

It is premature to identify any practices as best in the electronics industry since this was only the second BMP review. However, the Navy team did identify a number of potential best practices, each of which is listed and discussed in section III.

A practice that is considered to be one of USD's best is the attention given to manufacturing detail. The development of computerized process controls and instructions at the operator work station, and modifying standard manufacturing equipment to make the operator's job easier, has been a major contribution to the reduction in defects. Making the employees job easier and keeping them informed leads to job satisfaction, an important ingredient in high quality manufacturing.

Honeywell USD continues to work towards the improvement of electronics manufacturing. The development of overhead air ionization for control of electrostatic discharge and automatic tinning are just two of the more innovative efforts unfolding at USD. These efforts along with others make them a leader in the electronics industry.

## V. PROBLEM AREAS

The problem areas discussed below were identified by Honeywell USD as worthy of further investigation. More data on these areas will be collected and analyzed during future BMP reviews. Problems identified as having industry wide impact will be forwarded to the Electronic Manufacturing Productivity Facility, China Lake, California for research and resolution.

### COMPONENT SOLDERABILITY

Most of industry is experiencing component solderability problems. Honeywell USD has chosen to pre-tin components in-house to work around this problem. They are also in the process of developing an automated tinning system, discussed on page 9, which may help solve the problem. Ideally, if the system proves effective and component suppliers incorporate it in their process, the problem will be solved at the source.

### CLEANING COMPONENT LEADS AND PCBs

Component lead automated tinning equipment developed by Honeywell can satisfactorily tin only 60-70% of parts if RMA flux is used. The equipment works best with organic acid (O.A.) type flux, but it is not approved for military hardware. Honeywell is working with NWC China Lake to develop procedures and specifications for use of O.A. flux.

Post wave solder cleaning equipment does not completely remove RMA flux. The residue has negative effects on conformal coating adhesion and can attack solder at a later time. Honeywell is investigating the use of synthetic resin based fluxes since they clean up better. This work is being coordinated with NWC China Lake.

## ENGINEERING CHANGE PROPOSAL (ECP) APPROVAL

Honeywell USD is experiencing a lengthy approval cycle for ECPs. Approval delays often result in added cost to the government and can provide a less reliable product.

A normal ECP is processed through USD after the change has been identified. This ECP development and writing requires several Weeks. The Navy's technical agent requires a lengthy time to review the proposal. If technical approval is obtained, the ECP is sent to the USN program manager for administrative approval and funding, if required. This process takes additional time. In the meantime, USD is producing in less than a desirable manner, producing at a reduced rate or maybe even producing at a risk because the old technology requires parts that are not available.

## SPECIFICATION TAILORING

Honeywell USD has experienced time delaying and manufacturing difficulties as a result of some DoD agency's attitude toward specification tailoring. Changes in design, part substitution and better manufacturing practices have dictated changes in specifications. Yet these changes are often met with much resistance requiring Honeywell to continue labor intensive operations or unnecessary stress screening. Obtaining approval for specification tailoring is a very time consuming and costly process.

The Navy's new acquisition streamline hot line (1-800-NAVSPEC) was established to help resolve manufacturing problems of this nature. The program was designed to help identify and resolve unrealistic specification requirements.

## EPOXY APPLICATION TO PWBs

Honeywell USD uses a 3M epoxy adhesive to secure large components to PWBs assemblies to prevent adverse shock and vibration. This is done by applying a fillet of epoxy (1) along the length of the component to partially bond the component to the board and (2) where the leads exit from the component to give added strength. Because the epoxy is applied manually using a needle and syringe, the following problems can occur which result in rework:

- Inaccurate epoxy mixing and dispensing
- Missed components
- Excess epoxy on leads and solder joints.

To overcome these problems, Honeywell has designed a robot with a vision system to perform this operation. The epoxy application system, built from commercially available parts, consists of reservoirs for the two-part epoxy, a pump, a mixing head with disposable polypropylene dispensing tubes, a vision head, and a six-axis force sensor. The dispensing location, epoxy flow rate and traverse rate are computer controlled. The robot is taught by either a down-loaded program or a teach pendant. The vision head sees the X-Y location of the component to be secured and locates the dispensing tip against the body of the component. Contact of the tip is sensed by the force sensor and the dispenser program commences.

About ninety percent of components can be epoxied by the robot providing consistent workmanship. Some are too obstructed by wires and the high density of components on the board for the robot to see, and must be done manually. Even though this system is not scheduled to be operational until mid 1986, it has the potential of being a best practice.

## VI. CONCLUSIONS

Honeywell USD has been successful in developing a "quality first" attitude in their facility. Establishment of innovative employee programs and development and installation of the latest in equipment and facilities has made USD a leader in the electronics industry. Initiatives like the Material Quality Improvement Program, Transition from Development to Production Plan, Defect Reduction Program, Team Concepts, and the Process Instruction Tool have substantially improved USD's manufacturing performance.

One of the most significant and innovative improvements on the factory floor is the Process Instruction Tool. This system has made the operator's and assembler's job much easier by providing computerized graphic process instruction displays at the workstations with step by step instructions for performing the function. This practice is unique in the industry and is considered a best practice.

The incorporation of new initiatives and improvements in defect reduction at USD is impressive. The BMP survey team felt that many of the practices reviewed and documented in this report are indeed best manufacturing practices.

The manufacturing problems identified by USD are common to those identified by most of the industry. With the collection of more data and documentation of the facts, steps can be taken to resolve the problems that have industry wide impact. The technical problems will be referred to the Electronic Manufacturing Productivity Facility for study while others may require a change in Navy policy and procedures. Even if all of the problems are not solved, each one eliminated is a step in the right direction.