REPORT OF SURVEY CONDUCTED AT

SHARRETTS PLATING COMPANY, INC.
EMIGSVILLE, PA

June 1997

Best Manufacturing Practices

BEST MANUFACTURING PRACTICES CENTER OF EXCELLENCE
College Park, Maryland
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Foreword

This report was produced by the Best Manufacturing Practices (BMP) program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245-7.M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at Sharretts Plating Company, Emigsville, Pennsylvania conducted during the week of June 2, 1997. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from government, industry, and academia throughout the U.S. and Canada – *so the knowledge can be shared*. BMP also distributes this information through several interactive services which include CD-ROMs, BMPnet, and a World Wide Web Home Page located on the Internet at http://www.bmpcoe.org. The actual exchange of detailed data is between companies at their discretion.

Sharretts Plating is committed to continuous and ongoing improvement by promoting proactive approaches to environmental and safety issues; maintaining open communications with its employees; and striving for customer satisfaction by providing high-quality products. As the second plating company in North America to achieve ISO-9002 certification, Sharretts showed its determination by complying with stringent environmental regulations and establishing quality processes in training, communications, design, and maintenance. Among the best examples were Sharretts' accomplishments in source reduction and water reuse; plant task team; and ISO-9002 certification.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on Sharretts Plating Company expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

Ernie Renner
Director, Best Manufacturing Practices

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Section 1

Report Summary

Background

Sharretts Plating Company, Inc., a privately-owned company, has been in business in the Harrisburg, Pennsylvania area since 1925. Currently located in Emigsville, Pennsylvania, Sharretts employs 45 personnel, and encompasses 68,000 square feet. Maintaining its operations in the 95th percentile of U.S. platers, the company performs diversified, functional industrial electroplating (e.g., zinc, tin, palladium-nickel, gold) and some decorative plating. In 1993, Sharretts won the Pennsylvania Industrial Excellence Award for Environmental Achievements.

Sharretts represents the first plating company to be surveyed by the Best Manufacturing Practices program. The facility is run by a Plant Manger and an Environmental, Waste Minimization, and Safety Manger who support one another, perform diverse functions, and interact with employees. Committed to continuous and ongoing improvement, Sharretts promotes a proactive approach to environmental and safety issues; maintains open communications with its employees; and strives for customer satisfaction by providing high-quality, prompt service at a competitive price. Among the best examples were Sharretts' source reduction and water reuse; plant task team; and ISO-9002 certification.

Committed to reducing waste in all aspects of its business, Sharretts' primary goal is optimizing water usage while minimizing waste. Among the company's innovations are capturing water through a water reuse system and recirculating it through various operational processes; implementing cascading rinses for the running rinse tanks in all of its major plating lines; and installing evaporators on the still rinse tanks after the zinc-plating baths.

Sharretts has established a Plant Task Team to address the plant's overall appearance and the requirements for preventive and predictive maintenances. As a result of the team's efforts, Sharretts has improved its overall appearance; increased its productivity and profitability; and gained many benefits by emphasizing a formal system with dedicated personnel to monitor, track, and schedule facilities and maintenance needs.

ISO-9002 certification has provided Sharretts with well-documented procedures, effective ways to communicate, and a training system. The company believes that ISO certification has been well worth its implementation and maintenance costs. The major impact from certification has been a dramatic improvement in quality and consistency. Sharretts uses consistent operating procedures to run the shop, and customized line manuals for each plating line as well as support areas (e.g., office personnel; laboratory technician; shipping and receiving; quality assurance and control).

Overall, Sharretts has made great strides during its transition to become ISO-9002 certified. As the second plating company in North America to achieve this status, Sharretts showed its determination by complying with stringent environmental regulations and establishing quality processes in training, communications, design, and maintenance. The company has realized a 35% to 45% material cost reduction over three years as a result of certification. Sharretts' goal is to become ISO-14000 certified by the end of 1998. The BMP survey team considers the following practices to be among the best in industry and government.

Best Practices

The following best practices were documented at Sharretts Plating:

Item	Page
Optimization of Cleaning Baths	**5**
Sharretts has developed and implemented numerous innovations to optimize its cleaning baths and solutions. These innovations include a safe, environmentally-compatible bath solution to eliminate fuming and etching problems associated with hydrochloric acid-based solutions; an auxiliary system to remove oil from its cleaning baths; custom-designed barrels to eliminate contamination; and increased dwell times to reduce drag-in from other processing tanks.	
Optimization of Plating Baths	**5**
Sharretts implemented innovative improvements to optimize its plating baths. These improvements include filtering its zinc-plating solution; installing reusable filters; using an in-house reclaim system for tin and zinc solutions; and increasing dwell times to reduce drag-in from other processing tanks.	

Item	Page

Process Control 6

Sharretts achieved significant improvements in process control as a result of its quest to attain ISO-9002 certification. An important step was the company's decision to hire a chemical handler to augment the laboratory technician that had previously functioned in both roles. By collecting extensive data from various production processes, these employees calculate the precise amounts of chemicals needed on the production lines to produce quality parts, and ensure the exact chemical amount is allocated for each processing bath that will require chemical additions.

Production Monitoring 6

Sharretts established a Production Monitoring system to track the production of its three zinc-plating lines by week and shift. These plating lines are the largest cost drain to the company, considering they require 75% of Sharretts' resources. Since starting the system, Sharretts has documented a 300% increase in productivity of its zinc-plating line processes.

Solid Chemical Additions 7

Sharretts implemented a method of solubilizing dry chemicals for its zinc-plating operations. By using vessels with mixers, technicians premix dry chemicals with either an aqueous or zinc solution. The mixer blends the chemicals and liquid into a slurry, which keeps the chemicals in a liquid state. The slurry mixture is then added to the plating bath tanks as needed, resulting in 90% to 95% solubility.

Source Reduction and Water Reuse 7

Committed to reducing waste in all aspects of its business, Sharretts' primary goal is optimizing water usage while minimizing waste. Sharretts has identified and implemented several innovative ideas in these areas, resulting in mutually beneficial results for the company and the environment. Several techniques and process modifications have also been established to further reduce the amount of water used in process operations.

Plant Task Team 8

As a direct result of Sharretts' maintenance meetings and weekly management reviews, a Plant Task Team was established to address the plant's overall appearance and the requirements for preventive and predictive maintenance. The company has gained many benefits by emphasizing a formal system with dedicated personnel to monitor, track, and schedule its facilities and maintenance requirements.

ISO-9002 Certification 8

Sharretts was one of the first plating companies in the U.S. to become ISO-9002 certified. The company undertook the certification process nearly five years ago as a way to improve its operations and enter the global market. ISO certification has provided the company with well-documented procedures, effective ways to communicate, and a training system.

Material Cost Reduction 9

Sharretts implemented an aggressive Budget Tracking and Purchasing system using Microsoft Office 97 (Access, Word, Excel, PowerPoint) software package. The system allows the company to project costs six weeks in advance; implement corrections before a financial crisis develops; and operate with a more positive cash flow by assigning budgets to specific areas. In addition, budget planning eliminates crisis management and enables the company to spend more time costing out materials for the best price.

Information

The following information items were documented at Sharretts Plating:

Item	Page

Innovative Chromate Reduction 11

Chromium has been identified as a particularly toxic metal. As a result, environmental and safety concerns have increased in regard to chromium usage and employee exposure. In the plating industry, chromium is typically used in its hexavalent form since it produces quality results and allows the metal to be plated out of solution. However, Sharretts has successfully changed to chromium's more benevolent form, trivalent, for most of its chromium requirements.

Innovative Stripping 11

Sharretts previously used acid for stripping its defective zinc-plated parts. However, this method created excessive foaming. The company now uses an alkaline stripper which works well in this application. The stripper does not produce black smut, generate irritating or corrosive fumes, nor tarnish or etch the finest steel finish.

Employee Involvement

Sharretts has established a formal employee involvement program. Aspects include weekly management meetings to improve communication and awareness throughout the plant; weekly maintenance meetings to manage resources, plan for preventive maintenance, and increase operational efficiency; and a cross-training program to involve employees in more aspects of the plant and create a greater flexibility for meeting customers' needs.

Safety Program

Sharretts formalized its safety program in 1997. The company recognized the need for fundamental safety policies and procedures, and is actively identifying and implementing them throughout the plant. Although its safety program is still developing, Sharretts has effectively increased employee safety awareness and instituted basic safety requirements.

Point of Contact

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Section 2

Best Practices

Production

Optimization of Cleaning Baths

Various factors can reduce the effectiveness and lifespan of cleaning baths. Typical cleaning bath solutions consist of hydrochloric acid mixed with high-strength detergents. As the primary ingredient, hydrochloric acid can promote fuming and the etching of product parts. Oil build-up during the cleaning process and the deterioration of the cleaning bath's barrel can also be sources of contamination to the cleaning solution. Drag-in from other processing tanks, as well as tainted cleaning solutions, can reduce the lifespan of the cleaning baths. Sharretts Plating Company has developed and implemented numerous innovations to optimize its cleaning baths and solutions.

After analyzing alternative cleaning solutions (including heavily-regulated toxic chemicals), Sharretts developed a safe, environmentally-compatible solution to meet its needs. A cleaner, consisting of biodegradable non-toxic acids, detergents, penetrants, stabilizers, and other harmless additives, is mixed with a mildly-alkaline detergent that cleans and degreases. The new cleaning bath solution eliminates the fuming and etching problems associated with hydrochloric acid-based solutions. Sharretts has implemented its new solution in all cleaning processes which formerly used hydrochloric acid-based cleaning solutions.

To reduce oil build-up during the cleaning process, Sharretts installed an auxiliary oil removal system to its cleaning baths. The system skims the oil contamination from the cleaning solution while the bath is in use. By removing the oil on a real-time basis, Sharretts reduced the need to replenish the cleaning solution and increased the lifespan of the cleaning bath.

Custom-designed barrels are now being used in Sharretts' cleaning baths. The improved design has virtually eliminated the loss of parts in the baths as a source for contamination, and increased the lifespan of cleaning baths and other processing tanks. In addition, Sharretts has increased the dwell times over its processing tanks prior to the cleaning baths. Increased dwell times reduce the contaminant amounts carried from the processing tanks to the cleaning baths; improve the process control and productivity of the entire line; and increase the lifespan of the cleaning baths.

Through innovative improvements, Sharretts has optimized its cleaning baths. Benefits from these improvements include extending the lifespan of cleaning baths, using environmentally-safe solutions, eliminating problems associated with hydrochloric acid-based solutions, and reducing hazardous waste accumulation.

Optimization of Plating Baths

Since 1990, Sharretts has been filtering its zinc-plating solution, using disposable cartridge filters as a way to prolong the lifespan of plating baths. Although filtration successfully increased the lifespan, the procedure generated spent cartridge filters as a hazardous waste. To eliminate this hazardous waste, Sharretts installed reusable filters which could be cleaned as needed. In two applications, the company has successfully implemented filter presses as replacements for the cartridge filters.

Sharretts has also increased the dwell times over its processing tanks prior to the plating baths. Increased dwell times reduce the contaminant amounts carried from the processing tanks to the plating baths; improve the process control and productivity of the entire line; and increase the lifespan of the plating baths.

In cases where plating baths are spent and need to be replaced, Sharretts uses an in-house reclaim system for tin and zinc solutions. The spent bath solution is reclaimed by pumping the solution into a vessel; treating it to separate the organics and contaminating metals (e.g., iron, copper, lead), and running the solution through a final filtration. The solution is then analyzed and returned to the plating baths. Electroless nickel baths are shipped to an off-site reclaimer. By using reclaim methods, Sharretts eliminates these plating baths from being disposed as hazardous waste or as influent to the in-plant waste water treatment system. Chemical treatment costs are minimized and the volume of sludge is reduced.

Through innovative improvements, Sharretts has optimized its plating baths. Benefits from these improvements include extending the lifespan of plating baths, reclaiming spent plating bath solution, minimizing spent plating baths as hazardous waste, and implementing reusable cartridge filters in conjunction with an in-process filtration system.

Process Control

Sharretts has achieved significant improvements in process control as a result of its quest to attain ISO-9002 certification. An important step was the company's decision to hire a chemical handler to augment the laboratory technician that had previously functioned in both roles. These positions are responsible for ensuring that the exact chemical additions and adjustments are made to the processing baths at all times. By collecting extensive data from various production processes (e.g., set points, cycle times, control parameters), Sharretts can calculate the precise amounts of chemicals needed on the production lines to produce quality parts, and ensure the exact chemical amount is allocated for each processing bath that will require chemical additions.

The laboratory technician collects samples and performs analyses to evaluate the condition of the processing baths. By combining this data with historical information which relates product information to bath chemistry, the laboratory technician can determine the exact quantity of chemical additions needed for the subsequent operating shifts. This information is then given to the chemical handler who locates, dispenses, and provides the exact quantity of chemicals needed for each processing bath. This method enables operators to receive the correct quantities for maintaining proper bath chemistries during their shift. Sharretts plans to cross-train the two positions to increase the flexibility and coverage of its work requirements.

By implementing the new procedures, Sharretts can predict its chemical requirement needs and streamline its process control. Inventory control also improves since the company knows the chemical quantities needed based on known production parameters. Sharretts' process control improvements have increased the overall productivity of zinc-plating processes by 33%, and reduced material costs during the last three years by 35%.

Production Monitoring

Sharretts established a Production Monitoring system to track the production of its three zinc-plating lines by week and shift. These plating lines are the largest cost drain to the company, considering they require 75% of Sharretts' resources.

In September 1996, Sharretts began monitoring the cycle times of the zinc-plating lines. To document the processes, flow charts were developed. Since October 1996, Sharretts has posted graphs of the cycle times and performance parameters, and recorded the results (Figure 2-1) in a process information book. Chemical adjustments to a process are also identified through the monitoring system. Maintenance and frequency of breakdown tracking by the Production Monitoring system has led to scheduled preventive maintenance. Sharretts holds weekly meetings to address production and quality problems; maintenance issues; production forecasts and improvements;

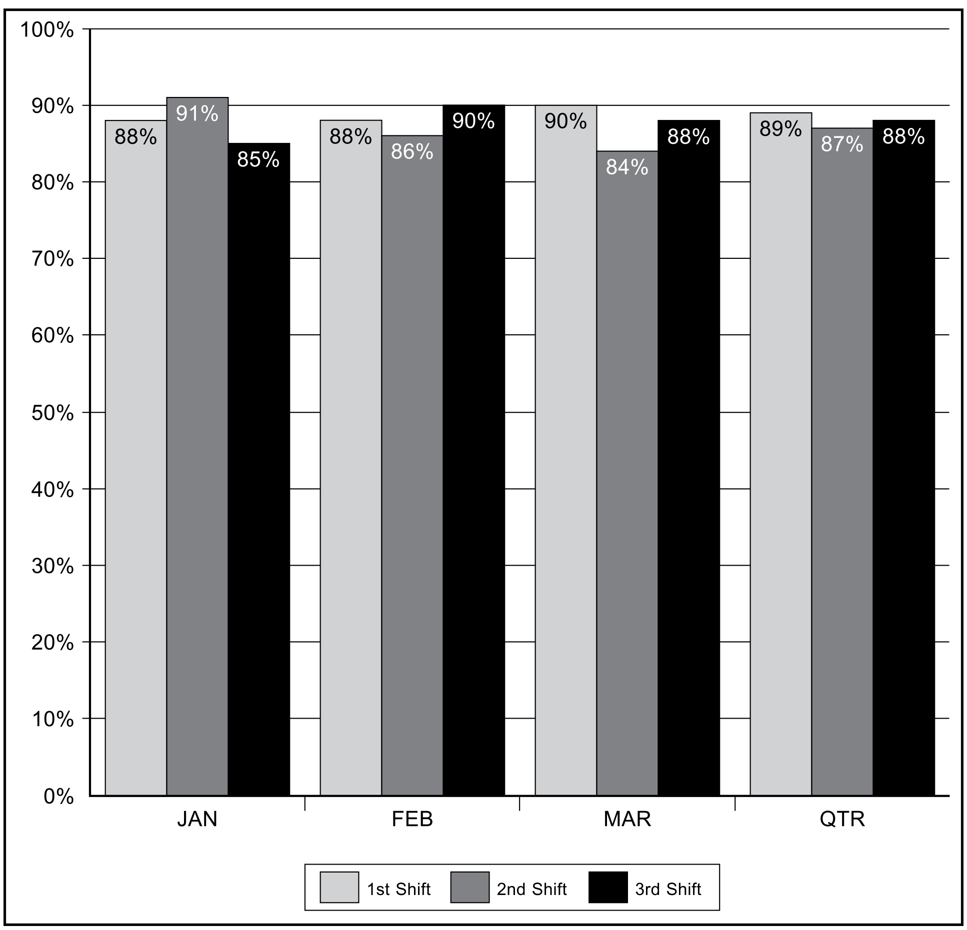


Figure 2-1. First Quarter 1997 Performance

environmental issues; or to have open-format discussions. Action items are identified at the meetings and assigned to personnel with due dates.

Since starting its Production Monitoring system, Sharretts has documented significant increases in the productivity of its line processes. Previously, one of the zinc-plating lines produced 45,000 pounds in five days. Production is now over 120,000 pounds in five days and productivity has increased by 300%. Significant reductions in the operating costs of the zinc lines have also been realized.

Solid Chemical Additions

Sharretts implemented a method of solubilizing dry chemicals for its zinc-plating operations. Previously, technicians would analyze the bath chemistries of the plating tanks and add dry chemicals (e.g., potassium chloride, ammonium chloride, boric acid, potassium permanganate) directly to the tanks if they were beyond specified parameters. However, technicians usually had to add twice as much chemicals as the analysis indicated before the tanks were within parameters. Upon investigation, Sharretts discovered that 50% to 60% of the dry chemicals never solubilized. As a result, large amounts of sludge were accumulating inside the plating bath tanks. The sludge was frequently cleaned out of the tanks and disposed as hazardous waste.

To resolve the situation, Sharretts purchased vessels that had mixers. Technicians now add dry chemicals to the vessel along with either an aqueous or zinc solution. The mixer blends the chemicals and liquid into a slurry, which keeps the chemicals in a liquid state. The slurry mixture is then added to the plating bath tanks as needed, resulting in 90% to 95% solubility. Sharretts also uses rinse water to replenish the tanks as the heated process baths evaporate. This procedure produces higher-quality rinse water for the tanks and less-concentrated process rinse water for the waste stream.

Sharretts' method of solubilizing dry chemicals for its zinc-plating operations has produced many benefits. By pre-mixing the dry chemicals, Sharretts has reduced chemical usage, minimized sludge disposal, and decreased the frequency of operational shutdowns for cleaning the plating tanks.

Source Reduction and Water Reuse

Committed to reducing waste in all aspects of its business, Sharretts' primary goal is optimizing water usage while minimizing waste. Sharretts has identified and implemented several innovative ideas in these areas, resulting in mutually beneficial results for the company and the environment. Several techniques and process modifications have also been established to further reduce the amount of water used in process operations.

After significant analysis and investigation, Sharretts determined that the effluent from the plant's treatment system (Figure 2-2) was sufficiently clean for reuse in other areas of the plant. After treating the plant's process water, the water reuse system captures the water in a water reuse tank and recirculates it through the various processes. Excess water is then discharged to the publicly-owned Treatment Works. Sharretts is also using a filter press to reduce the water content in the sludge produced during the waste water treatment process. The filtered water is adjusted to the proper pH level and then redistributed through the water reuse system for replenishment of process water.

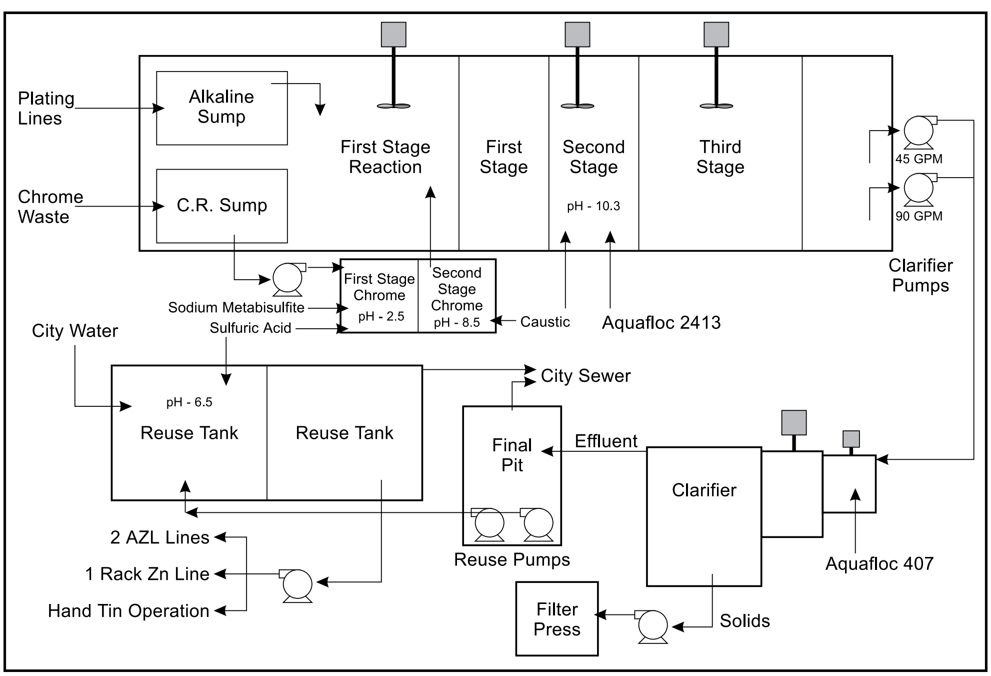


Figure 2-2. Emigsville Waste Water Treatment Plant

Sharretts implemented cascading rinses for the running rinse tanks in all of its major plating lines. This countercurrent rinse technique provides improved rinse quality with less water. Primary modifications for this improvement were the installation of baffling and some piping changes. In addition, Sharretts has installed restrictors in its running rinse lines. The restrictors manage and control the amount of water used at each location, while still providing sufficient water quantities to maintain product quality.

Another technique used at Sharretts is drag-out control. Contaminants can be carried (dragged out) from the previous processing tank to the next bath. By increasing the dwell time over the previous processing tank after the parts are removed, contaminants dragged to the next bath are minimized. This technique reduces the water quantity needed for rinsing and increases the lifespan of the baths. Sharretts has optimized its dwell times while still allowing for maximum productivity and through-put on each of its lines.

Sharretts has also installed evaporators on the still rinse tanks after the zinc-plating baths. The rinses are processed through a filtration system to remove contaminants and are then pumped through an evaporator. After the water is evaporated, the remaining concentrated liquid is pumped into the plating bath as a chloride addition, which reduces the amount of input materials required for the bath. Additional benefits include decreased water quantities to be processed through the plant treatment system, reduction of the volume of water purchased for plant operations, reduced hazardous waste generation, increased material savings, and the elimination of chlorides from the waste treatment system. Sharretts uses a similar system on the still rinse tanks after the cleaner stages on two of its production lines.

By initiating these improvements, Sharretts estimates that its hazardous waste production has decreased from 240,000 pounds per year in 1994 to 130,000 pounds per year in 1997. In addition, the company has decreased its chemical costs for waste water treatment from $35,000 to $21,000 over the same timeframe.

Facilities

Plant Task Team

As a direct result of Sharretts' maintenance meetings and weekly management reviews, a Plant Task Team was established to address the plant's overall appearance and the requirements for preventive and predictive maintenance. Currently, the team consists of two members. One is an experienced, retired employee who works two to three days a week. The other is a full-time employee from the shop who assists the retiree and devotes about two days a week to the team's activities.

The Plant Task Team monitors the overall appearance of the plant and the cleanliness of the work areas. Much of its effort is devoted to painting and cleaning equipment and facilities. An additional function of the team is to develop and implement preventive and predictive maintenance programs. Currently, one team member is performing regular preventive maintenance such as lubricating and aligning plating line barrel mechanisms, and daily cleaning and preventive maintenance of the filter units. Daily maintenance checks on the fork lifts (e.g., battery and hydraulic fluid levels) are also done by the team, while an outside contractor provides full maintenance service on the fork lifts every three months.

The Plant Task Team has compiled a preventive maintenance schedule that prescribes regular daily, weekly, and monthly checks. The team has also set up a system for tracking maintenance costs. Maintenance records are maintained on all plant equipment, citing parts and materials used, and repair costs. This equipment maintenance history guides Sharretts on decisions to repair or replace aging or frequently failing equipment. Chemical bath changes have been included in the preventive maintenance schedule which helps facilitate optimal plant utilization during bath changeovers. This schedule smooths out production and avoids line disruptions. Sharretts' future goal is to computerize the maintenance scheduling and cost tracking systems. Currently, maintenance cost data is being tracked by computer and has become more accurate because of improvements made by the Plant Task Team.

Sharretts has gained many benefits by emphasizing a formal system with dedicated personnel to monitor, track, and schedule its facilities and maintenance requirements. Through its Plant Task Team, Sharretts has improved the overall appearance of the plant and increased its productivity and profitability.

Management

ISO-9002 Certification

Sharretts was one of the first plating companies in the U.S. to become ISO-9002 certified. The company undertook the certification process nearly five years ago as a way to improve its operations and enter the global market. Sharretts hired a full-time ISO coordinator to lead the company through the certification process. Although previously employed by a company who completed ISO certification, the newly-hired coordinator was provided with extensive additional training in ISO standards and auditing by Sharretts.

The ISO coordinator managed preparations for certification; interpreted ISO standards and requirements; and developed and formatted Sharretts' documentation for certification. Most of the policies, procedures, manuals, and other required documentation had to be generated from scratch since it did not exist. This required a tremendous amount of time and effort from management staff and plant supervisors. Total preparation time for the certification audit required about 18 months.

After the company achieved certification about three years ago, the full-time ISO coordinator left. Sharretts refilled the position with an employee from the administrative office who was in the process of transitioning to part time. Although lacking formal ISO training, the new coordinator easily manages the established documentation and required administrative tasks. Sharretts provides additional ISO training to the coordinator as needed. The part-time coordinator spends about eight hours a week to maintain the company's certification. The company uses an outside firm to perform the required periodic audits. By using a part-time coordinator and an outside audit firm, Sharretts has saved more than $25,000 in annual salary costs for administrating and maintaining its ISO certification.

Presently, the ISO coordinator is converting all documentation from a WordPerfect format to a Microsoft Word format for better compatibility with Sharretts' software systems. During this process, Sharretts is also updating and revising the documentation to make it more accurate and easier to use. The coordinator performs most of the update and revision work off-site through electronic data transfer capabilities.

The ISO preparation and certification process has had a transforming effect on all aspects of Sharretts' operations and management. The certification has provided the company with well-documented procedures, effective ways to communicate, and a training system. One effective method initiated during the certification process was the Lot Traveler Tag Procedure system. Sharretts elected not to implement an expensive barcode system, but instead use a very effective manual system. Tags are color coded, one color for each week of the month. This allows for easy identification if the product is in the plant for longer than a week. If barcoding is added in the future, the tags could still be used with a barcode tag applied to them. The Lot Traveler Tag Procedure system has eliminated lost parts and materials within the plant.

Sharretts has also established an effective communications method known as the Immediate Operator Attention process. This process is frequently used when important information or changes (e.g., adjustments to chemical additions for the plating baths, modification of existing procedures) need to be brought to the attention of plant floor operating personnel. In these situations, new information is written down; hand-carried to the affected operator as well as everyone trained in the affected areas; verbally discussed to ensure understanding; signed by the operator to certify the information was received and understood; and then posted in the affected work areas. If the change is permanent, then the affected documentation must be updated in the ISO system within 30 days, and the posted information removed once the change is posted in all permanent ISO areas.

Sharretts believes that ISO certification has been well worth its implementation and maintenance costs. The major impact from certification has been a dramatic improvement in quality and consistency. Sharretts now uses consistent operating procedures to run the shop, and customized line manuals for each plating line. The fall-out rate for scrap and re-processed material has been reduced from nearly 50% to about 3%. Production capability has increased by more than 30%, and material costs have been reduced by nearly 45%. Effective management, planning, and scheduling have replaced crisis management as a way of doing business at Sharretts.

Material Cost Reduction

Previously, Sharretts had no computerized system for budgeting or effectively monitoring material purchases. In 1997, the company implemented an aggressive Budget Tracking and Purchasing system using Microsoft Office 97 (Access, Word, Excel, PowerPoint) software package. The system allows Sharretts to project costs six weeks in advance; implement corrections before a financial crisis develops; and operate with a more positive cash flow by assigning budgets to specific areas. In addition, budget planning eliminates crisis management and enables the company to spend more time costing out materials for the best price. Purchase approvals now require at least three sources for review prior to approval. Sharretts selects sources from the Thomas

Register and other comparable references, and will soon begin using the Internet to identify potential sources.

The computerized system generates a Flash Report which tracks a broad range of data on a weekly basis. In addition to standard accounting information (e.g., sales, orders, payroll, accounts receivable, disbursements), the report tracks key indicators such as chemistry usage and purchases; waste treatment costs and data; maintenance and repair part costs; quality status including scrap and rework; and utilization data for each production line. Since the software permits the books to be closed out every week, management keeps abreast of changes and can react appropriately.

Through its Budget Tracking and Purchasing system, Sharretts has improved its control capabilities for budgeting and purchasing, and can easily implement planning improvements for the plant's operations. These efficiencies, combined with more effective production monitoring, have produced significant improvements such as the overall productivity of Sharretts' zinc-plating processes which have increased by more than 33%.

Section 3

Information

Production

Innovative Chromate Reduction

Chromium has been identified as a particularly toxic metal. As a result, environmental and safety concerns have increased in regard to chromium usage and employee exposure. In the plating industry, chromium is typically used in its hexavalent form since it produces quality results and allows the metal to be plated out of solution. However, Sharretts has successfully changed to chromium's more benevolent form, trivalent, for most of its chromium requirements.

By using the trivalent form, Sharretts has reduced the total chromate concentration in its waste water stream, and can save on chemical costs (e.g., sulfuric acid, sodium metabisulfite) by bypassing the section of the waste water system where the chromium hexavalent is chemically treated. During the plating process, this section can still be used if a customer requests a chromium hexavalent finish. Currently, Sharretts uses the trivalent form in 95% of its chromium-plating work.

Innovative Stripping

Sharretts previously used acid for stripping its defective zinc-plated parts. However, this method created excessive foaming. The company now uses an alkaline stripper which works well in this application. The stripper is an alkaline powder that is dissolved in water. The parts are treated by immersing them into the stripper solution. Within a minute, the solution will remove 0.0005 inch of zinc plating from the part.

Since it produces no black smut during the stripping process, the stripper is very effective for stripping barrel-plated parts. In addition, the stripper does not generate irritating or corrosive fumes, and will not tarnish or etch the finest steel finish. Springs and other hardened stock may be stripped without endangering hardness because hydrogen embrittlement will not occur by using this stripper. As a long lasting solution, the stripper only needs to be discarded when the dissolved zinc exceeds one pound per gallon. Once this occurs, the stripper solution is neutralized (pH 7 to 8), and then disposed into the sewer. By switching to an alkaline stripper, Sharretts has improved its stripping process for zinc-plated parts.

Management

Employee Involvement

Throughout most of Sharretts' history, employee involvement has traditionally been very strong. Most employees stayed with the company for a long time. Gradually over time, this base of long-term employees was replaced by younger, more transient, and less-educated employees. As the workforce's nature changed, work ethics and employee loyalty eroded throughout the company. In addition, the region's low unemployment and a shortage of qualified candidates complicated Sharretts' ability to attract and retain knowledgeable, dedicated employees.

In response to these developments, Sharretts established a formal employee involvement program. Weekly management meetings are held between the plant manager and key area supervisors. Participants review the events from the preceding week and discuss plans for the upcoming week. Improved communication throughout the plant and overall awareness of operations and requirements are the main benefits gained from these meetings. Sharretts' management team also examines ways to increase employee participation. Various employee suggestion and recognition programs have been tried in the past with limited success.

Sharretts recognizes training as an important aspect of employee development and involvement. Prior to undergoing ISO-9002 certification three years ago, the company did not have a formal training program for its employees. Now, Sharretts has established a formal program to cross-train its employees. The training program allows employees to get involved in more aspects of the plant's operations, and gives the company greater flexibility for meeting its customers' requirements.

Weekly meetings of the plant's maintenance personnel have also been established to review ongoing maintenance requirements, identify needed improvements, and plan future maintenance projects. These meetings enable Sharretts to improve its management of maintenance resources, effectively plan for preventive maintenance, help contain maintenance costs, and efficiently increase its operations.

Employee involvement initiatives are just beginning at Sharretts. Future efforts will focus on developing greater involvement and participation by all employees in the plant.

Safety Program

Sharretts formalized its safety program in 1997. Previously, a safety program existed, but was not formally documented. Although the company has been very fortunate in recent years regarding serious injuries or significant safety-related problems, an injury accident occurred in 1996 and pinpointed the need for additional safety management and training.

The program at this stage is very basic. Sharretts appointed a safety manager to implement and develop the program. The safety manager, a senior management employee, performs the safety responsibilities as a collateral task. The program has direct involvement and participation of the plant manager. Weekly safety meetings are conducted and include the participation of management staff and shop floor personnel. At the meetings, participants discuss safety issues and identify needed improvements. The safety committee maintains minutes and action items at each meeting.

The safety committee has recognized the need for fundamental safety policies and procedures, and is actively identifying and implementing them throughout the company. One policy involved the establishment and enforcement of safety glasses in the shop area. The safety program focuses on employees' awareness of safety issues and their understanding of the importance of safe operating procedures. The safety committee also produces its own laminated safety signs and posters using PC-based graphics software. Another measure adopted in 1997 by the committee is a formal training and certification program for forklift operators. The company purchased forklift operator training materials including a video, and has certified all of its forklift operators.

Although its safety program is still developing, Sharretts has effectively increased employee safety awareness and instituted basic safety requirements. Future efforts will continue to focus on identifying and implementing needed safety policies and programs. The safety committee is examining methods to establish a drug-testing program for employees. These initiatives are creating a safer environment at Sharretts.

Appendix A

Table of Acronyms

No Acronyms were used in this survey report.

Appendix B

BMP Survey Team

Team Member	Activity	Function
Larry Robertson (812) 854-5336	**Crane Division** **Naval Surface Warfare Center** Crane, IN	**Team Chairman**
Caryl Lummis (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Technical Writer**

Team

Rick Purcell (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Team Leader**
Paul Gietka (410) 706-3233	**University of Maryland** Engineering Research Center Baltimore, MD	

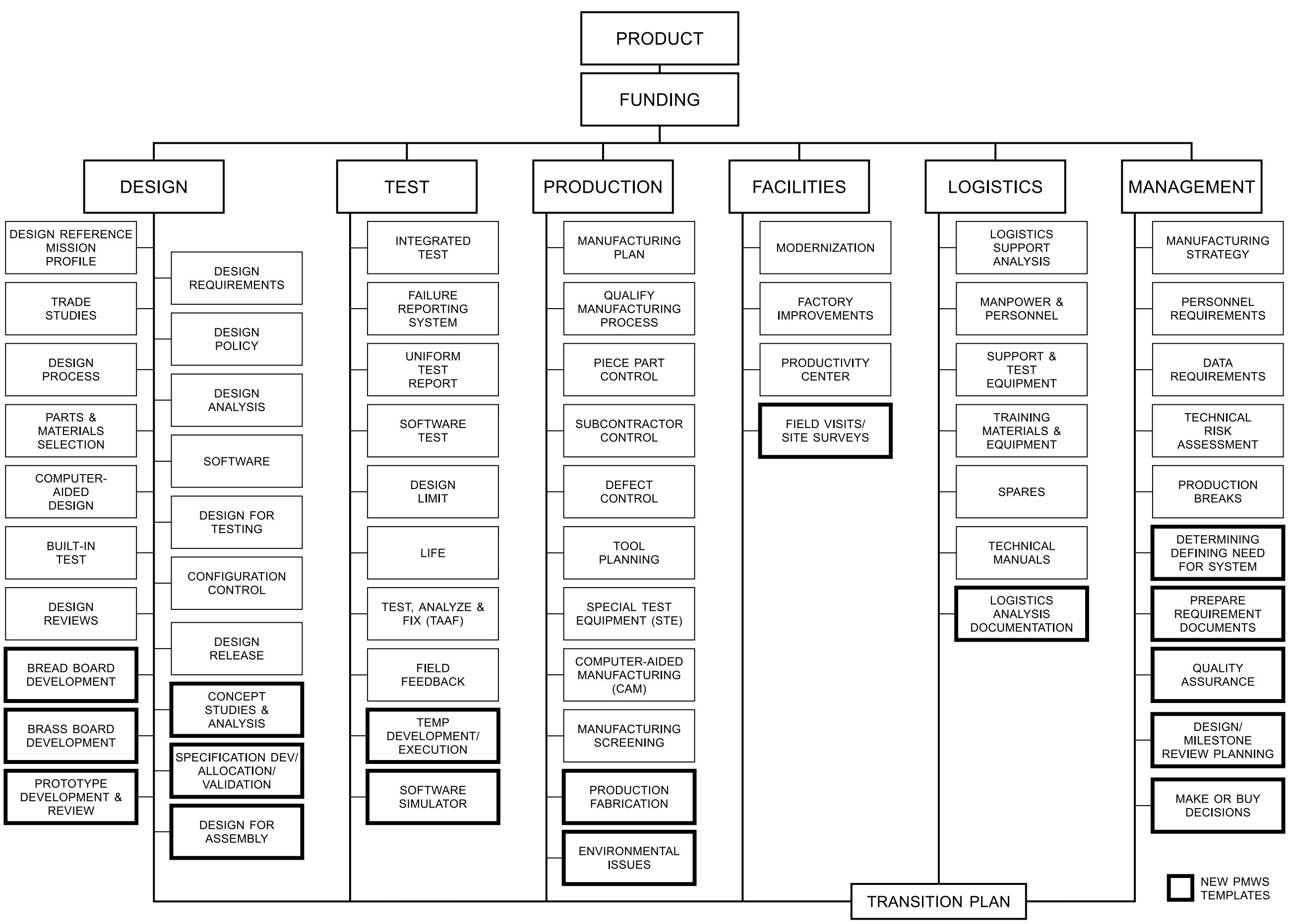
Appendix C

Critical Path Templates and BMP Templates

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, *Transition from Development to Production* document. This publication defines the proper tools—or templates—that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition process by addressing it as an *industrial* process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"

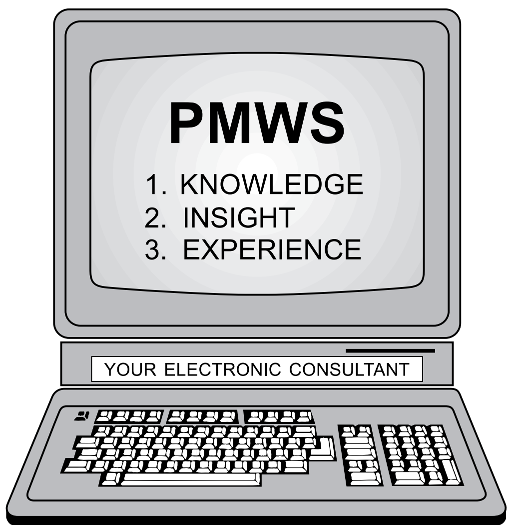


Appendix D

BMPnet and the Program Manager's WorkStation

The BMPnet, located at the Best Manufacturing Practices Center of Excellence (BMPCOE) in College Park, Maryland, supports several communication features. These features include the Program Manager's WorkStation (**PMWS**), electronic mail and file transfer capabilities, as well as access to Special Interest Groups (SIGs) for specific topic information and communication. The BMPnet can be accessed through the World Wide Web (at http://www.bmpcoe.org), through free software that connects directly over the Internet or through a modem. The PMWS software is also available on CD-ROM.

PMWS provides users with timely acquisition and engineering information through a series of interrelated software environments and knowledge-based packages. The main components of PMWS are KnowHow, SpecRite, the Technical Risk Identification and Mitigation System (TRIMS), and the BMP Database.



KnowHow is an intelligent, automated program that provides rapid access to information through an intelligent search capability. Information currently available in KnowHow handbooks includes Acquisition Streamlining, Non-Development Items, Value Engineering, NAVSO P-6071 (Best Practices Manual), MIL-STD-2167/2168 and the DoD 5000 series documents. KnowHow cuts document search time by 95%, providing critical, user-specific information in under three minutes.

SpecRite is a performance specification generator based on expert knowledge from all uniformed services. This program guides acquisition personnel in creating specifications for their requirements, and is structured for the build/approval process. SpecRite's knowledge-based guidance and assistance structure is modular, flexible, and provides output in MIL-STD 961D format in the form of editable WordPerfect® files.

TRIMS, based on DoD 4245.7-M (the transition templates), NAVSO P-6071, and DoD 5000 event-oriented acquisition, helps the user identify and rank a program's high-risk areas. By helping the user conduct a full range of risk assessments throughout the acquisition process, TRIMS highlights areas where corrective action can be initiated before risks develop into problems. It also helps users track key project documentation from concept through production including goals, responsible personnel, and next action dates for future activities.

The **BMP Database** contains proven best practices from industry, government, and the academic communities. These best practices are in the areas of design, test, production, facilities, management, and logistics. Each practice has been observed, verified, and documented by a team of government experts during BMP surveys.

Access to the BMPnet through dial-in or on Internet requires a special modem program. This program can be obtained by calling the BMPnet Help Desk at (301) 403-8179 or it can be downloaded from the World Wide Web at http://www.bmpcoe.org. To receive a user/e-mail account on the BMPnet, send a request to helpdesk@bmpcoe.org.

Appendix E

Best Manufacturing Practices Satellite Centers

There are currently six Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; identify regional experts for inclusion in the BMPnet SIG e-mail; and train regional personnel in the use of BMP resources such as the BMPnet.

The six BMP satellite centers include:

California

Chris Matzke
BMP Satellite Center Manager
Naval Warfare Assessment Division
Code QA-21, P.O. Box 5000
Corona, CA 91718-5000
(909) 273-4992
FAX: (909) 273-4123
cmatzke@bmpcoe.org

Jack Tamargo
BMP Satellite Center Manager
257 Cottonwood Drive
Vallejo, CA 94591
(707) 642-4267
FAX: (707) 642-4267
jtamargo@bmpcoe.org

District of Columbia

Margaret Cahill
BMP Satellite Center Manager
U.S. Department of Commerce
14th Street & Constitution Avenue, NW
Room 3876 BXA
Washington, DC 20230
(202) 482-8226/3795
FAX: (202) 482-5650
mcahill@bxa.doc.gov

Illinois

Thomas Clark
BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114
(815) 654-5515
FAX: (815) 654-4459
adme3tc@rvcux1.rvc.cc.il.us

Pennsylvania

Sherrie Snyder
BMP Satellite Center Manager
MANTEC, Inc.
P.O. Box 5046
York, PA 17405
(717) 843-5054, ext. 225
FAX: (717) 854-0087
snyderss@mantec.org

Tennessee

Tammy Graham
BMP Satellite Center Manager
Lockheed Martin Energy Systems
P.O. Box 2009, Bldg. 9737
M/S 8091
Oak Ridge, TN 37831-8091
(423) 576-5532
FAX: (423) 574-2000
tgraham@bmpcoe.org

Appendix F

Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Sciences and Technology Program established the following Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and Navy centers and laboratories. These COEs are consortium-structured for industry, academia, and government involvement in developing and implementing technologies. Each COE has a designated point of contact listed below with the individual COE information.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and promote exemplary manufacturing and business practices and to disseminate this information to the U.S. Industrial Base. The BMPCOE was established by the Navy's BMP program, Department of Commerce's National Institute of Standards and Technology, and the University of Maryland at College Park, Maryland. The BMPCOE improves the use of existing technology, promotes the introduction of improved technologies, and provides non-competitive means to address common problems, and has become a significant factor in countering foreign competition.

Point of Contact:
Mr. Ernie Renner
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
(301) 403-8100
FAX: (301) 403-8180
ernie@bmpcoe.org

Center of Excellence for Composites Manufacturing Technology

The Center of Excellence for Composites Manufacturing Technology (CECMT) provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors. The CECMT is managed by the GreatLakes Composites Consortium and represents a collaborative effort among industry, academia, and government to develop, evaluate, demonstrate, and test composites manufacturing technologies. The technical work is problem-driven to reflect current and future Navy needs in the composites industrial community.

Point of Contact:
Dr. Roger Fountain
Center of Excellence for Composites Manufacturing Technology
103 Trade Zone Drive
Suite 26C
West Columbia, SC 29170
(803) 822-3705
FAX: (803) 822-3730
rfglcc@glcc.org

Electronics Manufacturing Productivity Facility

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of industry, university, and government participants, led by the American Competitiveness Institute under a CRADA with the Navy.

Point of Contact:
Mr. Alan Criswell
Electronics Manufacturing Productivity Facility
Plymouth Executive Campus
Bldg 630, Suite 100
630 West Germantown Pike
Plymouth Meeting, PA 19462
(610) 832-8800
FAX: (610) 832-8810
http://www.engriupui.edu/empf/

National Center for Excellence in Metalworking Technology

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. The NCEMT, operated by Concurrent Technologies Corporation, helps the Navy and defense contractors improve manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

Point of Contact:
Mr. Richard Henry
National Center for Excellence in Metalworking Technology
1450 Scalp Avenue
Johnstown, PA 15904-3374
(814) 269-2532
FAX: (814) 269-2799
henry@ctc.com

Navy Joining Center

The Navy Joining Center (NJC) is operated by the Edison Welding Institute and provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues.

Point of Contact:
Mr. David P. Edmonds
Navy Joining Center
1100 Kinnear Road
Columbus, OH 43212-1161
(614) 487-5825
FAX: (614) 486-9528
dave_edmonds@ewi.org

Energetics Manufacturing Technology Center

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality energetics. The focus of the EMTC is on process technology with a goal of reducing manufacturing costs while improving product quality and reliability. The COE also maintains a goal of development and implementation of environmentally benign energetics manufacturing processes.

Point of Contact:
Mr. John Brough
Energetics Manufacturing Technology Center
Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035
(301) 743-4417
DSN: 354-4417
FAX: (301) 743-4187
mt@command.nosih.sea06.navy.mil

Manufacturing Science and Advanced Materials Processing Institute

The Manufacturing Science and Advanced Materials Processing Institute (MS&AMPI) is comprised of three centers including the National Center for Advanced Drivetrain Technologies (NCADT), The Surface Engineering Manufacturing Technology Center (SEMTC), and the Laser Applications Research Center (LaserARC). These centers are located at The Pennsylvania State University's Applied Research Laboratory. Each center is highlighted below.

Point of Contact for MS&AMPI:
Mr. Henry Watson
Manufacturing Science and Advanced Materials Processing Institute
ARL Penn State
P.O. Box 30
State College, PA 16804-0030
(814) 865-6345
FAX: (814) 863-1183
hew2@psu.edu

- **National Center for Advanced Drivetrain Technologies**
  The NCADT supports DoD by strengthening, revitalizing, and enhancing the technological capabilities of the U.S. gear and transmission industry. It provides a site for neutral testing to verify accuracy and performance of gear and transmission components.

  Point of Contact for NCADT:
  Dr. Suren Rao
  NCADT/Drivetrain Center
  ARL Penn State
  P.O. Box 30
  State College, PA 16804-0030
  (814) 865-3537
  FAX: (814) 863-6185
  http://www.arl.psu.edu/drivetrain_center.html/

- **Surface Engineering Manufacturing Technology Center**

  The SEMTC enables technology development in surface engineering—the systematic and rational modification of material surfaces to provide desirable material characteristics and performance. This can be implemented for complex optical, electrical, chemical, and mechanical functions or products that affect the cost, operation, maintainability, and reliability of weapon systems.

  Point of Contact for SEMTC:
  Dr. Maurice F. Amateau
  SEMTC/Surface Engineering Center
  P.O. Box 30
  State College, PA 16804-0030
  (814) 863-4214
  FAX: (814) 863-0006
  http://www/arl.psu.edu/divisions/arl_org.html

- **Laser Applications Research Center**

  The LaserARC is established to expand the technical capabilities of DOD by providing access to high-power industrial lasers for advanced material processing applications. LaserARC offers basic and applied research in laser-material interaction, process development, sensor technologies, and corresponding demonstrations of developed applications.

  Point of Contact for LaserARC:
  Mr. Paul Denney
  Laser Center
  ARL Penn State
  P.O. Box 30
  State College, PA 16804-0030
  (814) 865-2934
  FAX: (814) 863-1183
  http://www/arl.psu.edu/divisions/arl_org.html

Gulf Coast Region Maritime Technology Center

The Gulf Coast Region Maritime Technology Center (GCRMTC) is located at the University of New Orleans and will focus primarily on product developments in support of the U.S. shipbuilding industry. A sister site at Lamar University in Orange, Texas will focus on process improvements.

Point of Contact:
Dr. John Crisp
Gulf Coast Region Maritime Technology Center
University of New Orleans
Room N-212
New Orleans, LA 70148
(504) 286-3871
FAX: (504) 286-3898

Appendix G

Completed Surveys

As of this publication, 94 surveys have been conducted and published by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMPnet. Requests for copies of recent survey reports or inquiries regarding the BMPnet may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd., Suite 400
College Park, MD 20740
Attn: Mr. Ernie Renner, Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180
ernie@bmpcoe.org

1985	Litton Guidance & Control Systems Division - Woodland Hills, CA
1986	Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (Alliant TechSystems, Inc.) Texas Instruments Defense Systems & Electronics Group - Lewisville, TX General Dynamics Pomona Division - Pomona, CA Harris Corporation Government Support Systems Division - Syosset, NY IBM Corporation Federal Systems Division - Owego, NY Control Data Corporation Government Systems Division - Minneapolis, MN
1987	Hughes Aircraft Company Radar Systems Group - Los Angeles, CA ITT Avionics Division - Clifton, NJ Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA UNISYS Computer Systems Division - St. Paul, MN (Paramax)
1988	Motorola Government Electronics Group - Scottsdale, AZ General Dynamics Fort Worth Division - Fort Worth, TX Texas Instruments Defense Systems & Electronics Group - Dallas, TX Hughes Aircraft Company Missile Systems Group - Tucson, AZ Bell Helicopter Textron, Inc. - Fort Worth, TX Litton Data Systems Division - Van Nuys, CA GTE C^3 Systems Sector - Needham Heights, MA
1989	McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO Northrop Corporation Aircraft Division - Hawthorne, CA Litton Applied Technology Division - San Jose, CA Litton Amecom Division - College Park, MD Standard Industries - LaMirada, CA Engineered Circuit Research, Incorporated - Milpitas, CA Teledyne Industries Incorporated Electronics Division - Newbury Park, CA Lockheed Aeronautical Systems Company - Marietta, GA Lockheed Corporation Missile Systems Division - Sunnyvale, CA Westinghouse Electronic Systems Group - Baltimore, MD General Electric Naval & Drive Turbine Systems - Fitchburg, MA Rockwell International Corporation Autonetics Electronics Systems - Anaheim, CA TRICOR Systems, Incorporated - Elgin, IL
1990	Hughes Aircraft Company Ground Systems Group - Fullerton, CA TRW Military Electronics and Avionics Division - San Diego, CA MechTronics of Arizona, Inc. - Phoenix, AZ Boeing Aerospace & Electronics - Corinth, TX Technology Matrix Consortium - Traverse City, MI Textron Lycoming - Stratford, CT

1991	*Resurvey of Litton Guidance & Control Systems Division* - Woodland Hills, CA Norden Systems, Inc. - Norwalk, CT Naval Avionics Center - Indianapolis, IN United Electric Controls - Watertown, MA Kurt Manufacturing Co. - Minneapolis, MN MagneTek Defense Systems - Anaheim, CA Raytheon Missile Systems Division - Andover, MA AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ *Resurvey of Texas Instruments Defense Systems & Electronics Group* - Lewisville, TX
1992	Tandem Computers - Cupertino, CA Charleston Naval Shipyard - Charleston, SC Conax Florida Corporation - St. Petersburg, FL Texas Instruments Semiconductor Group Military Products - Midland, TX Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA Watervliet U.S. Army Arsenal - Watervliet, NY Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA Computing Devices International - Minneapolis, MN *(Resurvey of Control Data Corporation Government Systems Division)* Naval Aviation Depot Naval Air Station - Pensacola, FL
1993	NASA Marshall Space Flight Center - Huntsville, AL Naval Aviation Depot Naval Air Station - Jacksonville, FL Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN McDonnell Douglas Aerospace - Huntington Beach, CA Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY Philadelphia Naval Shipyard - Philadelphia, PA R. J. Reynolds Tobacco Company - Winston-Salem, NC Crystal Gateway Marriott Hotel - Arlington, VA Hamilton Standard Electronic Manufacturing Facility - Farmington, CT Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Melbourne, FL United Defense, L.P. Ground Systems Division - San Jose, CA Naval Undersea Warfare Center Division Keyport - Keyport, WA Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA Kaiser Electronics - San Jose, CA U.S. Army Combat Systems Test Activity - Aberdeen, MD Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM Rockwell Defense Electronics Collins Avionics & Communications Division - Cedar Rapids, IA *(Resurvey of Rockwell International Corporation Collins Defense Communications)* Lockheed Martin Electronics & Missiles - Orlando, FL McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO *(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)* Dayton Parts, Inc. - Harrisburg, PA Wainwright Industries - St. Peters, MO Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX *(Resurvey of General Dynamics Fort Worth Division)* Lockheed Martin Government Electronic Systems - Moorestown, NJ Sacramento Manufacturing and Services Division - Sacramento, CA JLG Industries, Inc. - McConnellsburg, PA
1996	City of Chattanooga - Chattanooga, TN Mason & Hanger Corporation - Pantex Plant - Amarillo, TX Nascote Industries, Inc. - Nashville, IL Weirton Steel Corporation - Weirton, WV NASA Kennedy Space Center - Cape Canaveral, FL Department of Energy, Oak Ridge Operations - Oak Ridge, TN

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL SAE International and Performance Review Institute - Warrendale, PA Polaroid Corporation - Waltham, MA Cincinnati Milacron, Inc. - Cincinnati, OH Lawrence Livermore National Laboratory - Livermore, CA Sharretts Plating Company, Inc. - Emigsville, PA