approval is received, engineering then forwards it to the production floor.

Solidworks offers a quantum improvement over previously used AutoCAD, permitting much faster design completion and verification by the engineering team. This in turn quickly sets the stage for same-day manufacturing and shipping. Physical proximity and easy access to the engineers by production personnel also reduces potential confusion and enables rapid correction of rare design errors.

While the engineering design process appears to be as rapid as currently possible, Inpro/Seal continues to study new ways to improve its already impressive design-to-production process.

On-Site Research and Experimentation

The Inpro / Seal Company developed a test facility where quantitative tests could be conducted with repeatability to measure the improvement provided by various proposed design changes. Having this process and on-site test capability has resulted in more rapid fielding of successful upgrades that meet customer needs in various and frequently adverse operating environments.

The Inpro/Seal Company of Rock Island, Illinois, is a leading producer of bearing isolators for rotating equipment. Inpro/Seal bearing isolators replace traditional rotating equipment seals. The company previously had few or any existing standards for comparing the performance of rotating equipment seals in various adverse operating environments. Few standards existed for determining the effectiveness of seals and bearing isolators in keeping contaminants out while retaining lubricating oil. The performance measures that existed were often pass or fail and provided no measure of relative performance.

As part of an ongoing product improvement effort to maintain the company's position as a leading supplier of long-lasting bearing isolators, Inpro/Seal developed an innovative research and experimentation program. A test facility was developed where quantitative tests could be conducted and repeated to measure the improvement provided by various proposed design changes. Test rigs to determine resistance to water intrusion, dust and dirt intrusion, and lubricant retention were developed. The water intrusion test determines (with repeatable results) the water-sealing capability of seals at different water velocities and various shaft rpms.

A test bed to test Inpro/Seal's new "Air Mizer" articulating bearing isolator was also developed and used with success. The research and experimentation test facilities were married up with a process of providing beta versions of new bearing isolators to volunteer customers for field testing under actual conditions. Inpro/Seal encouraged participation by guaranteeing satisfaction (and replacement of the bearing isolator if necessary) while allowing the participating companies a 120-day delayed payment plan to ensure they were satisfied with the new product. To date the experimentation facility and associated process have supported successful incremental design upgrades to the isolation capability of Inpro/Seal's initial bearing isolator line and has further resulted in a breakthrough new line of articulating bearing isolators. Having this process and on-site test capability have resulted in more rapid fielding of successful upgrades that meet customer needs as opposed to a trial-and-error approach in which upgrades are sent directly to field testing without the intermediate quantifiable lab experimentation currently used by Inpro/Seal.

Test

Innovative Test Procedures

Inpro / Seal has developed and uses innovative test procedures, test stands, and fixtures that far exceed industry requirements for the testing of electrical motors for water and dust resistance. Customers can now develop true life cycle cost for building and maintaining their products with data provided them by Inpro / Seal.

The Inpro/Seal Company of Rock Island, Illinois, is a manufacturer of bearing isolators or non-contact seals for use on any rotating shaft motor that must have the bearings protected from leakage of bearing lubricant or incursion of contaminants into the bearings. As one of the premier manufacturers of non-contact isolators, the company is always striving to develop procedures, processes, and equipment to improve and ensure the quality of its products.

The International Protection (IP) Code testing is the currently accepted test for degrees of protection for electrical enclosures. Inpro/Seal feels that this test method, while internationally accepted, fails to fully test the degree of protection afforded motor bearings. The test methods normally used by the

majority of industry are subjective in nature, providing only a pass or fail rating without meaningful metrics of the result. Inpro/Seal has developed test procedures and equipments that far exceed the requirements of the IP Codes. Through the use of its test procedures and in-house-built equipment, Inpro/Seal can now quantify or express the different tests in meaningful or empirical terms. The company also demonstrates repeatability for the testing process and uses hard metrics to address shortcomings. Inpro/Seal's philosophy is to test each product until it fails versus testing only to see if it passes. By testing product until there is a failure and analyzing the data from the test results, Inpro/Seal ensures that a given design will always pass the IP Code rating. This offers the company's customers a guarantee of the degree of protection and expected life expectancy its bearing isolators provide, which gives the end user a tool to develop a true life cycle cost of its end-use equipment. By having and using fixed tooling, test stands, procedures, and empirical data, Inpro/Seal can now accurately predict expected results when modifying existing designs or developing new designs for new non-contact bearing isolator applications.

International Electrotechnical Commission Test Stand

The Inpro/Seal Company has successfully reduced both cost and time by developing in-house testing to establish the ability of its seals to withstand dust and moisture, which has resulted in significant savings to its customers. Inpro/Seal previously relied on other companies to provide this testing and to provide an International Protection Code in accordance with standards from the International Electrotechnical Commission.

The industry standard for testing electrical enclosures is provided by the International Electrotechnical Commission (IEC). The standard provides methods to obtain an International Protection (IP) Code. The Inpro/Seal Company formerly relied on outside testing laboratories to perform tests on its bearing isolators in accordance with IEC standards. The tests consisted of subjective methods to determine whether or not the bearing isolators met certain standards for withstanding dust and moisture, after which an IP Code was assigned to the bearing isolator. These tests were both extremely costly ($40,000/test) and time consuming.

To better serve its customers, the Inpro/Seal Company developed in-house test stands that meet the IEC standards. To ensure the tests could be reproduced consistently, improvements were made that consisted of a standardized test stand and a defined angle at which testing was performed, enabling Inpro/Seal to greatly reduce the cost and time to acquire an IP Code rating. The test stand consists of a variable-speed motor, tachometers, variable-velocity water jets, a fixed-position stand, variable-angle water jets, and specialized equipment for dust-protection testing.

Inpro/Seal's tests provide repeatable testing, save money, and reduce the time required to perform the tests. In-house testing has also enabled Inpro/Seal to perform testing independent of external company-provided testing.

Production

Low Technologies That Work

The Inpro/Seal Company employs various low-technology solutions in its production cycle that save time and money on the shop floor. These solutions enable new employees to learn the processes more quickly while reducing confusion on the shop floor.

The Inpro/Seal Company uses several different low-technology solutions to solve several of its production problems and needs. These low-technology solutions are not temporary fixes but are time-tested solutions that keep production moving while helping to reduce production time and cost. Some of these simple solutions, along with streamlined production of parts, have helped Inpro/Seal to incur a cost increase of only 9% in the past seven years.

Simple color-coding is the first low technology that helps designate how much of the production process needs to be completed for an order. Blue paper is used for orders for parts that are currently in stock to prevent them from being reproduced and from wasting floor time. Yellow paper is used for isolator orders that already have parts in stock but need to enter final assembly before shipping. White paper is used for regular orders that need to proceed through the entire production process, from design to shipping. White forms

may receive a red-colored "hot" sticker that indicates they are priority orders in the production cells.

Color-coding is used in more than one area of the shop. The stock material is labeled with color codes to differentiate various types of steel. Since the two types of steel commonly used by Inpro/Seal are physically similar in appearance, it was decided to mark each type of stock with a color code to prevent any mistaken material identity. Stainless 303 is currently marked with red and stainless 316 is marked with green directly on the stock of each before being placed in a bin at a cell. This quick and simple coding method prevents many costly mistakes. Color-coding material is also applied to waste material. Since bronze scrap is recycled, the pure or "clean" bronze scrap is placed into barrels marked with a bright green color so that bronze with no contaminants can by sent to the recycling plant. This cost-effective process enables Inpro/Seal to receive a larger return since there are no foreign materials to be removed from its scrap.

A major innovation at Inpro/Seal is its parts cleaning process, which is actually a downgrade from a previous process during which parts had to be placed on a line, go through a cleaner, then ride on a conveyer belt while drying. This process was expensive due to energy consumed by the machine, time to load parts into the machine, and time wasted cleaning scraps out of the machine. This process has been replaced with a bucket of water containing water softener at each machine in the shop. As parts are completed by CNC machines or mills, they are blown off with air and dunked into the bucket of water. The air generally blows off any scrap material, while the water softener removes any cutting fluids from the tooling process without leaving any watermarks. This simple approach has been found to be cheaper and more effective than a parts cleaner designed to perform the same job. In the near future, the old parts cleaner is to be removed from the shop floor, freeing space for more production machines and other cells on the floor. Inpro/Seal hopes to sell the original cleaner assembly, which will partially pay for removal of the machine.

Even while using the more complicated tools in the shop, Inpro/Seal finds a way to simplify its process and keep it moving smoothly. Every part that comes into the company's programming department is designed to match the tooling of the CNC machines currently running. The programming department is responsible for writing the programs for CNC machines to design. This simplifies the process of machining parts by reducing the number of tool changes performed on the shop floor. This also helps to standardize designs and make the actual designing of the part run more quickly and efficiently.

Though there are many complicated machines used to cut the product out of raw stock, only a screwdriver that has been bent 90° and its sharp edges ground off is used to assemble the isolators. This simple tool allows the O-rings to quickly and easily be inserted into the parts without the need to have a custom tool created. These tools are also given to regional sales representatives to perform on-site fixes or final assembly demonstrations.

Simple setups are also used in the test lab area where all test stands and test setups are designed and created in house. This saves Inpro/Seal thousands of dollars that would be otherwise be spent on buying expensive test setups created by an outside company. Most of these test setups are simple by design yet perform their tests accurately. In-house ingenuity can be attributed to the effective use of materials to perform a multitude of tests, including the industry standard International Protection (IP) Code test.

Several software programs have also been effectively used at Inpro/Seal to save money on the purchase of expensive programs, save money on keeping licenses current, and save time using/training employees to use the program. Instead of using an expensive and complicated production planning software, Inpro/Seal uses a simple software tool that sends each job request to its appropriate destination and tracks the status of jobs in the production process. When an order comes from sales or engineering, a production manager receives the order on a screen in his/her office; if needed, the programming office also receives this order. The order is sent to a production cell to be completed, then to final assembly and shipping. This simple software allows the process to be tracked and standardized by creating a prioritized list of orders that must be completed to the appropriate shop locations and updating the locations using barcodes.

The tooling inventory program is also simplified. A simple Excel spreadsheet with read-only access in the cells is used by operators to ensure that all of their tools are in their cell everyday.

The spreadsheet indicates how many of the requisite tool sizes should be located in each cell; this information can be updated in the programming office if needed. The spreadsheet also contains embedded links to the procedures and standards for changing each tool. This helps even the inexperienced operators find the proper way to perform tooling changes without needing a hardcopy manual in the cell.

Inpro/Seal's use of low technologies in the production cycle has been economically advantageous while reducing production time.

Machine Cell Specification

Cell specialization based on similar products rather than similar processes has significantly increased the production capabilities at the Inpro/Seal Company. Cells creating similar products require less tooling changes and reduce machine downtime.

The Inpro/Seal Company implements several cell specification techniques to increase productivity by reducing the amount of machine downtime during production. This process is used to optimize production and increases one-day turnaround for which the company is known. Several different methods are employed to achieve specialization on various levels that reduce the manpower required for high-volume production or increase the efficiency of lower-volume production. Much of this specification is already being implemented, with one type of high-volume specification emerging in the near future.

The initial type of cell specification within Inpro/Seal's manufacturing process relates to the material used in the production of an order. Inpro/Seal creates its isolators using two basic materials – stainless steel and bronze (the primary material). Since these two materials have very different properties and fewer steel parts are made, there is a specific cell dedicated to steel parts. This separation and cell specialization reduces downtime for CNC machines used for tooling since there are less tooling changes on each machine. This separation also helps to increase the life of cutting tools used for production of bronze isolators since bronze is a relatively soft metal. Because the steel cutting tools in the machines need to be changed more often, the tools in this cell are also fitted with quick adapters to reduce downtime of the machine. The adapters and lower-rate production of this cell also lend it to perform more custom production, freeing up the rest of the plant for normal production. The separation of material also increases the return on bronze scraps by $.05 per pound, since recycling of "clean" or uncontaminated pure bronze scraps yields a higher return.

Cells are also specialized by the tooling required for a specific design. By assigning only those models that require a specified or very similar tooling, machine downtime is greatly reduced. When switching from one design to another, tooling changes can take up to 45 minutes before a machine is up and running again. Without tooling changes, the same machine will take only 7-8 minutes to prepare for the next model/design. This keeps machines up and running longer and greatly decreases downtime. This decreased downtime is apparent in the fact that on average, 2.8 of the 3 machines in a typical cell are running all 8 hours per shift. Operators in these cells will also organize the orders in their cell to finish those using the same stock sizes to further reduce the time for tooling changes.

This order can be compromised by so-called "hot" orders sent into the cell, supporting a pull system within the cell. Even though the operator can organize longer-term jobs to create a more efficient schedule for tooling changes, some orders take priority due to schedule constraints and will be moved up in the queue. "Hot" orders are sent to a specific cell that is most capable of completing the order quickly so the change in queue order will not disrupt the production of the other orders within the cell. Queue changing ensures that priority orders are accelerated and pulled to shipping from the cell specialized to expedite the order.

Inpro/Seal also makes use of specialization for the quantity required for production in one order. There is currently one cell dedicated to only high-production, low-margin orders. This cell contains four CNC machines that perform all of the lathe work and milling for either rotor or stator in one machine all controlled by one operator. All four machines are equipped with bar feeders to allow longer pieces of stock to be loaded into each machine. With stock loaded and the program set on the machine, these machines can be left to create the number of parts needed. This allows the operator to run each machine while still having time to clean the parts and perform final assembly and quality control by spot-checking some parts. A quality control/ final assembly person also works in the cell performing

dimension checks and assembling cleaned parts from the operators. This one cell currently produces almost half of the total parts produced each month. In the near future another cell will be added to complement the work done by this cell and increase production for large orders.

Since there is a cell specifically dedicated to high-level production runs, there must be a cell dedicated to one-offs and very low-volume production runs. Custom jobs are mostly accomplished in a manual-tooling cell. Here there are manual lathes and mills to complete jobs that would require tooling changes elsewhere. Rather than shutting down a CNC machine to change tooling for a single part, the manual tools are used to keep the other cells productive. This helps to keep machine downtime to a minimum while still completing small custom orders in a timely fashion. Manual cells follow the same procedures as the other cells, including their own quality control.

Control interfaces are also being specialized within cells and throughout the shop/production area. Inpro/Seal is moving toward standardizing the control interface of all new CNC machines to reduce the amount of training required for operators within each cell. Similar interfaces will not only increase production within a cell due to familiarity with the interface but will allow operator flexibility between cells. With similar control interfaces, operation of one machine should not differ much from the operation of a different machine, increasing operator confidence in using multiple machines and keeping the machines working at full speed.

Cell specialization will continue to be used to increase production rates at Inpro/Seal. An experimental cell is currently being used to test new ideas for the in-cell process that will increase productivity and reduce downtime. The specialization will continue to be more product-specific and less process-specific to further increase productivity.

Product Planning Process

The Inpro/Seal Company employs a remarkably efficient and continuous real-time production scheduling process. Using simple network-based software, the production queue is managed via shipping dates, which allows for priority same-day orders to be inserted at or near the top of the queue. Machine downtime is minimized by directing jobs to machine cells based on stock size and tooling similarities. The key to Inpro/Seal's impressive flexibility is placing responsibility for completion of portions of the queue into the hands of the machine operators.

The Inpro/Seal Company in Rock Island, Illinois, produces bearing isolators for rotating machinery. Inpro/Seal has developed a simple and efficient yet highly flexible product planning process that turns out 40,000 units per month and is able to boast same-day shipping of 30% of the company's output.

This pull process is initiated once a design has been translated into machine code for the CNC machine, released by the Production Programming Office, and enters the production queue. This triggers several events. First, the Production Control Office routes the design to one of seven CNC cells based on the material stock-size type and outer diameter to minimize retooling between jobs. Given that many jobs are single units or very small production runs, downtime for retooling is a critical metric at Inpro/Seal. Design release also triggers inventory staging of stock and O-rings at the appropriate production cell. Last, the process clock is started to measure the total time from design release to completion of packaging.

Production Control is responsible for managing the production queue and ensuring orders meet the requested shipping date by apportioning work in the queue to one of seven CNC cells based on stock size and tooling requirements. The simple computer-network-based queue is visible to virtually anyone in the sales and production offices, and any changes or additions are instantly posted. Each CNC cell consists of multiple machines (typically three) operated simultaneously by a crew of one to three operators. Three cells are unique in their orientation – one is reserved for manual machining, one is used for large quantity runs, and one is operated as a lean experimental cell. All three cells, however, can accept work from the queue like any other. The cell operators have the responsibility of managing their own queues. They have the freedom to reorder their queue and assign jobs to any of their machines based on stock size and tooling similarities, with the shipping date driving priorities.

This instant visibility of work in progress and the ability to resequence jobs is one of the key enablers to Inpro/Seal's impressive responsiveness to same-day shipping of the priority orders that constitute 30% of daily production. Upon receipt of a priority order, Production Control inserts it into the queue using the same criteria as any other job. Since the

shipping date drives the pull process, it instantly appears at or near the top of the queue. Associated paperwork receives a red "Must Ship Today" sticker to reinforce the priority status. This simple yet highly efficient handling of all orders – the so-called continuous real-time scheduling – eliminates perturbations in the production process.

As each job enters and leaves machining, milling, final assembly, and shipping, it is logged in and out using a simple barcode-based tracking system. The status of any job can be instantly determined; if adjustments are necessary to the design or production run, the job can be removed, altered, and reinserted into the queue. The tracking system also allows Inpro/Seal to determine and track several key metrics – machine time versus process time, and machine cell operation time versus operator work hours. The company's goal is to drive overall process time as close to actual machine time (including final hand assembly), minimizing the time that partial assemblies sit idle. The second metric, the ratio of machine cell operation to operator work hours, currently stands at 2.8:1 for a three-machine cell. This means that for each hour an operator is on the job, a total of 12 minutes of downtime is spread across his or her three machines (or an average of only four minutes of downtime per machine per hour).

Inpro/Seal has reached a remarkably high level of efficiency in its production process by using simple software tracking tools, remaining flexible at all points in the process and placing control of the process and responsibility for meeting customer deadlines in the hands of the machine operators.

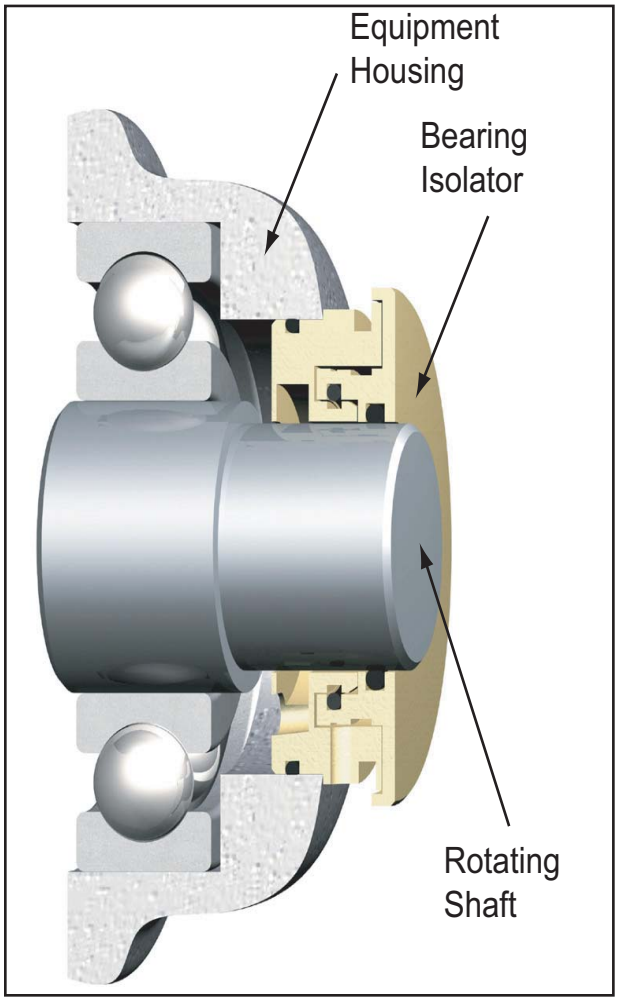


Figure 2-2. Typical Bearing Isolator (3-D Cutaway View)

Tool Spindle Protection Using Bearing Isolators

The Inpro/Seal Company has installed bearing isolators in its machine tooling spindles to virtually eliminate maintenance and increase reliability of the company's production CNC machines. The longevity and ability of the bearing isolator to perform in an absolute manner with respect to complete and permanent bearing protection has been an invaluable asset to the Inpro/Seal production process.

In any machining operation, spindle repair and rebuilding to restore machine tool spindles to maximum efficiency is an ongoing process and interrupts valuable production time. Spindles are rotating mechanisms that drive the cutting tool in lathes, CNC machining centers, and milling machines. The spindle is either attached directly to the machine tool or attached via a spindle-mounted adaptor system. Spindles are typically cylindrical units comprised of a variety of smaller components that include the spindle housing, a spindle shaft, various fittings, and precision bearings. The bearings in a spindle are extremely important because they are the key component in the tooling spindle that allows the shaft to rotate without contact with other parts. Given extensive use and exposure to cutting coolants, even the most well-designed spindles require regular maintenance and eventual repair or possible replacement following prolonged use.

Recognizing the cost of spindle repair and expensive production downtime, Inpro/Seal installed its own invention and design of bearing isolators in two

Mazak CNC machines tooling spindles and 12 Cincinnati Milacron CNC machine tooling spindles to virtually eliminate bearing maintenance and increase reliability of the company's CNC machines that support a production rate of 400,000 bearing isolators per year. Inpro/Seal's bearing isolators are sold around the world.

The Inpro/Seal bearing isolator is a non-contact, non-wearing, permanent bearing protective device containing a rotor and a stator; the two are unitized so they do not separate from one another while in use. The rotor typically turns with a rotating shaft while the stator is pressed into a bearing housing (Figure 2-2). The two components interact to keep coolant and other contamination out of the bearing enclosure and the lubricant in. Bearing isolators can be installed in virtually any type of rotating equipment that requires protection from hostile environments (e.g., pumps, electric motors, gear boxes, and mechanical drive steam turbines). Bearing isolators are made of metal, usually bronze, and utilize a vapor-blocking feature that inhibits the free transfer of vapor contamination when the rotating equipment is cycled on and off.

Before the introduction of bearing isolators, bearing protection for industrial and process equipment was generally limited to contact seals such as lip seals and face seals. A rubber lip seal with a maximum useful life of 3,000 hours (4 months) was used to protect bearings with a design life rating exceeding 150,000 hours (17 years). As a lip seal's condition deteriorates, it grooves the shaft or carbonizes at the point of contact with the shaft and loses its ability to effectively seal the bearing enclosure. Face seals, whether spring-loaded or magnetically loaded, were found to have a finite life and were unpredictable as to the timing of their abrupt and certain failure.

Because of these inadequacies, rotating equipment in the process industries is quite unreliable and catastrophic failures due to bearing degradation are commonplace. Not only do they contribute to a large amount of maintenance and tear-down time, they interrupt production and greatly increase non-value-added time to the process.

At Inpro/Seal, bearing isolators have replaced lip seals in CNC tooling spindles and have proved to be an economic alternative to what was once conventional contact sealing methods. Their longevity and ability to perform in an absolute manner with respect to complete and permanent bearing protection has been a tremendous contribution and benefit to the Inpro/Seal production process.

Logistics

Quick Turnaround

The Inpro/Seal Company's quick turnaround allows them to ship same-day orders. New orders for bearing isolators can be ordered, designed, manufactured, packaged, and shipped on the same day.

From the conception of the bearing isolator in the 1970s, Inpro/Seal knew the importance of getting products to its customers. Today Inpro/Seal can design, create, and manufacture custom-made bearing isolators for same-day shipment, with little-to-no storage of final products. This service is provided free of charge to customers. Inpro/Seal produces approximately 40,000 bearing isolators per month, 30% of which are manufactured for shipment the same day. Inpro/Seal can actually develop a new design, create, manufacture and ship product in as few as 21 minutes.

To accomplish shipment of products from order received to design, manufacture, and same-day shipping, Inpro/Seal has a number of resources that it uses, including more than 60,000 designs in the company's database as a starting point. The company's CNC code is generated and sent to manufacturing in minutes. A 30-day supply of raw material is always maintained, with multiple machine groupings to produce the product and three shifts working Monday through Friday (and Saturday if needed) to make a same-day turnaround and shipment possible.

Inpro/Seal knows that their bearing isolators are often retrofitted to machinery when machines are being repaired. They also know that downtime is very costly to the company. If Inpro/Seal cannot ship the same day, customers might take their business elsewhere. The sooner Inpro/Seal can get its product to its customers, the more money the customer can save. Inpro/Seal can eliminate the need for its customers to have to store inventory, which is space that can be used for other purposes. In addition to newly designed bearing isolators, Inpro/Seal can also provide its existing part numbers on a same-day basis. This can be very valuable to customers who have an unexpected ramp-up in their production as well. Being aware of customers needs and being able to provide products with a quick turnaround is one of Inpro/Seal's greatest assets and one that has made the company so highly successful.

Management

Outside Sales/Worldwide Support

The Inpro / Seal Company maintains a strong outside sales force and worldwide support base consisting of 22 regional managers, 103 distributors, and 65 independent factory representatives to ensure the development of new customers and to satisfy the company's present customers worldwide.

Aggressive marketing, competent sales, distribution, and customer support enable a company to maintain its customers and develop new clientele. At Inpro/Seal, a small company that has perfected the bearing isolator, this challenge includes customers not only in the United States, Canada, and Mexico, but in worldwide markets such as Japan, Taiwan, Korea, the United Kingdom, France, Brazil, Africa, and Australia. Maintaining a strong sales and a worldwide support base is imperative to customer satisfaction and the growth of the company. Inpro/Seal, headquartered in Rock Island, Illinois, is unique in meeting this challenge. Over the past 40 years, the Inpro/Seal Company has dedicated itself to constant improvement and refinement of its products and practices. Key to the company's success is its Outside Sales force that provides worldwide support.

Inpro/Seal consists of more than 100 employees – 80 are located at the main facility in Rock Island, while 22 are regional managers that make up the Outside Sales force that supports the various locations in the U.S. and around the world. All regional managers are responsible for recruiting and managing their own distributor network. Unique with Inpro/Seal is that they are not responsible for specific geographic locations but are "account-specific." This method not only balances the workload for regional managers but allows better support of open accounts. In all, there are more than 103 Inpro/Seal distributors and 65 independent factory representatives operating today, all of whom work closely with Inpro/Seal to deliver the superior quality for which the company has become known. Inpro/Seal's regional managers are the key interface with the distributors, OEMs, end users, Inpro/Seal Inside Sales, and Engineering (Figure 2-3). The distributors and factory representatives are selected and totally responsive to the Inpro/Seal regional managers. All distributors and factory representatives have access to anyone at Inpro/Seal. All regional managers have engineering degrees or engineering backgrounds and have extensive rotating equipment knowledge. Regional managers, distributors, and factory representatives receive a three-day training course taught by Inpro/Seal at the company's Rock Island headquarters.

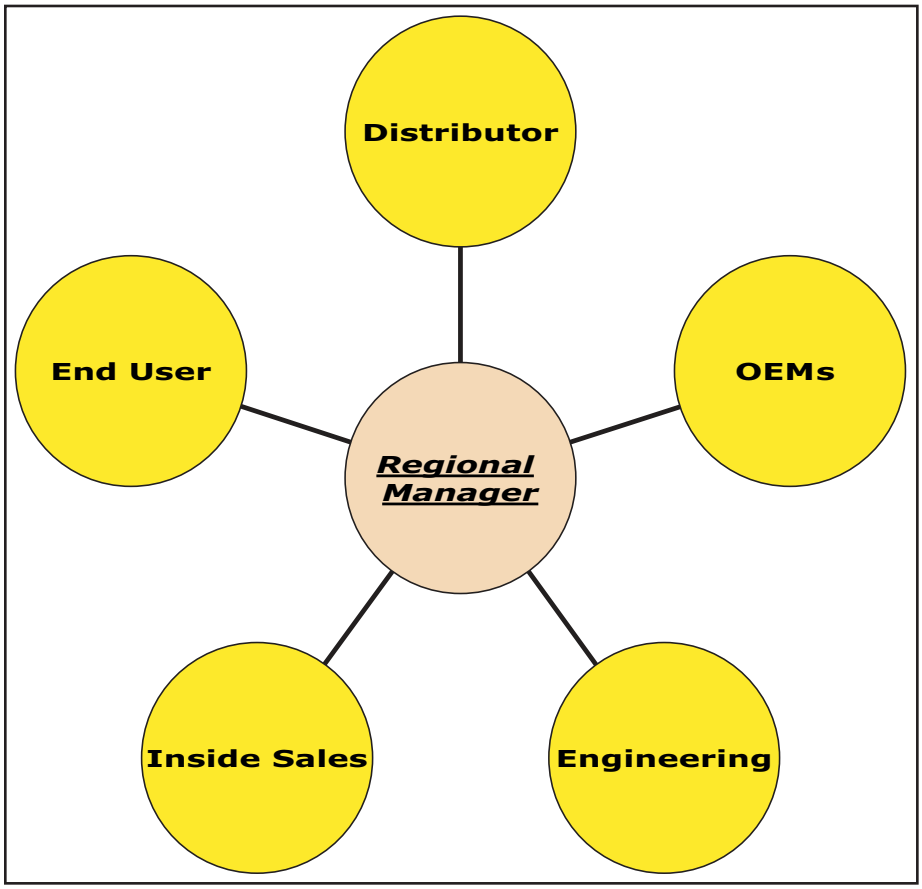


Figure 2-3. Access to Anyone

Inpro/Seal's commitment to customer satisfaction, as evidenced by its "Unconditional Satisfaction Guarantee" and policy of "Same-Day Shipments," ensures that the company will continue to meet the considerable demand for permanent, reliable, and timely bearing protection for industries worldwide.

Section 3

Information

Design

Custom Product Design

The Inpro/Seal Company combines a robust team of sales representatives, engineers, and production managers focused on providing custom solutions for its customers' bearing isolator needs. In-depth analysis of the application environment and the close proximity of these groups foster collaboration on unique design applications, enabling Inpro/Seal to amass a library consisting of more than 60,000 designs.

The Inpro/Seal Company, a Rock Island, Illinois-based bearing isolator manufacturer, prides itself on providing custom solutions for its customers' needs. The company has accumulated a library consisting of more than 60,000 specific bearing isolator designs by treating each order as a custom order. The fact that standard stock-size isolators do not fit the vast majority of applications brought about this departure from the traditional catalog approach and has increased the company's product output to a level of more than 40,000 units per month.

While many Inpro/Seal designs could be considered standard solutions to common rotating machinery applications, the area surrounding the rotating shaft often necessitates modification of some dimensions of the manufactured bearing isolator, making it a unique design. In other instances, customers request bearing isolators be designed for one-of-a-kind applications. The increasing frequency of these special solutions has resulted in Inpro/Seal's highly efficient custom design process. Once all necessary operational conditions and dimension information have been gathered for the required bearing isolator, engineers determine if an applicable design already exists. If not, a comparable design may be modified to provide a final solution. If the application is truly unique, a new design is started.

Engineers communicate freely with one another to ensure extensive corporate knowledge and previous experience are widely applied so that even the most complex designs are completed in less than one business day. In-depth analysis of the application environment is undertaken to customize the isolator design and minimize equipment modifications that the customer may have to arrange to accommodate the new bearing isolator.

Inpro/Seal sales managers, engineers, and production managers form a cohesive team under one roof, enabling more than 30% of units ordered to be shipped same-day, including many custom designs.

Production

Experimental Cell

The Inpro/Seal Company set up an experimental cell using Lean principles. The cell operates with continuous adjustments and fine-tuning from the operators at the same time that actual production parts are being run.

The Inpro/Seal Company has eight different manufacturing cells and has designated its seventh cell as an experimental cell that operates with real production and is continuously being used for experimental manufacturing techniques. The information gathered from the cell operation is then applied to other cells in the facility. The cell is able to perform all manufacturing operations and package final product, reducing the time parts sit idle and eliminating the need for unnecessary travel through Inpro/Seal's facility.

Inpro/Seal personnel are trained in lean principles and are given the freedom to provide feedback on the operation of the experimental cell. The cell's operators have significant input into the design and function of the cell. For example, the use of a second computer system enables two operators to perform simultaneous input to the system, reducing time waiting for the computer terminal. Cell personnel are then able to train other Inpro/Seal employees in operating the cell.

The experimental cell provides a basis for eliminating waste in the manufacturing of products while providing information to better utilize raw

materials. If more products can be manufactured out of the same raw material and wasteful movement can be eliminated, Inpro/Seal can continue to provide quality products at less cost.

Management

Continuous Product Improvement

The Inpro/Seal Company adheres to a policy of continuously improving its product design and performance through the company's in-house engineering, experimental machining cell, and experimental laboratory. The test procedures, test equipment, and metrics gained from the lab tests allow the company to quickly evaluate the incremental improvements that are made daily.

The Inpro/Seal Company of Rock Island, Illinois, is a manufacturer of non-contact bearing isolators for use on any rotating shaft that must be protected from leakage of bearing lubricant or incursion of contaminants into the bearings. The company has a history of continuously improving the quality and applications of its products. This is evident in the more than 54 U.S. and foreign patents the company has received on its products since 1975. As the company grew, it actively solicited ideas for product improvement from its employees, designers, customers, and in some cases – its competitors.

The addition of a research laboratory and the ability to collect and analyze performance data in real time has greatly added to Inpro/Seal's continuous product improvement effort. The company regards the laboratory as its Research and Experimentation (R&E) Laboratory versus a Research and Development Laboratory. The R&E Laboratory is equipped with a variety of test stations that include turning motors, applying water spray, and measuring power among others. With the R&E Laboratory, its in-house engineering capability, and its experimental machining cell, Inpro/Seal is able to quickly and inexpensively evaluate and verify improvements or the lack of improvements in proposals.

Inpro/Seal's goal of continuous improvement in product performance and experimentation of changes has led to an approximate 8- to10-fold increase in the ability of its isolators to keep contamination out of the bearings they are designed to protect. As an engineer-to-order company, Inpro/Seal can incorporate findings from its laboratory data and test into new designs on a daily basis.

On-Site Support

The Inside Sales/Product Support process used by the Inpro/Seal Company ensures that customers get the proper bearing isolator for their application by need-date. Having a central point of contact respond to request for quotes, order entries, technical support, and engineering design ensures that customers receive consistent and accurate information concerning the status of their bearing isolator request.

Inpro/Seal, a manufacturer of non-contact bearing isolators, has developed a unique process for inside sales or product support to assist their 22 regional managers who are located worldwide. The company has six inside sales representatives, each serving as the primary support individual for a given number of the regional managers. The role of the regional manager is to market Inpro/Seal's products to company customers, provide technical expertise in helping customers make the appropriate selection of bearing isolators for their application, and provide training and education to their customers. If needed, the regional manager will assist customers to install the seals in their products.

Each inside product support representative/inside sales representative is in daily contact with his or her respective regional managers and helps to solve technical issues that the regional managers face in the field along with assisting customers in getting timely quotes for their product needs. Each of the product support representatives receives extensive training in the technical/mechanical understanding of bearing isolators and their different possible applications, manufacturing processing, and product quoting skills.

When prospective customers want a quote for an Inpro/Seal products, they call one of the inside sales/product support specialists for a quote on price and delivery. The sales representatives fill out an Inpro/Seal Request for Quote data sheet that contains 17 critical questions relevant to the product. Based on the answers to the questions, the inside sales representatives are able to access internal databases and provide quotes almost instantly. If the requested isolator requires engineering support for a new design, the sales representative contacts Inpro/Seal's on-site engineers who will develop the new design/part number for the requested item. The quote is normally processed within the same workday.

The inside sales representatives are the primary contact for all orders placed with Inpro/Seal. They

work directly with distributors, original equipment manufacturers (OEMs), and other end-users for processing orders and shipments. They also work directly with the regional managers, in-house engineering, and manufacturing in processing all Requests for Quotes. By having a central point of contact for all quotes and orders, customer needs are met consistency and accurately. Since Inpro/Seal provides products to customers worldwide, this further ensures that customer needs and regional manager needs are met by having inside sales/product support personnel on duty on staggered work hours and holidays. This enables Inpro/Seal to ensure that its reputation for "Same-Day Delivery" of custom bearing isolators is maintained.

Process Improvement

The Inpro / Seal Company has implemented ongoing process improvement of its production cells through a dedicated experimental production test cell and a culture that encourages employee teamwork, participation, and ownership of work processes. Having the experimental cell and progressive employee culture has resulted in reduced cycle time and rapid fulfillment of customer orders. Urgent customer orders for same-day shipment are routinely inserted in the production process without disruption and at no additional cost for expedited orders.

The Inpro/Seal Company of Rock Island, Illinois, is a leading producer of bearing isolators for rotating equipment. Bearing isolators replace traditional rotating equipment seals. Inpro/Seal has instilled a culture of teamwork and continuous improvement to meet company goals and objectives. The institution of an experimental production cell at the company's Rock Island facility includes CNC, milling, and assembly stations for Inpro/Seal's bearing isolators with an objective to support process improvement by testing various cell layouts intended to reduce the overall cycle time for bearing isolator production.

At a top level, the company works to reduce the time it takes from the release of a job to start production to the time the product is shipped to the customer. The goal is to remove non-value-added or dead time, with an additional metric being to optimize machine operating time to overall process time. Inpro/Seal also measures material used per isolator to its standard to validate the standard and to explore other potential improvement efforts.

A key aspect to Inpro/Seal improvement is that the process improvement function is a recognized part of every employee's job. Management provides the goals, resources, and environment, including the experimentation cell. Volunteer operators are put in place to develop and then measure the performance of different configurations of the cell that might reduce cycle time and optimize machine-operating time. Production cell operators are relied on heavily in this continuous improvement process. Lessons learned from these efforts are then applied as appropriate in the plant by changing other production cell layouts or work processes. Inpro/Seal employees take obvious pride in the improvements they develop, which are a major contribution to the company's success.

Appendix A

Table of Acronyms

ACRONYM	DEFINITION
IEC	International Electrotechnical Commission
IP Code	International Protection Code
R&E	Research and Experimentation

Appendix B

BMP Survey Team

Team Member	Activity	Function
Larry Halbig 317-891-9901	**BMP Field Office - Indianapolis** Indianapolis, IN	**Team Chairman**
Gail Lavrusky 301-405-9990	**BMP Center of Excellence** College Park, MD	**Technical Writer**
	TEAM 1	
Don Hill 317-849-3202	**BMP Field Office - Indianapolis** Indianapolis, IN	**Team Leader**
Katie Erekson 309-782-3737	**Rock Island Arsenal** Rock Island, IL	
	TEAM 2	
Al Lang 843-818-9498	**BMP Field Office - Charleston** Charleston, SC	**Team Leader**
Nick Bouchat 301-405-9990	**BMP Center of Excellence** College Park, MD	
Tom McKavitt 301-405-9990	**BMP Center of Excellence** College Park, MD	

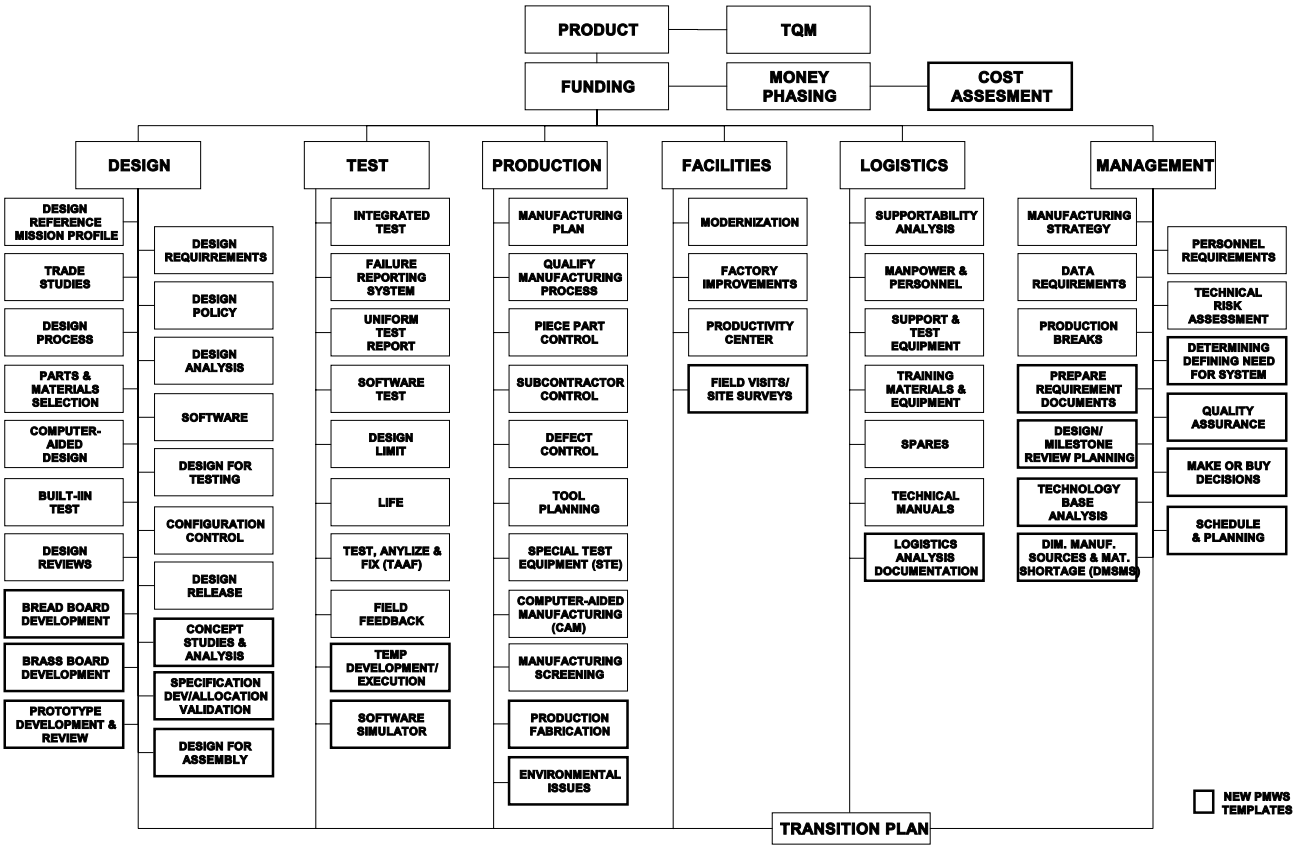
Appendix C

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.

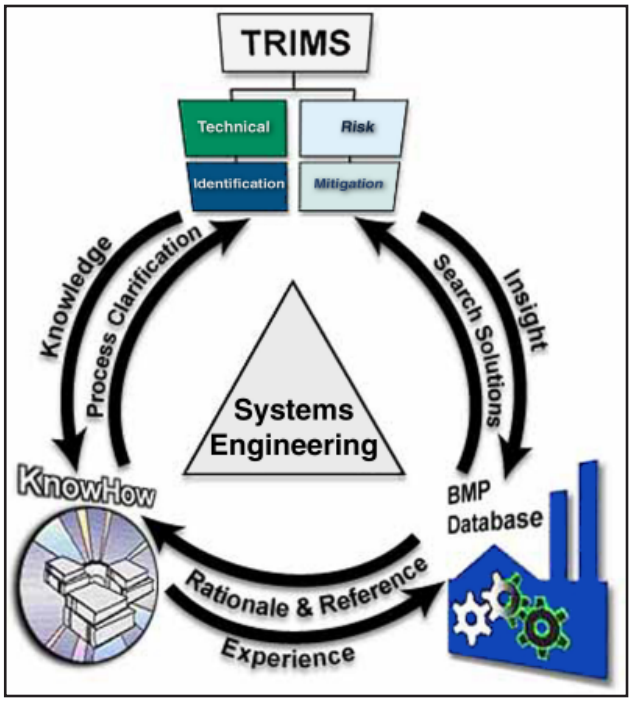
"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



Appendix D

The Program Manager's WorkStation

The Program Manager's WorkStation **(PMWS)** is an electronic suite of tools designed to provide timely acquisition and engineering information to the user. The main components of PMWS are KnowHow, the Technical Risk Identification and Mitigation System (TRIMS), and the BMP Database. These tools complement one another and provide users with the knowledge, insight, and experience to make informed decisions through and beyond all phases of product development and production.



KnowHow provides knowledge as an electronic library of technical reference handbooks, guidelines, and acquisition publications that cover a variety of engineering topics including the DoD 5000 series. The electronic collection consists of expert systems and simple digital books. In expert systems, KnowHow prompts the user to answer a series of questions to determine where the user is within a program's development. Recommendations are provided based on the book being used. In simple digital books, KnowHow leads the user through the process via an electronic table of contents to determine which books in the library will be the most helpful. The program also features a fuzzy logic text search capability so users can locate specific information by typing in keywords. KnowHow can reduce document search times by up to 95%.

TRIMS provides insight as a knowledge-based tool that manages technical risk rather than cost and schedule. Cost and schedule overruns are downstream indicators of technical problems. Programs generally have had process problems long before the technical problem is identified. To avoid this progression, TRIMS operates as a process-oriented tool based on a solid systems engineering approach. Process analysis and monitoring provide the earliest possible indication of potential problems. Early identification provides the time necessary to apply corrective actions, thereby preventing problems and mitigating their impact. TRIMS is extremely user-friendly and tailorable. This tool identifies areas of risk, tracks program goals and responsibilities, and can generate a variety of reports to meet the user's needs.

The **BMP Database** provides experience as a unique, one-of-a-kind resource with more than 5,000 best practices that have been verified and documented by an independent team of experts during BMP surveys. BMP publishes its findings in survey reports and provides the user with basic background, process descriptions, metrics and lessons learned, and a point of contact for further information. The BMP Database features a searching capability so users can locate specific topics by typing in keywords. Users can either view the results on screen or print them as individual abstracts, a single report, or a series of reports. The database can also be downloaded, run on-line, or purchased on CD-ROM from the BMP Center of Excellence. The BMP Database continues to grow as new surveys are completed. Additionally, the database is reviewed every other year by a BMP core team of experts to ensure the information remains current.

For additional information on PMWS, please contact the Help Desk at (301) 403-8179, or visit the BMP Web site at http://www.bmpcoe.org.

Appendix E

Best Manufacturing Practices Satellite Centers

There are currently nine 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, with the centers hosting 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; and train regional personnel in the use of BMP resources.

The nine BMP satellite centers include:

California

Izlay (Izzy) Mercankaya
BMP Satellite Center Manager
Naval Surface Warfare Center, Corona Division
Code QA-21, P.O. Box 5000
Corona, CA 92878-5000
(951) 273-5440
FAX: (951) 273-5315
izlay.mercankaya@navy.mil

District of Columbia

Brad Botwin
BMP Satellite Center Manager
U.S. Department of Commerce
Bureau of Industry & Security
14th Street & Constitution Avenue, N.W.
H3876
Washington, DC 20230
(202) 482-4060
FAX: (202) 482-5650
bbotwin@bis.doc.gov

Illinois

Robert Lindstrom
BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114-5699
(815) 921-2073
FAX: (815) 654-4343
r.lindstrom@rvc.cc.il.us

Iowa

Ron Cox
BMP Satellite Center Manager
Iowa Procurement Outreach Center
2273 Howe Hall, Suite 2617
Ames, IA 50011
(515) 289-0280 or (515) 294-5240
FAX: (515) 294-4925
rcox@iastate.edu

Louisiana

Gregory T. Dobson, Ph.D.
BMP Satellite Center Manager
Site Director, Simulation Based Design Center
University of New Orleans, College of Engineering
Gulf Coast Region Maritime Technology Center
c/o NGSS-Avondale Operations
Station 721-1-1
5100 River Road
New Orleans, LA 70094-2706
(504) 654-2773
FAX: (504) 654-3880
greg.dobson@gcrmtc.org

Ohio

Larry Brown
BMP Satellite Center Manager
Edison Welding Institiute
1250 Arthur E. Adams Drive
Columbus, OH 43221-3585
(614) 688-5080
FAX: (614) 688-5001
larry_brown@ewi.org

Pennsylvania

John W. Lloyd
BMP Satellite Center Manager
MANTEC, Inc.
P.O. Box 5046
York, PA 17405
(717) 843-5054
FAX: (717) 843-0087
lloydjw@mantec.org

South Carolina

Henry E. Watson
BMP Satellite Center Manager
South Carolina Research Authority - Applied Research and Development Institute
100 Fluor Daniel
Clemson, SC 29634
(864) 656-6566
FAX: (843) 767-3367
watson@scra.org

Tennessee

Duane Bias
BMP Satellite Center Manager
Y-12 National Security Complex
BWXT Y-12, L.L.C.
P.O. Box 2009
Bear Creek Road
Oak Ridge, TN 37831-8091
(865) 241-9288
FAX: (865) 574-4614
biasdl@y12.doe.gov

Appendix F

Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Technology Program has established 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 the Navy industrial facilities and laboratories. These consortium-structured COEs serve as corporate residences of expertise in particular technological areas. The following list provides a description and point of contact for each COE.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and share best manufacturing and business practices being used throughout government, industry, and academia. The BMPCOE was established by the Office of Naval Research's BMP Program, the Department of Commerce, and the University of Maryland at College Park. By improving the use of existing technology, promoting the introduction of improved technologies, and providing non-competitive means to address common problems, the BMPCOE has become a significant factor in countering foreign competition.

Point of Contact:
Rebecca Clayton
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
Phone: (301) 405-9990
FAX: (301) 403-8180
E-mail: rebecca@bmpcoe.org

Institute for Manufacturing and Sustainment Technologies

The Institute for Manufacturing and Sustainment Technologies (iMAST) is located at the Pennsylvania State University's Applied Research Laboratory. iMAST's primary objective is to address challenges relative to Navy and Marine Corps weapon system platforms in the areas of mechanical drive transmission technologies, materials processing technologies, laser processing technologies, advanced composites technologies, and repair technologies.

Point of Contact:
Mr. Robert Cook
Institute for Manufacturing and Sustainment Technologies
ARL Penn State University
P.O. Box 30
State College, PA 16804-0030
Phone: (814) 863-3880
FAX: (814) 863-1183
E-mail: rbc5@psu.edu

Composites Manufacturing Technology Center (operated by the South Carolina Research Authority)

The Composites Manufacturing Technology Center (CMTC) is a Center of Excellence for the Navy's Composites Manufacturing Technology Program. The South Carolina Research Authority (SCRA) operates the CMTC and the Composites Consortium (TCC) serves as the technology resource. The TCC has strong, in-depth knowledge and experience in composites manufacturing technology. The SCRA/CMTC provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors.

Point of Contact:
Mr. Henry Watson
Applied Research and Development Institute
Composites Manufacturing Technology Center
934-D Old Clemson Highway
Eagles Landing Professional Park
Seneca, SC 29672
Phone: (864) 656-6566
FAX: (864) 653-7434
E-mail: watson@scra.org

Electronics Manufacturing Productivity Facility (operated by American Competitiveness Institute)

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 government, industry, and academic participants led by the American Competitiveness Institute under a cooperative agreement with the Navy.

Point of Contact:
Mr. Michael Frederickson
Electronics Manufacturing Productivity Facility
One International Plaza, Suite 600
Philadelphia, PA 19113
Phone: (610) 362-1200, ext. 215
FAX: (610) 362-1288
E-mail: mfrederickson@aciusa.org

Electro-Optics Center (operated by the Pennsylvania State University's Applied Research Laboratory)

The Electro-Optics Center (EOC) is a national consortium of electro-optics industrial companies, universities, and government research centers that share their electro-optics expertise and capabilities through project teams focused on Navy requirements. Through its capability for national electronic communication and rapid reaction and response, the EOC can address issues of immediate concern to the Navy Systems Commands. The EOC is managed by the Pennsylvania State University's Applied Research Laboratory.

Point of Contact:
Dr. Karl Harris
Electro-Optics Center
West Hills Industrial Park
77 Glade Drive
Kittanning, PA 16201
Phone: (724) 545-9700
FAX: (724) 545-9797
E-mail: kharris@psu.edu

Navy Joining Center (operated by Edison Welding Institute)

The Navy Joining Center (NJC) 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. The NJC is operated by the Edison Welding Institute.

Point of Contact:
Mr. Harvey R. Castner
EWI/Navy Joining Center
1250 Arthur E. Adams Drive
Columbus, OH 43221-3585
Phone: (614) 688-5063
FAX: (614) 688-5001
E-mail: harvey_castner@ewi.org

Navy Metalworking Center (operated by Concurrent Technologies Corporation)

The Navy Metalworking Center provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. Operated by the Concurrent Technologies Corporation, the Navy Metalworking Center 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:
Dr. Daniel Winterscheidt
Navy Metalworking Center
c/o Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904-1935
Phone: (814) 269-6840
FAX: (814) 269-2501
E-mail: winter@ctcgsc.com

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, and safe energetics. The EMTC's focus is on technologies to reduce manufacturing costs, improve product quality and reliability, and develop environmentally benign manufacturing processes. The EMTC is located at the Indian Head Division of the Naval Surface Warfare Center.

Point of Contact:
Mr. John Brough
Naval Surface Warfare Center
Indian Head Division
101 Strauss Avenue
Building D326, Room 227
Indian Head, MD 20640-5035
Phone: (301) 744-4417
DSN: 354-4417
FAX: (301) 744-4187
E-mail: broughja@ih.navy.mil

Center for Naval Shipbuilding Technology

The Center for Naval Shipbuilding Technology (CNST) supports the Navy's ongoing effort to identify, develop and deploy in U.S. shipyards, advanced manufacturing technologies that will reduce the cost and time to build and repair Navy ships. CNST provides a focal point for developing and transferring new manufacturing processes and technologiy; benefits that will accrue not only to the Navy but to industry. CNST is operated and managed by ATI in Charleston, South Carolina.

Point of Contact:
Mr. Ron Glover
Center for Naval Shipbuilding Technology
5300 International Boulevard
Charleston, SC 29418
Phone: (843) 760-4606
FAX: (843) 760-4098
E-mail: glover@aticorp.org

Gulf Coast Region Maritime Technology Center (operated by the University of New Orleans, College of Engineering)

The Gulf Coast Region Maritime Technology Center (GCRMTC) fosters competition in shipbuilding technology through cooperation with the U.S. Navy, representatives of the maritime industries, and various academic and private research centers throughout the country. Located at the University of New Orleans, the GCRMTC focuses on improving design and production technologies for shipbuilding, reducing material and total ownership costs, providing education and training, and improving environmental engineering and management.

Point of Contact:
Mr. Frank Bordelon, New Orleans Site Director
Gulf Coast Region Maritime Technology Center
Research and Technology Park
CERM Building, Room 409
University of New Orleans
New Orleans, LA 70148-2200
Phone: (504) 280-5609
FAX: (504) 280-3898
E-mail: fbordelo@uno.edu

Appendix G

Completed Surveys

As of this publication, 152 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 BMP Web site. Requests for copies of recent survey reports or inquiries regarding BMP may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Road, Suite 400
College Park, MD 20740
Attn: Rebecca Clayton, Director
Phone: 1-800-789-4267
FAX: (301) 403-8180
rebecca@bmpcoe.org

1985	Litton Guidance & Control Systems Division - Woodland Hills, CA (now Northrop Grumman Navigation Systems)
1986	Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (now 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 (now Rockwell Collins) UNISYS Computer Systems Division - St. Paul, MN
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 (now Northrop Grumman Electronic Systems Division) Standard Industries - LaMirada, CA (now SI Manufacturing) Engineered Circuit Research, Incorporated - Milpitas, CA Teledyne Industries Incorporated Electronics Division - Newbury Park, CA Lockheed Aeronautical Systems Company - Marietta, GA Lockheed Missile Systems Division - Sunnyvale, CA (now Lockheed Martin Missiles and Space) Westinghouse Electronic Systems Group - Baltimore, MD (now Northrop Grumman Corporation) General Electric Naval & Drive Turbine Systems - Fitchburg, MA Rockwell Autonetics Electronics Systems - Anaheim, CA (now Boeing North American A&MSD) 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 (now Northrop Grumman Norden Systems)
	Naval Avionics Center - Indianapolis, IN
	United Electric Controls - Watertown, MA
	Kurt Manufacturing Company - Minneapolis, MN
	MagneTek Defense Systems - Anaheim, CA (now Power Paragon, Inc.)
	Raytheon Missile Systems Division - Andover, MA (now Raytheon Integrated Air Defense Center)
	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 (now General Dynamics Information Systems) (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 (now National Nuclear Security Administration)
	McDonnell Douglas Aerospace - Huntington Beach, CA (now Boeing Space Systems)
	Naval Surface Warfare Center Crane Division - 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 (now Hamilton Sundstrand)
	Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Palm Bay, FL (now Intersil Corporation)
	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 (now American Ordnance LLC)
	Kaiser Electronics - San Jose, CA
	U.S. Army Combat Systems Test Activity - Aberdeen, MD (now Aberdeen Test Center)
	Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM
	Rockwell Collins Avionics & Communications Division - Cedar Rapids, IA (now Rockwell Collins, Inc.) (Resurvey of Rockwell International Corporation Collins Defense Communications)
	Lockheed Martin Electronics & Missiles - Orlando, FL
	McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO (now Boeing Integrated Defense Systems) (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 (now Lockheed Martin Aeronautics Company) (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
	Resurvey of Department of Energy, Oak Ridge Operations - Oak Ridge, TN (now National Nuclear Security Administration)

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL (now Operational Support Command) SAE International and Performance Review Institute - Warrendale, PA Polaroid Corporation - Waltham, MA Cincinnati Milacron, Inc. - Cincinnati, OH (now Cincinnati Machine, LLC) Lawrence Livermore National Laboratory - Livermore, CA Sharretts Plating Company, Inc. - Emigsville, PA Thermacore, Inc. - Lancaster, PA Rock Island Arsenal - Rock Island, IL Northrop Grumman Corporation - El Segundo, CA (Resurvey of Northrop Corporation Aircraft Division) Letterkenny Army Depot - Chambersburg, PA Elizabethtown College - Elizabethtown, PA Tooele Army Depot - Tooele, UT
1998	United Electric Controls - Watertown, MA Strite Industries Limited - Cambridge, Ontario, Canada Northrop Grumman Corporation - El Segundo, CA Corpus Christi Army Depot - Corpus Christi, TX Anniston Army Depot - Anniston, AL Naval Air Warfare Center, Lakehurst - Lakehurst, NJ Sierra Army Depot - Herlong, CA ITT Industries Aerospace/Communications Division - Fort Wayne, IN Raytheon Missile Systems Company - Tucson, AZ Naval Aviation Depot North Island - San Diego, CA U.S.S. Carl Vinson (CVN-70) - Commander Naval Air Force, U.S. Pacific Fleet Tobyhanna Army Depot - Tobyhanna, PA
1999	Wilton Armetale - Mount Joy, PA Applied Research Laboratory, Pennsylvania State University - State College, PA Electric Boat Corporation, Quonset Point Facility - North Kingstown, RI Resurvey of NASA Marshall Space Flight Center - Huntsville, AL Orenda Turbines, Division of Magellan Aerospace Corporation - Mississauga, Ontario, Canada (now Orenda Turbines, Repair, Overhaul and Industrial - Division of Magellan Aerospace Corporation)
2000	Northrop Grumman, Defensive Systems Division - Rolling Meadows, IL Crane Army Ammunition Activity - Crane, IN Naval Sea Logistics Center, Detachment Portsmouth - Portsmouth, NH Stryker Howmedica Osteonics - Allendale, NJ (now Stryker Orthopaedics)
2001	The Tri-Cities Tennessee/Virginia Region - Johnson City, TN General Dynamics Armament Systems - Burlington, VT (now General Dynamics Armament and Technical Products) Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems - Moorestown, NJ (now Lockheed Martin MS-2) Frontier Electronic Systems - Stillwater, OK
2002	U.S. Coast Guard, Maintenance and Logistics Command-Atlantic - Norfolk, VA U.S. Coast Guard, Maintenance and Logistics Command-Pacific - Alameda, CA Directorate for Missiles and Surface Launchers (PEO TSC-M/L) - Arlington, VA (now Surface Ship Weapons & Launchers - PEO IWS 3.0) General Tool Company - Cincinnati, OH
2003	University of New Orleans, College of Engineering - New Orleans, LA Bender Shipbuilding and Repair Company, Inc. - Mobile, AL In Tolerance - Cedar Rapids, IA ABC Virtual Communications, Inc. - West Des Moines, IA Resurvey of Electric Boat Corporation, Quonset Point Facility - North Kingstown, RI United Defense, L.P. Ground Systems Division - Aiken, SC Auto-Valve, Inc. - Dayton, OH

2004	United Defense, L.P. Armament Systems Division - Aberdeen, SD
	TOMAK Precision - Lebanon, OH
	RB Tool & Manufacturing Company - Cincinnati, OH
	Forest City Gear - Roscoe, IL
	CALCE Electronic Products and Systems Center - College Park, MD (now Center for Advanced Life Cycle Engineering - CALCE)
	U.S. Army Aviation & Missile Command, Automation Division-Integrated Materiel Management Center - Redstone Arsenal, AL
2005	Northrop Grumman Electronic Systems - Baltimore, MD
	Raytheon Integrated Air Defense Center - Andover, MA
2006	Raytheon-Louisville - Louisville, KY
	Midwest Metal Products - Cedar Rapids, IA
	Rockwell Collins - Cedar Rapids, IA
	Resurvey of Tobyhanna Army Depot - Tobyhanna, PA
2007	Raytheon Network Centric Systems Manufacturing Center - Largo, FL
	Resurvey of University of New Orleans, College of Engineering - New Orleans, LA
	Inpro/Seal Company - Rock Island, IL