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REPORT OF SURVEY CONDUCTED AT

WEIRTON STEEL CORPORATION

WEIRTON, WV

AUGUST 1996

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 Weirton Steel Corporation, Weirton, West Virginia conducted during the week of August 26, 1996. 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 HomePage located on the Internet at <http://www.bmpcoe.org>. The actual exchange of detailed data is between companies at their discretion.

Overcoming challenge is a tradition at Weirton Steel. They have always shown courage, strength, and a strong commitment to the community. In keeping with that spirit, Weirton Steel elected to become the first steel company to be surveyed by the BMP program. The BMP survey team was impressed and intrigued by what they saw from an industrial leader. Among the best examples were Weirton Steel's accomplishments in MIS customer service, workers' compensation, safety, predictive maintenance, employee training, vessel assembly and changeout, and the rebuilding of the tandem and hot strip mills.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on Weirton Steel 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

Established in 1909 and becoming the world's largest, wholly employee-owned company in 1984, Weirton Steel Corporation (WSC) is located in Weirton, West Virginia. As the largest, private employer in West Virginia, WSC currently employs 5,600 personnel with a 1995 payroll exceeding \$350 million. The employees, who are unionized, now own 25% of the common stock but control 49% of the voting power. The operating units encompass 2,500 acres and have a production capacity of more than three million tons per year. WSC produces flat rolled carbon steel in both sheet and strip form, which is sold as hot rolled, cold rolled, or coated products, including hot dipped and electro-galvanized steel and tin mill products. WSC shipped a record 2.7 million tons of flat rolled products in 1995 and over 700 thousand tons during the first quarter of 1996. The company's major markets include food and beverage cans, general packaging, pipe and tube, service centers, construction, and shipping containers. Record annual sales for 1995 was \$1.3 billion, making WSC the eighth-largest, integrated, steelmaker in America.

Overcoming challenge is a tradition at Weirton Steel. Past accomplishments include settling its only union strike within two weeks in 1933; rallying to become employee-owned in 1982; fulfilling its promise to become a world-class facility in 1988; and rebuilding its fire-destroyed tandem mill within six months in 1994. The company has always shown courage, strength, and a strong commitment to the community of Weirton. In keeping with that spirit, WSC elected to become the first steel company to be surveyed by the Best Manufacturing Practices program. The BMP survey team was impressed and intrigued by what they saw from an industrial leader. Among the best examples were WSC's accomplishments in MIS customer service, workers' compensation, safety, predictive maintenance, employee training, vessel assembly and changeout, and the rebuilding of the tandem and hot strip mills.

Three years ago, WSC undertook a Management Information System (MIS) outsourcing initiative to improve its performance in this critical area. The internal evaluation revealed problem areas in ac-

countability, discipline, and service. Rather than outsource MIS, WSC decided to develop its internal organization into a world-class supplier of information services by maximizing people, processes, and technology. The Customer Service plan, launched in 1994, enables WSC to run its MIS Department as a profit center focused on customer service. A chargeback system has been established and end-users are now involved in all project phases including accountability for performance. The WSC Data Center was recently ranked in the top 25% in a national benchmarking study of major corporations conducted by the Mark Levon Company.

Workers' compensation benefits directly affect a company's cost because it adds no value to the product. Therefore, it is in the best interest of a company to aggressively pursue the reduction of payouts through safety awareness and an effective workers' compensation program. WSC has done both. Through innovative improvements made in 1996, injury claims are thoroughly reviewed, payout periods are monitored, and recovery is assisted. Unique to WSC's workers' compensation program is its rehab protocol which assists the injured worker by decreeing prompt scheduling of surgery, if needed, prescribed rehabilitation treatment, and a proper transition back to work. In addition, the Modified Duty program returns employees to the workplace in an area that is amenable to their injuries. Currently, WSC is developing a treatment protocol for high occurrence injuries such as back strain, knee injuries, and shoulder injuries. This aggressive, proactive approach has reduced the number of workers' compensation cases and produced substantial cost savings.

Because safety is a top priority at WSC, the Operations Service Department implemented the highly successful Safety & Health Awareness Requires Everyone (SHARE) program in 1991. It consists of a steering committee to oversee, administer, and coordinate safety efforts; subcommittees to address and recommend improvements; a core team to ensure acceptance of the improvements; and a safety coordinator to provide training and assure compliance with established guidelines. In addition, SHARE is tied to WSC's manage-the-business-better initiative, which is an endorsement by management to support SHARE. As a

result, WSC has made a safer working environment for its employees by reducing OSHA recordable injuries and workers' compensation costs. The Operations Service Department now ranks equal to the industry average in days-away-from-work (DAFW) case rates and just slightly below the industry average in recordable case rates, according to the American Iron and Steel Institute (AISI) safety data for integrated steelmakers.

Since downtime in a mill is costly, WSC established a predictive maintenance program for the #5 Pickler in the Hot Strip Mill in 1991 and expanded the program to the rest of this mill in 1993. The team, made-up of a site manager, analysis engineers, and technicians, collects data with the goal of centralizing each area's operations on a scheduled basis. Monthly reports are provided to maintenance management and planners who meet to discuss jobs in each area. Current technologies used include vibration readings and thermographic measurements. New technologies being added include motor current analysis, wear particle analysis, and ultrasonic monitoring. Training is also a key aspect of this program; monthly classes are conducted to teach maintenance personnel how to use and benefit from predictive maintenance techniques. These techniques have significantly improved operations by reducing downtime, product loss, and machine replacements. Future plans call for integrating the databases of predictive maintenance, oil analysis, preventive maintenance, and spares management.

Recognizing a need for structured, formal training, WSC developed Structured On-the-Job Training (SOJT) in 1991 and Modular Training in 1993. SOJT provides formal training to new or transferred employees so they can quickly develop a working knowledge of their job responsibilities. SOJT training manuals, specific to one job position, address the time schedule of activities to complete the training; an overview of the training; in-depth safety equipment and concerns for the position; basic information and detailed job task descriptions; exercises for the trainee; position evaluation and diagnostics; and job-related terminology. In addition, an SOJT Guidebook provides direction for consultants, managers, mentors, etc. who need to understand how the program works and ensures consistency when new SOJT training manuals are developed.

WSC's Modular Training program, developed with West Virginia University, established 85 formal, classroom training modules. The program's

goal was to achieve a 90% retention level from active learning versus the typical 20% from read-and-hear classroom techniques. Each training module, structured in 1 to 1½ hour sessions, covers a topic designed to meet employee needs. In addition, WSC established the train-the-trainer program to ensure consistency with its employee instructors' teaching methods. New modules must pass an Alpha Test, by a company team of non-experts, and a Beta Test, by subject-technical experts. This program has proven so successful that local businesses and WSC customers have requested not only training using WSC classroom materials, but also assistance from the WSC training group to establish similar programs at their companies.

WSC purchased a new furnace vessel for the Basic Oxygen Plant (BOP) in 1989. It was needed to replace one of two existing vessels, and was critical to operations that required two vessels to be continuously operated on an alternate, rotating basis. Fabrication specifications called for the new vessel to be delivered to WSC for assembly with minimal fitting and welding requirements. To accomplish this and to ensure a timely assembly and changeout of the old vessel without delaying plant operations, a team was tasked to develop a detailed process plan, which identified every step of the operation. These steps were documented through software to ensure that milestones and key events were accomplished as scheduled. By following this approach, WSC allowed for the creation of historical data that can be used with photographs and videotapes for future vessel changeouts. The project was completed a day early and under budget. Since in service, the new vessel has shown no measurable distortions, a good indicator that it will meet or exceed the 25-year service life requirement.

WSC suffered a major setback in April 1994 when its #9 Tandem Mill was destroyed by fire. This mill, Weirton's fastest and highest quality, light-gauge, cold reduction mill, was producing 60% of the coils needed for the company's tinplating operations. Fueled by hydraulic fluid, the fire caused extensive damage including destruction of all electrical controls and automation systems, severe damage to the mechanical systems, and major structural deformation. However, WSC turned this disaster into an opportunity by rebuilding the mill from the ground up, using the latest technology. In less than six months, the revamped facility was brought back on-line and began producing in October 1994. This massive \$87 million effort was accomplished through an experienced management team which had re-

cently completed a \$300 million modernization project on the hot rolling operations. Modernization included new safety features, automated x-ray gauges, rolling coolant dispersion systems, and fire-resistant water glycol for its hydraulic systems. WSC claims to be the only company in the world using 100% water glycol. Average yield on the new tandem mill is 98.9%.

Recognizing a need to improve their steelmaking capabilities in order to stay competitive, the employees of WSC made a commitment in 1988 to take their steelmaking capabilities to world-class levels. Using the Hot Strip Mill as the cornerstone of their factory improvement program, they invested more than \$300 million in the rebuild of this equipment. Improvements included two walking beam furnaces, a new reversing roughing mill, a hydraulic scale breaker, automated roll changing and roll bending, and a rotary crop shear. The rebuilt Hot Strip Mill has improved quality, increased efficiency, and broadened the product capabilities of the steel company. WSC has now positioned itself to compete as a world-class steel production facility.

Today, WSC remains a respected name in the U.S. steel industry. Surrounded by world-class facilities, dedicated employees, a loyal community, quality products, and a willingness to learn, WSC is still ready to face the demanding challenges of the future. The BMP survey team considered the following practices to be among the best in industry and government.

Best Practice

The following best practices were documented at Weirton.

Item	Page
BOP Ladle Refractory Improvements	7
The BOP operation requires the use of massive 350-ton ladles to receive the molten metal from the BOP vessel and transport it to the casters. These ladles are lined with refractory materials to insulate the steel shell from the molten metal. BOP personnel have been working to extend the life of these linings and have significantly reduced the associated replacement costs.	
Caster Improvements	7
WSC uses a four-strand continuous caster to produce the slabs, which are processed through various production steps and result in coils of	

Item	Page
thin strip material. The casting process is limited by the number of heats that can be put through the caster. A caster area team was formed to develop improvements to the casting process.	

Cold Roll	7
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WSC suffered a major production setback in April 1994 when its #9 Tandem Mill caught fire and was extensively damaged. This mill supported 60% of the coils needed for the company's tinplating operations. In less than six months, the revamped facility was brought back on-line and began producing in October 1994.

Plating Lines Area Team	8
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The platers area team served as a pilot program for TQM efforts within the Tin Mill at WSC. The team has demonstrated the effectiveness of the program by surpassing its overall cost reduction goal for the year.

Torpedo Bottles	8
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A fleet of refractory-lined, steel rail cars called torpedo bottles are used by WSC to transport molten BOP from the blast furnace linings to the BOP facility. The refractory linings in these torpedo bottles are periodically replaced. The new replacement process should extend the lining usage to over 600,000 tons.

Hot Strip Mill	9
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Rebuilding the Hot Strip Mill at WSC has been the cornerstone of the overall factory improvement program. With virtually all of the new equipment now in place, the mill can easily be defined as a world-class facility.

Predictive Maintenance Group	9
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Since downtime in a mill is costly, WSC established a predictive maintenance group in 1991. The predictive maintenance techniques developed by the group have significantly improved operations by reducing downtime, product loss, and machine replacements.

Vessel Assembly and Changeout Planning	10
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In 1989, WSC purchased a new furnace vessel for the BOP facility to replace one of two vessels which were continuously operated on an alternate, rotating basis. To ensure a timely assembly and changeout of the old vessel without delaying plant operations, a team was formed to develop a detailed process plan to identify every

Item	Page	Item	Page
step, from receipt to final assembly and changeover. All work was accomplished one day early and under budget.		ranked first in a survey by Jacobson & Associates for on-time delivery of customer products.	
Vessel Replacement Specification Development	10	Research and Development	15
In need of a vessel replacement for the BOP facility, WSC developed new specifications for the fabrication of a vessel. Completion and delivery occurred on schedule and \$500 thousand below the estimated cost.		Prior to 1992, WSC lacked methods to formally control costs, to assess the relative merits of starting new R&D projects, or to continue those already in process. WEIRTEC, the company's R&D organization, implemented an extensive program of R&D cost control and efficiency-enhancing measures to correct the previous problems.	
Apprenticeship Program	11	Safety Program	16
WSC instituted a Multicraft Apprenticeship program as part of its existing program. The company asserts that the craft training provides increased productivity and work efficiency, allows employees to keep up with the new technology, and provides qualified replacements for attrition.		At WSC, the Operations Service Department has implemented the highly successful SHARE program that has had a positive impact on safety performance and awareness by providing a formalized safety organization and structure.	
Energy Team	12	Sales and Marketing Initiatives	16
Using a systemic approach, the WSC's energy team reduced energy consumption costs by almost \$40 million per year.		In the last few years, WSC has implemented a wide range of sales and marketing initiatives to improve the management of orders; enhance annual sales; improve customer satisfaction and technical service; and reduce WSC costs.	
Foster-Wheeler Steam Generating Plant	12	Structured On-the-Job Training	17
Construction of a new, steam-generating facility and modifications to increase the boiler capacity have resulted in annual WSC savings exceeding \$1.5 million.		SOJT is the planned process of developing and delivering task-level expertise by having an experienced employee train a novice employee (one-on-one) at or near the actual work setting. WSC states that its SOJT training is more effective and efficient than the previously-used, traditional OJT.	
MIS Customer Service	13	Supplier Management Process	18
The MIS Customer Service plan was established to refocus the MIS Department on customer service. The WSC Data Center was recently ranked in the top 25% in a national benchmarking study conducted by the Mark Levon Company.		In 1996, WSC implemented an extensive program to identify, analyze, and control purchase item costs. A key element in the success of this program was the dedicated assignment of key members (100% of their time) to the team.	
Modular Training	14	Workers' Compensation Program	18
Recognizing the need for formal classroom training, WSC worked with West Virginia University to establish a program of formal classroom modules. It has proven so successful that WSC has received requests to set up similar programs at other companies.		WSC's workers' compensation program provides an aggressive, proactive approach toward case reduction, which has reduced the number of cases and produced substantial cost savings. Unique to its program is the Modified Duty program and the Options Rehab program.	
Operations Planning	14		
WSC initiated a major effort in automating its Operations Planning process that resulted in a \$5.4 million annual savings. The company was			

Information

The following information items were documented at Weirton.

Item	Page	Item	Page
#2 Weirlite Mill	21	Scrap Blending	23
This mill is a large, two-stand, double-reduction, cold rolling, tinplate steel machine used to reduce the gauge of tinplate steel and improve the stiffness, flatness, and surface finish of annealed tinplate steel.		In 1995, WSC set up a secondary scrap metal area to separate various types and qualities of scrap metals, and developed better defined, technical requirements for acceptable blends of various scrap metals.	
#5 Temper Mill	21	Tin Mill	24
This mill is a large, single-reduction, cold rolling, tinplate steel machine used to provide the proper stiffness to ensure the proper surface finish of annealed tinplate steel, prior to a secondary tin or chrome-plating operation.		This mill is the largest, single, tin-producing facility with the greatest capacity in the country. It provides the finishing touches to the company's basic products in accordance with customer requirements.	
Blast Furnace Upgrade	21	Transportation and Material Handling	24
The blast furnaces reduce iron ore into molten metal, which is further processed into steel. One of the current furnaces is scheduled to be rebuilt between November 1996 and April 1997.		Rail service plays an important part in the steel industry. WSC improved the effectiveness of its rail transportation system by centralizing the operation, instituting TQM, and improving the maintenance of its rolling stock.	
Continuous Annealing Line	21	Computerized Maintenance Management	25
WSC operates three continuous annealing lines to rapidly clean and anneal cold rolled steel. These lines can anneal steel in a fraction of the time required by a batch furnace method.		By using a Computerized Maintenance Management system, WSC addressed the need for effective maintenance scheduling, monitoring, and tracking which is critical to sustaining high quality and complex equipment capability.	
Environmental	22	Continuous Galvanized Line	25
WSC has demonstrated a strong proactive commitment to environmental responsibility. WSC's level of spending represents more than 13% of its capital expenditures and exceeds the steel industry's average of 8%.		WSC produces hot-dipped, galvanized sheet steel on three main continuous process lines. Various improvements have reduced costs and enhanced the process capability for WSC.	
Maintenance Planning	22	Preventive Maintenance	26
WSC has established a proactive approach to preventive maintenance to reduce downtimes and optimize the use of limited maintenance resources.		WSC is currently evaluating the scope of its preventive maintenance program to determine which preventive maintenance actions add value and which do not. The system is also being linked to other maintenance systems.	
Process Automation Group	23	Supplies and Spares Management Program	26
WSC established a process automation group that is responsible for maintaining and enhancing legacy systems; designing, developing, and installing systems; managing projects; and providing analysis and consultation on all Level I, II, and III, computer-related needs of the Operations Department.		Supplies and Spares Management is a three-phase program, implemented by WSC to minimize inventories and improve manpower utilization.	
		Computer-Based Training	27
		WSC discovered that it is cost effective to outsource nearly all of its computer-based training requirements. They are in the process of moving to 100% outsourcing.	

Item	Page	<i>Point of Contact</i>
<p>Cost Accounting</p> <p>WSC's cost accounting system has undergone many revisions unique to the company. The company plans to update its general ledger system in the near future by acquiring new software for most of the financial and accounting functions.</p>	27	<p>For further information on items in this report, please contact:</p> <p>Mr. Doug Velegol Weirton Steel Corporation 400 Three Springs Drive Weirton, West Virginia 26062 (304) 797-4354 FAX: (304) 797-4775</p>
<p>Oil Program</p> <p>The company chose a chemical management approach for updating its oil analysis program, concentrating on the areas of wear; additive packages; viscosity; contaminate particles and metal; moisture; and oil safety.</p>	27	
<p>Scanning Drawings</p> <p>In 1996, WSC implemented a system for converting hard copy blueprints and engineering drawings to electronic image files. The new system improves document control and simplifies the communication of revisions and redlines.</p>	28	
<p>Team Building</p> <p>WSC developed a team building concept currently being deployed throughout all of its operating divisions. Company goals are now being proposed and negotiated by the area teams.</p>	28	
<p>Total Quality Program</p> <p>As part of the company's new vision and commitment to quality, WSC established a continuous improvement program built around total quality. Employee participation groups have been very successful and are the primary approach to continuous improvement.</p>	29	

Section 2

Best Practices

Production

BOP Ladle Refractory Improvements

The Basic Oxygen Plant (BOP) operation at WSC requires the use of massive 350-ton ladles to receive the molten metal from the BOP vessel and transport it to the casters. These ladles are lined with refractory materials to insulate the steel shell from the molten metal. These refractory linings are subject to intense heat and rapid deterioration. In 1992, these linings lasted an average of 81.5 heats per ladle at a cost of 79¢ per ton of molten metal processed. BOP personnel have been working to extend the life of these linings and reduce the cost associated with frequent replacement.

The ladle-lining improvement efforts focused on the supplier base for developing new material compositions and lining designs. In 1992, the ladle team began to collect data on digout profiles. It documented all steel penetrations into the linings and recorded contact minutes of molten metal within the ladle. Next, it recomputed the contract to supply refractory materials and reduced the suppliers to two with a 70% to 30% work load split. By using this arrangement, WSC protects its interest with a secondary supplier and maintains the minimal work load needed to keep the secondary supplier viable. The suppliers have experimented with different material shapes and compositions. The use of newer compositions has led to thinner, longer-lasting liners.

As a result of these activities, the liner replacement cycle has been extended to 130 heats in 1996 with an average cost of 57¢ per ton of molten metal processed.

Caster Improvements

Weirton Steel uses a four-strand continuous caster to produce the slabs, which are processed through various production steps and result in coils of thin strip material. The casting process is limited by the number of heats that can be put through the caster. Molten metal is poured into the caster through a device called a tundish. The tundish maintains a constant pool of molten metal that is replenished

from bottom-pouring ladles. In the Weirton system, continuous casts can be run through the tundish for up to 16 hours. Ladle shrouds are fitted onto ladles and extend into the tundish when the ladle is lowered. A caster area team has been formed to develop improvements to the casting process.

The area team developed several improvements to the process. Slag inclusion can block the sliding gates or plug the holes, causing a break in the process flow. The team implemented a slag detection system to monitor the steel level in the tundish and to cut-off the draining before slag can carry over into the mold. A submerged pour method allows the pouring shrouds to be extended from the bottom of the ladle into the molten pool so that the pour emerges below the surface and is protected from exposure to the atmosphere. These changes have improved the process by keeping the openings free 97% of the time.

Cold Roll

Weirton Steel suffered a major production setback in April 1994 when its #9 Tandem Mill caught fire and burned out of control for several hours. This mill, Weirton's fastest and highest quality, light-gauge, cold reduction mill, was producing about 60% of the coils needed for the company's tinplating operations. As an immediate result of the loss, the company had to refocus and shift its product mix to offset the tinplating sales losses. The fire was fueled by hydraulic fluid and byproducts that had coated the interior of the structure. Extensive damage included destruction of all electrical controls and automation systems; severe damage to the various mechanical systems; and major structural deformation. The company turned this disaster into an opportunity by rebuilding the mill from the ground up, using the latest in advanced steel-making technology.

In less than six months, the revamped facility was brought back on-line and began producing in October 1994. This massive \$87 million effort was accomplished through an experienced management team which had recently completed a \$300 million modernization project to upgrade the hot rolling operations. The new #9 Tandem Mill is a five-stand,

four-high, automatic continuous tandem mill, featuring upgraded GE controls, five x-ray gauges, fireproof hydraulics, and automatic thickness controls. The mill generally accepts input coils of 0.095-inch and reduces them down to an average of 0.0104-inch.

Modernizations of the mill include improved safety features and advanced controls to produce better-quality, closer-tolerance coils of light-gauge steel products. The new system uses fire-resistant water glycol for its hydraulic systems, replacing the old mineral-based hydraulic fluids. WSC claims to be the only company in the world to use 100% water glycol. In a related-safety improvement, the fog exhaust system was upgraded and now is regularly cleaned with water flushes. Other features include replacing the old Buss gauges for size control with new, automated x-ray gauges. The old gauges required two people per gauge to adjust or calibrate the gauge, and turnaround time was 45 to 60 minutes. In the new system, the process is automated and takes about 15 minutes. The rolling coolant system has been upgraded from an emulsion system to a dispersion system. Average yields produced on this new Tandem Mill are currently running at 98.9%.

Plating Lines Area Team

The platers area team served as a pilot program for TQM efforts within the Tin Mill at Weirton Steel. The team meets daily to review the reports that include yield data, reject numbers, delay times, scrap rates, and other indicators that reflect line performance. Problem areas are discussed and potential solutions are developed. The team has successfully demonstrated the effectiveness of this concept.

The area team developed standard operating procedures (SOPs) for each operational position. They reviewed total process flows through the various lines in the plating areas and documented operational procedures. They examined each process and developed key process parameters, specified acceptable ranges, established specific measurements, noted required documentation, and identified responsibility areas. This effort also includes examination of all elements for the input and output streams. Weekly oil and chemical treatment reports are developed. Each SOP is given a unique number, and specific-detailed operational proce-

dures are documented. Set points have been developed for all plating lines that established a control range to offer guidelines for operators. These set points can be adjusted for future updates as changes occur. Operator-quality sheets which document process information are completed for each turn. All reports and documentation are used by the team to develop process improvement recommendations. As long as costs are justified within a two-year or less payback, recommendations under \$1 million can be approved locally without the endorsement of the Board of Directors. Larger efforts, however, require a higher-level corporate approval.

In 1996, 16 individual projects were completed, and 20 third and fourth quarter projects were identified and prioritized. Those completed projects have demonstrated the effectiveness of the platers area team by surpassing its overall cost reduction goal for the year.

Torpedo Bottles

A fleet of 22 refractory-lined, steel rail cars called torpedo bottles are used by Weirton Steel to transport molten metal from the blast furnace operation to the BOP facility. Torpedo bottles have a 225-ton capacity and can maintain the metal in a molten state for pouring into the BOP vessel for up to 22 hours. The refractory linings in the torpedo bottles are periodically replaced, causing critical transport capacity to be removed from the process flow. The frequency of the replacement process is constantly reviewed and improved.

In the past, torpedo bottles were relined after carrying 350,000 to 400,000 tons. Today, the number has grown to 500,000 tons and is still expanding. This increase has been achieved through various means. The refractory bricks are coated with a special gunning material to protect them. Inspections are conducted to monitor the shell temperature; visually inspect the linings; track the tons carried since the previous relining and gunning; and drill test holes. Thermographic readings are recorded each week. When data indicates the barrier is failing in a particular area, test holes are bored into the brick to determine the remaining thickness. These readings allow partial regunning in specific areas that extends the life of the bricks. These practices are expected to extend the lining usage to more than 600,000 tons.

Facilities

Hot Strip Mill

Rebuilding the Hot Strip Mill at Weirton Steel has been the cornerstone of the overall factory improvement program. With virtually all of the new equipment now in place, the Hot Strip Mill can easily be defined as a world-class facility.

Recognizing a need to improve their steelmaking capabilities in order to stay competitive, the employees of Weirton Steel made a commitment to take their steelmaking capabilities to world-class levels in Spring 1988. Using the Hot Strip Mill as the cornerstone of their factory improvement program, they invested more than \$300 million in the rebuild of this equipment. The rebuilt Hot Strip Mill has improved quality, increased efficiency, and broadened the product capabilities of Weirton Steel.

Replacing four pusher furnaces with two new walking beam furnaces improved fuel usage by 59%. The new reversing roughing mill now operates at higher speeds and greater capacities due to the increase of power. With two 7,000 hp motors, thicknesses of up to 0.75-inch are an improvement over the old mill that had a capacity of 0.25-inch. Finished gauge sizes are now controlled to +2% over the length of the roll, and a hydraulic scale breaker maintains better surface conditions. Repowered stands; new gear boxes; the addition of a hydraulic automatic gauge control; and automated roll changing and roll bending allow the processing of the strips to occur at increased speeds. The new rotary crop shear, which replaced the old manual crop shear, provides a consistent, optimized use of the slabs with capacities up to 2 x 50 inches.

With these improvements to the Hot Strip Mill, Weirton Steel has increased its production capacities and has positioned itself to compete as a world-class, steel production facility.

Predictive Maintenance Group

Since downtime in a mill is costly, Weirton Steel established a predictive maintenance group in 1991. This concept was first introduced in the Hot Strip Mill on the #5 Pickler where WSC employees collected and analyzed data. In 1993, an outside contractor was brought in to expand the program to the rest of the mill. The contractor team, made up of a site manager, three analysis engineers, and nine technicians, collected data with the goal of central-

izing operations for each area of the mill on a scheduled basis. Vibration and thermography data was collected. By 1994, vibration readings were being collected from 20,000 routine points each month. Thermographic readings covered all areas, once every six months. Reports were distributed to maintenance foremen, and a follow-up report, listing completed jobs and cost savings, was generated every week for the planners.

Currently, the two WSC analysts in the Hot Strip Mill's #5 Pickler are Level I certified. A new contractor has been retained to cover the rest of the mill with a site manager, two engineers, five analysts, and four technicians. Now, the analysts are located with the maintenance planners in each area of responsibility. Vibration data collection increased to 35,000 routine points per month. Maintenance personnel determine which machines are critical and require monitoring. A full-time engineer is dedicated to special vibration monitoring projects. Thermography now monitors one area at a time for periods of two to eight weeks. Special projects in such areas as batch anneal, clogged pipes, and misaligned couplings are conducted as required. Reports are distributed to the maintenance planners who meet and discuss the findings with the maintenance foremen; follow-up is extensive. Monthly update reports are provided to operation/maintenance management and planners who meet to discuss jobs in each area. All returned, predictive maintenance work orders are rechecked for improvement in vibration levels.

Predictive and condition-based maintenance at WSC applies several technologies. Vibration readings are taken to measure the impact force on a machine and to detect bearing defects, misalignment, imbalance, coupling problems, steam traps, and mechanical looseness. When vibration readings are taken, the technicians also perform a visual inspection to detect loose bolts or other problems. Thermography measures temperature and can detect problems in such areas as electrical switchgear, gearboxes, torpedo cars, substations, circuit breaker panels, steam lines, and process parameters. New technologies being added include motor current analysis to detect problems with rotor bar current harmonics, high voltage, discharge testing, and resistance measurements; wear particle analysis to identify wear in applications where metal meets metal such as gearboxes, bearings, and hydraulic systems; and ultrasonic monitoring to detect leaks in valves, steam traps, piping, and other process systems.

Training is a key aspect of the predictive maintenance program. Classes are conducted once a month to teach maintenance personnel how to use and benefit from predictive maintenance techniques. The purpose is to enable WSC maintenance personnel to gain an appreciation of these maintenance tools and have a better understanding of the information that the reports provide, so they can make better maintenance decisions.

Predictive maintenance techniques have significantly improved operations by reducing downtime, product loss, and machine replacements due to unanticipated failures. In 1993, the savings-to-investment ratio broke even. By 1995, the savings ratio was 9:1 and projected savings for 1996 are 11:1.

Future plans call for integrating the predictive maintenance program into other WSC programs including oil analysis, preventive maintenance, and spares management. New and more useful metrics are being developed to help evaluate effectiveness and return on investment. Acceptance testing of new installations is being adopted to monitor baseline levels and determine if installation was acceptable. The knowledge and experience gained is then applied to the development of acceptance specifications for new equipment acquisitions. Not only has this new program been gaining approval within the maintenance ranks, but it is facilitated by a quarterly newsletter and training. Maintenance personnel are beginning to appreciate the value of predictive maintenance methods.

Vessel Assembly and Changeout Planning

WSC purchased a new furnace vessel for the BOP in the third quarter of 1989. This vessel was needed to replace one of two existing vessels in the BOP, and was critical to operations which required two vessels to be continuously operated on an alternate, rotating basis. The fabrication specifications of this new vessel required that it be delivered to WSC for assembly with minimal fitting and welding requirements. To accomplish this and ensure a timely assembly and changeout of the old vessel without delaying plant operations, a team of WSC personnel was formed to develop a detailed process plan to identify every step of the operation required, from receipt to final assembly and changeover. This team represented all trades involved in the process. In addition to developing the process plan, individual team members performed as job leaders during their phase of the operation.

To document and manage the numerous steps involved in the assembly of the vessel as well as the changeout operation, the project team leader used the PC-based software package, Primavera. Use of this system helped to ensure that milestones and key events were accomplished as scheduled. This approach also allowed for the creation of historical data that can be used with photographs and videotapes for future vessel changeouts.

Appropriation for funding of this project was developed and approved in March 1992 for \$3.1 million. The assembly phase started in April 1992 and was completed in November 1992. All work was accomplished by WSC personnel and was completed one day early and under budget.

Changeout of the old vessel began on December 26, 1993 and was completed by the end of January 1994. The team was divided into two teams to provide around-the-clock coverage. Twice-daily meetings were held by the teams to update the status and to ensure no roadblocks developed. Face-to-face turnover by the two teams each day ensured that every detail was clearly understood and acted upon as scheduled.

Since the new vessel has been put into service, there has been no measurable distortion between the trunnion ring and the body shell. This is an indication that the useable life of this vessel is well on its way to meeting the 25-year service life requirement.

Vessel Replacement Specification Development

WSC began using the basic oxygen steelmaking process in Fall 1967. Two furnace vessels, used on an alternate, rotating basis, allow necessary routine maintenance and refractory relining work to occur on the idle vessel without disrupting daily operations. At 365 tons, these vessels have the largest capacity of this type in North America. Since becoming operational, one vessel has been replaced twice, in 1975 and 1986. The other vessel was repaired in 1988 to correct distortion between the trunnion ring and the body shell. This repair extended the vessel's useful life for another three to five years, and allowed WSC the time to develop a replacement vessel specification, arrange for the necessary funding, and assemble a new vessel. Lead time for fabricating a new vessel was 26 months with an additional 10 months for field assembly and changeout of the old vessel. This factor required that a specification be developed

and funded, so a new vessel could be purchased in time to support the extended end-life of the repaired vessel.

To develop the specification for the new vessel, WSC assembled a team to establish the requirements and ensure that input was provided by all responsible personnel who would be involved in the project. The team reviewed and evaluated the existing specifications from the previous purchases and recommended changes. They benchmarked with other steel producers and received technical input from recognized experts in the field of vessel design as well as vessel fabricators. The completed specification required that the new vessel be designed and built to last at least 25 years to offset the high cost of replacement. It had to be dimensionally identical to the other vessel in use, and be able to accept the reuse of existing components and spare parts. The design had to be such that it could be assembled on-site with minimal fitting and welding by WSC personnel.

The appropriation request for the new vessel was approved in 1989 for \$5.5 million with an understanding that the funds for the assembly and installation of the vessel would be requested at a future date to coincide with the extended end life of the repaired vessel.

Four companies bid on the proposal for the fabrication of the new vessel. The selection and award was made in the third quarter of 1989. Fabrication time was estimated at 17 months with an additional 10 days of inspections required at the builder's site by WSC personnel. The vessel was completed and delivered in May 1991, on schedule and at approximately \$500 thousand below the estimated cost.

Management

Apprenticeship Program

As part of its contract negotiations in 1989, Weirton instituted a Multicraft Apprenticeship program as part of its existing apprenticeship training program. As a result of the contract negotiations, a General Control Committee for the Apprenticeship Program, consisting of three union Executive Committee members and three Company Management members, was tasked to establish guidelines and procedures to enable the Joint Apprenticeship Committees to administer apprenticeship and craft training programs. In addition, the General Control Committee ensured the training quality, determined the pay rate for students and instructors, established instructor criteria, and de-

veloped the training format. A four-person, full-time staff administers the craft training program.

The apprenticeship program operates under the Weirton Standards of Apprenticeship in accordance with the U.S. Department of Labor Bureau of Apprenticeship and Training. These standards spell out the requirements for apprenticeship including classroom and on-the-job training for each craft. Apprentice training consists of eight to ten semesters depending on the individual craft. Classroom training is provided with two, 18-week semesters, four hours per week. This training is taken by the students on their own time. The company provides all necessary books and reimburses each student \$500 per class for travel expense.

Since April 1990, craft training classes have been conducted on-site at Weirton's dedicated training facility. The Multicraft program consists of three levels: Expanded I, Expanded II, and Multicraft. The Expanded I training is mandatory for all craft employees, except those 55 years of age or older or with 33 or more years of service. Upon graduation, the apprentice receives a two-job class increase and a \$250 bonus. The Expanded II training is mandatory for all employees accepting any apprentice bids. Maintenance Mechanic and Rigger/Pipefitter/Wireman/Crane Repair/Mobile Equipment Repair personnel each receive a two-job class increase plus a \$250 bonus. Maintenance Electricians receive a four-job class increase and a \$500 bonus. The Multicraft training allows employees to become journeymen in two or three crafts. Graduates of Multicraft training receive a two-job class increase and a \$250 bonus. In coordination with a local community college, the journeyman can then achieve an Associate degree by completing an additional 21 hours of on-campus instruction.

Instructors are active, salary non-exempt employees and must pass written and/or performance exams in the subject area. A 40-hour, occupational, teacher-training course is required and covers basic teaching principles and learning methods; occupational analysis; lesson plan development and execution; instructional management; and student evaluation.

More than 160,000 student-hours of classroom instruction was provided in 1995. Besides the training provided for Weirton employees, training was also conducted for Washington Steel and Wheeling-Pittsburgh Steel employees. The income generated from marketing the training services outside Weirton resulted in a net profit of \$205,941 which helped offset internal training costs.

A license for open enrollment has been requested, and approval is expected in September 1996 which will allow Weirton Steel to further market its training services. Weirton Steel asserts that the craft training provides increased productivity and work efficiency; allows employees to keep up with new technology; and provides qualified replacements for attrition.

Energy Team

In 1989 and 1990, WSC energy costs rose to account for more than 25% of the company's process costs in 1989. Using a systematic approach, WSC's energy team reduced energy consumption costs by almost \$40 million per year.

In an effort to reduce energy costs, WSC formed an energy team in 1991. Its purpose was to identify company energy consumption and cost; analyze energy information against other industry figures (benchmarking); determine major leverage areas; select high potential improvement opportunities; and ultimately reduce energy costs.

The energy team consisted of 12 cross-functional team members, each of whom was assigned to the team for 100% of the time for a minimum of 12 months. The team applied a systematic, problem-solving process to identify energy improvement opportunities. Their approach included breaking up energy consumption into subsets of purchasing, generation, and end use. Major leverage areas within each subset were identified, and areas of high potential for improvement were selected in accordance with a set of criteria defined by the team. The criteria included the minimum dollar value for the expected cost savings; the maximum investment cost and investment-to-payback ratio; and the implementation period to start the improvements.

Through use of their energy identification, analysis, and corrective action approach, the energy team's actions successfully saved the company more than \$12.4 million between May 1991 and December 1992. By the end of 1995, annual purchased energy costs were reduced to \$203 million, a savings of almost \$40 million per year compared with 1989.

Foster-Wheeler Steam Generating Plant

Construction of a new, steam-generating facility and modifications to increase the boiler capacity have resulted in annual WSC savings exceeding \$1.5 million. In the late 1970s, WSC lacked suffi-

cient boiler capacity, bought fuel at record-high prices, and used 25 to 60-year-old boilers with serious maintenance problems. WSC was also burning off (flaring) and wasting large quantities of byproduct, blast furnace gas (BFG), while having to purchase additional fuel due to insufficient BFG burning capacity.

In 1980, the company solved these problems by building a new, cost effective Foster-Wheeler steam generating plant. The facility takes water from the nearby Ohio River and converts it into 600,000 lb-m/hour (gross) of superheated steam at 825 psi and 825°F, delivering 500,000 lb-m/hour for steel mill operations. Cost effectiveness of the Foster-Wheeler steam generating plant comes from several sources such as its ability to proportionately switch fuel mix from 95% BFG (5% natural gas) to 100% natural gas automatically.

Besides the automatic fuel mix capability, improved boiler efficiency resulted from two 60% capacity induced-draft and forced-draft fans on each boiler; heat traps that include both air heaters and economizers which provide more than 85% efficiency; low excess O₂; and attempters to control finished-steam temperature. Boilers have a complete National Fire Protection Association burner management safety system and are fully environmentally compliant.

Another cost-effective measure comes from the high water quality using a water treatment process to produce deionized water that provides less than 1% boiler blowdown. The neutralization system complies with EPA requirements, and the water treatment process is automated (except carbon filters) with a programmable computer.

In 1993, as an element of the company's Total Quality process, WSC benchmarked its operating and maintenance strategies for the Foster-Wheeler plant against those of Florida Power and Light. Following the benchmarking, WSC's water plant capacity was increased 27% by using an improved ion exchange resin, resulting in an annual savings of \$100 thousand. An additional \$250 thousand in annual savings was achieved through increased capacity of the induced-draft fans' turbine-steam admission valve at a cost of only \$1 thousand per fan. A third improvement in plant capacity was achieved through the use of high pressure (20,000 psig maximum) water lasers (BFG) residue which reduced off-line time by 50%, and provided savings of more than \$750 thousand per year.

Further cost improvements have been realized at WSC through activation and enhancement of boiler

pressure control (rather than flow control) to reduce purchased fuel costs, and through tracking and trending excess air control. These changes resulted in a combined, annual savings of an additional \$375 thousand.

The company believes these process changes have provided insight to future opportunities which will yield savings approaching 10 times those achieved to date.

MIS Customer Service

Three years ago, WSC undertook a Management Information Systems (MIS) outsourcing initiative to improve its performance in this critical area. The internal evaluation revealed that the primary problems were lack of accountability for project priority or cost, and the fact that MIS viewed itself as a staff function rather than a service function. Benefits offered by external service providers were accountability, discipline, and service. Rather than outsourcing MIS, WSC decided to develop its internal organization into a world-class supplier of information services by maximizing people, processes, and technology. The Customer Service plan was launched in 1994 to bring about the organizational realignment and change needed to develop a world-class service organization. Now the MIS Department is run as a profit center focusing on customer service. A chargeback system has been established. End users are now involved in all project phases including accountability for performance.

A steering committee, which includes senior managers from manufacturing systems, business systems, and the MIS planning committee, directs and oversees Customer Service operations. This committee establishes project prioritization processes; authorizes additional resources to meet justified project needs; measures MIS performance against established objectives; implements a chargeback mechanism; and continues to build and evolve annual, business unit plans to form a corporate systems plan.

Application owners and service coordinators are assigned to each business area. Application owners are primary end users responsible for managing the strategic direction of a system (group of applications), as well as all application software and hardware requests affecting that system. They are responsible for managing application software systems from a business perspective. Application owners review the business justification of each project request, and then approve and prioritize the re-

quests. They develop a business plan and work with MIS to obtain the necessary resources for successful completion. Service coordinators are designated MIS advisors responsible for coordinating the delivery of MIS services to the respective business area for that application owner. They manage application software systems from a technical perspective. Service coordinators serve as a liaison between the business area and MIS. They provide technical consulting services (customer support and training) and ensure that service level agreements are met. The application owner and the service coordinator meet informally, communicate on a daily basis, and have formal project meetings monthly.

Service level agreements are written agreements between MIS and customers that define the services provided and the completion time frames for each type of service offered. The goal of the service agreement is to ensure timely and consistent customer service from MIS by defining the responsibilities and expectations associated with a successful, service request process.

Four types of customer service requests (emergency, ad hoc, hardware, and software) are managed under the Customer Service plan. Emergency requests involve work stoppage and are business-critical in nature. These are immediately acted upon without the application owner's approval. Ad hoc requests, typically completed in 30 minutes or less, are handled informally without formal approval, often without chargeback. Hardware requests require formal approval and are used for all hardware needs (computers, telephones, facsimiles, copiers, etc.), physical moves, and security. Software requests require formal approval, and require a baseline document if the project duration is greater than one week. Projects less than 320 hours in duration are considered minor projects and are normally paid for out of business unit resources. Projects exceeding 320 hours are considered major projects and must compete for corporate resources.

Customer focus is the driving force behind the Customer Service plan. Results from annual customer satisfaction surveys are published throughout the mill and used to improve performance. MIS provides initial training, documentation, and a train-the-trainer program to allow end users to take control of the technology.

The Customer Service plan approach has been very successful. It has eliminated the need to outsource the MIS function and provides an efficient

business-driven capability that is responsive and customer focused. Nice-to-have and non-critical projects have been eliminated by placing project responsibility and prioritization in the hands of the application owners rather than the MIS Department. Users feel more in control, and are encouraged by the process to think strategically and to manage their budget and resource limits. The WSC Data Center was recently ranked in the top 25% in a national benchmarking study of major corporations conducted by the Mark Levon Company.

In developing the Customer Service plan, WSC learned that one key to success was to carefully choose and screen the service coordinators. Not only should they be technically competent but they must also have strong interpersonal skills, be able to manage multiple tasks, and be resilient. Charging the cost of services back to the users to force the accountability and efficient use of resources is essential. Better internal communications between the departments and business units are needed so that customer requirements can be more effectively met with standardized solutions.

Modular Training

Recognizing the need for formal classroom training at WSC in 1993, the company began working with West Virginia University to establish a program of formal classroom modules. This format allowed WSC to meet a wide range of training requirements.

Partly funded by a governor's grant from the State of West Virginia, the company worked with West Virginia University to develop a set of 85 formal, classroom training modules. The program's goal was to achieve a 90% retention level as a result of an active learning experience, rather than the typical 20% retained using standard read-and-hear classroom techniques.

Each training module, structured in 1 to 1½ hour sessions, covers a topic designed to meet employee needs. In addition, the company established a train-the-trainer program to ensure consistency with its employee instructors' teaching methods. These instructors then conduct training for other employees in their area.

To ensure the quality of each training module, the company structured the module development to follow standardized formats which use Operations Department experts to generate the technical portions of each module. New modules are then

required to meet both an Alpha Test and a Beta Test before the module becomes part of the company's training program. The Alpha Test consists of a thorough review of the new module by a company team of non-experts, while the Beta Test is subsequently reviewed by subject-technical experts.

The company training program and modular training concept have proven so successful that both local businesses and WSC customers have requested not only training using WSC classroom materials, but also assistance from the WSC training group personnel to establish similar training programs at their companies.

Operations Planning

Weirton Steel has initiated a major effort in automating its Operations Planning process. This effort consisted of five-major, IBM-based, software components which have been internally developed since 1986. The individual components are being expanded and integrated to provide a totally integrated logistics and management information system for serving the company well into the future.

The first module, developed in 1984 through 1986, was the Order Entry system. Next came the Hot Mill Scheduling system in 1987, the Integrated Management Information System (IMIS) in 1991, and the Caster Scheduling system in 1993. The latest system, Logistics and Integrated Scheduling, began development in 1993 and will complete the integration of the major planning functions. The Order Entry system provides all order information in a relational database that can be queried throughout the day to provide a view of all production orders. The Hot Mill Scheduling system supports the Hot Strip Mill's automated computer process controller and schedules all slab areas. This produces better, more productive schedules and reduces slab handling requirements. The Caster Scheduling system builds a weekly plan that includes a detailed 32-hour schedule, and a reconciliation system which links scheduling and production.

The IMIS system was completed at a cost of approximately \$18 million. The system delivers real-time, production recording around the clock, and integrates order entry information, operating unit information, and plant floor production into a real-time, corporate order status. The Logistics and Integrated Scheduling system has been in development since 1993. This system incorporates a sched-

uling engine for integrated scheduling and will allow the overall flow of materials to be improved throughout the entire plant operation, leading to enhanced throughput.

All 40 operating units within the plant are now scheduled from a centralized planning organization. This has led to a reduction in planning personnel of two salaried positions and 107 salary non-exempt employees. This reduction amounts to a \$5.4 million annual savings. The company has also been ranked first in a survey conducted by Jacobson & Associates for on-time delivery of customer products.

Research and Development

Prior to 1992, WSC lacked methods to formally control costs, to assess the relative merits of starting new R&D projects, or to continue those already in process. Further, WSC's R&D project-schedule performance tracking was informal; research and development projects were funded solely by WSC; and significant inefficiencies existed in the R&D process due to the lack of significant computer modeling capability. At that time, WEIRTEC, the company's R&D organization, implemented an extensive program of R&D cost control and efficiency-enhancing measures to correct the previous problems.

A key action taken by WEIRTEC was the implementation of the stage-gate process. The process established a set of stage-gates (or milestones) at key points in the life of each R&D project. Each stage-gate had a specific set of deliverables and responsibilities that had to be met before a project was allowed to proceed to the next level. Representatives of general management, operations, engineering, WEIRTEC, marketing, and other functions defined responsibilities at each stage-gate, and senior

management approval of expenditures and responsibilities was required. Table 2-1 presents a list of criteria used by WEIRTEC to evaluate and rank the potential attractiveness of proposed R&D projects prior to expending significant company funds.

A second element, implemented by WEIRTEC in the formal control of R&D expenditures, was the formulation of both international and domestic alliances with other companies to more effectively leverage the technology resources of WSC. The alliances also expanded the scope and reach of available technology. The alliance concept now provides collaborative application development with WSC customers, international companies, and even other North American steel producers through the American Iron and Steel Institute (AISI).

Computer modeling has helped compress the time and resources required for process and product engineering. In some cases, such as high-speed forming of light gauge metal, computer modeling has proven to be the only cost effective engineering and testing method for meeting requirements that are beyond traditional engineering design techniques.

Further control of the company's R&D expenditures was achieved by using Microsoft Project software as a management tool to improve the plan-

Table 2-1. Developing a Technology Strategy

CRITERIA	DESCRIPTION
Strategic Fit	Fit of R&D program with business or corporate strategy.
Probability of Technical Success	Probability of overcoming technical hurdles within 5 years. Determined by assessment of program complexity, company technology skill base, available technical knowledge.
Probability of Commercial Success	Probability of overcoming technical hurdles within 5 years. Determined by projections of market need, WSC marketing capabilities, and WSC's application development skills. NOTE: In most process improvement programs, the commercial success probably will be high.
Intellectual Capital	Measures WSC's ability to maintain a protected competitive advantage as a result of a successful project. Ranges from easily copied to position protected.
Reward	Assessment of projected return on capital employed within 3 years of first commercial use and incremental profit impact (see attached).
R&D Cost to Commercialize	Cumulative R&D cost (from today into the future) expected until commercial operations begin. Measurements of level of R&D investment required, including R&D capital expenditures such as pilot plants.
Time to First Commercial Use/Sale	Number of years until the results of the program are actually used in producing a commercial product.
Environmental, Health & Safety Impact	Perceived impact on high profile issues.
Platform for Revenue Growth	Incremental revenues 3 years after project completion.
Capital at Risk	Fit of R&D program with business or corporate strategy.
Competitive Position Post Project (cost basis)	Impact of project on WSC's cost position within the industry (the applicable regional market).

ning and tracking of all development activities. This customized software incorporates project timelines, deliverables, and required resources, as well as project tracking, technical notes, and report generation.

Safety Program

Occupational safety and health is a top priority at Weirton Steel. On-the-job injuries cause needless physical, emotional, and financial suffering to those injured as well as their family members. Additionally, expenses attributed to accidents are costly and significantly impact the profitability of the Corporation. WSC's Operations Service Department implemented the highly successful Safety & Health Awareness Requires Everyone (SHARE) program that has had a positive impact on safety performance and awareness by providing a formalized safety organization and structure.

Prior to 1991, a Safety Department existed but had no formal safety focus or emphasis. Its safety structure and organization were somewhat fragmented, and its communication and cooperation between the Operations Department, the Medical Department, and the Benefits Department were unstructured or nonexistent. Safety awareness was limited, highlighted only after a serious injury occurred within the plant. Safety data and reporting were misleading, inaccurate, or impertinent. The company had limited training and documentation; little compliance with the rules; general apathy and ignorance; no uniformity; and no incentives or rewards for performance. Safety was mainly reactive and not proactive. Due to low priority and limited support from upper management, WSC and the Operations Service Department ranked in the bottom third for good safety records compared with the rest of the integrated steelmaking industry (AISI safety data survey). There were 552 OSHA recordable injuries in 1992, and 131 excessive days-away-from-work (DAFW) cases in 1990. Medical costs and workers' compensation payout skyrocketed to \$3.7 million during 1990-1991.

In 1991, the Operations Service Department formed a steering committee to undertake the problems of safety and health. The cross-functional, steering committee (both salary non-exempt workers and salaried employees) is responsible for overseeing, administering, and coordinating safety efforts. Subcommittees address and recommend improvements regarding safety such as tool safety, housekeeping, audits, ergonomics, OSHA, statis-

tics, and communication. Establishment of a core team of supervisory personnel ensures the acceptance of implemented improvements. A safety coordinator assures compliance with established guidelines and provides training assistance. This entire safety organization, now referred to as the SHARE organization or initiative, is tied to the Operations Service Department's managing-the-business-better initiative, which is an endorsement by management to support the SHARE initiatives.

The steering committee provides direction and jointly establishes safety goals and objectives with the subcommittees and the area management personnel. Subcommittees work on improvements to their specific assignments and ultimately make recommendations to the steering committee regarding these improvements. The steering committee evaluates proposals and establishes procedures and policies for division-wide adoption and implementation. Then, the committee communicates the new procedures and policies to the core team and the pertinent subcommittees. The core team is responsible for policy implementation and enforcement. Subcommittees also aid in implementation, education, compliance, and auditing. All progress, activities, and status are reported to the Communications Subcommittee for proper dissemination. The safety coordinator provides training in conformance with OSHA guidelines, monitors progress, maintains documentation, and assists supervisors with enforcement and compliance issues. Audits on the entire process occur twice annually. Issues and concerns are forwarded to the steering committee and area managers for appropriate action. Quarterly performance reviews with salaried personnel also assure compliance.

As a result of the SHARE organization and initiatives, a safer working environment for employees exists. OSHA recordable injuries dropped from 552 in 1991 to 340 in 1995. The DAFW case rate decreased from 5.8 in 1990 to 2.1 in 1995. Workers' compensation payouts have reduced from \$152 thousand per month in 1990 to \$101 thousand per month in 1995. The Operations Service Department now ranks equally to the industry average in DAFW case rates and just slightly below the industry average in recordable case rates, according to the AISI safety data for integrated steelmakers.

Sales and Marketing Initiatives

In the last few years, WSC has implemented a wide range of sales and marketing initiatives to

improve the management of orders; enhance annual sales; improve customer satisfaction and technical service; and reduce WSC costs. While all the initiatives have been effective for WSC, three have been highly effective.

WSC switched from the company's normal accounting method (based on annual standards) to a Net Actual Profitability method for a small number of highly competitive and low margin accounts. The Net Actual Profitability method provided improved identification of all WSC costs, directly and indirectly, associated with respective customers' products and accounts. Further, enhanced cost visibility has been provided on a three to six month rolling basis, rather than annually under the previous WSC approach.

The second key initiative implemented by WSC was the identification of Strategic Business Accounts (SBA). WSC identified key customers with large accounts essential to its business base, established SBAs to reflect those customers, and then made business decisions based on the fact that SBAs would make up 60% of WSC's annual sales. This unique (in the steel industry) development of long-term sales agreements with its customers was a major element in the successful application of SBAs in providing a stable business base for WSC. Long-term customer agreements provide benefits to both WSC and its customers, offering stable business for WSC and allowing the company to offer reduced and fixed long-term pricing to its customers.

The third key initiative was and continues to be improving customer satisfaction, quality assurance, and technical services to those customers. WSC established a process to survey customer satisfaction with WSC products and took corrective actions to eliminate any identified problems. In particular, WSC improved its overall delivery performance from one of the lowest in the industry to one of the highest according to a Jacobson & Associates survey. Further, the company established direct operator-to-operator contact between key WSC product personnel (salary non-exempt) and WSC customers to promptly correct technical problems and enhance technical services provided to those customers.

Structured On-the-Job Training

Structured On-the-Job Training (SOJT) is the planned process of developing and delivering task-level expertise by having an experienced employee

train a novice employee (one-on-one) at or near the actual work setting. The Training Department created the SOJT process to provide a more structured and effective training experience for its employees. The SOJT process is currently implemented throughout Weirton Steel's operating areas.

WSC started experiencing a significant number of retirements and transfers among its senior employees in its operations areas. New and transferring employees need to quickly develop a working knowledge of their job responsibilities. Although classroom training is the most popular, most learning occurs as a result of training conducted in the job setting itself. On-the-Job Training (OJT) allows an employee to pass job knowledge and skills to another employee in the work setting. Prior to 1991, WSC performed unstructured OJT. Trainees acquired job knowledge and skills from impromptu explanations or demonstrations, trial-and-error efforts, self-motivated reading, questioning on their own, and imitation of others. Unplanned OJT, typically driven by work demands and crises, prolonged the training period, delivered inconsistent learning, and did not always address the needs of the trainee.

During December 1991, a Total Quality Needs analysis revealed a problem with the traditional OJT method of breaking-in new personnel to these positions. Since OJT methods are typically ignored by most professional trainers, the necessary skills to plan and execute structured OJT are not widely known or published. WSC established a team to research SOJT and create a structured break-in training program that had a consistent format, served the needs of the trainee, and selected the best delivery method. SOJT methodology was developed in cooperation between the WSC training group and an outside consultant to ensure in-depth SOJT guidelines and instructions.

Based on this methodology, a guidebook was generated to provide guidelines for training consultants who select the best training delivery method for the training needs. The guidebook helps managers who may need to develop SOJT; project managers who coordinate the development process; technical consultants who actually develop the training materials; and mentors who want to better understand the whole SOJT system. The guidebook provides the definition of SOJT, the decision criteria for selecting SOJT as the training method, the procedures to follow when designing SOJT for a position, and the evaluation techniques for determining the change in a trainee's behavior as a

result of training. Each comprehensive SOJT training manual addresses the following guidelines: the time schedule of activities to complete the training; an overview of the specific training; in-depth safety equipment and concerns associated with the position; basic information and detailed job task descriptions; exercises for the trainee; position evaluation and diagnostics; and job-related terminology.

To date, SOJT training manuals, based on the Methodology Guidebook, document the training for more than 80 positions at Weirton Steel. For any given position, at least five or more personnel have completed SOJT training to date. WSC states that its SOJT training is more effective and efficient than the previously-used, traditional OJT.

Supplier Management Process

In early 1996, WSC implemented an extensive program to identify, analyze, and control purchased item costs. The program, referred to as the Supplier Management Process, consists of an eight-phase approach, each called a wave, which defines the WSC purchase item cost history and performs initial spend analyses of the highest cost items (spend buckets). Each spend bucket was further broken down into major cost subcategories to better define and localize cost drivers for corrective action. Figure 2-1 depicts the spend bucket breakdown for Electrical Parts and Supplies.

Once the spend bucket categories were identified, WSC charted spending for both the vendors

involved and the mill areas affected (Figure 2-2). Price trends over time were also quantified. Detailed spend analyses were performed including WSC current sourcing strategy, current and future market trends, relationships with current suppliers, other ongoing WSC initiatives in the affected area, and other considerations. Further, vendor capabilities, quality, and service were rated by WSC. The company identified all cost drivers in each category under its all-in cost analysis process, including acquisition price; and logistics, delivery, transportation, handling, and in-house costs.

Cost baselines were established for each piece of equipment; areas of waste and inefficiency were identified; and comparisons of as-is and could-be costs were developed. Methods to reduce internal, supplier/customer and purchased item costs were then identified and charted on a problem-solving tree for each spend category. Next, WSC implemented actions to reduce its costs.

Although still early in the WSC Supplier Management Process, significant, tangible benefits have already been derived in some of the early action areas, such as rubber rollers and chemical purchases. A key element in the success of this program was the dedicated assignment of key members (100% of their time) to the WSC Supplier Management Process team. The company believes that, without the full-time dedication of the team members, the process would not have succeeded.

Workers' Compensation Program

Workers' compensation benefits, paid to workers injured on the job, directly affect a company's cost of doing business. Because it adds no value to the product, it is in the best interest of the Corporation and its employees to aggressively pursue the reduction of workers' compensation payouts through safety awareness and an effective workers' compensation program. Weirton established a workers' compensation program to review, contain, and reduce the costs of workers' compensation. Through innovative improvements made in 1996, injury claims are now thoroughly reviewed, payout periods are monitored, and recovery is assisted.

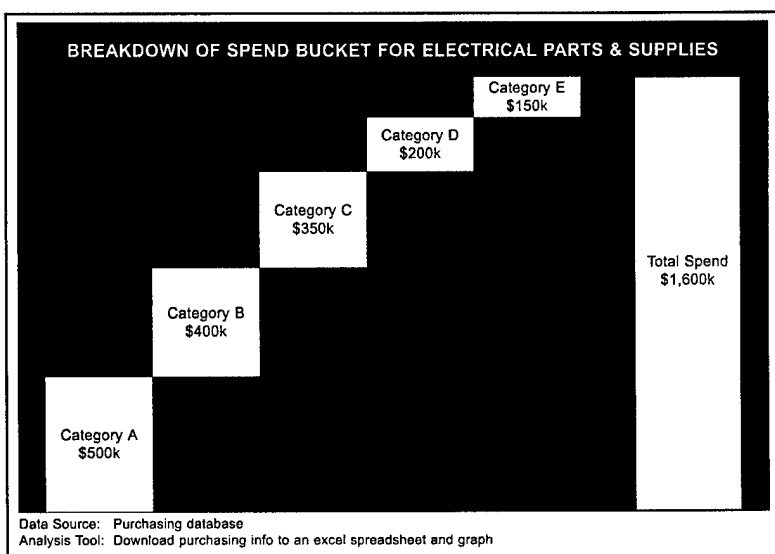


Figure 2-1. Initial Spend Analysis

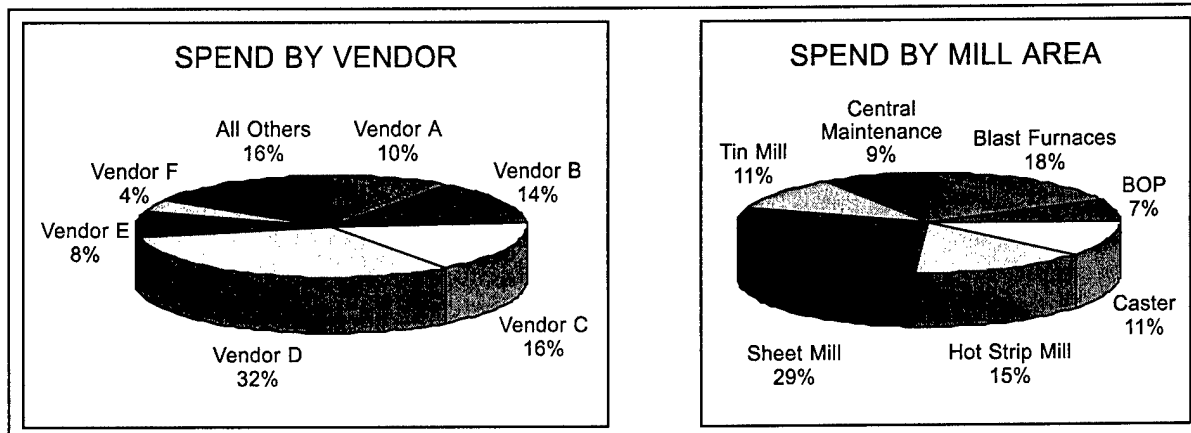


Figure 2-2. Vendor/Mill Area Chart

Prior to 1996, reductions in workers' compensation cases were primarily attributed to the established efforts of the safety program. Workers' compensation processing remained unchanged and unchallenged. The process for reporting injuries was modified to allow a more thorough review of the injuries by inclusion of independent medical examiners and third-party administrators. Accident reports are now submitted for a claims ruling within 24 hours of filing, or within three days if questioned. Weekly management meetings are conducted to review each case. In cooperation with the Operations Department, an aggressive Modified Duty program was established to return employees to the workplace in an area that is amenable to their injuries. Unique to the program is the Options Rehab program where the patient agrees to follow rehabilitation treatment. Rehab protocol decrees that if surgery is required, it should be performed

as soon as possible, followed by prescribed rehabilitation, and a proper transition back to work. The program is developing a treatment protocol for high occurrence injuries such as back strain, knee injuries, and shoulder injuries. The protocol is the standard of care for such injuries. Additionally, there is increased follow-up of patients off work through biweekly physician visits and calls from case managers.

WSC's workers' compensation program provides an aggressive, proactive approach toward case reduction, which has reduced the number of cases and produced substantial cost savings. Since implementing these changes into the process, the number of workers' compensation cases have dropped from 140 in July 1995 to 77 in July 1996. Payouts have reduced from \$153 thousand per month in 1991 to \$101 thousand per month in 1996.

Section 3

Information

Production

#2 Weirlite Mill

The #2 Weirlite Mill is a large, two-stand, double-reduction, cold rolling, tinplate steel machine located in the Tin Mill of WSC. Its primary functions are to reduce the gauge of tinplate steel, and to improve the stiffness, flatness and surface finish of annealed tinplate steel. This mill can process tinplate steel in widths from 20 to 40 inches wide, and gauge ranges from 0.005-inch to 0.0330-inch. The tinplate steel is loaded at one end of the machine, lubricated, reduced, run through an x-ray gauge, cut, wound, weighed, and removed. Tinplate steel can be run through this machine at speeds of 6,000 feet per minute with a production capacity of 385 tons per shift.

#5 Temper Mill

The #5 Temper Mill is a large, single-reduction, cold rolling, tinplate steel machine located in the Tin Mill of WSC. Its primary function is to provide the proper stiffness to ensure the proper surface finish of annealed tinplate steel, prior to a secondary tin or chrome-plating operation. Of the tinplate steel processed through this machine, 70% is from one of the continuous annealing lines and the remaining 30% is from one of the batch annealing furnaces. The machine can process coils from 20 to 42 inches wide and in gauge ranges from 0.0073-inch to 0.030-inch. The tinplate steel is loaded at one end of the machine, fed through two sets of rollers, and recoiled on the opposite side of the machine. After exiting the machine, the coil is weighed, marked, and forwarded to one of the plating lines. Tinplate steel runs through this machine at speeds over 6,000 feet per minute with a production capacity of 617 tons per shift.

Blast Furnace Upgrade

WSC continually operates two of its four blast furnaces to reduce iron ore into molten metal, which is then further processed into steel. The blast furnace is an irregularly-shaped cylinder that solids are fed into the top (iron ore, sinters, scrap,

limestone and coke), and hot air is blown into the bottom. Liquid slag and metal are tapped from the bottom of the furnace, while flue gases and dust escape from the top of the furnace. The blast furnace typically operates continuously for five to seven years before rebuilding is necessary.

One of the currently-active blast furnaces is scheduled to be rebuilt between November 1996 and April 1997. Because blast furnaces are major consumers of fuel, WSC is incorporating improvements into this overhaul modification to reduce fuel consumption and automate the process. Some planned improvements include increasing the air pressure of the hot air blown into the furnace to 40 psi at the bottom and 12 psi at the top; raising the temperature of the hot blast of air from the stoves of the furnace from 1650°F to 2000°F; incorporating computer control of the stoves; installing high density cooling coils around the refractory brick; installing a closed-loop cooling system; increasing the troughs of the furnace and incorporating a tilt system to better facilitate the filling of the hot metal cars with pig iron; automating the stock house; installing a computer control room to automate the running of the blast furnace and to perform computer modeling; and installing a new scrubber system to improve boiler operations.

Once capital investment to the blast furnace is completed, fuel consumption rates are estimated to drop from 970 pounds to 930 pounds of fuel per ton of iron produced. This \$78 to \$79 million project is projected to have a payback period of less than two years, and will increase the output to 4,200 tons per day.

Continuous Annealing Line

WSC operates three continuous annealing lines to rapidly clean and anneal (soften) cold rolled steel. Through the process of reducing nine-inch-thick steel slabs to thin gauge sheet steel, the metal is work hardened and contaminated with lubricating oil. To soften this material for finish processing, the steel must be cleaned and then annealed to the desired hardness.

The process of continuously annealing cold rolled steel begins by loading two coils of steel at the input of the continuous annealing line. The steel is put

through a clean and rinse bath followed by a hot rinse dryer. A vertical accumulator keeps the continuous line running while a changeover is made from coil #1 to coil #2. The steel is run down the line to the various machines in the process line. When coil #1 is expanded, the second coil is welded onto the tail end of the first coil by a continuous lap welder. However, the lines are not interrupted because of the additional length of steel in the accumulator. After these processes are completed, the steel travels through a furnace where it is heated to the required temperature, held at that temperature, cooled, and then cooled in a quench tank. After the quench tank, it is wound, cut and removed to another processing line for further operations.

These continuous annealing lines vary in speed from 1,000 to 1,800 feet per minute. Without these continuous annealing lines, WSC would have to anneal all cold rolled steel in batch furnaces that can only anneal 16 coils of cold rolled steel in 25 to 35 hours. Once started, a continuous annealing line can anneal the same amount of steel in four hours.

Environmental

Weirton Steel has been producing steel since 1909. Since then, many changes in the steelmaking process have occurred that affect the daily operations, as well as the environment. Because of the continued rising costs and increasing environmental restrictions, National Steel elected to opt out of the steelmaking business at Weirton and made an offer to sell the Weirton Steel Division to its employees. In 1984, the employees bought the division (establishing Weirton Steel Corporation) and assumed all of the environmental liabilities that had built up during the previous 75 years.

Averaging more than 900 water quality violations per year, it was clear that changes were necessary to stay operational. This meant that procedures would have to change, investments would have to be made, and the old ways of doing business would have to go. Since then, WSC has invested over \$75 million on projects directed at water pollution control.

Taking a proactive approach in 1993 to consolidate compliance responsibilities, WSC developed the Environmental Control Consolidated program. This program took all of the stand-alone, pollution control facilities within the plant and transferred them to the Environmental Control Department.

This consolidation established a 24-hour-per-day, 365-day-per-year, Environmental Control O&M supervisory function that was responsible for all violations. In addition, negotiations are ongoing with the Union to improve the flexibility of the O&M salary non-exempt workforce. Targeted areas for improvement include enhanced training and duties for O&M personnel at all pollution control facilities; mobility for wastewater treatment operators; incorporation of light maintenance work into operator duties; and the formation of a mobile maintenance group dedicated to environmental operations.

Since taking over the ownership of the company in 1984, the employees of WSC have demonstrated a strong proactive commitment to environmental responsibility. WSC has spent \$113 million on various environmental projects. This level of spending represents more than 13% of its capital expenditures and exceeds the steel industry's average of 8%. Incidents of noncompliance have decreased by more than 90% and continue to show a downward trend. In response to ever-changing environmental requirements, WSC is continuously implementing a comprehensive environmental management system for reducing further violations and improving its operations.

Maintenance Planning

In 1991, as part of the Hot Strip Mill modernization program, a pilot group of employees was formed to do maintenance planning. Two years later this pilot group, along with some new members, were reassigned to cover the remainder of the plant. The first new area to be formed was in the Tin Mill plater section. An area team, consisting of an operator, a mechanical and electrical maintenance person, and a maintenance planner, was assigned to the plater section. The team has complete responsibility of the plater section and meets daily to discuss issues such as safety, quality, delays, projects, and cost.

The maintenance planner keeps track of all predictive and preventive maintenance, plans downturn work, maintains records on completed work, and helps coordinate outside crafts that come to the area. Hartford Steam Boiler Reliability Technologies (HSBRT) administers the maintenance records maintained through the preventive maintenance system. Predictive maintenance measurements, taken by Computational Systems, Inc., are filtered

back to the areas through the maintenance planner. In addition, the maintenance planner handles all special requests for tools and materials.

WSC employees have benefited from the area team concept by more easily identifying what work needs to be done, more efficiently planning how to do the work, and more effectively solving problems together.

Process Automation Group

Because of WSC's commitment to continually review its operations to reduce cost, improve quality, and meet schedules, the demand has increased for new hardware and software; changes to existing computer systems; data accumulations; and other computer-related needs. This demand motivated WSC to establish a process automation group that is now responsible for maintaining and enhancing legacy systems; designing, developing, and installing systems; managing projects; and providing analysis and consultation on all Level I, II, and III, computer-related needs of the Operations Department.

The group was established in early 1995. Prior to that, the computer-related needs on the plant floor were minimal, and typically were handled through the standard channels for capital improvements or process troubleshooting. The group established a process automation methodology to define both the criteria for the project levels accepted by the group and the process flow of all projects coming into the group. The criteria is as follows: Level I is equipment-related; Level II is line-related; and Level III is area-related. Requests that affect department-wide operations (Level IV) and Corporate-wide operations (Level V) are not accepted by the group; however, the group may be called upon for assistance and advice.

To start the process, the requester submits a request form describing a necessary action. The group enters the action into the Request Tracking system that tracks and produces request tracking reports. Next, a preliminary investigation is conducted. Using a functional specification, the group generates a scope-of-work statement; documents the process, material and data flow; and determines the performance and interface requirements. The requester reviews the group's interpretation of the project; makes sure the project was communicated properly; and comprehends what the returns will be. A detailed investigation then follows. Using

a system-design document, the group identifies subsystems and components; documents how to implement functions; and performs architecture analysis. The group uses a detailed-design document to partition subsystems into modules; define input and output operations; and define communication mechanisms.

A method for handling the request is chosen: in-house, contract out, or hand-off to a systems integrator. Next, the request goes through the development, testing, system integration and implementation steps. Development deals with computer hardware assembly; generating module codes; compiling and debugging standards; module testing; implementing the database, operator interface, and alarm, and error handling; report generation; and man-machine interfacing. Testing involves the integration of the software and hardware as a total system. System integration, based on a test plan, tests the system and simulates operations; verifies internal functions and external interfaces; and tests operator interface, sequencing calculations, control, and timing response. The final step, implementation of the project in an actual, operational environment, includes the hardware/software installation and checkout; the operator, maintenance and engineer training; and the system start-up and verification.

The process automation methodology provides excellent control and tracking of projects within the process automation group. The entire project's process flow, description, details, and schedule are available on the Process Tracking system, a unique feature that allows the requester to monitor the progress and status anytime.

Scrap Blending

WSC uses the BOP to manufacture steel. This process uses a charge of 75% molten iron from the blast furnace and 25% scrap metal. Although existing standards permitted the usage of various types and qualities of scrap metal for each charge, WSC often purchased higher quality and, in turn, more expensive scrap metal because of insufficient space to separate scrap metal at its existing scrap metal area.

In October 1995, WSC set up a secondary scrap metal area to separate various types and qualities of scrap metals, and developed better-defined technical requirements for acceptable blends of various scrap metals. The new scrap sorting area was equipped with a weight scale and the necessary

material-handling equipment to transfer the proper blends to the primary scrap area. WSC could now purchase less expensive scrap metal and save millions of dollars annually. WSC continues to make improvements by maintaining a database of allowable blend combinations and by using portable spectrographic equipment to improve identification of scrap metals used.

Tin Mill

The Tin Mill at WSC is the largest, single, tin-producing facility with the greatest capacity in the country. It is currently producing 70,000 tons per month. Its unique equipment and extensive capabilities provide customers with a wide range of thin gauge products with various mechanical properties. Input material comes into the Tin Mill from the Strip Mill in the form of coils of full-hard strip steel. These coils are cleaned, annealed, single or double reduced, and plated with tin, chrome, zinc or prepared as a non-coated product. The Tin Mill provides the finishing touches to the company's basic products according to the customer's requirements.

The Tin Mill production facilities include cleaning lines that remove residue left from the Strip Mill operation and prepare the coils for the annealing process. Annealing is accomplished in a batch operation or through a continuous annealing process. Annealed product is then processed through temper mills or double reduction mills, depending on the end-product requirement. Once reduced to its final thickness, the product is processed through one of the plating lines, final coiled, and wrapped for shipment. The Tin Mill features advanced, computer-control systems and employs a variety of automated functions. Through a continuous improvement program, these facilities are constantly reviewed and updated to world-class, state-of-the-art capability.

As part of the continuous improvement process, the Tin Mill is constantly benchmarked against other steelmakers to stay current on the latest processes and technology. WSC participates on the tinplating committee of the AISI, and shares problems and concerns with its counterparts from other participating companies. These participating companies not only benchmark one another but also, in some instances, join together to fund common research projects.

The tinplate business offers WSC a target for market expansion. With this in mind, the Tin Mill

management aggressively pursues facility upgrades and modernization opportunities. Its 1996 goal is to surpass its 1995 business base by \$8 million; WSC has already achieved that goal. The company plans to become ISO certified by July 1997, and is working toward that goal with the formation of area teams and a total quality approach.

Transportation and Material Handling

Nearly all of WSC's raw materials used in the steelmaking process are delivered by rail. Intermill movement of these in-process products also depends heavily upon rail services. Geographic location of the WSC facility, and the congestion of the in-plant processing units, combine to make railroad activity a critical service requirement in the manufacturing process. In 1984, WSC realized improvements were needed for its fragmented industrial railroad. To improve the effectiveness of the transportation system, WSC looked at three main areas: centralizing the operation, instituting total quality management, and improving the maintenance of its rolling stock.

From 1984 to 1992, WSC reduced the number of yard offices from four to one, thus centralizing all transportation activities. Along with this, major reductions in personnel, trackage, rolling stock and locomotives decreased the transportation operating budget by \$13 million per year.

As part of a joint total quality management program, WSC's Transportation Department worked with its customers to define standards for delivery and metrics for measuring quality. They also determined acceptable turn-around times for transportation. Switch requests were monitored to measure the time frame of receiving requested transportation. This enabled the Transportation Department to measure its performance and to obtain information on corrective measures when set standards were not met.

WSC also improved the preventive maintenance program of its rolling stock. This was done by determining the required number of each type of equipment needed to support material movement, identifying each equipment requirement by location, determining the acceptable number of out-of-service equipment at any given time, determining average life of each rolling stock, and monitoring the operation continuously. The above initiatives have reduced cost, though WSC has increased its production since 1984.

Facilities

Computerized Maintenance Management

By using a Computerized Maintenance Management system, WSC addressed the need for effective maintenance scheduling, monitoring, and tracking which is critical to sustaining high quality and complex equipment capability. This system can plan and schedule daily maintenance; compile daily maintenance records for more than 7,800 pieces of operating equipment; provide spare parts control; and track data trends for preventive and predictive maintenance.

Prior to 1986, maintenance planning and tracking ran on an aging DEC 1170 which was becoming increasingly expensive to operate and maintain. The system could not reasonably be expanded to service the number of users required, especially if its primary function was to be a general plant maintenance system. It lacked the ability to capture daily maintenance records and provide spare parts control. The system was viewed as cumbersome, antiquated, and unreliable. During Fall 1986, maintenance superintendents and other key personnel established a team to address this problem and define the general requirements for a replacement system.

In 1988, representatives from maintenance, engineering, finance, and MIS, along with assistance from Boeing Computer Services, developed a detailed, requirements document for procuring a new system. The INDUS PassPort system was chosen among 13 prospective vendors. In 1990, a hot-switchover to the new system occurred. At the start-up, features and nomenclature of the old system were duplicated by the new system. The baseline product was heavily customized to fit the needs of WSC. For approximately two years, little effort was made to use the system for capturing equipment data, preventive or predictive maintenance, or spare parts control. The immediate use of the new system was primarily for infrastructural work planning and time distribution. Compiling data related to equipment operations for preventive and predictive maintenance is currently ongoing. HSBRT has been contracted to provide the necessary document generation, data entry, and data management. The system has been modified in-house to make it incrementally more useful for spare parts management.

Although the Computerized Maintenance Management system has proven beneficial, WSC is

seeking a better system to provide greater benefits for maintenance management. Key lessons learned during the implementation of the current system include avoiding customization of software, reducing the burden of data entry, realistically factoring in the amassing of the core data, and selecting a system that is adequate and flexible for maintenance management.

Continuous Galvanized Line

WSC's Sheet Mill produces hot-dipped, galvanized sheet steel on three main continuous process lines. These lines run at speeds up to 400 feet per minute and produce more than 600,000 tons of galvanized steel annually. The sheet lines produce galvanized steel in thickness ranges from 0.010-inch to 0.168-inch and in widths up to 48 inches. WSC offers galvanized sheet steel in commercial, lock forming, drawing, structural qualities, and all types of surface finishes.

The process of manufacturing galvanized sheet steel on #5 Continuous Galvanized Line begins with cold rolled, sheet steel for thicknesses less than 0.050-inch. Hot rolled steel is used for thicker material requirements on #3 Continuous Galvanized Line. Two steel coils are loaded at the start of the continuous process line with the first coil fed into a vertical accumulator. This accumulator keeps the continuous line running while a changeover is made from reel #1 to reel #2. The steel is run down the line to the various machines in the process line. When coil #1 is expended, the second coil is spliced onto the tail of the first by a continuous spot weld as the line continues to move. This is possible because of the additional length of steel in the accumulator. After passing through the accumulator, the steel is cleaned in a sodium hydroxide (NaOH) soap bath to remove oils and iron fines from the prior rolling processes. Following this operation, the steel is annealed in a large furnace, dipped in a bath of 99.4% zinc, and transversed through a specially-designed air knife to remove excess zinc from the sheet steel. Exiting the air knife, the steel may be reheated in a second furnace for galvanneal, then quenched and dried. Finally, an automated x-ray machine measures the zinc coating of the galvanized sheet steel, and the steel is cut and rewound.

To enhance the process capability, WSC changed the NaOH bath from a manual batch process to one that automatically adds soap and water, based on measured conductivity readings of the cleaning

bath. As a result, the company disposes of 24,000 fewer pounds of NaOH per year for an annual savings of \$80 thousand. The specially-designed air knife saves an additional \$280 thousand per year by reducing spooled-edge rejects by 83%. Finally, by upgrading the coating weight gauge, WSC eliminated the test coupon step of each galvanized sheet roll and reduced overcoating from 16% to less than 10%.

Preventive Maintenance

WSC has had a plant-wide preventive maintenance system in place since 1994. The system is administered by HSBRT, an outside vendor. HSBRT facilitates the operation of the preventive maintenance system including completion of paperwork, initial set up, reporting, and providing an on-site manager. WSC personnel conduct the actual tasking and performance of preventive maintenance actions. Approximately 7,800 machine units are covered by the system.

Preventive maintenance actions are scheduled by issuing preventive maintenance work orders that specify the preventive maintenance task description, materials or tools needed, required skills, completion date, and special instructions. When preventive maintenance actions uncover equipment needing repair, a repair work order is filled out indicating the nature of the problem and specifying the work and materials required. Monthly preventive maintenance performance summaries are published for each department. Unfinished scheduled preventive maintenances are also tracked monthly including the reasons why a preventive maintenance task was not completed.

WSC is currently evaluating the scope of its preventive maintenance program to determine which preventive maintenance actions add value and which do not. The preventive maintenance system is being linked to other maintenance systems including predictive maintenance, oil analysis, and motor spares management.

Supplies and Spares Management Program

Supplies and Spares Management is a three-phase program, implemented by WSC, to minimize inventories and improve manpower utilization for the ordering, releasing, receiving, storing, handling, and delivery of materials, supplies, and spares

required to efficiently fulfill operational needs. The key to the initiation of the program is a Union agreement signed in June 1996, allowing flexibility of the workforce. Phase I is in process, with Phases II and III scheduled for completion within two years.

WSC has supported a \$4 million inventory of supplies and spares for a number of years in as many as six store locations. Supplies and spares were distributed from stores to satellite storerooms, operations departments, maintenance, and other users. Because of a cumbersome procurement process, unreliable delivery, and inadequate control, inventories would accumulate to ensure that sufficient supplies and spares were readily available. Approximately 20,000 motors and large spare parts were in the inventory. No single ownership existed. Motors and spares were found throughout the plant. Many were obsolete or damaged when placed into service. In some cases, the motors or spares were misfiled. A centralized inventory distribution and control system was needed to correct the problem, but job infringement issues concerning the local Bargaining Unit delayed correcting the system for several years.

In 1996, WSC initiated a three-phase program to minimize inventories and improve manpower utilization. Phase I focused on the elimination of satellite storerooms which would require changing the job descriptions of 39 personnel involved in inventory maintenance such as movers, loaders, and storeroom clerks. The company could contract out, but the Bargaining Unit wanted to preserve jobs. An agreement was reached permitting WSC to establish new job descriptions that would provide the necessary flexibility of the workforce to accomplish Phase I. The Purchasing Department worked out new agreements with vendors to reduce the vendor population from 42 to 12. Storeroom commodities are now being sold back to the vendors. The armature shop was closed. Personnel from storerooms are being reassigned to manage and control the inventories. Vacated, storeroom facilities are being converted into control and procurement centers, and inventory costs are projected to reduce from \$4 to \$2 million.

Phase II will focus on centralizing the motor inventory control. All existing motors will be tagged, entered into the computer, and housed at a central store. A plant-wide, needs assessment will be conducted and viable spares will be sold. Obsolete motors will be scrapped. Centralized control will allow single, large volume procurement at discount

prices. Overall motor inventories will be reduced. Phase III will focus on implementing the spares inventory control and procurement centers, and will follow a similar approach for motor inventory control.

Some benefits are emerging from Phase I, and many more will be recorded after the completion of Phases II and III. Inventory control will be significantly improved and more efficient at fulfilling operational needs. Once inventories are reduced, more capital will be available for additional modernization improvements. Pricing discounts will be attainable because of negotiations with fewer vendors for volume buying. The workforce can be better utilized due to the flexibility of job descriptions. Improved inventory records will lead to reduced repair costs, reduced failure costs, and warranty repair tracking. Improved relations with the Bargaining Unit could lead to additional agreements in other areas requiring job flexibility to preserve the workforce.

Management

Computer-Based Training

WSC has discovered that it is cost effective to outsource nearly all of its computer-based training requirements. About 95% of WSC's computer training, including personal computer classes, is provided by Professional Services Group (PSG), an outside contractor. These courses are taught on-site at Weirton or at PSG's facility in Pittsburgh, Pennsylvania. Fees per student for each series of courses range from \$45 to \$90. The fees are charged back to the departments that sent the students to the courses. WSC is in the process of moving to 100% outsourcing of all computer-based training, which includes conducting, scheduling, and promoting the courses, and records management.

Cost Accounting

The current cost accounting system was installed in the 1960s when WSC was a division of National Steel Corporation. This was a standardized, performance-based, cost system with models developed specifically for the steel industry. A series of tables was developed and automated to measure yield and productivity performance of all downstream finishing units. The tables address many specific product types, widths, gauges, coatings, and special pro-

cessing. They have been maintained and updated since the early 1960s. The system generally remains intact to date, but has undergone many revisions unique to WSC. The current accounting process uses this system to establish budgets and develop product cost values. Raw material costs, energy prices, labor costs, product mix, operating levels, and other data are integrated using the standard computer models. Normal shipping levels are established, and this information is then worked backwards by the system to establish normal production requirements and plant loading. In addition, the system is used to develop budgets and charge rates for many shops such as maintenance, service, and utility cost centers that are not producing cost centers. The budgets are revised annually in the August to November time frame. The process takes about four months.

Income and expense charges are accumulated and processed at the end of each month to calculate variances, create cost center statements, and generate profit and loss worksheets. The income statement is developed using actual sales and standard cost of sales to arrive at a gross margin at standard. Standard cost of sales is plant production cost excluding overhead, SG&A, and depreciation. Variances are calculated and distributed to appropriate accounts to give gross margin at actual. Actual overhead, SG&A, depreciation, other financing costs or income, and federal income tax are subtracted to arrive at net income. Various reports useful for sales, inventory management, forecasting, detailed cost center analysis, and cost summarization can be generated.

WSC plans to update its general ledger system in the near future by acquiring new software for most of the financial and accounting functions. The current system is old, and vendor support is no longer available. During this upgrade, the company will determine whether the standard cost system should be replaced.

Oil Program

The WSC oil analysis program was conceptualized in the 1960s as a method for improving steel mill machinery reliability while potentially reducing lubricant costs. In the 1980s, the introduction of new laboratory techniques and instruments improved WSC's oil analysis capabilities, but the full potential of an oil analysis program was not being realized.

In 1992, the growing number of requests for oil analysis coming from various operations within WSC led to the revitalization of the company's oil analysis program emphasizing preventive, predictive, and proactive equipment maintenance and corrective action. WSC evaluated potential oil analyses through major oil companies; independent commercial laboratories; and a WSC facility-wide, chemical management program. The company chose the chemical management approach as best fitting its needs, selected an outside company as a partner, and set up a pilot program of oil analysis focusing on machine wear and contamination.

With support from top management, the oil analysis program has identified the costs of necessary testing and needed equipment; identified an oil analysis survey process; and defined the staffing required to implement the program. WSC's approach will concentrate on the areas of wear, additive packages, viscosity, contaminant particles/metal, moisture, and oil safety. Goals of the program are to identify the factors of sampling frequency, service/standards to be met, reporting requirements, training needs, and cost/benefit analysis.

Scanning Drawings

In January 1996, WSC implemented a system for converting hard copy blueprints and engineering drawings to electronic image files. Commonly-used maintenance drawings are being identified for conversion. Approximately 300,000 engineering drawings currently exist. Previously all official drawings existed in hard copy form and were stored in vaults in the Engineering Department. Maintenance personnel retained paper copies of the maintenance drawings. The Engineering Department used 12 Unigraphics CAD workstations to produce drawings in-house. Each month, approximately 30,000 blueprint reproductions were created by Engineering Department personnel to satisfy the demands of plant personnel.

Under the old system, keeping current maintenance copies in the plant was nearly impossible because approved drawings were frequently revised. A great amount of effort and storage space was required to maintain prints of drawings in the plant. The system was inefficient and permitted the use of out-of-date prints of drawings.

In conjunction with the implementation of electronic management of drawings, the Engineering

Department switched to AutoCAD, primarily because most of the company's engineering service vendors used AutoCAD. Currently, the image database is being developed by an outside vendor. Prior to conversion, the prints are copied in-house to ensure that a copy is always available. The original is then sent to the vendor for conversion. After conversion, the drawing images are generally available to any user of the system.

Vendors providing CAD services are required to use AutoCAD and to provide a copy of the CAD file to WSC. As new files are produced in AutoCAD, whether in-house or by a vendor, the files are incorporated into the new system. WSC purchased a new blueprint reproduction machine that scans the original and produces a large format output to a laser printer. As older drawings are manually revised, they will be scanned using the new machine, and the new version will be copied to the image server.

With the new system, images are quickly accessible to any user of the system and may be printed to a laser printer if hard copy is required. Cost savings have resulted from the decreased need for hard copy reproduction. The new system greatly improves document control and simplifies communication of revisions and redlines. Vendors can remotely access the system, review a drawing, modify it, and then submit it for approval automatically.

Team Building

WSC has developed a team building concept currently being deployed throughout its operating divisions. Within the Tin Mill, area teams were developed for each of the five major areas including cleaning and chemical treatment, batch anneal and continuous anneal, rolling, platers, and side trimmers. These teams are composed of area foremen, maintenance planners, and any other participants required to address specific problem areas. In place since 1995, these teams are already making a significant difference. Company goals, previously set by management for the various areas, are now being proposed and negotiated by the area teams. These teams meet daily to review production and maintenance problems, and recommend corrective actions.

The platers area team in the Tin Mill has been used as a pilot program. This team reviewed past operations within the plating area, and set a goal to decrease its operating costs to a specified goal

negotiated with and approved by management. Through active participation in monitoring reports on yields, delays, maintenance actions, and various other indicators, the platers area team has implemented significant improvement, surpassing the negotiated goal.

Total Quality Program

Prior to 1991, a total quality program did not exist at WSC. As part of the company's new vision and commitment to quality, WSC began establishing a continuous improvement program built around total quality. The commitment to improvement and quality was mandated by top management and fostered a wave of change throughout the company.

The centerpiece of the continuous improvement philosophy is the Supplier, Input, Process, Output, Customer (SIPOC) process. This is a formal, structured process used throughout the mill to dramatically improve performance in key processes. Dedicated cross-functional teams use total quality, problem-solving methods and tools to identify key process parameters, develop controls for each, and use these to improve the process. SIPOCs were created for each major unit in the mill. Each unit developed a Total Quality (TQ) plan to reduce downtime, decrease rejects, and improve overall performance. Pareto analysis is used to identify the top five drivers, and formal action plans are developed to address and correct the top drivers. Top-level goals

are set for each unit in terms of yield, production, and spending performance. The goals are reviewed with top management monthly.

The entire TQ process is well documented and tracked. Management is working to institutionalize the system consistently throughout the mill. ISO-9000 certification is one way that WSC is building a consistent TQ structure. Training in TQ methods, tools, and experience with the SIPOC process are paying off. Many successes such as the energy team improvements are occurring in all areas. The SIPOC process made it clear that most critical processes at WSC were not well defined or understood. The Tin Mill is one of the top TQ performers, reversing its situation from loss to profit. Last year, all top-level improvement goals were either met or exceeded, resulting in more than \$28 million worth of improvement.

One area in need of further development is to increase the involvement of the salary non-exempt workforce in TQ. The first step is to get first-line supervisors on board. This is being addressed through training and merit pay. The company has made some attempts to establish self-directed work teams and increase worker empowerment. Empowerment efforts have not worked well at WSC because of the company's culture and strong union orientation. Employee participation groups such as the energy efficiency team have been very successful and will continue to be the primary approach to continuous improvement.

Appendix A

Table of Acronyms

Acronym	Definition
AISI	American Iron and Steel Institute
BFG	Blast Furnace Gas
BOP	Basic Oxygen Plant
DAFW	Days-Away-From-Work
HSBRT	Hartford Steam Boiler Reliability Technologies
IMIS	Integrated Management Information System
MIS	Management Information System
OJT	On-the-Job Training
PSG	Professional Services Group
SBA	Strategic Business Accounts
SHARE	Safety & Health Awareness Requires Everyone
SIPOC	Supplier, Input, Process, Output, Customer
SOJT	Structured On-the-Job Training
SOP	Standard Operating Procedure
TQ	Total Quality
WSC	Weirton Steel Corporation

Appendix B

BMP Survey Team

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

Production Team

Bob Jenkins (703) 602-3002	Naval Sea Systems Command Washington, DC	Team Leader
Joe Perese (215) 897-1759	Naval Foundry & Propeller Center Philadelphia, PA	
Jack Tamargo (707) 642-4267	BMP Satellite Center Manager Vallejo, CA	

Management Team

Rick Purcell (301) 403-8100	BMP Center of Excellence College Park, MD	Team Leader
John Bissell (703) 602-5018	Naval Sea Systems Command Industrial Planning Division Arlington, VA	
Larry Halbig (317) 306-3781	Naval Air Warfare Center Aircraft Division Indianapolis, IN	

Appendix C

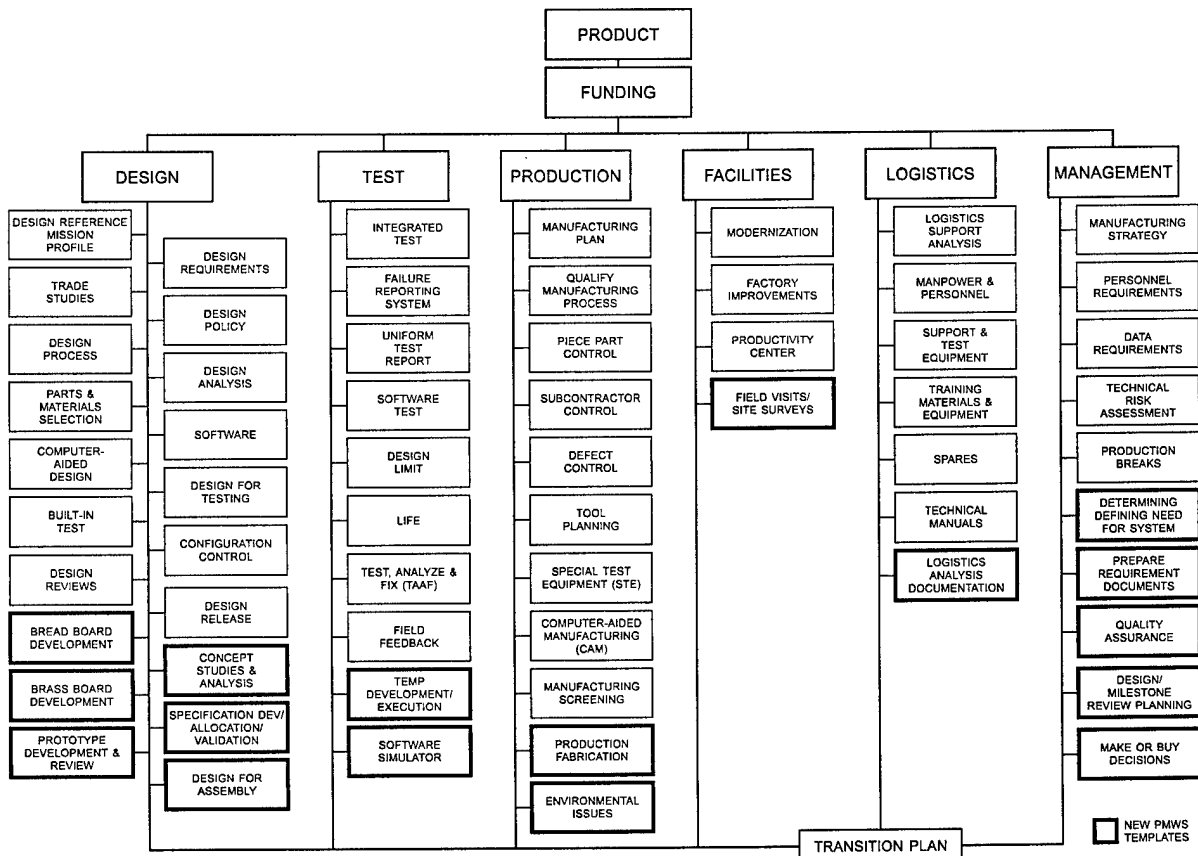
Critical Path Templates and BMP Templates

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 person-

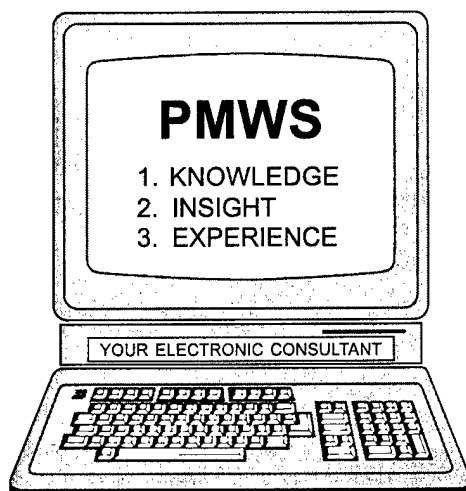
nel in creating specifications for their requirements, and is structured for the build/approval process. SpecRite's knowledge-based guidance and assistance structure is modular, flexible, and provides output in MIL-STD 961D format in the form of editable WordPerfect® files.

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
1456 Mariposa Drive
Corona, CA 91718
(909) 273-4992
FAX: (909) 273-5315
cmatzke@bmpcoe.org

Jack Tamargo

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

District of Columbia

Brad Botwin

BMP Satellite Center Manager
U.S. Department of Commerce
14th Street & Constitution Avenue, NW
Room 3878
Washington, DC 20230
(202) 482-4060
FAX: (202) 482-5650
bbotwin@bxa.doc.gov

Illinois

Dean Zaumseil

BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114
(815) 654-5530
FAX: (815) 654-4459
adme3dz@rvcux1.rvc.cc.il.us

Pennsylvania

Sherrie Snyder

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

Tennessee

Tammy Graham

BMP Satellite Center Manager
Martin Marietta Energy Systems
P. O. Box 2009, Bldg. 9737
MS 8091
Oak Ridge, TN 37831
(615) 576-5532
FAX: (615) 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
frglcc@aol.com

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&MPI) 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&MPI:

Mr. Dennis Herbert

Manufacturing Science and Advanced Materials
Processing Institute

ARL Penn State

P.O. Box 30

State College, PA 11804-0030

(814) 865-8205

FAX: (814) 863-0673

dbh5@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

National Center for Advanced Drivetrain
Technologies

ARL Penn State

P.O. Box 30

State College, PA 16804-0030

(814) 865-3537

FAX: (814) 863-1183

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:
Surface Engineering Manufacturing Technology Center
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, 86 surveys have been conducted 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

1990 (Continued)	Technology Matrix Consortium - Traverse City, MI Textron Lycoming - Stratford, CT
1991	<i>Resurvey of Litton Guidance & Control Systems Division</i> - 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 <i>Resurvey of Texas Instruments Defense Systems & Electronics Group</i> - 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 <i>(Resurvey of Control Data Corporation Government Systems Division)</i> 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 <i>(Resurvey of Rockwell International Corporation Collins Defense Communications)</i> Lockheed Martin Electronics & Missiles - Orlando, FL McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO <i>(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)</i> Dayton Parts, Inc. - Harrisburg, PA Wainwright Industries - St. Peters, MO Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX <i>(Resurvey of General Dynamics Fort Worth Division)</i> 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