ERDC/CERL TR-04-17

Construction Engineering Research Laboratory

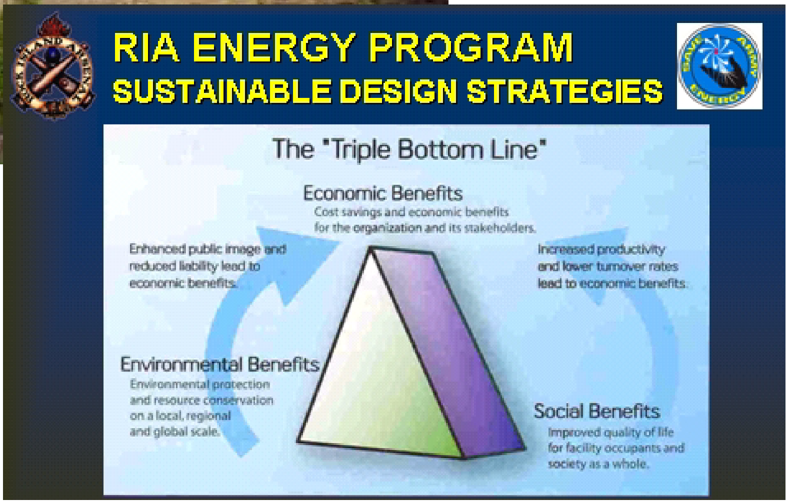
US Army Corps of Engineers®
Engineer Research and Development Center

Process and Energy Optimization Assessment

Rock Island Arsenal, IL

Mike C.J. Lin, Alexander M. Zhivov, Veera M. Boddu,
David Osborn, Walter P. Smith, Curt Bjork,
Michael J. Chimack and Robert A. Miller

September 2004



RIA ENERGY PROGRAM
SUSTAINABLE DESIGN STRATEGIES

The "Triple Bottom Line"

Economic Benefits
Cost savings and economic benefits for the organization and its stakeholders.

Enhanced public image and reduced liability lead to economic benefits.

Increased productivity and lower turnover rates lead to economic benefits.

Environmental Benefits
Environmental protection and resource conservation on a local, regional and global scale.

Social Benefits
Improved quality of life for facility occupants and society as a whole.

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Final Report

Prepared for Rock Island Arsenal
Rock Island, IL 61299

Under Work Unit No. CFE-G884

ABSTRACT: A Process and Energy Optimization Assessment (PEOA) was conducted at Rock Island Arsenal (RIA), IL to identify process, energy, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. The study was targeted at creating a holistic approach to energy optimization in industrial facilities and included measures related to industrial processes, building envelope, and energy and mechanical systems. A team of researchers and expert consultants performed a Phase-1 PEOA during the week of 21 June 2004. The scope of the PEOA included plating, painting, machining, welding, foundry, and heat treatment production processes, and also an assessment of the building envelope, ventilation, compressed air systems, and steam boilers. The study identified 36 energy conservation measures (ECMs); 23 of these were quantified economically. Implementing the 23 ECMs will reduce RIA energy and operating costs by approximately $1.75M, will yield an average simple payback of 1.7 years (21 months), and will improve the work environment.

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Conversion Factors

Non-SI[*] units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
British thermal units (Btu)	1.055056	Kilojoules (kJ)
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

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[*] *Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

Preface

This study was conducted for Rock Island Arsenal (RIA) under Project Requisition No. 2003-6060, “Analyze Factory Energy Processes,” via MIPR No. 4H13LRG040. The technical monitor was David Osborn, Energy Manager, Rock Island Arsenal.

The work was managed and executed by the Energy Branch (CF-E) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigators were Dr. Alexander Zhivov and Dr. Mike C.J. Lin. Appreciation is owed to David Osborn (RIA) for his coordination of the RIA team and to the RIA DPW and Joint Manufacturing and Technology Center staff, who contributed significantly to the information gathering and feasibility analysis. Major contributors to the study were Walter Smith (Energy Technology Services International, Inc. [ETSI]), Curt Bjork and Patrik Bergvall (Curt Bjork Fastighet & Konsult AB, Sweden), and Michael Chimack and Robert A. Miller (Energy Resources Center, University of Illinois at Chicago [UIC]).* Special thanks are owed to the Department of Energy Office of Industrial Technologies (DOEOIT) and Federal Energy Management Program. Dr. Tom Hartranft is Chief, CEERD-CF-E, and Mr. L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche, CEERD-CV-T. The technical editor was William J. Wolfe, Information Technology Laboratory. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL James R. Rowan, and the Director of ERDC is Dr. James R. Houston.

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* UIC was funded under subcontract with Oak Ridge National Laboratory, by the Federal Energy Management Program (FEMP) Industrial Facilities Initiative. Additional information on FEMP’s Industrial Facilities Initiative (and other FEMP Services) is available through Michaela Martin, Oak Ridge National Laboratory, tel. (865) 574-8688, or Alison Thomas, DOE Program Leader, tel. (202) 586-2099.

1 Introduction

Background

Rock Island Arsenal (RIA), located on a 946-acre island in the Mississippi River (Figure 1), is one of the world's largest weapons manufacturing facilities. RIA is our nation's largest government owned and operated arsenal, and the only active foundry in the Department of Army. Having produced weapons for the American military since the late 1800s, the Arsenal continues its long tradition of quality and excellence by producing a wide array of products for the joint military services. RIA provides the military with engineering and design, prototyping, production, and assembly of the finest weapons parts and equipment. The Arsenal's state-of-the-art facilities excel in meeting critical, urgent requirements of the nation's warfighters.

The Arsenal's success in its logistics mission has made it a major supplier of the military's tool sets, kits, and basic issue items. Trained logistics personnel fabricate and assemble large scale tool sets ranging from carrying-case tool sets to fully equipped shelters. Basic Issue Items sets for major end items are also fabricated and assembled at the Arsenal's Logistics Center. Arsenal personnel provide expertise in purchasing, information management, personnel administration, communications, building maintenance, fire protection, and security. The Arsenal also provides support to approximately 40 tenants and their 4000 employees.

Figure 1. Rock Island Arsenal.

During the past few years, the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (ERDC/CERL) has been involved in process and energy optimization to assist DOD installations in meeting energy efficiency and environmental compliance requirements and to create an improved work environment through a "Process and Energy Optimization Assessments" (PEOAs) The PEOA extends conventional energy and environmental auditing into the manufacturing processes. CERL has developed several tools to collect process and environmental data and to conduct comprehensive facility process energy and emissions analyses.

The key elements that guarantee success from a PEOA are: (1) the involvement of key facility personnel who know what the problems are, where they are, and have thought of many solutions; (2) the facility personnel sense of "ownership" of the ideas, which in turn develops a commitment for implementation; and (3) the PEOA focus on site-specific, critical cost issues, which, if solved, will make the greatest possible economic contribution to facility's bottom-line. Major cost issues are: capacity utilization (bottlenecks), material utilization (off spec, scrap, rework), labor (productivity, planning/scheduling), energy (steam, electricity, compressed air), waste (air, water, solid, hazardous), equipment (outdated or state-of-the-art), etc. From a cost perspective, process capacity, materials, and labor utilization are far more significant than energy and environmental concerns. However, all of these issues must be considered together to achieve DOD's mission of military readiness in the most efficient, cost-effective way.

Guided by RIA Directorate of Public Works (DPW) staff, CERL researchers toured the industrial buildings at RIA on 7 May 2003 to review performance improvement opportunities and develop workspace consolidation strategies. Researchers found that the DPW had achieved significant energy reduction goals using its own resources and through Energy Savings Performance Contracts (ESPCs). The brief tour and subsequent discussions made it clear that, due to a relatively low current level of production load at RIA, it could be beneficial to consider the holistic approach to energy optimization in the workspace based on the workload. This would include measures related to industrial processes, building envelope, and energy and mechanical systems, which would complement the ongoing Army Materiel Command's "Lean Thinking & Six Sigma" implementation. Energy conservation efforts will be combined with measures directed toward improved ventilation systems performance, resulting in a healthier and more comfortable working environment. Potential energy savings could be realized if the production people were held accountable for their own energy use. Improved working conditions can also increase operation efficiencies.

This study is the first of a series of similar studies to be done at four other Army Materiel Command installations to identify ventilation performance improvement opportunities, to develop workspace consolidation strategies, and to work with base engineers and contractors to apply these strategies. After these improvements, the site may become a showcase example for other DOD production facilities.

Objectives

The main objective of this study was to conduct a process and energy optimization assessment to enhance operational performance in process and building energy systems at Rock Island Arsenal. A secondary objective was to identify opportunities to increase efficiency and reduce pollutant emissions using the process energy and pollution reduction (PEPR) methodology and the process optimization guide, both of which are tools developed by CERL with consulting support by Energy Technology Services International, Inc.

Approach

The three levels of process and energy analysis differ in the objectives, scope, methodology, procedures, required instrumentation and approximate duration:

Level I. Preliminary energy and process optimization opportunity analysis (walk-through review; no instrumentation with basic analysis). A Level I audit usually takes from 2 to 5 days and allows identification of the dollar potential for process improvements and energy conservation to the bottom-line. No engineering measurements are made. The existing processes are challenged, and new practices and new technologies are considered. A Level I Audit would normally be followed by a Level II process audit to verify the Level I assumptions and to more fully develop the ideas from the Level I screening analysis.

Level II. Energy and process optimization analysis geared toward funds appropriation (calculated savings; partial instrumentation with cursory analysis). A Level II study typically takes 5 to 10 times the effort of a Level I, and could be accomplished over a 2- to 6-month period, depending on the scope of the effort. The Level II effort includes an in-depth analysis in which all assumptions are verified. The end product from Level II is a group of “appropriation grade” process improvement projects for funding and implementation.

Level III. Detailed engineering analysis with implementation, performance measurement and verification (M&V) assessment; fully instrumented diagnostic audit; 3 to 18 months in duration.

This work performed a Level I analysis during a Phase 1 study, and concluded with a list of ideas and recommendations for the Phase 2 (Level II) follow on work.

ERDC/CERL organized a project team consisting of CERL researchers and expert consultants from the following organizations: the U.S. Department of Energy Office of Industrial Technologies Industrial Assessment Center at the University of Illinois, Chicago campus (UIC), Energy Technology Services International, Inc. (ETSI), Curt Bjork Fastighet & Konsult AB (CBF&K), and several industry partners including Hastings Air-Energy Control, Inc., Johnson Controls, Inc., Palm International, Inc. and the Gas Technology Institute. Work was proposed to proceed in three phases. Phase 1 was to focus on review of existing energy-demanding system requirements and on development and analysis of potential energy saving opportunities. Phase 1 will develop a detailed scope of work for Phase 2, which will begin after sponsor's approval. Phase 2 will inspect the existing support equipment and develop renovation plans. Phase 3 will provide implementation monitoring and savings verification.

Scope

This Phase 1 energy assessment evaluated plating, painting, machining, welding, foundry and heat treatment production processes, and the building envelope, ventilation, compressed air systems, and corresponding boilers. This work assumes that technical solutions are possible and that economic calculations are approximations (accurate to ±40 percent). Only limited engineering measurements were made.

Mode of Technology Transfer

The results of this work will be presented to Rock Island Arsenal for their consideration in pursuing follow-on Phase 2 work. It is anticipated that the results of this work will contribute to further awareness of the Army Materiel Command installations, as well as to Corps, District, and other Army installation personnel, via implementation through associated regional Installation Management Agency (IMA). It is also planned to disseminate this information through workshops, presentations, and professional industrial energy technology conferences.

This report will also be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 The Process and Energy Optimization Assessment at Rock Island Arsenal

Major RIA Production Areas and Associated Processes

Rock Island Arsenal is noted for its expertise in the manufacture of weapons and weapon components, which are provided to both domestic and foreign markets. Every phase of development and production is available.

Manufacturing capabilities include forging, machining, finishing, foundry work, soft materials fabrication, tool, die and gauge manufacturing, spare and repair parts production, and prototype fabrication. Most of these production operations were consolidated under one roof more than a decade ago. Figures 2 and 3, respectively, show the Rock Island Arsenal Industrial Complex and the Major Charles B. Kingsbury Manufacturing Center.

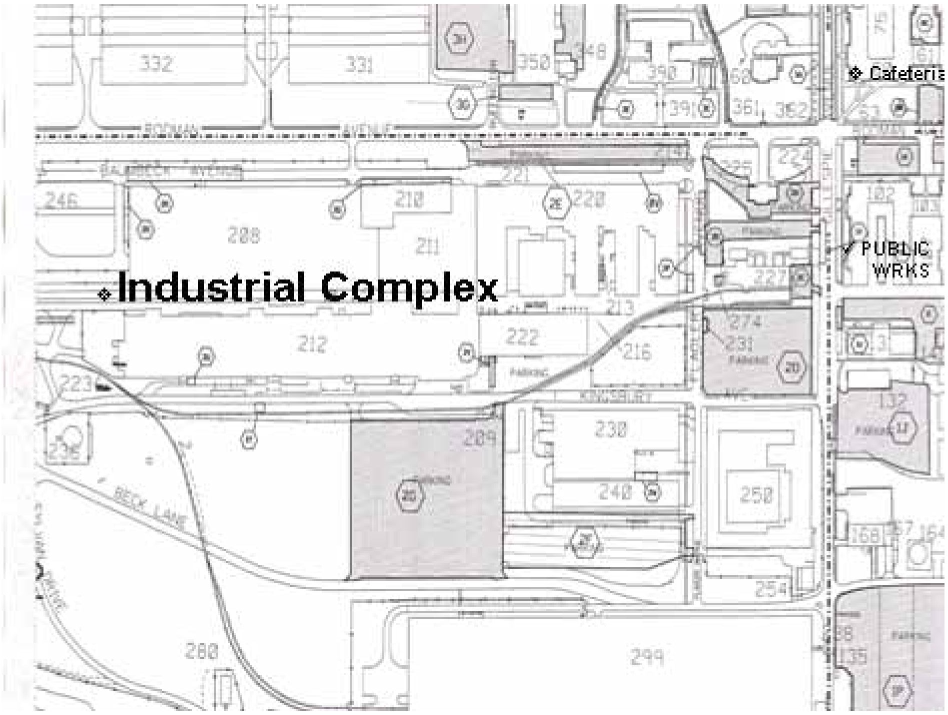

Figure 2. Map of Rock Island Arsenal industrial complex.

Figure 3. The Major Charles B. Kingsbury Manufacturing Center.

The center is reported to be one of the world's largest most modern government manufacturing facilities. It represents a $220 million investment on the part of the government under the Renovation of Armament Manufacturing (REARM) project.

Analysis of Energy Supply, Consumption, and Costs

In 2003, RIA consumed 68,544,000 kWh of electricity with an annual average daily load of 7,825 kW. About 76 percent of the electricity consumed were purchased (51,911,000 kWh costing $2,130,309) at an average cost of 4.10¢/kWh (or about $12/MMBtu). The balance was generated by Rock Island's own hydroelectric power plant (16,633,000 kWh). During the same period, the installation used 37,970 MMBtu (37,302 KCF) of natural gas, which cost $260,767, at an average cost of $6.87/MMBtu. In addition, RIA consumed 23,907 tons of eastern Kentucky coal at $1,204,435 to generate 453,754,000 lbs of steam. Average coal cost was about $1.91/MMBtu. RIA spent approximately $3,595,511 for energy for the entire year.

The plant energy systems convert the kWh of electricity and Btu of fuel into various productive utilities such as compressed air, steam, and shaft power to support various end uses. These annual purchased energy costs and variable unit costs are used as the cost basis of savings (CBoS) for the economic analysis of Energy Conservation Measures (ECMs). Table 1 lists RIA power consumption for FY 2002 and 2003 including electrical, coal, and natural gas. The rightmost column lists the difference between the 2 fiscal years in terms of a percent (%) decrease for FY 2003. Note that, for FY 2003, the average on-peak (between 8 a.m. and 8 p.m. Monday through Friday) electric energy charge is $0.03009 per kwh while off-peak is $0.01849 per kwh. The summer (June through September) demand charge is $9.14/kw-month and winter (October through May) $4.98/kw-month with the composite annual demand charge of $76.96/kw-yr. The Arsenal operates a hydroelectric generator of 3 MW capacity, the output of which is dependent on river head. The natural gas system at RIA operates at a pressure of 30 psi. The local utility (Mid American Energy) uses mercaptan to odorize the natural gas used at RIA.

Table 1. RIA power consumption summary.

	CUMULATIVE POWER SUMMARY(12 Months)			
	UNITS	FY 2002	FY 2003	
1. ELECTRICAL CONSUMPTION:				% Decrease
Month's Bill (Purchased)	$	2369067	2130309	10.1%
Mega Watt-Hours Purchased	MWH	54160	51911	4.2%
Mega Watt-Hours Generated	MWH	16305	16633	-2.0%
Total MWH Used	MWH	70465	68544	2.7%
Energy Consumed	MBTU	240480.7	233924	2.7%
Purchased vs. Total Usage	%	77%	76%	1.5%
Electric Unit Cost (Avg. Purch. Cost)	$/KWH	0.043742	0.041038	6.2%
2. COAL CONSUMPTION:				
Month's Bill (@ $50.38/TON OCT'02)	$	1190631	1204435	-1.2%
Coal Usage	TONS	23633	23907	-1.2%
Energy Consumed	MBTU	624336.6	631575.1	-1.2%
BTU Content (Ave. Apr 98 to Nov 98)	BTU/LB	13209	13209	
Coal Source: Eastern Kentucky				
Steam Produced	KLBS	450137	453754	-0.8%
Steam Produced/Energy Consumed	KLBS/MBT	0.720984	0.718448	0.4%
Degree Days: (Heating)	HDD	5435	6432	-18.3%
Degree Days: (Cooling)	CDD	1179	938	20.4%
Coal Unit Cost	$/KLBS	2.64504	2.654378	-0.4%
3. NATURAL GAS CONSUMPTION:				
Month's Bill (Purchased)	$	122109.1	260766.8	-113.6%
Volume Consumed	KCF	31891	37302	-17.0%
Energy Consumed/Volume Consumed	BTU/KCF	0.997512	1.017908	-2.0%
Energy Consumed	MBTU	31811.64	37970	-19.4%
Gas Unit Cost	$/KCF	3.828952	6.990693	-82.6%
4. TOTAL MBTU CONSUMPTION:		896629	903469.2	-0.8%
5. TOTAL PURCHASED ENERGY COST:		3681806	3595511	2.3%

Table 2. Cost Basis of Savings (CBoS).

Utility or cost factor	Derivation and Cost
1. Electricity	$0.041/kWh including both energy and demand. Energy cost = $0.03009/kWh on-peak for energy $0.01849/kWh off-peak for energy Demand charge = $4.98/kW-month winter; $9.14/kW-month summer $359/kW-year (combined energy and demand) = 1 kW used for 8,760 hrs/year $76.96/kW-year (demand only)
2. Horsepower	1 hp x 0.746 kW/Hp x 8760hrs/yr x $0.041/kWh = $268/hp-yr
3. Natural Gas	$6.87/MMBtu ($6.99/kCF; energy content 1,018Btu/kCF)
4. Coal	$1.91/MMBtu Eastern Kentucky, 13209 Btu/lb. $1,204,435/23907 ton coal for FY2003 = $50.38/ton coal $1,204,435/631575MMBtu= $1.91/MMBtu
5. Steam	135 psig, 358 °F saturated steam, 1194Btu/lb $3.00/klb (consider only fuel cost)
6. Water and Sewer	Water = $560,006/year = 157,000kgal/yr @ $3.57/kgal Sewer = $214,674/yr = 141,100kgal/yr @ $1.52/kgal

Unit Cost Calculations and CBoS

Since specific energy conservation measures focus on some type of end-use utility like compressed air, shaft power, lighting, etc. to support a process, the team needed a method to translate reduced consumption at the end use back to lower electricity usage or lower fuel consumption and the associated cost savings. As a result, researchers provided the team with translation formulas to convert incremental end use consumption back to the energy source and ultimately back to dollar cost, called the “Cost Basis of Savings” or (CBoS). Table 2 lists the cost values for an incremental unit of a utility and the underlying equation that derives this amount. The Post Energy Team (PET) may continue to use this table for future ECMs, and to use the formulas to modify the CBoS based on changes in operating assumptions.

Links Between Electricity and Environmental Emissions

Electricity: Basis for 1,000 kWh (1 MWh)

Electric Generation Assumption for the Midwestern United States.

This work assumed that, in Illinois, most electric generation in the region is coal fired at an average heat rate of 11,000 Btu/kWh.

Emission Assumptions for the Southeastern United States

1,000 kWh (coal-fired) = 2,170 lb CO_2 or 1.085 tons

1,000 kWh (coal-fired) = 4.5 lb NO_x

1,000 kWh (coal-fired) = 24.5 lb SO_2

PEOA Team and Schedule

The Rock Island Arsenal PEOA took place over a 5-day period between Monday, 21 June and Friday, 25 June 2004. Table 3 lists the team members and their affiliations. Table 4 lists sub-teams assigned to different process and energy system areas. Table 5 shows how the 5-Day Assessment process was organized by time, activities, and location to ensure that all of the critical areas in the scope of work were covered and that the process of the information collection, brainstorming sessions, and briefings to the management were built-in to the RIA personnel busy schedules. Outbriefing by the PEOA team with the RIA Commander and plant managers (Figure 4) was conducted in the morning of 25 June 2004.

Table 3. PEOA participants.

Rock Island Arsenal		
Patrick Van Acker	Norman Hatcher	Bradley Niles
David Bailey	Tim Heim	David Osborn
Mark Benes	Mike Hofer	David Peterson
Timothy Bolyard	Ronald Kessel	Robert Pettit
Stephen Clark	David Langum	Jay Richter
Gary Cook	Kentley Loewenstein	Dennis Ryan
Michael Fitzgerald	Scott Macomber	Jerome Sechser
Charles Gerdes	Thomas Michoski	Cathy Sonnenberg
Jerry Golden	Gary Milefchik	Charles Swynenberg
Hugh Halverson	Floria Moore	James Thompson
Dane Hansen	Curtis Morehead	Benny Wild
Sue Harrington	Scott Naeseth	Richard Wingert
Uinversity of IL in Chicago	**ERDC-CERL**	**Energy Tech. Serv.Internatnl.**
Mike Chimack	Veera Boddu	Walt Smith
Robert Miller	Mike Lin	
Andrew Sheaffer	Alexander Zhivov	**Palm International**
Steve Spentzas		Terry Hutchins
Matt Swanson	**CBF&K**	
	Patrik Bergvall	**Hastings Air Energy Control, Inc**
Gas Technology Institute	Curt Bjork	Mike Freeman
Brian Masterson		Doug Young

Table 4. RIA PEOA task assignment (21-25 June 2004).

Plating	Foundry	Painting
Curt Bjork	Walt Smith	Walt Smith
Patrick Bergvall	Mike Lin	Veera Boddu
Veera Boddu	Patrick Van Acker	Robert Miller
Kentley Loewenstein	Mark Benes	Dave Langum
Dick Wingert	Mike Fitzgerald	Patrick Van Acker
Mike Fitzgerald		Alexander Zhivov
Alexander Zhivov		
Mike Chimack		
Heat Treating	**Welding**	**Machining**
Walt Smith	Alexander Zhivov	Walt Smith
Brian Masterson	Mike Lin	Mike Lin
Mike Fitzgerald	Mike Freeman	Patrick Van Acker
Mark Benes	Doug Young	Mike Fitzgerald
Sue Harrington	Floria Moore	Mike Chimack
	Tim Heim	
Boiler Plant	**HVAC**	**Building Envelope**
Andrew Sheaffer	Curt Bjork	Curt Bjork
Jay Richter	Patrick Bergvall	Patrick Bergvall
Matt Swanson	Bob Pettit	Mark Benes
Steve Spentzas	Hugh Halverson	Sue Harrington
	Mike Hofer	
Compressed Air	**Lighting**	**Organizations**
Mike Chimack	Robert Miller	RIA
Andrew Sheaffer	Dave Osborne	CERL
Matt Swanson		UIC
Steve Spentzas		ETSI
		CBF&K
		JCI/RIIS

Table 5. Five-day schedule, RIA PEOA.

Monday (21 June 2004)	
8:00-8:10	Introduction (Dave Osborn, RIA)
8:10-8:30	Objectives, Scope, Approach, 5-Day Schedule (Alexander Zhivov, CERL)
8:30-9:30	Utility Systems O&M, Metering, Energy Projects (Gas, Elec., Steam, Compressed Air, Bldg. HVAC) (Dave Osborn and other DPW staffs)
9:30-9:45	Coffee Break
9:45-11:30	Plating, Painting, Machining, Welding, Foundry, Heat Treating, etc. (Process Flow, Production Schedule, Cost Issues, Future Needs) (RIA Process managers, Engineering staffs)
11:30-12:30	Lunch
12:30:13:30	Quick guided tour of Process & Heating Plants (Assessment Team and Plant Managers)
13:30-14:30	Plating (Curt, Patrik +PALM (Terry Hutchins) +CERL-CNE (Veera Boddu))
	Heat Treating (Walt + GTI (Brian Masterson) + Mike Lin)
	Welding (Alexander Zhivov + Hastings Air Energy Controls (Mike Freeman and Doug Young)
14:30-16:30	Brainstorming session with responsible operational staff
Tuesday (22 June 2004)	
7:00-15:00	Boiler plant (UIC + Mike Lin)
	HVAC and Process Ventilation Systems (Curt + Patrik)
	Painting (Walt + CERL-CNE (Veera Boddu))
15:00-17:00	Brainstorming session with responsible operational staff
Wednesday (23 June 2004)	
7:00-15:00	Compressed Air Systems and Lighting (UIC)
	Building Envelope (Curt + Patrik)
	Machine shop & Foundry (Walt + Mike Lin)
15:00-17:00	Brainstorming session with responsible operational staff
19:00-21:00	Assessment Team Review Discussion
Thursday (24 June 2004)	
Follow-up studies	
	List of ideas, priorities, solutions, economics
	Prepare debriefing
Friday (25 June 2004)	
7:00-12:00	Presentation (Assessment Team)
12:00-1:00	Lunch and Adjourn

Figure 4. PEOA Team Briefing, 25 June 2004.

3 Rock Island Arsenal Assessment Results

This Chapter includes assessment results for the processes and systems listed in Table 6.

Table 6. Evaluated processes and systems.

Processes		Systems	
1. Plating (PT)	4. Machining (MC)	7. Building Envelope (BE)	10. Lighting (LT)
2. Painting (PN)	5. Foundry (FD)	8. Building HVAC (BH)	11. Boiler Plant (BP)
3. Heat Treatment (HT)	6. Welding (WD)	9. Compressed Air (CA)	

Plating Area

The electroplating area (Figure 5) is located in the Building 212. One hundred twenty plating tanks* are used to apply chrome, nickel, cadmium, and copper, and to galvanize, parkerize, anodize, and apply oxide finishes. The production processes emit different acid mists, gases and steam. Plating tanks are equipped with the bilateral exhausts with downward plenums that capture contaminants. Water used in plating operations is treated in a reverse-osmosis system housed in the basement. Chemicals for the plating operations are supplied by a gravity feed system. Automated controls properly mix the chemicals, achieve and maintain correct temperatures, etc. About half of the tanks are heated. Some tanks have panel coil heat exchangers while others use shell-and-tube heat exchangers. The plating shop is kept under negative pressure with the make-up air at a rate of approximately 15 air changes per hour coming from adjacent production areas. Only a small percent of the plating tanks are used, while the extraction system is operated at 100 percent capacity. This operation requires ~500,000 cfm of exhaust and the same amount of make-up air systems operation.

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* Franklin H. Holcomb, et al., *Molten Carbonate Fuel Cells for DoD Applications: Rock Island Arsenal MCFC* Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) TR-00-34 (ERDC-CERL, Champaign, IL, 2000).

Figure 5. Plating operations in Building 212.

Recommendations for Plating Operation

General Observations

1. The plating facilities are adequately ventilated. The exhaust systems are designed to support emissions control for operation of all the tanks. Discussions revealed that all the tanks are not used at the same time. Therefore, with a proper coordination with machine shop/other customer scheduling/lumping the work orders may reduce the need to operate all the exhaust fans. (Energy and Materials Optimization.)
2. The existing plating tanks have pull-pull or push-pull type emissions air sweeping strategy. If any particular plating tank is not going to be used for more than a week (or 3 to 4 days), Plexiglas sheets (cut to fit the tanks) may be helpful in reducing the fan speed. (Energy and Material Savings.)
3. The heated tanks are not insulated. Insulating the tanks as much as possible will reduce the energy requirements and also achieve better process control. The temperature difference (between tank and ambient temperatures) may be significant during the winter and may reduce ambient cooling requirements during summer.
4. The filters on the roof-top vent systems need maintenance. The pressure drop may be significant and the energy loads may be high for such (observed) dirt-loaded filters.
5. The rinse water flow rates can be controlled efficiently by installing conductivity controls as practiced in private industry. This will not only yield savings in water costs, but also reduce wastewater treatment and disposal costs. (Industrial studies show the payback period is usually less than a year.)

6. The Palm covering system as initially thought may not be implemented at the RIA plating due to the space requirements of the system.
7. The total number of air exchanges can also be minimized (reduced) when the tanks are covered and emissions are reduced.

PL#1: Install Emission Elimination Devices (EED) on Chrome Plating Tanks

Existing Conditions

Chrome plating tanks are not covered. Exhaust air is withdrawn from tank tops to scrubbers, cleaning the air before it is released to the atmosphere. Residuals and wastewater from scrubbers are treated in a wastewater treatment plant. Further costs are incurred in taking care of hazardous waste.

Solution

Cover chrome plating tanks with emission elimination devices (Figure 6) developed by PALM International, Inc.

Savings

Savings accrue from eliminated airflow through scrubbers (fans and pumps), reduced supply air needs and eliminated waste (i.e., nothing leaves the tank). Covering the tanks also improves the IAQ by reducing emissions. Roughly calculated savings, based on experiences from previous similar installations, are $12,000 per tank at an electric rate of 4.1 cents/kWh.

Investments

The estimated investment for PL#1 amounts to $ 48,000 per tank.

Payback

The estimated payback for PL# occurs in 4 years.

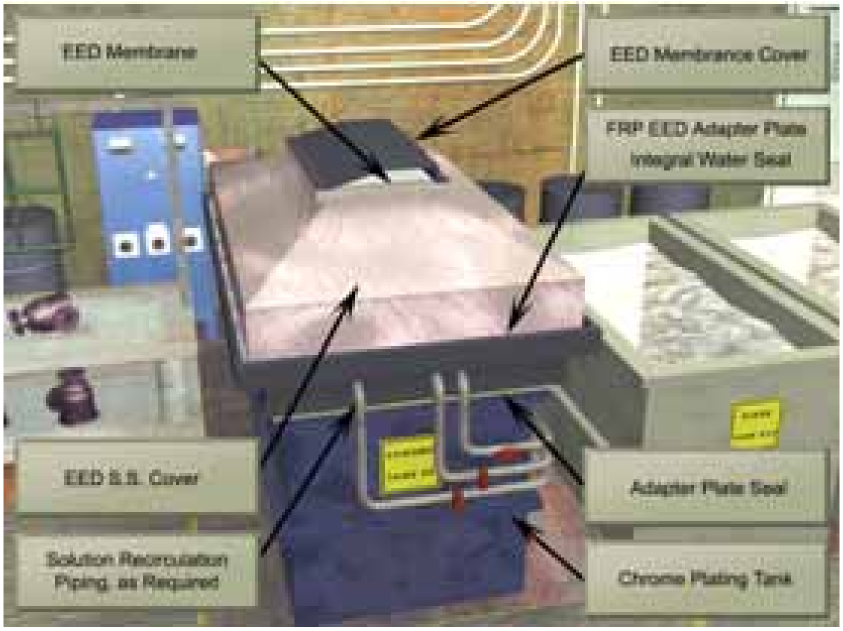

Figure 6. Emission elimination device developed by Palm International.

PL#2: Control Airflows and Steam Heating in Plating Shop

Existing Conditions

The plating shop presently operates 24 hrs/day, 7 days/wk. Normal operations are for 5 days per week. The plating shop is ventilated so that the indoor air is exchanged close to 13 times per hour (approximately 500,000 cfm). Exhaust air from chrome plating tanks and other tanks is taken through scrubbers that clean the exhaust air before it is released to the atmosphere. There are 11 scrubbers, each operating with one or several tanks. Scrubbers are switched on and off manually. They are normally on when the plating shop is running. A control system calculates the exhaust air flow and starts a sufficient number of MAUs (Makeup Air Units) to make the shop slightly under-pressured.

In theory, this should work, but in practice it does not; the plating shop suffers from a very high negative pressure. Concerns have been raised regarding the hazards related to opening and closing of doors to the plating shop. Arm breaking risks exist if one does not act fast enough. This happens because the ventilation control system does not work properly. Because of dirt build up in filters of the Make-up Air Units (MAUs), the static pressure drop increases over time and the make up airflow is reduced while the exhaust airflow remains constant, thus increasing the negative pressure. Also, at certain outdoor temperature conditions the ventilation system shuts down for the entire plating shop, which is a serious fault. In addition, steam heating control, for coils in MAUs, is not kept to today's standards. The steam valves are operated in an on/off mode instead of modulating. This tends to increase energy use. Plating shop operators also complain that poor steam flow control causes overheating. During the audit (with 80+ °F), researchers found that one studied heating coil was overheating.

Solution

Install Variable Frequency Drives (VFDs) on all scrubber fans, all other exhaust fans and the three MAU fans. VFDs for exhaust fans should have three positions: (1) off, (2) half flow (approximately, can be fine-tuned), and (3) full flow. VFDs for scrubbers shall have the same three positions but the full flow mode should be connected to a timer allowing whatever plating time is needed for every operation. A new control system should replace the old one. Pressure sensors inside and outdoors shall be installed and connected to the new control system. The system shall operate the MAUs (with and without VFDs) to keep the plating shop under a small negative pressure. Proper settings should be followed for the operation of the exhaust air units. If plating tanks are not used they should be on half flow or, if possible, turned off. In addition, modulating steam valves with feedback temperature control should be installed and incorporated in the new control system.

Savings

Based on the assumptions that the plating shop can go from more or less continuous ventilation at full speed to half flow, two-thirds of the time, electric energy savings have been calculated to be about $115,000 annually. The value of the steam savings amounts to $106,400 per year, for total savings of $220,000 per year. Additional savings (not included) accrue from wastewater savings and indoor air quality (IAQ).

Investments

Investments are roughly estimated to be about $400,000.

Payback

The payback period for PL#2 is estimated to be 2 years

Note

Total supply (and exhaust) air flow beforePL#2 amounts to 500,000 cfm, 156 hrs/wk. (They shut down for a day at the end of every 2-week period.) There is no heat recovery. The energy needed to heat to +22 °C (71.6 °F) with an average outdoor temperature of 6.4 °C (43.5 °F) from September–May amounts to 25,978 MWh.

The Changed operation would provide full airflow only for 52 hrs per week, and half airflow for 104 hrs/week. The energy needed to heat amounts to 13,878 MWh.

Savings

The energy saving resulting from implementation of PL#2 is estimated at 12,100 MWh in the Plating Shop. With 10 percent losses in steam distribution system, the savings are estimated at 13,300 MWh, @ $8/MWh = $106,400.

Controlling all exhaust fans and three air handling unit (AHU) fan motors, with VFDs, yields:

15 MAUs,
    21 hp/unit = 315 hp.
    Savings =
    80%, 252 hp at 65 % of time (104 hrs/week, 40 weeks): $32,000

Scrubbers: 2.5 kW/m^3/s, 165 m^3/s = 440 hp.
    Savings 80 %, 65 % of time as above: $56,000.

Other exhaust fans:
    Savings of at least $10,000.

Total Electric Savings

Total electric savings are calculated to be $98,000. This presumes operation at half or full flow. We will also be able to run fans in an “off” mode, which will yield further savings, for an estimated total of $115,000.

Investments

Investments are estimated to be $150,000 for VFDs. This would include 21 units with an average of 35 hp, $200/hp; $100,000 for steam valves, new controls etc.

PL#3: Insulate Hot Plating Tanks and Rinse Tanks

Existing Conditions

The present operation and its lack of scheduling in the plating shop operations leaves everything is “up and running” all the time (black oxide tank at 285 °F; hot rinse tanks at 180 °F; chrome tanks at 130 °F). Except for the black oxide tank, the tanks are not covered. The tanks are heated with steam and are uninsulated. Hot tanks are also ventilated, either with connected scrubber exhausts, or by exhaust to the atmosphere, both of which create a need to refill water after evaporation.

Solution

Insulate hot tanks to mitigate radiative and convective heat losses to the ambient environment.

Savings

With the present "always hot" operation, the savings by insulating a hot rinse tank (width 3 in., depth 6 in., length 12 in.) have been calculated at $300/year, assuming a U-value of 4.5 now and 0.5 after completed insulation. If this measure is combined with PL #5, allowing tanks to cool down when not in use, the savings will be lower.

Investments

This could probably be done at a cost of $1,500 per tank.

Payback

The estimated payback is 5 years (under "up and running" conditions).

Note

The number of tanks must be counted. For example, a tank, sized as in the report, to achieve a ΔT of 60 °C, insulated with a non-specified material (Styrofoam blocks or similar) with a conductivity of 0.045 W/m,K, which must be approximately 8 cm thick to decrease the U-value from 4.5 to 0.5. Savings will be 4x20x60 = 4800 W, for 8000 h = 38400 kWh, which at $8/MWh is $307/year. Investment could be very low-tech and should not be more than $1,500/tank (at $75/m^2).

PL#4: Improve Scheduling for Plating Operations so that Plating Shop Production Can Be Planned and Made More Effective

Existing Conditions

Today, it is impossible for the plating shop to know the type or quantity of jobs that will arrive during the next hour, day, or week. There is no possibility to plan for the constantly changing workload. The Plating Shop is supposed to be up and ready to do whatever plating that "MIGHT" be necessary whenever needed. Arriving pieces to be plated or treated in other processes are normally (almost always) labeled as very urgent, i.e., the pieces normally already should have been “sent back yesterday.” This causes significant energy bills, in maintaining all tanks at the right temperature, with the entire ventilation running, all lighting on, all pumps and cleaning systems always in operation.

Solution

Incorporate the Plating Shop in the scheduling within the industrial facilities of the Arsenal. The personnel that plan and take responsibility for the Arsenals commitment and orders should know exactly the type of operations that need to be done on every vehicle, howitzer etc. that comes in to the Arsenal for retrofitting or repair. The total workload must be known to some extent in advance, allowing for planning of operations and scheduling of resources and manpower.

If the Plating Shop could know in advance (1 day or 1 week in advance) what to do with which piece of equipment, it could plan ahead on which tanks to keep warm and when they could be shut down as soon as there is no more work to be done. If there is a certain time allowed for the plating operations to be completed, suppose that arriving material should be plated and delivered within 48 hrs, then the plating shop could be run more efficiently and lower energy costs. This would be especially true when combined with other suggested measures regarding improved ventilation in the plating shop.

Savings

Better scheduling procedures can save money for the Arsenal by:

- reducing energy costs in the plating shop itself (tank heating, pumps, fans, steam coils)
- reducing waiting costs in production units after the plating shop (machining, painting, assembly) will be reduced
- planning maintenance so it can be done by plating shop personnel while they are occupied with plating jobs
- reducing the running time for equipment, which will prolong equipment lifetime and reduce maintenance costs
- reducing wastewater treatment costs
- reducing costs for chemicals
- reducing labor costs by appropriately matching the number of to the workload.

Investments

In practice, PL#4 requires no investment except for the labor implicit in planning and scheduling. Existing software and planning tools can be used.

Payback

The payback for PL#4 is immediate.

PL#5: Allow Some Hot Plating and Rinse Tanks To Cool Down at Certain Times

Existing Conditions

With present operation and with the lack of scheduling in the plating shop operations, everything is “up and running” all the time (the black oxide tank at 285 °F, the hot rinse tanks at 180 °F, and the chrome tanks at 130 °F). Except for the black oxide tank, the tanks are not covered. Tanks are heated from steam, and all tanks are uninsulated. The hot tanks are ventilated, either with connected scrubber exhausts, or just exhausted to the atmosphere, both of which creates a need to refill water after evaporation.

Solution

Measure heat-up-time, in °F /hr, for every hot tank that could be considered to shut down during periods when they are not scheduled for operation. This information gives a curve that can be used to determine when the heat has to be turned on again so that the tank would reach setpoint temperature when operation starts again. This curve should be attached to operating panel of each hot tank.

Covers should be constructed and used for tanks where this can easily be done, e.g., hot rinse tanks where there is not much piping on top of tank. Use Plexiglas and insulated handles, two handles per cover. Do not forget to develop new heat-up curve when tank are equipped with covers because of changing conditions.

Savings

Savings must be measured and calculated in more detail. Savings are highly depending on scheduling procedures and on whether plating shop personnel actually adopt this new operation mode.

Investments

PL#5 requires investments in work-hours and Plexiglas. Work-hours already exist; the plating shop staff can develop operating curves and strategies.

Payback

Payback for PL#5 is estimated to be less than 1 year.

Note

Researchers will need to measure heat-up time to find out how long it takes from a certain temperature to reach the setpoint temperature again. The researchers could not justify the payback at the time of this study, but used some references from one of their Swedish customers.

PL#6: Retrofit MAUs To Use High Efficiency/Low Static Pressure Drop Filters

Existing Conditions

The plating shop requires 13 air exchanges per hour during normal operating conditions. Filters get clogged quickly, which increases fan HP needs for makeup air supply. Steam coils also get clogged, causing increased static pressure drop. This also reduces airflow, causing increased negative pressure in the plating shop.

Solution

Clean steam coils. Retrofit MAUs to use high efficiency/low static pressure drop filters to lower fan HP needed for makeup air supply.

Savings

With 20 MAUs operating 8,000 hrs per year, and assuming a 20 percent speed reduction of fans as a result of lower static pressure drop, the annual savings are calculated to approximately $45,000. Additional savings can be achieved by prolonged filter change intervals, thus reducing both filter costs and labor for maintenance staff. Additional benefits are: IAQ improvement and better heat transfer on steam coils.

Investments

Investments for PL#6 involve

- retrofit to new filter banks, at approximately $8,000/MAU, for a total of $160,000
- change in fan speed, $1,000/MAU, for a total of $20,000.

Payback

The payback for PL#6, can be calculated as:

$180,000 /$45,000 = 4 years.

Painting Area in the Building 208

The spray paint area located in the Building 208 (Figure 7) is capable of applying CARC (chemical agent resistant coatings). Other painting capabilities include production painting, camouflage, and powder paint. There are three paint booths (8 ft, 45 ft, and 50 ft by 20 ft wide), two conveyor lines (large parts up to 1000 lbs/300 ft long; small parts up to 500 ft long) and a drying booth (50 ft by 16 ft wide).

Figure 7. Open spray booth in the paint area.

Some observations for Paint Area are:

1. The paint booth is not enclosed from the top or on the sides. This leads to excessive air being drawn through the floor vents and exhaust fans and adds to the heating and cooling costs of the entire building. It was not clear if the exhaust fans on the paint booth are continuously operated at high flow rate even when no painting is taking place. Perhaps a scheme (with sensors) to reduce the speed of the fans could be devised.
2. Provide retractable covers for paint booth from both ends and from the top. A preliminary cost estimate shows a simple payback period of 2.1 years.
3. A retractable transparent cover would also help contain/reduce the in inadvertent cross contamination of the building with volatile organic chemicals (VOCs) and hazardous air pollutants (HAPs).
4. Radiant heating and paint curing area also needs better insulating shades. As such it appears the convective losses are high.

Recommendation for Painting Operation

PN#1: Enclose Drive-Thru Paint Booth

Background/Existing Situation

Excessive paint booth exhaust and excessive outside air make up are required for "open" booth design. The result is high fan exhaust energy and steam to heat cold make up air during the winter.

Descriptive Scope of Recommendation

Enclose the top and ends of the booth with an easy close/open design to accommodate (at least) 80 percent of all paint jobs with booth closed. Install VFDs (variable frequency drives) on four 40hp booth exhaust fans to average 70 percent of current flow.

Benefits and Advantages

The benefits of PN#1 are reduced energy costs

Basis for Economic Calculations: Assumptions and CBoS

Process PN – Paint Shop Annual Operating Budget	100% Budget (k$/yr)	Potential Savings Factors	
		10% (k$/yr)	1% (k$/yr)
Labor Cost (18 x $60k/yr)	$1,080	$108.0	$10.8
Materials cost	$400	$40.0	$4.0
Utilities cost	$250	$25.0	$2.5
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including environmental)	$370	$37.0	$3.7
Total shop budget	$2,100	TAT=$165.0*	TAT = $16.5
* TAT (turn around time) = ($2,100 x 10%) – $40 – ($25x20%) = $165k/year			

Process Operating Performance Data, Potential Savings, and Cost Estimates/Assumptions

This is based on a combination of actual data and “educated guesses” made jointly by the PEOA Painting Team.

- There are 18 employees (direct and indirect) @ $60k/yr
- Costs for materials, utilities, environmental and other were estimated by the Paint Team.

Savings Calculations

Savings Categories	Calculation	k$ savings (cost) / yr
1. Energy savings (fan energy)	4 motors x 40hp x 0.746kW/hp x (1-.7^3 or 66%) x 4,500 hrs/yr x $0.041/kWh	$14.6
2. Energy savings (steam energy)	(160,000 cfm – 80,000 cfm) x 1.08 x (80°F – 30°F) = 4.3 MMBtu/hr 4.3 MMBtu/hr x 50% on x ½ year x 8,760 hrs/yr x $5.00/MMBtu	$47.1
3. TAT savings	No savings	$0.0
4. Total savings with TAT	(1 + 2 + 3)	$61.7
5. Total savings without TAT	(4) – (3)	$61.7

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Purchase and install easy open/close enclosure on paint booth	Total installed cost	$40.0
2. Purchase and install (4) VFDs	4 VFDs x 40hp x $150/hp	$24.0
3. Total project cost	(1 + 2)	$64.0

SPB (simple payback) with TAT = $64k / ($61.7k/year) = 1.0 years

SPB without TAT = $64k / ($61.7k/year) = 1.0 years

Estimated Risk Level

TBD (to be determined) by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT Savings (k$/yr)	N/A
Materials cost savings (k$/year)	N/A
Labor savings (k$/yr)	N/A
Maintenance savings – MM&L (k$/yr)	N/A
Energy savings (k$/yr)	$61.4
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$61.4
Total savings without TAT (k$/yr)	$61.4
Installed cost (k$)	$64.0
Simple payback with TAT (years)	1.0
Simple payback without TAT (years)	1.0

Heat Treatment

Heat treating capabilities at RIA (Figure 8) include annealing, hardening, tempering, surface carburizing, carbon restoration, induction hardening, etc. Forty furnaces are available for use with envelope sized to 48 in. x 144 in. Load weight can be up to 60,000 lbs and uniformity surveyed up to 2400 °F. There is 24-hour monitoring system for quality control.

Figure 8. Heat treating operation in Building 222.

Recommendations for Heat Treating Operation

HT#1: Install Thermocouples To Provide Uniformity Surveys for Furnaces in Bldg. 222

Background/Existing Situation

Temperature surveys that check temperature uniformity in the furnaces are labor intensive, waste energy, and waste shop capacity. Surveys are done on 40 furnaces, 4 times each year. The furnaces operate empty, during these surveys for 1–3 days (assume 2 days per furnace per quarter).

Descriptive Scope of Recommendation

Permanently install thermocouples in each of 40 furnaces. Monitor temperature profiles continuously during normal production with product in furnaces. It is better to always know temperature uniformity and control on an ongoing basis rather than to “spot check” this important condition only four times per year. This eliminates 8 days of furnace operating time where no product is being produced.

Benefits and Advantages

- Reduced energy costs
- Labor savings
- Faster TAT (turn around time).

Basis for Economic Calculations: Assumptions and CBoS

Process HT – Heat Treat Shop Annual Operating Budget	100% Budget (k$/yr)	Potential Savings Factors 10% (k$/yr)	1% (k$/yr)
Labor cost (12 x $60k/yr)	$720	$72.0	$7.2
Materials cost	$300	$30.0	$3.0
Utilities cost (electric $200k/yr + CA $50k/yr)	$200	$20.0	$2.0
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including environmental)	$240	$24.0	$2.4
Total shop budget	$1,460	TAT=$112.0*	TAT = $11.2
* TAT= ($1,460 x 10%) – $30 – ($20x20%) = $112k/year			

Process Operating Performance Data, Potential Savings and Cost Estimates/Assumptions

This is based on a combination of actual data and "educated guesses" made jointly by the PEOA Heat Treat Team.[*]

- There are 12 employees (direct and indirect) @ $60k/yr
- Costs for materials, utilities, environmental and other were estimated by the Heat Treat Team.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Labor savings	[$720k/yr total x 5% savings] + $2.0k/yr (avoided maintenance cost)	$38.0
2. Energy savings	$200k/yr x 5% savings	$10.0
3. TAT savings	$112k/yr per 10% x 3.2%	$36.0
4. Total savings with TAT	(1 + 2 + 3)	$84.0
5. Total savings without TAT	(4) – (3)	$48.0

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Purchase and install thermocouples on (40) furnaces	40 Thermocouples x $5,000/thermocouple	$200.0

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[*] The PEOA Heat Treat Team members were: Mike Fitzgerald, RIA, Mark Benes, RIA, Sue Harrington, RIA, Brian Masterson, GTI, Walt Smith, ETSI.

SPB with TAT = $200k / ($84k/year) = 2.4 years

SPB without TAT = $200k / ($48k/year) = 4.2 years

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT savings (k$/yr)	$36.0
Materials cost savings (k$/year)	N/A
Labor savings (k$/yr)	$38.0
Maintenance savings – MM&L (k$/yr)	N/A
Energy savings (k$/yr)	$10.0
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$84.0
Total savings without TAT (k$/yr)	$48.0
Installed cost (k$)	$200.0
Simple payback with TAT (years)	2.4
Simple payback without TAT (years)	4.2

HT#2: Initiate a Stronger Preventative/Predictive Maintenance Program

Background/Existing Situation

The Heat Treat shop “does not have an adequate PM program.” The equipment is old and subject to frequent failure. Bearings in fans and other rotating equipment fail almost every month. This requires “emergency” maintenance, which is costly and routinely interrupts the production schedule. In the past few years, the Heat Treat shop has been losing the use of three furnaces/year for up to 6 months each.

Descriptive Scope of Recommendation:

Provide an additional (third) maintenance person with PM experience to support the Heat Treat shop. Analyze failure history to identify the “20 percent of the systems that cause (cost) 80 percent of the downtime and repair dollars.” Develop good PM analysis and practice to predict and repair prior to failure.

Benefits and Advantages

- Reduced maintenance labor
- Reduce maintenance materials
- Faster TAT

- Can meet production schedules better
- Reduces material losses
- Reduces risk of off-spec metal.

Basis for Economic Calculations: Assumptions and CBoS

Process HT – Heat Treat Shop Annual Operating Budget	**100% Budget (k$/yr)**	**Potential Savings Factors**	
		10% (k$/yr)	**1% (k$/yr)**
Labor cost (12 x $60k/yr)	$720	$72.0	$7.2
Materials cost	$300	$30.0	$3.0
Utilities cost (electric $200k/yr + CA $50k/yr)	$200	$20.0	$2.0
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including environmental)	$240	$24.0	$2.4
Total shop budget	$1,460	TAT=$112.0*	TAT = $11.2
* TAT= ($1,460 x 10%) – $30 – ($20x20%) = $112k/year			

Process Operating Performance Data, Potential Savings and Cost Estimates/Assumptions

This is based on a combination of actual data and “educated guesses” made jointly by the PEOA Heat Treat Team.

- There are 12 employees (direct and indirect) @ $60k/yr.
- Three furnaces of the 40 furnaces fail each year for up to 6 months of downtime each.
- RIA believes that a third maintenance/PM support person will solve 80 percent of these problems.
- Labor savings estimated at 2 work-years (maint + HT operator).
- Material savings estimated at 10 percent, plus $50k/yr maintenance materials.
- TAT reduction of 10 percent.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Labor savings (maintenance and operating labor)	2 work-years of emergency and operating maintenance = 2 work-years x $60k/work-year	$120.0
2. Materials savings	($300k/yr x 10% savings) + $50.0k/year maintenance materials saved	$80.0
3. TAT savings	$112k/yr per 10% savings	$112.0
4. Preventative maintenance (cost)	$60k (1- work-year) + $40k/yr (testing equipment and materials cost)	($100.0)
5. Total savings with TAT	(1 + 2 + 3 + 4)	$212.0
6. Total savings without TAT	(5) – (3)	$100.0

Cost Estimate Calculations

No capital cost

SPB with TAT = Immediate

SPB without TAT = Immediate

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT savings (k$/yr)	$112.0
Materials cost savings (k$/year)	$80.0
Labor savings (k$/yr)	$120.0
Preventative maintenance (cost) – MM&L (k$/yr)	($100.0)
Energy savings (k$/yr)	N/A
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$212.0
Total savings without TAT (k$/yr)	$100.0
Installed cost (k$)	$0.0
Simple payback with TAT (years)	Immediate
Simple payback without TAT (years)	Immediate

HT#3: Install an Endothermic Generator

Background/Existing Situation:

The Heat Treat shop purchases approximately $35k/yr of methanol and nitrogen as sources of carbon. (This need to be confirmed.). Carbon is added to metal in the heat treat process. A lower cost source of CH_4OH and N_2 is available from an "endothermic generator" that converts NG into methanol and nitrogen.

Descriptive Scope of Recommendation:

Install an endothermic generator (E.G.) to produce methanol and nitrogen from natural gas.

Benefits and Advantages

- Reduced materials cost
- Independent supply of CH_4OH and N_2 assures availability.

Basis for Economic Calculations: Assumptions and CBoS

Process HT – Heat Treat Shop Annual Operating Budget	100% Budget (k$/yr)	Potential Savings Factors	
		10% (k$/yr)	1% (k$/yr)
Labor cost (12 x $60k/yr)	$720	$72.0	$7.2
Materials cost	$300	$30.0	$3.0
Utilities cost (electric $200k/yr + CA $50k/yr)	$200	$20.0	$2.0
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including Environmental)	$240	$24.0	$2.4
Total shop budget	$1,460	TAT= $112.0*	TAT = $11.2
* TAT= ($1,460 x 10%) – $30 – ($20x20%) = $112k/year			

Process Operating Performance Data, Potential Savings and Cost Estimates/Assumptions

This is based on a combination of actual data and "educated guesses" made jointly by the PEOA Heat Treat Team.

- There are 12 employees (direct and indirect) @ $60k/yr.
- The annual cost of consumed CH_4OH and N_2 are based on:
  - CH_4OH: 700 gal/tank, use six tanks/yr, $1.50/gal
  - N_2 @ 200psi = $(3)^2$ x 3.1416 x 18 ft tall = 500gals, 12 tanks per year, $0.50/gal.
- Operating cost of the energy = $1,200/yr.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Methanol purchased	700 gal x 6 tank/yr x $1.50/gal	$6.3
2. Purchased nitrogen	500 gals/tank x 12 tanks/yr x $.50/gal	$3.0
3. Energy (cost)	$200/month (fuel to run endothermic generator) x 12 months/year	($2.4)
5. Total savings with TAT	(1 + 2 + 3)	$6.9
6. Total savings without TAT	(5) – (3)	$6.9

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Purchase and install an endothermic generator	The install cost must be < $41k for a 6 year payback	$41.0

SPB with TAT = $41.0k / $6.9k/year = 6.0 years

SPB without TAT = $41.0k / $6.9k/year = 6.0 years

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT savings (k$/yr)	N/A
Materials cost savings (k$/year)	$9.3
Labor savings (k$/yr)	N/A
Preventative maintenance (cost) – MM&L (k$/yr)	N/A
Energy savings (cost) (k$/yr)	($1.2)
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$6.9
Total savings without TAT (k$/yr)	$6.9
Installed cost (k$)	$41.0
Simple payback with TAT (years)	6.0
Simple payback without TAT (years)	6.0

HT#4: Improve Lighting Performance in Heat Treat

Background/Existing Situation

The ceiling in Heat Treat is very dark due to years of buildup of hazy furnace emissions. Additionally, the lamp lenses are dirty. The result is very low illumination levels, which is grossly inadequate and could be unsafe. Better, more effective lighting is needed to improve worker performance and safety. CCI#HT-4 suggests the economics be evaluated to improve Heat Treat lighting.

Descriptive Scope of Recommendation

1. Clean the ceiling and existing lamp lenses.
2. Paint the ceiling a light color to improve effective lighting performance
3. Provide task lighting (2 ft x 4 ft T5 high output fixtures) at 20 critical locations

Benefits and Advantages

- Improve safety
- Improved worker productivity and morale
- Labor savings from less rework/mistakes
- Faster TAT.

Basis for Economic Calculations: Assumptions and CBoS

Process HT – Heat Treat Shop Annual Operating Budget	**100% Budget (k$/yr)**	**Potential Savings Factors**	
		10% (k$/yr)	**1% (k$/yr)**
Labor cost (12 x $60k/yr)	$720	$72.0	$7.2
Materials cost	$300	$30.0	$3.0
Utilities cost (electric $200k/yr + CA $50k/yr)	$200	$20.0	$2.0
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including environmental)	$240	$24.0	$2.4
Total shop budget	$1,460	TAT=$112.0*	TAT = $11.2
* TAT= ($1,460 x 10%) – $30 – ($20x20%) = $112k/year			

Process Operating Performance Data, Potential Savings, and Cost Estimates/Assumptions

This is based on a combination of actual data and “educated guesses” made jointly by the PEOA Heat Treat Team.

- There are 12 employees (direct and indirect) @ $60k/yr
- Improved lighting performance is believed to result in the following:
  - Better morale & safety yields higher productivity with less labor (3 percent savings)
  - Reduced materials loss of 3 percent
  - Faster TAT of 5 percent
- Task lights cost $,1500/light (20 budgeted)

- Shop area for upgrade is 25,000 sift.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Labor savings from higher productivity and morale	$720k/yr total x 5% savings	$36.0
2. Materials savings	$300k/yr total x 3% savings	$9.0
3. Energy (cost)	20 lamps x 0.120kW/lamp x 4000hrs/yr x $0.041/kWh	($0.4)
4. TAT savings	$112k/yr per 10% x 5%	$56.0
5. Total savings with TAT	(1 + 2 + 3 + 4)	$100.6
6. Total savings without TAT	(5) – (4)	$44.6

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Clean and paint ceiling and lamp lenses	25,000 sq ft x $5/sqft	$125.0
2. Purchase and install 20 task lamps	20 lamps x $1,500/task fixture	$30.0
3. Total Project Cost	(1 + 2)	$155.0

SPB with TAT = $155k / $100.6k/year = 1.5 years

SPB without TAT = $155k / $44.6k/year = 3.5 years

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT Savings (k$/yr)	$56.0
Materials cost savings (k$/year)	$9.0
Labor savings (k$/yr)	$36.0
Energy savings (cost) (k$/yr)	($0.4)
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$100.6
Total savings without TAT (k$/yr)	$44.6
Installed cost (k$)	$155.0
Simple payback with TAT (years)	1.5
Simple payback without TAT (years)	3.5

Machining

Turning (lathe), milling, drilling, and tapping operations are done in the oldest part of the WWI Wing in the center (Figure 9). The newest computer controlled metal-working equipment (4-axis and 7-axis machines) are in the New Wing (Figure 10).

Figure 9. Machining operations in the World War I Wing.

Figure 10. CNC machines in the New Wing machine shop.

There are over 200 state-of-the-art CNC (computer numerical control) machines in the machine shop. They range from three-axis to seven-axis where the smallest work envelope is 14.x14x40 in. to the largest of 156x72x76 in. All are on a "Preventative" maintenance schedule as well as tied to a Direct Numerical Control (DNC) System for programming and downloading of files for speed, accuracy, and recording. RIA has two CNC Machines, two Conventional Gun Drill Machines, and a Boring Lathe. One of the CNC machines is equipped to work with HELLER BTA™ drilling tools and is capable of doing skiving and roller burnishing. Rock Island Arsenal has been using EDM (Electronic Discharge Machining) for over 20 years in the manufacture of components for artillery gun systems. They currently have six CNC operated machines used for Tool room, Prototype, and Production work.

Recommendations for Machining Operation

MC#1: Install Radiant Heaters for Carefully Selected Machines and Associated Work Stations in Bldg. 220

Background/Existing Situation

In the wintertime, the machine shop floor temperatures vary from 35 to 65 °F. This uncontrolled condition adversely impacts both the performance of the machinist and the machining precision. The existing heating system is incapable of heating the very high bay area (55 ft high x 40 ft x 400 ft) at the floor level. This combined with the inability to close the north wall windows results in a heating efficiency and effectiveness of only 10 to 20 percent. The consequence is: (1) low worker productivity, (2) product re-work due to wide variations in machine tolerances from temperature changes, and (3) low production capacity that extends TAT.

Descriptive Scope of Recommendation

Control the temperature of the machines and workers directly with infrared heat rather than attempting to heat the air. Install direct electric or NG radiant heaters for approximately 40 of the most heavily used and most critical tolerance requirement machines. Provide temperature control to maintain 65 to 75 °F during winter operation. The heaters could be wall mounted and/or mobile.

Benefits and Advantages

- Reduced energy costs
- Improved worker productivity
- Less rework from off spec product
- Faster TAT.

Basis for Economic Calculations: Assumptions and CBoS

Process MC – Machine Shop Annual Operating Budget	100% Budget (k$/yr)	Potential Savings Factors	
		10% (k$/yr)	1% (k$/yr)
Labor cost (38 x $60k/yr)	$2,280	$72.0	$7.2
Materials cost ($600k/yr + $200k/yr)	$1,100	$80.0	$8.0
Utilities cost (electric $200k/yr+Stm and CA $100k/yr)	$300	$30.0	$3.0
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler feed water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including environmental)	$775	$77.5	$7.8
Total shop budget	$4,455	TAT=$330.0*	TAT = $33.0
* TAT= ($4,455 x 10%) – $80 – ($30x20%) = $330k/year			

Process Operating Performance Data, Potential Savings and Cost Estimates/Assumptions

This is based on a combination of actual data and "educated guesses" made jointly by the PEOA Machine Shop Team.*

- There are 38 employees (direct and indirect) @ $60k/yr
- Costs for materials, utilities, environmental and other were estimated by the Machine Shop Team.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Labor savings	(a) rework labor savings: $2,280k/yr total x 3% labor savings (less rework) = $68.4k/yr (b) productivity labor savings: $2,280k/yr total x 3% labor savings (productivity savings) = $68.4k/yr Total labor savings = (a) $68.4k/yr + (b) $68.4k/yr	$136.8
2. Energy (cost)	Total annual energy cost for radiant heaters	($12.0)
3. TAT savings	$330k/yr per 10% x 1.5% improvement	$49.5
4. Total savings with TAT	(1 + 2 + 3)	$174.3
5. Total savings without TAT	(4) – (3)	$124.8

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* The PEOA Machine Shop Team members were: Pat Van Acker, RIA, Mike Fitzgerald, RIA, Michael Chimack, UIC, Mike Lin, CERL, Walt Smith, ETSI, and Alexander Zhivov, CERL.

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Purchase and install (40) radiant heaters	40 radiant heaters x $5k/radiant heater	$200.0

SPB with TAT = $200k / $174.3k/year = 1.1 years

SPB without TAT = $200k / $124.8k/year = 1.6 years

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT savings (k$/yr)	$49.5
Materials cost savings (k$/year)	N/A
Labor savings (k$/yr)	$136.8
Maintenance savings – MM&L (k$/yr)	N/A
Energy savings (cost) (k$/yr)	($12.0)
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$174.3
Total savings without TAT (k$/yr)	$124.8
Installed cost (k$)	$200.0
Simple payback with TAT (years)	1.1
Simple payback without TAT (years)	1.6

Foundry

The foundry (Figure 11) uses a variety of furnaces (e.g., electric induction,) to melt the various metals for casting/forging. The two direct arc electric furnaces are capable of handling up to 3 or 5 tons of material and of operating at temperatures of 3300 °F. Samples of the slugs from these furnaces are taken periodically to check on quality.

Non-ferrous metals are melted in the induction furnaces. About 22 lbs of alloys can be processed in 18 minutes. These materials are used in investment casting. This is a precision casting method that results in machined-like quality at significantly lower costs. The molds for the parts are made of Furan. Forging is accomplished with the use of hydraulic presses, which can exert up to 1,000 tons of pressure. Additionally, 16,000 psi hammers are used.

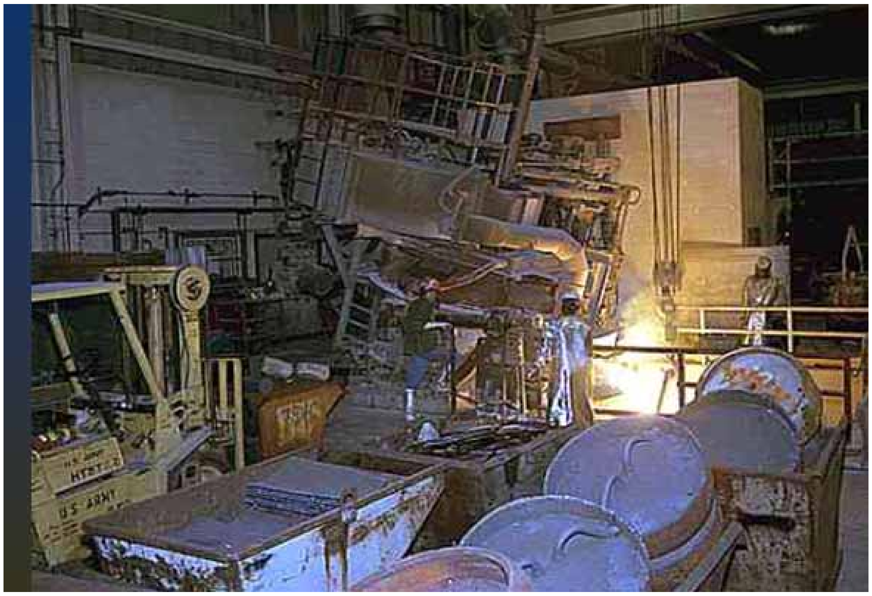

Figure 11. Electric induction furnace.

Foundry capabilities include sand castings and precision investment castings.

Sand castings include:

- Pattern making facility
- Laminated object manufacturing (LOM)
- High alloy steel castings up to 6,000 lbs
- Armor steel castings up to 6,000 lbs
- Stainless steel castings up to 6,000 lbs
- Austempered ductile iron castings up to 1,000 lbs
- Brass, bronze castings up to 1,000 lbs
- Aluminum castings up to 500 lbs.

Precision Investment Castings include:

- Casting production from (SLA) Patterns
- High alloy steel castings up to 50 lbs
- Armor steel castings up to 50 lbs
- Stainless steel castings up to 50 lbs
- Brass, bronze castings up to 50 lbs
- Aluminum castings up to 30 lbs.

Recommendations for Foundry Operation

FD#1: Replace Critical Foundry Equipment in Bldg. 212 West

Background/Existing Situation

Most of the existing foundry equipment is: (1) high maintenance, (2) unreliable with excessive downtime, (3) high energy and materials cost, and (4) a production bottleneck.

Descriptive Scope of Recommendation

Replace old, unreliable, inefficient foundry equipment that is critical to shop performance.

Benefits and Advantages

- Reduced down time
- Reduced maintenance costs
- Reduced turn-around-time (TAT)
- Reduced energy costs
- Higher labor efficiency
- Reduced materials cost.

Basis for Economic Calculations: Assumptions and CBoS

Process FD – Foundry Shop Annual Operating Budget	100% Budget (k$/yr)	Potential Savings Factors	
		10% (k$/yr)	1% (k$/yr)
Labor cost (12 x $60k/yr)	$720	$72.0	$7.2
Materials cost ($600k/yr + $200k/yr)	$800	$80.0	$8.0
Utilities cost (electric $200k/yr + CA $50k/yr)	$250	$25.0	$2.5
Electricity ($0.041/kWh); Comp air ($0.135/kcf) Air-conditioning ($41/k-ton hrs)			
NG ($7.00/MMBtu)			
Steam ($5.00/MMBtu)			
Water ($3.50/kgal); Boiler Feed Water ($5.00/kgal) Hazardous waste water ($500/kgal)			
Other (including Environmental)	$1,000	$100.0	$10.0
Total Shop Budget	$2,770	TAT=$192.0*	TAT = $19.2
* TAT= ($2,770 x 10%) – $80 – ($25x20%) = $192k/year			

Process Operating Performance Data, Potential Savings and Cost Estimates/Assumptions

This is based on a combination of actual data and "educated guesses" made jointly by the PEOA Foundry Team.[*]

- There are 12 employees (direct and indirect) @ $60k/yr
- Costs for materials, utilities, environmental and other were estimated by the Foundry Team.

Savings Calculation

Savings Categories	Calculation	k$ savings (cost) / yr
1. Labor savings	$720k/yr total x 10% savings (less rework)	$72.0
2. Materials savings	$800k/yr total x 5% savings	$40.0
3. Energy savings	$250k/yr total x 10% savings	$25.0
4. Maint., materials, labor savings	$250k/yr total maint., materials, labor x 10% savings	$25.0
5. TAT savings	$192k/yr per 10% x 10% savings	$192.0
6. Total savings with TAT	(1 + 2 + 3 + 4 + 5)	$354.0
7. Total savings without TAT	(6) – (5)	$162.0

Cost Estimate Calculations

Cost Categories	Calculation	k$ cost
1. Purchase and install manipulator to lift casting	Total installed cost	$225.0
2. Purchase and install blast unit – twin table, twin head	Total installed cost	$125.0
3. Purchase and install shell core machine	Total installed cost	$125.0
4. Purchase and install two (2) new mixers	Total installed cost	$125.0
5. Contingency	Extra unanticipated expense	$100.0
6. Total Project Cost	(1 + 2 + 3 + 4 + 5)	$700.0

Simple Payback (SPB) with TAT = $700k / ($354k/year) = 2.0 years

SPB without TAT = $700k / ($162k/year) = 4.3 years

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[*] The PEOA Foundry Team members were: Pat Van Acker, RIA, Mike Fitzgerald, RIA, Mark Benes, RIA, Mike Lin, CERL, and Walt Smith, ETSI.

Estimated Risk Level

TBD by RIA management

PEOA Economic and Benefit Summary

Net Savings, Cost, and Payback	
Improved TAT savings (k$/yr)	$192.0
Materials cost savings (k$/year)	$40.0
Labor savings (k$/yr)	$72.0
Maintenance savings – MM&L (k$/yr)	$24.0
Energy savings (k$/yr)	$25.0
Environmental savings (k$/yr)from	N/A
Total savings with TAT (k$/yr)	$354.0
Total savings without TAT (k$/yr)	$162.0
Installed cost (k$)	$700.0
Simple payback with TAT (years)	2.0
Simple payback without TAT (years)	4.5

FD#2: Improve Ventilation in the Foundry

Existing Conditions

All ventilation units in the foundry in Building 212 are operated manually. There are four AHUs, each at 50,000 cfm. The foundry suffers from large negative pressures, leading to slamming doors on occasions, with hazardous conditions for people passing through the doors. Exhaust air fans, some of which connected to bag houses, are also switched on and off manually. During the CERL visit, the activities in the foundry were on a very low level.

Solution

Install VFDs on AHUs. Install pressure sensors outdoors and inside the foundry. Control AHUs to match the exhaust air flow and to keep a low negative pressure in the foundry. (The AHUs can still be manually operated.) Connect AHUs to Johnson Controls' control centre to allow for scheduling of operation time.

Savings

Airflows can be reduced significantly during periods with low capacity utilization in the foundry. Savings are part of the savings calculated in BH#3 of section 8, building HVAC systems.

Investments

See BH#3 of Chapter 3, “Building HVAC Systems” (p 53).

Payback

The payback for FD#2 is estimated at less than 1 year.

Welding Area

The fabrication of weapons systems components manufactured at RIA requires different welding processes, e.g., MIG, TIG, Submerged Arc, Inertia, Electron Beam, Stick Welding, Robotics Welding, Orbital Welding and Flexible Welding System (Figures 12 and 13). In the later process, all parts are tack welded in dedicated fixtures, preheated in ovens, placed into finish weld fixtures, and then finish-welded by semiautomatic or manual means. Upon completion, they are sent to the inspection department for visual and magnetic particle inspection of all welds.

RIA has developed a flexible welding system (FWS) that enhances the efficiency of these operations and in turn improves productivity. The FWS consists of a Laser Guided Vehicle (LGV), a flow-through automatic preheat oven, two 6-axis articulated robots, and four 12,000-lb capacity positioners. Once the tacked weldments are loaded into a fixture, the FWS takes over the entire process. The operator does not touch the parts until the LGV delivers the finished product to the inspection/repair station. At that time, the operator performs visual and magnetic particle inspection and repairs any discontinuities. The benefits obtained include consistent, spatter free welds; a 75 percent reduction in post weld clean up; corner wrapping of welds, which reduces starts and stops by 75 percent; and simultaneous welding, material handling, and inspection operation on multiple parts in a designated 7,000 sq ft area. Welding shop also houses bronze overlaying operations.

Use of welding equipment and of welding materials varies depending on the workload. Table 7 lists usage of different welding materials in 2002-2004 (through May).

Table 7. Usage of welding materials at the RIA welding shop, lbs/year.

Material	FY2002	FY2003	FY2004 (through May)
Bronze	90	0	0
Steel	1890	1680	5075
Aluminum	2580	3320	1340

Figure 12. Welding area.

Figure 13. Welding booths with fume extraction arms.

The Welding Shop currently operates in two shifts and has about 28 welders. There are 30 welding booths available for use. Approximately eight stations are used at any one time. The ventilation rate is about 18,000 cfm. The following critical cost issues for welding shop were discussed during the site visit:

1. Not using existing local exhaust systems (not useful for big parts) because they are not user friendly and not well designed. (They are 15 years old.)

2. Have not evaluated bulk gas lines properly connecting into shop to check for leaks. (Gas consumption was known to be high.)
3. Do not have VFDs on main exhaust fans. (This involves 30 exhaust arms.)
4. Need task lighting in a number of booths.
5. Need two or three more air purifiers with adapters for breathing air (for work hood).
6. Significant down time due to equipment breakdown (~once per week and takes 3 to 5 days to fix).
7. Need to evaluate bulk inert gas (helium) purchase.

Note that last year, RIA paid $22,614 for bottled gas. An underground storage tank will cost $80k to install. The helium has to be compressed twice for bulk storage so the overall cost for the gas would be about $29,000 yearly. Savings results from not eliminating the labor of changing the bottles, and in educing the number of gas leaks. However, note that the Navy's bulk gas purchase experience revealed a 40 percent discount was obtained by purchasing inert gas in bulk. Currently, RIA buys argon in bulk.

Recommendation for Welding Operation

WD#1: Replace Extraction Arms in Welding Shop With a New Demand-Based Exhaust System

Existing Conditions

Ventilation system consists of a general supply system and a local exhaust system. Three constant air volume central exhaust systems are connected to flexible hoods positioned at each working place. Welding is taking place only at few booths (~ 30 percent), while the fan is operating at 100 percent of its capacity. Most of the hoods are clogged with weld dust and do not provide airflow rates sufficient for capturing weld. Each of the three exhaust systems has a fan and a filter unit to clean the exhaust air. The cleaned exhaust air is returned to the welding shop in winter and exhausted outside in summer. The change between winter and summer modes is done from a panel in the welding shop area. During our visit (in mid June) the switches were still in winter position and contaminated air (although cleaned from particulates in filters) was brought back to the welding shop. The exhaust units are operated and maintained by the Arsenal staff. Four AHUs for general ventilation, supplying 64,000 cfm each, are operated and maintained by Johnson Controls.

Solution

Replace exhaust arms with new ones equipped with automatic dampers, which open rapidly using a light or magnetic sensor that can detect the start of the welding processes (Figure 14). Extraction arms should also have built-in lamps to provide task lighting. Install VFDs on exhaust fans, which will control the constant negative pressure in the main exhaust duct, despite how many open exhaust air dampers. Exhaust contaminated air outside the welding shop year-around. Remove filters from the Air Handling Units and dismantle the compressed air filter cleaning system. This will reduce the pressure drop and the compressed air usage. It will also result in significantly improved Indoor Air Quality. Four existing AHUs should be used as follows: 100 percent recirculating air (no outdoor air) when there is no welding in progress and when air heating is required; 100 percent outdoor air supply for the building. When there is no welding in progress and no need for heating or cooling, these AHUs could be turned off. During welding and when heating is required, supply 20 percent outdoor air with 80 percent return air.

Savings

A 50 percent capacity reduction due to the workload combined with 40 percent of simultaneous operation with MIG/TIG welding reduces the typically required capacity of the controlled exhaust system to 20 percent of the current energy use. The electricity savings have been calculated to be about $10,500/year for the exhaust units. Filter costs, costs for compressed air and maintenance costs will also be avoided. This measure will also improve IAQ, morale, and productivity. It also solves the urgent problem regarding task lighting in the welding shop. Energy savings due to reduced pressure drop when removing filters have not been calculated, but will result in additional savings.

Investments

The estimated total new equipment cost (30 new exhaust arms with control dampers, sensors, VFDs and pressure sensors for each of three central exhaust systems with a 15 hp fan each) is ~$90,000 including the installation cost of $25,000.

Payback

The payback period for WD#1 is about 8.5 years

Figure 14. Articulated fume extraction arms with a built-in damper and a task light.

Building Envelope

From the standpoint of an energy savings, it is not (in most cases) easy to get quick payback using building envelope energy conservation measures. In Rock Island Arsenal, some buildings, particularly Building 220 (Figure 15), are in such a bad shape that parts of the building façade fall down to the ground. The investment required to upgrade such buildings to a certain standard, without endangering the passers-by, cannot be justified based on energy savings alone. Still, something must be done to save Building 220. Willingness to spend money is a must. The energy bill will go down when the building is better sealed and insulated—as a secondary effect—but this is only a bonus, it cannot be the basis for the investment decision.

Regarding the wings of Building 220, there is no economic basis for construction of walls to separate empty floors from the crane bay. With today's mode of operation of Air Handling Units in wintertime, only 10 to 20 percent of the air is makeup air. This means that the costs of heating, by ventilation, are only $1,000 per floor per year. It is better to leave the wings open to the crane bay and to control temperature on each floor using the dampers to open whenever the temperature goes below the setpoint. By keeping the floors heated, the building is preserved and the IAQ of the crane bay occupancy zone will not be affected negatively.

Figure 15. Building envelope of the Building 220.

Recommendations for Building Envelope

BE#1: Improve Working Conditions and IAQ in Crane Bay Occupancy Zone, Building 220

Existing Conditions

The windows in the Building 220 north wall are a major source of heat losses during wintertime. The single pane metal framed windows are relatively old. Thermal losses are increasing due to the fact that some of the windows can no longer be closed properly. Air infiltration into the building is quite substantial. Underneath the windows there are unit heaters, connected to the steam system, operated manually one by one. The control of heat supply is poor. There are no modulating steam valves. The ventilation of the area is also not up to a reasonable standard. Indoor air stays cold in winter and hot in summer.

Solution

Close and tighten all windows permanently. Take away all openers. Install a large (or several small) exhaust fan(s) on the roof. Also, install supply air fan to make up for the exhaust air. Connect the exhaust and supply air fans via ducts and dampers so that exhaust can be directed to the atmosphere in summer and back into the building in winter. Install new ventilation ducts and air diffusers, with air showers, making supply air reach the occupant and working zones. Diffusers could be placed under the balcony, aiming north. Coordinate control of heaters: One (1) central on/off-valve for the entire steam circuit for the “crane bay” area, controlled by a central thermostat or via Johnson Controls’ system. Use old thermostats for the individual heaters, but put these in “cages” not operable by the staff. Install fast doors at east and west entrances to the “crane bay” area of Building 220.

Savings

Steam savings have been calculated at $11,000/year, just by reducing the infiltration. Further savings will be obtained by better control of heaters and by getting the hot air down from the ceiling level to the working zones, using the new ventilation system. These additional savings are likely to be of the same magnitude as the calculated steam savings, thus cutting the payback time or allowing for higher investment costs.

Investments

The required investments to implement BE#1 amount to $55,000.

Payback

The estimated payback for BE#1 is 5 is years.

Note

The suggested measures are primarily to improve indoor climate to make working conditions bearable and to keep machines at a steady temperature so that quality measures can be maintained. The volume in the crane bay area is approximately 100,000 m^3. Infiltration: one air exchange per hour (which is on the low side). To heat 100,000 m^3/h requires 2870 MWh/year. We reduce this infiltration related heating need by half, or 1,400 MWh, worth $11,200. Investments include fans or AHU: $20,000, ducts and diffusers: $5,000, control unit heaters: $5,000, window closing and tightening: $5,000, and high-speed doors: $15,000. We recommend that something simple but effective be done here.

BE #2: Install High-Speed Doors Where Such Doors Do Not Exist Today

Existing Conditions

Large doors, e.g., in the machining area, with a door facing north between Buildings 220 and 210 or in the large eastbound door in Building 299 (shipping and goods entrance), are very slow. It is common to take 30 seconds up to few minutes to open or close a door. In Building 299 one particular door is said to be operated so often that it is open for 30 minutes per hour.

Solution

Install fast speed doors where large slow doors are used currently, between heated spaces and outdoor or significantly cooler spaces (e.g., warehouses are not heated).

Savings

The savings depend on the frequency of the opening and closing cycles of a door. Swedish experiences from large heated warehouses show that a door that is 12 X 12 ft, open 10 min/hour, causes heat losses of over 1,400 kWh/day or 170 MWh/year. In RIA, the cost of providing steam to make up for those heat losses is $1,360. Triple the time in open position and triple the size of the door and the annual cost is over $12,000/year. Major improvements can be done to improve indoor climate, especially since an open door affects indoor temperature over very large floor space areas when the outside temperature is very low. Installing a high-speed door would help to prevent staff from bringing portable electric heaters to keep them comfortable in the winter, which adds to the RIA electric bill.

Investments

The investment required to implement BE#2 would depend on the size of the door.

Payback

With RIA's low steam costs, the calculated payback for BE#2 would be about 2 to 3 years.

BE #3: Clean Roof Windows in Building 299 To Improve Working Conditions

Existing Conditions

The working conditions in Building 299 could be improved to enhance industrial production. Natural light enters to some extent through the plastic windows reinforced with chicken net, but the windows are quite dirty and need cleaning. On the other hand, if lighting cannot be switched off automatically, by daylight sensors, this is of minor importance. Between the warehouse and the area for incoming goods the door openings are only covered with plastic stripes in wintertime. Since these areas have different demands regarding temperature, something more permanent should be installed.

Solution

Clean the roof windows to allow more daylight to enter workspace. Install high-speed doors between the warehouse and the incoming goods area.

Savings

Savings for these measures can only calculated after measuring temperatures.

Investments

Required investments for these measures are yet to be determined.

Payback

The payback period for these measures cannot be calculated at this stage.

Building HVAC Systems

Johnson Controls Inc. (JCI) is responsible for the operation of most of the HVAC systems and in many cases these are computer supervised and scheduled (Figure 16). Some units are not remotely controlled or supervised; this results in large negative pressures and other problems. In most AHUs, the steam valves are modulating and working properly. However, this is not the case in the Plating Shop; the steam valves do not work very well in this location, even though the JCI operated systems generally are well maintained.

The Arsenal's existing HVAC systems were generally designed to provide ~ four air exchanges with outdoor air per hour. This air exchange rate provides acceptable thermal conditions during hot summer days. During wintertime, AHUs in many cases operate with only 10 percent of outdoor air (in theory, probably more in practice since dampers are not that accurate). This saves energy for heating.

Although the airflows are high, the systems do not function properly. Fresh air is supplied at the wrong places, too high up to reach the working zones, too far away from where it is needed, or at the wrong temperature. This results in upward airflows that prevents the air from reaching the work zones below. Short circuits in ventilation between supply and exhaust air result in poor ventilation efficiency. IAQ is not as good as it can or should be.

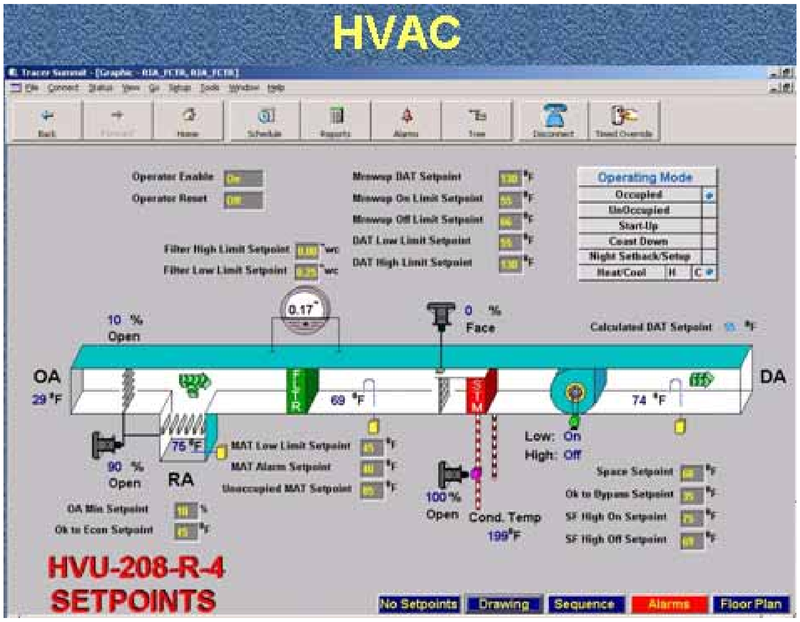

Figure 16. Schematics of a HVAC system operation with a computerized control.

Recommendations for the Building HVAC Systems Operation

BH#1: Improve Ventilation in RRMC, Rapid Response Manufacturing Cell

Existing Conditions

The Rapid Response Manufacturing Cell (RRMC) is located between buildings 208 and 211. The RRMC is a fairly new department with modern manufacturing capabilities. The facilities suffer from very high indoor temperatures, which also was verified during the time of our visit. The RRMC space is conditioned by three Air Handling Units, taking the supply air in separate air intakes faced down towards the black roof (2 ft over the roof surface). The roof temperature when the sun is shining was measured to 115 °F. The roof is lower than the roofs of buildings 208 and 211, which reduces air speed by wind; the RRMC roof is sheltered from the wind. The AHUs also have the possibilities to circulate indoor air back into the facilities, during wintertime when heating is more crucial. We noticed that the dampers that were supposed to be in summer position, i.e., closed for air circulation and 100 percent open for outdoor air intake, did not work properly. One AHU was fully open for both outdoor and indoor air to mix the supply air, one was half open for indoor and fully open for outdoor air, and the third one seemed to work properly. The total airflow is probably too low for cooling purposes in summer.

Solution

Fix dampers and control function so that all three AHUs work properly and according to intended function. Connect air intakes to a common duct and raise this duct so that the air intake ends about 20 ft above roof surface, facing east, downwards. An alternative would be to move the air intake all the way up to roof level of Building 211, which has a roof covered with white stones. Temperature measurements should be made to find which location of the air intake is the best. Increase fan speed for all three units by changing belt pulleys. This will increase airflow substantially. If this is not enough we also suggest to install new supply air ducts and connect to ducts on the other side of the wall to Building 211 where we consider air exchanges being too high in comparison to the types of operations and number of workers.

Savings

This is mainly an issue related to improving indoor air quality, which will lead to higher productivity. Energy savings are negligible unless you count avoided investments in cooling units to make working conditions acceptable. In fact, this could be a factor if nothing is done regarding the ventilation system and number of air exchanges. The suggested measures will also eliminate the needs for cooling fans that are currently in use.

Investments

Estimated investments required to implement BH#1 amount to less than $10,000 if the ductwork connection to ventilation system in Building 211 can be avoided.

Payback

With respect to existing conditions at the RRMC, the payback is immediate with respect to savings from increased productivity, reduced material waste, and avoided rework.

BH#2: Exchange VAV Boxes and Improve Control Equipment in Offices in Administrative Buildings

Existing Conditions

The administrative offices have pneumatically controlled VAV (Variable Air Volume) boxes and thermostats. The VAV boxes are constantly out of calibration because of inadequate resources to maintain them properly. The air compressors and dryers are high maintenance equipment and are energy inefficient. The productivity of office workers is affected during hot summer days when comfort levels cannot be properly maintained.

Solution

Install state of art digitally controlled actuators for modulation of the dampers in the VAV boxes. Dampers can be controlled by modulating damper position using new thermostats and a 0–10 V signal between minimum and maximum damper positions. This eliminates out of calibration problems and requirements of conditioned compressed air. Temperature control can be very accurate and can contribute substantially to a comfortable working climate.

Savings

Savings have to be calculated using data on compressors (hp and running hrs per year), maintenance accounts, and also by using productivity figures. Registered complaints and logged indoor temperature data will help in deriving savings for this measure.

Investments

The required investments to implement BH#2 are yet to be determined.

Payback

It is not possible to calculate the payback period for BH#2 at this stage.

Note

Investment costs cannot be estimated at this time because the researchers did not have sufficient time to study this complex problem during the site visit. This idea was suggested by the RIA DPW staff. Further investigation is warranted. The investment depends on whether to replace the boxes or only the controls. The number of boxes to be replaced is unknown. Some useful information is available at URL:

http://www.plantops.umich.edu/utilities/operations-engineering/ddc.html

where the cost to recalibrate or repair a pneumatic VAV is given (about $200).

BH#3: Install VFDs and Extend Ventilation Ducts To Improve Ventilation Efficiency and To Facilitate Possibilities To Use Variable Airflow

Existing Conditions

Although the industrial facilities in general have ventilation units designed for an average of four air exchanges per hour, the ventilation efficiency (defined as the ventilation system's ability to replace old indoor air with fresh outside air in occupancy zones) is poor. This is a result of the choice and location of air diffusers that govern the way fresh air is supplied to the work areas. The ducts end with diffusers too high or at places where the incoming fresh air does not reach the machines or the people working there. Also, system functions including damper control, filter maintenance, and steam valve control are poor with respect to some (but not all) of the AHUs.

Solution

In general, install VFDs on the AHUs that do not already have such installed. Extend ventilation ducts and in some cases also change their ending point location. Where needed (needs to be investigated further) also replace existing diffusers with air showers or displacement diffusers. VFDs shall be used to run AHUs on a lower mode (not more than half the nominal flow) in winter and at more than 100 percent in summer (for cooling purposes). These solutions could generally be applied in the Heat Treatment area, the Welding shop, the Foundry, and also in Buildings 208 and 211.

Case Example

The Heat Treatment Area, Building 222 is presently short circuited. Supply air stays under ceiling and is exhausted without reaching floor level. Since it is cold at floor level during winter, the Johnson Control staff is encouraged to increase the setpoint of the supply air temperature, which increases energy use but has only a small impact on the actual temperature at floor level. It just gets hotter underneath the ceiling. Ventilation ducts that connect to displacement diffusers with installed dampers in ducts should be extended to make it possible to run on one or two AHUs. A setpoint of 63 °F is recommended. Operate one AHU in winter, two in summer and when higher airflow is needed, e.g., during oil quenching.

Savings

Savings have been calculated for different parts of the RIA industrial facilities, mainly based on a 50 percent reduction of makeup air in winter. The savings are:

Heat Treatment shop: $10,000/year

Welding shop, foundry, buildings 208 and 211 together: $115,000/year

Investments

Required investments to implement BH#3 vary depending on actual measures in each shop or manufacturing area.

Payback

On average, the payback period for implementation of BH#3 is 1 year

Note

A heat treatment example would involve operation 24 hrs/day, 7 days/wk. Two AHUs at 32,500 cfm, 20 percent outdoor air heated to +25 °C (77 °F) because of the problems of heating this shop (information from Johnson Controls that they increase supply air setpoint), would consume 872 MWh/year. The new situation, based on half flow, heated to 66 °F, requires only 291 MWh/year, for a net savings of 581 MWh, or $4,600/year.

Electric Savings are calculated as:

30 hp @ $184/hp or $5,500. Total: $10,100/year.

Other savings were calculated by measuring floor space ratios (compared with heat treatment shop) and extrapolating the savings in heat treatment, but with consideration taken for the fact that in the other premises we could lower supply air temperature further. In this case, the calculations require a lower temperature setpoint to achieve similar savings.

Investments

Very moderate investments are required, a few new diffusers, some duct work and temperature sensors. Estimated investments for the Heat Treatment are $15,000. This would be less in other areas, e.g., in the Welding Shop where other solutions are considered (e.g., moving diffusers down, locking some ducts etc.).

BH#4: Coordinate Responsibilities, Control Mechanisms and Maintenance of HVAC Systems Operated by Arsenal Staff and by Johnson Controls

Existing Conditions

General ventilation units are normally scheduled, operated, and maintained by Johnson Controls. Scheduling is done based on various production hours in different shops. Process ventilation units are operated and maintained by Arsenal staff. Changes regarding process ventilation can be done without notifying Johnson Controls. This may lead to unbalanced ventilation, causing negative or positive pressure, depending on the type of change.

Solution

Coordinate operation of general and process ventilation. Schedule monthly meetings between Johnson Controls and Arsenal staff to discuss the present situation and planned changes. Perform function controls and revise maintenance schemes so that the function of the various systems is maintained. Control air balances—negative or positive pressure—and adjust to get expected ratio. Installing VFDs as suggested in BH#3 also facilitates this.

Savings

Savings come from avoiding unwanted drafts, which result in needs to heat up cold air, joint efforts regarding maintenance, better scheduling updates, improved IAQ etc. No attempt was made to estimate the savings in monetary terms at this stage.

Investments

Implementing BH#4 requires no investment.

Payback

Payback for implementing BH#4 is immediate.

BH#5: Install Separate Cooling Unit for Recoil Assembly and Machine Shop Area in the Basement of Building 208

Existing Conditions

In the basement of Building 208, northwest part, the indoor air climate is controlled with respect to temperature and relative humidity. This is required all year round 24 hrs/day, 7 days/wk. Cooling water is provided from the chiller on platform 2 in Building 211. The cooling water travels over a very long run resulting in cooling energy losses and an increased overall energy bill. The chiller is oversized during winter use and it runs on/off with very short intervals to cover the relatively small cooling load located far away. Other sources are reputedly cooled by this chiller just to avoid the very fast on/off duty cycles for the chiller, to save it from ruin under this kind of disadvantageous operation mode.

Solution

Install a properly sized chiller at the point of use. One possible option to solve the winter cooling needs is to use free-cooling opportunities.

Savings

Estimated savings from implementation of BH#5 may be calculated when chiller data, running hours, pipe distances, and state of insulation on pipes are available.

Investments

Required investments to implement BH#5 cannot yet be calculated.

Payback

It is not possible to calculate the payback period for BH#5 without further data.

BH#6: Install On/Off Dampers in Supply Air Ducts on Every Floor in Building 220, Wings 1 – 3

Existing Conditions

Manufacturing workspace consolidation is under way to move out of various floors in the wings of Building 220. When each floor is emptied, the need to ventilate the space is eliminated, except for heating purposes since the heat is provided by the ventilation system. Annual costs to heat and ventilate every separate floor today are about $1,000 per floor for steam and $4,000/year for electricity to run AHUs.

Solution

Install manual (or automatic) dampers in the supply duct on every floor. Cover half of the area of the exhaust air intake on every floor. If there is no VFD on the Air Handling Unit, exchange belt pulleys to reduce airflow. With VFD: Control dampers to open when temperature gets below the setpoint and to heat to the appropriate temperature. Close dampers when the proper temperature is reached. VFD controls fan speed to keep constant positive pressure in supply air ducts. Filter exchange savings can also be counted on.

Savings

Savings are calculated per floor after airflows change

Steam savings: $500/year

Electricity savings: $2,000/year

Investments

Required investments to implement BH#6 include installation of dampers, plates over exhaust air intakes, VFD(s), or changing belt drives, for a cost (without VFDs) of 2,000 $/floor, or (with VFDs), 6,000 $/floor

Payback

The estimated payback period for implementing BH#6 is 1 to 2.4 years depending on chosen solution.

Note

Assuming one AHU per wing, 64,000 cfm, divided by five floors, and 20 percent outdoor air during heating period, calculates to 130 MWh/year and floor:

130 x $8/MWh = $1,040.

Electricity: assuming 64,000 cfm = 109,000 m^3/h or 22,000 m^3/h per floor. SFP = 2.5 kW/m^3/s and operation for 7,000 hrs gives:

22,000/3,600 x 2.5 x 7000 x 0.041 = $4,300/year.

BH#7: Install Heat Recovery Coils in Paint Booth in Building 299

Existing Conditions

Painting takes place in the east part of Building 299. Large amounts of air are distributed through paint booth, blasting, and drying zone. All the air is heated outdoor air. There is no heat recovery from exhaust air.

Solution

Install heat recovery coils in existing systems, allowing incoming cold air to recover heat from the warm outgoing air.

Savings

With two units, each estimated to be around 60,000 cfm, the recovered heat during 1 year is calculated to be approximately 2,000 MWh. The value of the savings is then $16,000/year. The calculations are based on production between 06:30 – 24:00, Monday – Friday.

Investments

Required investments to implement BH#7 amount to $50,000.

Payback

The payback period for implementing BH#7 is 3.1 years.

Note

These calculations assume two booths, around 30 m^3/s per booth. All outdoor air is heated. Assumed costs are 4,000 MWh/year, so that a 50 percent heat recovery amounts to 2,000 MWh. This area needs to be studied in more detail. Investments include coils, piping, and pumps.

BH#8: Improve Indoor Air Quality in Building 299 Manufacturing Departments

Existing Conditions

Building 299 is used increasingly for manufacturing. The building does not have ventilation systems sufficient to provide acceptable working conditions with the type of production taking place inside. This causes pollution of indoor air from machine operations, from vehicles driven inside the building, and from a car wash. Since the building was initially a warehouse, there are not enough exhaust systems to evacuate hot indoor air during summer. This causes very high indoor temperatures. Condensers for the air-conditioning units that supply offices with cold air are located on internal roofs, and exhaust even more heat into the manufacturing areas.

Solution

Install separate exhaust air fans on roof to remove heat during hot summer days. Install local exhaust systems, including fans and ventilation ducts, to withdraw polluted air from machines, welders, and grinders in the "Tool Set" area. Flexible arms should preferably be used, as well as pressure controlled exhaust fans to allow changing workload. For vehicles, the "cigarette type filters" used by the automotive industry, are suggested. These filters are put into the vehicle's exhaust pipe and removed when the vehicle leaves the building. This is a very effective way to handle the emissions from the vehicle engines. Move air-conditioner condensers to the outside roof from the "inside roof" of the offices.

Savings

The savings from implementing BH#8 result from improved IAQ and better working conditions, both of which lead to higher rates and quality of production. Energy savings cannot be calculated since this building is without ventilation and increased ventilation always increases the energy needs.

Investments

Required investment costs are yet to be determined (but this can be done at very low costs).

Payback

It is not possible to calculate the payback period for BH#8 at this stage.

BH#9: Perform Further Energy Savings Measures in Building 222

Existing Conditions

Forging and heat treatment operations are carried out in Building 222. Measures regarding ventilation for the heat treatment area have been suggested in BH#3. In the forging area, three air compressors are connected to the compressed air net-work. These three compressors are mainly intended to supply compressed air to the forging machines. The heat that the compressors generate is supplied to the working space in wintertime. There is no ductwork connected to the compressors to distribute the heat to different workstations. The cooling system in Building 222 (for process cooling) is made up by a cooling tank and two circuits; one to the cooled objects and one to the cooling towers. There are at least three cooling towers on the roof, with connected circuits. The circuits connected to the objects probably must run all the time. However, with a cooling tank, it is not necessary to continuously run the pumps serving the cooling towers.

Solution

Connect air compressors to new ventilation ducts, aimed at heating also other parts of Building 222, e.g., the heat treatment area. Install thermostats on cooling tank and start cooling tower pumps only when needed.

Savings

Heat from air compressors will reduce the use of steam in AHUs providing heat to the heat treatment area. Savings will have to be calculated more in detail in phase 2 of the RIA energy audit. Normally this kind of measure has a payback time of less than 2 years. One of the cooling tower pumps has a 30 hp motor, which (probably) runs at 25 hp. Reducing the operating hours for a 25 hp motor from continuous to approximately half of the time, which we judge as the target for this measure, can save $3,300/year:

25 hp x 0.746 x 4,300 hrs x 0.041 = $3,288

Investments

Required investments to implement BH#9 involve ventilation ducts and diffusers ($10,000), and thermostats for cooling tower circuits ($500 per circuit).

Payback

The payback for implementing BH#9 is cannot be determined until the savings from heat distribution from air compressors are calculated. However, the estimate payback period for installation of thermostats is 2 months

Compressed Air System

A compressed air system survey* was conducted in 2001 at the Rock Island Arsenal to: (1) determine the suitability of RIA as a host site for a natural gas engine driven air compressor (NGEDAC) demonstration and (2) identify compressed air system cost reduction/energy saving opportunities. Science Applications International Corporation (SAIC), under contract to ERDC/CERL, provided technical assistance in carrying out the survey on 2 April 2001. Survey results are summarized below.

The compressed air system survey focused on Buildings 220 and 222, the largest users of compressed air and the buildings that house the main compressors. It was estimated that the compressed air costs RIA about $154,326 based on 3,486,960 kWh of energy use per year. This was based on an average electricity cost of $0.044/year. Building 220 has five compressors capable of providing 14,000 standard cubic feet per minute (scfm) of air at 100 lb/sq in. gauge (psig) pressure. However, the 4200 scfm Ingersoll Rand reciprocating compressor (Figure 17) and the 3700 scfm Worthington reciprocating compressor alternate in providing most of the facility's demand – 3000 scfm during normal production hours and 1800 scfm at all other times. These units are 1940s and 1950s vintage, but are capable of efficient operation. No operational problems were noted with the main compressors or ancillary equipment.

Compressed air is one of the primary energy input streams into the production process. Most of the facility compressed air is provided through a central compressed air distribution system that is supported by eight compressors. The compressor systems that were evaluated during the site survey were those located in Buildings 220 and 222 (Figure 18) where manufacturing, foundry, forge, and plating processes are housed.

The compressed air distribution piping in Buildings 220 and 222 is interconnected. Pressure loss after the refrigerated drying to the most distance usage is undetectable. Pressure drop is a concern when it exceeds 5 psig. Secondary distribution piping is also generously sized, which is very desirable for a compressed air system.

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* Mike C.J. Lin et al., *Compressed Air System Survey at Army Industrial Facilities*, ERDC/CERL TR-03-01 (CERL, January 2003).

Table 8. Building 220 operational compressor inventory—performance.

				scfm/kW			
CFM	Manufacturer	TYPE	YEAR	100%Load	75% Load	50% Load	25% Load
2500	Ingersoll Rand	Recip	1985	N/A	N/A	N/A	N/A
4200	IngersollRand	Recip	1951	6.43	6.35	5.96	4.21
3700	Worthington	Recip	1941	5.91	5.83	4.84	4.35
1200	Ingersoll Rand	Recip	1953	5.58	4.93	3.68	2.37
2400	Worthington	Recip	1919	5.8	N/A	N/A	N/A

Figure 17. 4200 Ingersoll Rand reciprocating compressor.

Table 9. Building 222 operational compressor inventory.

				scfm/kW			
CFM	Manufacturer	TYPE	YEAR	100%Load	75% Load	50% Load	25% Load
3000	Ingersoll Rand	Screw w/IM	1992	N/A	N/A	N/A	N/A
2500	IngersollRand	Screw w/IM	1992	6.12	N/A	N/A	N/A
2500	Ingersoll Rand	Screw w/IM	1992	6.12	N/A	N/A	N/A

Figure 18. Photo of three air compressors in Building 222.

Compressed Air Load Profile

Based on conversations with the compressor operators, the week-day air demand load profile was established as shown in Figure 19. Saturday, Sunday, and holiday compressed air consumption remains at the 1800 scfm baseload. Amp meter readings were used during the site visit to determine the loading on the reciprocating compressor in operation. The load remained at 2500 scfm during the period observed.

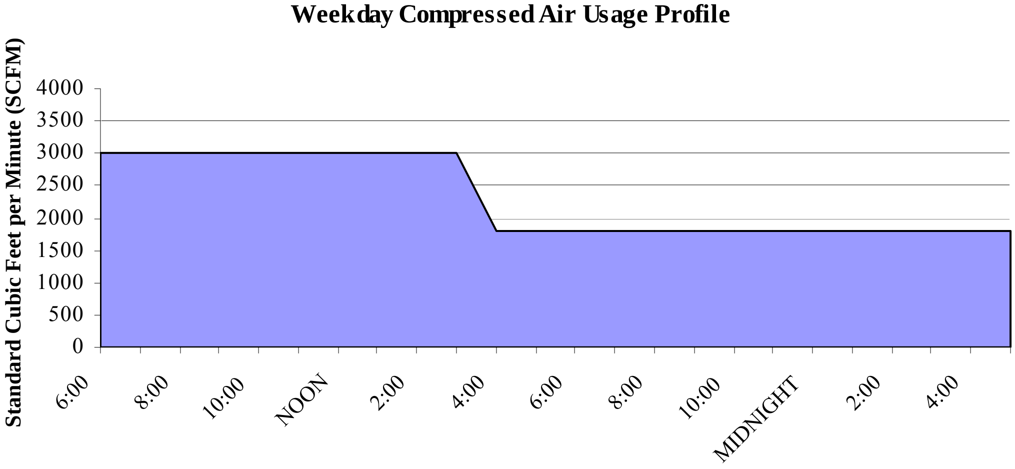

Figure 19. Weekday compressed air usage profile.

Air Compressor Controls

The reciprocating compressors in Building 220 have 100/75/50/25 percent loading capabilities for the compressor used to do load “trimming” or “modulating.” Each machine is controlled individually. Multiple machine operation is manually controlled by the compressed air operator.

The screw compressors in Building 222 have inlet modulation part-load controls and unload controls. No rotor shortening part-load control mechanism is in place. A lead-lag control mechanism is in place to even out operation hours on the compressors. After 1 hour of unloaded operation, the compressor will totally shut down.

Each compressor is controlled by its own pressure sensor. The master lead-lag control serves as the compressor sequencing control. The existing reciprocating compressor uses a dual control. The existing screw compressors have straight modulation control and have ratings in the report for 100 percent load.

Generation and Distribution Pressure/Condensate and Oil Elimination

All the end users interviewed reported that the compressed air system operated as desired; they noted no difficulties with water or oil in the lines or large pressure fluctuations. Past problems with these difficulties have been addressed. With the size of compressors in this building, typically only one of the compressors is operated at any one time. Occasionally, a pneumatic sand transport system in the foundry requires more than one compressor to be operated.

The pressure was surveyed at key points in the distribution system using a single air pressure gauge testing unit. A pressure drop of only 2 psig was measured from a point after the after-cooler to a point after the refrigerated-dryer. No pressure drop was measured from the point after the refrigerated-dryer to the furthest point of distribution piping away from the dryer. The maximum tolerable pressure drop is typically 5 psig. The only times condensate is reported to be present in the system is when there is a breakdown of the air-drying equipment. Similarly, the only time compressor oil has been noticed in the system is when the oil filter was damaged.

Compressed Air Energy Use and Energy Operating Costs

Table 10 summarizes the energy operating costs of the compressed air systems assuming Worthington and Ingersoll Rand composite performance characteristics. Compressor operating costs are estimated to be $154,326 based on 3,486,960 kWh of energy use per year.

Table 10. Compressed air energy use and energy operating costs.

	Shift Operating Load	Off-shift Operating Load	Total/Composite
Average Air Supplied (scfm)	3000	1800	2120
Average Input Power to Compressor (kW)	486	366	398
Supply Efficiency (scfm/kW)	6.17	4.92	5.25
Annual Hours of Operation	2,340	6,420	8,760
Energy Use (kWh)	1,137,240	2,349,720	3,486,960
Total Energy Cost ($)	50,039	103,388	153,426
Unit Energy Cost ($/scfm)	16.68	57.44	

RIA does not have an active leak management program, and could benefit from such an effort. It was estimated during the April 2001 survey, that leak reductions could save the installation $26,340 annually, based on 360 scfm of reduction in losses, and corresponding energy savings of 600,686 kWh. Additional cost cutting/energy savings opportunities identified include: (1) operating the most efficient compressor(s) rather than rotating use of the many compressors on hand—for annual savings of $7,297 and 165,840 kWh, and (2) heat recovery from compressor inter and after coolers for space heating—for annual savings of $14,853 in natural gas fuel expenses. Implementation of item 1 could also reduce operator time spent on the various units, freeing up this individual for the leak detection program.

Recommendations for Compressed Air System Operation

CA#1: Increase Pressure Gap

Existing Conditions

During the assessment, it was observed that the Ingersoll Rand screw compressor operating was loading and unloading despite the fact that it is intended to be a baseloaded compressor. The compressor was unloading because the Ingersoll Rand reciprocating compressor was simultaneously supplying air to the system and pushing the system pressure above the screw compressors unload pressure. To ensure that the screw compressor remains baseloaded at all times, the control band on the reciprocating compressor should be raised so it does not supply air until the screw compressor reaches 100 percent capacity.

Descriptive Scope

Increase the pressure gap to decrease the short cycling losses. Energy savings will result from the reduction in short cycling time.

Data Used for Economics

Actual fuel cost were:

- Electricity Cost (EC): $0.041/kWh
- The operating hours are 8,760 hrs/yr
- The compressors blowdown for 20 percent of the time (estimated)
- The full load power draw of the compressor is 369 kW
- The percentage of power draw during blowdown is 60 percent (estimated)
- Diversity factor is 50 percent (estimated).

Savings Calculation

Annual $ savings:

$$(369\text{ kW} \times 0.60) \times (8{,}760\text{ hr/yr} \times 0.20) \times 0.50 \times \$0.041\text{/kWh}$$

$$= \$7{,}952\text{/yr}$$

Cost Estimate Calculations

Due to the fact that there is minimal time required to change the setting of the compressors, the implementation cost is negligible.

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$7,952
Capital cost ($)	$0
Simple payback (years)	Immediate
Comments	Slam Dunk

CA#2: Reduce Compressed Air Leaks

Existing Conditions

Air leaks around valves and various fittings and holes in hoses represent a significant energy cost in manufacturing facilities. The cost of compressed air leaks is the energy cost to compress the volume of lost air from atmospheric pressure to the compressor operating pressure. The amount of lost air depends on the line pressure, the compressed air temperature at the point of the leak, the air temperature at the compressor inlet, and the estimated area of the leak. The Department of Energy estimates that, without a leak detection and repair program in place, 20 to 30 percent of compressed air is lost to leaks in a typical system. The leaks at this facility were calculated to consume 34 percent of all compressed air. Table 11 lists all air leaks and the associated cost savings.

Solution

Eliminate compressed air leaks in the facility to reduce the load on the compressors.

Data Used for Economics

Actual Compressed Air Costs:

- EC = $0.041/kWh (includes demand)
- Hours of leakage 8,760 hrs/yr
- Operating pressure of the compressors 129.7 psia
- Average inlet temperature of the compressor 70 °F
- Average line temperature at the leak 75 °F
- Estimated isentropic compressor efficiency 75 percent
- Estimated motor efficiency 95 percent.

Savings Calculation

Sample Calculation for annual $ savings found on the first line of Table 11:

$$V_f=\frac{1\times(70+460)\times\left(\frac{100+14.7}{14.7}\right)\times 28.37\times 60\times 0.8\times\frac{\pi\times\left(\frac{1}{16}\right)^2}{4}}{144\times\sqrt{75+460}}$$

V_f=5.19 cfm

$$L=\frac{14.7\times 144\times 5.19\times\left(\frac{1.4}{1.4-1}\right)\times 1\times\left(3.03\times 10^{-5}\right)\times\left[\left(\frac{129.7}{14.7}\right)^{\frac{1.4-1}{1.4\times 1}}-1\right]}{0.75\times 0.95}$$

L=1.41 hp

$$ES=1.41\times 8{,}760\times 0.746$$

$$ES=9{,}214 \text{ kWh/yr}$$

$$ECS=9{,}214\times\$0.041/\text{kWh}$$

$$ECS=\$378//\text{yr}$$

Cost Estimate Calculations

It is estimated that a compressed air leak can be fixed for an average cost of $100/leak. This totals $11,000 for all 110 leaks found.*

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$68,267
Capital cost ($)	$11,000
Simple payback (years)	2 months
Comments	Capital Project

Table 11. CA#2 energy and cost savings summary.

Area Considered	No. of Leaks	Diameter (in)	Line Pressure (psig)	V_f (cfm)	L (hp)	h (hr/yr)	ES (kWh/yr)	ECS ($/yr)
Open filter	1	1/16	100	5.19	1.41	8,760	9,214	$378
Stack solenoid	2	1/8	100	41.50	11.28	8,760	73,714	$3,022
32521	8	1/16	100	41.50	11.28	8,760	73,714	$3,022
Pipefitting	1	1/16	85	4.51	1.23	8,760	8,038	$330
Compressor	1	1/16	100	5.19	1.41	8,760	9,214	$378
33393	1	1/16	100	5.19	1.41	8,760	9,214	$378
32353	1	1/16	85	4.51	1.23	8,760	8,038	$330
32213	1	1/32	100	1.30	0.35	8,760	2,287	$94
33428	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
31871	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
33233	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
Tool fitting	1	1/16	85	4.51	1.23	8,760	8,038	$330
99969	1	1/16	85	4.51	1.23	8,760	8,038	$330
Air dryer	1	1/16	85	4.51	1.23	8,760	8,038	$330
31770	1	1/16	85	4.51	1.23	8,760	8,038	$330
31918	1	1/16	85	4.51	1.23	8,760	8,038	$330
32523	1	1/16	85	4.51	1.23	8,760	8,038	$330

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* This leak survey is a representative sampling of leaks found during the assessment. A complete survey should done as part of Phase II.

Area Considered	No. of Leaks	Diameter (in)	Line Pressure (psig)	V_f (cfm)	L (hp)	h (hr/yr)	ES (kWh/yr)	ECS ($/yr)
31675	1	1/16	85	4.51	1.23	8,760	8,038	$330
11839	1	1/16	85	4.51	1.23	8,760	8,038	$330
33075	1	1/32	85	1.13	0.31	8,760	2,026	$83
33468	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/64	85	0.28	0.08	8,760	523	$21
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Welding	1	1/16	85	4.51	1.23	8,760	8,038	$330
Machining	1	1/32	85	1.13	0.31	8,760	2,026	$83
Flow control valve	1	1/16	85	4.51	1.23	8,760	8,038	$330
Faulty PRV	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
Faulty PRV	1	1/32	85	1.13	0.31	8,760	2,026	$83
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
Faulty PRV	1	1/32	85	1.13	0.31	8,760	2,026	$83
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Open Filter	1	1/8	100	20.75	5.64	8,760	36,857	$1,511
Stack solenoid	4	1/4	100	331.97	90.25	8,760	589,780	$24,181
32521	8	1/16	100	41.50	11.28	8,760	73,714	$3,022
Pipefitting	1	1/16	85	4.51	1.23	8,760	8,038	$330
Compressor	1	1/16	100	5.19	1.41	8,760	9,214	$378
33393	1	1/16	100	5.19	1.41	8,760	9,214	$378
32353	1	1/16	85	4.51	1.23	8,760	8,038	$330
32213	1	1/16	100	5.19	1.41	8,760	9,214	$378
33428	1	1/4	85	72.14	19.61	8,760	128,151	$5,254
31871	1	1/16	85	4.51	1.23	8,760	8,038	$330
33233	1	1/16	85	4.51	1.23	8,760	8,038	$330
Tool fitting	1	1/8	85	18.03	4.90	8,760	32,021	$1,313
99969	1	1/8	85	18.03	4.90	8,760	32,021	$1,313

Area Considered	No. of Leaks	Diameter (in)	Line Pressure (psig)	V_f (cfm)	L (hp)	h (hr/yr)	ES (kWh/yr)	ECS ($/yr)
Air dryer	1	1/16	85	4.51	1.23	8,760	8,038	$330
31770	1	1/16	85	4.51	1.23	8,760	8,038	$330
31918	1	1/16	85	4.51	1.23	8,760	8,038	$330
32523	1	1/16	85	4.51	1.23	8,760	8,038	$330
31675	1	1/16	85	4.51	1.23	8,760	8,038	$330
11839	1	1/16	85	4.51	1.23	8,760	8,038	$330
33075	1	1/32	85	1.13	0.31	8,760	2,026	$83
33468	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/64	85	0.28	0.08	8,760	523	$21
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/32	85	1.13	0.31	8,760	2,026	$83
Foundry	1	1/4	85	72.14	19.61	8,760	128,151	$5,254
Welding	1	1/16	85	4.51	1.23	8,760	8,038	$330
Machining	1	1/32	85	1.13	0.31	8,760	2,026	$83
Flow control valve	1	1/16	85	4.51	1.23	8,760	8,038	$330
Faulty PRV	1	1/32	85	1.13	0.31	8,760	2,026	$83
Faulty PRV	1	1/32	85	1.13	0.31	8,760	2,026	$83
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/16	85	4.51	1.23	8,760	8,038	$330
Faulty PRV	1	1/32	85	1.13	0.31	8,760	2,026	$83
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Faulty PRV	1	1/64	85	0.28	0.08	8,760	523	$21
Totals	110	----	----	936	255		1,664,915	$68,267

Lighting

Rock Island Arsenal has recently completed a retrofit of its entire lighting inventory, replacing all of its incandescent, fluorescent and high intensity discharge (HID) lamps, and where applicable the associated magnetic ballasts, with energy efficient lamps and electronic ballasts. The bulk of this facility's lighting is provided by 4-ft, 32 watt T8 lamps, in one, two, three, and four lamp fixtures (Figure 20). At the time of the retrofit, these were one of the most efficient lamp types on the market, drawing significantly less power than the lamp type they replaced, the 4-ft 40W T12. In addition to requiring less wattage, T-8 lamps have dimming capabilities and often have a longer rated life than T-12 lamps. T-8 lamps also eliminate the flicker often associated with traditional T-12 fluorescent lighting.

Figure 20. Building lighting with new high intensity discharge (HID) lamps.

Recommendations for Lighting

LT#1: Install Spot/Task Lamps in Areas that Require Additional Illumination

Existing Conditions

After completion of the Arsenal lighting retrofit, concerns of insufficient lighting were raised by employees in some areas of the plant. These areas, normally performing detail work that requires increased illumination or in operations that are difficult to light, can be brightened by installing spot/task lamps. Using a combination of fixed/portable, bright/very bright and directional units, these "lighting stations" will increase the illumination of the work areas inside the facility. While the units will consume a small amount of energy, this cost will be greatly offset by the predicted increase in employee productivity.

Descriptive Scope

Install 50 spot/task lamps in areas that require additional illumination. The energy usage increase will be more than offset by worker productivity increase.

Data Used for Economics

Actual fuel costs were:

- EC: $0.041/kWh.
- A total of 50 lighting stations will be created.
- The fully burdened labor cost is $60,000 per worker per year.
- A productivity increase of 2 percent per worker can be expected.
- The lighting stations will cost $1,000 apiece.
- The increased power consumption by the lighting stations is negligible.

Savings Calculation

Annual $ savings = 50 workers × $60,000/worker × 0.02

= $60,000/yr

Cost Estimate Calculations

Total Cost = 50 stations × $1,000/station = $50,000

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$60,000
Capital cost ($)	$50,000
Simple payback (years)	<1
Comments	Slam dunk

LT#2: Replace the Current T8 Fluorescent Lamps with Higher Efficiency T8 Lamps

Existing Conditions

Since the lighting retrofit, a new T8 lamp has been brought to market. The new lamp, a 4-ft 25W T8 fluorescent lamp, uses approximately 7W less energy per lamp. The 25W T8 lamp also has a rated life of 25,000 hrs, 5,000 hrs longer than the current 32W T8 lamp. The longer lamp life will result in fewer lamp changes, reducing maintenance costs. The 25W T8 operates on any American National Standards Institute (ANSI) approved instant start ballast, which means it can replace the current 32W T8 lamp without any changes to the ballasts currently in place. In addition, the 25W T8 lamp has a color rendering index (CRI) of 85, compared to the 32W T8 lamp, which has a CRI of 78. This increase in CRI will be especially valuable in areas where detail work is conducted, because it lessens eye strain and makes it easier to complete work.

Descriptive Scope

Replace the existing 32 watt T-8 fluorescent lamps with 25 watt T-8 fluorescent lamps as they burn out.

Data Used for Economics

Actual fuel costs were:

- EC: $0.041/kWh.
- The number of existing lamps is 43,000.
- The number of proposed lamps is 43,000.
- The power rating of an existing lamp is 32W.
- The power rating of a proposed lamp is 25W.
- The lights operate 4,000 hrs per year.
- The conversion constant for watts to kilowatts is 1,000W/kW.
- The existing lamp change labor cost is $6 per lamp.
- The proposed lamp change labor cost is $6 per lamp.
- The existing lamp life is 20,000 hrs.
- The proposed lamp life is 25,000 hrs.
- The cost for an existing 32W lamp is $1.15.
- The cost for a replacement 25W lamp is $3.92.

Savings Calculation

Annual energy $ savings:

43,000 × (32W – 25W) × 4,000 hr/yr × 1kW/1,000W × $0.041/kWh

= $49,000/yr

Annual labor $ savings:

[(43,000 lamps / 20,000 hr) × $6 × 4,000 hr/yr] - [(43,000 lamps / 25,000 hr) × $6/lamp change × 4,000 hr/yr]

= $10,000/yr

Annual lamp $ savings:

[(4,000 hr/yr / 20,000 hr) × $1.15/lamp × 43,000 lamps] - [(4,000 hr/yr / 25,000 hr) × $3.92/lamp × 43,000 lamps] = ($17,000/yr)

Total annual $ savings

$49,000/yr + $10,000/yr + ($17,000)/yr = $42,000/yr

Cost Estimate Calculations

Total Cost = 43,000 lamps × ($3.92/lamp - $1.15/lamp) = $119,000

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$42,000
Capital cost ($)	$119,000
Simple payback (years)	2.8
Comments: Taking the lighting retrofit one step further	

LT#3: Reduce the Number of High Intensity Discharge (HID) Fixtures Left on at Night and Supplement with Compact Fluorescent Lamps

Existing Conditions

This facility currently uses a combination of HID and fluorescent lighting to provide illumination. The HID fixtures, which in larger rooms are controlled in banks and in smaller rooms are controlled in groups, are used in part to provide illumination at night. Numerous lights are left on at night to provide sufficient illumination in accordance with OSHA rules. In large rooms, a bank of lights at each end of the space is left on, while in smaller rooms all of the lighting is left on. For all rooms, two fixtures, one at either end, will provide sufficient nighttime illumination. Unfortunately, the current wiring of the fixtures does not allow fine control of the lights, resulting in large numbers of lights being left on at night. While this facility recently completed a retrofit of its entire lighting inventory, no provision was made to provide finer control of the HID fixtures. Rewiring the lighting circuits to allow control of the HID lights at the end of each room will reduce the number of lights left on at night, increasing lamp life and decreasing energy consumption. To ensure that there is enough illumination in these areas at night, supplemental compact fluorescent lamps (CFLs) will be installed over panels, switches, and other control points.

Descriptive Scope

Reduce the number of HID fixtures left on at night in the facility. Supplement these fixtures with CFLs over panels, switches, and other control points. This will reduce energy consumption while maintaining an adequate level of nighttime illumination necessary for employee safety.

Data Used for Economics

Actual fuel costs were:

- EC: $0.041/kWh.
- The night and weekend operating hours are 4,760 hrs/yr.
- The number of HID fixtures that need to be rewired is 12.

- The number of HID fixtures that can be turned off is 150.
- Each HID fixture draws 400W.
- Each HID fixture can be rewired for $500 apiece.
- A total of 50 CFLs will have to be installed at $300 apiece.
- The increased power consumption by the CFLs is negligible.

Savings Calculation

Annual $ savings:

150 HID fixtures × 400W/fixture × 4,760 hr/yr × 1kW/1,000W × $0.041/kWh

= $11,000/yr

Cost Estimate Calculations

Total Cost = (12 HID fixtures × $500/fixture) + (50 CFLs × $300/CFL) 4,760 =$21,000

Economic and Benefit Summary

Savings, Cost, and Payback	**Economics**
Net operating and energy savings ($/yr)	$11,000
Capital cost ($)	$21,000
Simple payback (years)	1.9
Comments	Creative solution

Coal-Fired Central Boiler Plant

Figure 21. General view of the coal-fired central boiler plant.

The coal-fired central boiler plant (Figure 21) was built in 1918. It originally had eight retort boilers, and there was a tall brick stack located beside the heating plant on the east side. These boilers have since been removed as well as the tall stack. Now the heating plant has four boilers and four stacks located on top of the heating plant (Table 12).*

Table 12. Boilers in the coal-fired central boiler plant.

No.	Brand Name	Type	Capacity(lbs/hr)	Installed
1	Babcock/Wilcox	Chain grate	100,000	1941
2	Babcock/Wilcox	Chain grate	100,000	1942
3	Wicks	Spreader stoker	125,000	1963
4	Wicks	Spreader stoker	75,000	1966

The total heating capacity of the heating plant is 400,000 lbs per hour. The present peak steam load in the winter is about 130,000 lbs per hour. It only requires two boilers to operate at that capacity. During the winter, one boiler, either number 1 or 2, is base loaded to about 50,000 pph and the second follows the trend of the steam load. Boiler 4 is considered the summer boiler. The boilers produce 135 psig, 358 °F saturated steam. No superheated steam is produced. The fourth boiler operates while the other three are renovated during the summer, and it is the last to be renovated at the summer's end. The heating plant has a system radius of about a half mile and heats about 54 buildings. A series of steam lines in the basements of the stone buildings and a number of steam tunnels connect various buildings with the central heating plant. The heating plant produces steam for heat, manufacturing, cooking (indirectly), steam cleaning in the factory, and operation of absorption chillers that produce chilled water for air-conditioning. The heating season contractually starts 15 October and ends on 15 May each year.

The softener (water treatment) room was later renovated in the 1960s and a hot zeolite lime/soda ash system was installed. A newer hot zeolite system was installed in the late 1980s to further improve the water treatment. This system resulted in water purity to 1 PPM, and virtually no scale builds up in the boilers. This results in higher efficiency, reduced maintenance, and improved reliability.

In about 1980, the bag house, located on the north side of the heating plant was installed. It was not properly designed, and it resulted in several years of follow up work to correct its design problems. In that same timeframe, a manufacturing

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* Information was provided during the PEOA by Mr. Jay Richter, Mechanical Engineer, the Directorate of Public Works (DPW)

renovation project, REARM, occurred and the need for additional steam capacity was questioned. A consultant was hired to determine if a fifth boiler would need to be added to the heating plant. The consultant provided a report that resulted in recommendation to improve the capacity and reliability of the existing four boilers rather than adding a fifth boiler. It took about 8 years, $2 million, and almost a full time engineer to implement about 40 contracts to make all of the changes, repairs, and improvements.

At the time of the consultant's study, it was impossible to have any of the boilers operate over 50 percent capacity without becoming unstable and having to shut the boilers down. The heating system was in a constant crisis mode because funding and emphasis for maintenance had been lost. The cost to install a now boiler was about 35 million dollars. The value engineering savings for this approach was about $33 million, in addition to filling the need for a system that operated properly. One of the improvements included changing the controls to direct digital control. We were nearly the first in the Army to do this. Employees with the authority can observe the operation of the heating plant online. Because we did not add a new boiler, we have been operating under an EPA grandfather clause regarding emissions. If RIA had added a new boiler, it would have been required to have a full time chemist and to treat all emissions for NOx and SOx. In case the EPA may review and change its policy toward "grandfathered" heating plants, CERL also considered RIA heating plant for a demonstration project for reducing emissions. (CERL later dropped the project because of funding problems). Furthermore, there are concerns regarding for the general age of the plant, and the stoker boiler industry's support for spare parts. Stoker boilers are old technology, and the industry supports only a few remaining plants.

RIA has requested funding for a study to look in the future for its heating plant and to consider making the changes required to have a reliable source of steam and heat for the Arsenal. In the past week (at the time of this writing), boiler performance tests were conducted. All four boilers were proved to be reliable again at 25, 50, 75, and 100 percent capacity. In 1980, this would have been impossible. In general, our heating is in excellent condition and a vigilant effort is continuously made to keep it that way. When a problem occurs, an individual job order (IJO) is submitted to make the repairs or changes. The most serious IJO at the time of this report is the repair of the coal elevator. The replacement of the elevator chain is being considered an emergency repair. This was identified in a required yearly review by a manufacturer's representative of the elevator company to look at the condition equipment. The chain will be repaired before the heating season starts.

The heating plant was contracted out in FY1987 after many of the improvements had been implemented or started. If these improvements had not been made, contracting would not have been possible. The contract has been rewritten about three times since that time, and the contract is considered a success.

The heating plant burns bituminous coal that comes from either Kentucky or Indiana. Presently, it burns about 28,000 or less tons of coal each year. The coal consumption has been dropping for various reasons. It did have a constant 40,000-ton consumption for many years. Changes in efficiency at the plant, energy efficiency projects, reduced load due to production changes, building closures, and warmer weather have resulted in reduced coal consumption.

RIA burns coal with reduced sulfur content, and with a heating content of about 13,000 BTU per pound. The cost of coal has been increasing, from a stable $45 per ton to $56, and recently to $78 per ton due to the natural gas crisis. The coal cost estimate for FY 2003 (POl-7351) was based on $56.89 per ton for 28,000 tons having a total cost of $1,592,920.

The heating plant has about 20 employees that, in total, work 24 hrs/day, 7 days/wk. All the employees are trained, are required to personally own a library of heating plant training literature, and are licensed through National Institute of Uniform Licensing of Power Engineers. All the employees have certification level of fourth class and the foreman has a required rating of first class. They are encouraged to continuously advance their certification.

A previous molten carbonate fuel cells site study[*] provided steam cost data. It stated that the smaller boiler, which services the manufacturing area, was used primarily for summer loads. The heating plant steam production was examined and the monthly average cost of steam for the period between 1992 and 1998 were calculated. Steam production peaks during the winter months at approximately 90,000 lb/month and falls off to 19,000 lb/month during the summer months. There had been a gradual decrease of summer load over the 7-year period. Steam costs had been decreasing since 1992 (about $2.50/1000 lb of steam) and were approximately $2.20/1000 lb of steam in the end of 1998. The steam cost reduction trend is primarily due to decreasing costs of coal, which have dropped from $48/ton to $42/ton during this period. With increasing coal prices, the steam costs are also increasing.

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[*] Franklin H. Holcomb, et al., Molten Carbonate Fuel Cells for DoD Applications: Rock Island Arsenal MCFC Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) TR-00-34 (ERDC-CERL, Champaign, IL, 2000).

Current cost of steam is about $3.00/1000 lb of steam when only fuel cost is considered.

Recommendations for the Boiler Plant Operation

BP#1: Upgrade the Deaerator Tank

Existing Conditions

This facility currently has four coal-fired boilers running all year. The boilers provide process steam as well as steam heat. The system currently has a condensate tank and a deaerator tank. According to the facility personnel, the system returns 63.7 percent of its condensate. The condensate enters the condensate tank at 180 °F. The condensate tanks are vented and set to atmospheric pressure. City water first is preheated through a blowdown heat recovery system to 119 °F. Then the water enters a steam-injected water softener, where the water is heated up to 225 °F. The water from the softener enters the condensate tank along with the condensate return from the various plants. The condensate from the plants enters the condensate tank at 180 °F. Water exits the condensate tank at 212 °F, where it is then pumped through a series of filters and then into the deaerator tank. The deaerator has a 7 psig steam injection system. The deaerator tank, however, is not pressurized, but still contains some level of pressure at the feedwater outlet. Water exits the deaerator at 220 °F due to the preheating effects of the steam injection. The boilers are estimated to blowdown 3 percent of the feedwater rate. The facility produces 52,063 lbs/hr of steam, and makes up 17,314 lbs/hr. These flow rates were provided by plant management. All flow rates in this recommendation are average values. Due to the complexity of the steam system and the lack of required data, the feedwater system will be modeled as a single deaerator tank.

Descriptive Scope

Upgrade the deaerator to eliminate the steam lost to venting and to preheat feedwater.

Data Used for Economics

Actual fuel cost were:

- Coal cost: $78/ton.
- The operating hours are 8,760 hrs/yr.
- Boiler Four has 83 percent combustion efficiency.
- The heating content of the coal is 13,000 Btu/lb.

- Condensate return flow rate / enthalpy, 33,164 lbs/hr, 148 Btu/lb.
- Feedwater flow rate / enthalpy, 53,625 lbs/hr, 188 Btu/lb.
- Makeup water flow rate / enthalpy, 17,314 lbs/hr, 88 Btu/lb.
- Enthalpy of the steam vent, 1,151 Btu/lb.
- Enthalpy of steam injection, 1,157 Btu/lb.
- Enthalpy of the proposed feedwater pressure, 197 Btu/lb.
- Enthalpy of vaporization at 220 °F, 965 Btu/lb.
- Enthalpy of vaporization at 7 psig, 960 Btu/lb.
- Conversion constant 2,000 lbs/ton.

Savings Calculation

Annual $ savings:

$$M_{Vent}=[53{,}625\text{ lbs/hr}\times(1{,}157-188)\text{ Btu/lb}+33{,}164\text{ lbs/hr}\times(148-1{,}157)\text{ Btu/lb}+17{,}314\text{ lbs/hr}\times(88-1{,}157)\text{ Btu/lb}]\,/(1{,}157-1{,}157)\text{ Btu/lb}=1{,}420\text{ lbs/hr}$$

$$CS=[53{,}625\text{ lbs/hr}\times(197-188)\text{ Btu/lb}+53{,}625\text{ lbs/hr}\times(965-960)\text{ Btu/lb}+1{,}420\text{ lbs/hr}\times(1{,}151-88)\text{ Btu/lb}]\,/(13{,}000\text{ Btu/lb}\times 0.83\times 2{,}000\text{ tons/lb})\times 8{,}760\text{ hr/yr}\times\$78\text{/ton}=\$71{,}604\text{/yr}$$

Cost Estimate Calculations

Total Cost=

A new deaerator costs $130,000. It will take $60,000 of labor to install the deaerator fro a total cost of $190,000.

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$71,604
Capital cost ($)	$190,000
Simple payback (years)	2.7 years
Comments	Capital Project

BP#2: Increase Condensate Return from Plant

Existing Conditions

Currently, this facility's condensate return system is set to 0 psig by several condensate return vessels through the complex. Each vessel has its own vent and high-pressure return pump. By setting the pressure of the condensate return, it is estimated that the condensate return rate can be increased by 10 percent. The increase in the return rate will result in more energy being returned to the boiler.

Descriptive Scope

Increase the condensate return rate by pressurizing the condensate return vessels and condensate tank. This will reduce the amount of make up water needed in the system and decrease the amount of energy needed to produce steam.

Data Used for Economics

Actual fuel cost were:

- Coals cost: $1,854,294/yr @ $78/ton.
- The operating hours are 8,760 hrs/yr.
- The system currently returns 33,164 lbs/hr.
- The system can recover 10 percent additional condensate or 3,316 lbs/hr additional condensate.
- The boilers have 83 percent combustion efficiency.
- The enthalpy of the proposed condensate return at 7 psig is 197 Btu/lb.
- The enthalpy of the current condensate return is 180 Btu/lb.
- The heating content of the coal is 13,000 Btu/lb.

Savings Calculation

Annual $ savings:

$$([(33{,}164\ \text{lbs/hr}+3{,}316\ \text{lbs/hr})\times 197\ \text{Btu/lb}]-3{,}316\ \text{lbs/hr}\times 180\ \text{Btu/lb})$$

$$\times(\$78/\text{ton})/(13{,}000\ \text{Btu/lb}\times 0.83\times 2{,}000\ \text{lbs/ton})=\$38{,}532/\text{yr}$$

Cost Estimate Calculations

The implementation of this recommendation requires the pressurization of the condensate return vessels as well as the condensate return tank. Pressurizing the system is estimated to cost $200,000.

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$38,532
Capital cost ($)	$200,000
Simple payback (years)	5.2 years
Comments	Capital Project

BP#3: Shut Down Boiler in the Summer Months

Existing Conditions

This facility operates one boiler (No. 4) to meet summer load—a 75,000 lb/hr coal boiler operating between 30 to 40 percent load. The summer season at this facility begins on 15 May and ends on 15 October. This recommendation considers a summer season of 1 May through 31 September. This facility houses four boilers in a boiler plant. The boiler plant feeds steam for a half-mile radius, to 54 buildings. Plant management states that the boiler plant must produce 17,000 lbs/hr of steam just to charge the lines. The facility creates 26,700 lbs/hr of steam on average during the summer. The rest of the steam system is used for HVAC applications and process equipment. Process equipment includes two absorption chillers, two steam-operated forge presses, immersion heaters for the electroplating lines, and other small processes. The coal boiler operates at 83 percent efficiency under current conditions. Boilers operate more efficiently at higher loads. Once the facility removes the chillers the boiler efficiency will likely decrease. This makes it more important to re-evaluate the boiler strategy at this facility. The facility is currently in the process of replacing the absorption chillers with electric chillers, and of lowering the steam load. RIA uses pneumatic forge presses in addition to the steam forge presses. Once the facility replaces the chillers and minimizes the use of the steam forge presses over the summer, the largest load will be the immersion heaters on the electroplating lines. Plant management estimate that the electroplating lines will require 6,000 lbs/hr of steam. A remote natural gas package boiler can sustain this load and would not require the same magnitude of steam to charge the lines.

Descriptive Scope

Turn off the coal boiler during summer months and install a remote boiler to sustain the process steam load. This will eliminate the excess steam produced by charging the lines.

Data Used for Economics

Actual fuel cost were:

- Natural Gas (NG): $7.00/MMBtu
- The summer operating hours are 3,672 hrs/yr
- The coal system requires 23,000 lbs/hr to provide heat for the electroplating line.
- The natural gas system requires 6,000 lbs/hr to provide heat for the electroplating line.
- Boiler Four has 83 percent combustion efficiency.

- The energy required to produce steam at 135 psig is 1,002 Btu/lb.
- The heating content of the coal is 13,000 Btu/lb.

Savings Calculation

Annual $ savings:

(23,000 lbs/hr×3,672 hrs/yr×1,002 Btu/lb)/(0.83×13,000 Btu/lb)
×($78/MMBtu)=$305,838/yr

(6,000 lbs/hr×3,672 hrs/yr×1,002 Btu/lb×(1×10^{-6} MMBtu/Btu)

/(0.80)=$193,165/yr

Total savings=$305,838/yr-$193,165/yr = $112,673/yr

Cost Estimate Calculations

A 12,000 lb/hr boiler is sufficient to supply the electroplating line load. At an estimated cost $25/(lb/hr) for a package boiler, a natural gas boiler costs $300,000.

Economic and Benefit Summary

Net Savings, Cost, and Payback	Economics
Net operating and energy savings ($/yr)	$112,673
Capital cost ($)	$300,000
Simple payback (years)	2.7 years
Comments	Capital Project

BP#4: Adjust Air-Fuel Ratio on the Boilers

Existing Conditions

This facility currently has four coal-fired boilers. The boilers have automatic dampers tied to an oxygen trim sensor to regulate airflow into the combustion chamber of each boiler. The damper controls, however have not worked properly since installation. The controls are tied to a single damper, which on occasion has a tendency to fail shut. This is a major problem, because when this damper shuts, combustion airflow stops and the boiler shuts down. To resolve the issue, the operating staff manually adjusts the dampers. This process can be inefficient. On the day of the assessment, it was observed that the oxygen level was set to 5 percent. This corresponds to an efficiency of 83 percent.[*] A variable frequency drive can be installed on the forced draft fans to create a similar effect as the dampers. The drive can be connected to the trim sensor to control the system automatically. With the drive in place, the dampers can blocked open, and the VFD will automatically control combustion airflow to maintain proper oxygen levels.

For the purposes of this recommendation, the combustion efficiency of Boiler No. 4 will be used to estimate the efficiency of all the boilers. The combustion efficiency of a boiler decreases with an increase in stack temperature. Boiler #4 runs at the lowest load and has the lowest stack temperature. Overall coal savings may be greater when combustion results are applied individually to all four boilers. Note that the three other boilers were not operational on the day of the assessment. Information regarding them could not be collected.

Descriptive Scope

Adjust the air-fuel ratio on the boilers by installing variable frequency drives on the forced draft fans. This will improve the combustion efficiency of each boiler. Combustion efficiency includes only combustion related effects. Overall thermal efficiencies will be less.

Data Used for Economics

Actual fuel costs were:

- Coal cost: $1,854,294/yr @ $78/ton
- Boiler #4 has 83 percent combustion efficiency
- The proposed boiler efficiency is 84 percent.

Savings Calculation

Annual $ savings:

$$(\$1,854,294/\text{yr})\times[1-(0.83/0.84)]=\$22,075$$

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[*] David F. Dyer and Glennon Maples, *Boiler Efficiency Improvement* (Boiler Efficiency Institute, Auburn AL, 1991).

Cost Estimate Calculations

The implementation of this recommendation requires the installation of a variable frequency drive and associated hardware. An inverter duty motor will be required to work in conjunction with the drive. The total installation cost of a variable speed drive including associated hardware is $74,000 according to an industry vendor.

Economic and Benefit Summary

Net Savings, Cost, and Payback	**Economics**
Net operating and energy savings ($/yr)	$22,075
Capital cost ($)	$74,000
Simple payback (years)	3.4 years
Comments	Capital Project

Summary of All Energy Conservation Measures

Of the 36 ECMs identified in this work, 23 were quantified with preliminary investment requirements (costs), estimated savings, and payback periods. Table 13 summarizes these 36 ECMs.

Table 13. Investment, savings, and payback of ECMs.

ECM	Description	Investment(k$)	Savings(k$)	Payback(yr)
PL#1	Install EED on chrome plating tanks	48	12	4
PL#2	Control airflows and steam heating	250	220	1.1
PL#3	Insulate hot plating tanks and rinse tanks	1.5/tank	0.3/tank	5
PL#4	Improve scheduling for plating operations	Minimum	TBD	Immediate
PL#5	Allow hot plating and rinse tanks to cool down	Minimum	TBD	<1
PL#6	Retrofit MAUs with low pressure drop filters	180	45	4
PN#1	Enclose Drive-Thru Paint Booth in Bldg. 208	64	61.7	1
HT#1	Install TCs for Furnance Uniformity Surveys	200	84	2.4
HT#2	Initiate a Preventative/Predictive Maintnce. Progm.	0	212	Immediate
HT#3	Install an Endothermic Generator	41	6.9	6
HT#4	Improve Lighting Performance in Heat Treat	155	100.6	1.5
MC#1	Install Radiant Heaters in Machining shop	200	174.3	1.1
FD#1	Replace Critical Foundry Equipment in B-212 W	700	354	2
FD#2	Improve ventilation in the foundry	TBD	TBD	<1
WD#1	Replace extraction arms with a new system	90	10.5	8.5
BE#1	Improve B-220 working conditions and IAQ	55	11	5
BE#2	Install high-speed doors where necessary	TBD	TBD	~3
BE#3	Clean roof windows in Building 299	TBD	TBD	TBD
BH#1	Improve ventilation in Rapid Response Mnfc. Cell	<10	TBD	<1
BH#2	Exchg. VAV boxes & improve cntrl. in ofce. Bldg.	TBD	TBD	TBD
BH#3	Install VFDs and extend ventl. ducts in B-208,211	TBD	125	~1
BH#4	Coordinate HVAC systems controls & maintnce.	0	TBD	Immediate
BH#5	Install separate cooling unit in B-208 basement	TBD	TBD	TBD
BH#6	Install on/off dampers in B-220 supply air ducts	6/floor	2.5/floor	2.4
BH#7	Install heat recovery coils in B-299 paint booth	50	16	3.1
BH#8	Improve IAQ in B-299 manufacturing departments	TBD	Low	TBD
BH#9	Perform further energy savings measures in B222	0.5	3.3	0.2
CA#1	Increase IR Compressor Pressure Gap	0	8	Immediate
CA#2	Reduce Compressed Air Leaks	11	68	0.2
LT#1	Install Task Lamps in Areas reqr. adtnl. Lighting	50	60	0.8
LT#2	Replace T8 Lamps with Higher Effcny. T8 Lamps	119	42	2.8
LT#3	Reduce the # of HIDs and exchg.with CF Lamps	21	11	1.9
BP#1	Upgrade the deaerator tank	190	71.6	2.7
BP#2	Increase condensate return from plant	200	38.5	5.2
BP#3	Shut down boiler in the summer months	300	112.7	2.7
BP#4	Adjust air-fuel ratio on the boilers	74	22	3.4
	TOTAL of the 23 quantified economically	2998.5	1745.1	1.7

4 Conclusions and Recommendations

Conclusions

The Phase 1 Process and Energy Optimization Assessment at Rock Island Arsenal conducted a Level I analysis to determine the economic potential for significant energy and cost reduction opportunities. The study identified solutions to critical cost issues and estimated the economics for the top ideas. Thirty six Energy Conservation Measures (ECMs) were identified in the Phase 1 of the study (summarized in Table 13 [p 90]). The 36 measures are identified with the following production processes and systems:

Processes	Systems
1. Plating	7. Building envelope
2. Painting	8. Building HVAC
3. Heat treatment	9. Compressed air
4. Machining	10. Lighting
5. Foundry	11. Boiler plant
6. Welding	

Economical quantification of 23 of the 36 ECMs (Table 14) shows that, when implemented, the ECMs will allow RIA to reduce its annual energy and operating costs by approximately $1.75M. The capital investment required to accomplish these savings is approximately $3M, indicating an average simple payback period of 1.7 years (21 months). Production-processes-related measures contribute to 73.4 percent of savings, building envelope 0.6 percent, and HVAC systems 1.1 percent, and other systems (compressed air, lighting, boilers) 24.9 percent.

Table 14. Investment, savings, and payback of the 23 quantified ECMs.

ECM	Description	Investment (k$)	Savings (k$)	Payback (yrs)
PL#1	Install EED on chrome plating tanks	48	12	4
PL#2	Control airflows and steam heating	250	220	1.1
PL#6	Retrofit MAUs with low pressure drop filters	180	45	4
PN#1	Enclose drive-thru paint booth in Bldg. 208	64	61.7	1
HT#1	Install TCs for furnace uniformity surveys	200	84	2.4
HT#2	Initiate preventive/predictive maintenance program.	0	212	Immediate
HT#3	Install an endothermic generator	41	6.9	6

ECM	Description	Investment (k$)	Savings (k$)	Payback (yrs)
HT#4	Improve lighting performance in heat treat	155	100.6	1.5
MC#1	Install radiant heaters in Machining Shop	200	174.3	1.1
FD#1	Replace critical foundry equipment in B-212 W	700	354	2
WD#1	Replace extraction arms with a new system	90	10.5	8.5
BE#1	Improve B-220 working conditions and IAQ	55	11	5
BH#7	Install heat recovery coils in B-299 paint booth	50	16	3.1
BH#9	Perform further energy savings measures in B-222	0.5	3.3	0.2
CA#1	Increase IR compressor pressure gap	0	8	Immediate
CA#2	Reduce compressed air leaks	11	68	0.2
LT#1	Install task lamps in areas reqr. adtnl. lighting	50	60	0.8
LT#2	Replace T8 lamps with higher efficiency. T8 lamps	119	42	2.8
LT#3	Reduce the # of HIDs and exchg.with CF lamps	21	11	1.9
BP#1	Upgrade the deaerator tank	190	71.6	2.7
BP#2	Increase condensate return from plant	200	38.5	5.2
BP#3	Shut down boiler in the summer months	300	112.7	2.7
BP#4	Adjust air-fuel ratio on the boilers	74	22	3.4
	Total of the 23 economically quantified ECMs	2998.5	1745.1	1.7

Recommendations

The Level 1 analysis of multiple complex processes and systems conducted during the Phase 1 is not intended to be (nor should it be) precise. The quantity and quality of the process improvements identified suggests that significant potential exists. It is recommended that RIA accomplish these potential cost savings by pursuing an aggressive program of process optimization linked to the ongoing “LEAN” efforts.

It is also recommended that RIA apply the identified low-cost/no-risk (so-called “slam dunk”) process improvement ideas from this analysis, which typically can be implemented quickly. However, the greatest profit opportunities need to be developed further by a Phase 2 effort, geared toward funds appropriation. This effort most often requires a combination of in-house and outside support.

It is recommended that RIA pursue Phase 2 of this PEOA. Recommendations for the scope of the Phase 2 study can be based on the Phase 1 results presented in Table 13. A specific Phase 2 scope will be jointly developed by the CERL and RIA teams through review and discussion of results documented in this Phase 1 report. Phase 2 will include a Level II analysis that “guesses at nothing – measures everything.” The results will be a set of demonstrated process and systems improvements based on hard numbers. CERL and expert consultants will provide guidance and further assistance in identifying a specific Phase 2 scope of work, respective roles, and the most expeditious implementation path. This will begin with a formal review of this (Phase 1) report, combined with a planning session to organize the Phase 2 program.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY) 09-2004	**2. REPORT TYPE** Final	**3. DATES COVERED (From - To)**

4. TITLE AND SUBTITLE
Process and Energy Optimization Assessment:
Rock Island Arsenal, IL

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Mike C.J. Lin, Alexander M. Zhivov, Veera M. Boddu, David Osborn, Walter P. Smith, Curt Bjork, and Robert A. Miller

5d. PROJECT NUMBER
MIPR

5e. TASK NUMBER
4H13LRG040

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL TR-04-17

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Commander, Rock Island Arsenal
1 Rock Island Arsenal
Rock Island, IL 61299-5000

10. SPONSOR/MONITOR'S ACRONYM(S)
Energy Manager

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

14. ABSTRACT

A Process and Energy Optimization Assessment (PEOA) was conducted at Rock Island Arsenal (RIA), IL to identify process, energy, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. The study was targeted at creating a holistic approach to energy optimization in industrial facilities and included measures related to industrial processes, building envelope, and energy and mechanical systems. A team of researchers and expert consultants performed a Phase-1 PEOA during the week of 21 June 2004. The scope of the PEOA included plating, painting, machining, welding, foundry, and heat treatment production processes, and also an assessment of the building envelope, ventilation, compressed air systems, and steam boilers. The study identified 36 energy conservation measures (ECMs); 23 of these were quantified economically. Implementing the 23 ECMs will reduce RIA energy and operating costs by approximately $1.75M, will yield an average simple payback of 1.7 years (21 months), and will improve the work environment.

15. SUBJECT TERMS

energy conservation
energy efficient
PEPR
Rock Island Arsenal, IL
pollution control
emissions

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Mike C.J. Lin
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	SAR	108	**19b. TELEPHONE NUMBER (include area code)** (217) 373-4519