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Improved Technologies for the Process Energy and Pollution Reduction (PEPR) Analysis Tool

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Foreword

This study was conducted for the Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Project 40162784AT45, "Facility Infrastructure Technology"; Work Unit XB9, "Industrial Energy Optimization Technology." The technical monitor was Dan Moore, HQIOC-IS.

The work was performed by the Energy Branch (CF-E) of the Facilities Division (CF), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL principal investigator was Dr. Mike C.J. Lin. The CERL technical editor was William J. Wolfe, Information Technology Laboratory. Larry Windingland is Chief, CEERD-CF-E; and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director is Dr. Paul Howdyshell. The Acting Director of CERL is Dr. Alan W. Moore.

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Executive Summary

As part of its strategy to meet the Department of Defense (DOD) energy efficiency goals, and to reduce emissions from industrial facilities, a Process Energy and Pollution Reduction (PEPR) software tool has been developed. The tool helps DOD facility personnel identify and quantify energy conservation and pollution prevention opportunities (ECOs and PPOs) — improved technologies — for specified industrial processes:

- load and pack (LAP) lines
- explosives production
- spray painting
- electroplating
- heat treating
- steam/hot water distribution
- compressed air distribution.

Along with data on existing processes and unit operations within these Processes, PEPR provides data on improved technologies and a calculation routine for quantifying the energy and environmental impacts of the improved technologies, and associated costs/benefits. This work documented the development of 14 additional ECOs/PPOs for these seven processes, and their incorporation into the PEPR tool (Table E1). In addition, this report includes “quick-start” instructions to ease the use of the tool (see Appendix C).

Improved technologies were identified via electronic Internet searches, as well as more traditional search methods. Appendix B includes additional sources of information. Follow-up calls with the information providers such as the equipment supplier, research organization, DOD facility, etc., were made to clarify the data and to ensure applicability to typical DOD operations. Each option selected for inclusion in PEPR was documented in an ECO summary form (see Appendix A). The specific data elements (process data) and associated descriptive information was incorporated as a new technology ECO/PPO in the PEPR software. Information under the Expert Advice Option, as well as suggestions for re-engineering, were also incorporated into the software.

Table E1 identifies the 14 selected ECOs resulting from this approach. Table E1 also provides estimates of the energy and economic benefits of these ECOs at any given installation. The information provided is intended to be illustrative and will vary depending on the specific process conditions at the installation, energy prices, local installation costs, etc. It is intended to give an idea of the magnitude of the opportunities. It is hoped that these additional ECOs and user enhancements will make the PEPR analysis tool of increasing value to DOD industrial facility personnel.

Table E1. Summary of ECOs.

Process ECO	Capital Cost ($)	O&M Savings ($/Yr)	Energy Savings (MBtu/Yr)	SPB (Yr)	IRR (%)	SIR
Load and Pack						
Install Motor Controllers	$6,000	$663	0	9.0	5.4	1.2
Install Power Factor Controllers	$9,750	NA	368.5	2.2	15.8	5.0
Explosives Production						
Recover Dryer Heat to Preheat Water	$120,000	NA	4704	9.1	5.8	1.4
Direct Steam Injection to Heat Wash Water	$11,300	NA	4891.6	0.8	19.3	15.6
Spray Painting						
Flashjet Coatings Removal Process	$3,500,000	$382,274	132.3	9.0	6.2	1.2
Electrostatic HVLP Spray Gun	$3,300	$26,000	12.0	0.1	31.4	107.3
Electroplating						
Energy Efficient Plating Barrel	$669	NA	6.8	4.4	14.0	2.5
Insulate Tanks over 150 °F	$275	NA	46.8	0.8	20.4	18.8
Heat Treating						
Convert Electric Furnace to Gas	$200,000	NA	-1953	2.2	13.0	5.3
Jetfire Gas-fired Mantle	$24,000	$2,823	-1910	5.1	7.5	2.0
Composite Radiant Furnace Tubes	$4,200	$1,200	35.0	3.1	34.3	3.6
Steam/Hot Water Distribution						
Gas-fired Infrared Radiant Tube Heaters	$1,200	NA	25.0	1.7	16.6	9.9
Insulate Steam Lines	$462	NA	726.6	0.2	29.4	78.6
Compressed Air Distribution						
Point-of-Use Pressure Control	$5,580	NA	267.4	1.4	15.8	8.7

Notes:

1. Abbreviations: O&M = Operation & Maintenance, SPB = Simple Payback; IRR = Internal Rate of Return, SIR = Savings-to-Investment Ratio

2. Payback, IRR, and SIR for the Jetfire Mantle are based on $28/MBtu electricity. Watervliet (WARS) $18.91692/MBtu Adjusted Electricity Cost was raised by $10 to run the economics.

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1 Introduction

As part of its strategy to meet the Department of Defense (DOD) energy efficiency goals, and to reduce emissions from industrial facilities, a Process Energy and Pollution Reduction (PEPR) software tool has been developed. The tool helps DOD facility personnel identify and quantify energy conservation and pollution prevention opportunities (ECOs and PPOs) for specified industrial processes:

- load and pack (LAP) lines
- explosives production
- spray painting
- electroplating
- heat treating
- steam/hot water distribution
- compressed air distribution.

Along with data on existing processes and unit operations within these processes, PEPR provides data on improved technologies, and a calculation routine for quantifying the energy and environmental impacts of the improved technologies, and associated costs/benefits. PEPR also provides suggestions for process improvements through the use of a “process expert.” PEPR software documentation, including information on the ECOs/PPOs and a user manual is contained in Construction Engineering Research Laboratory (CERL) Technical Report 96/84, *Development of the Process Energy and Pollution Reduction (PEPR) Analysis Tool* (August 1996). Since the initial report, the PEPR tool has had some minor upgrades, principally to provide more advisory capabilities with respect to the application of efficiency measures. Fundamentally, the program provides a structure for gathering/analyzing base energy and environmental data in the context of ECOs/PPOs.

In recent years a continued emphasis has been placed on improving energy efficiency and associated environmental performance — most notably greenhouse gas emissions reductions — which is embodied in Executive Order 13123: Greening the Government Through Efficient Energy Management (June 1999). In Section 203, concerning Industrial and Laboratory Facilities, the Order states “Through life-cycle cost-effective measures, each agency shall reduce energy consumption per square foot, per unit of production, or per other unit as applicable by 20 percent by 2005 and 25 percent by 2010 relative to 1990." Other legislation requires the Army to reduce toxic chemical and pollutant releases to the environment; to incorporate waste prevention and recycling in everyday operations; and to acquire and use "environmentally preferable" products and services to the maximum extent possible. The PEPR software tool is a potentially valuable asset in identifying energy efficiency and pollution prevention measures to help meet these requirements, and as a platform for collecting the necessary information for benchmarking progress (e.g., establishing baselines and measurement and verification [M&V]) relative to these energy consumption reduction targets and environmental goals. This report documents further enhancements to the PEPR tool to help it fulfill this potential.

Objectives

The principal objectives of this work were to increase the number of ECOs/PPOs available to the PEPR analysis tool, and to make the tool easier to use.

Approach

The approach involved carrying out the following tasks:

Task 1. *Conduct Literature/Database Search and Develop Improved Technologies*. This involved electronic searches via the Internet, as well as more traditional means to identify new ECOs (Appendix A) and PPOs to add to PEPR. Appendix B lists additional sources of information. Follow-up calls with the information providers such as the equipment supplier, research organization, DOD facility, etc., were made to clarify the data and to ensure applicability to typical DOD operations. Information on technology status/availability, energy savings, pollution reduction potential, and cost/economics was reviewed to aid in determining technology options that should be included in PEPR.

Task 2. *Develop and Implement Improved Technologies*. Each option selected for inclusion in PEPR was documented in an ECO summary form (Appendix A). The specific data elements (process data) and associated descriptive information were incorporated as a new technology ECO/PPO in the PEPR software. Information under the Expert Advice Option, as well as re-engineering suggestions were also incorporated into the software.

Task 3. *Prepare Technical Documentation*. This involved the preparation of the work plan, periodic progress reports, and this final technical report. The basic structure of this final report closely follows that of the earlier PEPR report, and serves as a companion for that report.

System Requirements

The system was developed using Microsoft® FoxPro® Version 2.6 for Windows™. FoxPro® is a Relational Data Base Management System (RDBMS) with a built-in programming language that allows the development of custom applications. PEPR requires an IBM® PC or compatible with an 80386 or higher microprocessor. It also requires approximately 15 megabytes of disk space and at least 8 megabytes of RAM. The system was developed for a Windows™ environment and requires Microsoft Windows™ 3.1 or higher to run properly. It also was developed for use with monitors having VGA resolution. If the PEPR program is used with super VGA resolution, the program screen will not fit the monitor screen properly. In this case, the monitor resolution must be set up for VGA.

Scope

The product developed from this project could be used by all DOD industrial operations. It is also applicable to commercial industries of similar operations. The ECOs identified are limited to the seven processes, as are the process data in the data base in this updated version of PEPR.

The basic structure of the PEPR software tool was developed to accommodate the most detailed and comprehensive set of process and emissions data, but the tool does not require the greatest amount of detail possible to accomplish its main purpose—which is to be a screening tool. PEPR is not a process simulator, although it does contain basic analytical routines and calculations designed to help users at the process engineering level analyze their data. PEPR does a complete and accurate analysis with data that are specific and sufficiently complete for a given situation. PEPR was designed to be flexible and easily expandable. Data on other processes and ECOs can be inserted easily into PEPR's databases for analysis. Other routines can be developed and included within the tool to help the user develop input data for a particular process.

Mode of Technology Transfer

It is anticipated that the information presented in this report will be disseminated in the Army Research, Development, and Acquisition Bulletin. It is recommended that the energy/emission review results obtained and the description of the software tool development be presented at the Industrial Energy Technology Conference. The PEPR program may be obtained by contacting CERL. The program will be transferred to Army Materiel Command Headquarters for further distribution.

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for International System of Units (SI) is provided below.

SI conversion factors		
1 in.	=	2.54 cm
1 ft	=	0.305 m
1 gal	=	3.78 L
1 lb	=	0.453 kg
1 psi	=	6.89 kPa
°F	=	(°C x 1.8) + 32

2 Using and Updating the PEPR Analysis Tool

Using the PEPR Analysis Tool

PEPR has been designed for maximum flexibility to enable the user to evaluate processes to whatever level of detail the data permits. Accordingly, PEPR has been configured to enable the user to put in substantial amounts of data associated with the processes and unit operations within the process. However, in many instances the user is interested in evaluating ECOs with only limited data, or where only a subset of the process is affected. In these cases, it is not necessary to complete many of the data fields that are available – substantially reducing input and analysis time. For example, the user may only be interested in the change-out of one component for an energy-efficient equivalent, where the upstream and downstream operations are not affected. In this instance information pertaining to the new component relative to the existing component may be all that is needed for comparative purposes. The user would not have to provide process information on the total process line and all the unit operations within that line – a considerable savings in time and effort. Appendix C provides examples of how a user can take such "short-cuts" to minimize the time it takes for PEPR analyses, given several typical user scenarios. This information is intended to augment the information provided in the PEPR Program User Manual. The user manual is contained in an appendix to CERL Technical Report 96/84, and has also been incorporated into the PEPR software.

Updating the PEPR Analysis Tool

Information on existing processes, ECOs/PPOs, and re-engineering suggestions form the basis for PEPR analyses. PEPR has been designed to make updates of this information (the addition of new processes, ECOs, etc.) straightforward so that the tool is easily maintained. This report documents a systematic effort at updating PEPR, based on developments in energy efficiency/process improvement over the past several years. With the growth of the Internet and broader availability of product information, engineering studies, etc., it is anticipated that users may find it of increasing interest to use PEPR to analyze new technologies that they encounter. By way of example, Appendix B lists the large number of data sources – a number of which are DOD-specific — that were used in identifying and developing the process and ECO information included in this latest update to PEPR. It is hoped that, as process conditions at the user's facility change or as new technologies become available, the users will find this tool of continuing value.

3 Load, Assemble, and Pack Line

Introduction

One very common general type of process carried out at many Army industrial bases is to "load, assemble, and pack" (LAP) various types of munitions. The same general process is used with some variation in individual unit operations or steps, for ammunition, various types of shells, and missiles. In the typical LAP line, there are only a few significant process operations involving either energy or emissions, and some of these operations may be slightly different, rearranged, or perhaps omitted for different types of munitions. Briefly, the most significant process unit operations are:

- Processing of the explosive – melting the trinitrotoluene (TNT) or perhaps blending powders with the aid of a solvent that is eventually evaporated.
- Preheating the empty shell (sometimes omitted).
- Probing the filled shell on a probe machine to eliminate cavities in the melted explosive and adding more explosive if necessary (sometimes omitted).
- Painting and stenciling as sources of emissions (not all can yet be controlled).
- Post-cyclic heating of the assembled projectile, which is by far the most conspicuous consumer of energy in the entire process.

In moving the materials between operations various conveying systems are used, from manual to electric drive, compressed air, or hydraulic systems, all of which consume energy.

Example — LAP Process for M106 Shells

PEPR currently contains LAP line process information obtained from "process energy inventory" studies conducted at the Iowa Army Ammunition Plant (IWAAP). The LAP line produces M106 shells — an 8-in. projectile weighing approximately 200 lb and containing approximately 36 lb of TNT. The process involves the following:

The metal parts are received at the loading line storage building and are transferred to the receiving and painting building when needed. There they are depalletized, inspected, placed on transfer carts, and moved to the melt loading building. TNT is received at the TNT service magazine and transferred to the TNT screening building as needed. It is inspected and screened, and then transferred to the melt loading building.

Projectiles are preheated in an oven maintained at 125 °F. TNT is melted on a 5-psig (228 °F) steam-heated melt grid. TNT is transferred to a Dopp kettle where it is mixed with unmelted TNT to the proper consistency for pouring (188 °F). Approximately 36 lb of TNT are poured into each projectile, and the filled projectiles are allowed to cool for a minimum of 2 hours.

The filled projectiles are probed with a hot probe (220 °F) to a depth of 15 in. to remove the cavitation formed in the casting during cooling. Melted TNT is then poured into the hole left from probing, and the projectiles are again allowed to cool. Following this cooling, a second hot probe is performed to a depth of 5 in., followed by a second add-pour operation.

When cooled, the projectiles are drilled and a liner is inserted for the supplementary charge. The projectiles are x-rayed to check for defects. Accepted shells are transferred to the final assembly building. Defective shells are transferred to the melt building where they are pumped out and recycled back into the process flow at the preheat-oven stage. The accepted shells are touch-up painted, weighed, and stenciled. The supplementary charge is inserted and the lifting plug is assembled. The shells are then transferred to the post-cyclic heating area where they are maintained at 135 °F for 12 to 18 hours, allowed to cool to not less than 70 °F for 12 hours, and reheated to between 135 and 150 °F for 12 to 18 hours. The shells are then shipped out or stored in appropriate locations.

Energy Conservation Opportunities

Common to all LAP processes, including the M106 production line are motor systems that are used in: (1) conveying materials from one operation to another, and (2) conveying materials to power production equipment. The operating efficiency of these motor systems can be improved by a number of means; properly sizing the motor for the load, replacing inefficient motors with more efficient ones, and various control strategies. Two of the more effective strategies involve motor system control: (1) install motor controllers to “soft-start” motor systems, and (2) install power factor controllers. Table 1 gives a description and estimate of the energy and economic benefits of these ECOs.

Table 1. List of ECOs for load and pack lines.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Install Motor Controllers	6000	$663	0	9.0	5.39	1.22
Install Power Factor Controllers	9750	NA	368	2.2	15.80	5.01

Install Motor Controllers for Electric and Air Motors

Starting power requirements for motors often significantly exceeds the power that is required once the system is in full operation. This is due to the high initial torque required to overcome the load's inertia for certain applications. Motors sized to meet start-up requirements may be oversized to enable quick start-up to overcome this inertia. This results in greater than necessary energy use and energy operating costs in steady-state operation. The use of motor controllers to "soft-start" (reduced voltage start) motors and control electrical draw based on actual load rather than full load rating decreases the likelihood of start-up-associated motor problems (e.g., large current surges that can result in overheating and damaged motors). Soft-start motor controllers gradually increase voltage at start-up, which avoids the rapid spike of starting current that would normally occur. This results in significantly improved motor life. Soft-starting can also enable some savings in other parts of the system by reducing power system component capacity requirements. However, this would be of greatest benefit in situations where these components were near the end of their useful service lives.

Install Power-Factor Controllers for Electric Motors

Power factor controllers are a class of controllers that vary the voltage supplied to the motor based on load requirements. They accomplish this by varying the input voltage to the minimum needed for operation. This can significantly reduce the losses of underloaded induction motors. Typical savings for three-phase motors are on the order of 10 to as high as 40 percent depending on the load fraction and hours operated at underloaded conditions. The savings increase with decreasing load fraction and increasing hours at underloaded conditions. Power factor controllers also provide "soft-start" by virtue of their voltage control capabilities. This helps reduce current in-rush during start-up, which helps reduce operational problems (e.g., power drops on other equipment during start-up, abrupt start-ups, wear and tear on the motor and associated power systems as a result of overheating caused by the current in-rush).

Re-Engineering Suggestions

Re-engineering suggestions that have previously been offered for the LAP Processes at IWAAP include: (1) re-design of the initial pour step to eliminate cavities, and thus the probe and add-pour steps, for more efficient operation, and (2) optimizing or eliminating post-cyclic heating operation. Another suggestion is to investigate the feasibility of substituting new casing materials (e.g., plastic) for the metal jackets currently in use. Such a substitution would have significant benefits in terms of weight reduction, perhaps reducing energy required for conveying equipment per projectile, and reducing/eliminating painting requirements.

4 Explosives Production

Introduction

One of the more energy-intensive types of industrial processes carried out in Army industrial facilities is the manufacture of explosives. Some of the explosives production processes involve chemical reactions with significant thermal effects and integrated heat exchange among process streams, although others – for example, the production of nitroglycerine – do not have significant energy consumption or thermal effects. The production of primary explosives, which are then shipped to other Army facilities for use as basic materials in assembling various munitions, tends to be concentrated in two facilities: (1) Radford Army Ammunition Plant, which produces TNT, nitroglycerine, and nitrocellulose (NC), and (2) Holston Army Ammunition Plant, which produces research development explosive (RDX) and high melting explosive (HMX). Although each of these explosives is produced with its own unique process, there are certain elements common to all of the processes; each process typically involves a nitration reaction with mixed acids followed by various purification steps to stabilize the nitrated product, neutralize it, and perhaps wash it. Information on the NC production process at Radford has been incorporated in the PEPR analysis tool as a representative explosives production process.

Example — NC Production

NC is a basic ingredient produced and used at Radford in the manufacture of smokeless powder, small arms propellants, and rocket propellants. It is produced by treating purified cellulose with a mixture of nitric and sulfuric acids in Hercules proprietary reactors in a multi-step process. The key steps in the process are:

- drying (no longer performed)
- nitration
- separation/washing
- boiling
- beating
- poaching

- blending
- wringing.

Substantial quantities of thermal energy are required for input in the boiling tub house and the poacher house. In addition, cooling is required in the agitator/nitrator and the separation/washing unit operations.

Energy Conservation Opportunities

The previous PEPR study (Lin, Fraser, and Lorand 1996a) identified several opportunities for reducing energy and pollutants based on the Radford NC production process. Two that are outlined here are: (1) use of a hot dryer exhaust to heat batch of hot water, and (2) use of direct steam injection to heat batch of wash water. These were briefly described (but not quantified) in the earlier study. Table 2 gives a description and estimate of the energy and economic benefits of these ECOs.

Table 2. List of ECOs for nitrocellulose lines.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Use Hot Dryer Exhaust To Heat Batch of Wash Water	100,000	NA	4704	9.1	5.81	1.41
Use Direct Steam Injection To Heat Batches of Wash Water	11,300	NA	4892	0.8	19.32	15.61

Use Hot Dryer Exhaust To Heat Batch of Wash Water

The first step in the NC production line at Radford Army Ammunition Depot (RAAD) involved the shredding and drying of the cellulosic feedstock. This was done to reduce the moisture content early in the process thereby reducing the amount of sulfuric acid required downstream for water take-up. The water is a byproduct of the nitration process. It was estimated that about 15 percent more water would have to be taken up if the drying step were eliminated. The dryer was estimated to use about 280 Btus for every pound of NC produced — a substantial amount of energy considering the average production rate was 14,000 lb NC/hr. At the time of the initial PEPR report, elimination of the dryer was being considered, but had not occurred. Since that time, analyses have indicated that the trade-off in additional sulfuric acid requirements vs. energy savings due to dryer elimination favored eliminating the dryer. Accordingly, the present process line no longer uses a dryer. However, since this report deals with potential options not only for the specific plant studied, but also for other plants that might have similar processes, an alternative to eliminating the dryer is provided. This would be to use the waste heat from a dryer to heat the wash water. The ECO involves the use of a heat exchanger to provide indirect heating of the water. Indirect heat exchange minimizes potential contamination issues or special filtration that would likely be required with direct heat exchange. What is required is the air-water heat exchanger, and ductwork/piping to enable transport of the heated water from the heat exchanger to the wash area(s).

Use Direct Steam Injection To Heat Batches of Wash Water

Wash water is used for various unit operations within a NC line. Steam is generally used to heat the water where required (e.g., boiling tub house and poacher house) either directly or indirectly. When indirect heating is used for such large volumes of water, this requires a significant time for preheating — on the average of 4 hours per tub after fill. This ECO involves the elimination of indirect heating and the direct heating of incoming water via in-line direct steam injection (DSI) heaters. Rather than heating the tub after it is filled, the DSI heaters instantaneously heat the water to boiling as it enters the tub — saving time and energy. The DSI strategy has been implemented at RAAD.

Re-Engineering Suggestions

As discussed above, the elimination of the dryer (a re-engineering concept) has been successfully demonstrated at RAAD. Two other suggestions made previously that have yet to be examined in detail are: (1) the re-use of water in the boiling tub and poacher houses, and (2) location of a cheaper source of cooling for the nitration reactor and the centrifuge.

5 Spray Painting

Introduction

Spray painting is a very common unit operation at Army industrial facilities. Virtually every Army facility has one or more spray paint booths, either as a standalone operation used sporadically a few hours each month in equipment maintenance or product touch-up, or continuously as an integral part of a production process. The painting in a spray paint booth may be done manually with a spray can, brush, roller, or spray gun, or automatically via spray nozzles. Various types of paints are used in these spray paint booths with significant potential particulate, volatile organic compound (VOC), and hazardous air pollutant (HAP) emissions. The degree of control of these potential emissions is usually dictated by local regulations. At the present time, particulate emissions are usually controlled, while VOCs may not be.

Depainting (paint removal) processes accompany painting operations. Examples of depainting approaches used at different DOD industrial facilities include:

- *Corpus Christi Army Depot (CCAD).* Plastic blasting media for helicopters.

- *Robins Air Force Base (RAFB).* High pressure baking soda washing systems for C-130 and C141 planes. Plastic blasting media for F-15 planes. Methylene chloride-based strippers are the most widely used to soften paint prior to depainting; however, on the C-141, benzyl alcohol-based paint remover is used.

- *Anniston Army Depot (ANAD).* Coal slag (primary blasting medium), sand, glass beads, steel shot, and walnut hull blasting media for tanks.

Media blasting operations consume compressed air energy. Used blasting media, which is a mixture containing the removed paint, is hazardous waste because of chemicals contained in the paint and stripper.

The following discussion presents ECOs that also help mitigate environmental problems with existing spray painting and blasting operations.

Example — Depainting Helicopters at CCAD

CCAD uses paint stripper and plastic media blasting for depainting. Depainting is done during one shift for a net operating time of 8 hours per shift, 4 days per week, 50 weeks per year. Labor, plastic blasting media, paint stripper, and miscellaneous material costs for this operation are shown in the ECO Summary Form for Coatings Removal at CCAD (Appendix A).

Energy Conservation Opportunity

The following depainting ECO, the Boeing Flashjet system, will result in both energy savings and environmental benefits at CCAD and RAFB, where it is being installed. At CCAD, the ECO will be installed on a seven-axis robot gantry system that will accommodate the largest U.S. Army helicopter, the CH-47 Chinook. Initially, the ECO will be used to depaint the AH-64 Apache, UH-60 Blackhawk, AH-1 Cobra, UH-1 Huey, SH-60 Seahawk, and OH-58 Kiowa helicopters. At RAFB, the ECO will be used to depaint composite radomes, flight control surfaces, fairings and other surfaces on the U.S. Air Force F-15 Eagle, C-130 Hercules, C-141 Starlifter, and C-5 Galaxy. Table 3 gives a description and estimate of the energy and economic benefits of this ECO.

Table 3. ECO for depainting.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Install Xenon Flash-lamp Depainting Process	3,500,000	382,274	132	9.0	6.16	1.23

Install Xenon Flash-lamp Depainting Process

In the Boeing Flashjet process, painted surfaces are exposed to high-intensity pulsed light energy from a xenon-flashlamp. The energy explodes the coating into a fine ash. A continuous stream of carbon dioxide pellets cools and cleans the surface and forces effluent ash into a capture system. The effluent capture system separates the ash and organic vapors. Ash goes through high efficiency particulate air (HEPA) filters; vapors are absorbed by activated charcoal.

The Flashjet process replaces plastic media blasting and solvent stripping depainting processes at CCAD, resulting in lower hourly energy use because the wattage of the Flashjet system is lower than for the plastic media blasting system, which uses compressed air. The Flashjet system also results in the following environmental benefits: (1) no requirement for paint stripper, and (2) no plastic media hazardous waste disposal problem. Additionally, the Flashjet system helps to realize significant labor cost savings, partly because less clean-up is required when plastic media and the accompanying waste disposal are eliminated.

Example – Vehicle Drive-Through Booth

CERL Technical Report 96/84 described the complete vehicle drive-through paint booth process, which includes air circulation, spray paint gun, and water circulation subsystems. Additionally, type of paint was included as a subsystem because its characteristics influence the performance of the paint booth, both in terms of energy consumption and (especially) emissions. The ECO discussed below addresses energy savings and reduction of paint waste, an environmental benefit for the spray paint gun subsystem.

Presently, there are four major processes of spray applications:

1. Compressed air atomization (conventional air spray and high-volume, low-pressure [HVLP] spray)

2. Airless atomization

3. Air-assisted airless atomization

4. Electrostatic atomization, which can be combined with any of the previous three processes.

Each process has its advantages and limitations. A complete discussion of all of these spray techniques is beyond the scope of this study. However, because HVLP is a relatively new technique now being introduced into some DOD facilities, it may be useful to compare this process with the older conventional spray process.

Conventional air spray, used at Rock Island Arsenal (RIA) (e.g., Binks Model 2001 spray guns with special tips), is the oldest system; it remains today as the finishing system most widely used in the industry. Conventional air spray has two main advantages: (1) it is the most controllable process available, and (2) it is the most versatile and the easiest system to operate and maintain. One disadvantage is a low level of transfer efficiency (around 35 to 40 percent); more material is wasted than is actually deposited on the part. It also consumes large amounts of compressed air, in the range of 7 to 35 cfm. Depending on the spray equipment, type of paint, and desired pattern, it requires air pressures in the range of 30 to 100 psi.

HVLP atomization works in a similar manner to conventional air spray except that the air jets exiting the nozzle are columns of high-volume, low-pressure air. The spray guns are specially constructed for this service. The benefits of HVLP atomization are: improved transfer efficiency (which may approach 75 percent), compliance with local finishing regulations, a softer spray that penetrates easily into recesses or cavities, reduced material consumption, which consequently reduces spray booth maintenance and hazardous waste. The most notable limitation is that the finish quality is not as fine as that obtained from conventional air spray. This may mean additional polishing, a change in the material formulation, or switching to electrostatic HVLP guns. Turbine-generated HVLP systems may be expensive to purchase and operate. High-volume production lines may find HVLP to be too slow. HVLP systems use from 15 to 30 cfm and 1 to 10 psi air pressure, depending on the type, density, and viscosity of paint.

Electrostatic HVLP spray guns add a charge to sprayed paint particles, which increases the transfer efficiency of the paint to the grounded piece being painted. Transfer efficiency for an electrostatic HVLP gun is about 90 percent. The result is less paint overspray, which translates into reduced paint waste and energy savings from disposing less waste.

Energy Conservation Opportunity

The following ECO addresses electrostatic HVLP spray guns. Two kinds of electrostatic HVLP spray guns have been identified. In one design, a high voltage ion cloud (e.g., 60 to 90 kv) is generated by the gun; atomized paint is charged as it is sprayed through the cloud. A more efficient alternative is to mount a grounded needle probe, charged to create a voltage field of 6 to 10 kv, at the outlet of the gun. Each paint particle receives a negative charge as it comes in contact with the charged field around the needle probe. Table 4 gives a description and estimate of the energy and economic benefits of this ECO.

Table 4. ECO for spray painting.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Convert to Electrostatic HVLP Spray Guns	3,300	26,000	12	0.1	31.39	107.27

Convert to Electrostatic HVLP Spray Guns

Conversion includes installing the spray gun, hose assembly, and production turbine or blower power supply to control one gun. The grounded needle probe technology patented by Accuspray, which is analyzed in Appendix A, has the following advantages relative to other electrostatic gun technologies:

- no Faraday cage effect (tendency of charged coating particles to deposit around entrances of cavities)
- no picture framing
- even particle distribution
- no metallic color shift.

Replacement of conventional non-HVLP spray guns with electrostatic HVLP guns results in an increase in the transfer efficiency, which yields the environmental benefit of reducing the amount of paint waste.

Re-Engineering Suggestions

Advanced depainting and spray painting technologies such as the Flashjet system and HVLP and electrostatic HVLP guns significantly reduce emissions and solid wastes that accompany the depainting and painting processes. The re-engineering suggestion is to analyze the impact these technologies have on ventilation and waste disposal systems. It may be possible to re-engineer these systems to achieve additional energy and cost savings.

6 Electroplating

Introduction

DOD installations use a wide variety of electroplating processes. These processes are used to apply coatings to metal parts for corrosion protection, passivation, lubrication, wear protection, and material buildup. CERL Technical Report 96/84 discussed process details for chrome plating on steel, one of the most commonly used processes. Electroplating in this and other operations takes place in plating tanks. Larger parts are placed on plating racks, which are lowered into the plating tank. Smaller parts are placed in polypropylene plating barrels that contain holes through which plating solution flows.

Energy is usually used in plating shops in the form of steam and electricity. Steam is usually used to maintain plating and rinse solutions in the plating tank at a required temperature. Plating solutions are often kept hot even when idle. Electricity is used to power lighting, air handlers, scrubber fans, air compressors, blast cabinets, ovens, filtration equipment, pumps, rectifiers, and other miscellaneous equipment. A large portion of the energy used in plating shops is consumed in the shop taken as a whole, as a fixed amount of consumption with little apparent variation with production level.

Example – Plating Barrels to Plate Smaller Parts at CCAD

Plating barrels with approximately 1 gallon of capacity are used to plate battery hardware. The conventional plating barrel is a hexagonal design constructed of polypropylene panels with drilled holes through which electrolytic solution flows. Plating barrels are lowered into a plating tank, where they are connected to a motor shaft that rotates the barrel during the plating operation.

Design elements that lead to optimal plating barrel performance include: (1) number of holes per unit area of barrel wall, and (2) hole geometry. Barrels with more holes per unit area enable unimpeded flow of electrolytic solution. Barrels with fewer holes may cause metal ions to be plated to a part faster than new ions can enter the barrel, resulting in a slower plating rate and potential quality problems. Barrel platers counteract this mass transfer problem by adding more power to the operation to maintain production rate and product quality. Ion depletion is a particular problem when plating alloys. In this case, the stoichiometric ratios of several metal ions must be maintained. Barrel platers maintain the ratios by adding to a plating solution, more of an ion that has a higher depletion rate. This practice raises the cost of chemicals.

Hole geometry has two impacts on barrel performance. First, through capillary action, plating solution collects in barrel holes. After a plating cycle, the barrel is placed in a rinsing bath to remove plating solution, which would otherwise damage the plated surface. Plating solution in the holes is rinsed out during this process. This lost plating solution, termed “drag-out,” is a source of hazardous waste and a cause of additional process heat consumption, since replacement solution must be heated to the required plating bath temperature. Thus, drag-out minimization is a consideration in barrel design. Second, hole geometry affects the current density on the plating surface. Geometry that leads to increased current density results in a decrease in plating cycle time, increasing the productivity of the plating process.

Energy Conservation Opportunity

The following ECO discusses a plating barrel that contains the performance-enhancing design elements discussed above. Energy data for plating barrels at CCAD was not available. Therefore, data from performance tests conducted by Whyco Technologies, Inc., manufacturer of the barrel, are used. Table 5 gives a description and estimate of the energy and economic benefits of this ECO.

Table 5. ECO for barrel plating.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Install Energy Efficient Plating Barrel	669	NA	6.8	4.4	13.95	2.49

Install Energy Efficient Plating Barrel With Improved Plating Efficiency

The Whyco Technologies, Inc., plating barrel has a staggered cell design that reduces plating time by 20 percent and reduces the amount of drag-out solution waste by up to 60 percent. These benefits are achieved by reducing the depth of the holes and by increasing the number of holes per unit area. The cells are machined into the polypropylene barrel wall, achieving a honeycomb effect where the walls of the cells enable the barrel to retain structural strength while reducing barrel wall thickness. Fluid transfer holes drilled into such a wall are

1/3 to 1/4 of the wall thickness, resulting in reduced solution drag-out compared to conventional barrels, where the hole is the full wall thickness. The full wall thickness of the Whyco barrel is ¾ in. Also, because the cell walls reinforce the barrel wall, the number of holes per open area of wall can be maximized, enhancing fluid transfer rate and plating speed. The reduced hole depth also causes a change in geometry that increases the current density on the plated surface, resulting in an increase in plating speed.

Example – Electroplating Tanks

Plating processes take place in tanks. Solution in the tanks is maintained at a desired process temperature by steam heat. Some solutions are maintained at temperatures over 150 °F.

Energy Conservation Opportunity

ECOs that minimize tank heat loss will reduce consumption of steam to maintain solution temperature. Table 6 gives a description and estimate of the energy and economic benefits of this ECO.

Table 6. ECO for electroplating tanks

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Insulate Tanks over 150 °F	275	NA	46.8	0.8	20.42	18.78

Insulate Tanks Maintained at Temperatures over 150 °F

Addition of insulation to electroplating tanks operated over 150 °F will reduce heat losses, thus reducing energy consumed to maintain electroplating solution at a specific temperature. Insulation would be added to the four sides of the tank. To reduce energy loss from the plating solution surface, which is exposed to air, consider floating polypropylene balls, another PEPR ECO, on the surface.

Re-Engineering Suggestions

Use of energy efficient plating barrels should be accompanied by analysis of possible benefits to process scheduling afforded by this higher productivity process. Additionally, the energy efficient plating barrels reduce liquid waste significantly. Evaluate the impact this reduction has on waste disposal system design and operating cost.

Tank insulation reduces heat loss to the work area. Heat loss is reduced further if polypropylene balls are floated on the solution surface. Evaluate the impact of reduced heat loss on ventilation requirements. It may be possible to re-engineer the ventilation system for additional energy savings.

7 Heat Treating

Introduction

Heat treating is a very common unit operation at Army industrial facilities. Heat treating is used in the production of forgings and metal parts. It is used to process finished products for a variety of reasons, and it is used to anneal metal parts such as the case and the bullet jacket for small-caliber ammunition. It is carried out in a number of different types of ovens and furnaces, which may be heated with electricity, steam, or the direct combustion of fuel. A variety of process conditions of time and temperature are used, depending on process requirements. The variety of furnace types, process conditions, fuels, and operating procedures means that a variety of specific energy conservation measures are possible, depending on the specific heat-treating situation.

Example – Quench and Temper Processes for Ferrous Parts

In the heat treating shop (Building 108) at Anniston Army Depot, one of the most common heat-treating operations is a two-step quench-and-temper operation to treat ferrous metal parts. The purpose of the process is to impart the desired properties to the part by changing the carbon content of the surface metal through treatment in a controlled atmosphere at high temperature. The process uses an integral quench furnace and a draw furnace. The natural gas-fired integral quench furnace, designated the No. 1 Furnace, is an Atmosphere Furnace Company Model UBQ-364830, which can go up to a temperature of 2000 °F. It is typically operated at 1500 to 1600 °F. The natural gas-fired draw furnace, designated the No. 2 Furnace, also made by Atmosphere Furnace, is operated typically at 800 to 1200 °F. Approximately 60 percent of the heat treating workload is processed by these furnaces.

Because both furnaces are constructed of firebrick, they are kept on all the time to minimize temperature cycling of the firebrick. They are turned down on weekends (1450 °F or so for No.1 and 300 °F for No. 2—No. 1 cannot be turned down below 1400 °F or else the controlled atmosphere will be affected). No. 1 is indirectly heated with combustion of natural gas; exhaust gases are at 1500 to

1600 °F. No. 2 is directly heated with natural gas; the exhaust is at the temperature of the furnace atmosphere.

The indirect heat for the No. 1 furnace comes from radiant furnace tubes that line the furnace wall. Combustion gases flow through the tubes; heat from the gases is transferred through the tube wall to the furnace chamber. Variations in heat transfer rate caused by failing or failed tubes affect product quality, requiring such product to be scraped or retreated. Retreating requires consumption of more energy.

In the quench-and-temper process, a part is heated in the No. 1 furnace at 1600 °F for a specified time (typically in the range of 1 to 2 hours) and then quenched in the oil bath, which is an integral part of the furnace. The part is then stress relieved in the No. 2 furnace by being treated at around 1000 °F for another 1 to 2 hours or so, after which time it is allowed to cool.

Other furnaces in the heat treating shop include Furnace No. 3, a gas-fired unit maintained at 400 to 600 °F, which processes 35 percent of the workload, and Furnace No. 6, an electric furnace maintained at 1550 to 2000 °F, which processes 5 percent of the workload.

Energy Conservation Opportunities

Table 7 gives a description and estimate of the energy and economic benefits of these ECOs.

Table 7. List of ECOs for heat treating.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Internal Rate of Return (%)	Savings-to-Investment Ratio (SIR)
Convert Electric Furnace to Natural Gas Furnace	200,000	NA	-1953	2.2	13.01	5.27
Install Jetfire Gas-fired Mantle	24,000	2,823	-1910	5.1	7.54	1.95
Convert to Composite Radiant Furnace Tubes	4,200	1,200	35	3.1	34.31	3.59

Convert Electric Furnace to Natural Gas Furnace

Conversion from electricity to natural gas may result in fuel cost savings, depending on the relative energy efficiency and fuel price of the electric furnace compared to the gas furnace. For furnaces where the operating temperature is below 1750 °F, natural gas is a technically feasible fuel. The analysis presented in Appendix A is for conversion of an integral quench furnace such as Furnace No. 6 at Anniston. Whether an electric furnace can be retrofitted with radiant tubes and natural gas burners depends on the size of the electric furnace. Small furnaces, such as the 16 kW No. 6 Furnace at Anniston, cannot be retrofitted because there is no room for the radiant tubes and burners. Therefore, the ECO for the Anniston case is to replace an electric furnace with a gas-fired furnace with a recuperator.

Install Jetfire Gas-fired Mantle

The Jetfire mantle provides indirect heat at a high heat transfer rate for a variety of heat treating applications including high temperature heat treating retort furnaces. The mantle uses a patented “Slot Jet Assembly” design to achieve a heat transfer coefficient that is higher than the corresponding coefficient for conventional gas-fired and electric mantles. The heat transfer coefficient, ranging from 25 to 60 Btu/(hr-sq ft-°F), or 142 to 341 W/(m^2-°C), which is three to five times higher than conventional gas-fired designs. The “Slot Jet Assembly” design consists of ceramic tile baffles placed between the mantle and retort furnace wall. High velocity, turbulent combustion gas flow results from gases passing through slots in these baffles. The result is an increased rate of convective heat transfer.

Convert to Composite Radiant Furnace Tubes

Conventional metallic and oxide ceramic (mullite) radiant tubes are prone to failure caused by carburization, creep, or thermal shock from rapid increases in temperature. As discussed above, tube failures may result in consumption of additional energy to retreat loads. Composite radiant tubes, which do not experience conventional tube failure modes, reduce the frequency of retreating; hence, they result in reduced energy consumption over a given period of time. Additionally, a low failure rate translates into significantly less downtime to replace failed tubes. Composite radiant tubes, composed of silicon and silicon carbide, operate at temperatures up to 2450 °F and are capable of rapid temperature recovery rates without experiencing thermal shock.

Re-Engineering Suggestions

The “Slot Jet Assembly” design that enables the Jetfire mantle to achieve a high heat transfer coefficient can be applied to other heating applications. Procedyne, the company that has patented this design approach, has used the “Slot Jet Assembly” in process heaters, gas to gas heat exchangers, and heat recuperating afterburners.

The composite radiant tube is recommended as a replacement for conventional metallic and oxide ceramic (mullite) radiant tubes when the heat treating application specifies temperatures from about 1700 up to 2450 °F. The re-engineering suggestion is to determine which heat treating operations performed at lower temperatures could be performed at higher temperatures. The lower temperatures may be maintained only to extend tube life. The operation may actually benefit from a higher cycle temperature. Benefits include reduced cycle time, resulting in higher productivity. Composite radiant tubes enable heat treating operations to be performed reliably at elevated temperatures.

8 Steam/Hot Water Distribution

Introduction

Steam is a common source of process heat for industrial facilities. Examples include steam heat for electroplating tanks, washing processes, the NC process, conditioned working spaces, and paint drying ovens.

Steam distribution system energy losses result in higher fuel consumption to ensure that sufficient quantities of steam are produced to meet process requirements. Energy losses are caused by improper steam line insulation (lack of insulation), steam leaks, and faulty steam traps. Additionally, more boiler fuel than necessary is consumed when steam is supplied: (1) to an end use at higher than necessary temperature and pressure, or (2) to an end use that may be served cost-effectively by nonsteam heat sources.

The above suggests the following steam distribution system energy management objectives:

- Minimize steam distribution system line losses by repairing leaks and maintaining or replacing steam traps.

- Match the steam pressure requirement to the end use, eliminating supply of high pressure steam to an end use that could be satisfied with lower pressure steam.

- Eliminate requirement for steam heat where an alternative energy source is more cost effective.

Example – Steam Distribution System

Site surveys (CERL 1996b) have noted the following opportunities for energy conservation:

- *Anniston Army Depot*. Steam space heaters are used in many buildings.

- *Norfolk Naval Shipyard*. Exposed steam piping in Building 510 (motor rewinding shop) – Motors failing the performance test are torn down and washed directly with 125 psia steam in a process that generates hazardous waste. The survey notes that a parts washer with a vacuum drier was on order. The parts washer/vacuum drier was intended to reduce drying time and hazardous waste. If the washer/vacuum drier has been installed, it may have replaced steam washing of motor parts. However, the benefit of insulating exposed steam piping is examined below as a generic case to serve as a model for other pipe insulation analyses.

Energy Conservation Opportunities

Table 8 gives a description and estimate of the energy and economic benefits of these ECOs.

Table 8. List of ECOs for steam distribution systems.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Return on Investment (%)	Savings-to-Investment Ratio (SIR)
Replace Steam Space Heaters with Direct Gas-fired Infrared Radiant Unit Heaters	1,200	NA	25	1.7	16.62	9.88
Insulate Lines	462	NA	727	0.2	29.36	78.58

Replace Steam Space Heaters With Direct Gas-fired Infrared Radiant Unit Heaters

Low intensity gas-fired infrared radiant tube heaters consist of a gas burner attached to a hot-rolled steel, aluminized steel, or porcelain-coated tube, which is housed in an aluminum radiant heat reflector. Gas combustion products flow through the tube, heating it. Heat is emitted from the surface of the tube as infrared radiation. Vacuum pumps are used to draw heat throughout the system. Infrared radiation transfers heat energy when it is absorbed by objects it contacts (e.g., people, floors, walls, machinery, and other objects in the heated space). The energy efficiency of these radiant heaters is 90 percent, which is more efficient than a steam radiator because: (1) the system energy efficiency for a radiator includes a gas-fired steam boiler with about 70 percent efficiency, steam distribution losses, and radiator heat transfer losses, (2) emissivity is higher for gas-fired radiant heaters than for steam radiators, and (3) radiant heat transfer is more efficient than heat transfer by convection, which is the primary means of radiator heat transfer.

Insulate Lines

Add insulation to uninsulated lines. Replace damaged or worn insulation on insulated lines.

Re-Engineering Suggestions

The steam ECOs represent two approaches to managing a steam system: (1) maintenance to ensure lines are well insulated and not leaking and to ensure that steam traps are maintained, and (2) re-engineering. Examples of re-engineering activities include:

- Remove from the steam distribution system loads that could be cost-effectively met with nonsteam technologies. This activity reduces the load on the central boiler system by: (1) eliminating the steam requirement for the end-use, and (2) eliminating the distribution losses associated with supplying the end-use.

- Match the supply of steam at a given pressure to the pressure requirements of the end-use. Avoid reducing steam pressure to match end-use requirements, and use steam at the lowest possible pressure. Low pressure steam should be used for reboilers and steam preheaters.

9 Compressed Air Distribution

Introduction

Compressed air has a variety of uses at industrial facilities, including, for:

- cleaning (e.g., remove dust and dirt) and drying parts – 30 to 40 psi air (e.g., at the plating shop at Anniston Army Depot)

- supplying air support function for rubber suits used by workers in blasting booths (e.g., in the depainting process at Anniston Army Depot)

- compressed air for spray paint guns – 30 psi air is required to operate the guns (e.g., in the painting operation at Robins Air Force Base)

- depainting – 100 psi air to propel blasting media (e.g., Anniston Army Depot); 100 psi air throttled down to 28 psi air for blasting (e.g., at Robins Air Force Base)

Generally, compressed air is generated centrally at 100 psi and distributed in pipes throughout an industrial facility. The above examples indicate that the compressed air is actually used at a lower pressure.

Energy savings in a compressed air distribution system can be achieved by:

- *Repairing leaks.* To compensate for leaks, the air compressor system supplies air at a pressure that is higher than necessary, resulting in additional electricity consumption.

- *Matching the compressed air pressure requirement to the end use.* An end use may not require 100 psi centrally generated air. Electricity consumption can be reduced by throttling the air pressure at the point of use to a lower pressure. Electricity consumption can also be reduced by meeting a lower point of use pressure requirement with a properly sized local air compressor.

- *Replacing end use technology that requires compressed air with a cost-effective technology* that uses electricity when the task can be performed effectively with an electric tool or with the latest generation of more energy efficient pneumatic tools.

Example – Compressed Air Distribution System

Centrally generated compressed air is used in DOD industrial operations such as painting, depainting, parts cleaning, and vehicle repair. The following ECOs reduce the load on the central compressor system, making it possible to operate the central compressors in a manner that reduces energy consumption. A rule-of-thumb for single-stage rotary screw compressors states that every 2 psig pressure drop at the central compressor results in a 1 percent energy savings. For a two-stage compressor the ratio is 0.8 percent energy savings for every 2 psig pressure drop.

Energy Conservation Opportunity

Table 9 gives a description and estimate of the energy and economic benefits of the point-of-use pressure control ECO. Qualitative information on upgrading tools as a means of reducing compressed air requirements is also provided.

Table 9. List of ECOs for compressed air distribution systems.

Description of ECO	Capital Cost ($)	O&M Saving ($/Yr)	Energy Savings (MBtu/Yr)	Payback (Yr)	Return on Investment (%)	Savings-to-Investment Ratio (SIR)
Point-of-Use Pressure Control	5,580	NA	267	1.4	15.84	8.65

Point-of-Use Pressure Control

Install smaller compressors locally to serve lower pressure requirement. This strategy: (1) enables the compressor size and performance to be optimized for the pressure and flow rate requirements, and (2) reduces the load on compressors in the central compressed air plant. As load on the central compressors is reduced, it becomes possible to re-engineer the central compressors to recognize energy savings. Re-engineering options include: (1) installing computer controls that enable the compressors to be operated at partial load to meet reduced site demand, or (2) reducing compressor system capacity.

Upgrade Pneumatic Tools

Compressed air powers pneumatic tools in various industrial operations. Examples include impact guns and wrenches, drills, air and rivet hammers, sanders, nailers, screwdrivers, riveters, and caulk and grease guns. The load on the central compressor system can be reduced if enough of these tools are upgraded to more energy efficient pneumatic technology that is available currently. When the load is reduced, re-engineering options may be pursued to recognize energy savings. These options include: (1) installing computer controls that enable the compressors to be operated at partial load to meet reduced site demand, or (2) reducing compressor system capacity. A rule of thumb states that a 1 percent energy savings is gained for every 2 psig central compressor system pressure drop. This ECO is only discussed in a re-engineering context.

Re-Engineering Suggestions

The compressed air ECOs reduce the load on the central compressor system. Point-of-use compressors remove load from the system. The current generation of pneumatic tools, designed to consume less air and produce less waste air, reduces the load on the system. These tools feature efficient nozzles, squeeze handles, shut-off valves, and timer controls. If the load on the central compressor can be reduced, then re-engineering options become possible. Re-engineering of the compressed air system requires a whole system approach. The system designer needs to consider the load profiles of compressed air end uses and the proximity of the end-user to the central generation plant.

Following are some operating and investment strategies that can lead to energy savings:

- Install computer controls to optimize compressor operation. Computer controls enable compressors to operate at partial load or to turn off when demand drops. This strategy is especially useful with multiple compressors. A multiple compressor control strategy seeks to operate each compressor at its optimum air output and to shut the compressor down if it is not required to meet a current demand.
- Install lower horsepower compressors in the central compressed air generation plant. This strategy works in combination with a point-of-use compressor strategy.
- Use point-of-use compressors to supply air for operations where use is concentrated, such as maintenance shops or spray painting operations. Energy savings relative to a central compressed air generation system are attribut-

able to proximity of the compressor to the end-user and to sizing a compressor to match the end-use load:

- *Proximity*: The length of air distribution line is shorter, so a smaller compressor size can be specified since less compressor capacity is needed to overcome pressure drops and leak losses.

- *Compressor sizing*: A compressor sized to meet a specific load requirement, in cubic feet per minute (cfm), is more likely to be energy efficient (e.g., deliver compressed air at a lower kW/cfm) because it is operating at an output for which it is designed (not operating at a less energy efficient partial load).

Consider replacing older pneumatic tools with newer models. Enough of these tools must be replaced to have an impact on central compressor load. New models are less forgiving than older models with respect to requiring clean air for trouble-free operation. Therefore, system design must consider upgrades to the air drying and filtering system.

References

Lin, Mike, Malcolm Fraser, and Robert Lorand, Technical Report (TR) 96/84/ADA317935 *Development of the Process Energy and Pollution Reduction (PEPR) Analysis Tool* (CERL August 1996a).

Lin, Mike, Malcolm Fraser, and Robert Lorand, *Review of Department of Defense Industrial Processes and Process Energy*, TR 96/85/ADA318032 (CERL August, 1996b).

E-Source, Inc., *Drive Power, Technology Atlas Series*, vol IV (Boulder, CO, 1996).

Appendix A: Details of Analyses of ECOs

ECO SUMMARY FORM

PROCESS CATEGORY: Load and Pack

SPECIFIC PROCESS: LAP M106 Shells at IWAAP

DESCRIPTION OF ECO:

Install Motor Controllers

A motor controller that reduces the voltage provided to a motor based on motor loading to provide "soft-start" capabilities. Motor controllers that provide soft-start reduce start-up related motor problems and can reduce motor wear and maintenance costs. This results in substantially increased motor life. Soft-start motor controllers gradually increase voltage at start-up, which avoids the rapid spike of starting current that would normally occur. This spike is several times full-load current and leads to rapid heat buildup in the motor. This limits the number of times a motor can be started over a given time interval. The soft-start motor controller reduces the starting current to about the same level as the full-load current. The controller can be applied to any motor in the process, with greater savings accruing to the larger motors. The motor controllers are particularly beneficial in situations where abrupt starting can disrupt material conveyance, where the current spike reduces power available to other equipment on the electrical system (flicker), and for high inertia loads — loads that require a disproportionate amount of start-up torque relative to steady-state power.

ASSUMPTIONS:

It is assumed that one motor controller is provided each of 3 to 50 hp motors (three controllers total). The motors operate for 6000 hours per year and have an expected life of 6 years.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

	Average kW consumption	Annual Runtime Hours	Annual Energy Use (kWh)
Full Load:	36	3,000	108,000
Part Load:	24	3,000	72,000
Total		6,000	180,000

Weight average load is 30 kW/motor (102,360 Btu/motor-hr)

CALCULATION OF ECO ENERGY AND EMISSIONS:

The energy savings of soft-start motor controllers is difficult to quantify. While they reduce the power draw (peak power), they prolong the period over which the energy is supplied. Therefore, the total energy use could be quite similar to the situation without the controller. They may be beneficial in reducing peak demands; however, since peak demand is typically measured over a 15-minute interval, and the reduction occurs over a period well under a minute, it is uncertain what the peak reduction would be. Therefore, the savings are based on the extended life of the motor – calculated as a reduced annual O&M cost.

COST DATA:

Capital Cost: $2,000/controller or $6,000 for 3 controllers.

Annual O&M Savings: Assume the motor life is extended by a factor of three. Then annualized savings per motor would be ([$2000/6 years] – [$2000/18 years]) = $221/year

Savings for 3 motors: 3 x $221 = $663

Additional savings associated with the motor drive system are also likely to accrue, but are not included.

REFERENCES:

Personal Communications between Textrol, Inc., Dallas, TX and Robert Lorand, Science Applications International Corporation (August 1999) regarding Carlo Gavazzi Soft Start Controls.

ECO SUMMARY FORM

PROCESS CATEGORY: Load and Pack

SPECIFIC PROCESS: LAP M106 Shells at IWAAP

DESCRIPTION OF ECO:

Install Power Factor Controllers

A power factor controller varies the voltage provided to a motor based on motor loading. The savings is based on the ability of the controller to better match voltage to loading requirements. This reduces power requirements, maintains a fairly constant power factor, and reduces any start-up related motor problems (incorporates "soft-start"). The reduced power requirements translate into energy savings. The savings are greatest in applications with motors that are significantly underloaded for long periods of time. The controller can be applied to any motor in the process, with greater savings accruing to the larger motors. The example shows the savings assuming 3 to 50 hp motors. Note that power factor controllers do not necessarily result in a high-power factor, but a more constant power factor. Power factor correction (e.g., capacitors) may still be needed to achieve power factor levels necessary to minimize/eliminate utility power factor penalties.

ASSUMPTIONS:

It is assumed that the one power factor controller is provided per motor. It is assumed that each motor is fully loaded for 50 percent of the time and partially loaded 50 percent of the time and operates for 6000 hours.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

Average kW consumption		Annual Runtime Hours	Annual Energy Use (kWh)
Full Load:	36	3,000	108,000
Part Load:	24	3,000	72,000
Total		6,000	180,000

CALCULATION OF ECO ENERGY AND EMISSIONS:

With Controller:

Average kW consumption		Annual Runtime Hours	Annual Energy Use (kWh)
Full Load:	33	3,000	99,000
Part Load:	15	3,000	45,000
Total		6,000	144,000

Annual Energy Savings: 180,000 kWh – 144,000 kWh = 36,000 kWh or 20 percent

For three motors, this would be 108,000 kWh (or 108,000 kWh x 3412 Btu/kWh = 368.5 Mbtu)

COST DATA:

Capital Cost: $3,250/controller or $9,750 for three controllers.

Annual O&M Savings: NA. However, additional savings in terms of longer-lived motor/associated hardware due to soft-start capability are likely (see ECO Summary Form on Motor Controllers).

REFERENCES:

Personal communication between Performance Control L.L.C and Robert Lorand, Science Applications International Corporation (August 1999).

ECO SUMMARY FORM

PROCESS CATEGORY: Explosives

SPECIFIC PROCESS: NC Production at RFAAP

DESCRIPTION OF ECO:

Recover Heat from the Dryer to Preheat Water

Heat that is exhausted from the dryer can be recovered using a water-to-air heat exchanger, and used to pre-heat water for a washing tub.

ASSUMPTIONS:

This ECO assumes that the distance between the dryer and the water to be pre-heated is not too great, so that the heat recovery costs are economic.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

The feedstock heating operation is estimated to consume 280 Btu steam per lb of NC (based on the amount of water evaporated and typical 15 percent efficiency of the drying operation). Approximately 200 Btu per lb of NC is available in the exhaust air stream.

A typical tub on boil uses 10879 MBtu/Yr. This is based on 1.654 MBtu/hr-tub (1,408 lb/hr of 40-psig steam @ 1176 Btu/lb) and operation for 75 percent of the year (6,570 hr/yr)

CALCULATION OF ECO ENERGY AND EMISSIONS:

A water-to-air heat exchanger could save 70 percent of the available heat:

0.7 x 240 Btu per lb of NC = 168 Btu per lb of NC

Annual savings assuming 28,000,000 lb of NC:

168 Btu per lb of NC x 28,000,000 lb of NC per year = 4704 MBtu/year

This would provide about 43 percent of the energy needs of a typical tub.

COST DATA:

Capital Cost: $120,000

Annual O&M Savings: NA

REFERENCES:

1. Lin, Mike, Fraser, Malcolm, and Lorand, Robert, Development of the Process Energy and Pollution Reduction (PEPR) Analysis Tool, USACERL Technical Report 96/84, August, 1996. (baseline information).

2. Personal communication between Bill Henshelwood of Richland, Inc. and Robert Lorand of Science Applications International Corporation (August 1999) for heat exchanger energy savings and cost data.

ECO SUMMARY FORM

PROCESS CATEGORY: Explosives

SPECIFIC PROCESS: NC Production at RFAAP

DESCRIPTION OF ECO:

Use Direct Steam Injection to Heat Batches of Wash Water

An in-line direct steam injection (DSI) heater is used to heat water entering tubs in the boiler house and poacher house during the fill cycle. This is in lieu of heating the water after it is filled either directly or indirectly via a jacketed tub. The DSI provides for more rapid heating of the water and improved heat transfer – this results in significant energy savings. The DSI is installed in the water inlet line to the tubs.

ASSUMPTIONS:

There are five tubs in the boiler house and three in the poacher house, each with the following dimensions: 18-ft diameter, 12-ft high, and 10-ft water depth

Water in each tank: $(3.14)(9\text{ ft})^2(10\text{ ft})$=2,544.7 cu ft or

2,544.7 cu ft x 7.481 gal/cu ft = 19,036.9 gal or

19,036.9 gal x 8.34 lb/gal = 158, 768 lb

Temperature of Fill Water = 55 °F and Final Temperature = 205 °F

40 psig saturated steam (1176 Btu/lb) provides heat input: latent heat = 918 Btu/lb, heat of condensate = 257 Btu/lb

Assuming 100 hours/cycle and each tub is used for 75 percent of the time: 0.75 x 8760 hours/year /100/hours/cycles = 65 cycles/tub/year

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

Energy required to heat one tub of water during one fill cycle:

158, 768 lb x (205 °F – 55 °F) x 1 Btu/lb- °F = 23. 815 MBtu/tub-cycle

For indirect heating this means the input steam requirements are:

23.815 MBtu/918 Btu/lb = 25,942 lb steam/tub-cycle

CALCULATION OF ECO ENERGY AND EMISSIONS:

The DSI heater enables the capture of the heat in the steam condensate and the condensed water:

1) Energy not accounting for condensed water:

23.815 MBtu/1176 Btu/lb = 20,251 lb of steam /tub-cycle

Savings not accounting for condensed water displacing fill water:

25,942 lb steam – 20,251 lb steam = 5,691 lb of steam/tub-cycle

2) Amount of condensate per tub-cycle:

20,521 lb/(158,769 lb + 20,521 lb) x 100 = 11.4 percent

of total water.

Actual fresh water needed is: 158,769 lb x (1 - .114) = 140,668 lb

Actual energy required is: 140,668 lb x (205 °F – 55 °F) x 1 Btu/lb-°F = 21.10 MBtu

21.10 MBtu/1176 Btu/lb = 17,942 lb of steam

3) Energy Savings per tub per fill cycle accounting for condensate is: 25,943 lb steam – 17,942 lb steam = 8001 lb of steam

Savings for eight tubs: 8001 lb steam/tub/cycle x 65 cycles/tub/year x eight tubs = 4.161 Mlbs of steam/year or 4.161 Mlbs of steam/year x 1176 Btu/lb steam = 4891.6 MBtu/yr

COST DATA:

Capital Cost: $11,300 ($9,300 for six constant flow DSI heaters with 15,000 lb/hr capacity each plus $2000 installation)

Heater sizing based on a 2 hour fill time vs. a 4 hr average fill time with indirect heating: 19,037 gal/(2 hr x 60 min/hr) = 158.6 gpm x (205 °F - 55 °F) x .43 = 10,232 lb steam/hr (average)

= 158.6 gpm x (205 °F - 35 °F) x .43 = 11,597 lb steam/hr (max)

Annual O&M Savings: NA

REFERENCES:

1. Lin, Mike, Fraser, Malcolm, and Lorand, Robert, Development of the Process Energy and Pollution Reduction (PEPR) Analysis Tool, USACERL Technical Report 96/84, August, 1996. (baseline information).

2. Personal communication between Slechter, Gilro Associates (Westminster, MD) and Robert Lorand of Science Applications International Corporation (August 1999) for Pick Heaters, Inc. (energy savings and cost data).

ECO SUMMARY FORM

PROCESS CATEGORY: Spray Painting

SPECIFIC PROCESS: Coatings Removal at CCAD

DESCRIPTION OF ECO:

Use FLASHJET Coatings Removal Process

The FLASHJET coatings removal process exposes painted surfaces to high-intensity pulsed light energy from a xenon-flashlamp. The energy explodes the coating into a fine ash. A continuous stream of carbon dioxide pellets cools and cleans the surface and forces effluent ash into a capture system. The effluent capture system separates the ash and organic vapors. Ash goes through high efficiency particulate air (HEPA) filters; vapors are absorbed by activated charcoal.

The FLASHJET process was developed by The Boeing Company. The process is being installed at the USAF Warner Robins Air Logistics Center in Georgia and the USA Corpus Christi Army Depot (CCAD) in Texas.

ASSUMPTIONS:

The following are based on information used in analyzing application of the Flashjet process at CCAD for depainting helicopters. The Flashjet process replaces the existing depainting process at CCAD, which involved blasting with plastic media and application of paint stripper.

Operating hours: The Flashjet process must be operated for more hours to achieve the same amount of depainting as the current plastic media/paint stripper method – Flashjet 1,864 hours/year; Plastic Media Blasting 1,600 hours/year.

Voltage requirement (480 VAC): Unchanged (Same for both Plastic Media Blasting to Flashjet.)

Annual O&M Savings:

Labor cost: Flashjet - $147,833/year; Plastic Media Blasting - $469,138/year. Flashjet labor is lower partly because less clean-up is required.

Material cost: No plastic media - $35,222/year; No paint stripper - $17,040/year; No miscellaneous material - $8,707/year.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

480 VAC x 400 amps x 1 kW/1,000 VAC-amps x 3,412 Btu/kWh = 655,104 Btu/hr

CALCULATION OF ECO ENERGY AND EMISSIONS:

480 VAC x 300 amps x 1 kW/1,000 VAC-amps x 3,412 Btu/kWh = 491,328 Btu/hr

COST DATA:

Capital Cost: $3.5 million for the system at CCAD.

Annual O&M Savings: ($469,138/year - $147,833/year) Labor Cost Savings + ($35,222/year + $17,040/year + $8,707/year) Material Cost Savings = $382,274/year

REFERENCES:

Personal communications between Thomas L. Nied, The Boeing Company, and William R. King, SAIC, 1999.

Personal communications between Jim Holiday, Corpus Christi Army Depot, and William R. King, SAIC, 1999.

"Boeing Books Two Sales of Flashjet Paint Removal System," The Boeing Company, December 10, 1998.

Other product literature and news releases from The Boeing Company.

"Flashjet Coatings Removal Process: Minimizing DOD Depainting Waste," U.S. Army Environmental Center, available through URL: wysiwyg://Homepage.8/http://aec-ww…8080/prod/usaec/et/pp/flashjet.htm

ECO SUMMARY FORM

PROCESS CATEGORY: Spray Painting

SPECIFIC PROCESS: Vehicle Drive-Through Paint Booth at RIARS

DESCRIPTION OF ECO: Convert from Conventional Non-HVLP Spray Gun to Electrostatic HVLP Spray Gun

Electrostatic HVLP spray guns add a charge to sprayed paint particles, which increases the transfer efficiency of the paint to the grounded piece being painted. The result is less paint overspray, which translates into reduced paint waste and energy savings from disposing less waste.

Two kinds of electrostatic HVLP spray guns have been identified. In one design, a high voltage ion cloud (e.g., 60 to 90 kv) is generated by the gun; atomized paint is charged as it is sprayed through the cloud. A more efficient alternative is to mount a grounded needle probe, charged to create a voltage field of 6 to 10 kv, at the outlet of the gun. Each paint particle receives a negative charge as it comes in contact with the charged field around the needle probe. The ECO analyzed in this summary is the HVLP spray gun using the grounded needle probe technology, which is patented by Accuspray. Advantages of the Accuspray electrostatic HVLP technology relative to other electrostatic gun technologies are no Faraday cage effect, no picture framing, even particle distribution, and no metallic color shift.

ASSUMPTIONS

Transfer Efficiency

The following table compares the transfer efficiency (percentage of paint transferred to the product) of the Accuspray gun to alternatives.

Type of Spray Gun	Transfer Efficiency (Percent)
Conventional Non-HVLP	40
HVLP	75
Electrostatic HVLP	90

A high transfer efficiency results in significant paint savings since less paint needs to be sprayed to transfer the same amount of paint to a part. The following table demonstrates this relationship, using as a reference 1 gal per hour of paint sprayed by a conventional system, which results in 0.4 gal per hour of paint transferred to the part.

Technology	Gal/hr sprayed x Transfer efficiency = Gal/hr transferred to part
Conventional	1 x 0.4 = 0.4
HVLP	0.53 x 0.75 = 0.4
Electrostatic HVLP	0.44 x 0.90 = 0.4

Capital Cost

The following table compares costs of different spray gun options. The high end of the HVLP gun price range reflects the cost of higher quality components in the gun. Higher quality components give the gun a much longer in-service life.

Type of Spray Gun	Capital Cost ($)/Gun
Conventional Non-HVLP	
HVLP	259 to 375
Electrostatic HVLP	3,300

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

Property and Emission Type	Paint Composition (polyurethane)	Conventional Emissions (1 gal sprayed/hr)		Electrostatic HVLP Emissions (0.44 gal sprayed/hr)	
		Uncontrolled[1]	Controlled[2]	Uncontrolled[1]	Controlled[2]
		(lb/hour)		(lb/hour)	
Density	11.68 lb/gal				
Solids	35.0%				
TSP		2.45	0.049[4]	0.18	0.004[4]
PM10[3]		1.23	0.025[4]	0.09	0.002[4]
VOCs	62.0%	7.24	7.24	3.19	3.19
HAPs					
Xylene	5%	0.58	0.58	0.26	0.26
Methyl ethyl ketone	10%	1.17	1.17	0.51	0.51
Chromium compounds	10%	0.70	0.014[4]	0.05	0.001[4]
Toluene	5%	0.58	0.58	0.26	0.26

[1] VOC and volatile HAP emissions equal their amount in the paint sprayed because they evaporate during spraying; therefore, Uncontrolled Emissions Amount (lb/hr) = Gal/hr sprayed x Paint Composition (%) x Paint Density (lb/gal). Gal/hr sprayed decreases as transfer efficiency increases; see the table under the Transfer Efficiency discussion, above. Solids and chromium are transferred in paint to the painted surface; therefore, only the amount contained in overspray is emissions. In this case, Uncontrolled Emissions Amount (lb/hr) = Gal/hr sprayed x (1-Transfer Efficiency) x Paint Composition (%) x Paint Density (lb/gal).

[2] VOC and volatile HAP emissions are usually not controlled, so Controlled emissions = Uncontrolled emissions.

[3] 50% of TSP is PM_{10}, assuming a waterfall booth. For a dry filter, 100% of TSP is PM_{10}.

[4] (1-0.98) x Uncontrolled Value, assuming 98% control of particulates.

CALCULATION OF ECO ENERGY AND EMISSIONS

See Electrostatic HVLP column in table under "Calculation of Baseline Energy and Emissions," above, for emissions savings. A HVLP spray gun uses compressed air at a lower pressure than does a conventional spray gun. However, to realize this potential energy savings, which is small, the supply of compressed air would have to be reduced in pressure or otherwise revamped. Usually, the compressed air is simply throttled to the lower pressure of the HVLP gun. Electrostatic HVLP guns consume electricity to generate charge, but any increase in electricity consumption relative to a conventional non-HVLP gun is presumed negligible because the high electrostatic HVLP gun transfer efficiency reduces the time needed to paint a part relative to the conventional gun.

COST DATA:

Capital Cost: $3,300 per gun (including $1,750 for one AccuCharge Low Pressure Inlet Gun, $390 for one 30-ft Hose Assembly for the Low Pressure Inlet Gun, and $1,160 for the Production Turbine or Blower Power Supply to control one gun)

Annual O&M Savings: 6.5 lb paint saved/hr x 2000 hr/yr x $2/lb of paint = $26,000/year

Case	Amount of Wasted Paint (lb/hr)	Paint Savings Relative to Baseline (lb/hr)
Baseline	1 gal/hr sprayed x (1 – 0.4 transfer effic.) x 11.68 lb/gal density = 7.01	—
ECO	0.44 gal/hr sprayed x (1 – 0.9 transfer effic.) x 11.68 lb/gal density = 0.51	6.5

REFERENCES:

U.S. Navy, "Electrostatic Paint Spray System," Joint Service Pollution Prevention Opportunity Handbook, http://enviro.nfesc.navy.mil/p2library/4-02_896.html, 1996.

Personal communications between Accuspray technical services personnel and William R. King, SAIC, 1999.

Accuspray product literature, including literature for the Accucharge product line, 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Electroplating

SPECIFIC PROCESS: Electroplating Small Parts in Barrels at CCAD

DESCRIPTION OF ECO:

Use Staggered Cell Plating Barrel

Plating barrels are used to electroplate small parts; the barrels at CCAD are approximately a gallon in capacity and are used to plate battery hardware. The conventional plating barrel is a hexagonal design constructed of polypropylene panels with drilled holes through which electrolytic solution flows. Whyco Technologies' staggered cell barrel design reduces plating time by 20 percent and reduces the amount of drag-out solution waste by up to 60 percent. These benefits are achieved by reducing the depth of the holes and by increasing the number of holes per unit area. The cells are machined into the polypropylene barrel wall, achieving a honeycomb effect where the walls of the cells enable the barrel to retain structural strength while reducing barrel wall thickness. Fluid transfer holes drilled into such a wall are 1/3 to 1/4 of the wall thickness, resulting in reduced solution drag-out compared to conventional barrels, where the hole is the full wall thickness. The full wall thickness of the Whyco barrel is 3/4 in. Also, because the cell walls reinforce the barrel wall, the number of holes per open area of wall can be maximized, enhancing fluid transfer rate and plating speed. The reduced hole depth also causes a change in geometry that increases the current density on the plated surface, resulting in an increase in plating speed.

The plating barrel is lowered mechanically or manually into a plating tank, where it is connected to a motor shaft for rotation.

ASSUMPTIONS:

The Whyco plating barrel replaces a conventional barrel. Both barrels are hexagonal. Both barrels are constructed of polypropylene, which can by used at temperatures up to 180 °F.

Based on performance tests by Whyco, the Whyco barrel reduces plating time by 20 percent. The power requirement is assumed to be 5 kW per plating barrel for either the conventional or Whyco barrels. The power requirement is based on

Whyco electricity metering data covering periods with and without barrel operation. Both of these parameters are averages; actual values depend on the chemical composition of finish being plated.

The cost of a 10-in. diameter, 12-in. length Whyco barrel with 1/16-in. diameter holes and a flat interior is $669. These barrel and hole sizes are the smallest made by Whyco. This barrel size approximates the gallon-size barrels used at Corpus Christi Army Depot (CCAD) to plate battery parts.

Barrel life is assumed to be 10 years.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

5 kW/barrel x 3,412 Btu/kWh = 17,060 Btu/barrel-hour

CALCULATION OF ECO ENERGY AND EMISSIONS:

Assuming 20 percent decrease in plating time because of increased plating efficiency.

0.8 x 5 kW/barrel x 3,412 Btu/kWh = 13,648 Btu/barrel-hour

COST DATA:

Capital Cost: $669/barrel for 10-in. diameter, 12-in. length barrel with flat (not dimpled) interior and 1/16-in. holes.

Annual O&M Savings: None.

REFERENCES:

Personal communications between Brian Lucas, Whyco Technologies, Inc., and William R. King, SAIC, 1999.

Product literature for Whyco Barrel, Whyco Technologies, Inc.

Whyco Technologies, Inc. information from NICE3 proposal submitted to USDOE.

"Waste-Minimizing Plating Barrel Increases Productivity," NICE3 Success Story, Office of Industrial Technologies, USDOE, February 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Electroplating

SPECIFIC PROCESS: Electroplating Shop at WARS

DESCRIPTION OF ECO:

Insulate Electroplating Tanks Operated over 150 °F

Addition of insulation to electroplating tanks operated over 150 °F will reduce heat losses, thus reducing energy consumed to maintain electroplating solution at a specific temperature. Insulation would be added to the four sides of the tank. To reduce energy loss from the plating solution surface, which is exposed to air, consider floating polypropylene balls, another PEPR ECO, on the surface.

ASSUMPTIONS:

The example specifications are for a phosphating tank that handles cannon parts.

Ambient temperature outside tank = 80 °F

Temperature inside tank = 190 °F

Tank dimensions (feet): length – 10; width – 5; height – 5

Average wind velocity = 0 mph

Outside surface emittance = 0.10

Uninsulated surface emittance = 0.90, for steel tank

Heat Losses (from North American Insulation Manufacturers Association, 3E Plus Insulation Thickness Computer Program, which uses ASTM C680 calculation method)

> Uninsulated tank loss = 233 Btu/(hr-sq ft)
> Insulated tank loss (for 1 in. of Armstrong AP Armaflex elastomeric ASTM C534-88 thermal insulation) = 25 Btu/(hr-sq ft). The four sides of the tank are insulated.

Operating hours per year = 1,500 hours/tank-year

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

233 Btu/(hr-sq ft) x (2 x 5 ft height x [10 ft length + 5 ft width]) = 34,950 Btu/hour heat loss

CALCULATION OF ECO ENERGY AND EMISSIONS:

25 Btu/(hr-sq ft) x (2 x 5 ft height x [10 ft length + 5 ft width]) = 3,750 Btu/hour heat loss

COST DATA:

Capital Cost: $1.83/sq ft x 150 sq ft = $275

Annual O&M Savings: None.

REFERENCES:

Personal communication between Jim Holiday, Corpus Christi Army Depot, and William R. King, SAIC, 1999.

Personal communication between Dave Trevett, Watervliet Arsenal, and William R. King, SAIC, 1999.

Personal communication between Smock & Schonthaler Industrial Insulation Sales, Inc., sales personnel and William R. King, SAIC, 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Heat Treating

SPECIFIC PROCESS: Quench and Temper Process for Ferrous Parts at WARS

DESCRIPTION OF ECO:

Convert Electric Furnace to Natural Gas Furnace

For furnaces where the operating temperature is below 1750 °F, natural gas is a technically feasible fuel. The following discussion focuses on conversion of an integral quench furnace such as Furnace No. 6 at Anniston. Whether an electric furnace can be retrofitted with radiant tubes and natural gas burners depends on the size of the electric furnace. Small furnaces, such as the 16 kW furnace at Anniston, cannot be retrofitted because there is no room for the radiant tubes and burners. Therefore, the ECO for the Anniston case is to replace an electric furnace with a gas-fired furnace with a recuperator. The gas-fired model analyzed below is an integral quench furnace with four U-tube radiant heaters, two on each side of the furnace chamber. Each U-tube has a gas entry side, to which the burner is attached, and an exhaust side. Hot combustion gases flow through the core of the tube, which radiates the heat. The model analyzed is the smallest with the capability of being configured as either an electric or a gas furnace. The electric version contains six 10 kW electric heating elements, each inserted into the core of a straight radiant tube, with three tubes on each side of the chamber.

The gas furnace requires periodic replacement of radiant furnace tubes; however, maintenance cost is not expected to differ significantly from that for an electric unit according to the manufacturer.

The decision to convert depends on the magnitude of fuel cost savings, which depends on the relative energy efficiency and fuel price of the electric furnace to the gas furnace.

ASSUMPTIONS:

Anniston furnace No. 6, a 16 kW integral quench furnace incorporating both a heating chamber and an oil quench bath, is an example of an electric heat treating furnace. It handles 5 percent of the Anniston heat treating workload. It is used 3 to 4 days per week for one 9-hour shift each day for hardening small metal parts (e.g., tank parts, screws). Furnace temperature is maintained continuously within a range of 1,550 to 2,000 °F, even when not in use. The actual operating profile for the existing furnace was not available.

Following are the specifications for the No. 6 furnace:

Manufacturer/Model: Lucifer Furnace, Inc. (Warrington, PA)/Model Number 7EQ136

Chamber Size: 10-in. high x 10-in. wide x 36-in. long

Input Wattage: 16 kW (equivalent to 54,592 Btu/hr)

Number of Electric Heating Elements: 3

Energy Efficiency: 1.00

Atmosphere Furnace Company (AFC) does not make a gas-fired model with a chamber as small as that in the No. 6 furnace. Therefore, the example electricity to gas conversion economics are based on the smallest gas-fired model with recuperator made by AFC. This model has a volume about six times that of the existing Lucifer furnace at Anniston. It is assumed that if Anniston were to use this option the furnace would be operated to take advantage of its higher load capacity. The economic analysis compares this model to an electric furnace with equivalent heat treating capacity. The only difference between the models is the energy efficiency factor, which is 1 (e.g., 100 percent) for the electric furnace and 0.75 (e.g., 75 percent) for the gas furnace with recuperator.

ECO Furnace Specifications:

Manufacturer/Model: Atmosphere Furnace Company (Wixom, MI)/Model Number UVQG243624 (the “G” indicates gas fuel; an “E” would designate electricity)

Chamber Size: 24-in. high x 24-in. wide x 36-in. long

Type of Radiant Tube Heater: Metal alloy

Furnace Rating (Btu/hour, input): 1 million Btu/hour

Maximum Furnace Load (lb): 1,100

Energy Efficiency: 0.75

Annual Operating Hours:

For illustrative purposes, the operating profile for the No. 1 Anniston gas-fired integral quench furnace will be used in the analysis. From available operating information (see above), the No. 6 furnace appears to operate in the same temperature ranges for the same number of hours per week.

1. Consumes 1.4 MBtu/hr (the maximum) for 20 hr/wk x 50 wk/yr = 1000 hr/yr

2. Consumes 1.0 MBtu/hr idling at 1600 °F for 20 hr/wk x 50 wk/yr = 1000 hr/yr

3. Consumes 0.8 MBtu/hr turned down to 1400 °F for (8676-2000) hr/yr = 6760 hr/yr

Total energy 7808.0 MBtu/yr (average 0.891 MBtu/hr)

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

The baseline is an electric furnace; therefore, the following converts the gas furnace MBtu/hr consumption operating profile shown in the Annual Operating Hours Assumptions, above, from a 75 percent gas furnace energy efficiency basis to a 100 percent electric furnace energy efficiency basis:

1. Consumes 1.4 MBtu/hr x (0.75/1.00) (the maximum) for 20 hr/wk x 50 wk/yr = 1000 hr/yr

2. Consumes 1.0 MBtu/hr x (0.75/1.00) idling at 1600 °F for 20 hr/wk x 50 wk/yr = 1000 hr/yr

3. Consumes 0.8 MBtu/hr x (0.75/1.00) turned down to 1400 °F for (8676-2000) hr/yr = 6760 hr/yr

4. Total energy 5856.0 MBtu/yr (average 0.668 MBtu/hr)

CALCULATION OF ECO ENERGY AND EMISSIONS:

1. Consumes 1.4 MBtu/hr (the maximum) for 20 hr/wk x 50 wk/yr = 1000 hr/yr

2. Consumes 1.0 MBtu/hr idling at 1600 °F for 20 hr/wk x 50 wk/yr = 1000 hr/yr

3. Consumes 0.8 MBtu/hr turned down to 1400 °F for (8676-2000) hr/yr = 6760 hr/yr

4. Total energy 7808.0 MBtu/yr (average 0.891 MBtu/hr)

Note Regarding Payback Calculation for Fuel-Switching Cases: The ECO appears to use more energy than the baseline case, because the end-use energy efficiency for gas is lower than for electricity; however, the payback calculation is based on the dollar savings of switching from electricity to gas fuel. The electricity generation efficiency, which is much lower than the gas end-use efficiency, is incorporated in the electricity price, making it much higher than the gas price and reflecting the fuel used in electricity generation.

COST DATA:

Capital Cost: $200,000, Uninstalled, for the Atmosphere Furnace Company gas-fired integral quench furnace with recuperator described above. Installation (moving, unpacking, reassembling on location, and furnace start-up) adds 17-20 percent to the uninstalled price. Assume $240,000, Installed.

Example Payback Calculation for Anniston: $240,000/(5856 MBtu/yr x ($0.0336/kWh average electricity price/0.003412 MBtu/kWh) – 7808 MBtu/yr x $4.90/MBtu gas price) = 12 years

NOTE: The discussion above presents furnace information for Anniston; however, a higher electricity price than that at Anniston is needed to bring payback into an acceptable range. Assuming a $0.05/kWh average electricity price, the payback would be 5 years. In the PEPR model, this ECO is placed at Watervliet Arsenal because of the higher electricity price at that arsenal.

Annual O&M Savings: None.

REFERENCES:

Personal communications between John Taylor and Bernard Parry, Atmosphere Furnace Company, and William R. King, SAIC, 1999.

Personal communication between Frank Wilson, Furnace Operator at Anniston, and William R. King, SAIC, 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Heat Treating

SPECIFIC PROCESS: Quench and Temper Process for Ferrous Parts at WARS

DESCRIPTION OF ECO:

Replace Electric Heating Technology With Jetfire Gas-fired Mantle Technology

The Jetfire mantle provides heat for a variety of heat treating applications including high temperature heat treating retort furnaces. An advantage of the mantle is its high heat transfer coefficient, ranging from 25 to 60 Btu/(hr-sq ft-°F), or 142 to 341 W/(m^2-°C), which is 3 to 5 times higher than conventional gas-fired designs. The high heat transfer coefficient is a result of the patented "Slot Jet Assembly" used in the mantle design. This assembly consists of ceramic tile baffles placed between the mantle and retort furnace wall. High velocity, turbulent combustion gas flow results from gases passing through slots in these baffles. The result is an increased rate of convective heat transfer.

Procedyne, a vendor of fluidized bed heat treat furnaces, developed the Jetfire mantle as an alternative to an electrically heated mantle. For a cold load placed into a fluid bed, the Jetfire mantle recovers setpoint temperature faster than electrically heated mantles used by Procedyne. Burner options for the Jetfire include a Hauck MGB-160 burner, standard low NO_x burners, or a pair of North American TwinBed regenerative burners.

ASSUMPTIONS:

The analysis conducted below compares performance of electric and Jetfire mantles on Procedyne fluidized bed technology. Procedyne has applied the "Slot Jet Assembly" technology in nonfluidized bed process heating applications. It is assumed that savings similar to those for the fluidized bed case would result. It is the capability of the "Slot Jet Assembly" technology to be applied to other heating applications that would be most useful to DOD heat treating applications.

The following assumptions are based on tests of the Jetfire mantle conducted for the Industrial Center, Inc., by AGAResearch. The Performance Comparison table, below, shows that for heat treating equivalent load ratings for equivalent cycle time an electric mantle furnace would require a larger diameter than the Jetfire mantle furnace. The Jetfire mantle and the Electric Furnace 3848 have equivalent rates of heat transfer to the load, as shown by multiplying thermal efficiencies of 25 percent and 100 percent, respectively, by the proper Heat Input Rating.

Performance Comparison

Characteristic	Units	Jetfire Unit	Electric Furnace 3848
Load Rating	Pounds	3300	3300
Working Diameter	Inches	30	38
Heat Input Rating	MBtu/hr	1.6	0.4
	kW	n/a	115
Fluidized Gas Rate	SCFM	22	30

The Monthly Fuel, Electricity, and Fluidized Gas Consumption table, below, shows data for one month of operation, equal to total furnace run time of 363 hours. During this month, operating parameters varied within the ranges shown in the Furnace Operation Range table, below.

Note: Both the Jetfire unit and the electric fluidized bed furnaces consume fluidizing gas.

Monthly Fuel and Electricity Consumption and Fluidized Gas Cost

Characteristic	Units	Jetfire Unit	Electric Furnace 3848
Gas Consumption – Mantle	MBtu/mo	194.057	0
Fluidizing Gas	$/mo	$646.83	$882.04
Electricity Consumption	kWh/mo	4,435.91	14,654.00
	MBtu/mo	15.14	50.00

Furnace Operation Range

Parameter	Range
Load Weight (lb)	912-3,324
Control Temperature (°F)	1,030-1,120
Tempering Cycle Times (hours)	2-3
Nitriding Cycle Times (hours)	9-35
Heat-up Times (hours)	0.66-2

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

50 MBtu/month x 12 months/year = 600 MBtu/year (68,493 Btu/hr @ 8760 hr/year)

Procedyne assumed an average electricity price of $0.097/kWh ($28.43/MBtu) in their economic calculations. At this rate, the electricity cost is $17,058.

Note: This ECO does not produce fuel cost savings relative to the baseline when lower electricity prices are assumed. For instance, the $9.85/MBtu ($0.0336/kWh) average price at Anniston is too low to generate fuel cost savings.

CALCULATION OF ECO ENERGY AND EMISSIONS:

Note: Relative to the baseline, this ECO consumes more Btus of a less expensive energy source, resulting in energy cost savings. Low ECO payback depends on fluidizing gas cost savings (see Annual O&M Savings, below).

194.1 MBtu/month gas consumption x 12 months/year + 15.1 MBtu/month electricity consumption x 12 months/year = 2510.4 MBtu/year

Fuel Consumption converted to Btu/hr:

Gas: (194.1 MBtu/month gas consumption x 12 m/yr)/8760 hr/yr = 265,890 Btu/hr

Electricity: (15.1 MBtu/month electricity consumption x 12 m/yr)/8760 hr/yr = 20,685 Btu/hr

Assuming a gas price of $4.90/MBtu for Anniston and the electricity cost of $28.43/MBtu assumed by Procedyne, annual energy cost is $11,413.08/year gas cost + $5,151.52/year electricity cost = $16,565, or a savings of $493/year relative to the baseline. Thus, O&M savings are critical to achieving a low payback (see calculations under "Cost Data").

COST DATA:

Capital Cost: $24,000 premium over the cost of a Procedyne 3848 electric furnace.

Annual O&M Savings: Cost of fluidizing gas, which is $882.04/month for the electric furnace and $646.83/month for the Jet-fire unit, leading to annual savings of ($882.04/mo-$646.83/month) x 12 = $2,822.52/year.

The following payback calculation includes both Energy Cost Savings and O&M Savings:

$24,000/($493/year fuel savings + $2823/year fluidizing gas savings) = 7 years

NOTE: A high electricity price is needed to obtain an acceptable payback. For this reason, this ECO is placed at Watervliet Arsenal in the PEPR model. Even at Watervliet, the Adjusted Electricity Cost had to be raised $10/MBtu, from $18.91692/MBtu to $28.91692/MBtu to get an acceptable payback. Procedyne designs other applications of the “Slot Jet Assembly” technology that may be more cost-effective for specific applications.

REFERENCES:

Personal communication between Karin Bickford, Procedyne, and William R. King, SAIC, 1999.

Gas Research Institute, GRINet (http://www.gri.org/), *Jetfire Mantle Furnace*, 1999.

Energy International, Inc. and AGAResearch, *“Jet-Fire” Heating Mantle Performance Evaluation*, Final Report, January 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Heat Treating

SPECIFIC PROCESS: Quench and Temper Process for Ferrous Parts at ANAD

DESCRIPTION OF ECO:

Replace Conventional Metallic or Mullite Furnace Tubes With Composite Radiant Furnace Tubes

Radiant furnace tubes enable heat from combustion gases, the by-products of burning natural gas, to be transferred indirectly to a heat treating furnace load. The furnace is lined with such tubes through which the gases flow. Indirect heating protects the furnace load from components of these gases that could harm product quality.

Conventional metallic and oxide ceramic (mullite) radiant tubes are prone to failure. Metallic tube failure is caused primarily by carburization and creep; mullite tube failure is caused primarily by thermal shock. Composite radiant tubes, composed of silicon and silicon carbide, do not experience these failure modes. They resist failure caused by creep, thermal shock, carburization, melt-through, and oxidation. The properties of a silicon/silicon carbide tube that enable it to resist failure also result in the following operational advantages:

- Withstands faster furnace recovery rates, improving furnace productivity and reducing energy wasted during start-up.

- Operates up to a higher temperature (up to 2450 °F) without failure than conventional tubes, also enabling faster furnace recovery times.

- Significantly reduces downtime required to replace failed tubes. Manufacturer experience with composite radiant tubes indicates an average age of 2.6 years, compared to an average life of 1.6 years for metallic tubes and 1.4 years for mullite tubes. Some composite tubes are still in service after about 8 years.

- Reduces frequency with which product quality will be compromised by a tube starting to fail or failing during a heat treating cycle. Variations in heat transfer rate caused by such tubes affect product quality.

Burners for U-shaped tubes and straight tubes are not interchangeable; therefore, if the existing furnace has U-shaped tubes and the change is from U-shaped tubes to straight composite radiant tubes, new burners are needed for all composite tubes.

ASSUMPTIONS:

The analysis is based on replacement of the existing HT alloy U-tubes in No. 1 Furnace at Anniston with composite radiant tubes of equivalent design (e.g., U-tube vs. straight tube) and dimensions. This furnace has the following specification:

- Gas-fired Integral Quench Furnace
- Atmosphere Furnace Company Model UBQ-364830, Serial No. 6988
- Contains 4 HT alloy U-tubes, attached to and fired from the top of the furnace
- U-tube Dimensions: 6 5/8-in. OD x 6 1/8-in. ID, with overall length of 6 ft 3 in.

Normally, composite radiant tubes are sold based on productivity advantages. They enable faster start-ups and quicker temperature recovery cycles because they can withstand faster firing rates without failing. Since the tubes last longer, they reduce downtime and the costs associated with downtime (e.g., lost production, labor costs to replace failed tubes and restart the furnace). Any energy savings associated with start-up and shut-down of a furnace has not been quantified.

The energy savings analysis is based on reducing the amount of product that needs to be reworked because a failed/failing tube altered the heat distribution in the furnace chamber, resulting in product that does not meet heat treating specifications. Assume that the heat treating chemistry is such that proper specifications can be obtained by retreating. At Anniston, product requiring retreating is placed in the furnace for another cycle to complete the treatment, resulting in consumption of additional energy.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

Integral Quench Furnace:

1. Consumes 1.4 MBtu/hr (the maximum) for 20 hr/wk x 50 wk/yr = 1000 hr/yr

2. Consumes 1.0 MBtu/hr idling at 1600 °F for 20 hr/wk x 50 wk/yr = 1000 hr/yr

3. Consumes 0.8 MBtu/hr turned down to 1400 °F for (8676-2000) hr/yr = 6760 hr/yr

4. Total energy 7808.0 MBtu/yr (average 0.891 MBtu/hr)

No information on emissions.

CALCULATION OF ECO ENERGY AND EMISSIONS:

The baseline operating profile shown above includes energy attributable to retreating in the 1.4 MBtu/hr portion of the profile. At Anniston, the amount of retreating apparently is not significant and was not quantifiable. Therefore, the following example assumes that with composite radiant tubes, furnace operating time at 1.4 MBtu/hr would be reduced by 10 percent. Payback should be based on the $4,200 incremental cost of four composite radiant U-tube over four HT U-tubes. Assuming an energy savings from a 10 percent reduction in the amount of furnace treating time because of less rework, valued at a gas price of $4.90/MBtu for Anniston, the payback would be:

$4,200/((7808 MBtu/yr-7768 MBtu/yr)x$4.90/MBtu) = 21 years.

When the payback calculation includes the reduced operating cost of less frequent replacement of failed tubes, an O&M savings, the payback is:

$4,200/((7808 MBtu/yr-7768 MBtu/yr)x$4.90/MBtu + $1200/yr) = 3 years.

Integral Quench Furnace:

1. Consumes 1.4 MBtu/hr (the maximum) for 20 hr/wk x (1-0.1) x 50 wk/yr = 900 hr/yr

2. Consumes 1.0 MBtu/hr idling at 1600 °F for 20 hr/wk x (1+0.1) x 50 wk/yr = 1100 hr/yr

3. Consumes 0.8 MBtu/hr turned down to 1400 °F for (8760-2000) hr/yr = 6760 hr/yr

4. Total energy 7768.0 MBtu/yr (average 0.887 MBtu/hr)

COST DATA:

Capital Cost: $2,250 per U-tube for an Inex composite radiant tube, compared to approximately $1,200 for a HT alloy tube or $1,300 for a HU alloy tube. For the No. 1 Furnace at Anniston, the cost of four composite radiant U-tubes to replace four HT alloy U-tubes would be $9,000. This quote is for tubes only and does not include any mounting hardware. Note: In April 1999, Inex began building a production line to make composite radiant U-tubes with the dimensions required at Anniston.

Annual O&M Savings: The following algorithm is from the GRI Payback Calculator for composite tube savings. It includes a calculation of average tubes replaced annually:

Savings attributable to longer tube life (reduced frequency of replacing tubes) = (4 U-tubes in furnace/1.6 year HT alloy tube life) x $1,200/tube – (4 U-tubes in furnace/5-year composite tube life) x $2,250/tube = $1,200/year savings.

Note: An average life of 2.6 years is cited under "Description of ECO" for composite tubes, but that such tubes are still in service after 8 years. The assumption of a composite tube life of 5 years assumes furnace operating temperatures would remain in the range specified for the tube. Anniston's operating temperatures are within this range.

Additional unquantified savings include labor and lost production costs associated with unscheduled shutdowns to replace failed tubes.

REFERENCES:

Personal communications between Michael Kasprzk, INEX, Inc., and William R. King, SAIC, 1999.

Gas Research Institute, GRINet (http://www.gri.org), "Composite Radiant Tube Deployment – Furnace Upgrades and Electric-to-Gas Conversions," 1999.

Gas Research Institute, GRINet (http://www.gri.org), *Composite Radiant Tube Tool Kit*, 1999.

Gas Research Institute, GRINet (http://www.gri.org), "Composite Radiant Tubes: Opportunity for the Heat Treating Industry," 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Steam/Hot Water Distribution

SPECIFIC PROCESS: Steam Space Heat at WARS

DESCRIPTION OF ECO:

Replace Steam Space Heaters With Direct Gas-Fired Unit Heaters

Low intensity gas-fired infrared radiant tube heaters consist of a gas burner attached to a hot-rolled steel, aluminized steel, or porcelain-coated tube, which is housed in an aluminum radiant heat reflector. Gas combustion products flow through the tube, heating it. Heat is emitted from the surface of the tube as infrared radiation. Vacuum pumps are used to draw heat throughout the system. Infrared radiation transfers heat energy when it is absorbed by objects it contacts (e.g., people, floors, walls, machinery, and other objects in the heated space). The energy efficiency of these radiant heaters is 90 percent, which is more efficient than a steam radiator for the following reasons: (1) the system energy efficiency for a radiator includes a gas-fired steam boiler with about 70 percent efficiency, steam distribution losses, and radiator heat transfer losses, (2) emissivity is higher for gas-fired radiant heaters than for steam radiators, and (3) radiant heat transfer is more efficient than heat transfer by convection, which is the primary means of radiator heat transfer.

ASSUMPTIONS:

Heated area (square feet): 1080 (area covered by one 100,000 Btu/hour (gas fuel input) Vantage II unitary gas-fired radiant heater)

Height of infrared heat above floor (feet): 18

Space heat requirement (Btu/hr): 90,000

Steam radiator specifications:

Energy efficiency (at radiator): 80 percent

Steam enthalpy (saturated vapor at 10 psig, in Btu/lb): 1160

Infrared heater specifications (Roberts-Gordon Vantage II unitary heater):

Energy efficiency: 90 percent

Heating hours per year: 2000

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

100,000 Btu/hr fuel consumption$_{\text{gas-fired radiant}}$ x (0.9 efficiency$_{\text{gas-fired radiant}}$/0.8 efficiency$_{\text{steam radiator}}$) = 112,500 Btu/hr (or 97 lb$_{\text{steam}}$/hr at enthalpy stated in Assumptions)

CALCULATION OF ECO ENERGY AND EMISSIONS:

100,000 Btu/hr (see Assumptions)

COST DATA:

Capital Cost: $1,200 per 30 ft long, 100,000 Btu/hr Vantage II unitary heater

Annual O&M Savings: N/A, positive savings relative to steam system

NOTE: Steam space heaters have been noted at both Anniston Army Depot and Norfolk Naval Ship Yard. The economics for this option have been evaluated using higher Watervliet energy prices.

REFERENCES:

Roberts-Gordon, Inc., product literature from Power Dynamics Corporation (Lanham, MD), 1999.

Roberts-Gordon, Inc., Co-Ray-Vac installation manual.

Personal communications between Chet Lipton, Power Dynamics Corporation, and William R. King, SAIC, 1999.

Rochester Gas and Electric Corporation, “Natural Gas Fired Infrared Heating System Reduces Energy Costs at Bausch and Lomb,” *Energy Highlights*, October 1981.

ECO SUMMARY FORM

PROCESS CATEGORY: Steam/Hot Water Distribution

SPECIFIC PROCESS: Steam Distribution at NRFLK

DESCRIPTION OF ECO:

Insulate Steam Lines

Add insulation to uninsulated lines. Replace damaged or worn insulation on insulated lines. The specific application analyzed below is addition of insulation to lines providing steam to wash disassembled motor parts in the NRFLK motor rewinding shop (Building 510). Motor parts are washed directly with 125-psia steam.

ASSUMPTIONS:

Ambient temperature = $T_{ambient}$ = 75 °F

Steam temperature (125-psia saturated steam) = Pipe surface temperature = T_{steam} = 344 °F

Length of steam line to be insulated = 50 linear feet

Diameter of steam line = 8 in. (ID)

> 8 in. diameter of steam line x 1 ft/12 in x 3.14159 x 50 ft length of steam line to be insulated = 105 sq ft steam line surface area

Average wind velocity = 0 mph

Outside surface emittance = 0.10

Uninsulated surface emittance = 0.90, for steel pipe

Heat Losses (from North American Insulation Manufacturers Association, 3Eplus Insulation Thickness Computer Program, which uses ASTM C680 calculation method)

> Uninsulated pipe loss = 1,764 Btu/(hr-linear foot)

Insulated pipe loss (for 2 in. of Johns Manville Micro-Lok fiber glass pipe insulation) = 105 Btu/(hr-linear foot)

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

1,764 Btu/(hr-linear foot) x 50 linear feet = 88,200 Btu/hour heat loss

CALCULATION OF ECO ENERGY AND EMISSIONS:

105 Btu/(hr-linear foot) x 50 linear feet = 5,250 Btu/hour heat loss

COST DATA:

Capital Cost: $9.24/linear foot x 50 linear feet = $462, uninstalled

Annual O&M Savings: None.

REFERENCES:

Personal communication between Smock & Schonthaler Industrial Insulation Sales, Inc., sales personnel and William R. King, SAIC, 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Compressed Air Distribution

SPECIFIC PROCESS: Compressed Air for Depainting and Painting at RBAFB

DESCRIPTION OF ECO:

Point-of-Use Pressure Control

Typically, compressed air is generated centrally by compressors at a pressure of 100 psi and distributed in a piping system throughout the industrial site. This generation pressure is higher than required for several of the end-uses at the site. For instance:

- Depainting –100 psi air throttled down to 28 psi air for blasting (e.g., Robins Air Force Base)
- Compressed air for spray paint guns – 30 psi air is required to operate the guns (e.g., painting operation at Robins Air Force Base)
- Cleaning (e.g., remove dust and dirt) and drying parts – 30-40 psi air (e.g., plating shop at Anniston Army Depot)

With a point-of-use control strategy, a compressor sized for the lower pressure requirement is installed locally, reducing the load on compressors in the central compressed air plant. As load on the central compressors is reduced, it becomes possible to re-engineer them to recognize energy savings. Re-engineering options include: (1) installing computer controls that enable the compressors to be operated at partial load to meet reduced site demand, or (2) reducing compressor system capacity. A rule of thumb states that a 1 percent energy savings is gained for every 2 psig pressure drop in the requirement placed on the central compressor system.

ASSUMPTIONS:

At RBAFB, F-15s are depainted and painted in Building 137. Depainting is accomplished with plastic blasting media propelled by 28 psi compressed air at 2300 cfm. The 28 psi compressed air pressure is obtained by throttling 100 psi air from the centrally generated supply. Paint guns consume 30 psi air at 10 to

12 cfm. The ECO is to serve these compressed air demands with a smaller compressor in Building 137 that is sized to meet a maximum 30 psi air demand.

The benefit of this ECO is based on removing enough 100 psi compressed air load from the central generation system so that the central system can be operated at part load. The central system consists of two, 450-hp compressors (each produces 2000 cfm at 110 psi), and one 350-hp compressor (producing1500 cfm). These compressors are screw-type single-stage.

Calculation of the ECO's impact on central compressor system operation requires knowledge of the depainting and painting compressed air load that was not available. Specifically, the number of plastic media blasting units and paint guns and the load profiles for blasting and painting were not available. Therefore, an analytical procedure that uses hypothetical data based on RBAFB and PEPR data follows. PEPR characterizes the total compressed air requirement in terms of: (1) air that accomplishes work (Legitimate Air), (2) leak losses, (3) losses from running the compressor at no load, and (4) "blow-off" losses.

1. Determine the energy consumption of the current central compressor system.

   PEPR characterizes energy consumption in terms of the following categories:

   Legitimate Air: 1,130,340 Btu/hr

   Leak Losses: 3,062,200 Btu/hr

   Run at No Load Loss: 371,300 Btu/hr

   Blow-off Loss: 1,375,200 Btu/hr

2. Assume the compressor will supply 40 cfm of air at 100 psi to paint spray guns in Building 137.

3. A 15 hp compressor will provide the service specified in Step 2, based on communications with Ingersoll-Rand technical representatives.

4. Determine the capital cost of the compressor specified in Step 3 (see Capital Cost, below).

5. Calculate the ratio of removed cfm load to total compressor load. For the 350 hp RBAFB compressor this ratio would be: 40 cfm/1500 cfm = 0.027.

6. The point-of-use-compressor reduces the Legitimate Air requirement by the ratio in Step 5; therefore, the remaining Legitimate Air requirement is (1-0.027) x 1,130,340 Btu/hr Legitimate Air = 1,099,821 Btu/hr.

Assume the following operating schedule for both painting operations: one 8 hour shift/day, 5 days/week, 50 weeks/year. Therefore, total annual hours equal 2000 hours/year.

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

Legitimate Air: 1,130,340 Btu/hr

CALCULATION OF ECO ENERGY AND EMISSIONS:

Legitimate Air: 1,099,821 Btu/hr

COST DATA:

Capital Cost: $5,580 for a reciprocal compressor or $9,005 for a rotary compressor. The rotary compressor delivers cleaner air and is quieter. Both price quotes, from Ingersoll-Rand, include $1,460 for an air dryer and $225 for a fine coalescing filter that achieves 0.01 micron filtration.

Annual O&M Savings: None.

REFERENCES:

USACERL, Technical Report 96/85, p 66.

Personal communications between Ingersoll-Rand Air Compressor Group technical personnel and William R. King, SAIC, 1999.

ECO SUMMARY FORM

PROCESS CATEGORY: Compressed Air Distribution

SPECIFIC PROCESS: Pneumatic Tools in Various Operations

DESCRIPTION OF ECO:

Upgrade Pneumatic Tools

Compressed air powers pneumatic tools in various industrial operations. Examples include impact guns and wrenches, drills, air and rivet hammers, sanders, nailers, screwdrivers, riveters, and caulk and grease guns. Pneumatic tools, which require 90 psi air, are designed for heavy duty tasks that would be difficult to perform with electric tools. For instance, a pneumatic tool will respond to a heavy duty task by slowing down, while an electric tool that is not variable speed will continue to operate at constant speed and will heat up. Relative to older pneumatic tools, the current generation of tools is more energy efficient. Their compressed air requirements are less than those of past generations. The load on the central compressor system can be reduced if enough old pneumatic tools can be upgraded. When the load is reduced, re-engineering options may be pursued to recognize energy savings. These options include: (1) installing computer controls that enable the compressors to be operated at partial load to meet reduced site demand, or (2) reducing compressor system capacity. A rule of thumb states that a 1 percent energy savings is gained for every 2 psig central compressor system pressure drop.

ASSUMPTIONS:

NOTE: This ECO is discussed in Chapter 9 of this report as a re-engineering option. Data was not available to calculate the ECO's impact on central compressor system operation. Calculation of the ECO's impact on energy use requires site-specific data on the type and number of pneumatic tools, on the amount of compressed air consumed by the tools, and on air pressure and flow rate requirements. Therefore, an example analytical procedure follows:

1. Determine the energy consumption of the current central compressor system.

   450 hp x 0.7457 kW/hp x 3,412 Btu/kWh = 1,144,948 Btu/hr

2. Determine the amount by which pneumatic tool load would have to be reduced to enable a 2 psig pressure drop in the central compressor system.

3. Define the peak kW rating for the group of tools specified in Step 2. The rating depends on the maximum number of tools expected to be operating at the same time. Convert the kW rating to Btu/hr.

   ___ kW maximum x 3,412 Btu/kWh = ____ Btu/hr

4. Determine the capital cost of the group of pneumatic tools characterized in Step 3.

5. Define central compressor system energy savings, which equal 1 percent of the compressor horsepower rating stated in Step 1 for every 2 psig pressure drop. Assume a 2 psig pressure drop, per Step 2.

   ((0.01 energy savings factor/2 psig pressure drop) x 2 psig pressure drop) x 450 hp x 0.7457 kW/hp x 3,412 Btu/kWh = 114,495 Btu/hr

6. Define ECO energy consumption, in Btu/hr, as follows: Step 1 Result – Step 5 Result + Step 3 Result

CALCULATION OF BASELINE ENERGY AND EMISSIONS:

N/A – Option only discussed in a re-engineering context.

CALCULATION OF ECO ENERGY AND EMISSIONS:

N/A – Option only discussed in a re-engineering context.

COST DATA: N/A – Option only discussed in a re-engineering context.

Capital Cost: N/A – Option only discussed in a re-engineering context.

Annual O&M Savings: N/A – Option only discussed in a re-engineering context.

REFERENCES:

Atlantic Tool Systems, Inc., http://www.atlantictoolsystems.com/

Taylor Automotive, Industrial and Construction Pneumatic Air Tools, http://www.nbmc.com/taylor/

Appendix B: Information Sources and Contacts

Contacts

Contacts are divided into the following two categories to separate product vendors from product end users: (1) Vendors of ECO Products and (2) U.S. Department of Defense Industrial Facilities. Entries are listed alphabetically by company name for product vendors and by facility name for defense industrial facilities.

Vendors of ECO Products

Accuspray
Rodd Kaczmarck, Technical Services
Randy Saley, Technical Services
23350 Mercantile Road
Cleveland, OH 44122
Tel. (800) 618-6860, Extension 156
e-mail: rkaczmarck@accuspray.net
e-mail: randysaley@accuspray.com
Product Line: Paint Spray Guns

Atlantic Tool Systems, Incorporated.
150 Fifth Avenue
Hawthorne, NJ 07506
Tel. (800) 524-0890; (973) 238-0009
Fax. (973) 238-0010
Product Line: Electric and Pneumatic Tools

Atmosphere Furnace Company/Pacific Industrial Furnace Company
Bernie (Bernard) Perry, Sales Manager – AFC
John Taylor, Engineering Manager - AFC
Wixom, MI
Tel. – for AFC (248) 624-8191
Fax. – for AFC (248) 624-3710
Tel. – for PIFCO (248) 669-7220
Fax. – for PIFCO (248) 669-7221
Product Line: Heat Treating Furnaces

The Boeing Company
Thomas L. Nied, Jr.
Manager, Business Development
Aerospace Support
Military Aircraft & Missile Systems Group
P.O. Box 516 MC S106-9620
St. Louis, MO 63166-0516
Tel. (314) 232-5761
Fax. (314) 233-2716
e-mail: thomas.l.nied-jr@boeing.com
Product Line: Flashjet Depainting Technology

Casso Solar
Mr. Canfield
Tel. (800) 988-4455
e-mail: dcanfield@cassosolar.com
Internet: www.cassosolar.com
Product Line: Infrared Technology for Process Heat

Inex
Michael Kasprzyk
Vice President, Business Development
INEX, Inc.
9229 Olean Road
Holland, NY 14080
Tel. (716) 537-2270
Fax. (716) 537-3218
Product Line: Composite Radiant Furnace Tubes for Indirect Heating Applications

Ingersoll-Rand
Air Compressor Group
Box 1840
Davidson, NC 28036
Tel. (704) 896-4000
Fax (704) 896-4366
Product Line: Compressed Air Systems

Lucifer Furnaces, Inc.
Kirk Echols, Electrical Engineer
Tom Dietrich, Mechanical Engineer
2048 Bunnell Road
Warrington, PA 18976
Tel. (215) 343-0411
Fax. (215) 343-7388
Product Line: Heat Treating Furnaces

Pick Heaters, Inc.
P.O. Box 516
West Bend, Wisconsin 53095
Tel. (414) 338-1191
Fax. (414) 338-8489
Product Line: Steam Injection Heaters

Performance Control. L.L.C.
4220 Varsity Dr., Suite E
Ann Arbor, MI 48101
Tel. (734) 975-9111
Fax. (734) 975-9115
e-mail: performance@mindspring.com
Product Line: Motor Controllers

Procedyne Corporation
Karin Bickford
VP, Furnace Products
Dr. Ken Staffin
11 Industrial Drive
New Brunswick, NJ 08901
Tel. (732) 249-8347, Extension 224
Fax. (732) 249-7220
e-mail: mail@procedyne.com
Product Line: Jetfire Mantle Technology for Indirect Gas-Fired Heating Applications

Richland, Inc.
Bill Henshilwood
1905 Mines Rd.
Pulaski, TN 38478
Tel. (931) 363-4160
Fax. (931) 424-1259
e-mail: henshilwoodb@pathwayb.com
Product Line: Heat Exchangers and Heat Recovery Systems

Smock & Schonthaler Industrial Insulation Sales, Inc.
Eric Lytle
Steve Smock
1311 Chestnut Street
Erie, PA 16501
Tel. (800) 734-8771
Fax. (814) 456-8346
e-mail: insulate@sandsinsulation.com
Product Line: Insulation for Industrial Applications

Whyco Technologies, Inc.
Brain M. Lucas
Sales Representative
670 Waterbury Road
Thomaston, CT 06787
Tel. (860) 283-5826
Fax. (860) 283-6153
e-mail: whyco@snet.net
e-mail: brianl@whyco.com
Product Line: Electroplating Barrel Technology

Textrol, Inc.
3160 Commonwealth Dr., Ste. 122
Dallas, TX 75247
Tel. (214) 637-6242
Fax. (214) 637-4723
Product Line: Motor Controllers

U.S. Department of Defense Industrial Facilities

Anniston Army Depot
Frank Bosworth, Director of Production
Tel. (256) 235-4166
Frankie Schulch, Director of Cleaning, Finishing, and Painting
Tel. (256) 235-4332
Sylvester Patterson, Director of Manufacturing
Tel. (256) 235-7306
Milton Daugherty, Machine Shop Manager (Milling, C&C and Conventional)
Roy H. Mayo, Heat Treating Manager, Bldg. 108
Tel. (256) 235-6872
Frank Wilson, Heat Treating Furnace Operator
Anniston, Alabama
Tel. (256) 235-7501 (main number)

Corpus Christi Army Depot
Jim Holiday
Tel. (361) 961-3243
e-mail: jholiday@engineer.com
Kelly Jackson
Tel. (361) 961-2214

Naval Facilities Engineering Command
Atlantic Division
1510 Gilbert Street, Naval Base
Norfolk, VA 23511-2699
Tel. (757) 322-4801

Watervliet Arsenal
Albany, NY
Tel. (518) 266-5111 (main number)
Dave Trevett, Benet Weapon Labs
Tel. (518) 266-3853

Internet Sources Used To Identify ECOs

Program or Data Resource	Internet Address/Comments
U.S. Department of Defense	
U.S. Army Environmental Center	http://aec-www.apgea.army.mil:8080/
Joint Service Pollution Prevention Opportunity Handbook	http://enviro.nfesc.navy.mil/p2library/index2.html
Navy Manufacturing Technology Program (MANTECH)	http://mantech.bmpcoe.org/
Best Manufacturing Practices Center of Excellence	http://www.bmpcoe.org/runonline/index.html Comments: This address is for the online database for technology applications case studies.
Technology Reinvestment Program Archives	http://www.arpa.mil/jdupo/archive.html
Manufacturing Technology Information Analysis Center	http://mtiac.hq.iitri.com/index.html Comments: Operated by IIT Research Institute; supports MANTECH
U.S. Department of Energy	
Energy Efficiency and Renewable Energy Database	http://www.doe.gov/html/eren/eren.html
Office of Industrial Technologies (OIT)	http://www.oit.doe.gov/
OIT Programs	http://www.oit.doe.gov/prog.shtml
OIT Tools	http://www.oit.doe.gov/tools.shtml
OIT Industrial Project Locator	http://bwonotes5.wdc.pnl.gov/IOF.nsf
NICE^3 – Project Successes	http://www.oit.doe.gov/nice3/projects/successes/successes.shtml
Compressed Air Challenge	http://www.knowpressure.org
Steam Challenge	http://www.oit.doe.gov/steam/
Industrial Assessment Database	http://oipea-www.rutgers.edu/database/ Comments: Data from surveys conducted under the Industrial Assessment Center program. Database maintained by the Office of Industrial Productivity and Energy Assessments at Rutgers University
U.S. Environmental Protection Agency	
Climate Wise	http://www.epa.gov/climatewise/
Design for the Environment	http://www.epa.gov/dfe/
Environmental Technology Initiative	http://www.epa.gov/oppe/eti/eti.html
National Institute of Standards and Technology Manufacturing Extension Partnership	http://www.mep.nist.gov/index1.html
Gas Research Institute Heat Treating/Reheating	http://www.gri.org/cgi-bin/re?url=http%3A//www.gri.org/pub/icgti.html

Program or Data Resource	Internet Address/Comments
Pacific Gas and Electric Company	
SmarterEnergy – Industrial Processes Guide	http://www.pge.com/smarterenergy/html/industrial_process_guide.html
SmarterEnergy – Compressed Air Systems Guide	http://www.pge.com/customer_services/business/energy/smart/html/compressed_air_guide.html
Michigan Manufacturing Technology Center	http://www.iti.org/
Ingersoll-Rand	
Corporate Home Page	http://www.ingersoll-rand.com/welcome.htm
Air Compressor Group	http://www.air.ingersoll-rand.com
Technical Guides	http://www.air.ingersoll-rand.com/AST/index.htm
Compressed Air Magazine	http://ingersoll-rand.com/compair/
E-Source	http://www.esource.com/

Appendix C: PEPR Quick Start Instructions

Introduction

The PEPR database contains: (1) Base Data and (2) Process Data. Energy Conservation Opportunities (ECOs) are characterized in the Process Data. The data provide the analyst with default values. Following are step-by-step instructions to help the user access and work with PEPR data as quickly as possible. The instructions cover the following PEPR tasks:

- Edit Base or Process Data – Change data, which are default values, to reflect current Base energy consumption and energy prices. Change Process Data to reflect actual process conditions, since the PEPR data provides ECO default values that apply to a specific operation and installation.

- Compare a “Baseline” Process to a “Comparison” Process – Once Base and Process Data are reviewed and edited as necessary, evaluate the economics of an ECO relative to a baseline process.

- Add a New “Baseline” or “Comparison” Process to Process Data – Expand the PEPR data to cover new processes that are of specific interest to an installation.

Refer to the PEPR User Manual for more detailed guidance. The manual is part of the PEPR software and can be accessed through the PEPR main menu as follows:

1. Click “Help” in the main menu.

2. Click “PEPR User Manual.”

3. Click any topic in the table of contents.

4. Click “OK.” At this point, the entire manual is accessible by using the “First,” “Prev,” “Next,” and “Last” options.

5. Click “Print” to print the manual.

6. Click “Close” to exit to the PEPR main menu.

Edit Base or Process Data

Base Data

1. Click “Base Data” on the main menu.

2. Click “Army,” “Navy,” or “Air Force.”

3. Click on desired installation, then click “OK.”

4. Click “Edit.” The cursor can now be moved to any entry on Page 1. Any entry on the page may be edited.

5. Click “Save.”

6. Click “Page 2.”

7. Click “Edit.” The cursor can now be moved to any entry on Page 2. Any entry on the page may be edited.

8. Click “Save.”

9. Click “Page 3.”

10. Click “Edit.” The cursor can now be moved to any entry on Page 3. Any entry on the page may be edited.

11. Click “Save.”

12. Click “Page 2,” then “Page 1,” the “Print” to print updated pages 1 through 3.

13. Click “Close” to return to PEPR’s main menu.

NOTE: To “Add” or “Delete” an entire Base data record, follow steps 1 through 3, above. Then, click “Add” or “Delete.”

Process Data

The numbered data fields in Figure A1 are those commonly edited when entering an ECO or Existing process record into PEPR. Note that Material Inputs, Material Outputs, and Emissions sections of Figure A1 are not critical for operating PEPR to calculate energy savings. Also note that the second and third pages represent one Operation. These pages are repeated for each Operation under a Process Name. Figure A1 shows a two Operation case. Operation 1 is called “Quench Furnace,” and Operation 2 is called “Temper.” Critical entries, referencing the corresponding entry number in Figure A1, include:

First Page Entries

1 – Service: Press menu button and make a selection.

2 – Base: Set automatically. See (3).

3 – Abbreviation: Press menu button and make a selection. Once the acronym is set, the entry for (2) appears automatically.

4 – Process Name: Define a name for the main process, which will cover one or more Operations. This process falls under a Process Category (see No. 8).

5 – Production Line: Enter a code for the production line. One production line code is unique to each Abbreviation/Process Name combination.

6 – System Type: Press menu button and make a selection.

7 – Process ECO: Enter a brief name for the ECO.

8 – Process Category: Press menu button and make a selection.

9 – One Unit Measures: Press menu button and make a selection. Also set the numerical value of the unit. The unit will be the basis for measuring mass and energy inputs to the process (e.g., Btu/hour). The choices are cubic feet, gallons, hours of operation, pounds, and processed parts.

10 – Data Source: Enter a brief description of data sources.

11 – Operating Hours per Year: Enter the relevant number.

12, 13, and 14 – These entries relate to the choices made under (9) and (11).

Second Page Entries

15 – Operation Number: These numbers are assigned in sequence, starting with 1.

16 – Enter a name for the Operation.

17 – Input, Btu: Enter input Btu per unit specified in (9).

18 and 19 – Pressure and Temperature entries are optional for running the model.

Third Page Entries

20 – Enter O&M savings relative to the existing technology. This field is blank for the Existing case. Also, only enter O&M in the Operation that is affected by the ECO. For example, this field has an entry in Operation 1 but not in Operation 2.

21 – Enter the Capital Cost for the ECO. This field is blank for the Existing case. Also, only enter Capital Cost in the Operation that is affected by the ECO. For example, this field has an entry in Operation 1 but not in Operation 2.

22 – Enter the Economic Life, in years, for the ECO. This field is blank for the Existing case. Also, only enter Economic Life in the Operation that is affected by the ECO. For example, this field has an entry in Operation 1 but not in Operation 2.

Example Process Data File

PROCESS DETAIL

25-Aug-99

(1) Service: ARMY **(2) Base:** ANNISTON DPT **(3) Abbreviation:** ANAD

(4) Process Name: QUENCH & TEMPER, FER **(5) Production Line:** F1F2

(6) System Type: MAINT/REPR **(7) Process ECO:** RECUPERATOR

(8) Process Category: HEAT TREATING Use this process version for aggregations: Y

Unit Product Name or Material Processed: 1 HOUR AVERAGE OPERATION

(9) ONE UNIT measures: 1 hours of operation

Technical Description: 2-PART HEAT TREAT, FERROUS; BRICK GAS FURNACES

(10) Data Source: ANNISTON ARMY DEPOT, MANUFACTURER'S DATA

Batch or Continuous: C

Number of Shifts/Day: 1

Number of Production Lines: 1 **Designation:**

(11) Operating Hours per Year: 8760

Operational Hazard: HOT OBJECTS AND AREA

Product Quality Variables:

#1: TEMPERATURE CONTROL
#2: FURNACE ATMOSPHERE **(12) Production Capacity, unit/hr:** 1
#3: **(13) Annual Production, units/yr:** 8760
#4: **(14) Annual Production, lb/yr:** 0
#5:

Re-Engineering Suggestions:

1. This ECO is the addition of a recuperator on the hot exhaust stream from a gas-fired furnace that is left on all the time to mitigate temperature cycling of the firebrick. The recuperator captures heat from the hot exhaust gases to preheat the incoming combustion air.

Operation Number: 2TEMPER

Comments: DRAW FURNACE

Name	Quantity (lb)	Pressure	Temperature	Specific Heat	Enthalpy Change for a Transition	Temperature of Transition
Material Inputs						
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
Material Outputs						
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0

Process Conditions

Process Temperature: 1000 **Process Pressure:** 0 **Residence Time:** 1

Energy

	Input (Btu)	Output (Btu)	Pressure (psig)	Temperature (°F)
Fuel:	347,000.0	0.0		
Motor Electricity:	63,600.0	0.0		
Non Motor Electricity:	0.0	0.0		
Compressed Air:	0.0	0.0	0.00	
Hot Water:	0.0	0.0	0.00	
Cold Water:	0.0	0.0	0.00	
Steam:	0.0	0.0	0.00	0.00
Hot Air:	0.0	0.0	0.00	100.00
Total Energy:	410,600.0	0.0		

(15) Operation Number: 1 **(16) QUENCH FURNACE**

Comments:

Material Inputs

Name	Quantity (lb)	Pressure	Temperature	Specific Heat	Enthalpy Change Transition	Temperature of Transition
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0

Material Outputs

	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0
	0.0000	0.0	0.0	0.000	0	0.0

Process Conditions

Process Temperature: 1500 Process Pressure: 0 Residence Time: 1

Energy

	Input (Btu (17))	Output (Btu)	(18) Pressure (psig)	(17) Temperature (°F)
Fuel:	785,000.0	0.0		
Motor Electricity:	63,600.0	0.0		
Non Motor Electricity:	0.0	0.0		
Compressed Air:	0.0	0.0	0.00	
Hot Water:	0.0	0.0		0.00
Cold Water:	0.0	0.0		0.00
Steam:	0.0	0.0	0.00	0.00
Hot Air:	0.0	0.0	0.00	150.00
Total Energy:	848,600.0	0.0		

Emissions

VOCS: 0.000000 0.00%
HAPS: 0.000000 0.00%
TSP: 0.000000 0.00%
PMIO: 0.000000 0.00%
SOX: 0.000000 0.00%
NOX: 0.000000 0.00%
CO: 0.000000 0.00%

Materials and Energy Balances

Total Material In: 0.0000
Total Material Out: 0.0000
Total Energy In: 848,600.0
Total Energy Out: 0.0
Theoretical Energy: 0.0

Economics | *Waste Water* | *Waste Material*

(20) 0&M Savings: $0

Gallons: 0.00 lb: 0

(21) Capital Cost: $13,000

Temperature: 0.00 Name:

Economic Life: 20

Equipment

Motor Size, hp: 25

Description: TEGRAL QUENCH FURNACE

Motor Efficiency: 0.0 %

HAP Emissions for this Operation

Pounds per Unit of Product:

HAP Emission:

Emissions

VOCS: 0.000000	0.00%
HAPS: 0.000000	0.00%
TSP: 0.000000	0.00%
PM1O: 0.000000	0.00%
SOX: 0.000000	0.00%
NOX: 0.000000	0.00%
CO: 0.000000	0.00%

Materials and Energy Balances

Total Material In: 0.0000

Total Material Out: 0.0000

Total Energy In: 410,600.0

Total Energy Out: 0.0

Theoretical Energy: 0.0

Economics | *Waste Water* | *Waste Material*

O&M Savings: $0

Gallons: 0.00 lb: 0 0

Capital Cost: $0

Economic Life: Temperature: 0.00 Name:

0

Equipment

Motor Size, hp: 25

Description: MOSPHERE DRAW FURNACE

Motor Efficiency: 0.0 %

HAP Emissions for this Operation

Pounds per Unit of Product

HAP Emission:

Fields shown in Figure A1 can be edited by using the following steps:

1. Click “Process Data” on the main menu.

2. Click “Process Database.”

3. Click on a Process ECO.

4. Click “Look at Process Details.”

5. Click “Edit.” The cursor can now be moved to any entry on the first page in the Process ECO’s file. Any entry on the page may be edited.

6. Click “Save.”

7. Click “Re-engineering Suggestions.” The cursor enables edits to be made immediately. Click “Undo” to cancel a change.

8. Click “Cancel” or “Exit” to return to the first page in the Process ECO file.

9. Click “Operations” to get to the records where each operation is characterized. The “Operation Number” and “Operation Name” are shown in boxes at the top of the page. Click “Next” in the menu at the bottom of the page to move from one operation to another. A process record in PEPR includes one or more Operations.” An ECO has an impact on one or more of the “Operations.”

10. Click “Edit.” The cursor can now be moved to any entry on Page 1. Any entry on the page may be edited. <u>NOTE</u>: No entries are required on Page 1.

11. Click “Save.”

12. Click “Page 2.”

13. Click “Edit.” The cursor can now be moved to any entry on Page 2. Any entry on the page may be edited. Entries required on this page are “Input, Btu” under the “Energy” section and “O&M Savings,” “Capital Cost,” and “Economic Life” under the “Economics” section. <u>NOTE</u>: Only enter data into the “Economics” section for the one operation impacted by the ECO.

14. Click “Save.”

15. Click “Calculate Material and Energy Balance.”

16. Click “Page 1.”

17. Click “Close.”

18. Click “Close,” again, to exit to the main menu.

NOTE: To “Add” or “Delete” an entire Process ECO record, follow steps 1 through 4, above. Then, click “Add” or “Delete.” To “Add” or “Delete” one or more Operations, follow steps 1 through 4 and 9, above. Then, move to the desired Operation. Click “Add” or “Delete.”

Compare a “Baseline” Process to a “Comparison” Process

The following approach does not allow the user to print results:

1. Click “Process Analyses” on the main menu.

2. Click “Army,” “Navy,” or “Air Force.”

3. Click “Compare Two Selected Processes.”

4. Click on an “Existing” Process ECO.

5. Click “Set Baseline.”

6. Click on an ECO in the Process ECO column to compare to the Baseline. The “Comparison” ECO should be from the same Service, Base, Process Category, and Process Name as the “Existing” Process ECO.

7. Click “Set Comparison.”

8. Click “OK.” At this point, PEPR performs the comparison calculations and shows Page 1 of the results. Click on “Page 2,” “Page 3,” or “Page 4” to view additional results. Click “Close” to exit to the Process ECO selection table, which returns the user to Step 4, above.

9. Click “Cancel” to return to the main menu.

The following approach does allow the user to print results:

1. Click “Reports.”

2. Click “Process Comparison.”

3. Click “Army,” “Navy,” or “Air Force.”

4. Follow steps 4 through 8, above. After clicking “OK” in step 8, PEPR shows output pages.

5. Printing output pages: Click the “File” option in the menu. Click the “Print” option.

6. Exit to the Process ECO selection table: Click the “File” option in the menu.

Add a New “Baseline” or “Comparison” Process To Process Data

1. Click “Process Data.”

2. Click “Duplicate Process to Create Improve Process.”

3. Follow the instructions in the “Note” box at the top of the page that appears. The “Clone” option actually duplicates the record.

4. Click “Close” to exit to the main menu.

After closing to the main menu, further data edits may be accomplished by following the Process Data editing instructions under “Edit Base or Process Data,” above.

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As part of its strategy to meet the Department of Defense (DOD) energy efficiency goals, and to reduce emissions from industrial facilities, a Process Energy and Pollution Reduction (PEPR) software tool has been developed. The PEPR tool helps DOD facility personnel identify and quantify energy conservation and pollution prevention opportunities for the following industrial processes: load and pack (LAP) lines, explosives production, spray painting, electroplating, heat treating, steam/hot water distribution, compressed air distribution.

This study developed 14 additional process improvement ideas for these seven processes and incorporated them into the PEPR tool. The information provided is intended to be illustrative and will vary depending on the specific process conditions at the installation, energy prices, local installation costs, etc. It is intended to give an idea of the magnitude of the opportunities. It is hoped that these additional energy conservation opportunities (ECOs) and user enhancements will make the PEPR analysis tool of increasing value to DOD industrial facility personnel.

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