ERDC/CERL TR-05-17

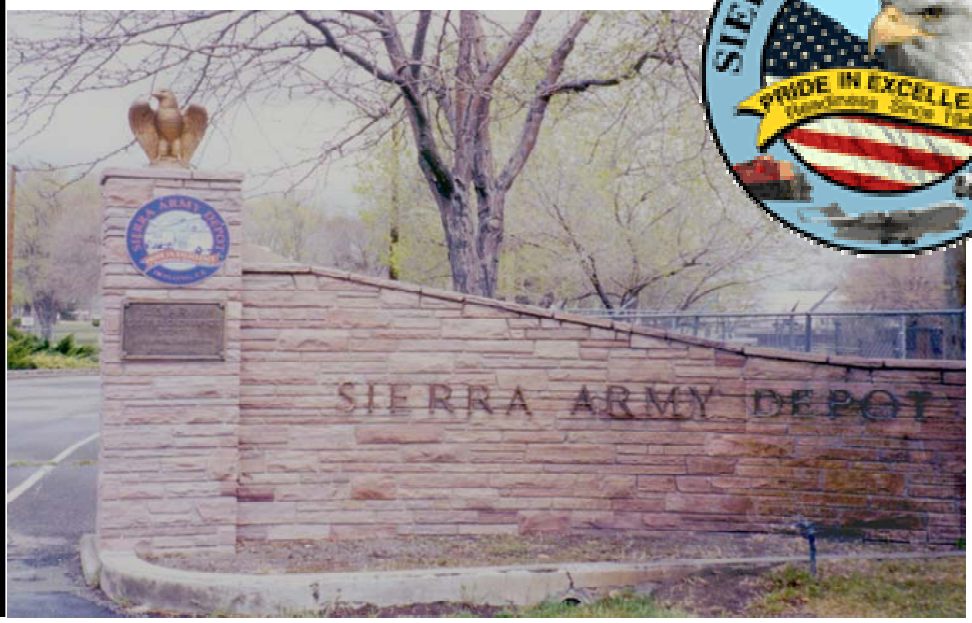
US Army Corps of Engineers®
Engineer Research and Development Center

Process and Energy Optimization Assessment

Sierra Army Depot, CA

Mike C.J. Lin, Alexander M. Zhivov, Alfred Woody, Michael J. Chimack, and Robert A. Miller

August 2005



Construction Engineering Research Laboratory

ERDC/CERL TR-05-17
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Process and Energy Optimization Assessment: Sierra Army Depot, CA

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Final Report

Prepared for Sierra Army Depot, CA

ABSTRACT: In January 2005, researchers from the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) led a Level I Process and Energy Optimization Assessment (PEOA) at Sierra Army Depot (SIAD) to identify process, energy, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. This Assessment is a part of showcase studies conducted by CERL at four sites (Rock Island Arsenal, Corpus Christi AD, Sierra AD, and Tobyhanna AD), which were selected by the Army Materiel Command to demonstrate energy reduction opportunities at industrial organic facilities and to promote the "Lean" concept and ways to render these facilities more efficient. The scope of the Level I analysis included improvements in painting, welding, and mechanical repair shops, building envelope, heating, ventilation, and air conditioning. This report gives detailed results of the Level I study. The study recommended 15 process and energy improvement projects, 11 of which were quantified economically. It was estimated by investing about $892k to implementing these 11 projects SIAD could achieve annual savings of $545k with an average simple payback of 1.6 years.

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Conversion Factors

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

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

*_Système International d'Unités_ ("International System of Measurement"), commonly known as the "metric system."

Preface

This Assessment is a part of showcase studies conducted by CERL at four sites (Rock Island Arsenal, Corpus Christi AD, Sierra AD, and Tobyhanna AD), which were selected by the Army Materiel Command to demonstrate energy reduction opportunities at industrial organic facilities and to promote the "Lean" concept and ways to render these facilities more efficient. This study was conducted for Sierra Army Depot (SIAD) under Project Requisition No. 0409684, "Process Energy Optimization Assessment," via Military Interdepartmental Purchase Request (MIPR) No. 4LFA04732B. The technical monitor was Robert Gee, General Engineer, Sierra Army Depot.

The work was managed and executed by the Energy Branch (CF-E) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigators were Dr. Alexander Zhivov and Dr. Mike C.J. Lin. Appreciation is owed to Robert Gee (SIAD) for his coordination of the SIAD team and to the SIAD DPW and Shop Division staff, who contributed significantly to the information gathering and analysis feedback. Major contributors to the study were Alfred Woody (Ventilation/Energy Applications, PLLC), Bruce Martin (PlymoVent Corporation), and Michael Chimack and Robert A. Miller (Energy Resource Center, University of Illinois at Chicago [UIC]). Dr. Tom Hartranft is Chief, CEERD-CF-E, and Mr. L. Michael Golish is Chief, CEERD-CF. The associated Technical Director is Dr. Paul A. Howdyshell CEERD-CV-T. The technical editor is William J. Wolfe, Information Technology Laboratory. The Acting Director of CERL is Dr. Ilker R. Adiguzel.

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

1 Introduction

Background

Sierra Army Depot (SIAD) is a Ground Systems Industrial Enterprise (GSIE) installation of the U. S. Army's Tank-automotive and Armaments Command (TACOM) under the U.S. Army Materiel Command. It is a government owned, government operated installation located in Herlong, CA (50 miles north/northwest of Reno, NV), in Lassen County's Honey Lake Valley, east of the Sierra Nevada mountains. SIAD's mission is to provide customers with high quality, cost effective operations in receipt, storage, repair, and issue of equipment and components for Operational Project Stock.

In 1993, SIAD was designated as the Army's Center of Technical Excellence for Operational Project Stocks. SIAD is home to the three largest Operational Project Stocks in the Army: Inland Petroleum Distribution System, Water Support System, and Force Provider. In addition, SIAD is home for other Operational Project Stocks including: Deployable Medical Systems—Non-Medical Equipment, Army Field Feeding Systems, Large Area Maintenance Shelters, Landing Mat Sets, and Bridging.

Over the past 3 years, the Sierra Army Depot's mission has completely changed. It is now directly tied to the Warfighter and provides support to the Department of Defense and Interagency within the Depot's core competencies: rapid deployment, power projection, and industrial operations. SIAD's mission has progressed from an ammunition demilitarization mission to a key provider of Expeditionary Logistics. SIAD has hired many new employees to accomplish this new mission and to handle the associated fourfold workload increase since 2002. SIAD expressed an interest in this CERL process study to find ways to more efficiently and cost effectively meet new and existing mission requirements.

During the past few years, the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) has been involved in process and energy optimization to help DOD installations meet energy efficiency and environmental compliance requirements and to create an improved work environment through a "Process and Energy Optimization Assessment" (PEOA). The key elements that guarantee success from a PEOA are: (1) the involvement of key

facility personnel, who know what the problems are, who know where the problems are located, and who have already thought of many solutions; (2) the facility personnel sense of "ownership" of the ideas, which in turn develops a commitment for implementation; and (3) the PEOA focus on site-specific, critical cost issues, which, if solved, will make the greatest possible economic contribution to facility's bottom line. This work would complement the Army Materiel Command's ongoing implementation of its "Lean Thinking & Six Sigma" strategy.

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

Objectives

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

Approach

In January 2005, a team of Army researchers and expert consultants performed a PEOA at SIAD to identify process, energy, and environmental opportunities that could significantly improve the installation's mission readiness and competitiveness. The three levels of process and energy analysis differ in the objectives, scope, methodology, procedures, required instrumentation and approximate duration:

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

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

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

Work was proposed to proceed in three phases. Phase 1 focused on review of existing energy-demanding system requirements and on development and analysis of potential energy saving opportunities. Phase 2 will inspect the existing support equipment and develop renovation plans. Phase 3 will monitor implementation and verify savings. The Phase 1 study described in this report will result in a detailed scope of work for Phase 2, which can begin after sponsor's approval.

Scope

This Phase 1 energy assessment evaluated several production processes, such as painting, sand blasting, machining, welding, mechanical repair, etc. The compressed air systems were also examined. This work assumes that technical solutions are possible and that economic calculations are approximations (accurate to ±20 percent). Only limited engineering measurements were made.

Mode of Technology Transfer

The results of this work were presented to SIAD in April 2005 for their consideration in pursuing follow-on Phase 2 work. It is anticipated that the results of this work will contribute to further awareness of the AMC installations, and to Corps, District, and other Army installation personnel, via implementation through associated regional Installation Management Agency (IMA). It is also planned to disseminate this information through workshops, presentations, and professional industrial energy technology conferences.

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

http://www.cecer.army.mil

2 Process and Energy Assessment at Sierra Army Depot

SIAD Facility Description and LEAN Program

SIAD currently employs a workforce of about 569 people. The Depot has 1,177 buildings totaling 5,518,516 sq ft of floor space, and covers an area of 96,792 acres. SIAD has more than 3.6 million sq ft of improved hardstand storage areas. SIAD's ample storage space with virtually unlimited room to expand for future projects, allows it to provide the Depot's active customers with free asset storage.

SIAD's high-desert location provides ideal conditions for storing Operational Project Stocks for extended periods of time. Pacific air that moves into the region loses most of its moisture before reaching the Honey Lake Valley, resulting in an average yearly high temperature of 66.9 °F, and a low of 36.4 °F. Average yearly precipitation is 7.49 in., with an average yearly humidity of only 30.96 percent. SIAD has ready access to all west coast ports. The Depot is connected by several all-weather highways, has an internal rail system linked with two transcontinental rail lines, and has a 7,100-ft runway that accommodates up to C5A aircraft.

Repair facilities located at SIAD include the management of the Inland Petroleum Distribution Systems; Water Support Systems; Force Provider; Army Field Feeding Systems; Large Area Maintenance Shelters; Landing Mat Sets; Bridging; and Reserve Component Hospital Detachment Associated Support Items of Equipment (non-medical). The activities at SIAD include receipt, storage, and care of supplies in storage, repair, assembly, disassembly, and shipment of major and secondary items for all systems.

Previously, SIAD also received, issued, stored, renovated, and demilitarized (destroyed) ammunition. Three facilities were identified specifically for demilitarization of ammunition at SIAD. The deactivation furnace was an incinerator that could demilitarize small arms ammunition, primers, fuses, and boosters. The Depot had approval from the state of California to demilitarize up to 0.50 caliber rounds in the deactivation furnace. As such, two general purpose buildings were used to download and pull apart ammunition for demilitarization. They were equipped with intrusion detection systems and rapid response deluge systems for safety.

SIAD was licensed by the Nuclear Regulatory Commission to receive, store, issue, renovate, and demilitarize (disassemble) depleted uranium rounds. SIAD had the largest open burn/open detonation capacity in the United States. Fourteen pits, permitted by the state of California, could detonate up to 10,000 lb net explosive weight per pit. The Depot's demilitarize grounds were also able to burn materials up to 100,000 lb net explosive weight. The open detonation pits were also used to dispose of large rocket motors with a 160,000-lb net explosive weight capacity for the pit area. The large open-burn/open-detonation capability of the Depot provided the Department of Defense and government contractors with the ability to destroy large rocket motors at a lower cost than any other location. SIAD takes every step possible to be a good neighbor. The installation operates under all local, state, and Federal Environmental Protection Agency regulations to get its job done with minimal environmental impact.

The mission of Sierra Army Depot is to enhance the U.S. Army's transformation by serving as a continental U.S. strategic power projection support platform providing world-wide, world class logistics support in the form of maintenance, assembly, containerization, and rapid shipment. SIAD is a strategic military transportation hub of critical operational project stocks for deployable medical systems, medical supplies, petroleum and water systems, aviation systems, and Force Provider.

SIAD has been invested time and resources in process improvements that refine and upgrade its core competencies: rapid deployment, power projection, and industrial operations. They save customer dollars through innovative depot employee ideas applied through a value-engineering program. They understand customer needs and are committed to working together to provide better service by finding more efficient solutions. As a charter member of the Ground Systems Industry Enterprise, SIAD contributes to a partnering arrangement that benefits such customers as the Tank-automotive and Armaments Command, the Army Medical Materiel Agency, the Soldier Biological Chemical Command, the U.S. Army Field Support Command, and the Operations Support Command.

SIAD is currently refining its business processes through the implementation of LEAN and Six Sigma, and the installation is being International Organization for Standardization (ISO) 9000 certified. SIAD was awarded the Value Engineering Commander's Excellence Award for government owned, government operated facilities in fiscal year (FY) 1998. SIAD earned the award for exceeding the Value Engineering program goal by 270 percent, for a total cost savings of $3,773,000. Another of SIAD's efforts resulted in the design and building of container rotation devices that significantly reduced the costs associated with container movement through each repair station. Recently, SIAD conducted its first official 3-P (Production Preparation Process) event. The 3P is a Lean tool to help prepare an Installation on

an up and coming program, or programs that the demand is going to increase. The tool is intended to analyze the Product, Parts, and the Process. With the help of Simpler Consulting Inc., they analyzed the mechanized vehicle to long term storage. The team identified and brainstormed seven different processes, weighted each process, and then drew a conclusion as to which was the best feasible process to be used by the Depot. This process identified and will net the Depot a 20 percent productivity improvement, decrease hours per unit by 35 percent, and reduce the Total Manual Cycle time by 26 percent. It was noted that the Defense Logistic Agency (DLA) charges the Installations $2,000.00 a vehicle for long term storage. This program involved 1,900 vehicles. This is a major cost avoidance for TACOM and will help SIAD avoid Base Realignment and Closure (BRAC).

Analysis of Energy Supply, Consumption, and Costs

In FY 2004, SIAD consumed 11,134,000 kWh of electricity with an annual average daily load of 1,268 kW. Total annual electricity cost was $1,186,182 with an average cost of $0.106/kWh. During the same period, the installation used 65,719 MMBtu (63,743 KCF) of natural gas, at a cost of $1,124,808. Natural gas was purchased from Texas Ohio West Company and the payment includes costs of amortized connection services and pipeline operation and maintenance as well as natural gas index price adjustment. In addition, SIAD consumed 78,338 gal of propane, which cost $108,064. SIAD spent approximately $2,419,054 for energy for the entire year.

The plant energy systems convert the kWh of electricity and Btu of fuel into various productive utilities such as compressed air, steam, and shaft power to support various end uses. These annual purchased energy costs and variable unit costs are used as the "Cost Basis of Savings" (CBoS) for the economic analysis of Energy Conservation Measures (ECMs). Table 1 lists SIAD utilities consumption for FY 2004 including electrical, natural gas, and propane.

Unit Cost Calculations and CBoS

Since specific energy conservation measures focus on some type of end-use utility like compressed air, shaft power, lighting, etc. to support a process, the team needed a method to translate reduced consumption at the end use back to lower electricity usage or lower fuel consumption and the associated cost savings. As a result, researchers provided the team with translation formulas to convert incremental end use consumption back to the energy source and ultimately back to dollar cost, or the CBoS.

Table 1. SIAD FY04 utilities unit costs.

Utility	Month	Facility Reporting Unit	Cost ($)	MBtu (Rounded)	$/Unit	$/MBtu
ELC	Oct-03	825 MWh	101,256	2,816	122.73	35.96
(MWh)	Nov	820	101,251	2,799	123.48	36.18
	Dec	1,002	121,904	3,420	121.66	35.65
	Jan-04	1,102	133,363	3,761	121.02	35.46
	Feb	1,019	124,338	3,478	122.02	35.75
	Mar	1,015	123,025	3,464	121.21	35.51
	Apr	1,022	123,203	3,488	120.55	35.32
	May	554	47,549	1,891	85.83	25.15
	Jun	902	73,101	3,079	81.04	23.75
	Jul	933	79,215	3,184	84.9	24.88
	Aug	1,047	85,154	3,573	81.33	23.83
	Sep	893	72,823	3,048	81.55	23.89
	FY04 Total	11134	1186182	38001	106.54	31.21
NAG	Oct-03	3,132 KCF	78,658	3,229	25.11	24.36
(KCF)	Nov	9,383	107,865	9,674	11.5	11.15
	Dec	10,804	124,336	11,139	11.51	11.16
	Jan-04	11,490	130,595	11,846	11.37	11.02
	Feb	10,250	122,412	10,568	11.94	11.58
	Mar	8,044	105,075	8,293	13.06	12.67
	Apr	6,551	98,734	6,754	15.07	14.62
	May	1,246	70,494	1,285	56.58	54.88
	Jun	924	69,033	953	74.71	72.46
	Jul	641	66,890	661	104.35	101.21
	Aug	102	72,506	105	710.84	689.47
	Sep	1,176	78,210	1,212	66.51	64.51
	FY04 Total	63743	1124808	65719	17.65	17.12
PPG	Oct-03	1,685 Gal.	1,955	160	1.16	12.21
(Gallons)	Nov	10,390	12,052	987	1.16	12.21
	Dec	18,009	20,890	1,711	1.16	12.21
	Jan-04	12,670	19,132	1,204	1.51	15.89
	Feb	15,728	23,749	1,494	1.51	15.89
	Mar	9,702	14,650	922	1.51	15.89
	Apr	2,463	3,719	234	1.51	15.89
	May	1,344	2,029	128	1.51	15.89
	Jun	349	527	33	1.51	15.9
	Jul	2,740	4,137	260	1.51	15.89
	Aug	1,926	3,293	183	1.71	18
	Sep	1,332	1,931	127	1.45	15.26
	FY04 Total	78338	108064	7443	1.38	14.52
FY04	***Grand Total***		***$2,419,054.00***	***111,163***		***21.76***

Table 2. Cost Basis of Savings.

Utility or cost factor	Derivation and Cost
1. Electricity	$0.106/kWh including both energy and demand. Energy cost = $0.075/kWh Demand charge = $7.01/kW-month, peak energy demand during 15 min period $929/kW-year (combined energy and demand) = 1 kW used for 8,760 hrs/year $84.12/kW-year (demand only)
2. Horsepower	1 hp x 0.746 kW/Hp x 8760hrs/yr x $0.106/kWh = $693/hp-yr
3. Natural Gas	$5.08/MMBtu ($5.24/kCF; energy content 1,031Btu/kCF)
5. Steam	100 psig, 338 °F saturated steam, 1189 Btu/lb $9.58/klb (consider only natural gas cost and 65% boiler efficiency)
6. Water and Sewer	Water = $104,146/year = 377,600kgal/yr @ $0.276/kgal Sewer = $88,435/yr = 20,595/kgal @ $4.294/kgal

Table 2 lists the cost values for an incremental unit of a utility and the underlying equation that derives this amount. These values are based on the following utility rate schedules:

- Electric Demand Charge (kW): Discounted Firm Demand $7.01/kW
- Electric Energy Charge (kWh): $0.07500/kWh.

The above electric rate is based on the Plumas-Sierra Rural Electric Cooperative, Portola, California Large Power Service and Schedule 350 (A-6) L-98, effective for service rendered on and after 27 August 2001. The values for other utilities are:

- Fuel Oil: $1.890/gal
- Natural Gas: $5.24/MBtu
- Propane $1.270/gal.

The above natural gas, fuel oil and propane rates are based on an average rate for FY04. It should be noted that in calculating the average natural gas rate, the fixed costs were removed from the equation. Labor costs were estimated at $47.87/hr for industrial building personnel.*

PEOA Team and Schedule

The SIAD PEOA took place over a 3-day period, from Monday to Wednesday, 24–26 January 2005. Table 3 lists the participants and their affiliations. Table 4 shows

* Personal communication between Mr. Wally Hamel of SIAD Accounting and Dr. Alexander Zhivov, 08 March 05.

how the 3-day assessment process was organized by time, activities, and location to ensure that all of the critical areas in the scope of work were covered and that the process of the information collection, brainstorming sessions, and briefings to the management were built-in to the SIAD personnel busy schedules. The PEOA team outbriefed the SIAD Commander and plant managers 26 January 2005.

Table 3. PEOA participants list.

Sierra Army Depot	ERDC-CERL	University of IL at Chicago	VEA	PlymoVent
Richard Andersen	Mike Lin	Mike Chimack	Alfred Woody	Bruce Martin
Donald Chase	Alexander Zhivov	Robert Miller		
Russel Collier				
Dave Foxworthy				
Larry Gallego				
Robert Gee				
Ray Hilliard				
Joe Horner				
Chris Jacobs				
Manual Leslie				
Geoff Williams				

Table 4. Three-day schedule, SIAD PEOA.

Monday (24 Jan 05)	
9:00-9:10	Introduction (Robert Gee, SIAD)
9:10-9:50	Objectives, Scope, Approach, 3-Day Schedule (Alexander Zhivov, CERL)
9:50-10:10	Utility Systems O&M, Energy Projects (Robert Gee and other DPW staffs)
10:10-11:00	Industrial Operations: Process and Schedule, Cost Issues, Future Needs (SIAD Plant managers, Shop Supervisors, Engineering staffs)
11:00-12:00	Quick Guided Shop Tour (SIAD Shop Supervisors & Assessment Team)
12:00-13:00	Lunch
13:00:17:00	Painting Shop Assessment (Woody, Miller, Zhivov, Shop Managers) Lighting and Compressed Air System (Chimack, Lin, DPW staff)
Tuesday (25 Jan 05)	
8:30-12:00	Welding Shop (Woody, Miller, Zhivov, Shop Managers)
	Building Envelope (Chimack, Lin, DPW and responsible operational staff)
12:00-13:00	Lunch
13:00-17:00	Mechanical Repair Shop (Chimack, Miller, Lin, Shop Managers) Building HVAC and Process ventilation systems (Woody, Zhivov, DPW)
Wednesday (26 Jan 05)	
8:00-12:00	Presentation (Assessment Team)
12:00-13:00	Lunch and Adjourn

3 Sierra Army Depot Assessment Results

This Chapter presents assessment results and makes recommendations for compressed air systems and building lighting for these industrial operation buildings:

- Building 206/207 (Box Shop)
- Building 208 (Mechanical Repair shop)
- Building 209 (Welding shop)
- Building 210 (Paint shop)
- Building 218 (Generator/Tire Test/Repair Shop)
- Building 52 (Vehicle Maintenance Shop)
- Building 61 (Locomotive Maintenance Shop)
- Building 672 (High-Mobility Multipurpose Wheeled Vehicle [HMMWV] Armor Building).

Building 210, Paint Shop

Building 210 is used for finishing (sand and shot blasting, and painting) vehicles, trailers, and other equipment of various types and size. The building has one large shot blast booth (Figure 1) with three shot blast lines and a small manual shot blast booth. There are also two paint booths (Figures 2 and 3) in this building, one small booth with one paint line and one much larger booth with six paint lines. The spray paint area located in the Building 210 is capable of applying chemical agent resistant coatings (CARC). Two more paint booths have been ordered for Building 210 to meet the increased production needs at SIAD.

Recommendation for Building 210 Operation

B210#1: Building 210 Paint Shop Vestibules

Existing Conditions

Army components are painted in Buildings 672 and 210. Building 672 contains a small paint booth used to paint components shipped out of that building. Building 210 contains the main paint shop, which is currently equipped with a large paint booth and a small side wall paint booth located there.

Figure 1. Shot blast booth in the Paint Shop.

Figure 2. Spray booth in the Paint Shop.

Figure 3. Drive-in spray booth in the Paint Shop.

Two more paint booths have been ordered for Building 210 to meet the need to increase the production at SIAD. These new booths will be placed in the north end of the building adjacent to the side wall painting booth. As a result, all four booths will open into a space 40 ft long, and 30 ft wide; this area will become quite congested leaving no room for activities that must occur before and after painting.

Most components receive a primer and top coat. The top coat currently used is MIL-C-53039, a single component polyurethane Chemical Agent Resistant Coating (CARC) paint. There are plans to switch to MIL-DTL-64159, a water dispersible polyurethane CARC paint. According to the applications procedure guide for CARC paint (MIL-DTL-53072C), the component being painted should be maintained dry and at a temperature between 60 °F and 90 °F for both paints. Both paints perform best when the paint booth is kept at a temperature from 70 °F to 80 °F. Mil-C-53039 paint will dry to touch in approximately 15 minutes and will dry hard in 3 hrs. The water dispersible polyurethane CARC paint, MIL-DTL-64159 takes approximately 30 minutes to flash off and 4 to 5 hrs to dry hard. According to MIL-DTL-53072C, this paint also should not be exposed to temperatures below 50 °F while drying.

The above information is important to the painting applications at SIAD since Building 210 has limited floor space to bring components from outside and allow them to reach room temperature (soak) when it is cold outside. The limited floor space for soaking parts to get to a proper temperature will worsen when the two new paint booths are installed. There is also little space to allow painted parts to dry inside. As the result most painted parts are taken outside to dry.

Solution

Provide vestibules for the two new paint booths and a larger vestibule for the door at the north end of the building (Figure 4). The building vestibule and one of the two small vestibules will act as drying spaces for painted parts. These spaces will be kept at approximately 75 °F to facilitate good drying of the components. They will be located adjacent to the paint booths so freshly painted parts can be moved to complete the paint drying and begin the initial paint curing phase. The other vestibule will become a soak space for one of the small new booths and will heat parts stored outside to the proper painting temperature. The paint booths themselves could be used for these activities, but that would slow down the painting throughput and personnel assigned to painting would not be able to paint during the soak and dry times of the painting cycle. It is projected the two new booths will be used together; the first one will handle masking and painting preparation while the other booth will be used for actual painting.

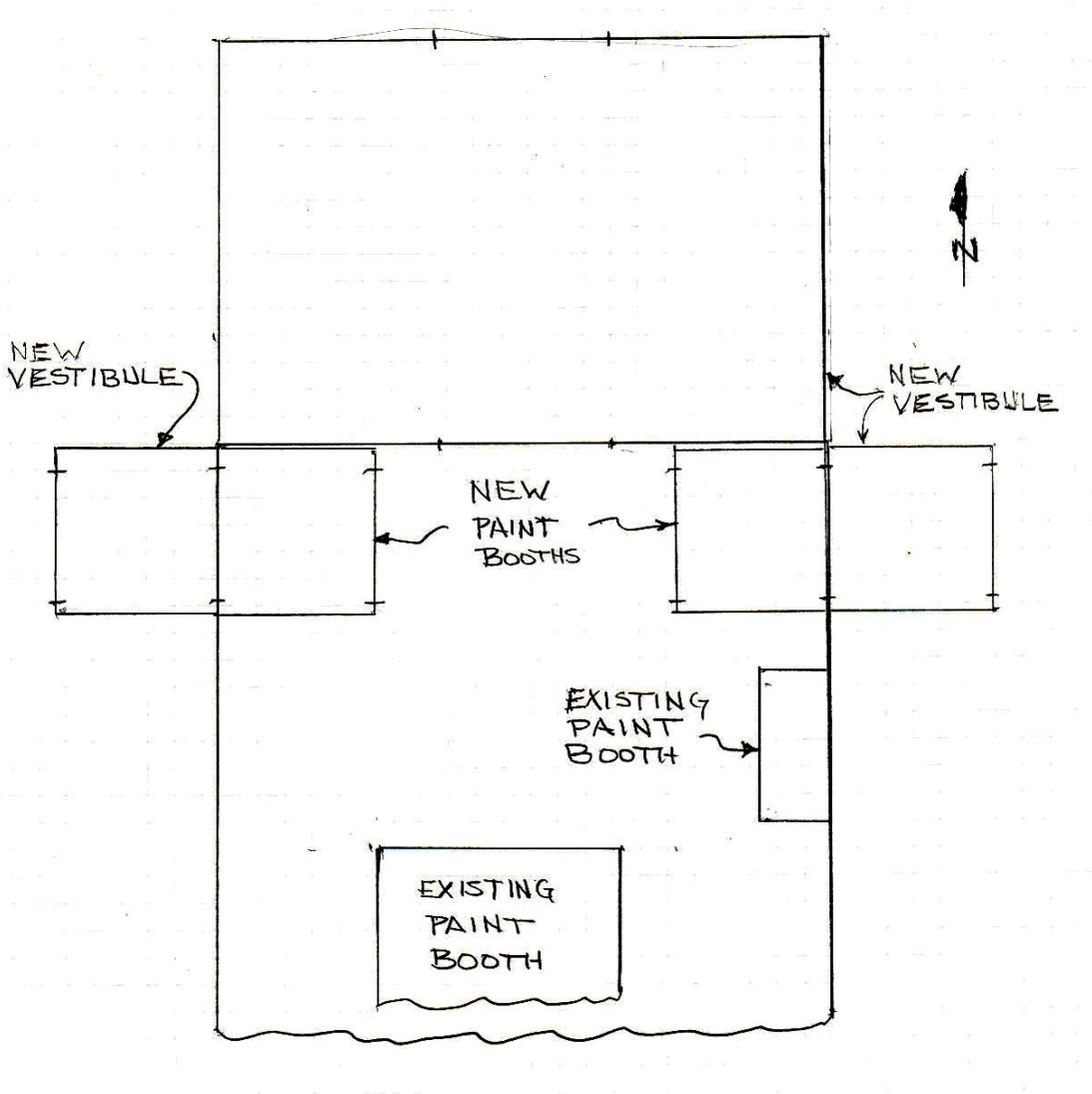

Figure 4. Proposed vestibules in Paint Shop, Building 210.

The two small vestibules would be approximately 16 ft long x 14 ft wide x 12 ft high. The larger vestibule would be 45 ft long x 20 ft wide x 16 ft high. The soak vestibule would get heat from the air compressor and would also have a radiant heating tube in the ceiling area. The two drying vestibules would be heated by steam unit heaters. All vestibules would have overhead lighting.

Savings

The savings provided by the vestibules result from the increased efficiency of the people working in the paint shop. By having the space to bring components to the correct temperature range, the painters will not have to wait until the proper temperature range is reached to begin painting. It is estimated a part would need to sit in the booth for 2 hrs to reach the right temperature on a winter day. The soak ves-

tibule allows the painter to work an additional 5 hrs in a 10-hr day that would otherwise have been spent waiting.

The drying vestibule also increases worker efficiency. After parts have been painted and the flash-off is completed, the parts can be moved to the drying vestibule space to adequately dry before placing them outdoors. These components take 2 to 4 hrs to dry hard. Without the drying vestibules the parts would stay in the booths until properly dried, which would limit the painting to 5 hrs per 10-hr shift.

Assuming a period of 15 winter weeks per year needed by the soak vestibule and 50 wks/yr for the drying vestibules, the labor savings would be 3450 hrs/yr. This estimate assumes that the painting operation works 6 days/wk. The soak vestibule would save 450 hrs/yr and the drying vestibules would save a total of 3000 hrs. At a rate of $47.87 for the labor cost per hour, the annual labor saving would be $165,150/yr.

These spaces would have an energy cost of operation. The lighting would be approximately 2W/sq ft. for 2.7 kW electrical demand or 8,100 kWh for 3000 hrs operation. At a cost of $0.075/kWh this amounts to $610/yr. The 1,348 sq ft of new space would use approximately 120 million Btu/yr for heating. At a cost of $8.06/million Btu, the heating cost is approximately $970/yr.

The resulting estimated annual savings is $163,570

Investment

An area of 1,348 sq ft of new construction at a cost of $100/sq ft would cost $134,800.

Payback

The simple payback is 0.82 years or 10 months.

B210#2: Building 210 Evaporative Cooling System

Existing Conditions

DOD weather data (TM 5 785) indicates that SIAD experiences 97 hrs above 93 °F in the summer. During this time, building spaces become too hot for productive work. A 93 °F outside temperature often results in even warmer conditions inside a building. A reduction in worker production of 10 percent is not uncommon when temperatures reach or exceed 90 °F. This building operates two shifts/wk; approximately 16 people are affected by the hot temperatures. Some summer relief is pro-

vided by two roll-around evaporative cooling units, but these units have a limited capability and require a significant amount of maintenance to keep them operational.

Solution

Install an evaporative cooling system for Building 210, which would consist of two air handling units with evaporative coolers located at each end of the building. These air handling units will discharge into a fabric duct to deliver the cool air throughout the building. For winter operation a duct will take warm air from the upper strata of the building and mix it with outside air for distribution. This will provide some building make-up air and help pressurize the building. This system will reduce cold drafts though openings in the walls.

Savings

It is estimated that the use of evaporative coolers will increase worker productivity by 10 percent during the summer months:

Labor cost savings = 16 people x 3 months x 160 hrs/month x 10% x $47.87 /hr
= $36,760/yr

Maintenance Saving

This analysis assumes that two of the roll-around evaporative cooling units service this building. The annual maintenance cost for these units is approximately $500/unit for a total maintenance cost of $1,000/yr. The maintenance cost of the larger units is estimated to be $500/yr for each unit. Thus there is no annual maintenance savings.

Energy Use

The two 20,000 CFM units will each have a 10 Hp fan motor. The roll-around evaporative cooling units have a fan motor estimated to be 3 HP. The proposed evaporative coolers with the mixed air ventilation option will operate about half the time. The roll-around evaporative cooling units will operate only during the 3 hottest months of the year.

Electrical Use = 50 wks x 44 hrs/wk x 50% x 2 x 10 Hp x 0.746 kWh/HP – 12 wks/yr x
44 hrs/wk x 2 units x 3 HP x 0.746kWh/HP = 14,049 kWh/yr

Additional electrical cost = 14,049 kWh/yr x $0.075/kWh = $1054/yr

Winter Heating savings

Assume building heating energy use is 80,000 Btu/yr/sq ft; using the upper strata heat to temper the make-up air will save 20 percent of the annual heating energy

Heating savings = 80,000 Btu/sq ft x 18,000 sq ft x 20% = 288 MBtu/yr

Heating energy cost = $0.524 ccf of natural gas x 10 ccf/MBtu / 65% boiler system efficiency = $8.06/MBtu

Cost of saved heat = 288 MBtu/yr x $8.06/ MBtu = $2,320/yr

Total saving per year = $36,760 - $1054 + $2,320 = $38,026/yr

Investment

Evaporative cooling units = 2 x $20,000 = $40,000

Installation = $30,000

Air distribution system = $20,000

Total cost = $90,000

Payback

$90,000/$38,026/yr = 2.37 yrs

Building 209, Welding Shop

Building 209 is used for a wide variety of metal work including welding, pressing, sheering, drilling, riveting, and many other metal tasks. This building is also referred to as the "Welding Shop" (Figure 5).

Figure 5. Welding Shop.

Recommendation for Building 209 Operation

B209#1: Building 209 Welding Operations Improvements

Existing Conditions

Building 209 is a space approximately 300 ft long by 60 ft wide that is the main weld shop at the Depot. There are nine welding areas in the Building 4 are along the east wall in the north of the building and the rest are along the west wall on the south end. The Welding Smoke Removal system used in this building actually is two separate systems; each uses four or five pivoting boom arms connected to a fan. All of the welding fume extraction devices incorporate a 10-ft long pivoting boom and a 10-ft long extraction arm attached to the end. The Boom Arms are all connected via galvanized spiral wound steel ductwork to a fan located outside the building. The method used to start the fans is a centrally mounted push button motor starter.

Many of the arms are in poor condition and nearly unusable by the welders. A major complaint from the welders is that the arms are either too long or to short for their needs (depending on where they are working or the size of the equipment they are working on). The booms are very difficult to pivot and the extraction arms have limited vertical movement. There is also a need for two future work stations, which would require additional fume removal equipment.

The fume removal system is often not operated when required. The reasons provided by the operators were that the extraction arms did not reach where they were needed, that they are too difficult to move and will not stay in place, that they are too noisy, and that the fan start/stop switch is inconveniently located. The two exhaust fans are operated by using a central switch, which requires the operators to walk from their locations whenever they need to start/stop the exhaust system.

Solution

Replace all of the existing boom arms with longer arms and relocate three existing extraction arms to three weld booths where it is practical to use them. The new pivoting boom arms should be 16 ft long with 14 ft extraction arms to allow the welders to reach the far side of shipping containers where welding is at times required. These arms should also be mounted a bit higher since the existing booms hit the top of the containers when they are brought in. Add automatic electronic dampers to each extraction arm location with either a sensor or manual switch to open the damper during welding. Add a frequency inverter and pressure transmitter to the existing fans. This control system will conserve electrical energy since the fan will only operate at a level equal to the need. It will also save heating energy as the exhaust system will only exhaust the air needed to do the level of work needed (rather than run at full speed all the time).

This control system takes advantage of the diversity of the welding operation. There may be adequate capacity available with the existing fans to handle the two additional weld booths that are going to be installed in the future.

Savings

Since the welders do not often use the existing welding fume exhaust system, an improvement to the system would benefit the welders' productivity and health.

When the welders do use the existing system, they need to take extra time to place the extraction arm in the proper location. This requires moving the part to be welded to a location reachable by arm. This extra time is estimated at about a half hour per day, a reduction in the welders' efficiency of 6 percent.

Labor cost savings = 10 people x 2000 hrs/yr x 6% x $47.87 /hr = $57,440/yr

If the existing systems were being used, they would need to run almost all the time —assume 80 percent. Assuming a 5 HP motor on each system, the electrical energy use would be 11,936 kWh/yr. A system that exhausts welding locations only during welding activity will operate at a lower average air flow achieved by slowing the fan

speed thus saving energy equal to the cube of the air flow reduction. Assume the average air flow will be 80 percent of the total flow. The resulting energy use will be 51 percent of the total or 5.1 HP. The annual electrical use of the modified system would be 6,111 kWh/yr, for a saving of 5,825 kWh/yr.

Existing system electrical use = 2x 5 HP x 2000 hrs x (80%) x 0.746 kWh/HP = 11,936 kWh/yr

Modified system electrical use = 2x 5 HP x 51% x 2000 hrs x 80% x 0.746 kWh/HP = 6,111 kWh/yr

Electrical cost savings = 5,825 kWh x $0.075/kWh = $437/yr

Heating Energy Savings

Average winter temperature = 65 – 5822 HDD/ (7x30days) = 37 °F

Exhaust air flow = 600 CFM/extraction arm x 9 arms = 5,400 CFM

Bldg. heat loss = 1.08 x 5,400 CFM (70 – 37 °F) x 7 months x 30 days = 40,400,000 Btu/yr

Heating energy cost savings = 40.4 MBtu/yr x $8.06/ MBtu = $326/yr

Total cost savings = $58,200/yr

Investment

The approximate cost of the modifications to the welding system =

9 arms x 3k = $27,000

2 variable frequency drive (VFD) x 2k = $4,000

Controls = $15,000

Total = $46,000

Payback

$46,000/$58,200/yr = 0.8 yrs or 9 months

B209#2: Building 209 Evaporative Cooling System

Existing Conditions

This building operates one shift/wk; approximately 10 people are affected by the hot temperatures in the summer. Some summer relief is provided by three roll-around evaporative cooling units, but these units have a limited capability and require a significant amount of maintenance.

Solution

Install an evaporative cooling system for Building 209, which would consist of two air handling units with evaporative coolers located at each end of the building. These air handling units will discharge into a fabric duct to deliver the cool air throughout the building. For winter operation a duct will take warm air from the upper strata of the building and mix it with outside air for distribution. This will provide some building make-up air and help pressurize the building. This system will reduce cold drafts though openings in the walls.

Savings

It is estimated the use of evaporative coolers will increase worker productivity by 10 percent in the summer months.

Labor cost savings = 10 people x 3 months x 160 hrs/month x 10% x $47.87 /hr = $22,980/yr

Maintenance Saving

This analysis assumes that three of the roll-around evaporative cooling units service this building. The annual maintenance cost for these units is approximately $500/unit for a total maintenance cost of $1,500/yr. The maintenance cost of the larger units is estimated to be $500/yr for each unit. The annual maintenance savings is approximately $500/yr.

Energy Use

The two 20,000 CFM units each will have a 10 Hp fan motor. The roll-around evaporative cooling units have a fan motor estimated to be 3 HP. The proposed evaporative coolers with the mixed air ventilation option will operate about half the time. The roll-around evaporative cooling units will operate only during the 3 hottest months of the year.

Electrical use = 50 wks x 44 hrs/wk x 50% x 2 x 10 Hp x 0.746 kWh/HP – 12 wks x 44 hrs/wk x 3 units x 3 HP x 0.746kWh/HP

= 12,867 kWh/yr

Additional electrical cost = 12,867 kWh/yr x 0.075/kWh = $965/yr

Winter Heating Savings

Assume building heating energy use is 80,000 Btu/yr/sq ft; using the upper strata heat to temper the make-up air will save 20 percent of the annual heating energy:

Heating savings = 80,000 Btu/sq ft x 18,000 sq ft x 20% = 288 MBtu/yr

Heating energy cost = $0.524 ccf of natural gas x 10 ccf/MBtu / 65% boiler system efficiency = $8.06/MBtu

Cost of saved heat = 288 MBtu/yr x $8.06/MBtu = $2,320/yr

Total saving per year = $22,980 + $500 - $965 + $2,320 = $24,835/yr

Investment

Evaporative cooling units = 2 x $20,000 = $40,000

Installation = $30,000

Air distribution system = $20,000

Total cost = $90,000

Payback

$90,000/$24,835/yr = 3.6 yrs

Building 208, Mechanical Repair Shop

Building 208 (Figure 6) is dedicated to maintenance and testing of equipment and machinery. This building is also referred to as Mechanical Repair shop.

Recommendation for Building 208 Operation

B208#1: Building 208 Evaporative Cooling System

Existing Conditions

This building operates two shifts/wk; approximately 27 people are affected by the hot temperatures in the summer. Some summer relief is provided by three roll-around evaporative cooling units. But these units have a limited capability and require a significant amount of maintenance to keep them operational.

Figure 6. Mechanical Repair Shop.

Solution

Install an evaporative cooling system for Building 208, which would consist of two air handling units with evaporative coolers located at each end of the building. These air handling units will discharge into a fabric duct to deliver the cool air throughout the building. For winter operation, a duct will take warm air from the upper strata of the building and mix it with outside air for distribution. This will provide some building make-up air and help pressurize the building. This system will reduce cold drafts though openings in the walls.

Savings

It is estimated that the use of evaporative coolers will increase worker productivity by 10 percent during the summer months:

Labor cost savings = 27 people x 3 months x 160 hrs/ month x 10% x $47.87 /hr
= $62,040/yr

Maintenance Saving

This analysis assumes that three of the roll-around evaporative cooling units service this building. The annual maintenance cost for these units is approximately $500/unit for a total maintenance cost of $1,500/yr. The maintenance cost of the lar-

ger units is estimated to be $500/yr for each unit. The annual maintenance savings is approximately $500/yr.

Energy Use

The two 20,000 CFM units each will have a 10 Hp fan motor. The roll-around evaporative cooling units have a fan motor estimated to be 3 HP. The proposed evaporative coolers with the mixed air ventilation option will operate about half the time. The roll-around evaporative cooling units will operate only during the 3 hottest months of the year.

Electrical use = 50 wks x 44 hrs/wk x 50% x 2 x 10 Hp x 0.746 kWh/HP – 12 wks/yr x 44 hrs/wk x 3 units x 3 HP x 0.746kWh/HP

= 12,867 kWh/yr

Additional electrical cost = 12,867 kWh/yr x 0.075/kWh = $965/yr

Winter Heating Savings

Assume building heating energy use is 80,000 Btu/yr/sq ft; using the upper strata heat to temper the make-up air will save 20 percent of the annual heating energy

Heating savings = 80,000 Btu/sq ft x 18,000 sq ft x 20% = 288 MBtu/yr

Heating energy cost = $0.524 ccf of natural gas x 10 ccf/MBtu / 65% boiler system efficiency = $8.06/MBtu

Cost of saved heat = 288 MBtu/yr x $8.06/MBtu = $2,320/yr

Total saving per year = $62,040 + $500 - $965 + $2,320 = $63,895/yr

Investment

Evaporative cooling units = 2 x $20,000 = $40,000

Installation = $30,000

Air distribution system = $20,000

Total cost = $90,000

Payback

$90,000/$63,895/yr = 1.4 yrs

Building 206/207, Box Shop

This building is used for woodworking, box/crate fabrication, and preparation of container packaging for storage or shipment.

Recommendation for Building 206/207 Operation

B207#1: Buildings 206/207 Evaporative Cooling System

Existing Conditions

These buildings operate one shift per wk; approximately 14 people are affected by the hot temperatures in the summer. Some summer relief is provided by four roll-around evaporative cooling units. But these units have a limited capability and require a significant amount of maintenance to keep them operational.

Solution

Install an evaporative cooling system for Buildings 206/207, which would consist of two air handling units with evaporative coolers located at each end of the building. These air handling units will discharge into the existing air distribution duct to deliver the cool air throughout the building.

Savings

It is estimated that the use of evaporative coolers will increase worker productivity by 10 percent during the summer months:

Labor cost savings = 14 people x 3 months x 160 hrs/ month x 10% x $47.87 /hr = $32,170/yr

Maintenance Saving

This analysis assumes that four of the roll-around evaporative cooling units service this building. The annual maintenance cost for these units is approximately $500/unit for a total maintenance cost of $2,000/yr. The maintenance cost of the larger units is estimated to be $500/yr for each unit. The annual maintenance savings is approximately $1,000/yr.

Energy Use

The two 16,000 CFM units each will have a 10 Hp fan motor. The roll-around evaporative cooling units have a fan motor estimated to be 3 HP. Both systems will operate only during the 3 hottest months of the year.

Electrical Use = 12 wks x 44 hrs/wk x 2 x 10 Hp x 0.746 kWh/HP – 12 wks x 44 hrs/wk x 4 units x 3 HP x 0.746kWh/HP
= 3,147 kWh/yr

Additional electrical cost = 3,147 kWh/yr x 0.075/kWh = $236/yr

Total saving per year = $32,170 + $1,000 - $236 = $32,930/yr

Investment

Evaporative cooling units = 2 x $18,000 = $36,000

Installation = $30,000

Air distribution system = $5,000

Total cost = $71,000

Payback

$71,000/$32,930/yr = 2.2 yrs

Building 61, Locomotive Maintenance Facility

This building (Figure 7) is used for diesel powered locomotive engine maintenance.

Recommendation for Building 61 Operation

B61#1: Building 61, Locomotive Maintenance Facility Ventilation Improvements

Existing Conditions

This building houses two diesel engine locomotives used to move rail cars around the base. Currently there is a canopy hood over the engine exhaust that has a small propeller fan at the roof level. The hood has been cut up and modified over the years. The hood is located above the exhaust pipes/stacks where the locomotive is parked but does not extend to the doors used for exiting the building.

Figure 7. Locomotive Maintenance Facility.

As a result, the building fills with diesel smoke when the locomotive is driven out of the building, and then all doors are opened to flush this smoke out of the building.

Information from the building occupants revealed that diesel engine locomotives maybe replaced by electric locomotives in the next year or so. These new models will only have a much smaller engine that is used to charge the batteries.

Solution

Diesel exhaust is a hazardous contaminant, but to effectively capture and remove it is a problem in this building. The best way to accomplish this is to install a long narrow hood over the locomotive for the entire length from the doors to where the locomotive is parked. There could be two or three roof exhausters installed with each hood to provide the airflow out of the space. The exhaust air volume would be approximately 30,000 CFM.

A better solution would be to switch to the battery powered locomotives and to use a smaller close capture exhaust system.

Savings

There is a minimal financial savings resulting from this project. It would consist of the heat required to heat up the building after outside air has purged out the diesel exhaust, which is estimated to be no more than $1,000/yr.

The biggest reason for installing the exhaust system is to improve the locomotive mechanic's health and safety by getting rid of most all of the diesel exhaust while they are warming up the locomotive and while driving it out of the building.

Investment

The cost for two 30,000 CFM exhaust systems would be approximately $75,000.

Payback

$75,000/$1,000/yr = 75 yrs

Building 218, Repair Shop

Building 218 is currently used for generator and other equipment testing, but the function of the building is changing to that of repairing vehicle/trailer tires.

Recommendation for Building 218 Operation

B218#1: Building 218, Repair Shop Ventilation Improvements

Existing Conditions

This small building has been used as a repair shop for electrical generators. For ventilation it has one overhead hose reel used to remove generator engine exhaust fumes. This unit is comprised of one hose reel with 4-in. hose and a direct mount fan. There are also two unit heaters in the building that are used to maintain building temperatures in the winter. There should be a supply air handling unit to bring outside air into the building. The function of the building is changing to that of repairing vehicle/trailer tires.

Solution

Install a supply air handling unit to provide ventilation air to this space. If this space is to continue repairing electrical generators, then the exhaust unit needs to be replaced with one that can accommodate a greater exhaust rate and that has components compatible with hot exhaust.

Savings

These recommendations are related to indoor air quality (IAQ) and will not contribute to any cost savings; their benefit is to help maintain the health of those who work in the building.

Investment

The supply air handling unit should be approximately 3,000 CFM in capacity and will cost approximately $10,000. Upgrading the exhaust can be accomplished at a cost of $4,000.

Payback

The payback consists of improving the IAQ and building worker health.

Building 52, Vehicle Maintenance Facility

This building is used for general maintenance of various type of vehicles used in the base (Figure 8), including routine scheduled maintenance, overhaul, and repair.

Recommendations for Building 52 Operation

B52#1: Vehicle Maintenance Facility Evaporative Cooling

Existing Conditions

This building operates one shift/wk; approximately eight people are affected by the hot temperatures in the summer. Some summer relief is provided by 2 roll-around evaporative cooling units. But these units have a limited capability and require a significant amount of maintenance to keep them operational.

Figure 8. Vehicle Maintenance Facility.

Solution

Install an evaporative cooling system for Building B52, which would consist of a 7000 CFM air handling unit with an evaporative cooler located at the end of the building. This air handling unit will discharge into a fabric duct to deliver the cool air throughout the building.

Savings

It is estimated that the use of evaporative coolers will increase worker productivity by 10 percent during the summer months:

Labor cost savings = 8 people x 3 months x 160 hrs/ month x 10% x $47.87 /hr = $18,380/yr

Maintenance Saving

This analysis assumes that two of the roll-around evaporative cooling units service this building. The annual maintenance cost for these units is approximately $500/unit for a total maintenance cost of $1,000/yr. The maintenance cost of the larger unit is estimated to be $500/yr for one unit. The annual maintenance savings is approximately $500/yr.

Energy Use

The 7,000 CFM unit each will have a 5 Hp fan motor. The roll-around evaporative cooling units have a fan motor estimated to be 3 HP. Both evaporative cooler systems will operate only during the 3 hottest months of the year.

Electrical saving = 12 wks x 44 hrs/wk x 2 units x 3 HP x 0.746 kWh/HP – 12 wks x 44 hrs/wk x 5 Hp x 0.746kWh/HP = 394 kWh/yr

Electrical cost saving = 394 kWh/yr x 0.075/kWh = $30/yr

Total saving per year = $18,380 + $500 + $30 = $18,910/yr

Investment

Evaporative cooling unit = $12,000

Installation = $10,000

Air distribution system = $5,000

Total cost = $27,000

Payback

$27,000/$18,910/yr = 1.4 yrs

Building 672, HMMWV Armor Building

Since it was constructed in 1942, SIAD has conducted various military support activities. SIAD's mission has consistently been to receive, store, transport, repair, and treat many types of munitions, explosives, propellants, and other materials. Until August 2001, a major operation at SIAD was treatment of large quantities of munitions, explosives, and propellants using open burning (OB), open detonation (OD), and incineration. Building 672, designed to store special weapons, is a legacy of these former missions. Currently, part of this building is being used for welding/painting/assembly operation primarily for preparing HMMWV replacement doors. HMMWV (High-Mobility Multipurpose Wheeled Vehicle), also known as "Humvee" and "Hummer"—a light, highly mobile, diesel-powered, four-wheel-drive vehicle.

Recommendations for Building 672 Operation

B672#1: Welding Exhaust Improvements

Existing Conditions

Part of the Building 672 is a welding/paint/assembly shop for preparing HMMWV replacement doors. There is one small weld shop where armor plated doors are being welded. In this area there are four portable fume removal exhaust filter units that are used to capture the smoke generated during the welding operations. There are two Micro Air self-cleaning portable units, one Airflow self-cleaning unit and one Impell unit with a HEPA filter. All the portable units have one extraction arm that is about 10 ft long. These arms are very difficult to move and position over the work area. The Impell portable unit that uses the HEPA filter is not working at the time of visit.

The future of this work area is in question. Using the portable units for heavy duty applications is not practical, but if this shop is not going to be used under a long term basis, their replacement cannot be justified.

Solution

Assuming welding operations continue in Building 672, a new welding smoke removal system should be installed to replace one portable filter and for the other three portable units replace their filters and extraction arms.

Savings

There is no energy savings associated with this recommendation. Replacing the extraction arms will reduce the time welders need to place the extraction arm in the proper location. It is estimated the new arms will save about a half hour per day, an improvement in the welders' efficiency of 6 percent.

Labor cost savings = 3 people x 2000 hrs/yr x 6% x $47.87 /hr = $17,230/yr

Investment

The cost for one new portable filter and to replace the filters and extraction arms for the other three machines will cost approximately $15,600.

Payback

$15,600/$17,230/yr= 0.9 yrs or approximately 11 months

B672#2: Install Door in North Wall

Existing Conditions

Previous missions at SIAD required construction of Building 672 with security and explosion containment as paramount concerns. Consequently, Building 672 was constructed with just one rolling overhead door providing equipment access to the structure. While single door access enhanced the building's security and enabled better explosion control for its old mission, use of the building for industrial operations requires a different layout.

Kit materials enter Building 672 through the rolling door, which is immediately adjacent to the painting and welding areas, and are moved into storage. As they are processed, the kit materials are moved further into the building in a back and forth process between the bays, painting and welding areas, using the central corridor to traverse the building. Completed kits are stored at the end of this central corridor against the back wall, in a location that is furthest distant from the rolling door. Once a shipment is ready to depart, these kits are moved back through the building, against other work already in process, and then out the building through the rolling overhead door. A portable ramp is put into place and the kits brought up the ramp into the waiting trailer. Once loaded, the trailer departs and the ramp is moved back behind the building.

This process is very inefficient. The completed kits have to be moved a great distance from the storage area to the staging area outside, a movement process that requires a great deal of time. More importantly, the completed kits have to move through and against the current work in process, disrupting and slowing both flows. Finally, the ramp must be moved, staged and then moved again for each loading operation. These operations add up to a significant time commitment that adds no value to the process or final product. As the workers who move the materials also conduct the actual processing of the materials, this time could be dedicated to processing instead of transport. Ultimately, the time saved would increase throughput of the operation and increase the number of armor door kits shipped each day.

Solution

A rolling overhead door should be installed in the north wall, outside of which should be a large cement pad for the shipping trailer to stage upon. A cement ramp should also be installed, providing access to the trailer bed for the forklift.

The storage area will grow larger to provide an access corridor for the forklift to move through the stacked kits, but this should not impact operations. This new

configuration will better serve the HMMWV armored kit and subsequent operations that will inhabit the building in the future.

Savings

According information provided by building personnel and distances measured by the CERL team, each finished kit must move a total of 240 ft to traverse Building 672, from the storage area along the north wall to final exit from the building through the rolling door. Assuming that the distance traveled upon exiting the proposed door is the same as the distance currently traveled through the overhead door, the total distance traversed is then 240 ft/kit. If a door is installed in the north wall, the kits will travel 240 ft less in departing the building.

Building 672 creates packages and ships 25 kits/day, 360 days/yr. Assuming that the materials are moved at a speed of 1 ft/second (a standard transport speed for forklifts and handlifts) by one person, the annual time savings is:

240 ft/kit × 25 kits/day × 360 days/yr × 1 sec/ft × 1 min/60 sec × 1 hr/60 min
= 600 hrs/yr

SIAD estimates its labor rate to be $47.87/hr. Applying the hourly labor rate to the hours saved:

600 hrs/yr × $47.86/hr = $29,000/yr

There is also the time taken to set up and take down the steel ramp that allows the forklift to access the trailer bed. SIAD personnel estimate that set up takes 40 minutes and take down a similar amount of time. The same personnel estimated that there are a total of seven trucks arriving and departing every 2 wks. With these numbers, the annual time savings is:

(40 min/truck setup + 40 min/truck takedown) × 1 hr/60 min × 7 truck setups and takedowns/2 wks × 52 wks/yr = 250 hrs/yr

Applying the hourly labor rate to the hours saved:

250 hrs/yr × $47.86/hr = $12,000/yr

The total savings is then:

$29,000/yr + $12,000/yr = $41,000/yr

The cost of implementing this measure is the cost of installing a door in the north wall, constructing a parking pad for the trailer and building a ramp to facilitate forklift access. Including ground preparation, labor, materials, and taking into ac-

count SIAD's remote location, the total cost of implementing this recommendation is estimated to cost $200,000. The simple payback is then:

$200,000 / $41,000 = 5 yrs

B672#3: Remove Fencing

Existing Conditions

Building 672 is of open bay design that is subdivided by a series of steel fence walls. These walls were formerly used to limit access between the bays while allowing for ventilation. These interior subdivisions create longer travel paths for work in process. Currently, to move materials from one area to another, they must be removed from the bay to the center corridor via handlift or forklift. The materials must travel the corridor until reaching the next step in the process, where they enter the destination bay. It would be much easier if the materials could be moved laterally from bay to bay. This would reduce the distance that must be traveled, decreasing the amount of labor and time dedicated to this operation. While the distances involved are not great, over the course of a week they represent a significant commitment of time. As the workers who move the materials also conduct the actual processing of the materials, this extra time could be committed to processing vice transport. Ultimately, the time saved would increase throughput of the operation and increase the number of armor door kits shipped each day.

Solution

The fencing in between the bays should be removed to facilitate faster transport and increased throughput. Current operations are in no way dependent on the fencing and would be enhanced without any detrimental effects.

Savings

According to information provided by building personnel and distances measured by the CERL team, each set of armor that will become a kit must move a total of 150 ft to traverse Building 672. This movement starts when the raw materials first enter the building and ends when the finished kits leave and includes all operations in between. If the fencing between the bays is removed, this distance can be reduced to just 70 ft, a difference of 80 ft/kit.

Building 672 creates, packages and ships 25 kits/day, 360 days/yr. Assuming that the materials are moved at a speed of 1 ft/second (a standard transport speed for forklifts and handlifts) by one person, the annual time savings are:

70 ft/kit × 25 kits/day × 360 days/yr × 1 sec/ft × 1 min/60 sec × 1 hr/60 min
= 175 hrs/yr

SIAD estimates its labor rate to be $47.87/hr. Applying the hourly labor rate to the hours saved:

175 hrs/yr × $47.86/hr
= $8,400/yr

While the monetary savings are not significant, the annual time savings, when combined with the other recommendations in this report, add to up to a large number that represents the opportunity for increased throughput, speeding kits to the soldier.

The cost of removing the fencing is estimated to take two persons 2 hrs apiece per 20-ft section. Estimating a total of 20 of these sections, the total cost is then:

2 hrs/person × 2 persons/fence section × $47.86/hr × 40 fence sections

= $7,700

The simple payback is then:

$7,700/$8,400

= 11 months

B672#4: Use Portable Jib Cranes

Existing Conditions

Currently, personnel in Building 672 use overhead gantry cranes to lift and transport heavy parts and materials while in the bays. The overhead gantry cranes servicing the bay areas are oversized for this type of work, each requiring three operators to move the crane, position the hoist and arrange the load. Once loaded, the gantry cranes are so large compared to their loads that extra care and time must be taken to move the items across the room. This adds up to extra labor and ultimately extra time costs.

Solution

Portable gantry cranes with motorized winches should be purchased and used within Building 672 to move kit pieces. The hoist should be rated to handle 500 to 1,000 lb and have a lift height of 8 to 10 ft.

Savings

According information provided by building personnel and times measured by the CERL team, it takes three persons approximately 1 minute to move the crane, position the hoist and arrange and move each kit piece. There are three pieces per box and two boxes per kit. Assuming that 25 kits are assembled each day, the current time dedicated to hoisting kit pieces is:

3 persons/move × 1 min/piece × 3 pieces/box × 2 boxes/kit × 25 kits/day ×
360 days/yr × 1 hr/60 min

= 2,700 hrs/yr

It is estimated that adopting the portable jib cranes will reduce the crew size by one person and reducing the time needed to move the kit pieces by 30 seconds. The proposed time to be dedicated to hoisting kit pieces with the portable jib cranes is:

2 persons/move × 0.5 min/piece × 3 pieces/box × 2 boxes/kit × 25 kits/day ×
360 days/yr × 1 hr/60 min

= 900 hrs/yr

The difference between the current and proposed arrangement is then:

2,700 hrs/yr – 900 hrs/yr

= 1,800 hrs/yr

SIAD estimates its labor rate to be $47.87 /hr. Applying the hourly labor rate to the hours saved:

1,800 hrs/yr × $47.86/hr

= $86,000/yr

The cost of implementing this measure is the cost of purchasing three portable jib cranes to move the kit pieces. Assuming a very conservative cost of $40,000 per jib crane, the total cost is $120,000.

The simple payback is then:

$120,000/$86,000

= 1.4 yrs

SIAD Compressed Air Systems

The existing central compressed air system located in Building 210 consisted of a natural gas engine driven air compressor (NGEDAC) and a backup electric compressor to provide compressed air for process use and an electric oil-free compressor for breathing air that is needed during shot/sand blasting and painting operations.

The NGEDAC compressor (Figure 9) was installed at the south-end of the compressor room in Building 210, and the oil-free compressor (Figure 10) was installed at the north-end in the same room as the backup 125 horse power Gardner Denver electric compressor (Figure 11). Adequate spacing of approximately 2 to 3 ft surrounds each compressor permitting easy maintenance and service. Piping arrangements were shown in Figure 12.

The Ingersoll-Rand/MAN NGEDAC (Gascom GCM635, natural gas engine driven air compressor) was supplied by Cisco Systems for $135,940. The Gardner Denver TA-40 electric motor driven oil-free air compressor was supplied by Accurate Air for $42,173. L.A. Perks Plumbing & Heating of Sparks, NV was the installation contractor for both compressors. The final installation cost for the NGEDAC was $85,000 (including pre-purchased items) and additional items that were found necessary during the construction process (primarily items related to the heat recovery system).

The output of the oil-free compressor is treated by a Nomonox air purifiers and there is a 240-gal receiver tank to meet surge demands as well as an air dryer to control moisture (Figure 13).

NGEDAC Heat Recovery System

In Building 210, there is a heat recovery system (Figure 14) to use the waste heat generated from the natural gas fired engine during winter. For monitoring purposes, temperature sensors and a water flow meter were installed in the heat recovery lines before and after the NGEDAC. Thermowells were used to enable insertion or removal of the temperature sensors without the need to shut down the heat recovery system.

Figure 9. The Ingersoll Rand/MAN NGEDAC, Gascom 635.

Figure 10. Gardner Denver TA-40 oil-free breathing air compressor.

Figure 11. Backup Gardner Denver electric compressor.

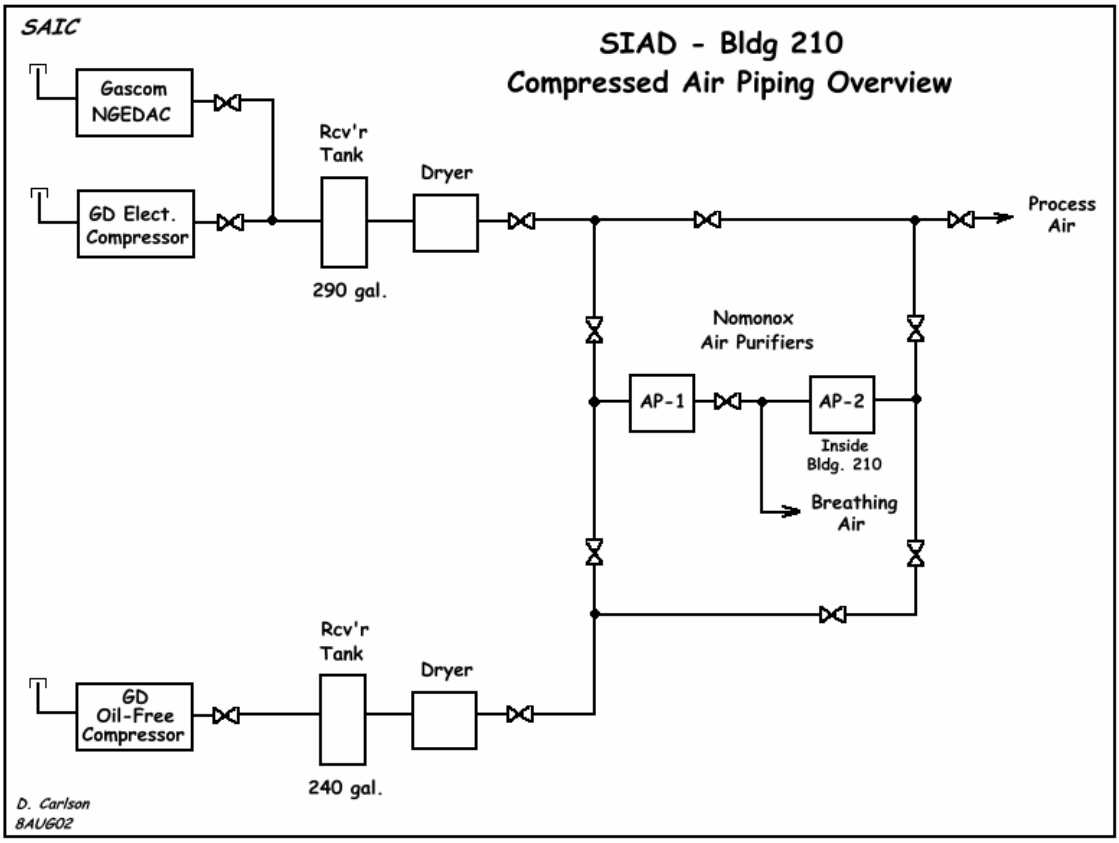

Figure 12. Compressed air piping overview.

Figure 13. Oil-free compressor receiver and dryer.

Figure 14. MAU-1 heat recovery coil.

Recommendations for Compressed Air Systems

CA#1: Provide Portable Breathing Air Backup Unit

Existing Conditions

Carbon monoxide, hydrocarbons (oil) and other chemical vapors (volatile organic compounds) and toxic gases can be extremely hazardous to ones health. These toxic contaminants may be present in the atmosphere in various concentrations while performing such tasks as spray painting, sandblasting, tank cleaning etc. Normally standard compressed air will contain liquid, water, and oil, gaseous hydrocarbons, dirt rust scale, and may contain other potentially hazardous contaminates, thus making the compressed air unsuitable for breathing purposes.

Currently Building 672 has an inadequate supply of breathing air for its painting operations. Building 672 has two painting stations, but only breathing air capacity for one person at a time. There is adequate compressed air capacity in the process side, however, that system cannot be used for breathing air.

The breathing air system in Building 210 (paint shop) is more robust than the system in Building 672, but there is no redundancy. If the breathing air system becomes inoperative for any reason, the paint shop becomes a production bottleneck.

It would be desirable to address both system shortfalls with a single solution.

Solution

It is proposed to supplement the existing breathing air systems with a portable breathing air system containing all the key hardware to supply Class D air. The hardware would be mounted to a movable skid so the breathable air system could be used at any building conducting a painting application or other application requiring Class D air.

The proposed system is designed to supply approximately 140 CFM of Class D breathing compressed air at up to 80 psig. Class D quality meets OSHA regulations for breathing air. The skid mounted system is comprised of several components. The first component of this system is the 40 hp oil-free rotary air compressor. This compressor does not use oil to lubricate or cool the compressor, therefore, atomized oil cannot be entrained in the air stream, which minimizes the amount of contaminants that must be filtered out of the air. The next component is the dryer and filtration system. It is recommended that this be purchased as an all in one unit to comply with size and portability concerns. Such a unit contains a desiccant dryer to

remove moisture from the air to a level suitable for breathing. This unit also has both coalescent filters that remove particulate and a catalyst that converts carbon monoxide into carbon dioxide. Over an extended period of time, the combined dryer and filtration system is expected to develop a pressure drop of 12 to 15 psi. However, the compressor is sized to account for this.

The final component is a series of tank receivers with approximately 1,200 gal of compressed air reserve. This capacitance of air would allow a continuing breathing air supply during a power interruption.

Exact sizing and capacity can be determined in a Phase 2 assessment. The information given below is for illustrative purposes only. Approximate dimensions and weights of the system components are shown in the Table 5. The total weight of these three components is 3.2 tons.

A simple schematic depicting the orientation of the breathing compressed air supply system is shown in Figure 15.

There are several concerns that need to be addressed when installing this system onto a portable skid. Although the rotary screw compressor creates a low level of vibration, any vibration would disrupt operation of the desiccant dryer and could cause a potential safety hazard with the receiver tank. The compressor must be mounted with a vibration damper. One alternative is to mount the compressor on a separate skid from the dryer and receiver tank. Finally, to preserve the longevity of the air compressor, the skid should be parked only on a level surface during periods of operation.

Savings

This assessment recommendation addresses plant needs not based on energy conservation. To develop an accurate savings numbers, the cost of not installing the system needs to be evaluated. This will occur during a Phase 2 assessment.

Table 5. Breathing air component dimensions and weights.

System Component	Height (in.)	Length (in.)	Width (in.)	Weight (lb)
Compressor	69	76	39	2,750
Filter and Dryer System	73	51	36	665
Receiver Tanks (6)	72	30	30	3,000

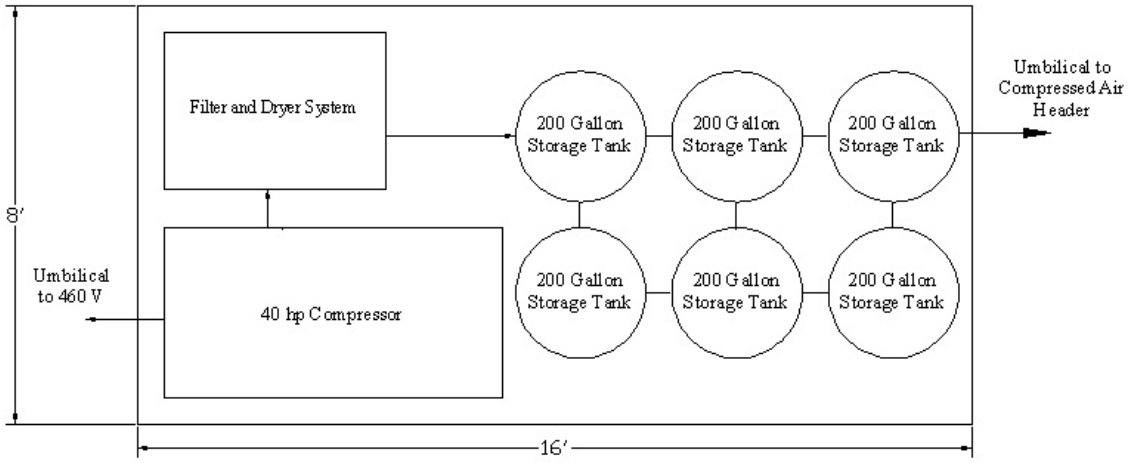

Figure 15. Breathing compressed air supply system.

Investment

This is a major project. The unit cost for each component is listed in Table 6 (not including the cost of the skid). The estimated total turnkey cost for the breathing compressed air supply system mounted on a skid is approximately $101,000. Accurate installed cost budget number will be based on measurements and further discussion conducted during a Phase 2 assessment.

Payback

The simple payback of this initiative is to be determined in Phase 2 assessment.

Table 6. Portable breathing compressed air system component cost breakdown.

System Component	Cost
Compressor	$42,400
Filter and Dryer System	$14,000
Piping, umbilicals, wiring labor, etc.	$20,000
Storage Tanks	$7,800
Engineering Contingency	20% ($16,800)
Estimated Total	$101,000

CA#2: Establish Compressed Air Leak Management Program

Existing Conditions

Leaks in a compressed air system can waste between 25 and 40 percent of a compressor's output. The problem of chronic air leaks is often addressed by installing excess (and unneeded) compressor capacity, which results in higher than necessary costs. Air leaks also decrease the life of compressors and ancillary equipment by causing frequent cycling and increased running time. They also can cause fluctuations in the system pressure resulting in less efficient operation of air-powered tools.

The best way to detect leaks is with an ultrasonic acoustic detector. These units are easy to use, but costs and sensitivities vary. A cheaper, but still effective, way to detect leaks is to apply soapy water to the suspected area with a paintbrush.

Compressed air leaks are most common in hoses and at couplings, fittings, quick disconnects, etc. Leakage rates vary depending on the supply pressure and, as illustrated in Table 7, the size of the leak orifice.

Solution

A leak survey should be completed at SIAD. This can be completed by in house staff, a compressed air service company or an energy services contracting company. All leaks should be cataloged and tagged for identification and future checking. Once the leaks are identified, they should be repaired as soon as possible. Repairing these leaks can realize significant electricity savings.

Table 7. Air flow leak rates.

Pressure (psig)	Orifice Diameter (in.)*					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.3	1.2	4.8	19.2	76.7	173
80	0.33	1.3	5.4	21.4	85.7	193
90	0.37	1.5	5.9	23.8	94.8	213
100	0.41	1.6	6.5	26.0	104	234
125	0.49	2.0	7.9	31.6	126	284

* for well-rounded orifices, multiply the values by 0.97
for sharp-edged orifices, multiply the values by 0.61
source: *Compressed Air Challenge*

Savings

Considering the decentralized nature of the compressors at SIAD, additional work needs to be completed including in-depth data monitoring to ascertain an accurate savings number. This number will be determined during a Phase 2 assessment.

Investment

This is a relatively easy project since leaks can be readily identified and tagged. Accurate installed cost budget numbers will be based on measurements conducted during a Phase 2 assessment. However, the magnitude of these costs is expected to be relatively low.

Payback

Based on previous experience investments of this type typically have a simple payback of less than 1 yr. This assessment recommendation should be implemented immediately.

4 Summary, Conclusions, and Recommendations

Summary of All Energy Conservation Measures (ECMs)

Of the 15 ECMs identified in this work, 11 were quantified with preliminary investment requirements (costs), estimated savings, and payback periods. Table 8 summarizes these 15 ECMs. Based on the savings category identified, each project funding source is suggested in the last column of the Table. Generally, energy saving projects can apply for Energy Conservation Investment Program (ECIP) funding while productivity and/or health/safety related improvement work is more suitable for Army Working Capital Funds (AWCF).

Conclusions

The Phase 1 Process and Energy Optimization Assessment at Sierra Army Depot conducted a Level I analysis to determine the economic potential for significant energy and cost reduction opportunities. The study identified solutions to critical cost issues and estimated the economics for the top ideas. Seventeen Energy Conservation Measures (ECMs) were identified in the Phase 1 of the study (summarized in Table 8). The 15 measures are associated with the following Buildings:

- Building 206/207 (Box Shop)
- Building 208 (Mechanical Repair Shop)
- Building 209 (Welding Shop)
- Building 210 (Paint Shop)
- Building 218 (Generator/Tire Test/Repair Shop)
- Building 52 (Vehicle Maintenance Shop)
- Building 61 (Locomotive Maintenance Shop)
- Building 672 (HMMWV Armor Building).

Economical quantification of 11 of the 15 ECMs (Table 8) shows that, when implemented, the ECMs will allow SIAD to reduce its annual energy and operating costs by approximately $0.545M. The capital investment required to accomplish these savings is approximately $0.892M, indicating an average simple payback period of 1.6 yrs (20 months).

Table 8. Investment, savings, and payback of 15 ECMs.

Area	ECM	Description	Investment (K$)	Savings (K$/Yr)	Payback (Yr)	Savings Category	Recommended Funding Sources
B210	1	Building 210 Paint Shop Vestibules	134.8	163.6	0.8	E, P	ECIP
B210	2	Building 210 Evaporative Cooling System	90	30	2.4	E, M	ECIP
B209	3	Building 209 Welding Operations Improvements	46	58.2	0.8	E, IAQ	AWCF
B209	4	Building 209 Evaporative Cooling System	90	24.8	3.6	E, M	ECIP
B208	5	Building 208 Evaporative Cooling System	90	63.9	1.4	E, M	ECIP
B207	6	Buildings 206/207 Evaporative Cooling System	71	32.9	2.2	E, M	ECIP
B61	7	Building 61Ventilation Improvements	75	1+IAQ	TBD	E, IAQ	AWCF
B218	8	Building 218 Ventilation Improvements	14	IAQ	TBD	IAQ	AWCF
B52	9	Buildings 52 Evaporative Cooling System	27	18.9	1.4	E, M	ECIP
B672	10	Building 672 Welding Exhaust Improvements	15.6	17.2	0.9	E, IAQ	AWCF
B672	11	Install Door in North Wall in Building 672	200	41	5	P	AWCF
B672	12	Remove Fencing from Building 672	7.7	8.4	0.9	P	AWCF
B672	13	Use Portable Jib Cranes in Building 672	120	86	1.4	P	AWCF
CA	14	Provide Portable Breathing Air Backup Unit	101	TBD	TBD	P	AWCF
CA	15	Establish Compressed Air Leak Management Program	Low	TBD	TBD	E	O&M
		Total of the 11 economically quantified ECMs	892.1	544.9	1.6		

Note: TBD=To be determined

CA=Compressed Air System; E=Energy; M=Maintenance; P=Productivity; IAQ=Indoor Air Quality; O&M=Operation & Maintenance Budget; ECIP=Energy Conservation Investment Program; AWCF=Army Working Capital Fund

Recommendations

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

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

It is recommended that SIAD pursue Phase 2 of this PEOA. Recommendations for the scope of the Phase 2 study can be based on the Phase 1 results presented in Table 8. A specific Phase 2 scope will be jointly developed by the CERL and SIAD teams through review and discussion of results documented in this Phase 1 report. Phase 2 will include a Level II analysis that "guesses at nothing – measures everything." The results will be a set of demonstrated process and systems improvements based on hard numbers. CERL and expert consultants will provide guidance and further assistance in identifying a specific Phase 2 scope of work, respective roles, and the most expeditious implementation path. This will begin with a formal review of this (Phase 1) report, combined with a planning session to organize the Phase 2 program.

Acronyms and Abbreviations

Term	Spellout
AMC	U.S. Army Materiel Command
ANSI	American National Standards Institute
AWCF	Army Working Capital Funds
BRAC	Base Realignment and Closure
CARC	Chemical Agent Resistant Coating
CERL	Construction Engineering Research Laboratory
CFM	cubic feet per minute
DLA	Defense Logistics Agency
DOD	Department of Defense
DPW	Directorate of Public Works
ECIP	Energy Conservation Investment Program
ECM	Energy Conservation Measure
ERDC	Engineer Research and Development Center
FY	fiscal year
GSIE	Ground Systems Industrial Enterprise
HDD	heating degree days
HEPA	high-efficiency particulate air
HMMWV	High-Mobility Multipurpose Wheeled Vehicle
HP	Horsepower
HVAC	heating, ventilating, and air conditioning
IAQ	indoor air quality
IMA	Installation Management Agency
ISO	International Organization for Standardization
MIPR	Military Interdepartmental Purchase Request
NGEDAC	natural gas engine driven air compressor
OB	open burning
OD	open detonation
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PEOA	Process Energy Optimization Assessment
PEPR	Process Energy and Pollution Reduction
SIAD	Sierra Army Depot
TACOM	U.S. Army Tank-automotive and Armaments Command
TBD	to be determined
TM	Army Technical Manual
TR	Technical Report
UIC	University of Illinois at Chicago
VEA	Ventilation/Energy Applications
VFD	variable frequency drive

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14. ABSTRACT

In January 2005, researchers from the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) led a Level I Process and Energy Optimization Assessment (PEOA) at Sierra Army Depot (SIAD) to identify process, energy, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. This Assessment is a part of showcase studies conducted by CERL at four sites (Rock Island Arsenal, Corpus Christi AD, Sierra AD, and Tobyhanna AD), which were selected by the Army Materiel Command to demonstrate energy reduction opportunities at industrial organic facilities and to promote the "Lean" concept and ways how to render these facilities more efficient. The scope of the Level I analysis included improvements in painting, welding, and mechanical repair shops, building envelope, heating, ventilation, and air conditioning. This report gives detailed results of the Level I study. The study recommended 15 process and energy improvement projects, 11 of which were quantified economically. It was estimated by investing about $892k to implementing these 11 projects SIAD could achieve annual savings of $545k with an average simple payback of 1.6 years.

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