A COMBINED LIMITED ENERGY STUDY OF ELECTRICAL ENERGY DEMAND AND USE AND HEATING SYSTEMS AT PINE BLUFF ARSENAL, ARKANSAS

VOLUME IV
PROGRAMMING DOCUMENTATION

FINAL SUBMITTAL

Prepared for
U. S. Army Engineer District, Little Rock

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DEPARTMENT OF THE ARMY
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ENERGY PROJECT SUMMARY SHEET

Installation and Location	Pine Bluff Arsenal, Pine Bluff, Arkansas
Project Title	Repair Steam Pipe and Fittings
Project Funding Category	Federal Energy Management Program (FEMP)
Total Investment	$78,000
Annual Cost Savings	$472,100
Savings-to-Invest. Ratio (SIR)	112.6
Simple Payback Period	0.2 Years

<u>**Contents**</u>

1. COMPONENT	FY 19___ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		September 6, 1996

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Pine Bluff Arsenal, Pine Bluff Arkansas	Repair Steam Pipe and Fittings - FEMP

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
			$78

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
Repair/replace steam traps, piping, valves and fittings. Remove and dispose of asbestos insulation. Install new fiberglass insulation. See attached detailed estimate.				
Subtotal Construction Cost				$63.2
Contingency (10%)				$6.3
Total Construction Cost				$69.5
Design Fee (6%)				$4.2
SIOH (6%)				$4.2
Total Cost				$77.9
Total Requested (rounded)				$78

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The scope of work for this project consist of repairing and/or replacing all of the failed valves, fittings and steam traps on the existing steam distribution piping system served by the boilers in Buildings 32-060, 33-060 and 34-140. The work also includes asbestos abatement which will be required during removal of the existing fitting insulation. New fiberglass insulation will be installed to replace the removed asbestos.

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(WHEN DATA IS ENTERED)

ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 1

LIFE CYCLE COST ANALYSIS SUMMARY

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: ECO-H1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID FY95 (92)
INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3
PROJECT NO. & TITLE: ECO-H1 IMPROVE STEAM DISTRIBUTION SYSTEM
FISCAL YEAR 1997 DISCRETE PORTION NAME: OPTION A - REPAIR EXISTING
ANALYSIS DATE: 07-01-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$ 69572.		
B. SIOH	$ 4175.		
C. DESIGN COST	$ 4175.		
D. TOTAL COST (1A+1B+1C)	$ 77922.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 77922.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 16.79	0.	$ 0.	15.08	$ 0.
B. DIST	$ .00	0.	$ 0.	18.57	$ 0.
C. RESID	$ .00	0.	$ 0.	21.02	$ 0.
D. NAT G	$ 2.81	168000.	$ 472080.	18.58	$ 8771246.
E. COAL	$ .00	0.	$ 0.	16.83	$ 0.
F. PPG	$ .00	0.	$ 0.	17.38	$ 0.
M. DEMAND SAVINGS			$ 0.	14.88	$ 0.
N. TOTAL		168000.	$ 472080.		$ 8771246.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 14.88
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)$ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))$ 472080.

5. SIMPLE PAYBACK PERIOD (1G/4) .17 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 8771246.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 112.56
(IF < 1 PROJECT DOES NOT QUALIFY)

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 2

DESCRIPTION OF WORK TO BE ACCOMPLISHED

ECO-H1

Modifications and improvements to the steam distribution piping system.

Description

This project consist of installing new steam distribution piping from the boilers in Buildings 32-060, 33-060 and 34-140 to the point of connection to all of the facilities currently served by the existing system. The work also includes asbestos abatement which will be required during removal of the existing pipe and fitting insulation.

A field survey was performed to identify all steam leaks from the steam piping located in production areas 31, 32, 33, and 34. The survey involved a visual inspection of all steam piping from the boilers to the entrance of the end use buildings. Observations during the field survey revealed many holes in the condensate return and compressed air distribution piping systems. However, all of the steam leaks found during the survey of the steam distribution system were associated with valves, fittings and steam traps. This indicates the steam distribution piping system has not failed and still has some useful life remaining.

The energy losses due to steam leaks within Production Areas 31, 32, 33 and 34 were estimated by performing a monthly natural gas balance for the entire Arsenal for calendar year 1995. This involved subtracting all identified steam consumption and steam losses from the total natural gas consumption for the Arsenal. Steam consumption at PBA includes process heating, process humidification and comfort heating. Steam losses include condensate leaks, thermal losses due to conduction and convection, system (boiler) efficiency and steam leaks.

A total of 104 steam leaks were identified along the steam distribution piping in Areas 31, 32, 33 and 34 and the heat trace piping for the white phosphorus area. The calculated losses due to steam leaks in these areas is about 14,000 MBtu per month. The total annual energy and cost savings achieved by eliminating the steam leaks is 168,000 MBtu and $472,000, respectively.

The cost estimate for for this project assumes all 104 leaking valves, fittings and steam traps will be removed and replaced. An additional 24 leaks were assumed for the above ground tanks which were not operating during the survey. Some of the leaks can be eliminated by tightening or repairing the items, however, the cost estimate used replacement equipment to be conservative. The cost estimate also includes removal and disposal of the existing asbestos insulation and installation of new fiberglass insulation.

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 3

SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA

ECO-H1 CALCULATIONS

ESTIMATE OF ENERGY LOSS FROM STEAM LEAKS

The energy losses due to steam leaks within Production Areas 31, 32, 33 and 34 were estimated by performing a monthly natural gas balance for the entire Arsenal for calendar year 1995. This involved subtracting all identified steam consumption and steam losses from the total natural gas consumption for the Arsenal. Steam consumption at PBA includes process heating, process humidification and comfort heating. Steam losses include condensate leaks, thermal losses due to conduction and convection, system (boiler) efficiency and steam leaks. The methods used for identifying and calculating the natural gas consumption for all of the identified users and losses are described in the following paragraphs.

All of the identified steam leaks are located in production areas 31, 32, 33, and 34. The steam system in area 44 is very small and any leaks associated with this system are negligible. The natural gas used in these areas is equal to the total natural gas energy supplied to the arsenal less the sum of the natural gas consumed by all other buildings within the Arsenal. The following equation was used to determine the natural gas consumption by the steam systems in Production Areas 31, 32, 33, 34, and 44:

$$\Sigma SS_P = NG_B - \Sigma IB_M \qquad (1)$$

Where: ΣSS_P = The monthly natural gas consumption for the steam systems (production and distribution) in Areas 31, 32, 33, 34 and 44.

NG_B = Total monthly facility natural gas consumption as shown on the monthly bills from the supplier.

ΣIB_M = Sum of the monthly natural gas use for the 71 individual buildings with working natural gas meters.

The natural gas supply for PBA is provided through a single supply line and main meter. The monthly readings from the main meter are the basis for determining the total monthly natural gas consumption (NG_B) at PBA and the monthly billing by the natural gas supplier. The natural gas is then distributed to approximately 75 buildings within the Arsenal. These facilities are equipped with plurality functioning gas flow meters that are read on the 25th of every month.

Ideally, the total natural gas consumption at PBA (as shown on the monthly bill) would be equal to the sum of the natural gas use for the 75 individually metered buildings. However, the meters for the boiler houses in Areas 32, 33, 34, & 44 have reportedly been broken for some time and no readings are taken for these buildings. The natural gas consumption for all of the other 71 buildings with working meters (including the laundry and incinerator) was calculated from the meter readings. The natural gas consumption of these facilities was totaled on an monthly basis. These monthly totals are used as IB_M in the natural gas balance equations.

The natural gas consumed by the steam systems in the production areas is divided into three main groups: process steam use, comfort heating, and steam production and distribution system losses. This is described by the following equation.

$$\Sigma SS_P = PE_P + CH_P + SL_P \qquad (2)$$

Where:

PE_P = Process steam used for process heating and humidification.

CH_P = Energy used for comfort (space) heating.

SL_P = System losses from the steam production and distribution system.

Process steam energy is defined as steam heating or humidification utilized for the direct production of a product. The steam demand for process heating/humidification and for comfort heating for each building within the production areas is defined in Exhibit F of the Contingency Master Planning Program Steam and Compressed Air Utility Study prepared by CDG in October 1994 (CDG Utility Study). Steam demand values given in the CDG Utility Study were checked and updated by the Production staff. Total energy consumption for the steam systems in the production areas is therefore equal to the summation of the energy requirements for each area.

$$PE_P = PS_{31} + PS_{32} + PS_{33} + PS_{34} + PS_{44} \qquad (3)$$

Where: PS_{31} = Process steam consumption in production area 31.

PS_{32} = Process steam consumption in production area 32.

PS_{33} = Process steam consumption in production area 33.

PS_{34} = Process steam consumption in production area 34.

PS_{44} = Process steam consumption in production area 44.

System losses (SL_P) from the steam production and distribution system include conversion losses from changing the chemical energy of the natural gas to steam energy (boiler efficiency), thermal losses due to convection and conduction from the distribution system piping, losses as a result of not returning the warm condensate, and losses due to steam leaks from the distribution system piping. The losses from the steam system are described by the following equation:

$$SL_P = CL_P + TL_P + LEAKS_P \quad (4)$$

Where:

CL_P = Energy losses from condensate system leaks.

TL_P = Thermal energy losses through the pipe insulation.

$LEAKS_P$ = Leaks from the steam distribution system.

Boiler efficiency measurements and calculations indicated that the 70 percent efficiency used by the PBA staff was a fairly accurate average. The conversion efficiency losses are taken into account by dividing all of the calculated steam consumption values (in MBtu of steam) for areas 31, 32, 33 and 34 by 0.7 to obtain MBtu of natural gas. The calculated steam consumption values (in MBtu of steam) for area 44 were divided by 0.8 to obtain MBtu of natural gas. Since boiler efficiency is accounted for in the calculations for all of the steam consumption values listed in Equations 1 through 4, a separate term for conversion losses was not included in the system losses equation.

The condensate return system at PBA is in very poor condition and is scheduled for replacement in the near future. Calculations of the natural gas energy losses due to the poor condition of the condensate system assumed approximately 10 percent of the available condensate is currently being returned, the condensate temperature is 120 degrees F and the make-up water temperature is about 68 degrees F.

Thermal losses (TL_P) from the steam supply piping to the atmosphere due to conduction and convection were calculated for each month of the year. The amount of these losses is influenced by the temperature of the pipe and the outside air temperature. Thirty year averages were used for monthly temperatures in these calculations.

By combining equations 1, 2 and 4, and rearranging, the following expression was derived for calculating natural gas use due to steam leaks in the production areas:

$$LEAKS_P = NG_B - IB_M - PE_P - CH_P - CL_P - TL_P \quad (5)$$

Table 3.2-1 PBA Natural Gas Balance for 1995

	Estimated Monthly Natural Gas Consumption (MBtu)											
Natural Gas Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Natural Gas Bills (NG_B)	72,425	65,166	58,220	47,855	37,697	38,392	37,838	34,199	35,284	41,937	58,597	77,672
2. Bldgs w/ Meters (IB_M)	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,079	6,715	9,367
3. Process Heat (PE_P)	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544
4. Comfort Heat (CH_P)	35,117	27,788	20,787	6,854	2,517	271	73	137	1,322	7,812	18,317	30,387
5. Condensate Loss (CL_P)	4,228	3,669	3,382	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567
6. Conduction Loss (TL_P)	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530
7. Steam Leaks ($LEAKS_P$)	9,148	8,700	9,849	18,005	15,277	16,257	14,024	12,505	13,417	11,234	15,977	18,278
Steam Leaks (7) = (1) - (2) - (3) - (4) - (5) - (6)												

The first line of Table 3.2-1 lists the natural gas consumption for the entire Arsenal for each month of 1995. The second line shows the monthly consumption of all buildings within the Arsenal that have working natural gas meters. Line three of Table 3.2-1 lists the calculated natural gas use for process heating and humidification in areas 31, 32, 33, 34 and 44. The estimated natural gas consumption for space (comfort) heating is listed in line four. The monthly estimates of additional natural gas consumption required due to the poor condition of the condensate return system are shown in line five. Line six shows the estimated energy required to overcome the thermal losses through the steam supply pipe insulation. The estimated natural gas consumption that is wasted due to steam leaks is tabulated in line seven.

The estimated losses due to steam leaks are lower during the winter months of January, February and March. Regardless of how and where the steam leaks occur, the driving force for steam leaks is the system operating pressure. Since the boilers and distribution system pressure are kept fairly constant throughout the year, the steam leaks should also remain constant throughout the year. This indicates the actual winter conditions during 1995 were probably milder than the average bin data that was used to calculate the energy use for space heating. Therefore, if the calculated energy use for space heating was decreased to match the actual 1995 energy consumption for space heating, the estimated steam leaks would increase during these winter months.

The estimated energy use for comfort heating during the summer months is negligible. Therefore, the steam leak estimates for these months should more accurately reflect the average value of the actual steam leaks. The average estimated loss due to steam leaks during June, July and August is 14,260 MBtu per month. Based on this value, the economic analyses assume that the steam leaks remain constant at 14,000 MBtu per month throughout the year. Therefore, the total annual estimated energy loss due to steam leaks at the Arsenal is about 168,000 MBtu per year. Using $2.81 per MBtu as the average cost of natural gas, the cost of steam leaks at PBA is approximately $472,000 per year.

To ensure that all of the natural gas consumed at PBA was accounted for, an additional calculation was performed using the consumption data from the boiler logs. The PBA staff estimates the monthly natural gas use for the boiler houses by taking the steam totalizer readings and dividing that value by an assumed boiler efficiency of 70 percent. Our boiler efficiency measurements and calculations indicate the boilers in areas 32, 33 and 34 operate at an average efficiency of about 70 percent and the boiler in area 44 operates at an efficiency of about 80 percent.

The total natural gas consumption at PBA should equal the estimated natural gas use for the boilers in areas 32, 33 and 34 plus the total natural gas use for the 71 metered buildings plus the calculated natural gas use for the boiler in area 44. The estimated natural gas use is a little higher than the actual for the first three months and lower than the actual for the remainder of the year. The annual total of the estimated natural gas use is within about five percent of the actual natural gas use.

PBA Natural Gas Balance

Nat. Gas Bal. (MBtu/Mo)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total MBtu/yr	Total Cost
Natural Gas Bills (1)	72,425	65,166	58,220	47,855	37,697	38,392	37,838	34,199	35,284	41,937	58,597	77,672	605,282	$1,700,842
Buildings w/ Meters (2)	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,079	6,715	9,367	75,872	$213,200
Process Heat (3)	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849	$364,875
Condensate Losses (4)	4,228	3,669	3,382	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567	35,395	$99,460
Conduction Losses (5)	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530	50,114	$140,821
Comfort Heating (6)	35,117	27,788	20,787	6,854	2,517	271	73	137	1,322	7,812	18,317	30,387	151,382	$425,382
Steam Leaks (7)	9,148	8,700	9,849	18,005	15,277	16,257	14,024	12,505	13,417	11,234	15,977	18,278	162,671	$457,105
														$1,700,842

(1) Monthly natural gas bills for entire Arsenal from Falling Tree Enterprises.
(2) Monthly totals from the 71 metered buildings at PBA, see attached table.
(3) See Process Energy Use Calculations.
(4) Assumes: 10% of condensate is returned, TC = 120 °F TGW = 68 °F Boiler eff = 70%
(5) See Conduction Loss Calculations.
(6) See Comfort Heating Calculations - Bin Temperature Method.
(7) Steam leaks (7) = (1) - (2) - (3) - (4) - (5) - (6)

PBA Natural Gas Balance - Corrected

Corr. N.G. Bal. (MBtu/Mo)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total MBtu/yr	Total $
Natural Gas Bills	72,425	65,166	58,220	47,855	37,697	38,392	37,838	34,199	35,284	41,937	58,597	77,672	605,282	$1,700,842
Bldgs w/ Meters	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,079	6,715	9,367	75,872	$213,200
Process Heat	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849	$364,875
Condensate Losses	4,228	3,669	3,382	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567	35,395	$99,460
Conduction Losses	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530	50,114	$140,821
Comfort Heating (8)	32,853	24,499	20,202	12,196	2,517	271	73	137	394	5,473	21,497	37,920	158,031	$444,067
Steam Leaks	11,412	11,989	10,434	12,662	15,277	16,257	14,024	12,505	14,346	13,572	12,797	10,745	156,021	$438,420
														$1,700,842

Comfort Heating Correction Calculations (actual weather was not the same as the bin data)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space Heat w/ Summer = 0 (9)	32,853	24,499	20,202	12,196	4,807	4,193	2,220	(1,463)	394	5,473	21,497	37,920
Calculated Corr. Values (10)	2,264	3,289	585	(5,342)	(2,290)	(3,922)	(2,147)	1,600	928	2,339	(3,180)	(7,533)
Comfort Heat Corr. Values (11)	2,264	3,289	585	(5,342)	0	0	0	0	928	2,339	(3,180)	(7,533)

(8) Calculated Comfort Heating (6) - Comfort Heat Corr. Value (11)
(9) Current Month Nat. Gas Use (1) - Aug Nat. Gas Use (1) - (Current metered bldgs use (2) - Jun metered bldgs use(2))
(10) Calculated Comfort Heating (6) - Space Heat w/ Summer = 0 (9)
(11) Values from item (10) for heating months only.

PINE BLUFF ARSENAL

1995 Monthly Gas Meter Readings

GROUP 1 BUILDINGS

Bldg No.	32100	32070	32090	32130	32035	33060	23390	23330	23310	23370	24770	24610	17120	17110	17130		13130	13050	13080	13090	13100	13005	13060	13020		Sub Total
Bldg. Name		Laundry						Supply	LCL	E&T	PDO	Union & Jan Serv.	Moody School Contrac	Moody School Pub. Aff.	Moody School Person.	NCO Capehart			Lab	Training Ofc.					Club & BOQ-Staff Row	Group 1 Buildings
25-Jan-95	224	200	128	27	261	18	1	638	178	62	10	26	79	26	37	500	12	11	51	20	25	6	15	37	153	2747
25-Feb-95	225	166	105	31	341	17	1	623	193	52	11	29	24	30	49	467	39	13	71	43	44	12	62	66	97	2833
25-Mar-95	133	192	49	11	166	8	0	446	88	26	6	15	10	17	17	331	18	213	28	21	18	4	19	24	47	1909
25-Apr-95	44	234	3	1	22	3	0	198	26	11	0	2	2	3	12	187	2	20	3	6	4	1	6	8	39	837
25-May-95	20	170	3	0	14	1	0	95	17	3	0	1	1	1	2	156	3	9	4	8	0	0	4	0	29	541
25-Jun-95	1	204	1	0	3	0	1	11	3	1	0	1	1	0	0	81	2	4	2	0	0	1	0	0	29	346
25-Jul-95	1	249	1	0	3	0	0	5	3	1	0	1	1	0	3	79	2	3	2	1	0	0	0	0	32	367
25-Aug-95	1	176	1	0	4	0	0	4	3	2	0	1	0	0	2	62	2	2	2	0	0	0	0	0	26	310
25-Sep-95	3	169	1	0	3	1	0	26	4	2	0	1	1	0	2	93	2	4	1	0	0	0	0	0	42	377
25-Oct-95	26	322	2	0	4	0	1	128	6	8	0	201	1	1	2	141	3	6	2	3	0	1	1	1	96	963
25-Nov-95	73	137	45	3	102	8	1	354	95	30	7	15	5	20	16	264	11	57	15	15	3	2	14	18	146	1476
25-Dec-95	231	140	98	23	274	18	1	518	301	63	11	30	24	42	44	429	21	112	48	31	10	10	30	43	166	2736

GROUP 2 BUILDINGS

Bldg No.	10050		10020	$10030		12410	50610	54010	57160	51570	51570	53100	93500	53160	51420	60090	60400	60060	60070	63120	63010	63110	63200	63220	63410	Sub Total
Bldg. Name	Fire Station	Staff Row	Admin. Bldg.	BRT & Environ.	Farm Hse & Ofcr Capehart	Farm house	BZ Plant Warehse		BZ Plant Ofc		DMMD Portion				Halfway house	Traffic	DMMD Carp. Shop				Dock					Group 2 Buildings
25-Jan-95	117	145	266	59	143	36	35	0	20	43	150	70	52	21	75	6	127	24	121	217	44	26	90	111	110	2110
25-Feb-95	102	163	244	104	149	26	29	0	26	59	430	81	74	9	72	20	217	63	104	266	70	110	141	349	145	3036
25-Mar-95	71	96	190	53	97	14	2	0	14	34	171	44	35	33	44	6	114	23	50	120	37	59	56	114	66	1569
25-Apr-95	36	50	6	15	57	6	2	0	5	23	95	21	17	17	2	3	11	7	20	39	23	2	9	37	62	567
25-May-95	24	30	2	7	46	4	2	0	3	20	65	5	11	3	2	3	7	3	17	17	16	1	2	11	39	340
25-Jun-95	14	12	0	4	29	3	2	0	0	6	16	1	1	3	1	3	3	0	8	1	1	1	1	1	39	150
25-Jul-95	14	12	0	4	28	3	2	0	0	6	13	0	1	3	1	3	4	2	4	1	1	1	1	0	29	142
25-Aug-95	14	13	0	4	29	3	2	0	0	6	13	0	1	4	2	3	4	1	4	1	0	1	1	0	37	145
25-Sep-95	18	18	1	5	34	1	2	0	0	10	15	0	1	1	3	3	5	1	4	17	0	0	1	10	39	165
25-Oct-95	31	27	2	8	48	1	2	1	1	22	27	1	1	5	3	3	16	7	8	38	0	5	6	14	53	331
25-Nov-95	65	93	164	36	79	23	2	6	12	50	47	25	45	27	15	5	100	21	26	164	0	94	37	66	53	1316
25-Dec-95	110	153	264	62	142	21	166	11	29	49	223	62	68	56	40	15	152	44	105	220	48	142	105	178	195	2666

GROUP 3 BUILDINGS

Bldg No.	60120	18140	18076	18175	18190	18210	18220	18230	18250	18270	18340	18310	18440	34960	34810	44101	44300	42965	42970	42930	34121	Sub Total
Bldg. Name			Pool	Day Care							PX	Rec. Cntr.	Cred. Union				Dlly Farm		Incin.	CWT	Gate 5	Group 3 Buildings
25-Jan-95	26	51	0	14	87	35	22	21	14	22	4	165	16	7	12	6	0	26	3,711	77	10	4,330
25-Feb-95	91	54	0	4	113	66	56	39	23	24	5	162	10	15	15	7	0	24	3,711	22	10	4,413
25-Mar-95	17	40	0	6	67	42	22	16	11	47	2	99	9	5	16	9	0	22	3,711	12	2	4,155
25-Apr-95	2	14	0	2	33	20	20	5	4	17	2	15	2	1	6	1	0	9	3,711	2	2	3,870
25-May-95	0	6	0	0	7	4	7	6	1	2	2	12	0	1	2	0	0	9	1,550	5	2	1,624
25-Jun-95	0	2	2	0	23	4	4	5	0	2	2	33	0	0	10	0	0	3	3,227	1	0	3,316
25-Jul-95	0	3	1	0	22	5	3	4	0	1	2	18	0	0	7	0	0	3	4,633	2	0	4,704
25-Aug-95	0	3	1	0	17	5	1	5	0	1	2	31	0	0	6	0	0	2	4,745	2	1	4,822
25-Sep-95	0	3	1	0	18	5	9	5	0	1	2	10	0	0	6	0	0	5	3,873	2	1	3,943
25-Oct-95	1	3	1	0	18	5	14	6	2	1	2	18	0	3	10	0	0	10	4,667	2	2	4,765
25-Nov-95	17	32	0	5	66	21	3	32	12	3	2	55	6	10	6	5	14	22	3,593	9	4	3,923
25-Dec-95	43	67	0	10	111	39	22	36	22	30	9	70	15	13	9	6	27	28	3,374	23	9	3,965

TOTALS

Sub Total Group 1 Buildings (above)	Sub Total Group 2 Buildings (above)	Sub Total Group 3 Buildings (above)	Sub Total Sum of All Meters	PBA Total 1995 Gas Bills (MBTU)	Boilers Areas 31, 32, 33, 34, 44
2747	2110	4,330	9,187	72,425	63,238
2833	3036	4,413	10,282	65,166	54,884
1909	1569	4,155	7,633	58,220	50,587
837	567	3,870	5,274	47,855	42,581
541	340	1,624	2,505	37,697	35,192
346	150	3,316	3,814	38,392	34,578
367	142	4,704	5,233	37,838	32,605
310	145	4,822	5,277	34,199	28,922
377	165	3,943	4,505	35,284	30,779
963	331	4,765	6,079	41,837	35,858
1476	1316	3,923	6,715	56,597	51,882
2736	2666	3,965	9,367	77,672	68,305
			75,872	605,262	529,410

A.5.H1-16

Process Energy Use Calculations		
	Steam	N. Gas
Natural Gas Demand - Calcs	lbs/hr	MBtu/hr
	(1)	(2)
Process Area 31 (3)	375	0.54
Process Area 32 (3)	637	0.91
Process Area 33 (3)	75	0.11
Area 34 Operational (4)	21158	30.23
Area 34 Stand By (5)	8463	12.09
Process Area 44	33	0.04
Totals	30,741	43.91

NOTES:

(1) From 1994 CDG Utility Study updated by PBA Production staff.
(2) Assumes 1000 Btu/lb of steam, boiler efficiency = 70% for areas 32, 33 & 34 and 80% for area 44.
(3) Assumes the production operating level is: 50% of maximum capacity.
(4) Assumes WP production operating level is: 50% of maximum capacity.
(5) Assumes WP stand-by energy use level is: 40% of maximum capacity.
(6) From The Weather Almanac, Fourth Edition, 30 year average monthly temperatures.
(7) From WP Production Schedule dated March 6, 1996.
(8) N. Gas MBtu/hr x Oper. Hrs/Mo + Stand-by N. Gas x (Total Hours/Month - Oper. Hrs/Mo)
(9) N. Gas MBtu/hr x Total Hours/Month

Operating and Weather Data													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Average OA Temp. (6)	41.4	44.6	53	62.4	70.2	78.2	81.5	80.6	74.2	63.7	51.9	43.7	
Days per month	31	28	31	30	31	30	31	31	30	31	30	31	365
Total Hours/Month	744	672	744	720	744	720	744	744	720	744	720	744	8760
Area 34 Op. Hrs/Mo (7)	0	80	110	50	40	110	120	10	10	0	0	20	550
Process Energy (MBtu/Mo)													
Area 34 (8)	8995	9576	10990	9612	8721	10700	11172	9177	8887	8995	8705	9358	115,887
Area 31 (9)	399	360	399	386	399	386	399	399	386	399	386	399	4,693
Area 32 (9)	677	611	677	655	677	655	677	677	655	677	655	677	7,969
Area 33 (9)	80	72	80	77	80	77	80	80	77	80	77	80	939
Area 44 (9)	31	28	31	30	31	30	31	31	30	31	30	31	361
Total Process Heating	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849

A.5.H1-11

EXHIBIT F
STEAM DEMAND FOR MOBILIZATION CONDITION

CDG UTILITY STUDY

EQUIPMENT EFFECTIVNESS FACTOR %

PINE BLUFF ARSENAL, ARKANSAS
DEPARTMENT OF THE ARMY

STEAM DEMANDS

BUILDING NUMBER	BLDG USE	VENILATION CFM	HEATIING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
31080	ELECTRONIC CALIBRATION FACILITY		349.99		349.99		349.99		349.99
31100	MAINT FACILITY		1,730.12		1,730.12		1,730.12		1,730.12
31150	PRODUCTION OFFICE		248.92		248.92		248.92		248.92
31310	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31330	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31420	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31440	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31520	MIX BUILDING	15,290	2,005.00		2,005.00		2,005.00		2,005.00
31530	FILL AND PRESS	29,010	3,728.00	750 750	4,478.00	1500	5,228.00	1500	5,228.00
31531	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
31540	DOWNLOAD FACILITY		947.03		947.03		947.03		947.03
31570	MUNITIONS STORAGE		1,187.97		1,187.97		1,187.97		1,187.97
L 31620	PYRO MIX BLDG (THERMATE MIX)	14,860	0 1,949.00	0 20	1,969.00	20	1,969.00	20	1,969.00
L 31630	FILL AND PRESS	10,000	0 2,852.19	0 300	3,152.19	0	2,852.19	500	3,352.19
31631	BREAK AND RESTROOMS		239.26		239.26		239.26		239.26
31640	ASSEMBLY		947.03		947.03		947.03		947.03
31670	STORAGE		1,187.97		1,187.97		1,187.97		1,187.97
L 31720	PYROTECHNIC PRODUCTION	2,870	0 454.00	0 100	554.00	100	554.00	100	554.00
31730	STORAGE		149.86		149.86		149.86		149.86
31820	STORAGE		301.43		301.43		301.43		301.43
31830	AMMO QUAL FAC		149.86		149.86		149.86		149.86
31860	STORAGE		159.50		159.50		159.50		159.50
			20919 26,174.42	750 1,170.00	27,344.42	1,620.00	27,794.42	2,120.00	28,294.42
32000	CAFETERIA		512.16		512.16		512.16		512.16
32030	INSPECTION GARAGE		706.04		706.04		706.04		706.04
32035	ORDINANCE SHOP		0.00		0.00		0.00		0.00
32070	IMPREG AND LAUNDRY		1,909.25	93	2,002.25	93	2,002.25	93	2,002.25
32080	MHE BATTERY SHOP		349.99		349.99		349.99		349.99
32090	WAREHOUSE		855.31		855.31		855.31		855.31
32100	ELECTRONIC CALIBRATION FACILITY		1,730.12		1,730.12		1,730.12		1,730.12
32130	AMMO QUAL FAC		561.96		561.96		561.96		561.96
32150	AMMO QUAL FAC		248.92		248.92		248.92		248.92
32230	FILTER BLDG		1,628.91		1,628.91		1,628.91		1,628.91
32270	WAREHOUSE		1,628.91	0	1,628.91	0	1,628.91	0	1,628.91
32310	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32330	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32420	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32440	EQUIPEMENT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32510	PROD ENGR LAB		518.13		518.13		518.13		518.13
32520	PROD ENGR LAB		1,067.96		1,067.96		1,067.96		1,067.96
32530	FORMER BZ FACILITY		2,543.52		2,543.52		2,543.52		2,543.52
32531			151.46		151.46		151.46		151.46

CDG UTILITY STUDY

EXHIBIT F
STEAM DEMAND FOR MOBILIZATION CONDITION

EQUIPMENT EFFECTIVNESS FACTOR %

STEAM DEMANDS

PINE BLUFF ARSENAL, ARKANSAS
DEPARTMENT OF THE ARMY

BUILDING NUMBER	BLDG USE	VENILATION CFM	HEATIING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
32540	FORMER BZ FACILITY		947.03		947.03		947.03		947.03
32550	AMMO QUAL FAC		353.92		353.92		353.92		353.92
32570	OPERATIONS GENERAL PURPOSE		1,209.30		1,209.30		1,209.30		1,209.30
32610	DRYING	14,900	1,705.00	7.26	1,712.26	7.26	1,712.26	7.26	1,712.26
32620	COLORED SMOKE MIX (GLATT)	15,290	2,005.00	100% OA 436	2,441.00	872	2,877.00	872	2,877.00
32630	STORAGE		1,673.76		1,673.76		1,673.76		1,673.76
32631	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
32640	PYROTECHNIC PRODUCTION	12,510	2,206.10	(100)	2,206.10		2,206.10		2,206.10
32670	SUU-7 TEST		1,187.97		1,187.97		1,187.97		1,187.97
32720	PROD ENGR LAB		418.58		418.58		418.58		418.58
32730	PROD ENGR LAB		173.74		173.74		173.74		173.74
32820	MATERIAL STORAGE		301.43		301.43		301.43		301.43
32830	MATERIAL STORAGE		149.86		149.86		149.86		149.86
32860	STORAGE		159.50		159.50		159.50		159.50
			34,491.10	636 536.26	35,027.36	972.26	35,463.36	972.26	35,463.36
33080	SAFETY EQUIP		349.99		349.99		349.99		349.99
33100	CHANGE HOUSE		1,730.12		1,730.12		1,730.12		1,730.12
33150	PRODUCTION		248.92		248.92		248.92		248.92
33310	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33330	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33420	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33440	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33520	MIX BUILDING	16,610	1,944.00		1,944.00		1,944.00		1,944.00
33530	FILL AND PRESS	26,900	4,675.86	50	4,725.86	50	4,725.86	50	4,725.86
33531	PUBLIC TOILET		239.26		239.26		239.26		239.26
33540	STORAGE		948.37		948.37		948.37		948.37
33550	IN PROCESS STORAGE		388.02		388.02		388.02		388.02
33570	LAP		1,187.97	0	1,187.97	0	1,187.97	0	1,187.97
33620	STARTER MIX BUILDING		1,067.96	100	1,167.96	100	1,167.96	100	1,167.96
33630 (1)	FILL AND PRESS	10,000	0 2,420.61	0	2,420.61	300	2,720.61	300	2,720.61
33631	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
33640	ASSEMBLY BUILDING		947.03		947.03		947.03		947.03
33650	IN PROCESS STORAGE		353.92		353.92		353.92		353.92
33670	M116 LAP		1,187.97		1,187.97		1,187.97		1,187.97
33720	KC103 PROP		301.43		301.43		301.43		301.43
33730	QC TEST FAC		149.86		149.86		149.86		149.86
33820	STARTER MIX SLUGS		301.43		301.43		301.43		301.43
33830	COMPONENT STORAGE		149.86		149.86		149.86		149.86
33860	STORAGE IGLOO		159.50		159.50		159.50		159.50
			23919 26,339.36	150 150.00	26,489.36	450.00	26,789.36	450.00	26,789.36

A.5.H1-13

CGD UTILITY STUDY

EXHIBIT F
STEAM DEMAND FOR MOBILIZATION CONDITION

QUIPMENT EFFECTIVNESS FACTOR %

STEAM DEMANDS

INE BLUFF ARSENAL, ARKANSAS
EPARTMENT OF THE ARMY

UILDING UMBER	BLDG USE	VENILATION CFM	HEATIING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
110	WP FILLING	139,310	16,957.00	10602.42	27,559.42	14136.56	31,093.56	14136.56	31,093.56
120	AMMO QUAL FAC		1,221.45		1,221.45		1,221.45		1,221.45
130	WP UNLOAD TANKS		474.95	7555.06	8,030.01	7555.06	8,030.01	7555.06	8,030.01
170	WP BULK STORAGE			21659.27	21,659.27	21659.27	21,659.27	21659.27	21,659.27
4350	ASSEMBLY AND PACKOUT		879.89		879.89		879.89		879.89
4370			331.19		331.19		331.19		331.19
4420			319.82		319.82		319.82		319.82
4430	RAW MATERIAL WAREHOUSE		1,861.28		1,861.28		1,861.28		1,861.28
4620			1,768.37		1,768.37		1,768.37		1,768.37
4630	PYROTECHNIC PRODUCTION	8,000	2,270.12	1200	3,470.12	1200	3,470.12	1200	3,470.12
4640	HC MIX	57,820	5,761.00	(1200)	5,761.00		5,761.00		5,761.00
4650	START MIX SLEEVE		1,369.83	(100)	1,369.83		1,369.83		1,369.83
4660	SUB ASSEMBLY		326.47		326.47		326.47		326.47
4820	STORAGE		159.50		159.50		159.50		159.50
34910	FE MAINTENANCE SHOP		9,632.65		9,632.65		9,632.65		9,632.65
4970	ADMIN BUILDING		451.97		451.97		451.97		451.97
			43,785.48	42317 41,016.75	84,802.23	44,550.89	88,336.37	44,550.89	88,336.37
12960	GRENADE TEST BUILDING		421.00		421.00		421.00		421.00
4110	LAP		3,957.49	33	3,990.49	33	3,990.49	33	3,990.49
			135,168.85	42,906.01	178,074.86	47,626.15	182,795.00	48,126.15	183,295.00

127493 43886

A.5.H1-14

RS&H

SUBJECT: WP Energy Use | AEP NO: 694 1331 004
SHEET ____ OF ____
DESIGNER: W. Todd | DATE: 6-12-96
CHECKER: ____ | DATE: ____

Estimate Steam Demand for WP Area:

Bldg. No.	Building Name	Max. lb/hr	Oper. lb/hr	Stdby. lb/hr
34110	WP Filling	10600 (1)	10600 (2)	8480 (5)
34130	WP Unload Tanks	7550	750 (3)	-0- (6)
34170	WP Bulk Storage	21660	6500 (4)	6500 (4)
34630	Pyrotechnic Prod.	1200	1200 (2)	-0- (6)
34640	HC Mix	1200	1200 (2)	-0- (6)
34650	Start Mix Sleeve	100	100 (2)	-0- (6)
	Totals	42310	20350	14980

$$\text{Oper. \%} = \frac{20350}{42310} = 48.1\% \Rightarrow \text{say } 50\%$$

$$\text{Stand by \%} = \frac{14980}{42310} = 35.4\% \Rightarrow \text{say } 40\%$$

(1) From CDG Utility Study see attached copies.
(2) Assume these operations are at or near 100% utilizied.
(3) Assume this is a batch process operating 10% of the time.
(4) Assume after WP is at its production temperature, that 30% of energy is required to maintain the temperature (overcome the thermal losses)
(5) Assume 80% of energy is used during stand-by. See attached telephone call confirmation with E&T staff.
(6) Assume thess operations are shut down during stand-by.

RS&H
Reynolds, Smith and Hills, Inc.
Architectural, Engineering, Planning and Environmental Services

Telephone Call Confirmation

Date:	June 12, 1996		
Project Number:	694-1331-004		
Project Name:	PBA Electric and Heating Study		
Received:		**Placed:**	by W. Todd
Local:		**Long Dist.:**	501-540-2918
Conversed with:	Pat Lawrence		
of	Pine Bluff Arsenal E&T Division		
Regarding:	Steam energy consumption for the WP area.		

During the last five years the WP production building has been operating one line out of the four available lines (two wet fill and two dry fill).

During Production:

- Dry fill lines use more energy than wet fill lines.
- One-half of the leak test ovens are on only during the shift.
- WP transport pipes are kept hot.

During Stand-by (nights and weekends):

- Dry fill and wet fill cabinets kept hot.
- All of the leak test ovens are off.
- WP transport pipes are kept hot.

During Extended Stand-by (when no production for about one month):

- Almost everything will be turned off.

Distribution: PBA File By William T. Todd, PE

A.5.H1-16

SIOPB-PWN

5 March 1996

WP Production Schedule

	No. Shifts Per Month	Hrs Worked Per Shift	Hrs Worked Per Month
Feb 95	8	10	80
Mar 95	11	10	110
Apr 95	5	10	50
May 95	4	10	40
Jun 95	11	10	110
Jul 95	12	10	120
Aug 95	1	10	10
Sep 95	1	10	10
Oct 95	0	0	0
Nov 95	0	0	0
Dec 95	2	10	20
Jan 96	0	0	0
Feb 96	0	0	0
		TOTAL HRS WORKED:	550

NOTE: Each shift consists of 10 hrs, 0630 - 1700 hrs, four days/week.

Comfort Heating Calculations - Bin Temperature Method													
Design IAT =		70	°F		(1)	From ASHRAE Handbook, 1981 Fundamentals.							
Balance Temp =		65	°F		(2)	From CDG Utility Study updated by PBA Production staff. Steam demand reduced by							
Design OAT (1) =		16	°F			30% for CDG's assumed losses & by (Bal T-Des OAT)/(Des IAT - 0°), boiler eff = 70%.							
Heating Load (2) =		89.2	MBtu/Hr		(3)	Bin temperature data from Engineering Weather Data, TM 5-785.							
					(4)	Percent Load = (Balance Temp - OA Temp) / (Balance Temp - Design OAT)							
					(5)	MBtu = Heating Load x Percent Load x Hours							
												Jun	
OA Temp	% Load	Jan		Feb		Mar		Apr		May		Hours	MBtu
(3)	(4)	Hours (3)	MBtu (5)	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu	24	131
62	6%	36	197	32	175	77	421	127	694	95	519	8	117
57	16%	44	641	49	714	92	1340	105	1530	55	801	1	24
52	27%	54	1279	71	1681	103	2439	83	1965	29	687		0
47	37%	81	2655	96	3147	115	3770	43	1410	13	426		0
42	47%	103	4315	117	4901	112	4692	21	880	2	84		0
37	57%	108	5508	102	5202	75	3825	5	255		0		0
32	67%	122	7333	91	5469	44	2645	2	120		0		0
27	78%	84	5814	60	4153	17	1177		0		0		0
22	88%	48	3759	21	1645	5	392		0		0		0
17	98%	23	2011	7	612	1	87		0		0		0
12	100%	11	982	1	89	0	0		0		0		0
7	100%	5	446	0	0	0	0		0		0		0
2	100%	2	178	0	0	0	0		0		0		271
	Totals		35117		27788		20787		6854		2517		
												Dec	
OA Temp	% Load	Jul		Aug		Sep		Oct		Nov		Hours	MBtu
(3)	(4)	Hours (3)	MBtu (5)	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu	44	240
62	6%	8	44	17	93	63	344	123	672	86	470	62	903
57	16%	2	29	3	44	38	554	109	1588	102	1486	77	1823
52	27%		0		0	12	284	90	2131	122	2889	107	3508
47	37%		0		0	3	98	55	1803	106	3475	129	5404
42	47%		0		0	1	42	26	1089	86	3603	121	6171
37	57%		0		0		0	8	408	61	3111	85	5109
32	67%		0		0		0	2	120	33	1983	57	3946
27	78%		0		0		0		0	13	900	24	1880
22	88%		0		0		0		0	4	313	13	1137
17	98%		0		0		0		0	1	87	3	268
12	100%		0		0		0		0		0	0	0
7	100%		0		0		0		0		0	0	0
2	100%		0		0		0		0		0		30387

Conduction Loss Calculations

	Pipe Temperature =		350.1	°F (for 120 psig, see attached steam tables)							
	Insultion Thickness =		2.5	inches							
Nominal	Pipe IR	Steam	Pipe OR	Still Air	Ins. OR	Out. Air	k pipe (1)	k ins (1)	Pipe	Steam (3)	N. Gas (4)
Pipe Dia.	r_a (ft)	h_a (1)	r_b (ft)	h_b (1)	r_c (ft)	h_c (1)	B•ft/h•sf°F	B•ft/h•sf°F	Lnth Ft (2)	Btu/hr°F	MBtu/hr°F
1"	0.0874	2000	0.0985	1.65	0.307	6.00	27	0.03	5280	744	0.0011
2"	0.172	2000	0.185	1.65	0.393	6.00	27	0.03	3960	863	0.0012
3"	0.256	2000	0.274	1.65	0.482	6.00	27	0.03	3960	1161	0.0017
4"	0.336	2000	0.355	1.65	0.564	6.00	27	0.03	3960	1431	0.0020
5"	0.421	2000	0.442	1.65	0.650	6.00	27	0.03	3960	1716	0.0025
6"	0.505	2000	0.529	1.65	0.737	6.00	27	0.03	15840	7995	0.0114
										Total	0.0199

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OAT (5)	41.4	44.6	53	62.4	70.2	78.2	81.5	80.6	74.2	63.7	51.9	43.7
Hrs/Mo	744	672	744	720	744	720	744	744	720	744	720	744
MB/Mo (6)	4564	4080	4392	4116	4138	3890	3971	3984	3947	4234	4266	4530

(1) From the Mechanical Engineering Review Manual, Table 3.2 and Table 3.3, see attached pages.
(2) Pipe length estimated from General Heating Maps for PBA, pages 73 and 74.
(3) From the Mechanical Engineering Review Manual, Equation 3.15, page 3-6, see attached.
(4) N. Gas MBtu/hr°F = (Steam Btu/hr°F / boiler eff.) x (1MBtu / 1000000Btu), assumes boiler eff. = 70%.
(5) Average outside air temperatures from The Weather Almanac, Fourth Edition, 30 year average monthly temperatures.
(6) Conduction Losses MBtu/Mo = N. Gas MBtu/hr°F x (Pipe Temp - OAT) x Hrs/Mo.

A.5.H1-19

At common temperatures, conductivity in solids varies according to

$$k(T) = k_o(1 + \gamma T) \qquad 3.3$$

γ is positive for amorphous materials and insulators (e.g., brick, graphite, etc.) and negative for crystalline materials (with the exceptions of aluminum and brass). Tabulated values of γ are not common, having been replaced with tabulations of k itself versus T for various common materials. In most calculations, the average thermal conductivity (conductivity at the arithmetic mean temperature) is used, and no other attention is paid to variations in conductivity with temperature.

In liquids, heat is transmitted by longitudinal vibrations, similar to sound waves. According to Bridgeman (1921),

$$k = \frac{3k^*a}{d^2} \qquad 3.4$$

Conductivity in water and aqueous solutions increases with increases in temperature up to around 250°F, and then gradually decreases. Conductivity decreases with increased concentrations of aqueous solutions, as it does with most other liquids. Conductivity increases with increases in pressure. Of the non-metallic liquids, water is the best thermal conductor.

The net transport theory can be used to explain heat conduction through gases. Hot molecules move faster than cold molecules, traveling to cold areas with greater frequency than cold molecules travel to hot areas. It can be shown that

$$k = \frac{N\bar{v}fk^*\lambda}{6} \qquad 3.5$$

Conductivity in gases increases almost linearly with increases in temperature, but is fairly independent of pressure in common ranges.

The table below gives the thermal conductivities for some of the more common materials. The back of this chapter has a more extensive list. Notice that BTU-ft/hr-ft²-°R is the same as BTU/hr-°R-ft. However, these are not the same as BTU-in/hr-°R-ft² which is also widely used. Multiply cal-cm/sec-°K-cm² by 241.9 to get ft-English units.

Table 3.2

Typical Thermal Conductivities, BTU-ft/hr-ft²-°R

Material	k	Material	k	Material	k
Silver	242	Lead	20.	Hydrogen	.11
Copper	224	Ice	1.3	Fiberglass	.03
Aluminum	117	Concrete	.5	Cork	.025
Brass	56	Glass	.63	Air	.014
Steel 1%C	27	Water	.32	Oxygen	.016

All of the above conductivities were evaluated at 32°F except hydrogen which was evaluated at 100°F.

A.5.H1-20

2. Conduction

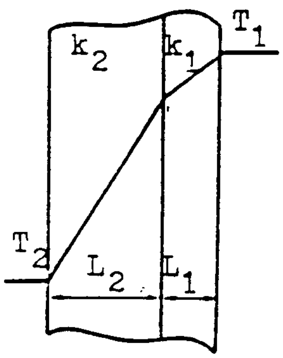
Conduction, the flow of heat through solids, is given by Fourier's law:

$$q = kA\left(\frac{dT}{dL}\right) \qquad 3.6$$

If the heat transmission is steady and both k and A are constant, heat flow through a single slab of thickness L is given by equation 3.7:

Figure 3.1

$$q = kA\Delta T/L \qquad 3.7$$



The heat flow due to conduction for composite sandwiched materials, as shown in Figure 3.1, is:

$$q = \frac{A\Delta T}{\Sigma\left(\frac{L_i}{k_i}\right)} \qquad 3.8$$

To further complicate the problem, there is usually a film on the exposed surfaces. There may also be a film between layers, although perfect bonding is usually assumed.

To account for films on exposed surfaces without having to measure the film thickness, the film thermal resistance is given by a film coefficient, h. The heat flow through a film is

$$q = hA\Delta T \qquad 3.9$$

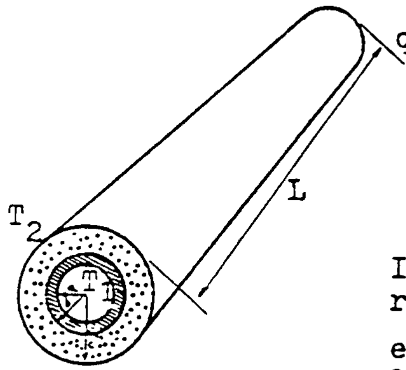
Table 3.3 (5:69)

Film Coefficients in BTU/hr-ft^2-°F

No change in state	
air, still	1.65
air, with 15 mph wind	6.00
water	150 to 2000
other gases	3 to 50
gasoline, kerosene, alcohol and other organic solvents	60 to 500
oils	10 to 120
Condensing	
steam	1000 to 3000
organic solvents	150 to 500
light oils	200 to 400
heavy oils	20 to 50
ammonia	500 to 1000
Evaporating	
water	800 to 2000
organic solvents	100 to 300
light oils	150 to 300
heavy oils	10 to 50
ammonia	200 to 400
R-12	100 to 600

The commonly encountered insulated pipe with films can be solved by using equation 3.15, which requires all dimensions to be in feet.

Figure 3.2



$$q = \frac{2\pi L \Delta T}{\frac{1}{r_a h_a} + \frac{\ln(\frac{r_b}{r_a})}{k_{pipe}} + \frac{1}{r_b h_b} + \frac{\ln(\frac{r_c}{r_b})}{k_{insul.}} + \frac{1}{r_c h_c}} \qquad 3.15$$

If the wall and layers are very thin, or if the radii are large so that $A = A_a = A_c$, then the effects of curvature can be ignored and equation 3.10 can be used.

Example 3.2

Liquid oxygen at -290°F is stored in a 5' inside diameter, 20' long cylindrical stainless steel tank covered with 1 foot of powdered diatomaceous silica with average thermal conductivity of .022 BTU/ft-hr-°F. The environment temperature is 70°F and the wind is 15 mph. The tank walls are 3/8" thick. Compare the heat gain to the liquid oxygen using equations 3.15 and 3.10.

Required data:

material	t	k	h
stainless	.031	28.0	
silica	1.0	.022	
air, outside			6.0
oxygen, inside			∞

Equation 3.15 gives the exact solution as

$$q = \frac{2\pi(20)(70 + 290)}{\frac{\ln(\frac{2.53}{2.50})}{28.0} + \frac{\ln(\frac{3.53}{2.53})}{.022} + \frac{1}{(3.53)(6.0)}} = 2980 \text{ BTU/hr}$$

If the effects of curvature are ignored, equation 3.10 predicts the heat loss based on the outside area to be:

$$q = \frac{2\pi(3.53)(20)(70+290)}{\frac{.031}{28.0} + \frac{1.0}{.022} + \frac{1}{6}} = 3500 \text{ BTU/hr}$$

Since the addition of a covering (insulation) to a bare pipe also increases the surface area, adding insulation up to the critical thickness will actually increase the heat loss above bare-pipe levels. This critical radius is usually very small, and is most relevant in the cases of thin wires or capillaries. The critical radius is given by:

$$r_{critical} = \frac{k_{insulation}}{h} \qquad 3.16$$

CONSTRUCTION COST ESTIMATE

Project:	Repair Existing Steam Pipe & Fittings	RS&H No.:	694-1331-004
Location:	Pine Bluff Arsenal, AR	Date:	6/27/96
Basis:	Schematic Design	Estimator:	GWF
ECO Number:	H1-A	Filename:	EST-H1A.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR (1)		TOTAL COST	SOURCE	
	No.	Unit	$/Unit	Total	$/Unit	Total		Material	Labor
90° Elbows 1"	3	Ea	2.29	7	37	111	118	MMp145	MMp145
2"	1	Ea	6.95	7	44	44	51	MMp145	MMp145
6"	2	Ea	43	86	86	172	258	MMp158	MMp158
Gaskets 2"	2	Ea	4.87	10	37	74	84	MMp 157	MMp 157
Gage pig tail 1"	2	Ea	5	10	10	20	30	Estimate	Estimate
Piping 1"	8	LF	2.5	20	8.9	71	91	MMp 139	MMp 139
2"	2	LF	4.49	9	13.5	27	36	MMp 139	MMp 139
Tees 1"	2	Ea	2.9	6	60	120	126	MMp 145	MMp 145
Steam Traps 1"	18	Ea	234	4,212	54	972	5,184	MMp 263	MMp 263
2"	2	Ea	590	1,180	81	162	1,342	MMp 264	MMp 264
Unions 1"	1	Ea	28	28	30	30	58	MMp 157	MMp 157
Valves 1"	45	Ea	26	1,170	25.3	1,139	2,309	MMp 188	MMp 188
2"	13	Ea	59.5	774	44	572	1,346	MMp 188	MMp 188
3"	9	Ea	195	1,755	67	603	2,358	MMp 188	MMp 188
4"	4	Ea	940	3,760	288	1,152	4,912	MMp 196	MMp 196
6"	13	Ea	1475	19,175	448	5,824	24,999	MMp 196	MMp 196
Wyes 1"	1	Ea	13.25	13	30.3	30	43	MMp 271	MMp 271
Asbestos Abatement	128	Ea	11.5	1,472	46	5,888	7,360	MMp 24	MMp 24
Asbestos Disposal	6	CY	160	960	0	0	960	MMp 24	MMp 24
Insulation (2)	271	L.F.	4.06	1,100	3.16	856	1,956	MMp 239	MMp 239
Personnel hoist rental	2	Mo.	1450	2,900		0	2,900	MMp 15	MMp 15
Subtotal Bare Costs				38,654		17,867	56,521		
Retrofit Cost Factors			5%	1,933	9%	1,608	3,541	MMp6	MMp6
Subtotal				40,587		19,475	60,062		
City Cost Index			0.952	(1,948)	0.632	(7,167)	(9,115)	MMp533	MMp533
Subtotal				38,639		12,308	50,947		
OH & Profit Markups			10%	3,864	53%	6,523	10,387	MMp7	MMp475
Subtotal				42,503		18,831	61,334		
State Sales Taxes			4.5%	1,913		N.A.	1,913	MMp476	
Subtotal				44,416		18,831	63,247		
Contingency			10%	4,442	10%	1,883	6,325	MEp6	MEp6
Total Construction Cost				48,858		20,714	$69,572		
Design Fee				N.A.	6.0%	4,174	4,174		
SIOH				N.A.	6.0%	4,174	4,174		
Total Project Cost				48,858		29,062	$77,920		

LEGEND:

MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
Note (1)	Except for asbestos and insulation items, labor rates are doubled to cover cost for removal of existing material.
Note (2)	From Means, assumes 3 L.F. per fitting; uses cost for 4" diameter as an average.

ECO H1-A

PBA

Leak Survey

area	building	fitting	characterization	size	action
31	220/150	Trap	1	1	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace
31	520	Valve	5	2	Replace
31	520	Trap	4	1	Replace
31	520	Gasket	4	2	Replace
31	529	Valve	2	1	Replace
31	530	Gasket	7	2	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Trap	1	2	Replace
31	620	Valve	3	1	Replace
31	630	Valve	3	4	Replace
31	630	Valve	1	2	Replace

AG - WP Above ground tanks
IG - WP In-ground tanks
HL - High line

ECO H1-A

PBA
Leak Survey

area	building	fitting	characterization	size	action
32	trailers	Trap	3	1	Replace
32	060	Valve	3	1	Replace
32	060	Valve	2	6	Replace
32	060	Valve	1	6	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	516	Valve	2	2	Replace
32	520	Valve	2	3	Replace
32	520	Valve	1	1	Replace
32	529	Trap	5	2	Replace
32	530	Valve	1	6	Replace
32	530	Valve	2	1	Replace
32	530	Valve	3	2	Replace
32	540	Valve	6	1	Replace
32	610	Trap	3	1	Replace
32	619	Valve	4	3	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	639	Valve	5	1	Replace
32	640	Valve	1	2	Replace
32	640	Trap	2	1	Replace
32	720	elbow	7	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace

AG - WP Above ground tanks
IG - WP In-ground tanks
HL - High line

ECO H1-A

PBA

Leak Survey

area	building	fitting	characterization	size	action
33	060	Valve	2	6	Replace
33	060	Valve	2	6	Replace
33	060	Valve	3	1	Replace
33	060	elbow	8	6	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
33	550	Valve	2	2	Replace
33	579	y	3	1	Replace
33	620	Valve	3	2	Replace
33	630	Valve	3	3	Replace
33	630	Valve	2	2	Replace
33	640	Valve	1	3	Replace
33	640	Valve	1	1	Replace
33	729	Valve	1	2	Replace

AG - WP Above ground tanks
IG - WP In-ground tanks
HL - High line

ECO H1-A

PBA

Leak Survey

area	building	fitting	characterization	size	action
34	110	Valve	3	1	Replace
34	110	Valve	1	4	Replace
34	118	Valve	10	1	Replace
34	170	Valve	2	2	Replace
34	170	Valve	1	6	Replace
34	170	Valve	1	6	Replace
34	182	Valve	3	4	Replace
34	184	elbow	1	6	Replace
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	184	Valve	4	6	Replace
34	185	Valve	6	3	Replace
34	197	Valve	10	1	Replace
34	350	Valve	7	2	Replace
34	630	Valve	2	4	Replace
34	640	elbow	3	2	Replace
34	640	trap	1	1	Replace
34	640	union	4	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	AG	elbow		1	Replace
34	AG	pig tail		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	T		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
34	HL	Valve	1	1	Replace
34	HL	Valve	1	6	Replace
34	HL	Valve	1	6	Replace
34	IG	elbow	8	1	Replace

AG - WP Above ground tanks (not operating during survey, assume same as IG)
IG - WP In-ground tanks
HL - High line

A.5.H1-27

ECO H1-A

sort fitt'g

area	building	fitting	characterization	size	action
32	720	elbow	7	1	Replace
34	IG	elbow	8	1	Replace
34	AG	elbow		1	Replace
34	640	elbow	3	2	Replace
33	060	elbow	8	6	Replace
34	184	elbow	1	6	Replace
31	520	Gasket	4	2	Replace
31	530	Gasket	7	2	Replace
34	IG	pig tail	6	1	Replace
34	AG	pig tail		1	Replace
34	IG	pipe	1	1	Replace
34	IG	pipe	7	1	Replace
34	IG	pipe	8	1	Replace
34	IG	pipe	8	1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
34	IG	T	3	1	Replace
34	AG	T		1	Replace
31	520	Trap	4	1	Replace
31	220/150	Trap	1	1	Replace
32	610	Trap	3	1	Replace
32	640	Trap	2	1	Replace
32	trailers	Trap	3	1	Replace
34	640	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	8	1	Replace
34	IG	trap	3	1	Replace
34	IG	trap	3	1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
31	620	Trap	1	2	Replace
32	529	Trap	5	2	Replace
34	640	union	4	1	Replace
31	529	Valve	2	1	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Valve	3	1	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	520	Valve	1	1	Replace
32	530	Valve	2	1	Replace
32	540	Valve	6	1	Replace
32	639	Valve	5	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace
32	060	Valve	3	1	Replace
33	640	Valve	1	1	Replace
33	060	Valve	3	1	Replace
34	110	Valve	3	1	Replace
34	118	Valve	10	1	Replace

AG-WP Above ground tanks
IG - WP In-ground str'g tanks
HL - High line

A.5.H1-28

ECO H1-A

area	building	fitting	characterization	size	action
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	197	Valve	10	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	HL	Valve	1	1	Replace
34	IG	Valve	5	1	Replace
34	IG	Valve	1	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	6	1	Replace
34	IG	Valve	4	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	9	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	2	1	Replace
34	slag pit	Valve	8	1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
31	520	Valve	5	2	Replace
31	630	Valve	1	2	Replace
32	516	Valve	2	2	Replace
32	530	Valve	3	2	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	640	Valve	1	2	Replace
33	550	Valve	2	2	Replace
33	620	Valve	3	2	Replace
33	630	Valve	2	2	Replace
33	729	Valve	1	2	Replace
34	170	Valve	2	2	Replace
34	350	Valve	7	2	Replace
32	520	Valve	2	3	Replace
32	619	Valve	4	3	Replace
33	630	Valve	3	3	Replace
33	640	Valve	1	3	Replace
34	185	Valve	6	3	Replace
34	IG	Valve	6	3	Replace
34	IG	Valve	1	3	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
31	630	Valve	3	4	Replace
34	110	Valve	1	4	Replace
34	182	Valve	3	4	Replace
34	630	Valve	2	4	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace

AG-WP Above ground tanks
IG - WP In-ground str'g tanks
HL - High line

Sort size

ECO H1-A

area	building	fitting	characterization	size	action
32	720	elbow	7	1	Replace
34	IG	elbow	8	1	Replace
34	AG	elbow		1	Replace
34	IG	pig tail	6	1	Replace
34	AG	pig tail		1	Replace
34	IG	pipe	1	1	Replace
34	IG	pipe	7	1	Replace
34	IG	pipe	8	1	Replace
34	IG	pipe	8	1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	IG	T	3	1	Replace
34	AG	T		1	Replace
31	520	Trap	4	1	Replace
31	220/150	Trap	1	1	Replace
32	610	Trap	3	1	Replace
32	640	Trap	2	1	Replace
32	trailers	Trap	3	1	Replace
34	640	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	8	1	Replace
34	IG	trap	3	1	Replace
34	IG	trap	3	1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	640	union	4	1	Replace
31	529	Valve	2	1	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Valve	3	1	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	520	Valve	1	1	Replace
32	530	Valve	2	1	Replace
32	540	Valve	6	1	Replace
32	639	Valve	5	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace
32	060	Valve	3	1	Replace
33	640	Valve	1	1	Replace
33	060	Valve	3	1	Replace
34	110	Valve	3	1	Replace

AG - WP above ground tanks
IG - WP in-ground tanks
HL - High line

ECO H1-A

Sort size

area	building	fitting	characterization	size	action
34	118	Valve	10	1	Replace
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	197	Valve	10	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	HL	Valve	1	1	Replace
34	IG	Valve	5	1	Replace
34	IG	Valve	1	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	6	1	Replace
34	IG	Valve	4	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	9	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	2	1	Replace
34	slag pit	Valve	8	1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
33	579	y	3	1	Replace
34	640	elbow	3	2	Replace
31	520	Gasket	4	2	Replace
31	530	Gasket	7	2	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
31	620	Trap	1	2	Replace
32	529	Trap	5	2	Replace
31	520	Valve	5	2	Replace
31	630	Valve	1	2	Replace
32	516	Valve	2	2	Replace
32	530	Valve	3	2	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	640	Valve	1	2	Replace
33	550	Valve	2	2	Replace
33	620	Valve	3	2	Replace
33	630	Valve	2	2	Replace
33	729	Valve	1	2	Replace
34	170	Valve	2	2	Replace
34	350	Valve	7	2	Replace

AG - WP above ground tanks
IG - WP in-ground tanks
HL - High line

ECO H1-A

Sort size

area	building	fitting	characterization	size	action
32	520	Valve	2	3	Replace
32	619	Valve	4	3	Replace
33	630	Valve	3	3	Replace
33	640	Valve	1	3	Replace
34	185	Valve	6	3	Replace
34	IG	Valve	6	3	Replace
34	IG	Valve	1	3	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
31	630	Valve	3	4	Replace
34	110	Valve	1	4	Replace
34	182	Valve	3	4	Replace
34	630	Valve	2	4	Replace
33	060	elbow	8	6	Replace
34	184	elbow	1	6	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace
32	530	Valve	1	6	Replace
32	060	Valve	2	6	Replace
32	060	Valve	1	6	Replace
33	060	Valve	2	6	Replace
33	060	Valve	2	6	Replace
34	170	Valve	1	6	Replace
34	170	Valve	1	6	Replace
34	184	Valve	4	6	Replace
34	HL	Valve	1	6	Replace
34	HL	Valve	1	6	Replace
size	thkness	area	No	CY	
1	2	0.5	80	1	
2	2	1	40	1	
3	2	1.5	27	1	
4	2	2	16	1	
6	2	2.5	90	2	
				6	

AG - WP above ground tanks
IG - WP in-ground tanks
HL - High line

A.5.H1-32

ENERGY PROJECT SUMMARY SHEET

Installation and Location	Pine Bluff Arsenal, Pine Bluff, Arkansas
Project Title	Boiler Efficiency Improvements
Project Funding Category	Federal Energy Management Program (FEMP)
Total Investment	$93,000
Annual Cost Savings	$26,700
Savings-to-Invest. Ratio (SIR)	5.34
Simple Payback Period	3.5 Years

Contents

1. COMPONENT ARMY	FY 19___ MILITARY CONSTRUCTION PROJECT DATA		2. DATE September 6, 1996
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas		4. PROJECT TITLE Boiler Efficiency Improvements - FEMP	
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000) $93

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
Remove stacks, install economizers, piping, valves and controls on two York-Shipley boilers. Reinstall stacks and repair roof. See attached detailed estimate.				$69.6
Install and adjust jackshaft cam kits on the two boilers in Building 33-060. See attached detailed estimate.				$5.8
Subtotal Construction Cost				$75.4
Contingency (10%)				$7.5
Total Construction Cost				$82.9
Design Fee (6%)				$5.0
SIOH (6%)				$5.0
Total Cost				$92.9
Total Requested (rounded)				$93

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The scope of work for this project includes the following two items:

1. Purchase and install stack gas economizers on the two York-Shipley boilers located in Building 32-060. The top portion of the stacks will be removed, the economizers and all necessary boiler feedwater piping, valves and controls will be installed to allow the boiler feedwater to be heated by the hot combustion gases. The stacks will be reinstalled and the roof around the stacks will be repaired where required.

2. An adjustable cam kit will be purchased and installed on each boiler located in Building 33-060. The cams will be positioned in the connecting link between the burner jack shaft and the forced draft inlet vane. After they are installed, the cams will be set up to provide proper proportioning of the air and fuel over the entire operating load range of the boilers.

ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 1

LIFE CYCLE COST ANALYSIS SUMMARY

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: H2D-H3B
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID FY95 (92)
INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3
PROJECT NO. & TITLE: H2D&H3B BOILER EFFICIENCY IMPROVEMENTS
FISCAL YEAR 1997 DISCRETE PORTION NAME: ECO-H2D AND ECO-H3B COMBINED
ANALYSIS DATE: 08-22-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$ 82990.		
B. SIOH	$ 4980.		
C. DESIGN COST	$ 4980.		
D. TOTAL COST (1A+1B+1C)	$ 92950.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 92950.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 16.79	0.	$ 0.	15.08	$ 0.
B. DIST	$ .00	0.	$ 0.	18.57	$ 0.
C. RESID	$ .00	0.	$ 0.	21.02	$ 0.
D. NAT G	$ 2.81	9506.	$ 26712.	18.58	$ 496306.
E. COAL	$ .00	0.	$ 0.	16.83	$ 0.
F. PPG	$ .00	0.	$ 0.	17.38	$ 0.
M. DEMAND SAVINGS			$ 0.	14.88	$ 0.
N. TOTAL		9506.	$ 26712.		$ 496306.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 14.88
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)$ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))$ 26712.

5. SIMPLE PAYBACK PERIOD (1G/4) 3.48 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 496306.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 5.34
(IF < 1 PROJECT DOES NOT QUALIFY)

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 2

DESCRIPTION OF WORK TO BE ACCOMPLISHED

ECO-H2

Modifications and improvements to boilers in Building 32-060.

Description

This project consist of installing stack gas economizers on the two York-Shipley boilers. The top portion of the stacks will be removed, the economizers and all necessary boiler feedwater piping, valves and controls will be installed to allow the boiler feedwater to be heated by the hot combustion gases. The stacks will be reinstalled and the roof around the stacks will be repaired where required.

During the course of preparing this report, demolition of the existing boilers and preparation for installing the surplus boilers was started. This ECO was added and analyzed because the current construction contact for the boiler replacement project does not include the purchase and installation of economizers.

The existing boilers are being removed and replaced with two new York Shipley, 600 hp, fire tube boilers. The new boilers are equipped with O_2 trim to optimize the fuel-to-air ratio. These controls will allow the new boilers to operate at an efficiency of about 80 percent when operating between ten percent load and full load.

The economizers will allow the new boilers to maintain the exhaust gas temperature at about 250 degrees F over the boiler's entire operating load range. Fire tube boilers typically have exhaust gas temperatures that range between 50 degrees F to 150 degrees F above the saturation temperature corresponding to their operating pressure. PBA operates the boilers at a pressure of about 130 psig. The corresponding saturation temperature would be 355 degrees F, and the exit gas temperature should be between 405 degrees F and 505 degrees F. The economizer can reduce the exhaust gas temperature to 250 degrees F. Boiler efficiency increases about one percent for every 40 degrees F reduction in exhaust gas temperature. Therefore, the boilers will pick up four to six efficiency points by adding an economizer.

The energy savings calculations assume adding an economizer and a stack gas temperature control loop to maintain the stack temperature at 250 degrees F will raise the operating efficiency of the York-Shipley boilers from about 80 percent to approximately 85 percent.

ECO-H3

Modifications and improvements to boilers in Building 33-060.

Description

An adjustable cam kit will be purchased and installed on each boiler. The cams are positioned in the connecting link between the burner jack shaft and the forced draft inlet vane. After they are installed, the cams will be set up to provide proper proportioning of the air and fuel over the entire operating load range of the boilers.

The existing boilers were originally installed in 1942 during the beginning of World War II. The burners were replaced about 20 years ago but were never properly adjusted. The existing connecting links between the burner jack shaft and the forced draft fan do not permit proper adjustment of the air-to-fuel ratio over the operating load range of the boiler. As a result the boilers are currently operating with far too much excess air. Field tests at various operating loads indicate the excess air for these boilers ranges from 72 percent to 191 percent. The normal, and most efficient, operating range is 10 percent to 15 percent excess air.

The high excess air amounts are reducing the operating efficiency of these boilers by three to eight percent. The calculated annual average efficiency based on the average annual load factor for these boilers is about 75 percent. Installation of the adjustable cam will maintain the residual stack gas O_2 concentration at about 1.7 percent and the excess air at approximately 10 percent when firing natural gas. This retrofit will allow the boilers to operate at an efficiency of about 80 percent over their entire operating load range.

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 3

SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA

Pine Bluff Arsenal

Energy Savings Calculations

ECO Number:	H2D	
		Notes
Building Number:	32-060	
Natural Gas consumption (MBtu/Yr):	107,613	(1)
Current Boiler Efficiency:	0.80	(2)
Boiler Efficiency w/ Economizer:	0.85	(3)

Notes:

(1) Assumes steam leaks are repaired, see attached calculation sheet.
(2) Efficiency of a new boiler with properly operating air-fuel controls.
(3) Efficiency with an economizer, (450°-250°)/40 = 5% improvement.

Energy Savings = (Improved efficiency - Current efficiency) x Natural gas consumption

= (0.85 - 0.80) x 107,613 MBtu/Yr

Energy Savings = 5,381 MBtu/Yr

CONSTRUCTION COST ESTIMATE

Project: Modifications & Improvements to boilers in Bldg.32-060
Location: Pine Bluff Arsenal, AR
Basis: Schematic Design
ECO Number: H2-D: Retrofit economizers on surplus boilers.

RS&H No.: 694-1331-004
Date: 8/15/96
Estimator: WTT
Filename: EST-H2D.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR		TOTAL COST	SOURCE	
	No.	Unit	$/Unit	Total	$/Unit	Total		Material	Labor
Economizer for Y-S boiler	2	Ea	18000	36,000	5000	10,000	46,000	Vendor	Vendor
Peripheral equipment; piping, valves, controls, etc.	2	Ea	4500	9,000	1250	2,500	11,500	Use 25%	Use 25%
Remove stack (50 ft each)	100	L.F.		0	21.5	2,150	2,150		MMp 246
Re-install stack (50 ft each)	100	L.F.		0	21.5	2,150	2,150		MMp 246
Roof flashing, 28" dia.	2	Ea	259	518	63	126	644	MMp 244	MMp 244
Repair/replace roofing	50	SF	0.95	48	1.53	77	125	MRp 272	MRp 272
Hoist, truck mounted, 12 ton	1	Wk	2107	2,107	1070	1,070	3,177	MMp 15	MMp 475
Subtotal Bare Costs				47,673		18,073	65,746		
Retrofit Cost Factors			0%	0	0%	0	0	MMp6	MMp6
Subtotal				47,673		18,073	65,746		
City Cost Index			0.952	(2,288)	0.632	(6,651)	(8,939)	MMp533	MMp533
Subtotal				45,385		11,422	56,807		
OH & Profit Markups			10%	4,539	53%	6,054	10,593	MMp7	MMp475
Subtotal				49,924		17,476	67,400		
State Sales Taxes			4.5%	2,247		N.A.	2,247	MMp476	
Subtotal				52,171		17,476	69,647		
Contingency			10%	5,217	10%	1,748	6,965	MEp6	MEp6
Total Construction Cost				57,388		19,224	$76,612		
Design Fee				N.A.	6.0%	4,597	4,597		
SIOH				N.A.	6.0%	4,597	4,597		
Total Project Cost				57,388		28,418	$85,806		

LEGEND:

MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
MRp###	1991 Means Repair and Remodling Cost Data, page ###, exclated at 3%/yr.
Vendor	Vendor estimate, see attached telephone call confirmation.

RS&H

Telephone Call Confirmation

Project Number 694-1331-004

Local ______ L.D. X Placed X Rec'd ______ Date 6-4-96

Conversed with MARK CUTTER Of McCAIN ENGINEERING PELHAM ALABAMA.

Regarding ECONOMIZER FOR YORK SHIPLEY BOILER

MAT'L COST ≈ $18,000 CIRCULAR ECONOMIZER

INSTALLATION ≈ $5000 BECAUSE NOT RETROFIT IF INSTALLED DURING CONSTRUCTION

George Fallon Jr.

Distribution:

A.5.H2-16

Pine Bluff Arsenal

Energy Savings Calculations

ECO Number:	H3B	
		Notes
Building Number:	33-060	
Natural Gas consumption (MBtu/Yr):	82,495	(1)
Current Boiler Efficiency:	0.75	(2)
New/Improved Boiler Efficiency:	0.80	(3)

Notes:

(1) Assumes steam leaks are repaired, see attached calculation sheet.
(2) Actual efficiency calculated from field measurements.
(3) Efficiency of a new or properly operating boiler.

Energy Savings = (Improved efficiency - Current efficiency) x Natural gas consumption

= (0.80 - 0.75) x 82,495 MBtu/yr

Energy Savings = 4,125 MBtu/yr

CONSTRUCTION COST ESTIMATE

Project:	Modifications & Improvements to boilers in Bldg.33-060	RS&H No.:	694-1331-004
Location:	Pine Bluff Arsenal, AR	Date:	6/26/96
Basis:	Schematic Design	Estimator:	GWF
ECO Number:	H3-B: Improve efficiency of existing boilers	Filename:	EST-H3B.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR		TOTAL COST	SOURCE	
	No.	Unit	$/Unit	Total	$/Unit	Total		Material	Labor
Jackshaft cam kit for boiler	2	Ea	527.82	1,056	2400	4,800	5,856	Vendor	Est. (1)
Subtotal Bare Costs				1,056		4,800	5,856		
Retrofit Cost Factors			0%	0	0%	0	0	MMp6	MMp6
Subtotal				1,056		4,800	5,856		
City Cost Index			0.952	(51)	0.632	(1,766)	(1,817)	MMp533	MMp533
Subtotal				1,005		3,034	4,039		
OH & Profit Markups			10%	101	53%	1,608	1,709	MMp7	MMp475
Subtotal				1,106		4,642	5,748		
State Sales Taxes			4.5%	50		N.A.	50	MMp476	
Subtotal				1,156		4,642	5,798		
Contingency			10%	116	10%	464	580	MEp6	MEp6
Total Construction Cost				**1,272**		**5,106**	**$6,378**		
Design Fee				N.A.	6.0%	383	383		
SIOH				N.A.	6.0%	383	383		
Total Project Cost				**1,272**		**5,872**	**$7,144**		

LEGEND:

Note (1)	Assumes 3 days to install, $800 per day for labor and expenses.
MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
Vendor	Vendor quote, see attached fax.

A.5.H3-7

PINE BLUFF ARSENAL

Annual Energy Consumption in Production Area Boiler Buildings

1995 Energy Use Data (from boiler operating logs)

Area 32 Nat Gas Consumption (MBtu/yr) = 163,392

Area 33 Nat Gas Consumption (MBtu/yr) = 125,255

Area 34 Nat Gas Consumption (MBtu/yr) = 203,467

1995 Natural Gas Consumption in 32, 33 & 34 Boilers

Total Consumption (MBtu/yr) = Sum of Areas 32, 33 and 34

Total Consumption = 163,392 + 125,255 + 203,467

Total Consumption = 492,114 MBtu/yr

Percent Share of Total for Each Area

Area 32 = 163,392 / 492,114 = 33%

Area 33 = 125,255 / 492,114 = 25%

Area 34 = 203,467 / 492,114 = 41%

Energy Loss From Steam Leaks

Estimated energy loss due to steam leaks (1995) = 168,000 MBtu/yr

Estimated Energy Consumption w/o Steam Leaks

Forcast Consumption = Total Consumption for 1995 - Steam Leaks for 1995

= 492,114 - 168,000

= 324,114 MBtu/yr

Forcast Area Energy Consumption

Forcast area 32 = 324,114 × 33% =107,613 MBtu/yr

Forcast area 33 = 324,114 × 25% = 82,495 MBtu/yr

Forcast area 34 = 324,114 x 41%= 134,007 MBtu/yr

Determination of Average Annual boiler efficiency

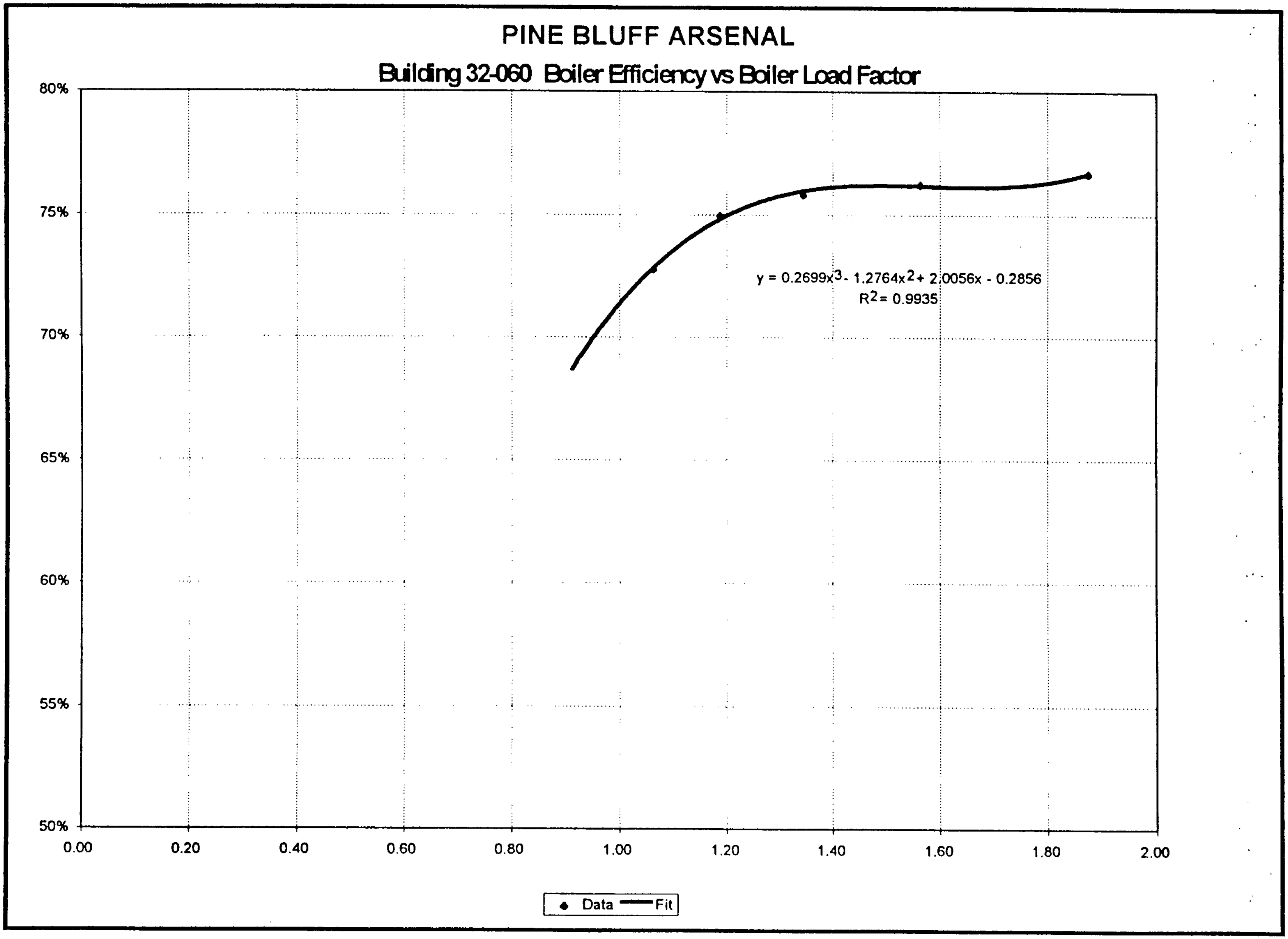
To determine the average annual boiler efficiency, stack gas analysis data was taken at five different boiler loads. The five load points ranged between the boiler's published 100% and 200% capacity because that is the range where the boiler typically operates . A curve was then drawn through the data points.

A monthly load factor was calculated from boiler operating logs. An annual average load factor was calculated from the monthly data and used to select an annual average boiler efficiency. The table below summarizes the results:

Building	Average Annual Load factor (1)	Average Annual Efficiency (2)
32-060	110%	74%
33-060	125%	75%
34-140	160%	72%

(1) Calculated from boiler operating logs. Boilers usually operate between 100% and 200% of published boiler capacity.

(2) Average annual efficiency of the boilers determined from attached graph at the average annual load factor.


PINE BLUFF ARSENAL
Building 32-060 Boiler Efficiency vs Boiler Load Factor
80%
75%
70%
65%
60%
55%
50%
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
y = 0.2699x3 - 1.2764x2 + 2.0056x - 0.2856
R2 = 0.9935
Data
Fit

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ILLINGWORTH ENGINEERING COMPANY

manufacturers agent

FAX TRANSMITTAL

DATE: 6/26/96

TO:

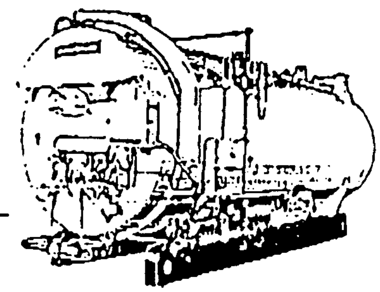
ATTN: [redacted]

FAX NO: 279-2489

FROM: CHUCK STRACENER

PAGES: 1 (Including Cover Sheet)

RE:



MESSAGE:

1 EA 3/4 JACKSHAFT KIT P/N 880-339

$527.82

IF YOU DID NOT RECEIVE ALL THE PAGES, PLEASE CALL BACK AS SOON AS POSSIBLE.

A.5.H3-13

ENERGY PROJECT SUMMARY SHEET

Installation and Location	Pine Bluff Arsenal, Pine Bluff, Arkansas
Project Title	Repair Compressed Air Pipe and Fittings
Project Funding Category	Federal Energy Management Program (FEMP)
Total Investment	$84,000
Annual Cost Savings	$98,200
Savings-to-Invest. Ratio (SIR)	17.7
Simple Payback Period	0.9 Years

<u>Contents</u>

1. COMPONENT ARMY	FY 19___ MILITARY CONSTRUCTION PROJECT DATA		2. DATE September 6, 1996
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas		4. PROJECT TITLE Repair Compressed Air Pipe and Fittings - FEMP	
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000) $84

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
Locate compressed air leaks. Repair/replace leaking piping, valves and fittings. See attached detailed estimate.				
Subtotal Construction Cost				$67.9
Contingency (10%)				$6.8
Total Construction Cost				$74.7
Design Fee (6%)				$4.5
SIOH (6%)				$4.5
Total Cost				$83.7
Total Requested (rounded)				$84

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The scope of work for this project consists of repairing and/or replacing all of the failed valves, fittings and pipe sections on the existing air distribution piping system served by the compressors in Buildings 32-060, 33-060 and 34-140. An ultrasonic leak detector will be utilized to locate the compressed air leaks.

ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 1

LIFE CYCLE COST ANALYSIS SUMMARY

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: ECO-C3
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID FY95 (92)
INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3
PROJECT NO. & TITLE: ECO-C3 COMPRESSED AIR SYSTEM MODIFICATIONS
FISCAL YEAR 1997 DISCRETE PORTION NAME: OPTION C - REPAIR CA PIPING
ANALYSIS DATE: 07-02-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT
A. CONSTRUCTION COST $ 74718.
B. SIOH $ 4483.
C. DESIGN COST $ 4483.
D. TOTAL COST (1A+1B+1C) $ 83684.
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
F. PUBLIC UTILITY COMPANY REBATE $ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F) $ 83684.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 16.79	5847.	$ 98176.	15.08	$ 1480497.
B. DIST	$ .00	0.	$ 0.	18.57	$ 0.
C. RESID	$ .00	0.	$ 0.	21.02	$ 0.
D. NAT G	$ 2.81	0.	$ 0.	18.58	$ 0.
E. COAL	$ .00	0.	$ 0.	16.83	$ 0.
F. PPG	$ .00	0.	$ 0.	17.38	$ 0.
M. DEMAND SAVINGS			$ 0.	14.88	$ 0.
N. TOTAL		5847.	$ 98176.		$ 1480497.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 14.88
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)$ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))$ 98176.

5. SIMPLE PAYBACK PERIOD (1G/4) .85 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 1480497.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 17.69
(IF < 1 PROJECT DOES NOT QUALIFY)

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 2

DESCRIPTION OF WORK TO BE ACCOMPLISHED

ECO-C3

Modifications and improvements to the compressed air system.

Description

This project consist of locating compressed air leaks with a ultrasonic leak detector and then repairing and/or replacing all of the failed valves, fittings and pipe sections on the existing air distribution piping system served by the compressors in Buildings 32-060, 33-060 and 34-140.

Discussions with the air compressor operating staff indicated between two and three compressors operate during non-production times and between four and six of the compressors will operate during production times. Since very little process air is required during non-production hours, the analysis assumes one compressor operates at full load and one compressor operates at half load during this time to supply leaks in the distribution system. Energy and cost savings are based on reduced compressor air supply requirements due to elimination of the leaks in the distribution system.

A comprehensive survey of the compressed air lines was not included in the Scope of Work for this study, however, many compressed air leaks were observed during the survey of the steam distribution system. The analysis uses the air flow from a 1/16 inch diameter leak to calculate the number of leaks in the system. The project construction cost was then calculated based on the calculated number of leaks.

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 3

SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA

RS&H

SUBJECT PBA ELEC & HTG STUDY — DEDICATED COMPRESSORS
AEP NO 694-1331-004
SHEET ____ OF ____
DESIGNER W. TODD
DATE 6-25-96
CHECKER ____
DATE ____

ECO-C3-A, INSTALL DEDICATED COMPRESSORS

Compressed Air Demand:

Bldg. No.	CFM Req'd (1)	No. Compressors Req'd. 10 Cfm	100 CFM	200 Cfm	600 Cfm
31530	200 cfm			1	
31620	200			1	
31630	1800				3
31640	10	1			
31720	10	1			
Subtotals	2220	2	0	2	3
32070	10	1			
32230	400			2	
32270	1800				3
32610	100		1		
32620	178			1	
32640	1200				2
Subtotals	3688	1	1	3	5
33530	2100		1	1	3
33620	10	1			
33670	600				1
Subtotals	2710	1	1	1	4
34110	600				1
34630	120			1	
34640	100		1		
Subtotals	820	0	1	1	1
Totals	9438 cfm	4	3	7	13

(1) From CDG Utility Study, Exhibit G, see attached pages.

ECO - C3 (continued)

According to the PBA production staff, Buildings 31620, 31630 and 31720 are in layaway. There are also 2 - 600 cfm compressor packages available (already purchased by DPW) to install. The 10 cfm compressors are very small and will not be considered in the cost estimate for this analysis. The number of compressors required now becomes:

100 cfm : 3 each

200 cfm : 7 - 1 (Bldg. 31620) = 6 each

600 cfm ; 13 - 3 (Bldg. 31630) - 2 (surplus) = 8 each

According to the DPW operating staff: 2 to 3 of the existing 6 compressors operate during non-production times and 4 to 6 of them operate during production. The existing compressors have a rated output of 825 cfm each.

A detailed survey of the C.A. system was not included in the scope of this study, however, during the steam line survey many compressed air leaks were observed. The following assumptions / estimates will be used for the analysis of this ECO:

- The process load during non-production is ~412 cfm ($\frac{1}{2}$ compressor)
- Leaks at or inside process buildings is ~412 cfm ($\frac{1}{2}$ compressor)
- Leaks in the main distribution piping is ~1237 cfm ($1\frac{1}{2}$ compressors)

- Process air load = 5 compressors - $1\frac{1}{2}$ (main leaks) - $\frac{1}{2}$ (bldg. leaks) = 3 comp.

ECO - C3 - B Replace Compressed Air (CA) Piping

Since a detailed study of the CA piping was not in the Scope of Work, this analysis makes the following assumptions:

1) The CA pipe is 30% 4" and 70% 2" diameter.

2) The compressed air distribution system is the same length as the steam distribution system.

3) The new CA piping will utilize the existing supports and hangers.

4) The savings is based on reduced compressor operating time. See attached calculations.

Savings = 5847.3 MBtu /YR

5) There is currently little or no maintenance on the existing system, so no O&M savings were considered for this ECO.

ECO CALCULATIONS

Project:	Replace Compressed Air Piping	RSH No.:	694-1331-004
Location:	Pine Bluff Arsenal, AR	Date:	7/2/96
ECO No.:	C3-B	Designer:	W. Todd

Assumptions:

1.	Number compressors operating at full load during production:		5	(estimated by operating staff)
2.	Number compressors operating at half load during production:		0	(estimated by operating staff)
3.	Number compressors operating at full load during non-production:		2	(estimated by operating staff)
4.	Number compressors operating at half load during non-production:		1	(estimated by operating staff)
5.	Exist. compressors:	Design CA supply capacity:	825 cfm	(from nameplate data)
		Calculated electric demand:	145.9 kW	(from nameplate data)
		Measured electric demand:	130.7 kW	(measured during survey)
		Actual percent motor load:	0.90	(measured kW / nameplate kW)
		Demand per design supply cfm:	0.158 kW/cfm	(measured kW / design cfm)
6.	New Compressors:	Design CA supply capacity:	825 cfm	(from nameplate data)
		Electric demand at full load:	145.9 kW	(from nameplate data)
		Estimated percent motor load:	0.90	(measured kW / nameplate kW)
		Estimated electric demand:	130.7 kW	(measured during survey)
		Demand per design supply cfm:	0.158 kW/cfm	(measured kW / design cfm)
7.	Production schedule: 10 hr/day, 4 day/wk, 52 wks/yr			
8.	Compressed air distribution:	Process buildings (production) =	60%	(Assume 3.0 comp. / 5 comp)
		Process buildings (non-prod) =	10%	(Assume 0.5 comp. / 5 comp)
		Leaks at or in buildings =	10%	(Assume 0.5 comp. / 5 comp)
		Leaks in main CA dist. piping =	30%	(Assume 1.5 comp. / 5 comp)
9.	Average cost of electric energy consumed at PBA :		$16.79 /MBtu	(calculated from electric bills)

<u>Estimate of compressed air supplied by the main system:</u>

During Production = 5 comp. x 825 cfm/co. + 0 comp. x 412.5 cfm/co. = 4125 cfm

During Non-prod. = 2 comp. x 825 cfm/co. + 1 comp. x 412.5 cfm/co. = 2063 cfm

<u>Estimate of current energy consumption:</u>

During Production = 0.158 kW/cfm x 4125 cfm = 651.8 kW

651.8 kW x 2080 hrs/year = 1355744 kWh/yr

1355744 kWh/yr x 0.003413 MB/kWh= 4627.2 MBtu/yr

During Non-prod. = 0.158 kW/cfm x 2063 cfm = 326.0 kW

326.0 kW x 6680 hrs/year = 2177680 kWh/yr

2177680 kWh/yr x 0.003413 MB/kWh= 7432.4 MBtu/yr

Total = 4627.2 MBtu/yr + 7432.4 MBtu/yr = 12059.6 MBtu/yr

Estimate of compressed air required at the buildings:

During Production =	4125 cfm	x	60%	+	4125 cfm	x	10%	=	2888 cfm
During Non-prod. =	4125 cfm	x	10%	+	4125 cfm	x	10%	=	825 cfm

Estimate of energy consumption after ECO implementation:

During Production =	0.158 kW/cfm	x	2888 cfm	=	456.3 kW
	456.3 kW	x	2080 hrs/year	=	949104 kWh/yr
	949104 kWh/yr	x	0.003413 MB/kWh	=	3239.3 MBtu/yr
During Non-prod. =	0.158 kW/cfm	x	825 cfm	=	130.4 kW
	130.4 kW	x	6680 hrs/year	=	871072 kWh/yr
	871072 kWh/yr	x	0.003413 MB/kWh	=	2973 MBtu/yr
Total =	3239.3 MBtu/yr	+	2973 MBtu/yr	=	6212.3 MBtu/yr

Estimate of annual energy and cost savings:

Energy Savings =	12059.6 MBtu/yr	-	6212.3 MBtu/yr	=	5847.3 MBtu/yr
Cost Savings =	5847.3 MBtu/yr	x	$16.79 /MBtu	=	$98,176 /Year

RS&H

SUBJECT	PBA ELEC & HTG STUDY COMPRESSED AIR PIPING	AEP NO	694-1331-004
		SHEET	OF
DESIGNER	W. TODD	DATE	7-1-96
CHECKER		DATE	

ECO - C3 - C REPAIR COMPRESSED AIR PIPING

To be conservative it is assumed that all of the leaks are equivalent to about 1/16" diameter. From Compressed Air Systems, the leakage rate at 100 psig is about 4 cfm.

$$\text{Total estimated leaks} = \frac{1237 \text{ cfm}}{4 \text{ cfm/leak}} = 309 \Rightarrow 300 \text{ leaks}$$

We did not observe this many leaks but feel this is a very conservative method of estimating the cost of repair.

Assume the leaks are distributed as follows:

100 valves, Remove and replace

100 fittings, remove and replace

100 pipe sections, remove and replace.

The energy savings are the same as that estimated for ECO - C3 - B:

Savings = 5847.3 MBtu/YR

CONSTRUCTION COST ESTIMATE

Project:	Repair Compressed Air Distribution Piping	RS&H No.:	694-1331-004
Location:	Pine Bluff Arsenal, AR	Date:	7/1/96
Basis:	Schematic Design	Estimator:	W. Todd
ECO Number:	C3-C	Filename:	EST-C3C.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR		TOTAL COST	SOURCE	
	No.	Unit	$/Unit	Total	$/Unit	Total		Material	Labor
Rental Leak Detector	1	Mo.	200	200		0	200	Vendor	
Survey CA piping for leaks	20	Day		0	600	12,000	12,000		Est. (1)
Replace Leaking Valves									
Remove existing valve	100			0	48	4,800	4,800		MMp191
Install new valve, 2", gate	100		252	25,200	48	4,800	30,000	MMp191	MMp191
Repair Leaking Piping									
Cut existing pipe section	100	Ea		0	15.15	1,515	1,515		Est. (2)
Pipe, 2", sch 40 steel	100	LF	4.82	482		0	482	MMp139	
Joint weld - equip & labor	200	Ea	3.29	658	27	5,400	6,058	MMp144	MMp144
Repair Leaking Fittings									
Cut existing fitting	100	Ea		0	15.15	1,515	1,515		Est. (2)
90 deg elbow, steel	100	LF	6.65	665		0	665	MMp158	
Joint weld - equip & labor	200	Ea	3.29	658	27	5,400	6,058	MMp144	MMp144
Personnal Hoist Rental	2	Mo.	1450	2,900		0	2,900	MMp15	
Subtotal Bare Costs				30,763		35,430	66,193		
Retrofit Cost Factors			0%	0	0%	0	0	MMp6	MMp6
Subtotal				30,763		35,430	66,193		
City Cost Index			0.952	(1,477)	0.632	(13,038)	(14,515)	MMp533	MMp533
Subtotal				29,286		22,392	51,678		
OH & Profit Markups			10%	2,929	53%	11,868	14,797	MMp7	MMp475
Subtotal				32,215		34,260	66,475		
State Sales Taxes			4.5%	1,450		N.A.	1,450	MMp476	
Subtotal				33,665		34,260	67,925		
Contingency			10%	3,367	10%	3,426	6,793	MEp6	MEp6
Total Construction Cost				**37,032**		**37,686**	**$74,718**		
Design Fee				N.A.	6.0%	4,483	4,483		
SIOH				N.A.	6.0%	4,483	4,483		
Total Project Cost				**37,032**		**46,652**	**$83,684**		

LEGEND:

Note (1)	Assumes 20 man-days to survey the comp air piping system.	$550 /day + travel
Note (2)	Assumes 15 minutes per cut x 2 cuts at $30.30 per hour (MMp475).	
MEp###	1996 Means Electrical Cost Data, page ###.	
MMp###	1996 Means Mechanical Cost Data, page ###.	
Vendor	Quote from GE Rents, see attached information.	

ECO-C3-A

AIR COMPRESSOR DATA

Survey by: GWF / WTT Date: 3/27/96

Maintenance Name: Phone:

Building Number: 34-140 Compressor I.D. No.: 4

Service area or Loads: Area 3 Section 4 and Sections 1, 2 and 3 via header piping system.

Compressor Specifications:

Mfg. & Model #: INGERSOLL-RAND, TYPE XLE, MODEL 16-10x7

Type: Recip.: ✓ Cent.: ____ Other: Date = 1967 SN: JH4868

Capacity (cfm): 825 Operating Pressure (psig): 130

Electric Motor:

Type: Synchronous ✓ Induction: ____ Other: ____

Volts: 460 Amps: 206 Phases: 3 Hz: 60 RPM: 600

HP: 173 Mfg: GE Model No.: 5SR684A60

Operation Schedule: hr/da: 24 da/wk: 7 mn/yr: 12

Cooling Method: Air: ____ Water: ✓

Air Source Location: Outdoors: ✓ Other: ____

Control System: Pneumatic staging control - 2 stages
Manual on/off control.

Maintenance Schedule: as required, no PM

O&M log available: (Yes) No Copies Obtained: (Yes) No

Auxiliary Equipment: (Air Dryer, Heat Recovery, etc.)
Air dryer disconnected.

Heat Recovery Potential: (Accessibility, heat load nearby) Use cooling water to preheat boiler feed water? ~25°ΔT

General Condition/Comments/Problems:
PANEL { AC Amps = 169
DC Amps = 345 }

ELECTRIC MOTOR DATA SHEET

Survey Date: 3/27 & 1/30/96; Survey By: WTT / CSW

Equipment ID/Function: Compressor No. 4

Location: Bldg. 34 140

Nameplate Data:

Manufacturer: General Electric

Model No.: 5SR 684 A60; Serial No.: DE 837 1527

Insulation Class: ____; NEMA Design: ____; Code: A; Efficiency: ____

Horsepower 173; Frame 965Y; RPM 600; Service Factor ____

Volts 460; Amps 206; Phases 3; Hz 60; PF 0.8; kW ____

Type: Synchronous ✓; Induction ____; Other TYPE TS

For Synchronous Motors: DC Excitation Volts 125; Amps 33

Electrical Measurements: ← CSW → | ← WTT →

Measurements	Phase 1	Phase 2	Phase 3	Phase	Phase 1-2	Phase 2-3
Volts(rms)	478.6	4.15	483.1		511.1	502.6
Amps(rms)	176.6	191.0	195.1		168.8	185.5
kW	86.12	-0.38	51.58		89.95	36.61
kVAR	1.77 LE	0.65 LA	80.07 LE		2.73 LE	80.29 LE
kVA	86.16	0.76	95.27		90.02	88.27
Power Factor	0.99	-0.5	0.54	-	0.99	0.41
dPF	0.99	-0.5	0.54		0.99	0.41
kdVA	2.010	44.43	1.995		2.092	2.103

General Condition/Comments: Motor Control Panel Readings:
169 Amps AC ; 34.5 Amps DC

ECO-C3-C

Compressed Air Systems by E.M. TALBOTT

strainers should perform well for many years; however, they require periodic inspection and service.

4.3.5 Filter/Lubricators

The filter, regulator and lubricator are used to cleanse the air at the point of use, to regulate the pressure and thus the power or thrust of the tool or other pneumatic equipment, and finally, to lubricate that equipment, in that order. If the tool or other pneumatic equipment is not protected (by a filter) from serious contaminants, or if the equipment is not properly lubricated, it may wear more rapidly and thus may reduce efficiency and expend more air to accomplish the same job.

A clogged filter will have the effect of added pressure drop and a resulting loss of energy as explained previously. Only regular inspection and attention can keep these items in proper order.

The in-line lubricator is available in several designs. Different air users may require different types of lubricators. Manufacturers' tests have indicated that proper lubrication of air tools results in reduced air consumption for governed tools (up to 50% compared to dry tools) and increased speeds for ungoverned tools.

4.3.6 System Leakage

Of all of the maintenance failures, system leakage probably results in more lost compressed air energy than any other single factor. Plants have been observed where leakage losses are a modest 10% of the total compressed air capacity. Although this is "modest" by leakage standards, it is a significant annual dollar cost. Other plants have been observed with leakage rates in the range of 20% to 40% of total air usage. The cost of this leakage is high and avoidable.

The table below shows a conservative estimate of the annual cost of leaks of various sizes:

Equivalent Hole Diameter	Leakage Rate scfm	10^3 scf per year (4000 hrs)	Cost per year, $ (@25¢/1000 cf)
1/64"	0.25	60	15
1/32"	0.99	238	59
1/16"	3.96	950	238
1/8 "	15.86	3806	952
1/4 "	63.44	15226	3806
3/8 "	142.74	34258	8564

Air at 100 psig
Orifice with sharp edges (Coefficient of flow = 0.61. Leakage and cost could be increased 60 percent for well rounded hole - coefficient = 0.97).

[illegible]

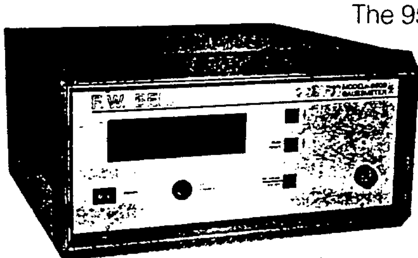
ECO-C3-C

Gaussmeters

F.W. Bell

F.W. Bell 9200 Digital Gaussmeter
Microprocessor-based gaussmeter measures either ac or dc magnetic fields. 3.5-digit display has peak hold function and reads in either gauss or telsa. Six measurement ranges from 20 G to 20 kG. DC accuracy: ±0.5%. Frequency response: dc to 5 kHz. Analog output of 2 volts full scale for recording. Built-in zero chamber. Autoranging. Includes axial and transverse probes. Rechargeable battery. Net weight: 8 lb.

F.W. Bell 9500 Digital Gaussmeter



The 9500 is a microprocessor-based, menu-driven gaussmeter with eight measurement ranges from 3 G to 30 kG. 3.75-digit LCD display with analog bar-graph and peak hold. Measurement results can be displayed in either gauss or telsa. DC accuracy: ±0.25%. Frequency response: dc to 5 kHz. Analog output: 3 volts full scale. Includes axial and transverse probes. Net weight: 19 lb.

Holaday

Holaday HI-3604 ELF/Power Frequency Survey Meter
Measures electric and magnetic fields associated with 50/60 Hz power lines and electrically operated equipment. Frequency range: 30 to 1000 Hz. Magnetic field: 0.1 mG to 20 G in five ranges. Electrical field: 1 V/m (volt per meter) to 200 kV/m in five ranges. Features LCD display, bar-graph analog indicator for quickly locating maximum field strength and "hot spots", full autoranging, sealed membrane switch control panel, and data logging capability which allows saving up to 127 readings in internal memory. Net weight: 5 lb.

Leak Detectors

Biddle

Keith at X-7015
Rent for $200 / month

Biddle 569001 Leak and Corona Detector
Ultrasonic leak and corona detector for use with electrical corona sources and gas leaks. Visual and audible outputs indicate presence of ultrasonic signals from poor connections, faulty equipment or RF signal sources. Unit can detect a 0.002 in. leak at 5 ft. with only 10 psi of pressure. Frequency range: 35 to 45 kHz. Battery powered. Net weight: 6 lb.

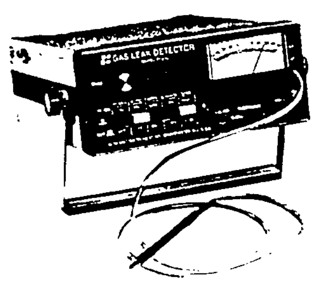
General Electric

General Electric H25 Ferret Halogen Leak Detector
Measures leaks down to 0.0005 oz/yr. Senses presence of halogen gas. Manual or automatic zero to background level. Complete with probe. Net weight: 17 lb.

General Electric LS-20 Halogen Leak Standard
Standard used for calibrating halogen leak detectors. Must specify leak rate desired: 0 to 0.005/0.05/0.5/5.0/15.0 oz/yr. Net weight: 4 lb.

Gow-Mac

Gow-Mac 21-250 Gas Leak Detector
Gas leak detector for helium, argon, carbon dioxide and refrigerants. Audible tone varies proportionally with meter deflection. Sensitivity: 1 x 10^{-5} cc/s (helium). Operates on 115 V/230 V, 50/60 Hz or internal rechargeable batteries. Net weight: 9 lb.



If You Have A Particular Need, But Don't See The Equipment Listed Here, Call 1-800-GE-RENTS.

A.5. C3-25

EXHIBIT G
COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

EQUIPMENT EFFECTIVNESS FACTOR %

PINE BLUFF ARSENAL, ARKANSAS
DEPARTMENT OF THE ARMY

COMPRESSED AIR

BUILDING NUMBER	BLDG USE	CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE
31080	ELECTRONIC CALIBRATION FACILITY						
31100	MAINT FACILITY						
31150	PRODUCTION OFFICE						
31310	RAW MAT. WAREHOUSE						
31330	RAW MAT. WAREHOUSE						
31420	RAW MAT. WAREHOUSE						
31440	RAW MAT. WAREHOUSE						
31520	MIX BUILDING						
31530	FILL AND PRESS	200	120	200	120	200	120
31531	OFFICE AND RESTROOMS						
31540	DOWNLOAD FACILITY						
31570	MUNITIONS STORAGE						
31620	PYRO MIX BLDG (THERMATE MIX)	200	120	200	120	200	120
31630	FILL AND PRESS	1800	120	0	0	3000	120
31631	BREAK AND RESTROOMS						
31640	ASSEMBLY	10	110	10	110	10	110
31670	STORAGE						
31720	PYROTECHNIC PRODUCTION	10	120	10	120	10	10
31730	STORAGE						
31820	STORAGE						
31830	AMMO QUAL FAC						
31860	STORAGE						
		2220		420		3420	
32000	CAFETERIA						
32030	INSPECTION GARAGE						
32035	ORDINANCE SHOP						
32070	IMPREG AND LAUNDRY	10	120	10	120	10	120
32080	MHE BATTERY SHOP						
32090	WAREHOUSE						
32100	ELECTRONIC CALIBRATION FACILITY						
32130	AMMO QUAL FAC						
32150	AMMO QUAL FAC						
32230	FILTER BLDG	400	120	400	120	400	120
32270	WAREHOUSE	1800	120	1800	120	1800	120

A.5.C3-26

E6-C3

EXHIBIT G
COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

COMPRESSED AIR

EQUIPMENT EFFECTIVNESS FACTOR %

PINE BLUFF ARSENAL, ARKANSAS
DEPARTMENT OF THE ARMY

BUILDING NUMBER	BLDG USE	CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE
32310	RAW MAT. WAREHOUSE						
32330	RAW MAT. WAREHOUSE						
32420	RAW MAT. WAREHOUSE						
32440	EQUIPEMENT WAREHOUSE						
32510	PROD ENGR LAB						
32520	PROD ENGR LAB						
32530	FORMER BZ FACILITY						
32531							
32540	FORMER BZ FACILITY						
32550	AMMO QUAL FAC						
32570	OPERATIONS GENERAL PURPOSE						
32610	DRYING	100	120	100	120	100	120
32620	COLORED SMOKE MIX (GLATT)	178	120	356	120	356	120
32630	STORAGE						
32631	OFFICE AND RESTROOMS						
32640	PYROTECHNIC PRODUCTION	1200	120	0	0	1200	120
32670	SUU-7 TEST						
32720	PROD ENGR LAB						
32730	PROD ENGR LAB						
32820	MATERIAL STORAGE						
32830	MATERIAL STORAGE						
32860	STORAGE						
		3688		2666		3866	
33080	SAFETY EQUIP						
33100	CHANGE HOUSE						
33150	PRODUCTION						
33310	RAW MAT. WAREHOUSE						
33330	RAW MAT. WAREHOUSE						
33420	RAW MAT. WAREHOUSE						
33440	RAW MAT. WAREHOUSE						
33520	MIX BUILDING						
33530	FILL AND PRESS	2100	120	2100	120	2100	120
33531	PUBLIC TOILET						
33540	STORAGE						
33550	IN PROCESS STORAGE						

A.5.C3-27

ECO-C3

EXHIBIT G
COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

EQUIPMENT EFFECTIVNESS FACTOR %

PINE BLUFF ARSENAL, ARKANSAS
DEPARTMENT OF THE ARMY

COMPRESSED AIR

BUILDING NUMBER	BLDG USE	CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE
33570	LAP	0	0	0	0	0	0
33620	STARTER MIX BUILDING	10	120	10	120	10	120
33630	FILL AND PRESS	0	0	1800	120	1800	120
33631	OFFICE AND RESTROOMS						
33640	ASSEMBLY BUILDING						
33650	IN PROCESS STORAGE						
33670	M116 LAP	600	120	600	120	600	120
33720	KC103 PROP						
33730	QC TEST FAC						
33820	STARTER MIX SLUGS						
33830	COMPONENT STORAGE						
33860	STORAGE IGLOO						
		2710		4510		4510	
34110	WP FILLING	600	120	600	120	600	120
34120	AMMO QUAL FAC						
34130	WP UNLOAD TANKS						
34170	WP BULK STORAGE						
34350	ASSEMBLY AND PACKOUT						
34370							
34420							
34430	RAW MATERIAL WAREHOUSE						
34620							
34630	PYROTECHNIC PRODUCTION	120	130	120	130	120	130
34640	HC MIX	100	120	100	120	100	120
34650	START MIX SLEEVE						
34660	SUB ASSEMBLY						
34820	STORAGE						
34910	FE MAINTENANCE SHOP						
34970	ADMIN BUILDING						
		820		820		820	
42960	GRENADE TEST BUILDING						
44110	LAP	600	120	600	120	600	120

A.5.C3-28

ECO-C3

ECO-C3

PBA Compressor Operating Hours									6/17/96
		32060		33060		34140		Total	Total
		No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	Comp.	Comp.
Day	Date	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	% Hrs
Tuesday	1/16/96	20.00	0.00	24.00	0.00	0.00	10.00	54.00	38%
Wednesday	1/17/96	19.25	0.00	24.00	13.50	0.00	9.00	65.75	46%
Thursday	1/18/96	24.00	0.00	24.00	23.00	0.00	17.00	88.00	61%
Friday	1/19/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Saturday	1/20/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Sunday	1/21/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Monday	1/22/96	21.00	0.00	24.00	0.00	0.00	24.00	69.00	48%
Total Oper. Hours		156.25	0.00	168.00	36.50	0.00	132.00	492.75	
Total Available Hours		168	168	168	168	168	168	1008	
Percent Oper. Hours		93%	0%	100%	22%	0%	79%	49%	

ENERGY PROJECT SUMMARY SHEET

Installation and Location	Pine Bluff Arsenal, Pine Bluff, Arkansas
Project Title	Replace Filtered Water Pump Motors
Project Funding Category	Federal Energy Management Program (FEMP)
Total Investment	$9,000
Annual Cost Savings	$1,200
Savings-to-Invest. Ratio (SIR)	2.09
Simple Payback Period	7.2 Years

Contents

DD Form 1391, Front Sheet

Attachment 1 - Life Cycle Cost Analysis Summary

Attachment 2 - Description of Work to be Accomplished

Attachment 3 - Savings Calculations, Cost Estimate and Back-up Data

1. COMPONENT **ARMY**	**FY 19___ MILITARY CONSTRUCTION PROJECT DATA**	2. DATE September 6, 1996

3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas	4. PROJECT TITLE Replace Filtered Water Pump Motors - FEMP

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000) $9

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
Remove four 30 HP motors. Install four new 30 HP premium efficient motors. Replace overload thermal units. See attached detailed estimate.				
Subtotal Construction Cost				$6.8
Contingency (10%)				$0.7
Total Construction Cost				$7.5
Design Fee (6%)				$0.4
SIOH (6%)				$0.4
Total Cost				$8.3
Total Requested (rounded)				$9

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The scope of work for this project consists of replacing all four of the existing filtered water pump motors with new energy efficient motors. The pumps are located in building 42-210 and are driven by 30 horsepower, standard efficient, electric induction motors. The existing motors will be removed and new premium efficient motors installed and connected to the existing electric circuits. The overload thermal units will be checked and replaced if necessary.

FOR OFFICIAL USE ONLY

(WHEN DATA IS ENTERED)

ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 1

LIFE CYCLE COST ANALYSIS SUMMARY

LIFE CYCLE COST ANALYSIS SUMMARY — STUDY: ECO-E4
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) — LCCID FY95 (92)
INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3
PROJECT NO. & TITLE: ECO-E4 EFFICIENT MOTORS FOR FILTERED WTR PUMPS
FISCAL YEAR 1997 DISCRETE PORTION NAME: COMPLETE PROJECT
ANALYSIS DATE: 07-01-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT
A. CONSTRUCTION COST $ 7429.
B. SIOH $ 446.
C. DESIGN COST $ 446.
D. TOTAL COST (1A+1B+1C) $ 8321.
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
F. PUBLIC UTILITY COMPANY REBATE $ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F) $ 8321.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 16.79	69.	$ 1155.	15.08	$ 17420.
B. DIST	$ .00	0.	$ 0.	18.57	$ 0.
C. RESID	$ .00	0.	$ 0.	21.02	$ 0.
D. NAT G	$ 2.81	0.	$ 0.	18.58	$ 0.
E. COAL	$ .00	0.	$ 0.	16.83	$ 0.
F. PPG	$ .00	0.	$ 0.	17.38	$ 0.
M. DEMAND SAVINGS			$ 0.	14.88	$ 0.
N. TOTAL		69.	$ 1155.		$ 17420.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 14.88
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4) $ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 1155.

5. SIMPLE PAYBACK PERIOD (1G/4) 7.20 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 17420.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.09
(IF < 1 PROJECT DOES NOT QUALIFY)

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 2

DESCRIPTION OF WORK TO BE ACCOMPLISHED

ECO-E4

Replace the filtered water pump motors in Building 42-210 with energy efficient motors.

__Description__

There are four filtered water pumps that pump the stored ground water from the holding tank through filters and chlorinators and then to the high tanks for distribution to the Arsenal. The pumps are driven by 30 horsepower electric induction motors. This project consists of replacing all four of the existing filtered water pump motors with new energy efficient motors.

The four filtered water pump motors are located in Building 42-210. The pumps are operated on an alternating schedule that has two of them running during any given day. A typical schedule for nine days is to run pumps 1 and 2 one day, then 1 and 3 the next day, 1 and 4, 2 and 3, 2 and 4, 2 and 1, 3 and 4, 3 and 1, 3 and 2 and back to pumps 1 and 2 on the tenth day. The pump logs indicate these pumps operated for a total of about 9170 hours during calendar year 1995. The annual operating hours represent an average of approximately 2290 hours per year per motor.

The PBA DPW staff indicated they plan to replace the existing filtered water pumping system including the four pumps, motors and some of the piping. The new pumping system will utilize two larger pumps and motors.

The existing motors are old and have an estimated efficiency of 88 percent. New 30 horsepower premium efficiency motors have an efficiency of about 94 percent. Field measurements of motor kW indicate these motors are operating at approximately 90 percent of full load.

Due to the pending replacement of the filtered water pumping system, the payback for replacing the existing motors may be longer than the motors will be utilized. Therefore, this ECO is recommended only if the new pumping system will not be installed before the end of the 7.2 year payback period.

PROGRAMMING DOCUMENTATION - FEMP

ATTACHMENT 3

SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA

RS&H

SUBJECT PBA ELEC + HTG STUDY
EFF. FILTERED WTR PUMP MOTORS
DESIGNER W. TODD
CHECKER

AEP NO 694-1331-004
SHEET ___ OF ___
DATE 6-20-96
DATE

ECO-E4 ENERGY EFFICIENT MOTORS FOR FILTERED WATER PUMPS

There are 4 filtered water pump in Bldg. 42-210. They are used to pump treated water from the water plant up to the water towers. Two of the pumps are used at one time and they are all alternated into service on a daily schedule: day 1 - pumps 1+2, day 2 - pumps 1 and 3, day 3 - pumps 1 and 4, day 4 pumps 2 and 3, etc.

Actual operating hours were obtained from the water plant staff. See attached message from G. Burris, and calculation of annual operating hours.

The motor operating kw was measured and the average kw was used in the energy savings calculations. See attached Electric Motor Data Sheets.

$$\text{AVG kW} = (26.4 + 22.1 + 23.6 + 22.4)\text{kw} \div 4 = 23.6 \text{ kW}$$

The existing motors are very old; the efficiency was estimated based on a C/S Engineer article (see attached) to be ~ 88%

Energy savings for one motor was calculated by the attached spreadsheet.

Total Energy Savings = 17.2 × 4 = 68.8 MBtu/YR

CONSTRUCTION COST ESTIMATE

Project:	Energy Efficient Motors - Filtered Water Pumps	RS&H No.:	694-1331-004
Location:	Pine Bluff Arsenal, AR	Date:	6/21/96
Basis:	Schematic Design	Estimator:	W. Todd
ECO Number:	E4	Filename:	EST-E4.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR		TOTAL COST	SOURCE	
	No.	Unit	$/Unit	Total	$/Unit	Total		Material	Labor
Remove 30 HP Motors	0.86	Ton		0	395	340	340		MMp21
30 HP Premium Eff. Motor	4	Ea	997	3,988	97.5	390	4,378	GRp27	MEp199
Restricted Area Handling	4	Ea		0	390	1,560	1,560		MEp199
Overload Thermal Units	12	Ea	9	108	4.88	59	167	SDp23-18	Note (1)
Subtotal Bare Costs				4,096		2,349	6,445		
Retrofit Cost Factors			0%	0	0%	0	0	MMp6	MMp6
Subtotal				4,096		2,349	6,445		
City Cost Index			0.952	(197)	0.632	(864)	(1,061)	MMp533	MMp533
Subtotal				3,899		1,485	5,384		
OH & Profit Markups			10%	390	53%	787	1,177	MMp7	MMp475
Subtotal				4,289		2,272	6,561		
State Sales Taxes			4.5%	193		N.A.	193	MMp476	
Subtotal				4,482		2,272	6,754		
Contingency			10%	448	10%	227	675	MEp6	MEp6
Total Construction Cost				**4,930**		**2,499**	**$7,429**		
Design Fee				N.A.	6.0%	446	446		
SIOH				N.A.	6.0%	446	446		
Total Project Cost				**4,930**		**3,391**	**$8,321**		

LEGEND:

Note (1)	Assumes 10 minutes to install each thermal unit.
GRp###	Grainger General catalog Number 386, page ###.
MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
SDp###	Square-D Digest Number 170, page ###.

ECO CALCULATIONS
Energy Efficient Motors

Project:	Filtered Water Pumps - Bldg. 42-210	RSH No.:	6941331004
Location:	Pine Bluff Arsenal, AR	Date:	6/20/96
ECO No.:	E4	Designer:	W. Todd

Assumptions:	(1)	Motor nameplate horsepower =	30	(Name plate data)
	(2)	Efficiency of existing motor =	88%	(C/S Engineer Article)
	(3)	Exist. motor electric data:	440 V	(Name plate data)
			36 A	"
			3 ph	"
			0.84 pf	(Estimated)
	(4)	Measured/estimated kW =	23.6	(Avg. of measurements)
	(5)	Avg. annual operaing hours =	2293	(Operating logs)
	(6)	New motor premium efficiency =	94%	(Grainger No. 386)

Max kW of existing motor = $\frac{440 \text{ V} \times 36 \text{ A} \times 1.73 \times 0.84}{0.88 \times 1000}$ = 26.2 kW

Percent operating load = $\frac{23.6 \text{ kW}}{26.2 \text{ kW}}$ = 90.1%

Operating kW of new motor = $\frac{30 \text{ hp} \times 0.901 \times 0.7457 \text{ kW/bhp}}{0.94}$ = 21.4 kW

Electric Demand Savings = 23.6 kW - 21.4 kW = 2.2 kW

Electric Energy Savings = 2.2 kW x 2293 Hr/Yr = 5,045 kWh/Yr

Electric Energy Savings = 5,045 kWh/Yr x 0.003413 $\frac{\text{MBtu}}{\text{kWh}}$ = 17.2 MBtu/Yr

Pine Bluff Arsenal - Electrical Demand and Heating Study
Building 42-210, Filtered Water Pumps
Date: 6/20/96

ASSUMPTIONS:

1) Operating schedule obtained from PBA staff, see attached.
2) Two pumps operate and the other two are standby.

Mon-YR	Total Op. Hr/Da (1)	Available Hr/Da (2)	Diversity (1) / (2)	Number Days/Mo	Total Hrs/Mo (1) x Day/Mo
Jan-95	26.3	96	0.27	31	815
Feb-95	27.0	96	0.28	28	756
Mar-95	25.3	96	0.26	31	784
Apr-95	25.3	96	0.26	30	759
May-95	24.5	96	0.26	31	760
Jun-95	25.8	96	0.27	30	773
Jul-95	25.0	96	0.26	31	775
Aug-95	24.0	96	0.25	31	744
Sep-95	22.8	96	0.24	30	684
Oct-95	23.7	96	0.25	31	735
Nov-95	26.3	96	0.27	30	788
Dec-95	25.8	96	0.27	31	800

Total annual operating hours = 9172

Average annual operating hours per pump motor = 2293

MESSAGE DISPLAY FOR NANCY RIMMER

NANCY RIMMER
CC GREGORY BURRIS

From: GREGORY BURRIS Host: MVB
Postmark: Feb 05,96 12:47 PM Delivered: Feb 05,96 12:47 PM
Status: Certified Previously read
Subject: RAW WATER HOURS PER DAY FILTERED WATER HOURS PER.DAY

Message:

JAN.95	9.00 HRS.	26.30 HRS. PER TWO PUMPS
FEB.95	8.75	27.00
MAR.95	9.75	25.30
APR.95	9.40	25.30
MAY 95	9.50	24.50
JUN.95	9.60	25.75
JULY.95	9.75	25.00
AUG.95	9.75	24.00
SEPT.95	9.75	22.80
OCT.95	9.60	23.70
NOV.95	10.90	26.25
DEC.95	10.30	25.80

-------=======X======-------

A.5. E4-7

By DARRYL J. VAN SON
Baldor
Fort Smith, Ark.

Last year, the World Watch Institute in Washington, D.C., released a study called "Building on Success: The Age of Energy Efficiency." It gives an overview of the long-term implications of energy use and waste. The authors say an environmentally sound energy strategy is a prerequisite to a sustainable society and that a prerequisite to any viable strategy is more efficient energy use.

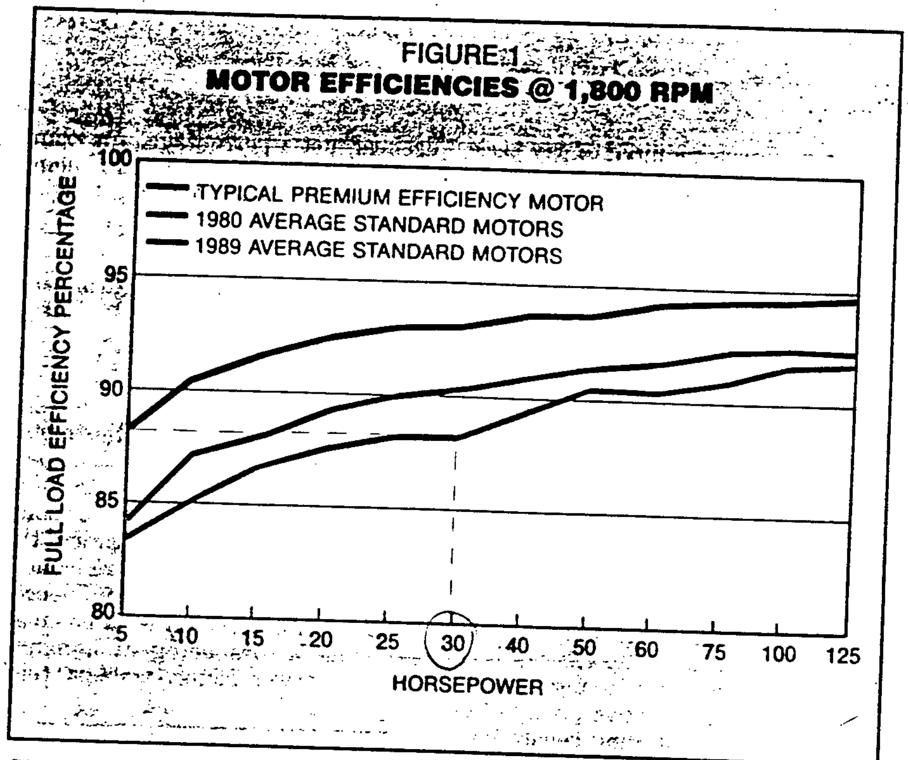
The good news in this report is how much we have accomplished collectively in the last 15 years. Since the Arab oil embargo of 1973, the world has saved far more energy through improved efficiency than it has gained from all new sources. The United States reduced energy intensity by more than 20%. From 1973 to 1987, our GNP went up 40% but total energy use grew by only 3%. This vast improvement has occurred largely without notice. The World Watch authors state, "We feel it is now possible in most industrialized countries to keep energy consumption level for the foreseeable future without sacrificing economic growth."

Part of the reason we did not notice these improvements was that there was no single sweeping technological breakthrough or new "wonder" source discovery. It was accomplished and will continue to be accomplished through a myriad of small incremental improvements in everything we design and build. The United States now spends 11.2% of its GNP on energy, but as much as 50% of this is wasted on inefficiencies of one form or another. There is much room for improvement in the future.

Between 50% and 60% of U.S. electricity is used to drive electric motors. Therefore, they are an obvious target for careful specifying. Of this electricity, more than 80% drives integral horsepower, polyphase motors. Although fractional horsepower motors represent the highest unit volume, they consume only 7% of the electricity used.

Motor efficiency

To look at reducing motor energy use, it is best to investigate two areas: the motor's efficiency and the operating system efficiency. In the last 10 years, virtually every motor manufacturer has introduced a line of premium-efficiency motors. This technology also filtered down to standard motors. In other words, the



Since the late 1970s, average efficiencies for standard motors have improved significantly.

motor industry has continued to improve products across the board (see Figure 1).

The U.S. Department of Energy studied motor efficiency and published the "Classification and Evaluation of Electric Motors and Pumps" in February 1980. Comparing "Average Standard Motors" of the late

Between 50% and 60% of U.S. electricity is used to drive electric motors

1970s to today's nonpremium motors shows that even "normal" motors have reduced wasted energy by more than 11% on average. For example, a 75-hp, four-pole motor in 1979 had a typical efficiency of 90.8%. In 1989, that same motor typically has a 92.1% efficiency. That same rating in a premium motor will, on average, be 94.3% efficient.

Many manufacturers offer products with labels such as high efficiency, premium efficiency, super efficient and extra efficient. However, of greater importance is the actual efficiency on the nameplate. Domestic manufacturers have now standardized on IEEE 112B test methods, so direct comparison of nameplates is practical. Most motor manufacturers have some form of computerized savings and payback analysis. However, a quick approximation of annual savings can be calculated with this formula:

Annual Savings = Efficiency difference × kw × \$/kwh × hrs/yr × 1.15

Where:

Efficiency difference = Motor A − Motor B (decimal, not percent)
kw = hp × .746
\$/kwh = local power rate
hrs/yr = hours/day × days/year

Example: 75 hp, 94.3% efficiency vs. 90.8% efficiency, continuous duty at 6 cents per kwh: 0.035 × 55.95 × 0.06 × 8736 × 1.15 = \$1,180 annual savings.

This boils down to greater savings. The more the motor is used, the higher the energy cost, the higher the horsepower or the greater the efficiency improvement.

As a rule-of-thumb, premium-efficiency motors are the best choice if power rates are more than 6 cents per kilowatt-hour and the motor is used two shifts per day or more.

The next logical step is payback analysis. This is a simple calculation of annual savings divided by the premium price differential greater than a standard motor. This yields the

A.5.E4-8

ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31 & 3/27/96; Survey By: CSW / WTT

Equipment ID/Function: Filtered Watered Pump No. 1

Location: Building 42-210

Nameplate Data:

Manufacturer: Sterling Motor

Model No.: TYPE KF; Serial No.: 145090

Insulation Class: ____; NEMA Design: ____; Code: ____; Efficiency: ____

Horsepower 30; Frame 405; RPM 1800; Service Factor ____

Volts 220/440; Amps 72/36; Phases 3; Hz 60; PF ____; kW ____

Type: Synchronous ____; Induction ✓; Other 40°C Rating

For Synchronous Motors: DC Excitation Volts ____; Amps ____

Electrical Measurements:

Measurements	Phase	Phase	Phase	~~Phase~~ TOTAL	Phase	Phase
Volts(rms)	281.7	277.3	283.2			
Amps(rms)	36.37	34.05	35.5			
kW	9.217	8.399	8.781	26.4		
kVAR	LA 4.501	LA 4.247	LA 4.926			
kVA	10.25	9.413	10.07			
Power Factor	0.89	0.89	0.87			
dPF	"	"	"			
kdVA	174.7	137.6	158.9			

General Condition/Comments: ____

ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW

Equipment ID/Function: Filtered Water Pump No. 2

Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: ______

Model No.: ______; Serial No.: ______

Insulation Class: ____; NEMA Design: ____; Code: ____; Efficiency: ____

Horsepower 30; Frame ______; RPM ____; Service Factor ____

Volts ______; Amps ______; Phases ___; Hz ____; PF ____; kW ____

Type: Synchronous ____; Induction ____; Other ______

For Synchronous Motors: DC Excitation Volts ____; Amps ____

Electrical Measurements:

Measurements	Phase	Phase	Phase	~~Phase~~ TOTAL	Phase	Phase
Volts(rms)	282.0	278.0	284.9			
Amps(rms)	31.37	29.54	30.55			
kW	7.673	7.109	7.343	22.1		
kVAR	4.415 LAG	4.091 LAG	4.092 LAG			
kVA	8.854	8.204	8.716			
Power Factor	0.86	0.86	0.84			
dPF	"	"	"			
kdVA	152.2	138.7	146.9			

General Condition/Comments: ______

ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW

Equipment ID/Function: Filtered Water Pump No. 2

Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: ____________________

Model No.: ____________________; Serial No.: ____________________

Insulation Class: ____; NEMA Design: ____; Code: ____; Efficiency: ____

Horsepower 30; Frame ________; RPM ____; Service Factor ____

Volts 220/440; Amps ______; Phases 3; Hz ____; PF ____; kW ____

Type: Synchronous ____; Induction ____; Other ____________

For Synchronous Motors: DC Excitation Volts ____; Amps ____

Electrical Measurements:

Measurements	Phase	Phase	Phase	~~Phase~~ TOTAL	Phase	Phase
Volts(rms)	282.2	278.4	284.7			
Amps(rms)	34.22	31.29	32.83			
kW	8.350	7.495	7.715	23.6		
kVAR	4.874 LAG	4.452 LAG	5.323 LAG			
kVA	9.670	8.719	9.375			
Power Factor	0.86	0.85	0.82			
dPF	"	"	"			
kdVA	183.3	154.8	136.1			

General Condition/Comments: Pump Data: 700 GPM, 130 ft HD Gardner-Denver, Cent. Pump, Quincy, Ill. Size 5, TYPE F, SN 261495, 1750 RPM

A.5.E4-11

ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW

Equipment ID/Function: Filtered Water Pump No. 4

Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: ____

Model No.: ____; Serial No.: ____

Insulation Class: ____; NEMA Design: ____; Code: ____; Efficiency: ____

Horsepower ____; Frame ____; RPM ____; Service Factor ____

Volts ____; Amps ____; Phases ___; Hz ____; PF ____; kW ____

Type: Synchronous ____; Induction ____; Other ____

For Synchronous Motors: DC Excitation Volts ____; Amps ____

Electrical Measurements:

Measurements	Phase	Phase	Phase	~~Phase~~ TOTAL	Phase	Phase
Volts(rms)	281.9	277.4	283.1			
Amps(rms)	32.73	29.67	31.06			
kW	8.015	7.110	7.301	22.4		
kVAR	4.577 LAG	4.192 LAG	4.898 LAG			
kVA	9.232	8.255	8.793			
Power Factor	0.86	0.86	0.83			
dPF	"	"	"			
kdVA	187.5	142.4	153.4			

General Condition/Comments: ____