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BURNS AND ROE ENTERPRISES, INC.

Audit Report
ZAPOROZHYE COKE AND CHEMICAL FACTORY
ZAPOROZHYE, UKRAINE

FINAL

August 1997

Prepared by:	**Resource Management Associates of Madison, Inc.**
Under Subcontract to:	**Burns and Roe Enterprises, Inc.**
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A

RESOURCE MANAGEMENT ASSOCIATES
of Madison, Inc

RMA/UKR-DO6-R-05

Delivery Order # 6 - Ukraine: Energy Efficiency and Reliability
Task #3 - Industrial Energy Efficiency
Subtask #6 - Energy Audits

ZAPOROZHYE COKE AND CHEMICAL PLANT
Zaporozhye, Ukraine

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Preface

The work described in this report is being carried out by Resource Management Associates of Madison, Inc (RMA), within the framework of the US Agency for International Development (USAID) Emergency Energy Program for the Newly Independent States (NIS), under contract with Burns and Roe Company, NIS Energy Efficiency and Market Reform Project, Contract Number CCN-0002-Q-00-3154-00

This is a working document published informally by RMA This report has been prepared, in the interest of timeliness, to present the results of the project in a working document format with light review

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1.0 EXECUTIVE SUMMARY

As part of Delivery Order #6 of the NIS Energy Efficiency and Market Reform Project, the United States Agency for International Development (USAID) sponsored a total of five industrial energy audits at large energy consuming industries in Ukraine Two of the audits were completed by Resource Management Associates (RMA) of Madison, Wisconsin (USA), the other three audits were conducted by Burns & Roe Enterprises and Foster-Wheeler This report details the findings of the RMA's energy audit performed at the Zaporozhye Coke and Chemical Plant located in Zaporozhye, Ukraine

The five industrial audit sites were selected under previous activities within this Delivery Order This selection process included working with Ukrainian agencies and the Ukrainian IDEA Staff to identify the largest and most intensive electrical energy consuming sectors Plants typical of each sector were suggested for audits Site visits to each plant were coordinated by the IDEA staff, team leaders from RMA and Foster Wheeler reviewed these facilities in order to select the five most appropriate sites Each facility was evaluated using a numerical ranking form, and the five plants scoring the highest were selected The chosen sites were then notified that they had been selected to participate in the energy audits and demonstration activity In addition to the Zaporozhye Coke and Chemical Plant, the following four plants were selected Kiev Artistic Glass Plant in Kiev (also audited by RMA), Strojindustrial Building Materials in Kiev; Komunar Car Plant in Zaporozhye, and Donetsk Metallurgical Plant in Donetsk Following notification, audit schedules were coordinated, and the audits conducted

The energy audit objectives were to

- promote the importance of energy conservation to successful plant operation,
- identify short payback energy conservation projects utilizing US-manufactured equipment,
- identify large energy conservation opportunities requiring further investigation, and
- transfer hands-on energy auditing experience to plant staff and a local engineer

This audit report includes specification of energy conservation equipment. USAID-approved equipment will be procured by Burns & Roe Enterprises staff, and shipped to the facility for installation Once the equipment is installed, it will be monitored to determine the energy savings realized Finally, a workshop will be conducted in Ukraine to promote the results of the audits, the energy efficiency equipment recommended, and the demonstration conservation projects

The Zaporozhye Coke and Chemical Plant produces blast furnace coke from coal Zaporozhye Coke Plant supplies coke exclusively to the adjacent steel making facility, Zaporozhstal Numerous chemical products, which are derived from the by-products of coke making, are also sold by the Plant throughout Ukraine and Russia

The Zaporozhye Plant 1994 energy consumption, based on energy content, was broken down as follows

Coke Gas[1]	53%
Purchased Steam and Hot Water	29%
Purchased Electricity	11%
Purchased Blast Furnace Gas	7%
Total	100 %

Note: Coal is considered a raw material for their process, not a fuel.

Six energy conservation opportunities (ECOs) which met the audit objectives were recommended. These ECOs are as follows:

ECO #1 - Combustion Air Control on the Ovens of Coke Battery #1
ECO #2 - Coke Battery Oven Temperature Monitoring Accuracy
ECO #3 - Combustion Air Control for Enriched Straw Oil Stove
ECO #4 -Variable Speed Drive for Pump #14
ECO #5 - Level Control for the Coke Tar Settling Tank
ECO #6 - Energy Management Program Enhancement

The energy conservation opportunities identified above were discussed with plant management and technical staff. They understood the energy conservation opportunities presented by the auditors and were open to implementing them. The audit team recommends that the plant be contacted with specific equipment to be installed prior to purchase. This will ensure that the plant is prepared to implement specific equipment purchases.

The conservation opportunities identified have a cumulative first-year energy cost savings of $528,417 at local energy prices and $1,361,918 at world energy values. This represents a 4% reduction in consumption compared to consumption during 1994. These savings can be accomplished with a total investment of $101,000. Financial payback of this investment is slightly more than two months using current local energy costs, and one month at world energy values. Methods to quantify energy savings from the above recommendations are found in Section 8 of this report.

[1] any coke gas not used is sold to the neighboring steel plant

Table 1.1 Summary of Energy Conservation Opportunities (ECOs)

				Annual $ Cost Saving			Simple Payback	
ECO #	DESCRIPTION	ANNUAL FUEL SAVED	ANNUAL ENERGY SAVED	World Energy Prices	Local Energy Prices	Project Cost (US $)	World Energy Prices	Local Energy Prices
1	Combustion air control on the ovens of coke battery #1	20,638,156 m^3 of coke gas	81,190 Gcal (322,164 MMBtu)	$644,324	$256,037	$7,000	4 days	10 days
2	Coke Ovens #1&2 Temperature Meter Accuracy	2,628,000 m^3 of coke gas and 876,000 m^3 of blast oven gas	11,017 Gcal (43,717 MMBtu)	$87,434	$35,988	$4,000	17 days	41 days
3	Straw Oil Stove Excess Air Control	3,866,667 m^3 of coke gas	15,211 Gcal / yr. 60,359 MMBtu	$120,718	$47,970	$7,000	21 days	53 days
4	Purified Water Pump #14 Variable Speed Drive	665,000 kWh	665,000 kWh	$25,850	$9,300	$25,000	1 year	2 7 years
5	Tar Settling Tank Level Indication	780 Gcal of thermal energy	780 Gcal (3095 MMBtu)	$4,333	$2,233	$3,500	0 8 year	1 6 year
6	Energy Management Program Equipment	961,070 kWh of electricity, 6,201,940 m^3 of coke gas, 1,947,200 m^3 of blast furnace gas 7,072 Gcal of steam and water	961,070 kWh 32,980 Gcal (130,863 MMBtu)	$479,259	$176,889	$55,000	1 4 month	3 7 months
	TOTALS	1,626,070 kWh of electricity, 33,334,763 m^3 of coke gas, 1,947,200 m^3 of blast furnace gas 7,852 Gcal total thermal energy	1,626,070 kWh 141,178 Gcal (560,198 MMBtu)	1,361,918	528,417	101,000		

2.0 INTRODUCTION

Fifteen newly independent states (NIS) emerged from the Former Soviet Union (FSU) breakup in 1991 The United States Agency for International Development (USAID) is addressing and managing economic assistance to these countries Initial assistance has indicated that there are considerable opportunities to reduce energy consumption and environmental degradation

Presently, industries are unable to compete in the world market place due to many factors, including energy inefficient plants To modernize these plants, they need to have the hard, stable currency that exports would bring in Energy efficiency improvements are believed to be part of the cure to this cyclical problem

This report details the findings and analysis of the RMA audit team at the Zaporozhye Coke and Chemical Plant The plant is located in Zaporozhye, Ukraine Included is a list of the low cost, short payback energy conservation opportunities which were identified Equipment specifications for the recommended equipment, as well as long range energy conservation opportunities requiring further investigation are also included in this report

During February 1995, an energy audit was performed at the Zaporozhye Coke Chemical PLANT. The audit team consisted of RMA engineers Yevgeny Guterman and Doug Presny, local engineer Vladimir Kursa of Dnieprenergo (Zaporozhye's electrical utility company), and numerous Zaporozhye Plant staff

An initial meeting was held with the Chief Engineer Valery N Rubchevsky, Chief Energy Manager Yevgeny P Ivashutkin, the auditors, representatives of USAID, and IDEA-PADCO[2] to discuss objectives of the audit This meeting was followed by a plant tour

The plant energy management staff were initially not convinced of the necessity to conserve energy. Although the plant employs one person specifically assigned to energy conservation, the position has focused more on determining better methods of ensuring an adequate supply of energy resources, rather than reducing consumption

Given the large plant size, the audit focused on the areas of largest energy consumption The plant is divided into "shops", each of which is a division within the plant Based on the amount and type of energy consumption, a schedule of shop audits was determined This schedule was found to be very beneficial in conducting the audit Each shop received an advance copy of the audit schedule and objectives This allowed the plant personnel to be prepared and to participate in the audit

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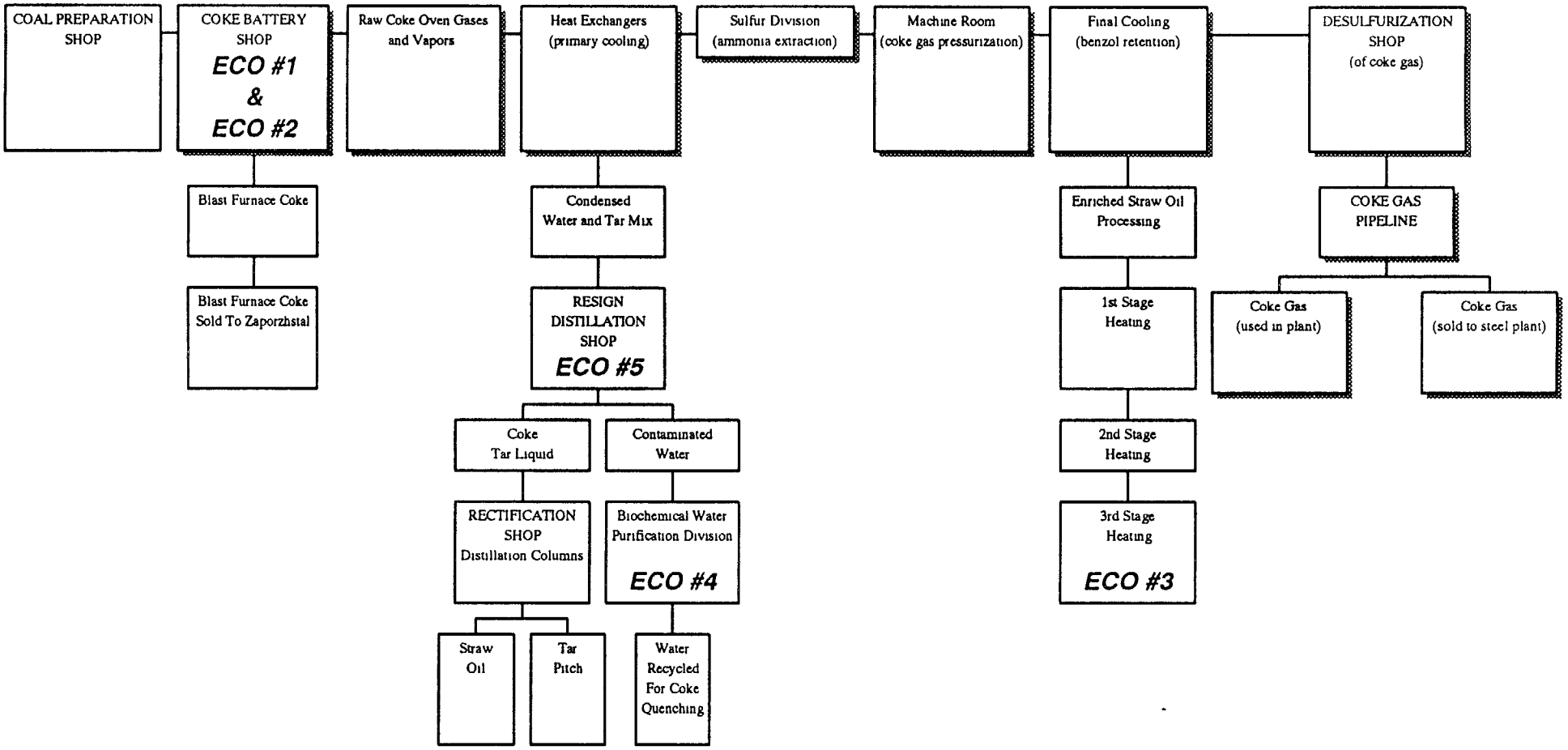
[2] IDEA-PADCO staff provide support services to USAID-Ukraine

Following a very aggressive schedule, the auditors were able to work with four of the five major shops in the plant (The only major shop not included in the audit was the Coal Preparation Shop) The audit covered the following plant shops (see Figure #1 for a plant process flow diagram) Resin Distillation, Chemical By-Product Retention, Coke Battery, and Hydrogen Sulfide Removal Shop In addition, the auditors also covered an auxiliary support energy shop

Upon completion of the plant audit, initial recommendations were discussed with the plant management, including each of the shop chief managers Agreement was reached regarding the potential energy savings of each ECO The Chief Engineer indicated agreement to host the USAID funded demonstration of the technologies Upon USAID approval to fund the equipment to be installed, a written proposal should be made to the plant This will verify their agreement to install and monitor specific equipment purchased

Figure 2.1 Plant Process Flow Diagram



ECO #6 Applies to all process areas

3.0 FACILITY BACKGROUND

3.1 Description of Facility

The Zaporozhye Plant is located in the city of Zaporozhye, Ukraine It employs 2,100 production staff and 900 administrative and support services employees The plant produces coke and commercially sold chemical products derived from the byproducts of coke making

Coke batteries #1 and #2 consist of 65 coke ovens grouped together The coke batteries are the core plant process area These groups of ovens heat coal over a period of 14 to 25 hours to produce coke All of the coke produced at the Zaporozhye Plant is blast furnace coke[3] It is sold exclusively to the neighboring steel plant "Zaporozhstal" Blast furnace coke has two functions in the steel making process The first is to supply carbon monoxide for chemically changing the iron ore, and the second is to supply heat to melt the iron

Chemical by-products produced while making coke include, coke gas (a heating fuel with 50% of the heating content of natural gas), tar for roads, pitch for electrodes, fuel for automobiles, and light oils which contain chemicals used in industry There is a good market for all of these by-products, and they are sold throughout Ukraine and Russia Thirty-five percent of the raw material costs can be recovered by selling the by-products of the coking process[4], the coke plant revealed that 20% of their total revenue comes from sale of by-products

The Zaporozhye Plant began production on April 15, 1934 with one coke battery By 1939, four coke batteries were in operation with a total capacity of 1 3 millions metric tons of coke per year The plant was totally destroyed during the second World War. Plant reconstruction started in October, 1943 Limited production began in November 1947, and full restoration was completed by the end of 1951 A plant expansion was started in 1953 and completed in 1957

During the period between 1978 to 1988, the entire facility was upgraded with the objective of improving emissions and product quality This stage of upgrade included the addition of two coke batteries (#1 and #2) each with capacity of 925,000 metric tons per year and upgrade of two existing coke batteries (#5 and #6) each with capacity of 440,000 metric tons per year During this plant upgrade, the capability to process coke making by-products was installed

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[3] Other types of coke include, foundry coke, domestic coke, water-gas coke, pitch coke, and petroleum coke

[4] Marks' Standard Handbook for Mechanical Engineers, Ninth Edition, Eugene A. Avallone, Theodore Baumeister III, McGraw-Hill Book Company - New York, page 7-10

The plant has 5 main divisions known as "shops" which include

Coal Preparation Shop
This area provides facilities for coal receiving, storage, cleaning, and loading batteries

In the future this shop will include a facility (presently under construction) for brick manufacturing The site, with a design capacity of 30 millions bricks per year, will utilize waste aggregate from the coal cleaning process to produce the bricks Given the large demand for residential housing construction materials in Ukraine, there is great potential for this new facility

Coke Battery Shop
The coke battery shop produces blast furnace coke from coal. It has a total of six coke batteries, of which four are currently in operation The four batteries operating consist of two large batteries built in 1980 and 1982 with capacities of 925,000 metric tons per year each, and two smaller batteries built in the 1950s with capacities of 440,000 metric tons per year each Present operation is approximately one half of the design capacity due to physical problems with coal supply Regardless of problems with coal supply, batteries must remain continuously heated because of great stress created during cooling In order to maintain continuous production (and therefore continuous battery heat) with limited coal supplies, the batteries operate at lower temperatures for longer periods of time A normal coking cycle may last 16 hours, whereas present coking cycles may last as long as 35 hours.

Chemical By-Product Retention Shop
As coal is heated, it begins to decompose, giving off vapors and gas The function of the Chemical By-Product Retention Shop is to condense out and separate chemicals and fuels from this gaseous mixture This is done by cooling the gas in several stages, collecting the condensed liquids, and refining them through distillation or addition of stripping chemicals

Hydrogen Sulfide Removal Shop
The function of this shop is to remove remaining acidic gases remaining in the coke gas after it leaves the Chemical By-Product Retention Shop This is accomplished by application of chemicals which combine with the gases to form sulfur.

Resign Distillation Shop
This area processes the condensed coke-tar and water mixture into chemical products that can be sold or recycled Purified water, which is recycled through the system, provides cooling for hot coke gas

In addition to the five main shops, eight auxiliary support shops exist including general repair, energy, railway transportation, and automobile transportation

3.1.1 *Management Structure*

The Plant is beginning to privatize. As of January 1, 1995, the Zaporozhye Plant restructured to form a joint stock company. Currently the state remains the dominant shareholder and the plant enterprise owns 12% of the shares. The facility is run by a general manager of the joint stock company. Issues related to plant technical performance are under authority of the Vice President / Chief Engineer. See Appendix I for a list of contacts made at the Plant.

Energy supply and conservation is the responsibility of the Power Management Department. Within this department, one person has been dedicated to energy conservation. Any energy conservation opportunities and necessary funding require the approval of the Chief Engineer. At the time of the audit, there were no financial payback criteria set up for implementation of conservation opportunities. Discussions on this topic revealed that measures paying themselves back within one year would be considered. Due to the absence of financial criteria, plant investment decisions are based on their effect to production only.

3.1.2 *Hours of Operation*

All process areas audited were in continuous operation. Due to damage which would result if cooled, coke batteries are only shut down for rebuilding, once every 25 years. This makes small improvements in energy efficiency very beneficial.

Auxiliary equipment is designed with redundancy to insure continuous operation. This provides a good opportunity for equipment upgrade without interfering with process requirements.

3.1.3 *Viability of Facility*

The plant is currently purchasing its coal from Russia, Poland, and Ukraine. Although transportation costs associated with using local coal are low, Ukrainian mining is quite costly. This has resulted in local coking coal prices being higher than the cost of importing foreign coal. Russian coal was reported to be the least expensive, although the current price was not provided. Imported Polish coal was reported to be higher at a cost of $45 to $50 per metric ton delivered. Current Ukrainian coking coal was reported to cost $60 to $70 per metric ton (world price is $58 per metric ton).

There is a partial explanation of the high cost of Ukrainian coking coal. Coal production has been a major industry in the eastern region of Ukraine for many years. There are large coal fields in this region, but the coal quality has gradually decreased. This causes the mines to go deeper into the earth. Many of these mines are presently around 1,000 meters below the earth's surface. The demand for coal has dropped up to 40 % from previous levels. This is due to a deterioration of the country's economy. With less industry, less coal is needed This skyrocketed the energy intensity of coal extraction, and in combination with increased depth of excavation, made expenses very high.

Facility management has stated that there is a very good market on all finished products They also maintain that the plant makes a reasonable profit This profit could provide a source of funding for energy conservation projects, in addition to plant production improvements

Of total plant income, 8% comes from export sale of chemical by-products These chemicals are sold primarily to Russia Taxes on exported goods are assumed to hinder additional export sales Revenue from sale of coke and coke gas to the neighboring steel plant provides approximately 80% of the Zaporozhye Plant's income Demand for additional production currently exists The limiting factor is the physical availability of coal As Ukraine's infrastructure for coal delivery increases, it is anticipated that production of the plant will also increase

A facility for manufacturing ceramic bricks from the waste of coal separation is currently under construction This product will have good market, especially for the growing Ukrainian sectors of residential and commercial construction

Present plant capacity utilized is 51 3 % (coke production in the year 1994 was 1.4 million metric tons versus 2 73 metric ton per year design capacity) Facility management indicated an expected 30% increase of output during 1995 as compared with 1994 The increase is based on larger volumes of available coal expected

3.1.4 *Impact of Changing Energy Prices on Business Viability*

Energy cost accounts for about 20% of the Plant's production expenses During 1994, the cost of energy (converted in $ US) grew on average about 30% The exception to this was electricity which increased by 137% (see *Table 3 1*)

Presently the costs of production are passed on to the end users It is assumed that future viability of each plant will depend on its cost competitiveness in relation to other domestic suppliers, as well as to world markets To become competitive, plants will not be able to automatically pass on production costs, but rather they will need to minimize costs As energy costs increase to world levels, the existing share of energy cost in production will also increase This will make energy conservation a very crucial factor in business viability

Table 3.1 Energy Price Changes During 1994

FUEL	UNIT	January 1994	December 1994	PERCENT INCREASE
Coke Gas	karb/000 cub m $US/Million Btu	304,000 $ 0.779	1,650,000[5] $ 1.031	33 3 %
Blast Furnace Gas	karb/000 cub m $US/Million Btu	75,640 $ 0.98	514,000 $ 1.257	28 3 %
Electricity	karb/kWh $US/kWh	190 $ 0 0076	2400 $ 0.018	136 8 %
Thermal Energy	karb/Gcal $US/Million Btu	212,500 $ 2.14	1,412,000 $ 2 79	30 2 %

3.2 Energy Conservation History

The history of energy conservation at the Zaporozhye Plant is very short. Until recently, energy management meant only acquiring sufficient energy supplies to support production. The management is now beginning to understand the future importance of controlling energy costs. This is demonstrated by the recent dedication of one person in the Energy Management Department[6] to implementing energy conservation.

Following decline in production, due to reduced availability of coal, the plant has reduced the amount of auxiliary equipment operating in order to reduce energy consumption. Determining which equipment to shut down has historically has been based on the amount of equipment is necessary to keep the process operating, rather than equipment efficiency. If the plant had access to electrical and combustion metering, it could choose the most efficient equipment combinations which met production needs.

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5 The rate of local currency (Ukrainian karbovanets) exchange to $ US increased in that time from 25,000 to 133,000

6 Mr. Genady I. Miroshnichenko is assigned to energy conservation implementation..

Heat recovery was being installed in the stack of a straw oil heating stove while the audit team was on site The stove's hot stack gases will be used to increase the temperature of purchased steam The steam is currently difficult to use without additional reheating This heat recovery will supply supplemental steam heating without energy cost This will be a large energy savings for the plant

Building maintenance related to energy savings is typically performed Broken windows and doors are replaced Steam leaks in valves are common, but the lines themselves are quite new and in good shape In the 1980s, a major plant upgrade replaced underground piping with aboveground insulated distribution lines Plant staff reported that underground piping had been extremely difficult to maintain Although the plant does a good job of steam distribution, there is still potential to eliminate steam distribution loss

Absence of general auditing equipment at this plant hampers routine efficiency tests There are companies in Ukraine which have performed such services in the past (State Coke and Chemical Station), but this service is slow to respond, expensive, and considered unreliable

Available capital is prioritized as follows

1) Necessary repairs and wages to keep the plant operating

2) Expanding production (construction ceramic brick shop as example)

3) Improvements in production efficiency The concept of reducing costs to make more profit per unit, or to be competitive is not currently in practice When costs of production cannot easily be passed on to the steel plant, energy conservation will become a very import means of reducing production costs The coke plant is aware of what it may need to do some day, but currently there is not a large incentive to save production costs or energy

3.3 Facility Energy Use

3.3.1 *Consumption*

Six types of energy are consumed at the Zaporozhye Plant (see *Table 3.2*) electricity, coke gas; blast furnace gas, superheated steam intermediate pressure, superheated steam low pressure, and hot water

Figure 3.1 shows 1994 Plant energy consumption by heat value The breakdown was as follows

53% coke gas
29% steam and hot water
12% electricity
6% blast furnace gas

Energy consumption does not always relate to energy cost For example, steam and hot water supplied 29% of the Plant's total energy value, while they accounted for 49% of energy expenditures The cost of internal coke gas consumption equaled one third of the energy budget, whereas it supplied 53% of plant energy used The Plant should look at the future opportunities of switching energy sources to minimize their energy expenditures (see Long-Term Recommendations in Section 5)

Coal is purchased by the Plant, but not included as a energy source because it is not consumed as a fuel The coal is heated to produce coke, during which coke gas is produced Coke gas is used as a fuel with about one half the Btu content of natural gas The steel plant and the coke plant work in a partnership The coke plant provides coke and coke gas to the steel plant In return, the steel plant provides blast furnace gas, steam, and hot water to the coke plant The Zaporozhcoke sells a greater value of resources to the steel facility, and receives payment for the difference

Steam supplied by the steel plant did not appear to meet contracted parameters at the coke plants end use points The coke plant puts blame on distribution losses, but was interested if the audit team could verify temperature and pressure at their plant boundary The Zaporozhcoke Plant pays for thermal energy based on volume delivered and heat content contract specifications Because the steam lines appeared to be in good condition, future investigations may lead to reduced steam costs

The coke plant purchases electricity from the local utility grid Capacity of electricity supplied is limited by a maximum contracted demand The coke plant indicated that they would have use for much more capacity than what is presently allocated, but they were not able to identify how they currently got along without this additional necessary capacity

The Zaporozhye plant never shuts down, but its energy consumption does vary Process fuel consumed is based on amount of coal available to be processed This may change when the plant adjusts coking times to match coal supply Plant auxiliary equipment will reduce consumption when production is down, but reduction is not expected to be proportional especially without efficiency metering In addition to process variations, space heating steam is needed during seven winter months

Figure 3-1 Zaporozhcoke Plant 1994 Gcal of Energy Consumption

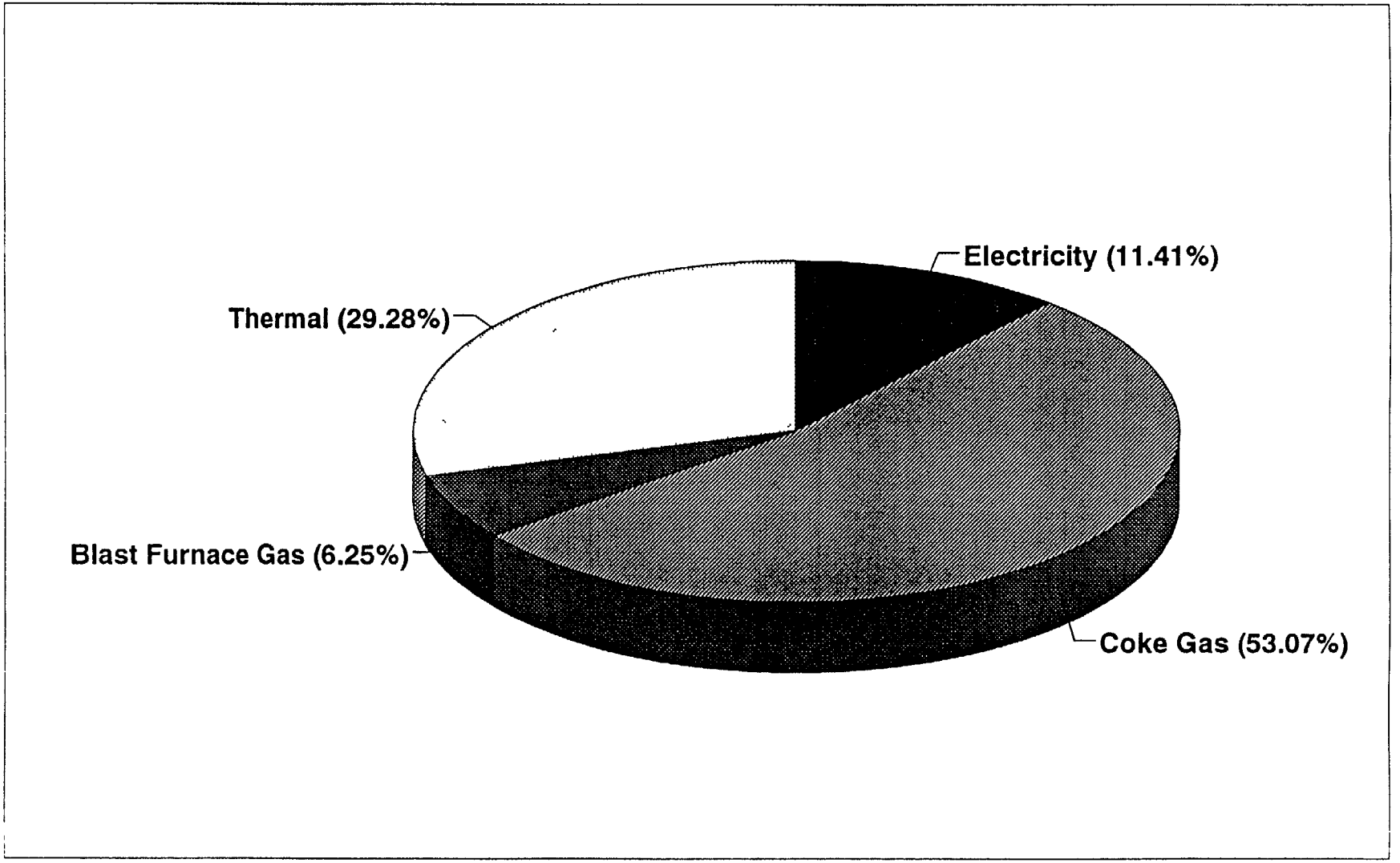

Table 3.2 Forms of Energy Consumed at Zaporozhye Facility

ENERGY TYPE	UNIT	CONSUMPTION REPORTED AT TIME OF AUDIT	SOURCE
Electricity	kWh	96,107,000 /yr	Dnieprenergo Utility Company Grid
Coke gas	m^3	325,891,000 /yr	By-Product of Coke Making
Blast furnace gas	m^3	194,720,000 /yr	Zaporozhstal Steel Plant
Superheated steam intermediate pressure[7] 12 kg/cm^2, 350°C	kg	24,000 /hr	Zaporozhstal Steel Plant
Superheated steam low pressure steam[8] 7 kg/cm^2, 250°C	kg	85,000 /hr	Zaporozhstal Steel Plant
Hot Water (100°C assumed)	kg	300,000 /hr	Zaporozhstal Steel Plant

3.3.2 *Fuel Costs*

Ukrainian energy costs continue to increase toward world values Presently they remain at approximately one third of the world prices[9] It is believed that Ukrainian prices for energy will meet world levels in the next several years, although the plant could not confirm this forecast

Cost increases of energy slightly led the pace of Ukraine inflation Electricity costs were the exception with an increase of 50% during 1994 (see *Figure 3. 2*) Local prices for thermal energy significantly increased as winter progressed (see *Figure 3.3*) The cost for thermal energy during January and February of 1994 were low, which eliminates notions of increased costs during higher demand periods

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[7] actual delivery pressure is 5 to 8 kg/cm^2 and 190 °C

[8] actual delivery is at 3 to 3 5 kg/cm^2 and 180 °C

[9] see Appendix C for world energy prices

Coke battery ovens consume both coke gas and blast furnace gas Once again, as the winter season progressed, the costs of both these fuels increased (see *Figure 3 4*) Information was not available on how the costs are established between the two companies It is known that a formal contract exists regarding the exchange of energy sources

Figure 3.2 Zaporozhye 1994 Electricity Prices

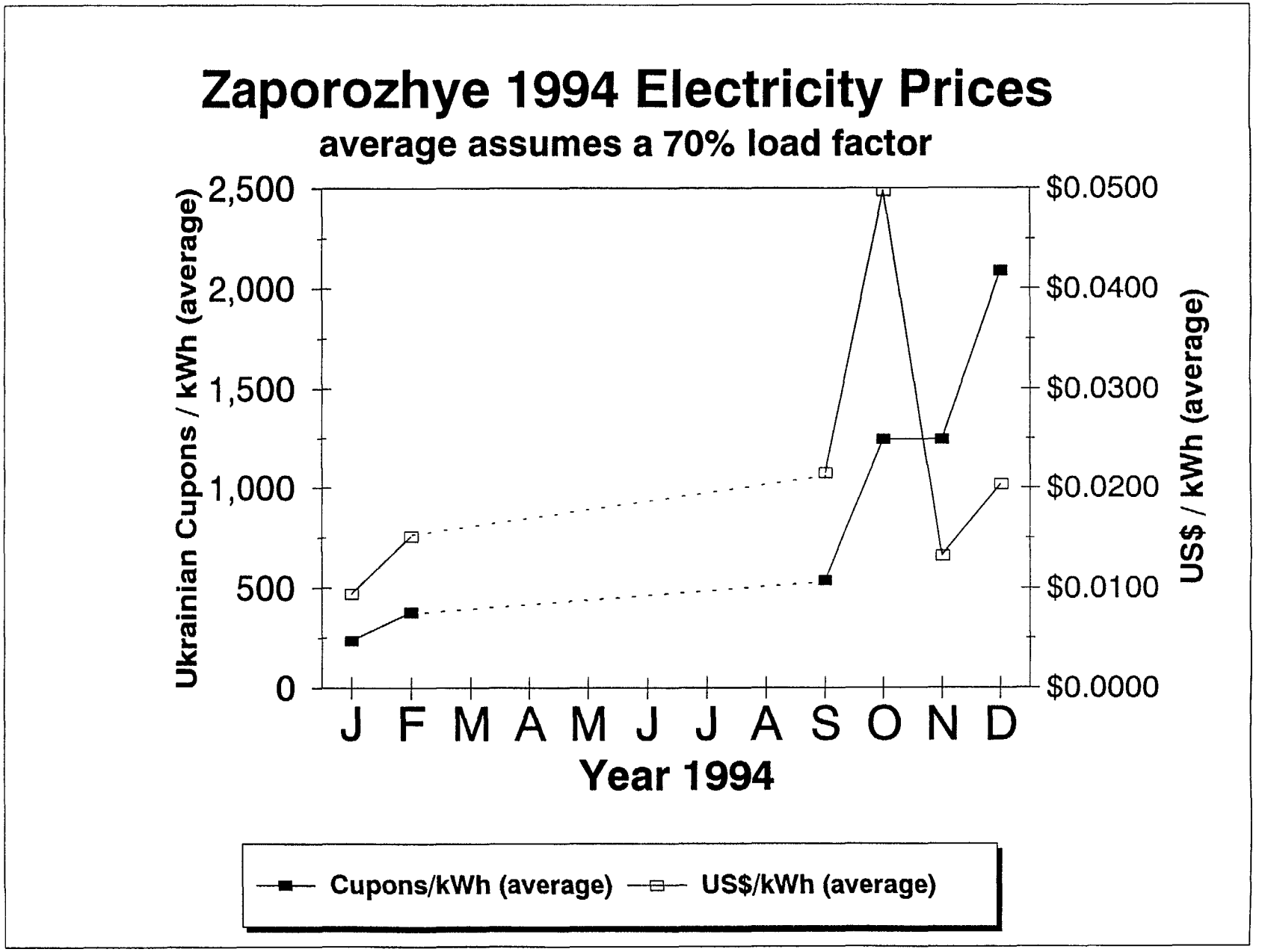


Figure 3.3 Zaporozhye 1994 Thermal Energy Prices

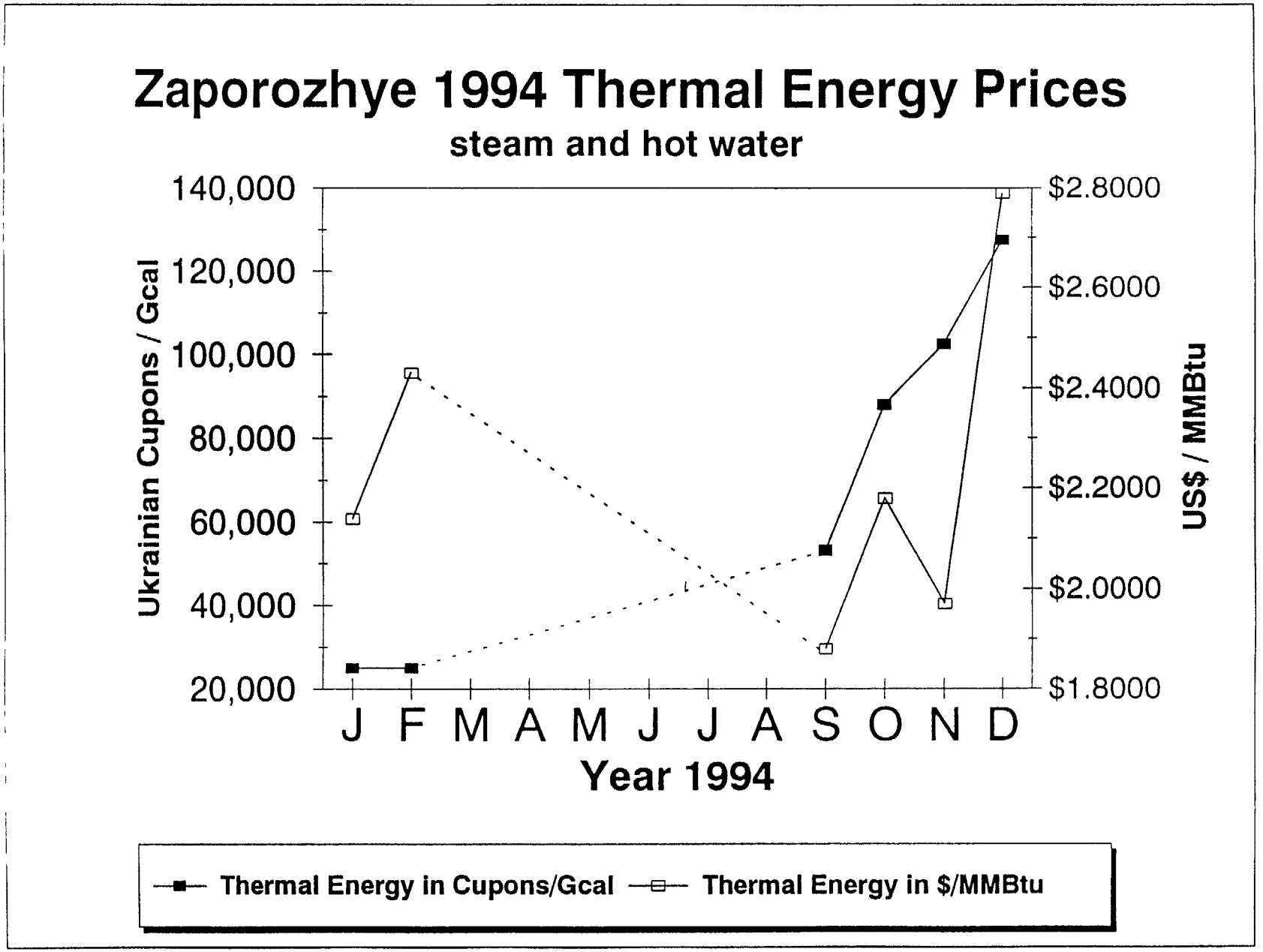
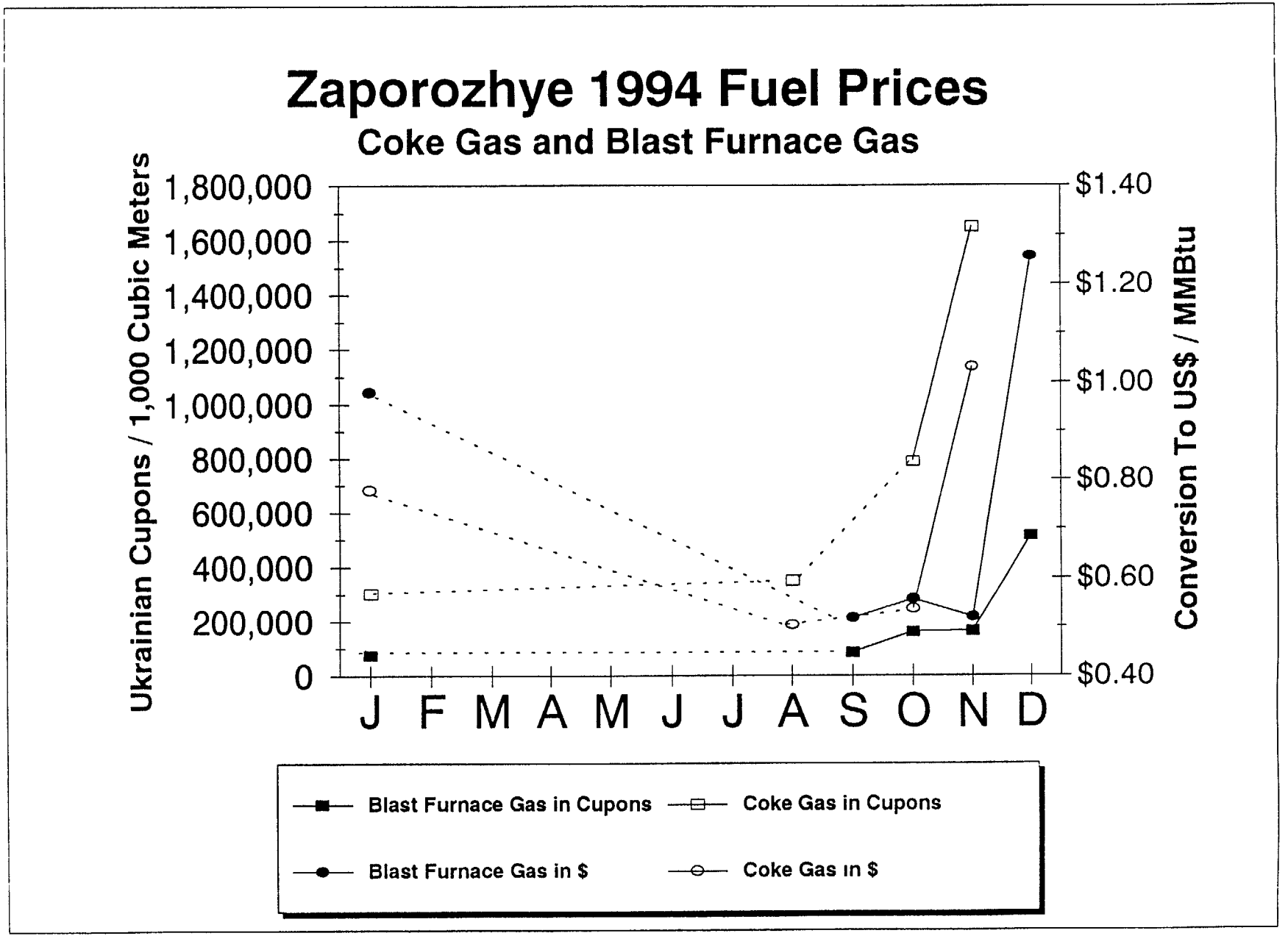


Figure 3.4 Zaporozhye 1994 Fuel Prices



4.0 SYSTEMS AUDITED – SHORT-TERM RECOMMENDATIONS

4.1 ECO #1 - Combustion Air Control on the Ovens of Coke Battery #1

Together, the auditors, coke battery operators, and plant energy conservation staff performed combustion measurements of coke battery fuel utilization (see Photo #1 in Appendix B) Using a portable combustion analyzer, significant amounts of excess air were found to be present in the exit gases of the coke battery (see actual measurements in Appendix A, ECO # 1)

Presently no adjustment of coke ovens combustion efficiency is made Combustion efficiency of any oven depends on the matching design, current heat content of fuel, condition of walls, and temperature and infiltration of ambient air The existing method of monitoring combustion efficiency takes a long time for each measurement, and only gives the result during the instant the gas sample was drawn

In oven number 161, 236% of excess air was present in the exhaust gases To verify potential savings, plant battery operators partially closed the manual air inlet slide gate (see Photo #2 in Appendix B) The excess air amount was reduced to 106% This improved the fuel utilization efficiency by 9 2% from 68 9% to 78 1% Further testing provided replicability of this opportunity.

To maximize fuel utilization efficiency, adjustment of the manual air intake gates is required on a routine basis depending on time of year and amount of fuel being utilized To accomplish this, this report recommends a portable combustion analyzer to monitor the combustion parameters, and adjust on a monthly basis at all ovens The combustion efficiency measurements made on similarly designed battery #2, revealed combustion efficiency that was about 20 % higher To be conservative this measure assumes increase of fuel utilization efficiency of 9 2 % Additional exploration of opportunities to increase efficiency is recommended With 106 % of excess air, the ovens have great potential for additional savings

The 9 2% average improvement in utilization efficiency will save 20,638,156 m^3 of coke gas per year or 322,164 MMBtu This has a local value of $256,037, and a world value of $644,324 per year

Implementation of a portable combustion analyzer would payback its investment in 10 days at local energy prices, and 4 days at world energy prices (see Appendix A, ECO #1 for details)

4.2 ECO #2 - Coke Battery Oven Temperature Monitoring Accuracy

This opportunity involves a plant process modification Thanks to participation of plant process personnel, this measure was deemed feasible

Temperature of coke inside the oven determines completion of a coke batch cycle Present optical pyrometer technology used requires the user to estimate the temperature by visual heated element comparison The measurements are subject to relatively large error, and are not replicable between different users To ensure the coking process is complete (all coal has been converted to coke), larger temperature at the end of a batch is maintained This safety factor is necessary due to the uncertainty of coke temperature measurement (see Photo #3 in Appendix B for location)

Utilization of a infrared non contact thermometer with digital display will provide replicability of measurement regardless of user With replicability in the measurement, the plant will be able to determine coking cycle completion with less margin of overheating

Supply of heating fuel to the coke batteries will be reduced due to decreasing flow rate of coke gas As reported by plant personnel, this recommendation has an additional advantage that less of the final product will be scrap, as reported by plant personnel Attaining sufficient coking times to ensure continuous process (with limited coal supply) will be obtained by reduction of process temperature

Although efficiency improvement potential is believed to be much greater, savings are calculated based on 1% savings of coke gas input per batch

Investment in a high temperature infrared non-contact thermometer will reduce annual fuel consumption by 2,628,000 m^3 of coke gas and 876,000m^3 of blast furnace gas (43,717 MMBtu) per year This investment would pay for itself in 41 days at local prices, and 17 days if the fuel is valued at world prices (see Appendix A, ECO #2 for details)

In addition, the fuel feed rate has potential to be reduced Similar ovens in Battery #2' are run on the mix of coke gas and blast furnace gas Blast furnace gas has a much lower energy value as compared to coke gas During combustion testing, with utilization of blast furnace gas it was able to achieve much higher efficiencies, although Battery #2 is only two years newer than Battery #1 This occurs while the heat exchange geometry of the two batteries is similar This indicates that the heat available in the present flow of coke gas in battery #1 is in excess of what can be transferred into the coke It is recommended to research the possibility of reducing burner fuel volume, thus allowing more time for heat transfer Flame temperature will be maximized with control of excess combustion air supply

4.3 ECO #3 - Combustion Air Control for Enriched Straw Oil Stove

Straw oil is heated from 30 degrees Celsius to 160 degrees Celsius in a large vertical oven fueled with coke gas (see Photo #4 in Appendix B) The pipes which contain the oil zigzag inside the oven to form the heat exchange surface Coke gas is fired from 18 burners at the base of the stove (see Photo #5 in Appendix B) The auditors and plant operators took combustion measurements of the stoves operation (see Photo #6 in Appendix B) Excess air of 221% was measured after the last stage of heated piping In addition, the stack temperature at this point was 515 degrees Celsius These factors lead to a fuel utilization efficiency of 48 4%

To improve this efficiency, this report recommends use of a portable combustion analyzer to adjust the amount of excess air which is fed to the burners By reducing the volume of excess air, fuel utilization efficiency will be increased for two reasons First the flame temperature will be hotter, thus increasing radiant and conductive heat transfer Secondly, the time which the combustion products remain in contact with the heat exchange surface will be increased, also increasing heat transfer

A conservative improvement in fuel is quantified to demonstrate the great potential for this energy conservation opportunity Utilization of fuel is assumed to increase from 48 4% to 60% (stack loss reduced from 51 6% to 40%)

The 11 6% increase will save 3,866,667 m^3 of coke gas per year (60,359 MMBtu) Energy savings is valued at $47,970 per year at local prices, and $120,718 at world prices Implementation of this recommendation will payback the investment in 53 days at local energy values, and 21 days at world energy values (see Appendix A, ECO #3 for details)

Typically two ovens of this type are continuously in operation At the time of the audit, only one was in operation due to a heat recovery project being installed at the second stove Savings are based on one stove only This recommendation is valid for both stoves, and would add significantly to other estimated savings if performed on both stoves

4.4 ECO #4 -Variable Speed Drive for Pump #14

Contaminated waste water is collected and purified on plant site The cleansed water this then reused to cool solid coke and coke gas During a typical day, the demand for this water varies from 100 cubic meters per hour to no load The pump responsible for moving this water must pressurize the line all during the day so that if one of the end users opens a water supply valve, the product will be delivered

Because of this varied demand on the pump, it does not work in its most efficient pumping range In addition, the pump generates pressure above what is necessary when flows are low The end result is that a significant portion of pumping energy is wasted

By installing a pressure controlled variable speed drive on the pump motor, the speed of the motor will be reduced when the water demand on the system is reduced This control will allow the pumps efficiency to be maximized while maintaining constant pressure in the water system regardless of flow

A variable speed drive for this motor will save 665,000 kWh per year This investment will pay itself back in 2 7 years using local energy prices, and 1 year using world energy values

4.5 ECO #5 - Level Control for the Coke Tar Settling Tank

When hot coke tar vapor condenses, water vapor condenses along with it To separate the two liquids, simple settling tanks are used Since operators of the tank pumps cannot see inside the tanks, they wait until the tank becomes full prior to pumping the heated coke tar off the bottom of the tank Because coke tar is heated after being pumped from the settling tank, it will save energy if the coke tar is pumped as soon as possible from the tank This will minimize heat lost through the walls of the metal tank

During the audit, plant personnel found that they could determine the level of the coke tar in the tank by using the infrared non-contact thermometer Using this they demonstrated that the operator would be able to pump from the tank while keeping watch of the level The operator could easily stop the pump prior to the pump beginning to pump water Presently the process is done in batches by filling up the tank, letting it settle, drawing off all water, and then pumping off the oil By using the non-contact thermometer, they will be able to pump the coke tar much quicker from the tank, and save at least 20 degrees Celsius of additional oil temperature according to the process operator

Since the coke tar is reheated using coke gas, saving 20 degrees Celsius of temperature will save the plant 780 Gcal per year The value of this savings is $2,233 per year at local energy prices, and $4,333 at world energy prices. This savings will recover the equipment investment in 1 6 year with local energy prices and 0 8 year with world energy prices (see Appendix A, ECO #5 for details)

4.6 ECO #6 - Energy Management Program Enhancement

Presently The Zaporozhye Plant has staff dedicated to energy management As was demonstrated during the audit activity, with proper audit equipment, plant staff can easily identify opportunities

for energy efficiency improvement Given the enormity of the facility, a set of energy auditing tools will enable the energy management staff to continue the work started during the audit

The following metering tools are recommended for this facility

- Two non-contact ultrasonic flow meters,
- One Non-contact temperature measuring device,
- One 3- phase electrical meter with logging and downloading capability,
- Ultrasonic leak detection device, and
- Laptop computer with plant energy management software

Facility energy management is traditionally felt to be the responsibility of persons with the title of energy manager With large plants, this task is similar to that of the safety manager The energy manager must promote energy conservation awareness to all end users of energy The end users must be the ones responsible for finding the most efficient way to utilize energy in their work area The responsibility of the energy management department is to work with plant personnel to

EDUCATE all plant personnel on energy use awareness,
MOTIVATE all plant personnel to find energy conservation opportunities in their work areas,
REWARD all plant personnel for identifying potential energy conservation opportunities,
QUANTIFY each conservation opportunity potential savings and investment payback,
PLAN and update a rolling 5 year energy management strategy to implement conservation,
SOLICIT funding for energy conservation projects,
IMPLEMENT conservation opportunities where funded or no cost,
FOLLOW UP after implementation and quantify actual savings,
ADVERTISE successful energy conservation projects and lessons learned, and
REPLICATE successful conservation projects to all parts of the plant

Plant energy management concepts have already been "perfected" throughout the world A plant desiring to improve their existing demand side energy management program need only to research programs that other similar plants have implemented. The following are programs that have been utilized and found to be useful in plants of the size and nature of The Zaporozhye Plant These programs will need to be tailored to each plants "personality", but they are very simple in concept, low in cost, and are proven to save energy

The following are low cost / no cost programs to minimize energy waste, and promote energy conservation

CONSERVATION OPPORTUNITY "ECO" OF THE MONTH PROMOTION

Each month promote one new way to save energy to the plant staff This may be as simple as advertising the cost of leaving lighting on, or advanced as promoting methods to control electrical demand The desire is to give personnel areas to look for submissions for the ECO of the month award

ENERGY CONSERVATION OPPORTUNITY OF THE MONTH AWARD

Each month reward one work group from the plant that submits the best energy conservation opportunity suggestion Rewards may be paid time off from work, paid dinners out for the personnel and their families, televisions, plant jackets with energy logo on it, etc

STEAM TEAM

Dedicate a person or group of people to do nothing except locate steam leaks, find a way to schedule their repair, and physically repair the leaks In addition, these personnel should trace steam lines to find abandoned sections which are still pressurized and losing heat

INSULATION TEAM

Dedicate a person or group of people to do nothing except find uninsulated piping or piping with damaged insulation When poor insulation is found, it is this group that is responsible for making the repair

MOTOR TEAM

Dedicate a person or group of people to do nothing except evaluate each motor in the plant to determine if it is properly sized, or where it may be traded to keep all motors at least 50% loaded If no options exist, it should be tagged to be downsized at the end of its useful life

LIGHTING TEAM

Dedicate a person or group of people to do nothing except evaluate the operation of all lighting on plant site This group must understand all lighting technologies available including methods of switching automatically They must develop a plan to upgrade the entire plant with efficient lighting technologies Proven technology is available to cut the energy consumption of lighting in a plant by 50% without reducing lighting levels

NEW CONSTRUCTION ENERGY REVIEW

As part of the design process, include a review of energy saving opportunities prior to the construction

USE UTILITY BUDGET TO IMPLEMENT QUICK PAYBACK PROJECTS

Projects with quick pay backs but no funding can be implemented using funding set aside to pay utility bills. Since the bills will be reduced in the future due to the project implementation, the project will pay the energy budget back from the savings.

METER TO MANAGE

History has shown that once energy is metered, the awareness of the amount that is used each month leads to automatic energy conservation from the end users.

ASSESS ENERGY USE EACH MONTH

Quantify the energy used in each shop (estimates if necessary) and develop indicators to determine whether the consumption appears abnormal accounting for production changes. Typically determining why energy varies in each shop will lead you to ways to reduce the consumption.

By using the above recommended metering tools, along with programs similar to those described above, a plant can effectively minimize their consumption of energy. Within one year, one percent of the plants energy can be reduced by the awareness created with the above recommended metering alone. This savings will be seen in no cost / low cost management measures. One percent of the plant energy saved equals the value of $176,889 at local energy pricing and $479,259 at world energy prices. Investment in the above equipment would payback within 3.7 months at local energy prices, and 1.4 month at world energy values (see Appendix A, ECO #6 for additional information).

5.0 SYSTEMS AUDITED – LONG-TERM RECOMMENDATIONS

The scope of this project provided a 7 day audit of the facility to identify low-cost / no-cost opportunities for energy savings In addition to the no-cost / low-cost opportunities identified, numerous technically feasible, but more complex energy savings opportunities exist on plant site which justify future investigation Below are several examples of such long term recommendations

Two categories of opportunities exist The first is in automated control of air in the combustion processes The second is heat recovery on the plant site to generate steam

5.1 Automated Excess Air Supply Controls For Coke Batteries - Batteries #1 and #2

Coke batteries are the largest energy consumers on plant site Automatic control of excess air on a continuous basis will provide maximum energy savings in this area Each battery consists of 66 combustion chambers Each chamber should be retrofit with automated excess air control Utilization of a portable combustion analyzer will determine minimum level of excess oxygen based on the level of carbon monoxide in the flue gases The controls will obtain a signal from the oxygen sensor to maintain this minimum excess air amount during changing atmospheric conditions A detailed design will interlock the fuel and air supply to safely optimize the efficiency of this combustion process

5.2 Automated Excess Air Supply Control For Straw Oil Heating Stoves

Each of these two stoves currently consumes 2,500 cubic meters of coke gas per hour It is recommended to retrofit the existing manually controlled air dampers with automated air dampers Atmospheric conditions vary which affects the efficiency of the stoves Automated dampers will continuously minimize the amount of excess air which is used in the combustion process A detailed design will interlock the two banks of 9 burners and stack damper for optimum efficiency

5.3 Automated Excess Air Supply Control For Coal Tar Pitch Heating Ovens

Four pitch ovens exist, although three ovens were in operation at the time of the audit Currently the total gas consumption of this process was 1,300 cubic meters of coke gas per hour Each oven consists of 8 heating chambers Again, continuously monitoring and controlling the excess air supplied will optimize the combustion efficiency of this process This recommendation is to retrofit all heating chambers with automated combustion air controls In total, 32 ovens would require oxygen sensors and automatic air dampers Final design of this installation will interlock air and fuel regulation

5.4 Heat Recovery To Generate Plant Steam Needs

Several high temperature stack gases exist on plant site These hot gases can be used to generate steam for use on plant site Areas of potential heat recovery included

Coking oven stack	(300°C)
Straw oil heating ovens	(500°C)
Pitch coke oven stack	(400°C)

The plant purchased over 700,000 Gcal of steam and hot water from the neighboring steel plant during 1994 This energy is valued at over 7 million dollars based on local prices in December of 1994 Even if not in its entirety, this steam and hot water can be produced on plant site using waste heat from the above processes

5.5 Automated Flow Control Of Cooling Water For Coke Gas Cooling

Five large pumps (4,000 m^3/hr each @ 95 meters of water head) are installed to deliver water to heat exchangers which cool the coke gas Each pump has a 630 kW motor During the winter, only two of the pumps were necessary, but during the summer the water temperature differential is less, so more pumps are operated The persons responsible for this process were convinced that if flow was regulated by temperature measurement that significantly less pumping volume would be required They felt that the existing condition pumped much larger quantities of water than was necessary to do the job

Additional energy saving could be reached by closely monitoring heat exchanger fouling, and timely maintenance

6.0 TRAINING ACCOMPLISHED

An objective of this project was to transfer as much information and hands on training of energy auditing techniques to local technical personnel as possible so that they may continue this work after the foreign consultants have completed their brief visit

6.1 Local Engineer

The local engineer, Vladimir Kursa, was an experienced staff person of the local electrical utility, Dnieprenergo His academic background was in electrical engineering Previous experience included work with the energy inspection agency (Energonadzor)

His experiences during this audit included

- discussion with plant energy management staff of audit purpose and anticipated results,
- participation in setting up the audit plan and itinerary,
- participation in obtaining plant energy consumption history,
- one-on-one training with audit equipment operation and potential uses (see audit equipment list in Appendix G),
- participation in conducting the audit to identify potential conservation measures;
- hands on utilization of audit equipment to quantify potential energy savings,
- discussions with plant staff to determine feasibility of conservation measure,
- participation in final "report out" meeting with plant Chief Engineer and Shop Managers,
- received copy and reviewed format and function of final report content, and
- discussion of similarities and differences of audits based on plant size, type, attitude, and funding availability

6.2 Plant Staff

More than 30 personnel from the plant were involved at various phases of the audit. The energy management staff was involved for the entire audit process Appendix E contains a list of contacts made during the audit

The plant energy management staff experience during this audit included

- discussion of audit purpose and anticipated results,
- participation in setting up the audit plan and itinerary,
- one on one training with audit equipment operation and potential uses (see audit equipment list in Appendix G),

- participation in conducting the audit to identify potential conservation measures,
- hands on utilization of audit equipment to quantify potential energy savings,
- discussions of typical energy management practices is the US ,
- participation in final "report out" meeting with plant Chief Engineer and Shop Managers,
- reviewed format and function of final report content

7.0 IMPACT OF ENERGY CONSERVATION OPPORTUNITIES (ECOS)

Energy Savings

Implementation of the recommended short term efficiency measures are projected to reduce the plant energy consumption by 1,626,070 kWh of power and 14,178 Gcal (560,198 MMBtu) of other types of energy. This provides an energy savings of 1.7% (electricity) and 9.9% (heating fuels) as compared to the Plant's consumption during year 1994[10].

Financial Benefits

The viability of this facility is dependent on how competitive their neighboring steel plant is. Passing on additional costs of coke production in the future may jeopardize the viability of both plants. Minimizing production costs by conservation of energy may be a key component of both plants' future survival

Effect on Production Capacity

The low cost conservation measures recommended in this report will not reduce the plants production capacity. Actually two of the measures will improve production capacity

Effect on Product Quality

Product quality will be positively effected in the temperature measurement recommendation (ECO #2) by reducing the amount of scrap produced. This was reported by plant personnel.

Effect on Working Conditions

During the plant audit, it was very apparent that the plant employees were anxious to provide suggestions which utilized their knowledge of the plant to meet the end goal of saving energy.

Energy management programs give a sense of pride and ownership to plant personnel in allowing them to make recommendations which positively change the operation of the plant.

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[10] based on 1994 plant consumption

8.0 MONITORING

After projects are implemented in this facility, it is important to follow-up with the implementations to determine actual savings achieved from the investments. To accomplish this, the local engineer that worked with the audit team could be used to track implementation savings.

The metering equipment in ECO #6 can be used to perform follow up monitoring as discussed below. *Figures 8.1* through *8.5* are forms to collect necessary data and quantify the energy savings achieved.

ECO #1 - Combustion Air Control on the Ovens of Coke Battery #1

Combustion efficiency tests can be taken with the specified combustion analyzer two months before and two months after tuning on weekly intervals during initial implementation. After a four month period, the operators will be able to judge the efficiency lost without routine tuning of the ovens.

ECO #2 - Coke Oven Temperature Monitoring Accuracy

Plant operators are determining completion of the coking time utilizing non-precise optical pyrometer. Plant management daily and monthly collects information on the coal and coking gas consumption, on coke production, and on the amount of the waste. The similar information will be collected during one month after ECO implementation, applying precise infrared non-contact thermometer. Then production and consumption information can be compared. The difference in the rate of coke gas consumption per unit of produced coke, as well as rate of waste per unit of produced coke will indicate the savings.

ECO #3 - Straw Oil Heating Stove, Combustion Air Control

Combustion efficiency tests can be taken with the specified combustion analyzer before and after tuning on daily intervals during initial implementation. After a four-week period, the operators will be able to judge the efficiency savings.

ECO #4 - VSD for Pump #14 Supplying Water for Coke Quenching

Monitoring pump motor energy consumption before and after installation with the power analyzer included in the energy management package will determine the savings.

ECO #5 - Coke Tar Settling Tank Level Control

Operators will measure and record the outgoing temperature of the tar. Discharge flow of tar can be measured using the ultrasonic non-contact flow meters. Flow, temperature change, and specific heat will determine the savings.

Each measure implemented as a result of this equipment will be recorded and monitored by plant staff A continuous energy savings total can be kept by plant energy management staff

9.0 RESULTS OF FOLLOW-UP VISIT

9.1 Objectives of Visit

The objectives of the July 1997 equipment follow-up visit were to

- Verify arrival of demonstration energy efficiency equipment
- Inspect delivered energy efficiency equipment for damage and completeness
- Provide hands-on training on equipment use to facility staff where needed
- Determine facility operational changes since 1995 energy audit
- Identify follow-up necessary to resolve equipment difficulties
- Assess energy conservation achievements in response to the 1995 audit

The original program design allowed time for the plant to implement recommended energy efficiency measures and begin monitoring the results prior to the equipment follow-up visit. The actual follow-up visit occurred after the plant received its first group of equipment, but prior to some equipment being cleared from customs.

9.2 Main Energy Conservation Opportunities Identified in 1995

Of the Energy Conservation Opportunities (ECOs) identified during the 1995 plant energy audit, the following ECOs were accepted for implementation by the plant

ECO #1.	Combustion air control on the ovens of Coke Battery #1
ECO #2	Coke battery oven temperature monitoring accuracy
ECO #3	Combustion air control for enriched straw oil stove
ECO #4.	Variable-speed drive for pump #14
ECO #5	Level control for the coke tar settling tank
ECO #6	Energy management program enhancement

9.3 Status of Plant During July 1997 Visit

In the two-year period between visits, the coke plant had reduced its operation level During the initial plant energy audit, almost all of the coke produced by the plant was being sold to the neighboring steel mill. Currently, the steel mill has significantly reduced its production, resulting in a greatly reduced demand for coke At the time of the visit, the coke being produced was being stockpiled The plant production had also been reduced from five to four days per week

9.4 Accomplishments During Visit

ECO #1. COMBUSTION AIR CONTROL ON THE OVENS OF COKE BATTERY #1
One of the two combustion analyzers supplied is intended to improve combustion efficiency of the coke ovens This is especially true for the ovens of Coke Battery #1 The plant personnel received the analyzers about two weeks prior to the July 1997 visit During this time, they assigned the analyzers to the Deputy Chief Environmental Engineer He studied the translated manual thoroughly and field tested the analyzers by testing the coke battery exhaust stack Specialists from the Autozaz Car Plant were invited to participate in the demonstration of the combustion analyzer Autozaz is another Zaporozhye plant that participated in the USAID industrial plant audit/demonstration program The combustion analyzer specified for their plant had not cleared customs, and they were interested in receiving instruction on its use

This meeting was a very beneficial interaction between the two plants The Deputy Chief Environmental Engineer from the coke plant knew the analyzer so well that he performed the entire demonstration (see photo ZCP-1) At the close of the meeting, representatives from the two plants exchanged contact information for future communication

The Deputy Chief Environmental Engineer said that his plan was to test the coke batteries routinely, once a month, in addition to whenever the type of coal was being changed. *Figure 8 1* can be used to quantify the savings from this measure

ECO #2. COKE BATTERY OVEN TEMPERATURE MONITORING ACCURACY
Prior to our visit, the plant had received the high-temperature non-contact thermometer The Deputy Chief of the Coke Shop had tested the meter along with the Coke Battery Temperature Technician, so they were familiar with its use They had a concern that the measurements could not be made fast enough with the new meter The technician has ten minutes to make 66 measurements This is about nine seconds per measurement After trying the measurements during our visit, they decided that, over time, the Temperature Technician would become agile with the new instrument They are planning to use the instrument in conjunction with the existing pyrometer measurements until they gain confidence in the new meter's accuracy and replicability During the demonstration, temperatures of 1,280 °C was measured (see photo ZCP-2) A temperature of 1,050 °C is reported to be the point at which the coke can be removed The additional temperature rise is a buffer needed because of the limited precision available using the existing pyrometer With the infrared digital thermometer, it is possible to reduce this buffer The plant can use *Figure 8 2* to quantify the energy saved by this measure.

ECO #3 COMBUSTION AIR CONTROL FOR ENRICHED STRAW OIL STOVE
This measure follows along with the ECO #1 because it uses the same equipment. Please refer to the description of activity described above in ECO #1 *Figure 8 3* can be used by the plant to quantify the energy saved by this measure

ECO #4 VARIABLE-SPEED DRIVE FOR PUMP #14

The variable-speed drive had been received just prior to our follow-up plant visit, and it was still in the shipping crate (see photo ZCP-3) The plant electrical staff had reviewed the installation instructions and felt comfortable with installation and operation of the drive. We were informed by the energy manager that the drive would be installed following the completion of previously scheduled projects *Figure 8 4* is a table that will assist with determination of energy savings resulting from implementation This will also require the use of the Rustrak Ranger Power Meter which was supplied as part of this project.

ECO #5 LEVEL CONTROL FOR THE COKE TAR SETTLING TANK

Prior to our visit, staff from the utilities department had become familiar with operation of the non-contact temperature meter and put it into use Since our last visit, they had implemented a system to determine tar level, which allowed continuous pumping of tar rather than batch pumping. The non-contact thermometer will be used to verify proper operation

The plant has developed the valuable concept of using the non-contact thermometer for measuring the temperature across the large number of heat exchangers in the plant. In the past, fouling of heat exchangers was difficult to diagnose This resulted in excess amounts of cooling water being pumped to complete a task. With the use of the non-contact thermometer, staff will now be able identify and repair fouled heat exchangers, thus reducing the amount of cooling water pumped.

Plant staff felt this to be so valuable to the plant, that they are looking to get two more of the instruments

ECO #6 ENERGY MANAGEMENT PROGRAM ENHANCEMENT

Rustrak Ranger - Recording Electric Power Meter

This meter will allow the plant to quantify existing electrical loads so they can compare the results of modifications intended to save energy The review team worked with specialists from the plant electrical shop to instruct them regarding set-up and installation procedures for the meter Setup of the analyzer was completed on an electrical branch circuit in the plant (see photo ZCP - 4)

A software program is provided with the meter to facilitate both initial setup, and long-term monitoring analysis The vendor program is written in English only This will require plant staff to work with translators to identify the procedure for using the software This meter will be used to monitor the energy efficiency savings of the variable-speed drive implementation.

Peek Model ISTT-P Ultrasonic (Transit Time) Flow Meter

This meter will be used to quantify numerous supplies of cooling water throughout the plant The ability to quantify flows will greatly enhance the ability to determine existence of leaks

Prior to the July 1997 visit, the plant had become familiar with operation of the meter using the manuals that had been translated into Russian Despite understanding the operation of the meter, the plant received an error message of "no signal detected " During the July 1997 follow-up visit, the meter was thoroughly tested on several installations The meter continued the "no signal detected" error message (see photo ZCP - 5) The plant even set up a test using a new piece of pipe (to eliminate corrosion), vertically mounted (to eliminate possible air pockets), and filled the pipe with clean water Unfortunately, the ultrasonic meter consistently reported that a signal was not received (see photo ZCP - 6) After significant trouble shooting, including contact with the manufacturer, it was determined that the meter should be returned to the manufacturer for diagnosis of the problem

Laptop Computer and Laser Printer

Computers have become a necessary part of energy management. They provide a means to set up and retrieve data from monitoring equipment in addition to providing the capability to perform complex estimation and track calculations which would otherwise be ignored In addition, they have the capability of creating attention-getting reports which lend credibility when promoting energy savings projects

The computer provided, had been set up and tested by the plant's computer department. The computer was originally received with the English version of Windows 95. The plant was in the approval process of procuring a copy of the Russian version of Windows 95 along with a word processing and spreadsheet program (see photo ZCP - 7).

This computer will also be necessary to install software which is used to facilitate setup and allow output of several pieces of the equipment provided to the plant. The software provided with the monitoring equipment is only available in English This is currently a barrier because of the limited English skills of plant technical staff. Despite this, plant technical staff was confident that they could follow the software manuals which had been translated from English to Russian

The pieces of equipment with computer assisted setup and downloading capability included the combustion analyzers, electrical power meter, and ultrasonic flow meter.

Ultrasonic Leak Detection Monitor

The ultrasonic leak detection monitor was tested in an area where there was a known underground leak. Plant staff were able to locate the site of the leak despite their unfamiliarity with the equipment (see photo ZCP - 8). The monitor came with a cassette tape, which familiarizes users with the sounds emitted by the monitor to indicate the presence of leaks. The English wording on the tape was translated on a piece of paper to make use of the tape possible

9.5 Equipment Provided to Plant to Accomplish Implementation of ECOs

Below is a list of equipment supplied to the Zaporozhye Coke Plant to implement ECOs supported by plant management

	Quantity	Equipment
ECO #1	(1)One	Enerac 2000 combustion analyzer
ECO #2	(1)One	Mikron Infrared thermometer, high-range
ECO #3	(1)One	Enerac 2000 combustion analyzer
ECO #4	(1)One	Saftronics variable-speed drive for a 200 Hp motor
ECO #5	(1)One	Infrared thermometer mid-range, Mikron M90B
ECO #6	(2)Two	Ultrasonic, transit time flow meters by Peek Meas , ISTT-P
	(1)One	Electric power meter, Rustrak RR-1233A-2-0-0
	(1)One	Laptop computer and laser printer
	(1)One	Ultrasonic leak detection analyzer
	Set	Books (energy management, $250 total cost)

9.6 Work Required to Complete Implementation

Peek Model ISTT-P Ultrasonic (Transit Time) Flow Meter Operations

As discussed above, the ultrasonic flow meter did not operate properly during the plant visit It is necessary to ship the meter and all support equipment to the manufacturer for diagnosis of the problem If the meter is determined to be operational upon receipt by the manufacturer, a determination must be made by the manufacturer of the probable cause of malfunction under field conditions In addition, a calibration block was not present in the support equipment delivered with the ultrasonic meter This piece of equipment must be obtained and delivered to the plant Presence of the calibration block may have assisted the trouble-shooting process in the field, although manufacturer technical support reported that this would not be the cause of the meter's reporting of "no signal detected." The Peek / Polysonics contact person is Mr Santos Martinez at (281) 879-3700.

Rustrak Ranger, Model 1233 - Recording Electric Power Meter Equipment Correction

Provide three pairs, or a total of six (6) current transformer cord adapters for 0 to 1000 Amp (1 amp = 1 mV) current transformers included in the set The connection from the meter itself is a male, and the connections on each current transformer cord are also male The Rustrak contact person is Mr Fred Gineki at (401) 884-6800 ext 215

PLANT QUESTIONS

Can other locally available conductant greases be used for the ultrasonic flow meter?

Does continuous use of the high temperature, non-contact thermometer produce inaccuracies ?
How can the non-contact thermometers be calibrated ?

9.7 Lessons Learned

Several lessons learned are discussed in this section to benefit future projects of similar nature

When available, all software supplied should be in a local language This could most easily be done with local procurement of software

All monitoring equipment should be field tested in the U S. by someone other than the manufacturer. This would include testing of the equipment in addition to verification that all support equipment is present

All monitoring equipment should be provided with a description of the technique and support equipment necessary to calibrate the instrument

9.8 Photographs Taken During July 1997 Visit

PHOTO ZCP-1 Combustion Analyzer Training

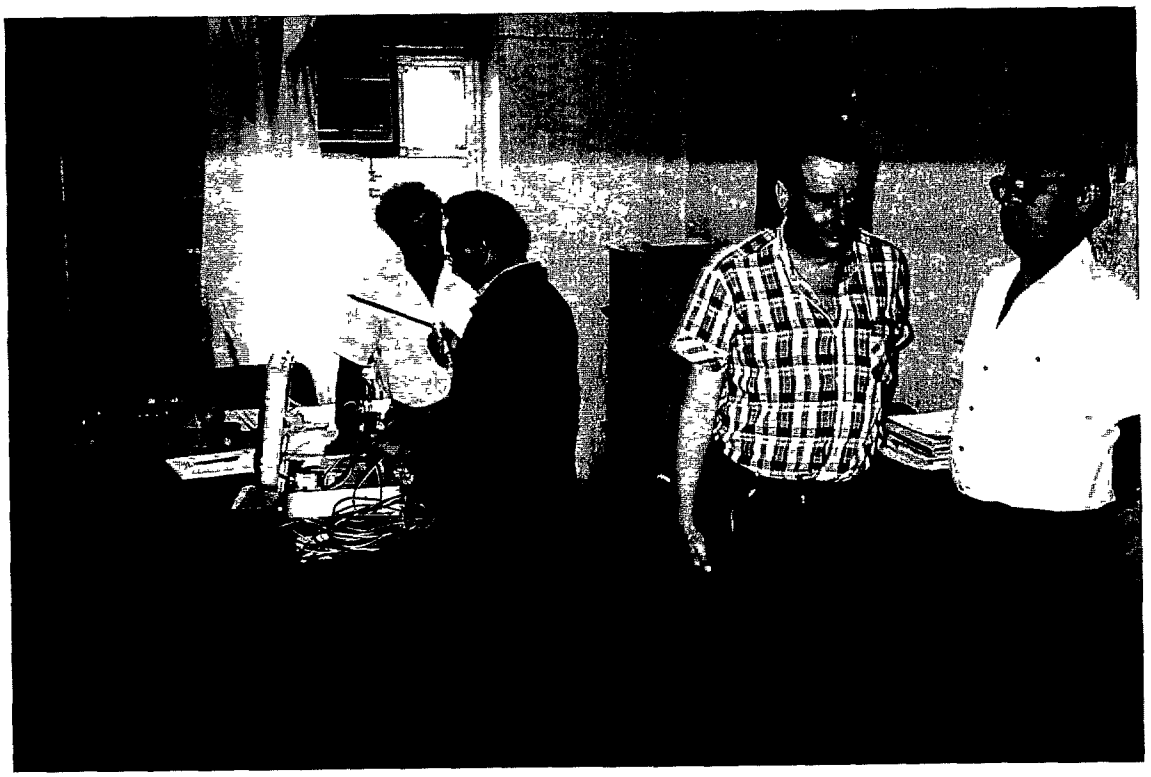

PHOTO ZCP - 2 Test Monitoring of Coke Battery Internal Temperature

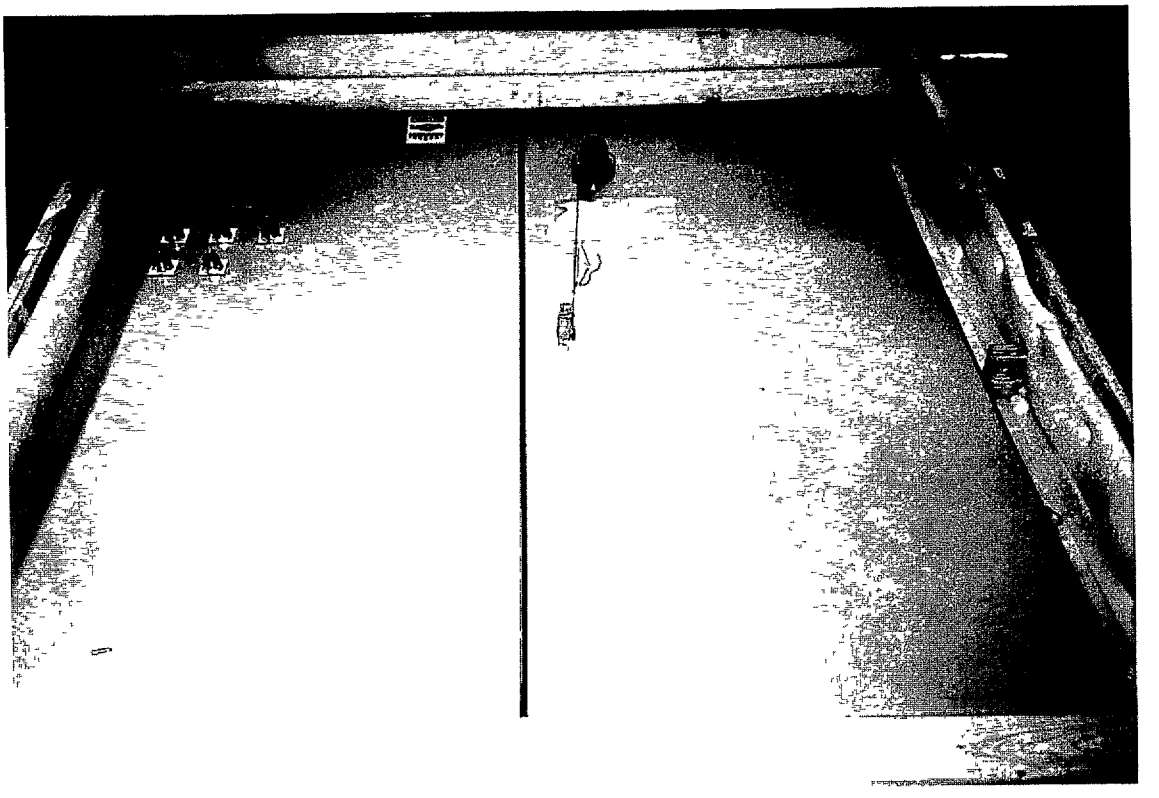

PHOTO ZCP - 3 Variable-Speed Drive in Shipping Crate

PHOTO ZCP - 4 Power Meter Installation on Branch Circuit

PHOTO ZCP - 5 Ultrasonic Flow Meter Installation on Water Pipe

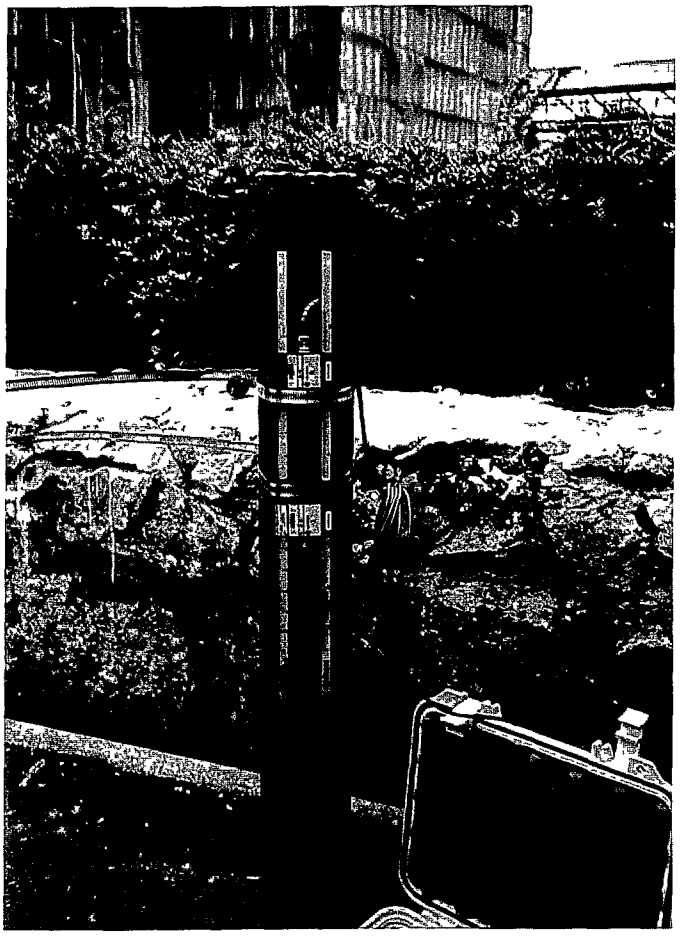

PHOTO ZCP - 6. Ultrasonic Flow Meter Test Pipe Installation

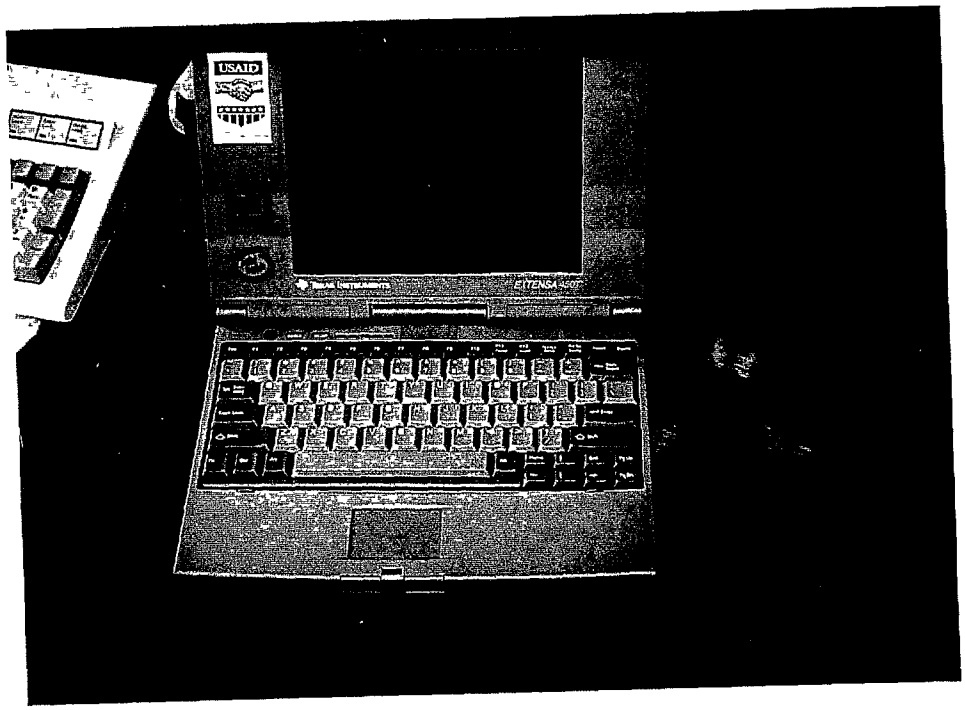

PHOTO ZCP - 7: Laptop Computer Provided to Plant

PHOTO ZCP - 8: Ultrasonic Leak Detection Device Testing on Buried Piping

9.9 Plant Contacts Made During July 1997 Visit

Plant Address:
Zaporozhcoke
Ukraine, 330600, Zaporozhye
P/b - 681, Zaporozhcoke

Telephone. (380-612) 39-33-44 or 39-23-96
Fax· (380-612) 35-01-41

Yevgeny P Ivashutkin
Chief Energy Manager

Arkadiy Pavlovich Omelyanenko
Utilities Assistant

Vladimir Zinovyevich Chumak
Utilities Foreman

Vladimir I. Markov
Deputy Chief of Coke Battery Shop

Aleksander Anatolyevich Schavinskiy
Computer Programming Engineer

Vitaliy Nikolayevich Varentsov
Environmental Deputy Chief Engineer

Valeriy Ivanovich Yelistratov
Foreman of Electrical Technical Laboratory

Figure 8.1 ECO-1 Monitoring Data Sheet

COKE BATTERY # 1 COMBUSTION - EXCESS AIR CONTROL

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Week	Average Temperature of Ambient Air, °C	Excess of Air, %	Average Stack Temperature °C	Average Combustion Efficiency, %	Week	Average Temperature of Ambient Air, °C	Excess of Air, %	Average Stack Temperature °C	Average Combustion Efficiency, %	Changes in Efficiency %
1					1					
2					2					
3					3					
4					4					
5					5					
6					6					
7					7					
8					8					
9					9					
Coke gas consumption per period, m^3 - Coke production per period, metric tons -					Coke gas consumption per period, m^3 - Coke production per period, metric tons -					Changes in Consumption m^3/metric ton

Figure 8.2 ECO 2 Monitoring Data Sheet

COKE BATTERIES # 1 & # 2 - TEMPERATURE METERING ACCURACY

		Consumption or Production		Weekly Changes in Production or Consumption			
Week	Name of Product	Before	After	Coal	Coke	Coke Gas	Waste
1	Coal						
	Coke						
	Coke Gas						
	Waste						
2	Coal						
	Coke						
	Coke Gas						
	Waste						
3	Coal						
	Coke						
	Coke Gas						
	Waste						
4	Coal						
	Coke						
	Coke Gas						
	Waste						
Total	Coal						
	Coke						
	Coke Gas						
	Waste						

Figure 8.3 ECO 3 Monitoring Data Sheet

STRAW OIL HEATING STOVE, COMBUSTION AIR CONTROL

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Date a	Temperature of Ambient Air, °C	Excess Air, %	Stack Temperature °C	Combustion Efficiency, %	Date a	Temperature of Ambient Air, °C	Excess Air, %	Stack Temperature °C	Combustion Efficiency, %	Changes in Efficiency %
Coke gas consumption per period, m^3 -					Coke gas consumption per period, m^3 -					Changes in Consumption m^3

Figure 8.4 ECO 4 Monitoring Data Sheet

VSD FOR PUMP #14 SUPPLYING WATER FOR COKE QUENCHING

BEFORE IMPLEMENTATION			AFTER IMPLEMENTATION			
Date	Average Daily Load, kW	Daily Consumption, kWh	Date	Average Daily Load, kW	Daily Consumption, kWh	Changes in Consumption kWh
Total power consumption per period, kWh -			Total power consumption per period, kWh -			

Figure 8.5 ECO 5 Monitoring Data Sheet

COKE TAR SETTLING TANK LEVEL CONTROL

Average temperature of the tar before and after implementation

DATE	TAR TEMPERATURE DISCHARGE, °C	DAILY TAR FLOW RATE, Metric tons per day

Recovered Heat Total, Gcal/period

APPENDIX A

Energy Conservation Opportunities (ECOs)
Calculation of Fuel and Fuel Cost Savings
Calculation of Implementation Costs

A.1 ECO # 1 - COKE BATTERY #1 COMBUSTION - EXCESS AIR CONTROL

The existing oven condition shows an excess air of 236% and an efficiency of 68 9% By adjusting the excess air quantity using a combustion analyzer, an improved efficiency of operation can be achieved This was tested by adjustment of inlet slot opening by plant staff This adjustment led to a 9 2 % increase in efficiency The replicability of this type of adjustment was verified by monitoring combustion in other ovens

By reduction of excess air, it is conservative that oven efficiency can be increased by 9 2 % for coke battery #1 This is because combustion efficiency of coke battery #2 was about 20 % higher Efficiency will be improved by increasing flame temperature, thus increasing radiation and conduction heat transfer Additional efficiency will be gained due to reduced quantity of flue gas discharge

Annual Fuel and Energy Saving

These efficiency improvements represent an annual savings of

$FS = A * B * [1 - (\eta_{exist} / \eta_{new})]$, m^3/yr,

$ES = FS * HC / C * D$, MMBtu/yr, where

FS --	Fuel saving, m^3/yr
ES --	Energy savings, MMBtu/yr
A --	Gas consumption rate of furnace, m^3/hr
B --	Annual hours of operation of furnace, hr/yr
HC --	Heat Content of coke gas, 3934 kilocalories/m^3
C --	Conversion Factor, 1,000, 000 kcal/Gcal
D --	Conversion Factor, 3,968 MMBtu/Gcal
η --	Oven efficiencies, %

$FS = 20{,}000\ m^3/hr * 8760\ hr/yr * [1-(68\ 9/78\ 1)] = 20{,}638{,}156\ m^3/yr$

$ES = 20{,}638{,}156\ m^3 * 3934\ kcal/m^3 / 1{,}000{,}000\ kcal/Gcal * 3{,}968\ MMBtu/Gcal =$

$= 322{,}164$ MMBtu/yr

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Annual Cost Savings

Local Prices

CS = 20,638,156 m^3/yr * 1,650 karb/ m^3 / 133,000 karb/$US = $256,037/year

World Prices

CS = 322,162 MMBtu per year * US $2[11] / MMBtu = $644,324/yr (gas)

Implementation Cost:

US $7,000 including cost of shipping and handling

Simple Payback:

At Local Prices = $7,000 / $256,037 = 10 days

At World Prices = $7,000 / $644,324 = 4 days

Measurements on Battery #1, Oven #161 taken during audit

	"As Found"	"Adjusted"
Oxygen (O_2)	14 7 %	10 8 %
Excess Air %	236 %	106 %
Carbon dioxide (CO_2)	6 1 %	10 0 %
Stack temperature	317°C	339°C
Combustion Air Temperature	25°C	25°C
Efficiency %	68 9 %	78 1%

[11]The world price for coke gas assumed equal to world price of coking coal $ 2 US per MMBtu

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Reg. 16
as found

BACHARACH
COMBUSTION ANALYZER

ID: _____

SER NO- YCO 587

TIME: 03:13

DATE- 16.02.95

FUEL COAL

PRIMRY TEMP (C) 25

STACK TEMP (C) 317

% OXYGEN. 14 7

% EXCESS AIR: 236

% CARBON - DIOXIDE 6 1

PPM CARBON - MONOXIDE: 283

PPM NOX: 132

PPM SULFUR - DIOXIDE 8

% EFFICIENCY 68.9

% STACK LOSS 31 1

TEST PERFORMED BY

_____ _____

COMMENTS

Regular 16
after cleaning
air blow

BACHARACH
MODEL CA500MSX
COMBUSTION ANALYZER

ID: _____

SER NO: YCO 587

TIME: 03:16

DATE 16.02.95

FUEL: COAL

PRIMRY TEMP (C) 25

STACK TEMP (C) 339

% OXYGEN: 18.6

% EXCESS AIR: 186

% CARBON - DIOXIDE. 18.8

PPM CARBON - MONOXIDE. 504

PPM NOX: 75

PPM SULFUR - DIOXIDE: 3

% EFFICIENCY: 70.1

% STACK LOSS: 21 9

TEST PERFORMED BY:

_____

COMMENTS ....

161
after 20 m.m.

BACHARACH
MODEL CA500MSX

ID _____

SER NO: YCO 587

TIME: 03:52

DATE: 16.02.95

FUEL: COAL

PRIMRY TEMP (C) 25

STACK TEMP (C) 339

% OXYGEN: 13 7

% EXCESS AIR: 189

% CARBON - DIOXIDE. 7.1

PPM CARBON MONOXIDE. 483

PPM NOX: 143

PPM SULFUR - DIOXIDE: 14

% EFFICIENCY: 71.2

% STACK LOSS 28.8

TEST PERFORMED BY.

_____

COMMENTS

53

Regenerator 215 Beginning of cycle.

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER

SER NO VCO 587

TIME: 06:43

DATE: 16.02.95

FUEL: LOW ENERGY GAS

PRIMRY TEMP (C) 33

STACK TEMP (C) 194

% OXYGEN: 9.1

% EXCESS AIR: 71

% CARBON - DIOXIDE: 7.5

PPM CARBON - MONOXIDE: 3284

PPM NOX: 35

PPM SULFUR - DIOXIDE: 26

% STACK LOSS: 18.3

TEST PERFORMED BY:

COMMENTS ....

Regenerator 215 middle of cycle.

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER

SER NO: VCO 587

TIME: 06:52

DATE: 16.02.95

FUEL: LOW ENERGY GAS

PRIMRY TEMP (C) 33

STACK TEMP (C) 225

% OXYGEN: 9.1

% EXCESS AIR: 71

% CARBON - DIOXIDE 7.5

PPM CARBON - MONOXIDE: 118

PPM NOX 66

PPM SULFUR - DIOXIDE 21

% STACK LOSS. 12.3

TEST PERFORMED BY:

COMMENTS ..

Regenerator 215 Beg End of cycle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER

SER NO VCO 587

TIME: 07:00

DATE: 16.02.95

FUEL: LOW ENERGY GAS

PRIMRY TEMP (C) 33

STACK TEMP (C) 241

% OXYGEN: 9.1

% EXCESS AIR: 71

% CARBON - DIOXIDE: 7.5

PPM CARBON - MONOXIDE. 87

PPM NOX: 65

PPM SULFUR DIOXIDE: 28

% STACK LOSS: 13.3

TEST PERFORMED BY

COMMENTS

Regenerator 238 Beginning of cycle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER

ID:

SER NO VCO 587

TIME. 07 06

DATE: 16.02.95

FUEL LOW ENERGY GAS

PRIMRY TEMP (C) 33

STACK TEMP (C) 213

% OXYGEN: 10.0

% EXCESS AIR: 85

% CARBON - DIOXIDE: 6.9

PPM CARBON MONOXIDE: 547

PPM NOX: 69

PPM SULFUR - DIOXIDE: 8

% STACK LOSS: 12.3

TEST PERFORMED BY:

COMMENTS ....

Regenerator 238 Middle of cycle

BACHARACH
MODEL CA300NSX

ID: ----------

SER NO: VCO 587

TIME: 07:12

DATE: 16.02.95

FUEL: LOW ENERGY GAS

PRIMRY TEMP (C) 33

STACK TEMP (C) 239

% OXYGEN: 9.6

% EXCESS AIR: 79

% CARBON - DIOXIDE: 7.1

PPM CARBON - MONOXIDE: 115

PPM NOX: 73

PPM SULFUR - DIOXIDE: 11

% STACK LOSS: 13.7

TEST PERFORMED BY:

COMMENTS . .

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Regener 215 Midle of cicle.

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER
ID: _____
GER NO: YCO 587
TIME: 04:52
DATE: 16.02.95
FUEL: LOW ENERGY GAS
PRIMRY TEMP (C) 33
STACK TEMP (C) 223
% OXYGEN: 9.1
% EXCESS AIR: 71
% CARBON - DIOXIDE: 7.5
PPM CARBON - MONOXIDE: 136
PPM NOX: 64
SULFUR - DIOXIDE: 28
% EFFICIENCY: 87.7
% STACK LOSS: 12.3
TEST PERFORMED BY:
COMMENTS

Regener 215 Beg End of cicle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER
ID: _____
GER NO: YCO 587
TIME: 07:00
DATE: 16.02.95
FUEL: LOW ENERGY GAS
PRIMRY TEMP (C) 33
STACK TEMP (C) 24[illegible]
% OXYGEN: 9.4
% EXCESS AIR: 71
% CARBON - DIOXIDE: 7.3
PPM CARBON - MONOXIDE: 87
PPM NOX: 69
SULFUR - DIOXIDE: 28
% EFFICIENCY: 86.7
% STACK LOSS: 13.3
TEST PERFORMED BY:
COMMENTS

Regener 238 beginning of cicle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER
ID _____
GER NO YCO 587
TIME: 07 06
DATE: 16.02.95
FUEL: LOW ENERGY GAS
PRIMRY TEMP (C) 33
STACK TEMP (C) 213
% OXYGEN 10.0
% EXCESS AIR 85
% CARBON - DIOXIDE: 6.9
PPM CARBON - MONOXIDE 547
PPM NOX: 69
SULFUR - DIOXIDE 8
% EFFICIENCY 87.7
% STACK LOSS 12.3
TEST PERFORMED BY
COMMENTS

Regener 238 Midle of cicle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER
ID. _____
GER NO: YCO 587
TIME. 07 12
DATE. 16 02.95
FUEL: LOW ENERGY GAS
PRIMRY TEMP (C) 33
STACK TEMP (C) 239
% OXYGEN: 9.6
% EXCESS AIR: 79
% CARBON - DIOXIDE. 7.1
PPM CARBON - MONOXIDE: 115
PPM NOX: 73
SULFUR - DIOXIDE. 13
% EFFICIENCY: 86.5
% STACK LOSS: 13.7
TEST PERFORMED BY:
COMMENTS

Regener 238 End of cicle

BACHARACH
MODEL CA300NSX
COMBUSTION ANALYZER
ID. _____
GER NO YCO 587
TIME: 07:20
DATE: 16.02.95
FUEL LOW ENERGY GAS
PRIMRY TEMP (C) 33
STACK TEMP (C) 234
% OXYGEN 9.4
% EXCESS AIR: 76
% CARBON - DIOXIDE 7.3
PPM CARBON - MONOXIDE: 41
PPM NOX: 75
SULFUR - DIOXIDE: 13
% EFFICIENCY. 85.5
% STACK LOSS: 14.5
TEST PERFORMED BY:

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Время 3 12+8г	BHCHARACH MODEL CA3000MSX ********** COMBUSTION ANALYZER	BHCHARACH MODEL CA3000MSX ********** COMBUSTION ANALYZER
	ID: ----------	ID: ----------
	SER NO: YCO 507	SER NO: YCO 507
Дата	TIME: 03:32	TIME: 03:44
	DATE: 16.02.95	DATE 16 02 95
Топливо Уголь	FUEL COAL	FUEL: COAL
Первичная темп (снаруж. воздух)	PRIMARY TEMP (C) 25	PRIMARY TEMP (C) 25
Температура в газоходе	STACK TEMP (C) 336	STACK TEMP (C) 343
Кислород, %	% OXYGEN 14.1	% OXYGEN 12 9
Избыток воздуха %	% EXCESS AIR: 287	% EXCESS AIR 168
Двуокись углерода, %	% CARBON - DIOXIDE. 6 7	% CARBON - DIOXIDE: 7 9
Окись углерода, часть на миллион	PPM CARBON - MONOXIDE: 435	PPM CARBON - MONOXIDE: 584
Окислы азота, часть на миллион	PPM NOX. 115	PPM NOX: 97
Двуокись серы, часть на миллион	PPM SULFUR - DIOXIDE: 6	PPM SULFUR - DIOXIDE: 28
К.П.Д.	% EFFICIENCY: 69.5	% EFFICIENCY: 73.8
Потеря с уходящими газами	% STACK LOSS: 30.5	% STACK LOSS: 27 8
	TEST PERFORMED BY.	TEST PERFORMED BY:
	COMMENTS .	COMMENTS

BEST AVAILABLE COPY

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A.2 ECO # 2 - COKE BATTERIES #1 & #2 - TEMPERATURE METERING ACCURACY

Utilization of a infrared thermometer with digital display will provide replicability of measurement regardless of user. With replicability in the measurement, the plant will be able to determine the completion of a coking cycle with less margin of overheating.

Supply of heating fuel to the coke batteries will be reduced due to reduction of fuel input per time. An additional advantage is that less of the final product will be scrap as reported by plant personnel. Attaining sufficient coking times to ensure continuous process (with limited coal supply) will be obtained by reduction of process temperature.

Annual Fuel and Energy Saving

Although efficiency improvement potential is believed to be much greater, savings are calculated based on a 1% savings of coke gas input per batch for a 25 hour coke batch.

Total fuel used in battery #1 & #2 — @ #1 -- 20,000 m^3/hr of coke gas
@ #2 -- 10,000 m^3/hr of coke gas and 10,000 m^3 of blast furnace gas per hour

Annual hours of operation = 8,760 hours per year

Annual fuel used in battery #1 & #2

Coke gas = (20,000 + 10,000) * 8760 = 262,800,000 m^3 per year

Blast furnace gas = 10,000 * 8760 = 87,600,000 m^3 per year

$FS_{COKE\ GAS}$ = 262,800,000 m^3/year * 1% = 2,628,000 m^3/yr

$FS_{BLAST\ FURNACE\ GAS}$ = 87,600,000 m^3/year * 1% = 876,000 m^3/yr

$ES_{COKE\ GAS}$ = 2628000 * 3934 kcal/ m^3 /1,000,000 kcal/Gcal * 3.968 MMBtu/Gcal =
= 41,023 MMBtu/yr

$ES_{BLAST\ FURNACE}$ = 876,000 * 775 kcal/ m^3 /1,000,000 kcal/Gcal * 3.968 MMBtu/Gcal =
= 2,694 MMBtu/yr

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Annual Cost Savings

Local Prices

CS = (2,628,000 m^3/yr * 1,650 karb/ m^3 + 876,000 m^3/yr * 514 karb/ m^3) / 133,000 karb/$US =
= $35,988 /year

World Prices

CS = (41,023 MMBtu/yr + 2,694 MMBtu/yr) * $2 = $ 87,434/yr

Implementation cost:

$ 4,000 US including shipping and handling

Simple Payback:

At Local Prices = $4,000 / $35,988 = 41 days

At World Prices = $4,000 / $87,434 = 17 days

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A.3 ECO # 3 STRAW OIL HEATING OVEN - EXCESS AIR CONTROL

With monthly use of a portable combustion analyzer, the excess air quantity can be adjusted down to provide much improved fuel utilization By reduction of excess air, it is conservative that oven efficiency can be increased to 60% Efficiency will be improved by increasing flame temperature, thus increasing heat transfer Additional efficiency will be gained due to a reduced amount of flue gasses discharge

Oven measurements taken during audit

Oxygen (O_2)	14 4 %
Carbon dioxide (CO_2)	6 4 %
Stack temperature	515° C
Combustion Air Temperature	13° C
Combustion Efficiency	48 4 %

Annual Fuel and Energy Saving

These efficiency improvements represent an annual savings of

$FS = A * B * [1 - (\eta_{exist} / \eta_{new})]$, m^3/yr,

$ES = FS * HC / C * D$, MMBtu/yr, where

FS --	Fuel saving, m^3/yr
ES --	Energy savings, MMBtu/yr
A --	Gas consumption rate of oven, m^3/hr
B --	Annual hours of operation of oven, hr/yr
HC --	Heat Content of coke gas, 3934 kilocalories/m^3
C --	Conversion Factor, 1,000, 000 kcal/Gcal
D --	Conversion Factor, 3,968 MMBtu/Gcal
η --	Oven efficiencies, %

$FS = 2500\ m^3/hr * 8000\ hr/yr * [1-(48\ 4/60)] = 3{,}866{,}667\ m^3/yr$

$ES = 3{,}866{,}667\ m^3/yr * 3934\ Kcal/m^3 / 1{,}000{,}000\ kcal/Gcal * 3\ 968\ MMBtu/Gcal =$
$= 60{,}359$ MMBtu/yr

Annual Cost Savings

Local Prices

CS = 3,866,667 m^3/yr * 1,650 karb/ m^3 / 133,000 karb/$US = $47,970 /year

World Prices

CS = 60,359 MMBtu/yr * $2 = $ 120,718/yr

Implementation Cost:

US $7,000 including cost of shipping and handling

Simple Payback:

At Local Prices = ($7,000/$47,970) = 53 days

At World Prices = ($7,000/$120,718) = 21 days

Трубчатая печь в цехе каменноугольного масла

MODEL CA300KSX
****
COMBUSTION ANALYZER

ID: ----- ---------

SER NO YCD 587

TIME. 03 17

DATE. 15.02.95

FUEL. COAL

PRIMRY TEMP (C) 13

STACK TEMP (C) 515

% OXYGEN: 14 4

% EXCESS AIR: 221

% CARBON - DIOXIDE: 6.4

PPM CARBON - MONOXIDE: 1

PPM NOX: 66

PPM SULFUR - DIOXIDE: 0

% EFFICIENCY: 48.4

% STACK LOSS: 51 6

TEST PERFORMED BY:

COMMENTS

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A.4 ECO # 4 - VARIABLE SPEED DRIVE FOR PURIFIED WATER PUMP #14

To maximize the pumps efficiency, a variable speed drive is recommended to slow the revolutions of the motor when water pumping demand is less This will ensure that the pump will operate at its maximum efficiency possible, regardless of flow rate required In addition, this saves energy by not delivering water at a higher pressure than is required A pressure sensor installed in the discharge piping will control the output of the pump to deliver a consistent pressure regardless of flow The portable electrical meter specified in the energy management program will quantify energy savings prior to and after use of the variable speed drive

Parameters of Operation

Design pump head = 50 meters (estimate), or

50 meters x 3 28 feet per meter = 164 feet of head at rated flow

Design Flow = 100 cubic meters per hour or 440 GPM

Motor Voltage = 380 volts phase to phase, 3 wire delta

1500 RPM, 50 Hz, 380 volts phase to phase

Run hours are continuous minus one week per year maintenance

Annual run hours = 8760 hours per year - (7 days x 24 hours per day) =
= 8590 hours per year running time

Operational Schedule

8 hours/day 100% load -- 8 hours/day 70% load -- 8 hours/day 5% load

Annual Energy Saving

Energy consumption was modeled based on both the present condition of pump operation, as well as operating the pump using a variable speed drive (see following pages) Energy consumption of the pump is projected to be reduced by over 60% Presently this energy goes toward losses inside the pump as well delivery of water at a higher pressure than is required The anticipating savings is 665,000 kWh per year

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Annual Cost Savings

$Savings_{LOCAL}$ = \$ 9,300 / yr (see following pages)

$Savings_{WORLD}$ = \$25,850 / yr (see following pages)

Implementation Cost:

Cost to install 200 hp Variable Speed Drive and all necessary support equipment
$Cost_{VSD}$ = \$25,000 (see following pages)

The investment necessary to install a variable speed drive will have a simple payback of

Simple Payback:

At Local Prices = \$25,000 / \$9,300 per year = 2 7 years

At World Prices = \$25,000 / \$25,850 per year = 1 year

DOUG PFESNY
CAPOROZHCOKE
RBM

FAN DUTY CYCLE

SYSTEM PARAMETERS		% AIR FLOW (CFM)		% OPERATING TIME
HOURS PER DAY	24	90	SPECIFIC	24
DAYS PER WEEK	6	66		33
WEEKS PER YEAR	50			
CENTS PER KWH	2.30	5		33
HORSEPOWER	177.00			

PROJECTED ANNUAL ENERGY COST FOR		PROJECTED ANNUAL ENERGY SAVINGS FOR	
CONSTANT SPEED	$ 24,577	ADJUSTABLE FREQUENCY VS CONSTANT SPEED	$ 15,290
INLET VANES	$ 13,008	ADJUSTABLE FREQUENCY VS INLET VANES	$ 2,21
ADJUSTABLE FREQUENCY FAN DRIVE	$ 9,287		

THANK YOU FOR YOUR INTEREST IN VACPROS FOR ASSISTANCE IN SELECTING DYNAMATIC ADJUSTABLE SPEED DRIVES. PLEASE CONTACT

J DRISCOLL

CSI INDUSTRIAL
W239 N1690 BUSSE RD
WAUKESHA, WI 54186
414-548-3950

BEST AVAILABLE COPY

DOUG FRESKY
ZAPOROZHCOKE
RMA

FAN DUTY CYCLE

SYSTEM PARAMETERS		% AIR FLOW (CFM)		% OPERATING TIME
HOURS PER DAY	24	70	SPECIFIC	34
DAYS PER WEEK . . .	6	66		33
WEEKS PER YEAR . .	50			
CENTS PER KWH . . .	6.40	5		33
HORSEPOWER . . .	177.00			

PROJECTED ANNUAL ENERGY COST FOR.

CONSTANT SPEED	$ 68,389
INLET VANES	$ 36,200
ADJUSTABLE FREQUENCY FAN DRIVE .	$ 25,844

PROJECTED ANNUAL ENERGY SAVINGS FOR.

ADJUSTABLE FREQUENCY VS. CONSTANT SPEED ,	$ 42,545
ADJUSTABLE FREQUENCY VS INLET VANES . .	$ 10,356

THANK YOU FOR YOUR INTEREST IN VACPROS FOR ASSISTANCE IN SELECTING DYNAMATIC ADJUSTABLE SPEED DRIVES PLEASE CONTACT

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W239 N1690 BUSSE RD
WAUKESHA WI 53188
414-548 3950

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ENERGY SAVINGS IN PUMP APPLICATIONS

1 Pump Categories - There are two types of pumps

1 1 Centrifugal pumps
1 2 Positive displacement pumps

Centrifugal pumps are the most common, and will be treated in this technical note However, Saftronics G3 and H2 inverters are widely used in Position Displacement pump energy saving applications, such as in refrigeration equipment used in Super markets.

2 Affinity Laws - For centrifugal pumps under zero head (back-pressure) conditions

2.1 Flow Rate varies Directly as Speed $Q_2/Q_1 = (n_2/n_1)$

2 2 Pressure varies with the Square of Speed $P_2/P_1 = (n_2/n_1)^2$

2 3 Power Consumed varies with the Cube of Speed $kW_2/kW_1 = (n_2/n_1)^3$

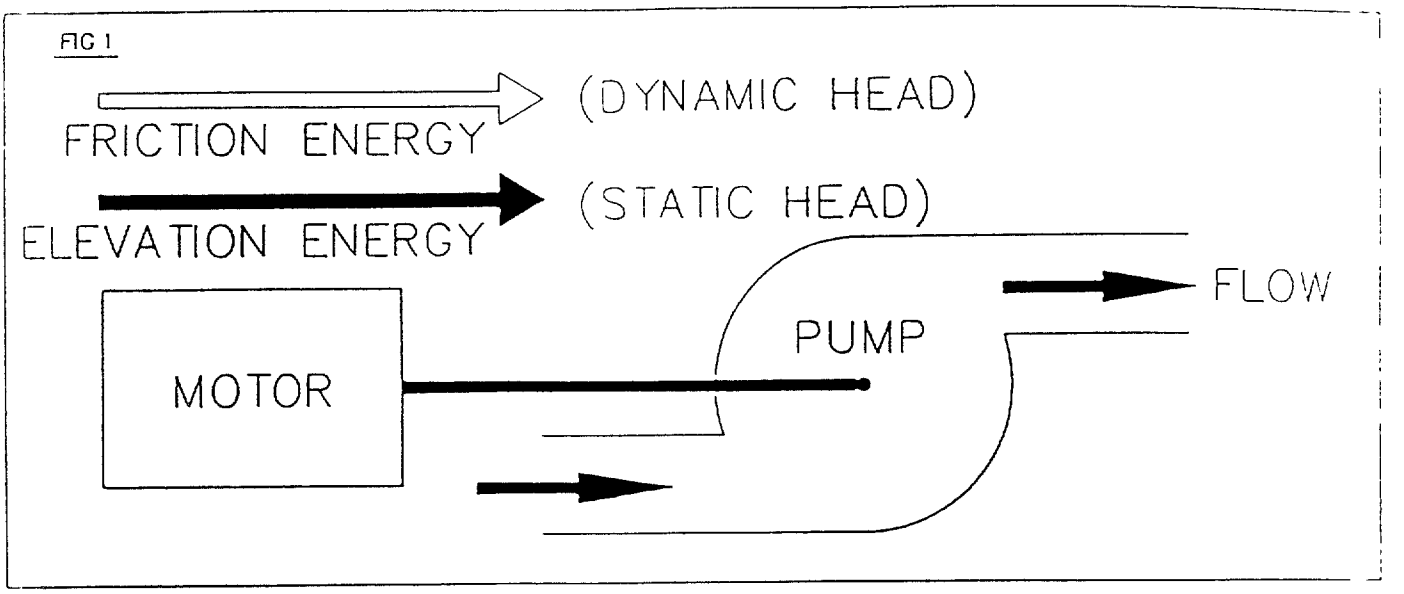
Where:
Q is flow (gallons per minute)
n is pump speed (RPM)
P is pressure (feet of head)
kW is power in kW

Formula 2.3 gives us an idea of the significant energy-saving possibilities Under zero head conditions, the power consumed at 50% speed would be $(1/2)^3$ or 12.5% of full speed power. An 87.5% energy saving!

Unfortunately, a pump normally has to work against a some "head" and this modifies equation 2 3 to decrease the energy savings. Nonetheless, energy savings will still be substantial, and the following simplified treatment will provide a rough idea of the energy savings possible.

3 Nature of Centrifugal Pump Load

3 1 Allocation of Motor Energy



In Fig. 1 the motor provides energy to overcome "elevation", or "Static Head", measured in feet, and must push fluid through the pipes to overcome friction. In pump language, the pressure required to overcome friction is called "Dynamic Head," which varies as the square of pump speed (or flow rate) - see formulas 2 1 and 2 2 The "Dynamic Head" can be made equivalent to a "Head" measured in feet.

4 Pump Curve

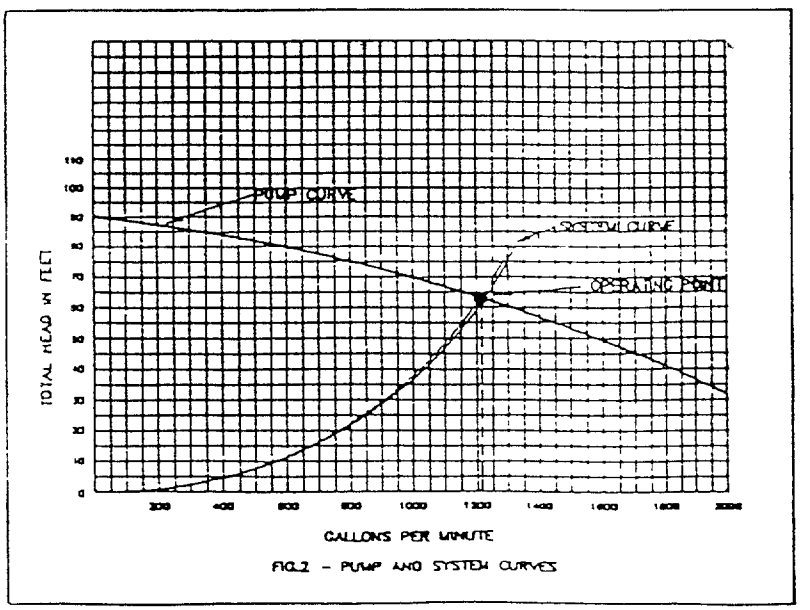


Fig. 2 shows a characteristic flow versus total head (friction and elevation) curve for a 14" impeller pump. This is the "pump curve" The "System Curve" is a performance description dependent on the installation - that is, pipe diameter number of bends, length of pipe etc Where these two curves meet is where the pump operates - In Fig 2, operation would be at 1230gpm

5 Flow Control - We shall consider a pump system with 0 ft static head Before the availability of reliable variable frequency drives, flow control was achieved by throttling the output of the pump In Fig 3, we can decrease the flow rate to 720gpm by partially closing the valve, which modifies the system curve to system #2 When we throttle fluid flow like this, we save energy In this case, at 1230gpm, we would consume 20 7kW, and at 720gpm, we would consume 17 5kW - a small savings of only 3 2kW Why can't we restrict the inlet flow to the pump, such as was done with fans (Variable Inlet Vane Control)? For fans, VIV control yields greater energy saving than Outlet Vane control The answer is that restricting fluid flow into the pump would cause cavitation, resulting in eventual mechanical damage to the pump's impeller This is why, when compared to mechanical flow control systems, Variable Frequency Drives (VFD's) will provide greater energy savings in pump than in fan applications.

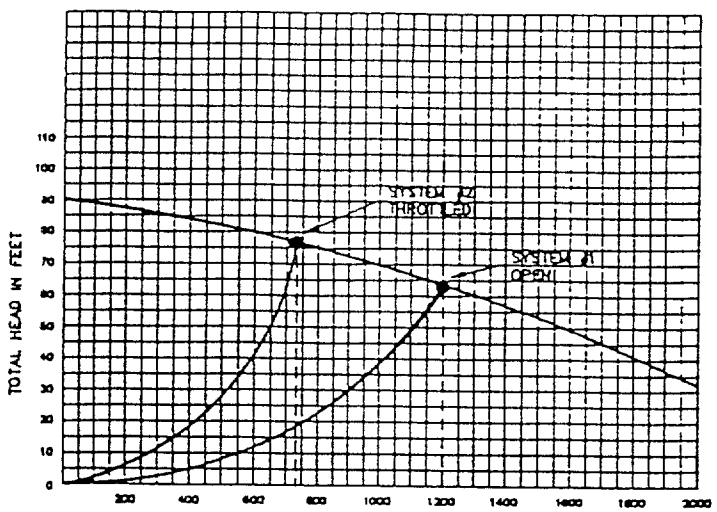


FIG 3 FLOW CONTROL BY THROTTLING

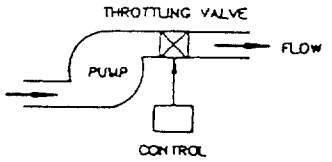


Fig 4 shows flow control by means of pump speed control Unlike Fig. 3, the System Curve has remained the same. But the "Pump Curve" at speed 2 has changed, and as in Fig. 3, we again obtain 720gpm. But with a VFD, the power consumed has decreased from 20 7kW to 4 5kW - a saving of 16 2kW (compare with 3 2kW saving with throttling valve)

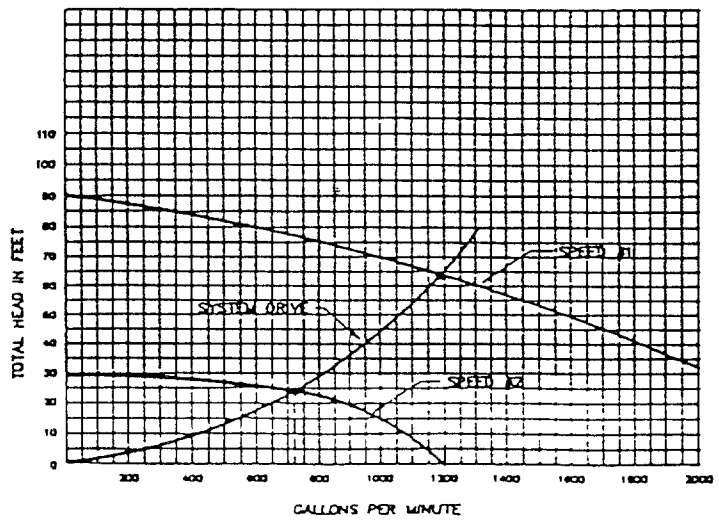
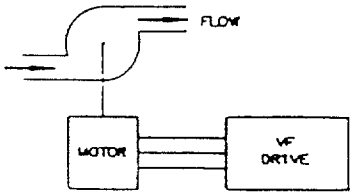


FIG. 4 FLOW CONTROL BY VF DRIVE



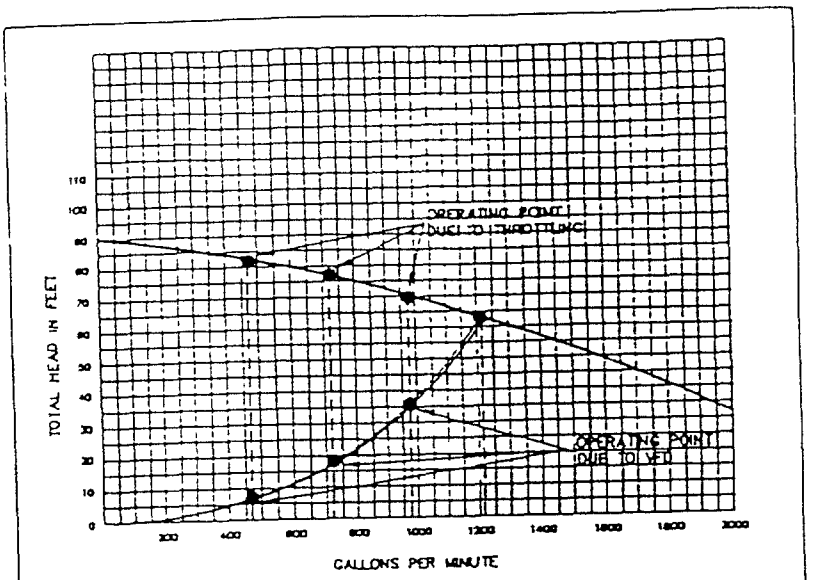


FIG.5 – VARIABLE SPEED OPERATION

FLOW	THROTTLING		VARIABLE SPEED	
GPM	TOTAL HEAD (FT)	KW	TOTAL HEAD (FT)	KW
1220	83	20.8	83	20.8
960	69	19.2	40.3	10.7
720	75	17.5	22.7	4.5
480	81	15.8	10	1.3

Fig 5 shows a comparison of operating points due to throttling and due to VFD operation. The power consumption for throttling flow control is obtained from the manufacturer's pump curves, but the method used to extract this information is beyond the scope of this tech note The results are listed in Fig 5 The power consumption for Variable Speed drive operation is calculated from the affinity law formula in 2.3 ($kW_2/kW_1 = (n_2/n_1)^3$, which applies here because of the "0" static head condition

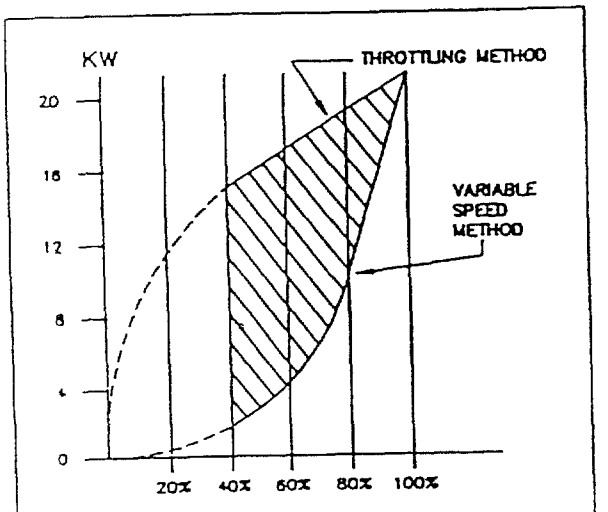


FIG.6 – POWER REQUIREMENT VS. % OF FLOW

Fig 6 shows a comparison of power consumed for the two methods, and the shaded area shows energy savings achieved with VFD operation.

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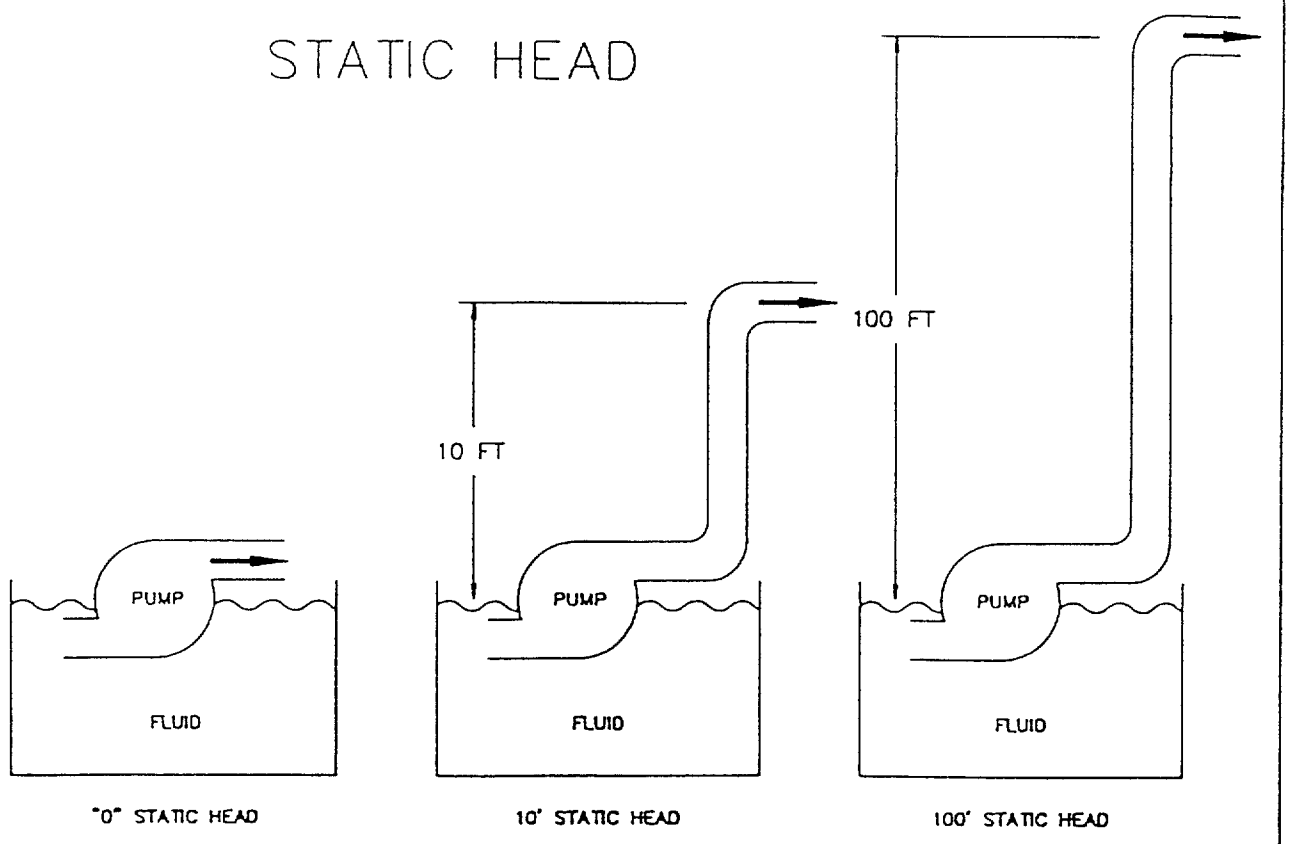
6 Flow Control With Static Head

As stated before, the examples shown had only "Friction" or "Dynamic Head", and no "Static Head" or elevation associated with it Fig 7 depicts what is meant by "Static Head"

FIG 7



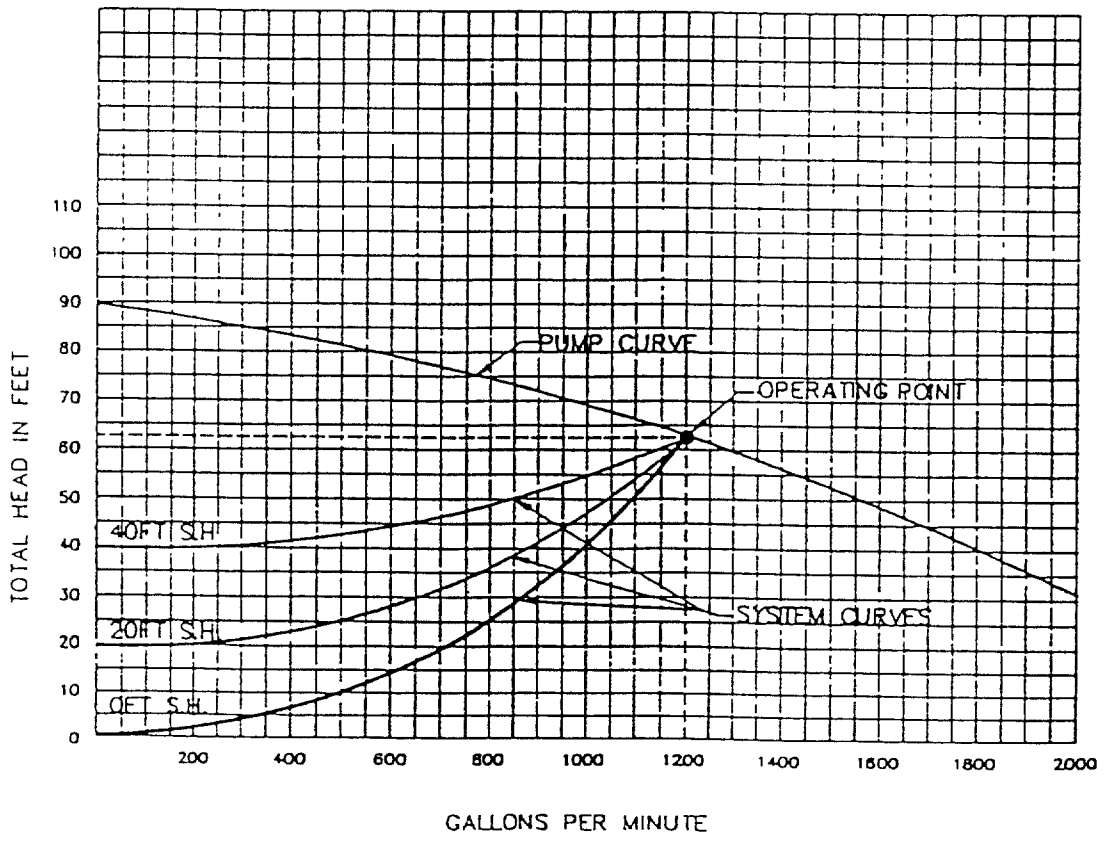
Static Head changes the "System Curve" and the power requirements will be different. Affinity law 2.2 states: $P_2 = P_1 \times (n_2/n_1)^2$
and $P_2 = P_1 \times (Q_2/Q_1)^2$ from 2.1
$\therefore P_2 = Q_2^2 \times (P_1/Q_1^2) = KQ_2^2$
Where $K = (P_1/Q_1^2) = K$ _ _ _ _ _ 4.1

With static head, the system formula becomes

Total Head (ft) $= K_1 \times (\text{Flow})^2 + K_2$ _ _ _ _ _ (4 2)
where K_1 is system constant (in ft)
K_2 is static head (in ft)
Flow is in gpm

Using 4 2 the power curve can be calculated, but we need to know both pump and system curves, and the analysis may require the use of a computer Saftronics has a better method, and that is, to use the ultra-compact G3 inverter for pumps up to 75HP (460V) on a trial basis The G3 has both RPM (frequency) and kW readouts, and the pump user can quickly determine his energy saving by temporarily operating his pump at full speed against a throttling valve, and then at the desired flow rate at reduced speed, with the valve wide open.

Fig 8 shows 3 systems curves for differing static heads Note that the "Static Head" is shown on the vertical axis at 0gpm, and we have system curves for 0 ft , 20 ft. and 40 ft of Static Head In all cases, we still operate at 1230gpm at a total head of 63 ft , but at 20 ft , the Static Head is 31% of total head, and at 40 ft , the Static Head is 63% of total head



S.H. = STATIC HEAD FIGURE 8 – STATIC HEAD SYSTEM CURVES

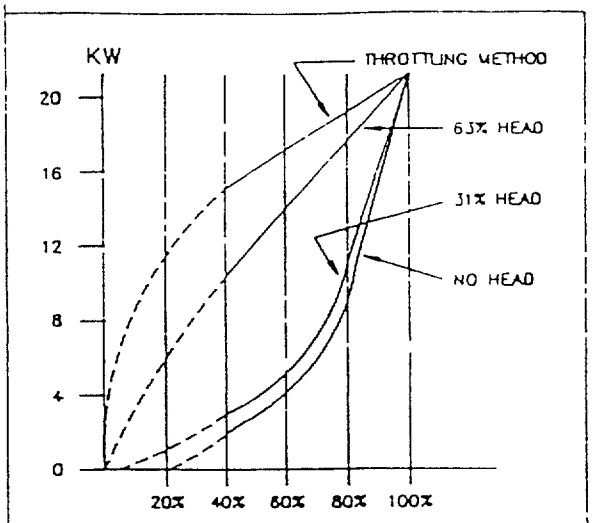


FIGURE 9 – SYSTEM POWER REQUIREMENTS

Fig 9 shows a comparison of flow control by throttling and by VFD under the three different static heads of Fig 8 Note that the energy savings difference decreases as the static head increases, but is still significant, even at 63% static head.

7 Actual Example

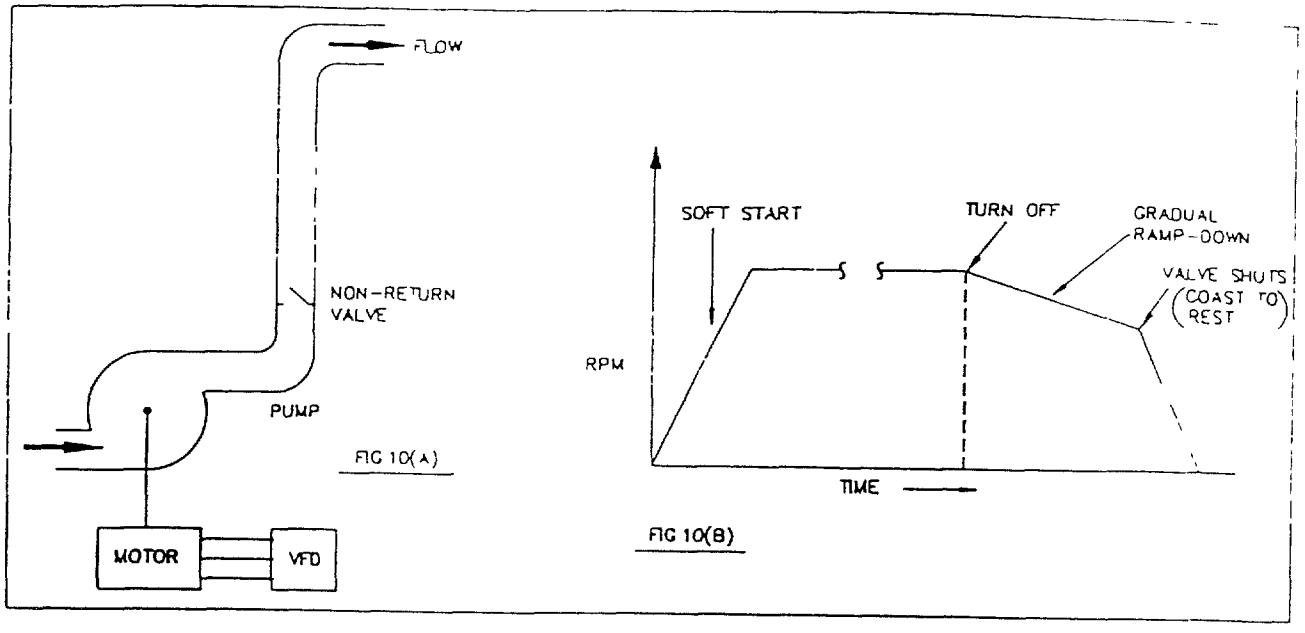
60HP deep-well pump capable of delivering 1000gpm, and operating against a Static Head of 65 ft is throttled back to deliver 250gpm Operation under this condition is 24 hr./day for 200 days and 12 hrs /day for the rest of the year. Measured values are: 65A at 480V. Power Factor is 0 8 What annual energy savings can be achieved by use a Saftronics Variable Speed Drive?

Total operating time is 6780 hrs./year
Present power consumption is 65 x 480 x $\sqrt{3}$ x 0 8 = 43.2kW
Application of a VFD shows a current draw of 35A at P.F = 1 = 29.1kW

Energy saving is 43 2 - 29.1 = 14 1kW

Annual energy saving is 14.1 x 6780 = 95,598 kW-hrs.
at $0.05/kW hr., annual saving = $4,780 00
at $0.075/kW hr , annual savings = $7,170.00

8 Water Hammer



All Saftronics Variable Frequency drives have separately adjustable acceleration and deceleration times They can be used to provide a "soft" start, as well as provide gradual reduction of fluid flow when the pump is shut off to completely eliminate "water hammer" caused by the column of water crashing onto the non-return valve see Fig. 10(A) When the pump is abruptly shut-off, see Fig. 10(B). In areas prone to frequent power outages, Saftronics inverters can be provided with battery back-up to provide 2 second "ride-through" capability, or to provide controlled deceleration if the outage lasts for more than 2 seconds

In addition, there are other advantages, such as soft-starting, less system pressure, resulting in longer-lasting seals and bearings, quieter operation, cooler running motor, and less downtime, all of which have monetary benefits often exceeding the energy savings. Saftronics inverters can be supplied with a 2 second power outage "ride-through" option to maintain pumping operation even in lightning-prone areas where power outages are frequent

For further information contact

SAFTRONICS INC
5580 ENTERPRISE PARKWAY
FT MYERS, FL 33905
PHONE (813)693-7200
TOLL FREE (800)533-0031
FAX (824)693-2431

A.5 ECO # 5 COKE TAR SETTLING TANK - LEVEL CONTROL

Using the audit team's infrared non-contact thermometer, the manager of this process found that he could easily tell the division between the coke tar and water The substances have different specific heats Given consistent heat loss at all heights of the tank, the different substances put in at the same time will change temperature at different rates This creates a noticeable temperature difference at the division line After seeing a noticeable temperature differences between the substances, he came up with the idea that the tar could be pumped off the bottom as a continuous process because he could monitor where the level of the coke tar was and stop the pump if necessary

Savings from this measure are seen by reducing heat lost from tar prior to reheating for distillation

Annual Energy Saving

$Savings_{Kcal} = M_{TAR} \times S\ H_{TAR} \times (T_{SAVED})$

M_{TAR} -- Mass of tar processed per year, kilograms
= 9,000 Kg per hour x 24 hours per day x 365 days per year = 78,000,000 Kg per year

$S\ H_{TAR}$ = Specific Heat of Tar Oil = 0 5 Kcal / Kg * ∘C

T_{SAVED} = Degrees C of temperature improvement by reducing waiting time = 20∘C

ES = (78,000,000 Kg / year) * (0 5 Kcal/Kg* ∘C) * (20∘C) /1,000,000 kcal/Gcal
= 780 Gcal/yr or
= 780 * 3 968 MMBtu/Gcal = 3095 MMBtu/yr

Annual Cost Savings

Local Prices

CS = (780 Gcal/year) * (US $4 091/Gcal) / (70% efficiency) = $2,233 per year

World Prices

CS = (780 Gcal/year) * 3 968 MMBtu/Gcal * (US $2 00/MMBtu) / (70% efficiency) =
= $4,333 per year

Implementation Cost:

US $3,500 including cost of shipping and handling

Simple Payback:

At Local Prices = $3,500 / $2,233 per year = 1 57 years

At World Prices = $3,500 / $4,333 per year = 0 81 year

A.6 ECO # 6 ENERGY MANAGEMENT PROGRAM ENHANCEMENT

This recommendation is to provide the plant necessary metering tools to identify and quantify energy conservation opportunities By metering, the plant can quantify energy savings so they can prioritize conservation technology expenditures among competing production enhancing investments

Included is typical energy management campaigns to achieve a successful basic energy conservation program These will provide examples of simple programs that are proven to be profitable investments of manpower

Energy awareness and conservation participation of all plant staff is crucial to a successful demand side energy management program

Annual Fuel and Energy Saving

By using the above recommended metering tools, along with programs similar to those described above, a plant can effectively minimize their consumption of energy Within one year, one percent of the plants energy will be reduced by the awareness created with the above recommended metering alone This savings will be seen in no cost / low cost management measures

ES = Total plant energy consumption in the year 1994 * 1%

ES_{POWER} = 96,107,000 kWh * 0 01 = 961,070 kWh/yr

$FS_{COKE\ GAS}$ = 620,194,000 m^3 * 0 01 = 6,201,940 m^3/yr

$ES_{COKE\ GAS}$ = 6,201,940 * 3934 kcal/ m^3 /1,000,000 kcal/Gcal * 3 968 MMBtu/Gcal =
= 96,813 MMBtu

$FS_{BLAST\ FURNACE\ GAS}$ = 194,720,000 m^3 * 0 01 = 1,947,200 m^3/yr

$ES_{BLAST\ FURNACE\ GAS}$ = 1,947,200 * 775 kcal/ m^3 /1,000,000 kcal/Gcal * 3 968 MMBtu/Gcal =
= 5,988 MMBtu/yr

$ES_{THERMAL\ ENERGY}$ = 707,224Gcal/yr * 0 01= 7,072 Gcal / yr or
7,072 * 3 968 MMBtu/Gcal = 28,062 MMBtu/yr

Annual Cost Savings

Local Prices

CS = (961,070 kWh/yr * 2400 karb/kWh + 6,201,940 m^3/yr * 1,650 karb/ m^3 +
+1,947,200 m^3/yr *514 karb/ m^3 + 7,072 Gcal / yr * 1,412,000 karb/Gcal) / 133,000 karb/$US =
= $176,889/yr

World Prices

CS = 961,070 kWh/yr * $0 064/kWh + (96,813 MMBtu + 5,988 MMBtu/yr) *
* $2/MMBtu + 28,062 MMBtu/yr * $7 56/MMBtu = $479,259/yr

Simple Payback:

At Local Prices = $55,000 / $176,889 = 3 7 months

At World Prices = $55,000 / $479,259 = 1,4 month

11

Steam Loss From Different Size Leaks At Various Pressures

STEAM LOSS IN POUNDS PER YEAR

STEAM PRESSURE IN PSI	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
15	30,064	120,262	480,583	1,922,292
50	64,753	259,025	1,035,103	4,140,322
100	115,630	462,545	1,848,398	7,393,432
150	165,351	661,439	2,643,209	10,572,608
200	216,228	864,959	3,456,504	13,825,718
300	316,826	1,267,373	5,064,611	20,258,004
600	618,621	2,474,616	9,888,929	39,554,861

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN ATMOSPHERES	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 0	13,665	54,664	218,447	873,769
3 4	29,433	117,739	470,501	1,881,965
6 8	52,559	210,248	840,181	3,360,651
10 2	75,159	300,654	1,201,459	4,805,731
13 6	98,286	393,163	1,571,138	6,284,417
20 4	144,012	576,079	2,302,096	9,208,183
40 8	281,191	1,124,825	4,494,968	17,979,482

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN KG/SQ CM.	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 1	13,665	54,664	218,447	873,769
3.5	29,433	117,739	470,501	1,881,965
7 0	52,559	210,248	840,181	3,360,651
10 5	75,159	300,654	1,201,459	4,805,731
14 1	98,286	393,163	1,571,138	6,284,417
21.1	144,012	576,079	2,302,096	9,208,183
42.2	281,191	1,124,825	4,494,968	17,979,482

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN KILOPASCALS	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
103 4	13,665	54,664	218,447	873,769
344 7	29,433	117,739	470,501	1,881,965
689 5	52,559	210,248	840,181	3,360,651
1,034 2	75,159	300,654	1,201,459	4,805,731
1,379 0	98,286	393,163	1,571,138	6,284,417
2,068 4	144,012	576,079	2,302,096	9,208,183
4,136 9	281,191	1,124,825	4,494,968	17,979,482

STEAM LOSS IN DOLLARS PER YEAR AT A FUEL PRICE OF:

$4.00 Per million BTU's

STEAM PRESSURE IN PSI	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
15	172	687	2,746	10,985
50	370	1,480	5,915	23,659
100	661	2,643	10,562	42,248
150	945	3,780	15,104	60,415
200	1,236	4,943	19,751	79,004
300	1,810	7,242	28,941	115,760
600	3,535	14,141	56,508	226,028

STEAM PRESSURE IN ATMOSPHERES	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 0	172	687	2,746	10,985
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344 7	370	1,480	5,915	23,659
689 5	661	2,643	10,562	42,248
1,034 2	945	3,780	15,104	60,415
1,379 0	1,236	4,943	19,751	79,004
2,068 4	1,810	7,242	28,941	115,760
4,136 9	3,535	14,141	56,508	226,028

HEAT LOST PER FOOT OF UNINSULATED PIPE - In Dollars per year

Fuel Cost = $4.00 per 1 million BTU's
70 degrees Fahrenheit ambient temperature
emissivity = 95
air velocity = 0 miles per hour

COST OF FUEL FROM BARE PIPE HEAT LOSS USING 70% EFFICIENCY TO POINT OF LOST HEAT

PIPE SIZE (in inches)	OPERATING TEMPERATURE IN DEGREES FAHRENHEIT 212	300	400	500	600	700	800	900	1000	1100	1200
0 50	$4	$8	$14	$21	$31	$43	$58	$76	$99	$126	$158
0 75	$5	$10	$17	$26	$38	$53	$72	$95	$123	$156	$197
1 00	$6	$12	$21	$32	$47	$66	$89	$117	$152	$195	$245
1.25	$8	$15	$26	$40	$59	$82	$111	$147	$191	$244	$307
1.50	$9	$17	$29	$46	$67	$93	$126	$167	$217	$278	$350
2.00	$11	$21	$37	$56	$82	$115	$156	$207	$270	$345	$435
2.50	$13	$25	$43	$67	$99	$138	$188	$249	$325	$416	$525
3.00	$15	$30	$52	$81	$119	$167	$227	$301	$393	$503	$636
4.00	$19	$38	$66	$103	$151	$212	$289	$384	$501	$643	$813
5.00	$24	$46	$80	$126	$184	$260	$354	$472	$616	$790	$1,000
6.00	$28	$54	$95	$148	$218	$307	$419	$559	$730	$937	$1,186
8 00	$35	$69	$121	$190	$280	$395	$541	$722	$943	$1,213	$1,536
10.00	$43	$85	$149	$234	$346	$489	$669	$894	$1,169	$1,504	$1,906
12 00	$51	$100	$175	$276	$407	$576	$789	$1,055	$1,381	$1,777	$2,253
14 00	$56	$109	$191	$301	$445	$630	$864	$1,155	$1,513	$1,948	$2,470
16 00	$63	$124	$217	$342	$506	$717	$983	$1,315	$1,724	$2,220	$2,816
18 00	$70	$138	$243	$383	$567	$803	$1,102	$1,475	$1,934	$2,491	$3,161
20 00	$78	$153	$269	$424	$627	$889	$1,221	$1,635	$2,144	$2,762	$3,506
24 00	$92	$182	$319	$504	$705	$1,061	$1,457	$1,953	$2,561	$3,303	$4,194
FLAT / SQ FT	$16	$32	$55	$86	$127	$178	$243	$324	$423	$543	$687

LIGHTING ENERGY USE - TOTAL FIXTURE KILOWATT-HOURS WITH BALLAST

(based on, medium or mogal base, clear, general service, Philips Brand lamps)

INCANDESCENT	TOTAL WATTS	INITIAL LUMENS OUTPUT	INITIAL LUMENS PER WATT	SERVICE LIFE	COST	1000 HOURS PER YEAR	2000 HOURS PER YEAR	3000 HOURS PER YEAR	4000 HOURS PER YEAR	5000 HOURS PER YEAR	6000 HOURS PER YEAR	7000 HOURS PER YEAR	8000 HOURS PER YEAR	8760 HOURS PER YEAR
15 watt	15	126	8 4	2500	$2 11	15	30	45	60	75	90	105	120	131
25 watt	25	260	10 4	1000	$1 31	25	50	75	100	125	150	175	200	219
40 watt	40	480	12 0	1500	$1 31	40	80	120	160	200	240	280	320	350
60 watt	60	890	14.8	1000	$1 14	60	120	180	240	300	360	420	480	526
75 watt	75	1220	16 3	750	$1 31	75	150	225	300	375	450	525	600	657
100 watt	100	1750	17 5	750	$1 31	100	200	300	400	500	600	700	800	876
150 watt	150	2850	19 0	750	$1 87	150	300	450	600	750	900	1,050	1,200	1,314
200 watt	200	3900	19 5	750	$2 25	200	400	600	800	1,000	1,200	1 400	1,600	1,752
300 watt	300	6300	21.0	750	$3 20	300	600	900	1,200	1,500	1,800	2 100	2,400	2,628
500 watt	500	10750	21 5	1000	$7 61	500	1,000	1,500	2,000	2,500	3,000	3 500	4,000	4,380
750 watt	750	16700	22 3	1000	$23 85	750	1,500	2,250	3,000	3,750	4,500	5,250	6,000	6,570
1000 watt	1000	23100	23 1	1000	$18 14	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	8,760
1500 watt	1500	33300	22 2	1000	$29 60	1,500	3,000	4,500	6,000	7,500	9,000	10 500	12,000	13 140
FLUORESCENT														
2 x 40 watt lamps standard C&C ballast cool white lamps	95	6100	64 2	20000		95	190	285	380	475	570	665	760	832
2 x 32 watt lamps electronic ballast F032 tri phos lamps	58	6100	105 2	20000	$45 00 2 lamps & electronic ballast	58	116	174	232	290	348	406	464	508

LIGHTING ENERGY COST - TOTAL FIXTURE CONSUMPTION WITH BALLAST

(based on, medium or mogal base, clear, general service, Philips Brand lamps)

OPERATION COST BASED ON KWH PRICE OF **$0.064** PER KWH

INCANDESCENT	TOTAL WATTS	INITIAL LUMENS OUTPUT	INITIAL LUMENS PER WATT	SERVICE LIFE	COST	1000 HOURS PER YEAR	2000 HOURS PER YEAR	3000 HOURS PER YEAR	4000 HOURS PER YEAR	5000 HOURS PER YEAR	6000 HOURS PER YEAR	7000 HOURS PER YEAR	8000 HOURS PER YEAR	8760 HOURS PER YEAR
15 watt	15	126	8 4	2500	$2 11	$1	$2	$3	$4	$5	$6	$7	$8	$8
25 watt	25	260	10 4	1000	$1 31	$2	$3	$5	$6	$8	$10	$11	$13	$14
40 watt	40	480	12.0	1500	$1.31	$3	$5	$8	$10	$13	$15	$18	$20	$22
60 watt	60	890	14 8	1000	$1 14	$4	$8	$12	$15	$19	$23	$27	$31	$34
75 watt	75	1220	16 3	750	$1 31	$5	$10	$14	$19	$24	$29	$34	$38	$42
100 watt	100	1750	17 5	750	$1 31	$6	$13	$19	$26	$32	$38	$45	$51	$56
150 watt	150	2850	19.0	750	$1 87	$10	$19	$29	$38	$48	$58	$67	$77	$84
200 watt	200	3900	19 5	750	$2 25	$13	$26	$38	$51	$64	$77	$90	$102	$112
300 watt	300	6300	21 0	750	$3 20	$19	$38	$58	$77	$96	$115	$134	$154	$168
500 watt	500	10750	21 5	1000	$7 61	$32	$64	$96	$128	$160	$192	$224	$256	$280
750 watt	750	16700	22 3	1000	$23 85	$48	$96	$144	$192	$240	$288	$336	$384	$420
1000 watt	1000	23100	23 1	1000	$18 14	$64	$128	$192	$256	$320	$384	$448	$512	$561
1500 watt	1500	33300	22 2	1000	$29 60	$96	$192	$288	$384	$480	$576	$672	$768	$841
FLUORESCENT														
2 x 40 watt lamps standard C&C ballast cool white lamps	95	6100	64 2	20000		$6	$12	$18	$24	$30	$36	$43	$49	$53
2 x 32 watt lamps electronic ballast F032 tri phos lamps	58	6100	105 2	20000	$45 00 2 lamps & electronic ballast	$4	$7	$11	$15	$19	$22	$26	$30	$33

APPENDIX B
Photographs of Facility and Equipment

Photo #1 - Local Engineer and Process Operator
Performing Combustion Efficiency Monitoring of Coke Ovens

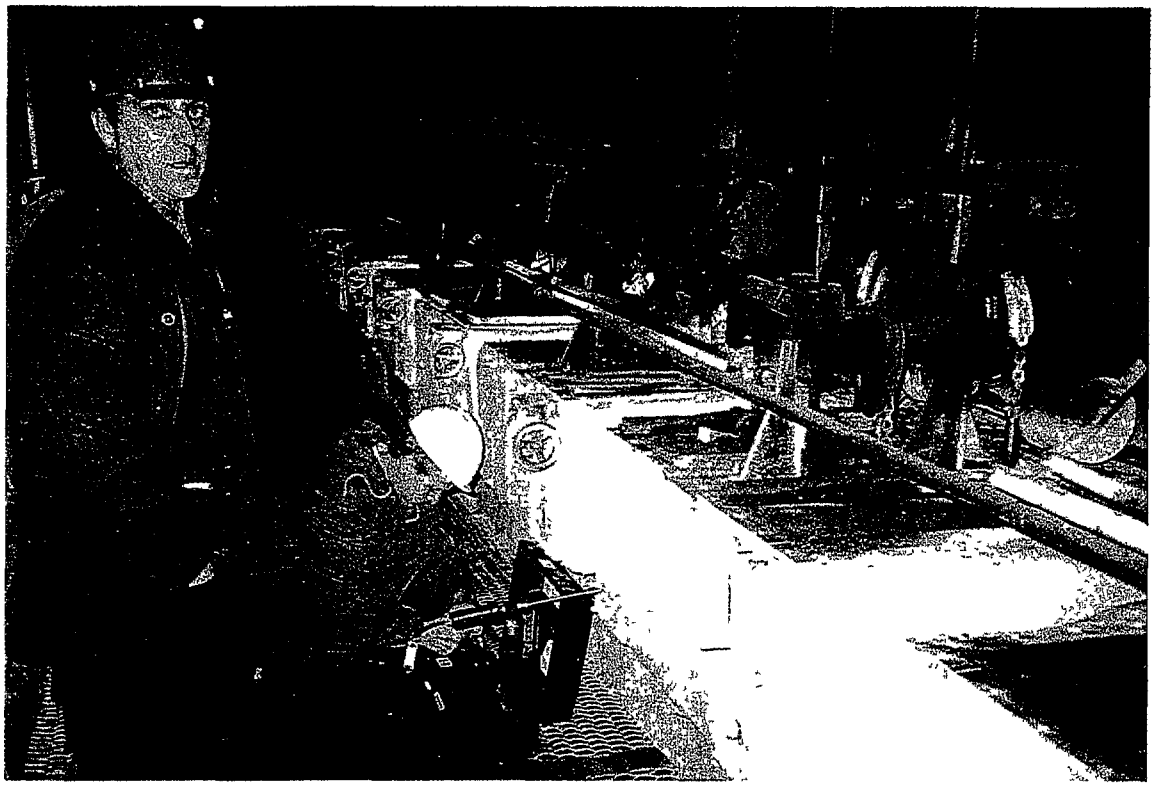


Photo #2 - Coke Oven Air Intake Opening

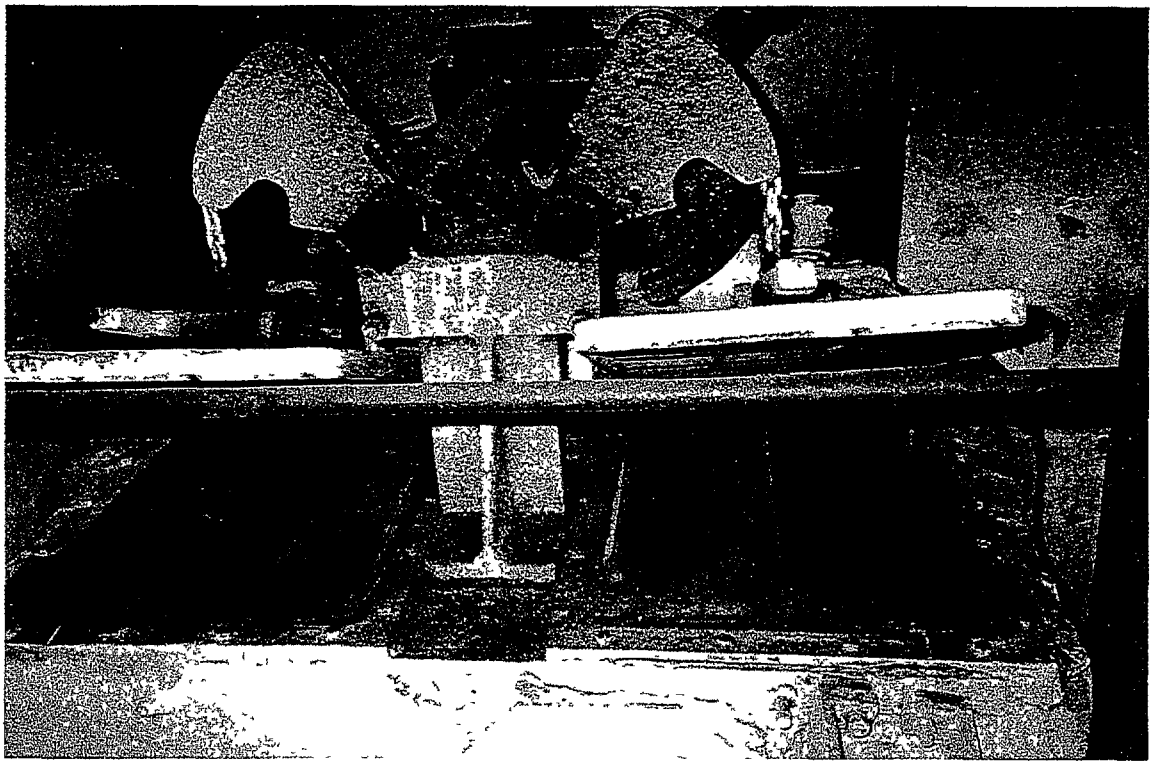


Photo #3 - Coke Oven Ports and Coal Loading Ports (top of battery)

Photo #4 - Enriched Straw Oil Heating Stove

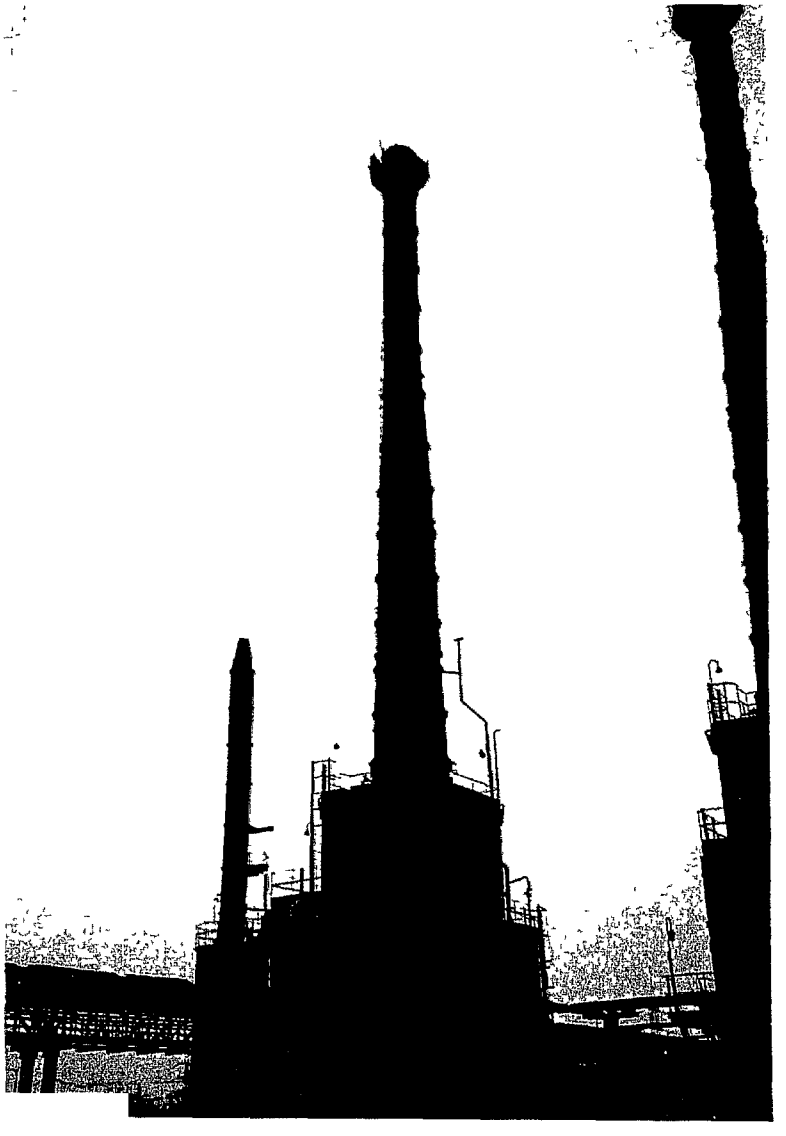


Photo #5 - Enriched Straw Oil Heating Stove - Bank Of Nine Burners

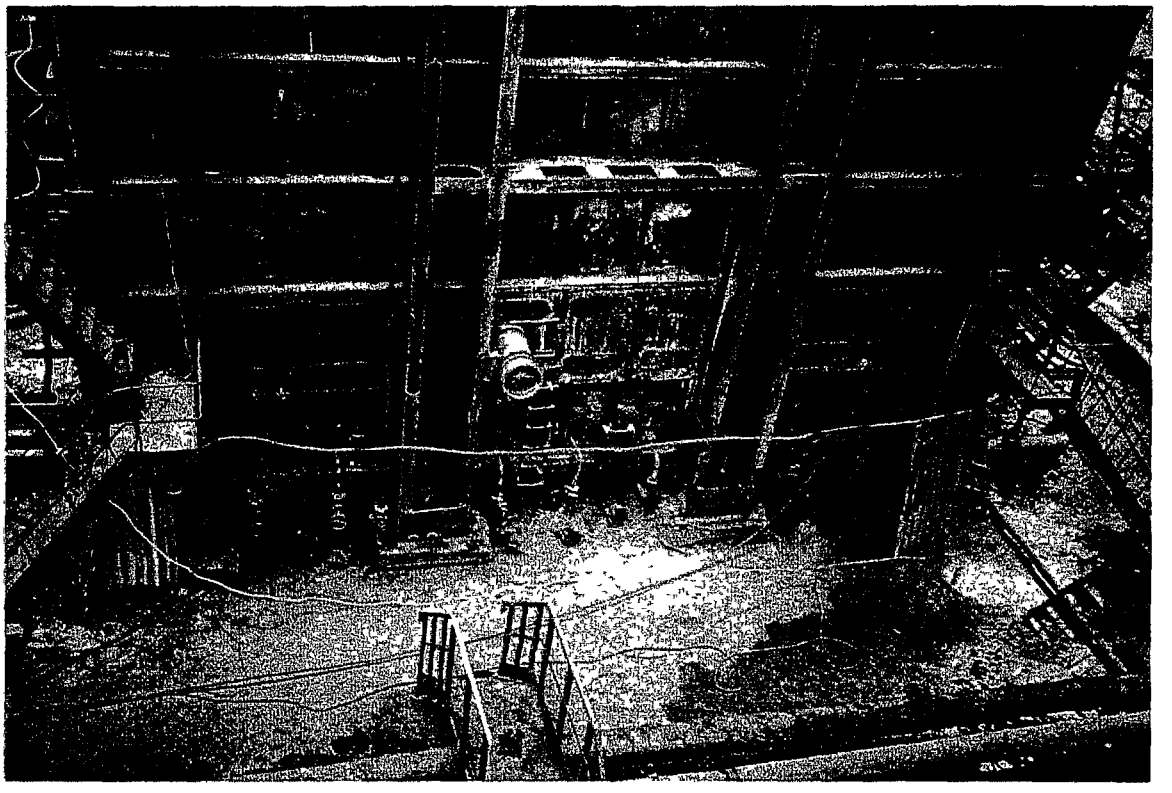
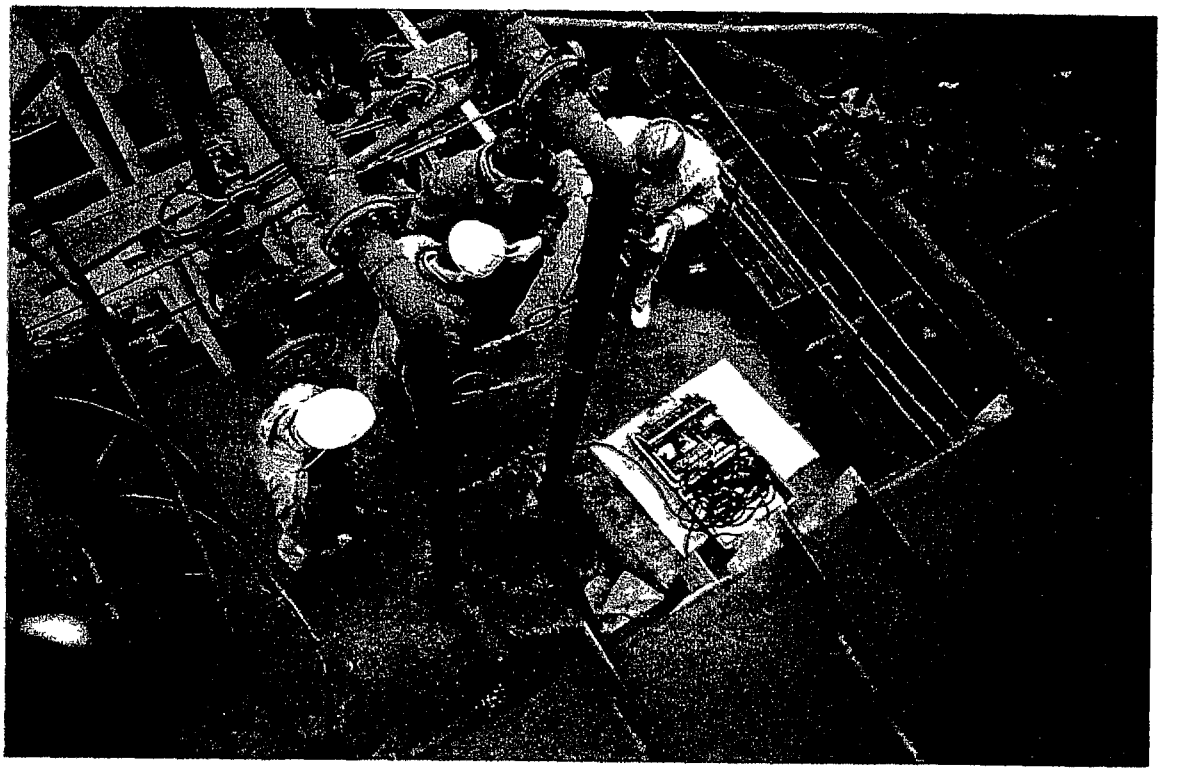


Photo #6 - Combustion Efficiency Measurement Of Enriched Straw Oil Heating Stove



APPENDIX C
World Energy Prices

Table C.1 World Energy Prices; OECD Europe

Industrial Sector	Fuel	US$/toe	US$/mmBtu	US$ per
	Light Fuel Oil	290	7	383 tonne
	Heavy Fuel Oil	151	4	158 tonne
	Electricity	742	19	0 064 kWh
	Natural Gas	151	4	141 km^3
	Steam Coal	128	3	90 tonne
	Coking Coal	92	2	58 tonne
	Thermal	298	8	30 Gcal

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APPENDIX D
Plant Fuels Analysis

Table D.1 Plant Fuels Analysis

	Unit	Coke Gas	Blast Furnace Gas
Lower Heating Value	kcal/norm cub m	3934	730 -- 820
Density per normal condition (20°C, 760 mm. of water)	kg/norm cub m	0 438	
Carbon Dioxide, CO_2	%	2 2	16 3
Oxygen, O_2	%	1 1	0 4 -- 0 5
Carbon Monoxide, CO	%	7 1	21 1
Hydrogen, H_2	%	57 6	5 7
Methane, CH_4	%	25 2	
Nitrogen, N_2	%	4 7	56 4
Illuminants, CmH_n	%	2 1	
Hydrogen Sulfide, H_2S	%	0 3 -- 0 4	

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Table D.2 Plant Energy Consumption History
Energy Consumption and Production, Year 1994

1. ELECTRICITY	**000 kWh.**
Total Consumption	96,107
Including	
Process needs (drying, heating, electric welding)	192
Motors	91,910
Lighting	3,213
Losses within the lines and transformers	792

Claimed maximum demand
25,000 kW, between 01/01/94 -- 07/31/94
17,000 kW, between 08/01/94 -- 12/31/94

2. COKE GAS	**000 cub.m**
Total Production	620,194
Total Consumption	325,891
Including	
By Coke-Oven Batteries (combustion within heat walls)	270,162
Sell to Zaporozhstal	287,975
Losses in the Coking Process	6,328
3. BLAST FURNACE GAS	**000 cub.m**
Consumption by Coke-Oven Battery (Consumption started from 06/09/94)	194,720
4. THERMAL ENERGY (STEAM AND HOT WATER)	**Gcal**
Total Consumption	707,224

APPENDIX E
Contacts Made During Site Audit

Ukraine, Country Code = 7
Zaporozhye, City Code = 0612
FAX # 35-01-41

PLANT ADDRESS Zaporozhcoke,
Ukraine, 330600, Zaporozhye
P/b - 681, Zaporozhcoke

Valery N Rubchevsky
Vice President (Chief Engineer)
Phone 39-33-87 or 62-69-43

Genady I Miroshnichenko
Deputy Energy Manager in charge
of energy conservation

Alexander I Kompaniets
Chief of Resin and Pitch Processing Shop
Phone 39-22-38 or 42-91-17

Vladimir S Sharagin
Chief of Energy Shop
Phone contact via Chief Energy Manager

Leonid V Prosenchuk
Resin and Pitch Processing Shop
Manager of Biochemistry Division
Phone 39-35-73

Yakov D Kachan
Shop of Chemical Products Retention
in Coking Process, Manager of Division
of Final Cooling of coke gas and retention
of aromatic hydrocarbons (benzol)
Phone contact via Chief Energy Manager

Yevgeny P Ivashutkin
Chief Energy Manager
Phone Office 9-33-44 or 39-23-96
Home 42-98-83

Georgy V Shakun
Chief of Coke Battery Shop
Phone 39-27-27

Sergey N Danilov
Chief of the Shop of Retention Chemical
Products in the Coking Process
Phone 39-21-85

Vladimir I Markov
Coke Battery Shop, Deputy Chief
(in charge of combustion gas usage)
Phone contact via Chief of Coke Shop

Valintin G Bylkov
Chemical Products Retention in Coking
Process, Deputy Chief in charge of primary
cooling (coke resign water separation
and catalytic pollution gas incineration)
Phone 39-32-22 or 29-92-52

Arkady P Omelyanenko
Deputy Chief of the Energy Shop
Phone contact via Chief Energy Manager

Yelena S Komova
Senior Electrical Foreman
Phone contact via Chief Energy Manager

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APPENDIX F
USAID Letter of Audit Intent - Ukrainian Translation

APPENDIX "F"
USAID LETTER OF AUDIT INTENT - UKRAINIAN TRANSLATION

USAID

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

24 жовтня 1994 року

Кого це може стосуватися

Агентство США з Міжнародного Розвитку (USAID), що є офіційною частиною Посольства США в Києві, Україні засвідчує Вам свою повагу і має за честь надати наступну інформацію.

Агентство США з Міжнародного Розвитку є урядовим органом, що здійснює технічну та гуманітарну допомогу Україні в таких галузях як охорона здоров'я, приватизація, охорона навколишнього середовища, енергетика та природні ресурси. Стосовно програм з енергетики, одним з важливих проектів є підвищення ефективності використання енергії в промислових підприємствах. Здійснюють цей проект три американські фірми Burns and Roe Enterprises, Foster Wheeler, Resource Management Associates.

Завданням зазначених вище фірм є проведення аудиторської роботи в декількох підприємствах, що інтенсивно споживають електроенергію, визначити заходи щодо зменшення рівня споживання енергії, та визначити типи обладнання для проведення демонстраційного проекту Агентство США з Міжнародного Розвитку має намір надати до 100 тис доларів США на обладнання для демонстраційного проекту кожному з визначених підприємств Сподіваємося, що керівництво підприємств погодиться провести монтаж цього обладнання та періодично проводити виміри щодо споживання енергії в умовах роботи нового енергозберігаючого обладнання

В Агентстві США з Міжнародного Розвитку ми сподіваємося, що за допомогою високоефективного енергозберігаючого обладнання можна значно ефективніше використовувати енергію і розповсюдити цей досвід в Україні.

Сподіваємося на Ваше розуміння важливості цієї роботи в тих складних умовах з енергопостачанням в Україні. Ваша підтримка надасть можливість безкоштовно для підприємств встановити обладнання, за допомогою якого з'явиться можливість зберігати енергію.

З повагою,

Андрій Партнов
Радник керівника програм з енергетики

320 TWENTY-FIRST STREET N.W. WASHINGTON D.C. 20523

APPENDIX G
Audit Equipment List

RESOURCE MANAGEMENT ASSOCIATES
of Madison Inc

202 State Street
Suite 303
Madison, WI 53703 U.S.A.

Telephone 608/283 2880
Facsimile 608/283 2881

EQUIPMENT TURNED OVER TO THE KIEV OFFICE OF THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID) c/o IDEA\PADCO

ITEM	EQUIPMENT DESCRIPTION	QUANTITY	RECEIVED
1	Platinum RTD thermometer w/ probes	1	DMP
2	Wahl Heat Spy infrared thermometer	1	DMP
3	Rechargeable battery pack for Heat Spy	1	DMP
4	TIF 2000A clamp-on digital wattmeter	1	DMP
5	Fluke 85 digital multimeter	1	DMP
6	Fluke 80i-410 current probe for multimeter	1	DMP
7	TIF 2300 power factor meter	1	DMP
8	Sperry SLM-110 digital light meter	1	DMP
9	Kurz 444 hot wire anemometer	1	DMP
10	24" probe for Kurz anemometer	1	DMP
11	Battery recharger	1	DMP
12	Voltage converter	2	DMP
13	Foreign plug adaptor	2	DMP
14	Rechargeable 9 volt battenes	12	DMP
15	Dranetz / PowerStar manuals	1	DMP
16	Dranetz 808A power analyzer including - 3 current probes, cables, paper	1	DMP
17	Canon INNOVA laptop computer	1	DMP
18	HP DeskJet printer	1	DMP
19	Nova Strobe DB stroboscopic tachometer	1	DMP
20	Bacharach 300NSX combustion analyzer	1	DMP
21	Bacharach 48" probe for combustion analyzer	1	DMP

The equipment listed above has been turned over to the Kiev office of the United States Agency for International Development (USAID) By signing this form the receiver accepts full responsibility for the care and custody of all items and must be able to provide accountability reports if requested This equipment was originaly procured by Burns & Roe Company and is being turned over on their behalf

Turned over by:

Signature

Name DOUG TRESNY

Title ENERGY ENGINEER

Date FEB 22, 1995

Received by:

Signature

Name DARIAN DIACHOK

Title CHIEF-OF-PARTY, IDEA\PADCO - KIEV

Date FEB 22, 1995

APPENDIX H
Standard Abbreviations and Conventions Used in Report

Glossary

AC	Alternating Current
amps	amperes
atm	atmosphere(s) - 14 696 pounds per square inch
bar	100,000 pascals - 14 504 pounds per squared inch
BTU or Btu	British thermal unit
cfm	cubic feet per minute
cm	centimeter = 0 3927 inches
cm^2	square centimeter - 0 155 square inches
CO	carbon monoxide
CO_2	carbon dioxide
°C	degree(s) CelsiusT = 5/9 [T° F - 32]
°F	degree(s) FahrenheitT
°R	degree(s) RankineT = T° F + 460
DC	Direct Current
DSM	Demand-Side Management
E	East
EAF	Electric Arc Furnace
ECO	Energy Conservation Opportunity
eff	efficiency
EEM	Energy Efficiency Measure
ex air	excess air
ft^2	square feet
ft^3	cubic feet
Gcal	Gigacalorie(s) = 1 billion calories = 3 968 million BTU
GJ	Gigajoule(s) = 1 billion joules
gph	US gallons per hour
gpm	US gallons per minute
GWh	GigaWatt hour(s) = (10^6 kWh) = 1 billion watt hours
H_2	hydrogen
H_2O	water
H_2SO_4	sulfuric acid
hectare	10,000 square meters = 2 471 acres
hectoliter	100 liters = 26 42 US gallons
Hg	mercury
hp	horsepower

hps	high-pressure sodium lighting
hr	hour
Hz	hertz = cycles per second
J	joule(s)
kcal	kilocalories = 1 thousand calories = 3 968 BTU
kg	kilogram
Kgcc	7,000 kcal = 27,776 BTU
kJ	kilojoules = 1 thousand joules = 0 947813 BTU
km	kilometer = 0 621 miles
kN	kilonewton = 1 thousand newtons
kp	kopeck = 01 ruble
kPa	kilopascal(s) = 1 thousand pascals = - 14504 pounds per square inch
kV	kilovolts = 1 thousand volts
kVA	kilovolt-amperes
kVAr	kilovars = 1 thousand volt=amperes (reactive)
kW	kiloWatt(s)
kWh	kiloWatt hour(s)
lb(s)	pound(s)
liter	0 2642 US gallons = 0 03531 cubic feet
m	meter(s)
m^2	square meter(s)
m^3	cubic meter
mA	milliampere = 0 001 amperes
MBTU or MMBTU	mega BTU = 1 million BTU
MCal	megacalorie = 1 million calories
metric ton	1 thousand kilograms = 1 1023 US tons
mg	milligram(s)
min	minute
MCF	one thousand cubic feet
MJ	megajoules
MM or mln	million
MPa	1 million pascals = 145 04 pounds per square inch
mv	mercury vapor lighting
MW	megawatts
MWh	megawatt hours = 1 million watt hours
NG or n g	natural gas

nm	nanometer
Nm^3	cubic meters at standard conditions of temperature and pressure (20° C and 1 atmosphere)
NO_x	nitrogen oxide
O_2	oxygen
P	pressure
PC	personal computer
ppm	parts per million
psig	pounds per square inch (gauge)
R	ruble
RMA	Resource Management Associates of Madison, Inc
RPM or rpm	Revolutions Per Minute
s	second
SO_2	sulfur dioxide
sq ft	square feet
T	temperature
Tcal	teracalorie = 1 trillion calories = 3 968 billion BTU
therm	volume of natural gas 100 cubic feet, 100,000 BTU
TPS	Thermal Power Station
TWh	TeraWatt hour(s) (10^9 kWh)
U S or US	United States
V	volt(s)
VA	volt-amps
VArs	volt-amps (reactive)
VSD	variable speed drive
$US	United States Dollars
yr	year

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APPENDIX I
Specifications for Recommended Equipment

Combustion Analyzer Specification

One - Bacharach Model CA300NSX combustion analyzer with accessories

Fuels capability

- Natural Gas (local composition)
- #5 fuel oil
- Coal
- Blast furnace gas
- Coke gas
- Mixes of above gasses

Measurement Capacity

O_2, CO, NO_2,, SO_2,,Temperature

Calculation Capacity

- Combustion efficiency
- CO_2 concentration
- Excess air ratio

Accuracy

NO_2	+/- 5% of reading
SO_2	+/- 5% of reading

Probes	12-inch and 48-inch
Sampling hose	20 feet minimum
Output	Thermal printer in unit
Power supply	Rechargeable battery

Manufacturer	Bacharach
Model	CA 300 NSXE N 24-8032

IMPLEMENTATION OF ABOVE EQUIPMENT

Cost for purchase and shipping = $7,000

Infrared Non-Contact Thermometer Specification
(High Temperatures)

Wahl Brand Infrared thermometer, model DHS-29XT or Equal

Range	900 to 3,200 degrees Fahrenheit (482 to 1,760 degrees Celsius)
Accuracy	+ or - 0 3% of full scale reading
Aiming	telescope sight
Emissivity	adjustable
Scale	Fahrenheit and Celsius switchable
Resolution	1 degree
Warranty.	3 years
Power.	battery for portability
Options	220 volt rechargeable battery pack - 40 hours continuous operation

IMPLEMENTATION PRICING

$3,500 base unit
$ 400 rechargeable battery pack
$ 100 shipping

$4,000 Total

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Combustion Analyzer Specification

One - Bacharach Model CA300NSX combustion analyzer with accessories

Fuels capability

Natural Gas (Local composition)
#5 fuel oil
Coal
Blast furnace gas
Coke gas
Mixes of above gasses

Measurement Capacity

O_2, CO, NO_2, SO_2, Temperature

Calculation Capacity

Combustion efficiency
CO_2 concentration
Excess air ratio

Accuracy

NO_2 +/- 5% of reading
SO_2 +/- 5% of reading

Probes	12-inch and 48-inch
Sampling hose	20 feet minimum
Output	Thermal printer in unit
Power supply	Rechargeable battery
Manufacturer	Bacharach
Model	CA 300 NSXE N 24-8032
Spare Cells	two year supply with frequent use
Spare Thermal Paper	100 rolls (nominal)
Operating Manual	translated into the Russian language

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VARIABLE SPEED DRIVE SPECIFICATION

1 Safetronics model FPC-2000 VFD with PID Control - or Equal
- 0 to 10 vDC or 4 to 20 mA speed reference input
- isolated form C contact for remote inverter fault indication
- set point control in software
- elapsed time meter
- kWh meter
- analog output proportional to output power
- line reactor

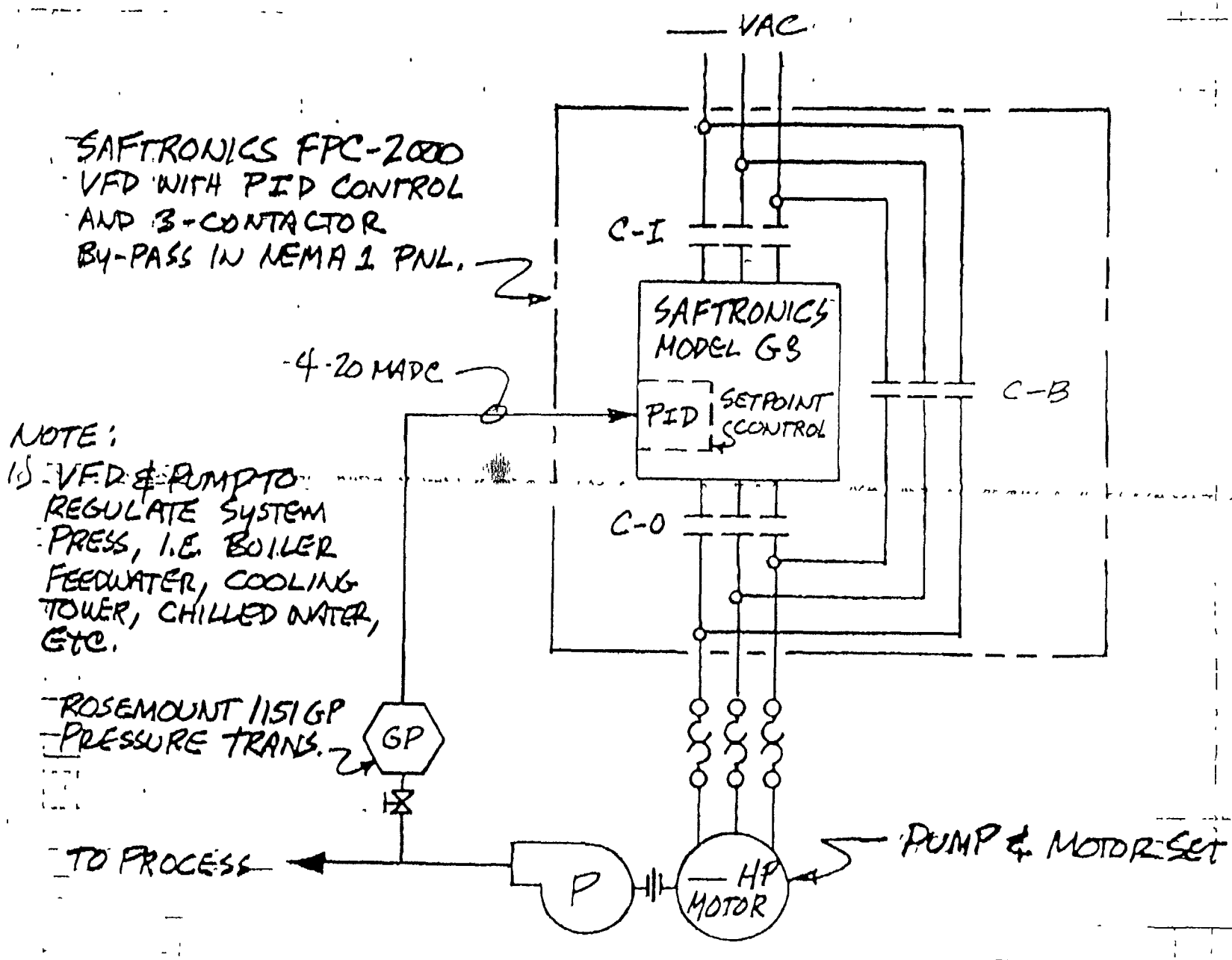
2 Rosemont 1151 GP pressure transducer (4 - 20 maDC) compatible with item #1 PID with 3 valve manifold and appropriate piping tap fittings

3 3 contactor VFD bypass switch

4 Nema-1 Wall Mounted Enclosure for above
- door interlocked circuit breaker
- door mounted digital operator station
- drive / off / bypass selector switch
- drive run / test selector switch
- manual / auto switch via input contact points

5 Enclosure completely assembled and tested

6 Installation instructions and operating manual translated into Russian



COMBUSTION SYSTEMS
WAUKESHA, WISCONSIN

PROJECT: SAFTRONICS VFD-PUMP CONTROL
LOCATION:

Infrared Non-Contact Thermometer Specification
(Midrange Temperatures)

Wahl Brand Infrared thermometer, model DHS-26XL1 or Equal

Range	0 to 2,000 degrees Fahrenheit or -20 to 1,000 degrees Celsius
Accuracy	+ or - 0 3% of reading
Aiming	LCD laser sight
Emissivity	adjustable
Scale	Fahrenheit and Celsius switchable
Resolution	1 degree
Warranty	3 years
Power	battery for portability
Options	220 volt rechargeable battery pack
Pricing	$3,000 base unit
	$ 400 rechargeable battery pack
	$ 100 shipping

	$3,500 Total

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Easy to Use and Easily the Best

Infrared Thermometer
NIST Traceable Accuracy

Heat Spy Digital Infrared Thermometer with NIST traceable accuracy is the most advanced, easy to use and durable IR thermometer in the world. Its precision ground mirror, protected by a rare earth germanium filter, tightly focuses IR energy on the patented detector for accuracy as good as ±0.3% full scale with 1°F/°C resolution.

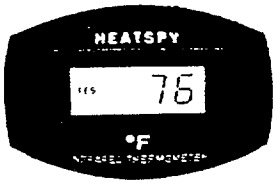
Temperature readings are updated a quick-fire 3 times per second on a unique liquid crystal display — more readable than black. The entire body is cast or extruded aluminum which provides greater shielding than plastic against stray EMF from machinery and engines.

Factory Mutual Approved models for potentially explosive environments are also available (see page 29)

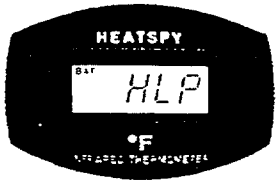
Use Heat Spy with confidence. Thousands have been in trouble-free service for 10 years or longer. We stand behind them with a three-year warranty, factory recalibration and service.

Measured temperature is updated 3 times per second on large LCD

PEAK holds highest temperature and is especially useful in high temperature scans



TEST mode flashes room temperature to show Heat Spy is working properly



BATT displays low battery. HLP flashes when instrument is out of specification

---- means measurement is over or under the range of the instrument

U.S. Department of Commerce National Institute of Standards and Technology, formerly National Bureau of Standards (NBS)

BEST AVAILABLE COPY

Rugged Metal Construction and 3-Year Warranty

Model	DHS-24X, XL DHS-24L	DHS-26X, -XT DHS-26L, -XL	DHS-27X	DHS-28X DHS-28XT, XL	DHS-29X DHS-29XT	DHS-35XT	DHS-10X	DHS-8X (see box below)
Application	General Use Best Accuracy Glass Surfaces	General Use including Glass Surfaces	Check Temperature of Flames	High Temp including Glass Surfaces	High Temp Measures Thru Glass/Flames	High Temp Furnace Tubes Annealing Work	Economy Model General Use	Small Targets Electronic Components
Temperature Range	0 to 1000°F 20 to +550°C	0 to 2000°F 20 to 1000°C	600 to 3000°F 316 to 1649°C	32 to 2500°F 0 to 1380°C	900 to 3200°F 482 to 1760°C	800 to 3200°F 426 to 1760 C	0 to 550°F or 20 to 275°C	0 to 1000°F 20 to 550°C
Spectral Range (μ)	8-14	8 14	4 320 4 472	8 14	2 1 2 5	3 5 4 1	8-14	8 14
Accuracy at 77°F ±5°	±0 3% FS	±0 3% FS	0 5% FS	±0 3% FS	±0 3% FS	±0 5% FS	±0 5% FS	0 3% FS
Resolution	1°F/°C	1°F/°C	1°F/°C	1°F/°C	1°F/°C	1°F/°C	1°F/°C	1°F/°C
Ambient Operation Temperature	25 to 125°F -4 to 52°C	25 to 125°F -4 to 52°C	25 to 125°F -4 to 52°C	25 to 125°F -4 to 52°C	25 to 125°F 4 to 52°C	25 to 125°F -4 to 52°C	40 to 110°F 5 to 43°C	25 to 125°F -4 to 52°C
Temp Coefficient	±0 1 deg/deg	±0 1 deg/deg	±0 1 deg/deg	±0 1 deg/deg	±0 1 deg/deg	±0 1 deg/deg	±0.2 deg/deg	±0 1 deg/deg
Repeatability	±1°F	±2°F	±3°F	±3°F	±3°F	±3°F	±2°F	±2°F
Response Time to 95% of Reading	1 sec	1 sec	1 sec.	1 sec	1 sec	1 sec	2 sec	1 sec
Target Size at Focal Point	1 in dia @2 ft	1 in dia @2 ft	3 in dia @10 ft	1 in dia @ 2 ft	1 in dia @10 ft	1 in dia @10 ft	2 in dia @2 ft	0 15 in dia @1 in
Distance to Target Size Beyond Focal Point	20 1	20 1	40 1	20 1	100 1	100 1	20 1	N/A
Practical Working Distance	0 to 40 ft	0 to 40 ft	0 to 100 ft	0 to 40 ft	0 to 150 ft	0 to 150 ft	0 to 40 ft	0 to 8 in
Sighting System	Enclosed Sight or Laser	Enclosed Laser or Telescope	Enclosed Optical Sight	Enclosed Laser or Telescope	Enclosed Sight or Telescope	Enclosed or Telescope	Optical Sight	Light Beam on Center Line
Adjustable Emissivity Range	0 2 1 0	0 2 - 1 0	0.2 - 1 0	0 2 1 0	0 2 1 0	0 2 1 0	Pre-set 0 95	0 2 to 1 0
Output to Recorder	1 mV/deg	1 mV/deg	1 mV/deg	1 mV/deg	1 mV/deg	1mV/deg	None	1 mV/deg
Continuous Operating Time Per Battery	40 hrs Laser 5 hrs	40 hrs Laser 5 hrs	40 hrs	40 hrs Laser 5 hrs	40 hrs	40 hrs	25 hrs	40 hrs
Weight Lbs	2 2	2 2 (T) 2 8	2 5	2 2 (T) 2 8	2 5 (T) 3 0	2 5 (T) 3 0	2 2	2 5

Prices include carrying case spare battery, owners manual, trigger lock, AC adapter (specify 110 or 220 VAC)

MADE IN THE USA

3 YR

ACCREDITED NIST

FM APPROVED

FM Approved for Hazardous Environments

Wahl offers Heat Spy models tested and approved by Factory Mutual laboratories Models are approved for use in Class I and Class II Groups C D, E, F and G hazardous locations This assures safety when used in petrochemical plants, underground mines and other locations where combustible gases, grains and dust are present

FM Approved models are dedicated °F or °C and are furnished without a connection for AC adapter external battery pack or recorder output

To order specify F or °C

DHS-24X (F or C) -FM	LCD
DHS-24 (F or C) -FM	LED
DHS-26X (F or C) -FM	LCD
DHS-26 (F or C) -FM	LED
DHS-28X (F or C) -FM	LCD

For telescopic sight on FM models DHS 26X and DHS 28X add suffix "T" e g DHS-26XTF FM

Price includes carrying case spare battery owners manual and trigger lock

More Useful Accessories

Part No	Description
11441-1	Spare AC Adapter, 110VAC
11441-2	Spare AC Adapter, 220VAC
9852	Spare Trigger Lock
9990	Heat Spy Carrying Case
B-11	Bench Stand
CRM	Calibration/Repair Manual Specify Model/Serial No
EP-10	Emissivity Coating Black Spray Paint
H7D	Leather Holster (except for models with telescopic sight)
MN1604	Standard 9V Alkaline Battery
NIST-HS	NIST Traceable Test Data
RHS-15	Heat Spy Portable Strip Chart Recorder 12 selectable chart speeds 110VAC and rechargeable internal battery
T-12	Heavy Duty Tripod
W2111	Spare Owners Manual, specify model and serial no
BP12-110	Rechg Battery Pack, 110V
BP12-220	Rechg Battery Pack, 220V
WS-14	Safety Wrist Strap

Call Wahl for more great infrared products and blackbody calibration sources or our full line Handbook of Temperature Instruments

CALL TOLL FREE IN THE USA AND CANADA (800) 421-2853 • FAX (310) 670-2840

110

Heat Spy® Has Superior Accuracy and Target Resolution. New Optional Laser Aiming Sight.

Applications

Steam Traps • Electrical Busses
Bearings • Paper • Plastic • Rubber
Glass • Ceramic • Painted Surfaces
Grains • Chips • Asphalt • Wood
Stacks • Furnaces • Shells • Dies
Heat Treating • Chemical Processes
Circuit Boards • Wave Soldering
Welding • High Voltage Targets
Moving and Rotating Machinery
Distant and Hard to Reach Objects

High-Temperature DHS-28X

32 to 2500°F, 0 to 1400°C

We took our general purpose Heat Spy one step higher for those glass gobs, heat treating, annealing and welding applications You still get 3% FS accuracy and 3°F repeatability Laser aiming sight optional

At high temperatures, you probably won t get very close to your target, so we recommend the telescopic sight

3-Year Warranty

DHS-28X	
DHS-28XT	Telescopic Sight
DHS-28XL1	Laser Sight

Economy Model DHS-10X

0 to 550°F, -20 to 275°C

If you can use a Heat Spy-quality general purpose I R thermometer for a low price select the DHS-10X Emissivity is fixed at 95 which is the most common for general applications Measure organic materials painted surfaces, plastics, insulation and factory machinery (Recorder output and peak hold not available)

3-Year Warranty

DHS-10X

DHS-10X Target Diameter vs. Distance

Distance (feet)	2'	10	20
Target Diameter (inches)	2"	7"	13

Enclosed Optical Sight

For most applications the standard enclosed optical sight provides target definition at 4 ft and 20 ft with parallax correction

Ultra-High-Accuracy DHS-24X

0 to 1000°F 20 to 550°C

You can t get more accuracy or sensitivity between these temperature ranges ±3°F/±1 5°C to be precise Repeatability is a tight ±1°F Use the DHS-24X to measure all normal materials including glass surfaces Carbon dioxide and water vapor won't affect readings Laser aiming sight with LED display and FM approved models are available

3 Year Warranty

DHS-24X	LCD Display
DHS-24XL1	LCD Laser Sight
DHS-24L1	LED Display, Laser Sight

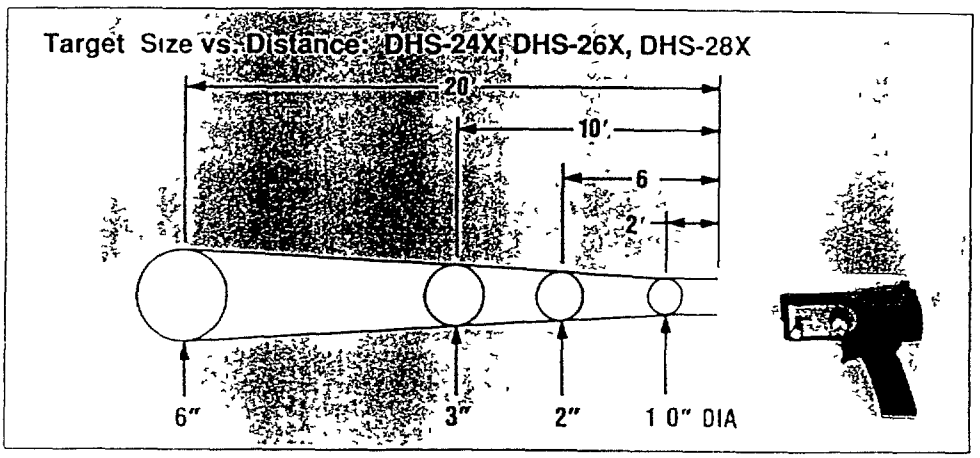
Wide Range DHS-26X

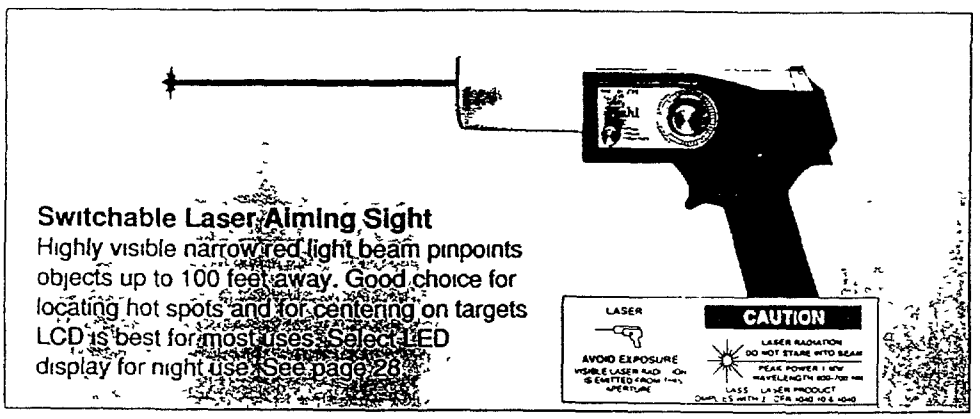
0 to 2000°F 20 to 1000°C

Our most popular Heat Spy combines the ± 3% accuracy of the DHS 24X with a temperature range suitable to most general purpose maintenance and process applica tions The DHS 26X features an optional telescopic sight as well as LED laser sight and FM approved models

3 Year Warranty

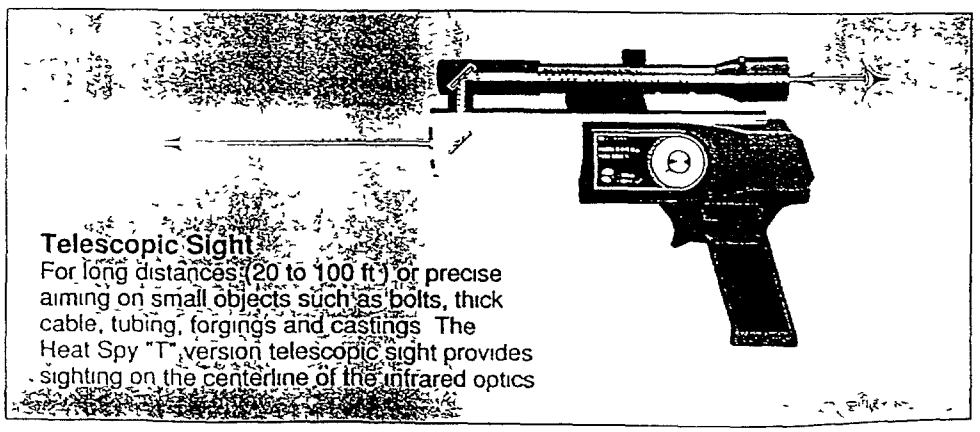
DHS-26X	LCD Display
DHS-26XT	LCDTelescopic Sight
DHS-26XL1	LCD Laser Sight
DHS-26L1	LED Display Laser Sight





Switchable Laser Aiming Sight

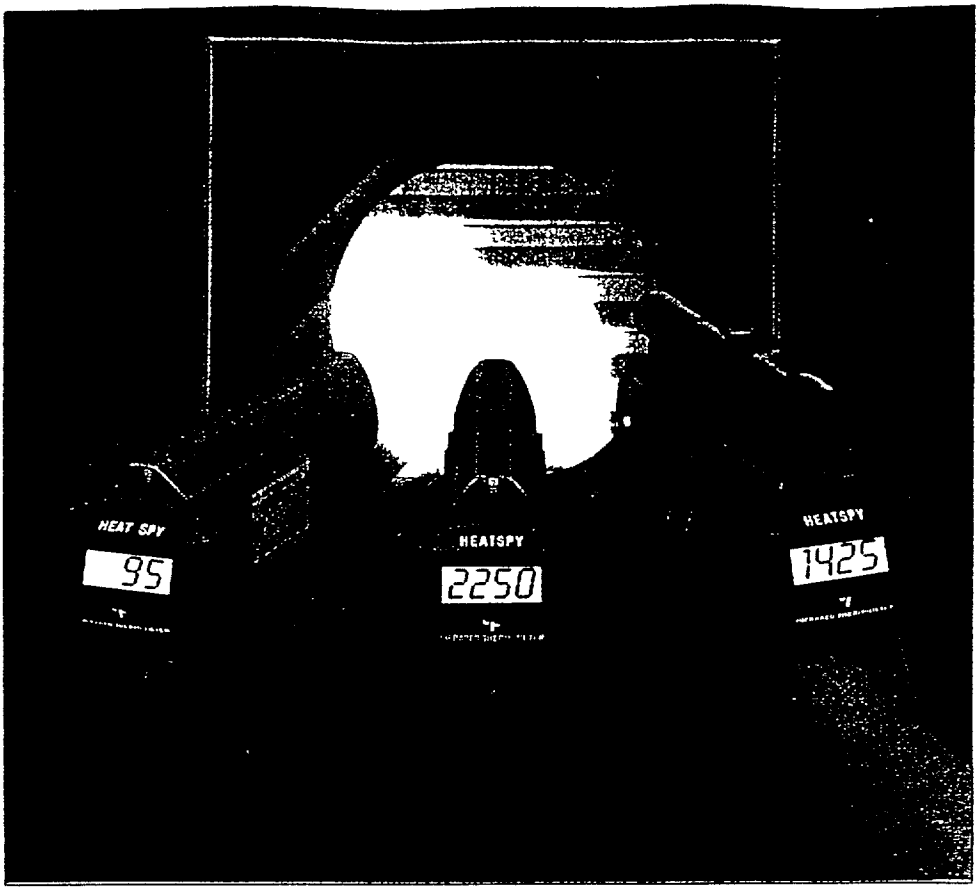
Highly visible narrow red light beam pinpoints objects up to 100 feet away. Good choice for locating hot spots and for centering on targets LCD is best for most uses. Select LED display for night use. See page 28



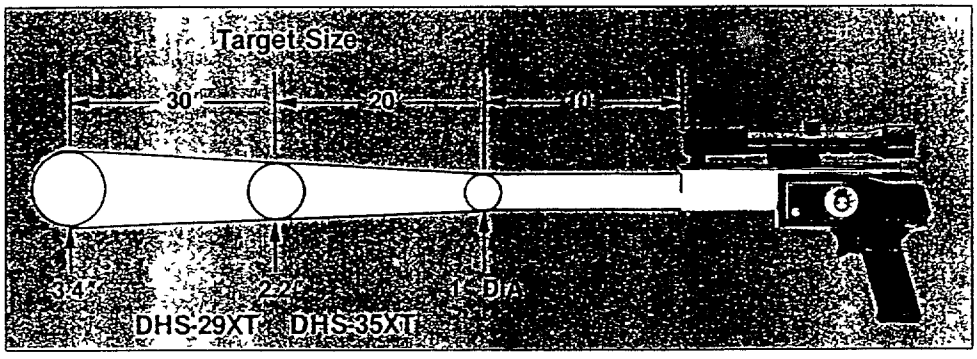
Telescopic Sight

For long distances (20 to 100 ft) or precise aiming on small objects such as bolts, thick cable, tubing, forgings and castings The Heat Spy "T" version telescopic sight provides sighting on the centerline of the infrared optics

FOR HEAT SPY SPECIFICATIONS, REFER TO PAGE 29



Heat Spy measures surface temperatures of glass, furnace walls and furnace tubes



Heat Spy®

For crucial high temperature applications tap into Wahl's "hands-off experience"

Infrared thermometry is one of the very best ways to measure surfaces at very high temperatures Special narrow spectral ranges are required however depending upon the application

Wahl designed and built two Heat Spy models from the bottom up for precise, accurate measurement of high temperatures under the toughest factory conditions

DHS-29X measures through glass ports
900 to 3200°F, 482 to 1760°C
Measure through glass, flames and products of combustion using the DHS-29X (2 1 2 5 microns) Its small target resolution and long telescopic range make the DHS-29X ideal for aiming through ports in furnace walls at refractories, glass gobs, furnace tubes, ceramics, billets, slag and annealing materials A sapphire window protects the silicon optics from heat and contamination
3-Year Warranty

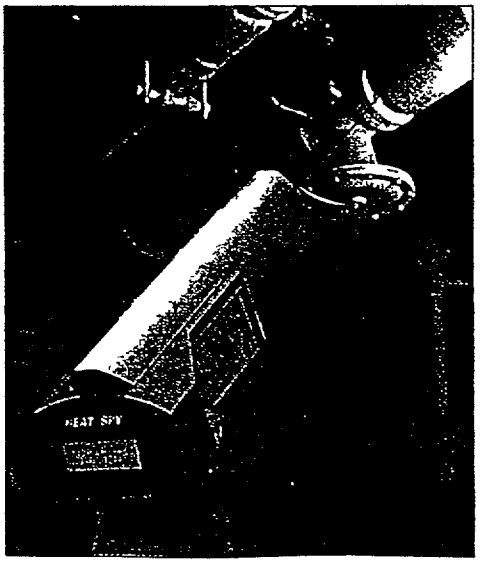
DHS-29X Standard Sight
DHS-29XT Telescopic Sight

DHS-35XT measures furnace tubes
800 to 3200°F 426 to 1760°C
In the narrow spectral range of 3 5 4 1 microns the DHS-35XT minimizes errors caused by reflectance from walls and flames That makes it excellent for measuring furnace tube temperatures through open ports It is also your best choice for high temperature general purpose applications
3 Year Warranty

DHS-35XT Telescopic Sight

Use Laser for Tough Aiming Situations

- Available on most of our popular models DHS-24L, -24XL, -26L, -26XL, -28XL
- Add the laser aiming option for
  - Precise centering on target
  - Night and low-light conditions
  - Measuring in cramped and awkward areas
- Meets U S Federal Safety Regulations
  - CRF 1040 10 Class II Certified less than 1 0mW power
  - Optional CFR 1040 10 Class III-A Certified less than 5 0mW max power
  - Separate laser switch and indicating light
  - Laser is on only when reading temperature



How Laser Aiming Works to Your Advantage

The high-coherency laser aiming beam adds a powerful dimension to precise temperature measurements The laser places a visible red dot on the center of the target surface

You can hold the Heat Spy in any position and at any level It is especially useful in cramped areas and in awkward conditions such as standing on ladders and platforms

The laser is very effective indoors under all lighting conditions and dramatically useful at night outdoors In bright sunlight use Heat Spy s enclosed optical sight Avoid viewing the laser sight directly or when reflected from shiny surfaces Laser energy from low reflective targets such as painted surfaces or oxidized metals is considered safe for viewing

CALL TOLL FREE IN THE USA AND CANADA (800)421-2853 • FAX (310) 670-2840

International Price List

W1129P-Intl
Effective Oct 1, 1994

Page	Part No	Description	Unit	Price
24	ST2203C	Soldering Iron Tester Deg C	EA	1028 00
24	ST2203F	Soldering Iron Tester Deg F	EA	1028 00
24	WST 02	Heavy Duty Band	EA	111 00
24	WST 02B	Band With Bonnet	EA	123 00
24	WST-03	Wire Band	EA	56 00
24	WST 34	Carrying Case	EA	94 00
24	WST-02 KIT	Replacement Band Kit	EA	56 00
24	WST 02B KIT	Replacement Band Kit	EA	56 00
24	WST-03 KIT	Replacement Band Kit	EA	38 00
25	B-1504	Battery 9 Volts	EA	4 00
25	HSA 201	Heat Spy Telematic	EA	3222 00
25	HSA 201 2	Heat Spy Telematic	EA	3222 00
25	HSA 201 3	Heat Spy Telematic	EA	3328 00
25	HSA 201 4	Heat Spy Telematic	EA	3328 00
25	T 12	Heavy Duty Tripod Adjustable Tilt	EA	175 00
27	DHS 10XC	Digital Heat Spy LCD Deg C	EA	1110 00
27	DHS-10XF	Digital Heat Spy LCD Deg F	EA	1110 00
27	DHS-24L	Digital Heat Spy LED Laser	EA	2617 00
27	DHS 24X	Digital Heat Spy LCD	EA	2339 00
27	DHS-24XL	Digital Heat Spy LCD Laser	EA	2550 00
27	DHS 26L	Digital Heat Spy LED Laser	EA	2706 00
27	DHS-26X	Digital Heat Spy LCD	EA	2428 00
27	DHS 26XL	Digital Heat Spy LCD Laser	EA	2639 00
27	DHS-26XT	Digital Heat Spy LCD Telescopic	EA	2922 00
27	DHS-28X	Digital Heat Spy LCD	EA	2428 00
27	DHS 28XL	Digital Heat Spy LCD Laser	EA	2639 00
27	DHS 28XT	Digital Heat Spy LCD Telescopic	EA	2922 00
28	DHS-29X	Digital Heat Spy LCD	EA	2711 00
28	DHS-29XT	Digital Heat Spy LCD Telescopic	EA	3206 00
28	DHS-35XT	Digital Heat Spy LCD Telescopic	EA	3272 00
29	11441 1	Spare AC Adapter 110 VAC	EA	24 00
29	11441 2	Spare AC Adapter, 220 VAC	EA	33 00
29	9852	Spare Trigger Lock	EA	6 00
29	9990	Heat Spy Carrying Case	EA	56 00
29	B-11	Bench Stand	EA	73 00
29	CRM	Calibration and Repair Manual	EA	56 00
29	DHS-8XC	Digital Heat Spy LCD Deg C	EA	2589 00
29	DHS-8XF	Digital Heat Spy LCD Deg F	EA	2589 00
29	DHS 10XC	Digital Heat Spy LCD	EA	1110 00
29	DHS 10XF	Digital Heat Spy LCD	EA	1110 00
29	DHS 24L	Digital Heat Spy LED Laser	EA	2617 00
29	DHS-24X	Digital Heat Spy LCD	EA	2339 00
29	DHS 24XL	Digital Heat Spy LCD Laser	EA	2550 00
29	DHS-24C-FM	Heat Spy FM Approved LED Deg C	EA	2289 00
29	DHS 24F-FM	Heat Spy FM Approved LED Deg F	EA	2289 00
29	DHS-24XC-FM	Heat Spy FM Approved LCD Deg C	EA	2217 00
29	DHS-24XF FM	Heat Spy FM Approved LCD Deg F	EA	2217 00
29	DHS-26L	Digital Heat Spy LED Laser	EA	2706 00
29	DHS-26X	Digital Heat Spy LCD	EA	2428 00
29	DHS-26XL	Digital Heat Spy LCD Laser	EA	2639 00
29	DHS-26XT	Digital Heat Spy LCD, Telescopic	EA	2922 00
29	DHS-26F-FM	Heat Spy, FM Approved, LED, Deg F	EA	2378 00
29	DHS-26XC-FM	Heat Spy FM Approved, LCD Deg C	EA	2306 00
29	DHS 26XF FM	Heat Spy FM Approved LCD Deg F	EA	2306 00
29	DHS 27X	Digital Heat Spy LCD	EA	2695 00
29	DHS 28X*	Heat Spy LCD 0-1380°C	EA	2428 00
29	DHS-28XL*	Heat Spy LCD Laser 0-1380°C	EA	2639 00
29	DHS-28XT	Heat Spy LCD Telescopic 0-1380°C	EA	2922 00
29	DHS 28XC-FM*	Heat Spy FM Appr LCD 0-1380°C	EA	2306 00
29	DHS 28XF FM	Heat Spy FM Appr LCD, 32-2500°F	EA	2306 00
29	DHS 29X	Digital Heat Spy LCD	EA	2711 00
29	DHS 29XT	Digital Heat Spy LCD Telescopic	EA	3206 00
29	DHS 35XT	Digital Heat Spy LCD Telescopic	EA	3272 00
29	EP 10	Emissivity Coating	EA	12 00
29	H7D	Leather Holster	EA	100 00
29	MN1604	Standard 9V Alkaline Battery	EA	4 00
29	NIST HS	NIST Traceable Test Data	EA	222 00
29	RHS 15	Portable Chart Recorder	EA	1619 00
29	T 12	Heavy Duty Tripod	EA	175 00
29	W2111	Spare Owner's Manual	EA	17 00
29	WS 14	Safety Wrist Strap	EA	17 00
29	BP12 110	Rechg Battery Pack 110 V	EA	344 00
29	BP12 220	Rechg Battery Pack 220V	EA	361 00
30	531 1	AC Power Adapter 110 VAC	EA	94 00
30	531 2	AC Power Adapter 220 VAC	EA	210 00

Temperature Range listed as 0-1400°C is 0-1380°C

Page	Part No	Description	Unit	Price
30	DHS 53C	Digital Heat Spy LCD Deg C	EA	3581 00
30	DHS-53F	Digital Heat Spy LCD Deg F	EA	3581 00
30	DHS 53AC	Digital Heat Spy LCD Deg C	EA	3843 00
30	DHS-53AF	Digital Heat Spy LCD Deg F	EA	3843 00
30	DAC 53	Digital to-Analog Converter	EA	886 00
30	L 50	Close-Up Lens	EA	256 00
31	531 3	AC Adapter DHS 34	EA	94 00
31	A3401	Viewfinder Camera Kit	EA	1613 00
31	DHS-33SC	Small Target Digital Heat Spy	EA	3975 00
31	DHS-33SF	Small Target Digital Heat Spy	EA	3975 00
31	A5301	Long Eye Relief Eyepiece	EA	201 00
31	A5302	Angled Viewfinder	EA	275 00
31	DHS-34A	Autofocus Digital Heat Spy Deg C/F	EA	4499 00
31	DHS-34S	Std Digital Heat Spy LCD Deg C/F	EA	4106 00
33	DHS-12X	Digital Heat Spy LCD	EA	827 00
33	DHS-12XE	Digital Heat Spy LCD	EA	1104 00
33	DHS-12XW	Digital Heat Spy LCD	EA	1439 00
33	DHS-12XM	Digital Heat Spy LCD	EA	1772 00
33	12A10	Close Focus Option, Add	EA	222 00
33	12A11	AC Power Adapter 110 VAC 60 HZ	EA	28 00
33	12A12	AC Power Adapter, 220 VAC	EA	44 00
33	12A13	60" Analog Output Cable	EA	28 00
33	12A14	Thermal-Type Printer	EA	549 00
33	12A15	Software Program 5-1/4" Disk	EA	111 00
33	12A16	Software Program, 3-1/2" Disk	EA	111 00
33	12A17	Printer Paper Box of 5 Rolls	BX	44 00
33	12A18	Sub-Zero Option, Add	EA	167 00
33	12A19	Adjustable Emissivity Option Add	EA	111 00
33	12A20	60" Computer Cable	EA	44 00
33	12A21	Spare Owner's Manual	EA	11 00
33	12A22	0 1 Deg Resolution Option, Add	EA	56 00
33	12A23	NIST Certificate Option, Add	EA	83 00
33	12A24	Intrinsically Safe Option Add	EA	111 00
33	12A25	Laser Sighting Option, Add	EA	167 00
34	DHS-11X	Digital Heat Spy LCD	EA	199 00
34	DHS-11XE	Digital Heat Spy LCD	EA	349 00
34	11A02	Belt-Clip Pouch	EA	30 00
34	11A03	Waterproof Carrying Case	EA	70 00
35	DHS 5X	Digital Heat Spy LCD	EA	624 00
36 37 38		Temp-Plate and Temp-Spy Recorders Add suffix according to temperature range desired		
36	101 6-( )	Temp-Plate Recorder Box of 10	BX	33 00
36	101 8 ( )	Temp-Plate Recorder, Box of 10	BX	44 00
36	240K 1C	Temp-Plate Low Range Kit	BX	28 00
36	240K 1F	Temp-Plate Low Range Kit	BX	28 00
36	240K 2C	Temp-Plate High Range Kit	BX	28 00
36	240K 2F	Temp-Plate High Range Kit	BX	28 00
37	101 4 ( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	101-4V-( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	240-( )	Temp-Plate Recorder, Box of 10	BX	23 00
37	430-( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	440-( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	441 ( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	442 ( )	Temp-Plate Recorder, Box of 10	BX	28 00
37	444 ( )	Temp-Plate Recorder Box of 10	BX	23 00
38	240-( )	Temp-Plate Recorder Stainless Steel Series, Box of 10	BX	73 00
38	410-( )	Temp-Plate Recorder, Box of 20	BX	17 00
38	414 ( )	Temp-Plate Recorder Box of 20	BX	17 00
38	WD1260	Temp-Plate Temp Decal	BX	56 00
38	WD1270	Temp-Plate Temp Decal	BX	56 00
38	WD1280	Temp-Plate Temp Decal	BX	56 00
38	WD1290	Temp-Plate Temp Decal	BX	56 00
38	WD1300	Temp-Plate Temp Decal	BX	56 00
39	730 ( )	Chart Paper Select Range 100/Pkg	PK	26 00
39	731 ( )	Chart Recorder 24 Hr Select Range	EA	338 00
39	732 ( )	Chart Recorder 7 Day Select Range	EA	338 00
39	E 700-( )A	Economy Therm Select Range	EA	30 00
39	S 700 ( )A	Surface Therm Select Range	EA	39 00
39	S 700-( )B	Surface Therm Select Range	EA	41 00
39	S 701 ( )P	Surface Therm Select Range	EA	48 00
39	S 702 ( )P	Surface Therm Select Range	EA	48 00

Prices subject to change without notice

Wahl

WAHL INSTRUMENTS INC • 5750 HANNUM AVE • CULVER CITY, CA 90231 USA • TELEPHONE (310) 641-6931 • TELEX 66-4406

FAX: (310) 670-2840

Specification of Equipment for Energy Management Program

Items included

a) Two non-contact ultrasonic flow meters - $16,000 total
b) One Non-contact thermometer - $3,500
c) Two 3- phase electrical meter with logging and downloading capability - $26,500 total
d) Ultrasonic leak detection device - $1,500
e) Laptop computer with plant energy management software - $4,000
f) Laser printer - $3,000
g) Energy management reference books - $500

Total = $55,000

COMPLETENESS OF EQUIPMENT SUPPORT MATERIAL AND MAINTENANCE

The equipment is to be packaged and delivered to the end user with all available support equipment including but not limited to, cables, computer download and upload interfaces, software, maintenance contracts, and calibration equipment such that it is self sustaining for a period of two years without any additional investment for these items Local suppliers or service facilities are not expected to be available during this time period In addition, the end user will not have budget to purchase additional goods or services

ALL EQUIPMENT MUST INCLUDE AS A MINIMUM

I Internal design or appropriate adaptation equipment to recharge and operate equipment on 220 volt, 50 hertz power source, using Former Soviet Union standard 4 millimeter round prongs Ground pin to be supplied if necessary for safe operation

II All recharging equipment necessary to support battery operation of the equipment Recharging equipment must meet criteria (I) electrical requirements

III Sufficient rechargeable batteries to support 2,400 hours of intermittent audit usage over a two year period, with a minimum of two units

IV All available cables, connections, software, and adapters to interface with personal computer data storage and available uploading features

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V Consumable parts and data output media for the equipment to be used 2,400 hours intermittently over a two year period

VI All costs associated with two years of recommended calibration and preventative maintenance Express shipping and full replacement loss insurance must be included from Russia to the nearest authorized service facility

VII Written translation of all manuals and safety information to the Russian language

VIII All equipment must meet applicable United States standards

IX All portable equipment will be fitted with rigid reusable carrying cases to protect the equipment from frequent travel conditions Each unit of equipment is to be packaged in a single case unless weight exceeds 50 pounds, or a probe greater than 24 inches exists

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a) ULTRASONIC FLOW METER AND TOTALIZER

(Two complete units are specified per set)

Repeatability	+/- 0 1% of full scale
Linearity	+/- 0 1% of full scale
System accuracy	+/- 5%
Rate readout	Metric units
Volume readout	Metric units
Flow rate range	Metric equal to 0 5 to 20 feet per second
Pipe diameters	15 to 2,000 mm (0 6 to 79 inches)
Totalizer	Metric units
Transducer	High temperature to 400 F (204 C)
Transducer cable	20 feet minimum
Capability	Must measure clear and suspended particle media
Power source	Rechargeable battery

Manufacturer	Dynasonics, Inc
Model	M3-902 OR EQUAL

b) INFRARED NON-CONTACT THERMOMETER (MIDRANGE TEMPERATURES)

Wahl Brand Infrared thermometer, model DHS-26XL1 or Equal

Range 0 to 2,000 degrees Fahrenheit or -20 to 1,000 degrees Celsius

Accuracy	+ or - 0 3% of reading
Aiming	LCD laser sight
Emissivity	adjustable
Scale	Fahrenheit and Celsius switchable
Resolution	1 degree
Warranty	3 years
Power	battery for portability

Options	220 volt rechargeable battery pack

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Pricing	$3,000 base unit
	$400 rechargeable battery pack
	$100 shipping

	$3,500 Total

c) THREE PHASE ENERGY ANALYZER

(Two complete units are specified)

Quantities Monitored
Kilowatt Hours
Kilowatts
RkVAH
KVA
Power Factor
Volts
Amps
Harmonic Analysis

Data Storage	All quantities monitored
Memory	7 day recording of all parameters
Software	To display and print results in graphical format from PC
Display	LCD and Paper Tape Printer
Power supply	Rechargeable, field replaceable

Current Transformers

range #1	0 to 10 amps
range #2	0 to 150 amps
range #3	15 to 300 amps
range #4	50 to 1,000 amps
range #5	100 to 3,000 amps

Manufacturer	Dranetz
Model	8,000 OR EQUAL

d) ULTRASOUND LISTENING DEVICE FOR LEAK DETECTION

(Two complete units are specified for each set)

Power supply	Rechargeable battery
Circuitry	Solid state
Repeatability	+/- 1%
Headphones	8 Ohm (low impedance) noise isolating headset

Manufacturer	Davis-Instruments
Model	Leakcheck OR EQUAL

e) COMPUTER EQUIPMENT

e) Notebook Computer

Bus architecture	486
Processor speed	33 Megahertz
Ram	4 Megabyte
Hard drive	200 Megabyte minimum
Floppy drive	3 5 inch, 1 44 MB
Keyboard	85 key full size
Display	9 5 inch dual matrix color
Battery	Rechargeable
Battery life	3 hours continuous use minimum
Communication	Fax/modem installed
	internal 9600/2400 with V 42bis
PCMCIA slots	Two of type II
Pointing device	Built in trackball
Preinstalled software	Windows version 3 1
	Lotus 1-2-3 for windows
	Winfax Pro for windows
Pre-formatted disks	100 each, 3 5 inch, 1 44 MB
Miscellaneous	Inverted "T" cursor control

	Ports for external VGA monitor, keyboard, and mouse connection AC adapter (240 volt, 50 hertz) with Russian 4 mm round plug
Manufacturer	IBM
Model	Thinkpad 750C

f) LASER PRINTER

Resolution	600 dpi
Speed	8 pages per minute minimum
Memory	4 Megabytes
Paper format	A4
Emulation	HP PCL 5
Interface	Centronics
Manufacturer	Hewlett - Packard
Model	HP 4 OR EQUAL

g) ENERGY CONSERVATION REFERENCE BOOKS
(One of each book - translation not required)

I Title	Energy Conservation Techniques for Engineers
Author	Harry B Zackrison, Jr
ii Title	Energy Conservation Through Control
Author	F G Shinskey, Foxboro Company
iii Title	Energy Efficient Electric Motors and Application
Author	Howard E Jordan, Reliance Electric Company
iv Title	The Energy Saving Guide
Author	G Helcke

v Title	Energy for Industry
Author	P W O'Callaghan
Supplier	OMEGA Vol 1 Scientific and Technical Books Pages CE-33, MS-42, EE-44, MS-34, MS-34 OR EQUAL

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