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BURNS AND ROE ENTERPRISES, INC.

Audit Report
KOURAKHOVSKA POWER PLANT
UKRAINE

FINAL

August 1997

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Energy Efficiency and Reliability - Ukraine
Task 2 - Power Plants Combustion Efficiency

Final Audit Report
Kourakhovska Power Plant

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COMBUSTION EFFICIENCY AUDIT REPORT
UKRAINIAN POWER PLANTS
KOURAKHOVSKA POWER PLANT

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

The work described in this report has been carried out by Burns and Roe Enterprises, Inc within the framework of the U.S Agency for International Development (USAID) Emergency Energy Program for the Newly Independent States (NIS), Delivery Order No 6 Energy Efficiency and Reliability - Ukraine, Technology Based Project, Energy Efficiency and Market Reform Project (EEMRP), Task 2 - Power Plants Combustion Efficiency.

U S AID/Kiev has initiated an energy savings program by providing instrumentation equipment to combined heat and power plants (CHP) and power plant stations to improve combustion efficiency of the boilers as a first step towards life extension of these plants The purpose of Task 2 is to implement this energy saving program at seven power and/or CHP plants The project team visited Ukraine September 14-October 13, 1994, to select representative plants and to gather preliminary information at the selected plants The project teams performed combustion audits during February and March 1995.

During these audits, the project teams trained plant personnel on the use of portable combustion efficiency instrumentation A set of portable combustion efficiency instrumentation was given to plant in 1995. In 1997 the plant received and accepted oxygen analyzer, general range and high range infrared thermometer, liquid flow meter, combustion analyzer consumables, laboratory calorimeter and sulfur analyzer. Installation of oxygen analyzers was initiated in July 1997

The Kourakhovska power plant is presently 51% government owned The plant consists of one subcritical 200 MW unit and six subcritical 210 MW units with a total of 1460 MW installed capacity. The plant was commissioned between 1972 and 1975 The coal supplied to the power station has poor quality, with caloric values of 2200 to 4000 kcal/kg and 36 to 46% ash content Typically, the plant fires coal alone and coal supplemented by mazut Plans are in place to reconstruct this station However, the schedule for reconstruction is dependent upon development of the new boiler design and availability of funds

1.2 Principal Findings

Several Energy Conservation Opportunities (ECO's) were identified for the Kourakhovska power plant for short term "no-cost low-cost" measures. The "no-cost low-cost" measures include instrumentation for measuring excess air and fuel consumption which would result in short payback periods.

Very high (by western standards) in-leakage rates in the furnace, the economizer and the air heater (total in-leakage 65% and higher) are typical These make readings of any oxygen analyzer dependent on its location (distance from the furnace), distorts the measurement of combustion air flow and makes automatic control of combustion very difficult High leakage rates inherent in

the boiler technology used for the Kourakhovska power plant cannot be remedied at a reasonable cost Most of the insulating material used at the plant is asbestos Considering the age of the power plant, it is recommended that longer range plans should consider complete replacement or major repowering and rehabilitation

1.3 Recommendations

Boiler efficiency can be improved, emissions reduced and the life expectancy of the Kourakhovska power plant extended based on the recommendations listed in the following Table The Table summarizes several energy conservation opportunities which will pay for themselves within short periods of time.

An investment of $134,500 in boiler efficiency improvements (ECO-04,05,06,07) will result in an annual savings of $173,500, which corresponds to 6,900 tons of coal and 400 tons of mazut. An additional investment of $25,000 in energy conservation programs (ECO-01,02,03,) may result in an annual savings of up to $607,000 which corresponds to 24,000 tons of coal and 1,400 tons of mazut.

Many other opportunities exist within the power plant for energy savings which could be the subject of further audits and actions by the plant staff The energy conservation opportunities also have applications in other power plants.

Summary of Energy Conservation Opportunities (ECOs)

ECO#	Description	Annual Savings in US$ (1995 Prices)	Project Cost in US$ (1995 Prices)	Simple Payback
				Current Energy Prices
01 *	Energy Conservation Management Program	$506,000	$25,000 Note 1	< 1 year
02 *	Energy Conservation Training Program	$101,200	Note 1	< 1 year
03 *	Fuel Quality Improvement Program	See ECO-03	Note 1	< 1 year
04 *	In-Situ Oxygen Analyzer One Boiler - 2 Probes	$72,290	$29,000	4 8 Mo.

ECO#	Description	Annual Savings in US$ (1995 Prices)	Project Cost in US$ (1995 Prices)	Simple Payback
				Current Energy Prices
05 *	Portable Infrared Video Monitors (Bottom Ash)	Included with ECO-04	$4,200	Included with ECO-04
06 *	Sulfur Laboratory Analyzer and Testing Sieve Shaker	$101,200	$45,000	5 34 Mo
07 *	Coal Flow Meters - One Boiler Portable Liquid Flow Meter	Included with ECO-04	$46,500 $9,800	Included with ECO-04

Note 1 See Section 5 *** Highly Recommended**

1.4 Implementation

The plant is presently in a very difficult financial position since it pays world prices for fuel but sell electrical power at the rate set by the government Both load factors and quality of coal have declined since 1995. Typically only 2 units out of 7 are operating at 60 - 70% MCR At this time the plant is overwhelmed by political and economic factors out of its control and it is a testimony to the management's efforts that the adjusted efficiency of the plant remained the same or improved since 1994

ECO-02 (energy conservation training program), and ECO-03 (fuel quality improvement program) were not implemented due to lack of funds Salaries were not paid for 6 to 8 months and the management began layoffs Under these circumstances implementation of the above programs would be very difficult even if the program funds were available.

Some of ECO-01 (energy management conservation program) goals were realized despite the lack of funds for a formal energy management conservation program Since 1995 the plant utilized the audit equipment that was left behind by the BREI audit team as part of the USAID boiler efficiency improvement demonstration program There were improvements in efficiency due to lower excess air combustion as well as savings in tons of environmental pollutants and avoided environmental fines For more details see section 6 of this report

2.0 BACKGROUND

Twelve Newly Independent States (NIS) emerged from the collapse of the former Soviet Union in 1991 USAID is addressing and managing assistance to these countries through the newly formed Bureau for Europe and the New Independent States (USAID/ENI)

Funding activities in the energy sector support the cost of technical assistance, training, and limited capital assistance in support of energy-related equipment and cooperation with local institutions.

Ukraine, with a population of 52 million, is considered one of the most energy intensive states Initial assistance has shown that there are many opportunities to reduce energy consumption and to reduce environmental degradation. The breakup of the Soviet Union has resulted in the cut-off of supplies and spare parts required by the Ukrainian Energy Suppliers, which threatens the reliability of major power plants This situation is compounded by a lack of funds to pay for needed supplies and fuels.

Most of the thermal power plants are coal fired units that are co-fired with mazut and natural gas, complimented by natural gas and mazut fired units in populated areas

These units often supply hot water for district heating and steam for industrial use Decreasing coal supplies and declining quality of coal supplies is affecting the ability of the Ukraine to meet its needs for electricity Also, electricity and district heating supplies are threatened because The Ukraine is unable to pay for imported coal, oil and gas at prices approaching world fuel prices.

2.1 Objectives of Energy Saving Program

USAID/Kiev has implemented an expanded energy program in the Ukraine to enhance the reliability of power generation and reduce dependency on imported oil and gas and improve energy productivity

The purpose of these efforts will be to provide services and, where appropriate, U.S and local products, directed toward improving energy and operating efficiencies in power generation, and in the equipment and controls required to use energy efficiently and cost-effectively

The purpose of Task #2 was to improve boiler efficiency at seven power plants and/or combined power and district heating plants which were selected by USAID/Kiev in consultation with the Ministry of Energy and Electrification These plants are fired with natural gas, fuel oil or coal The objectives are to (1) foster improved management of boiler/plant operations by identifying and implementing immediately cost-effective "low cost - no cost" efficiency improvements, (2) provide equipment support to implement low-cost operations, improve monitoring and energy management, (3) provide operation training

2.2 Purpose of the Audit

The purpose of the audit was to

- Assess overall technical and management capabilities, plant energy efficiency, and capital investment decision-making processes for each plant, assess plant procedures for identifying and executing energy saving investments requiring management changes, and capital investment.

- Identify short-term no-cost/low-cost efficiency measures with savings potential and pay backs

- Provide preliminary identification of energy conservation opportunities (ECO's) requiring larger capital investment

3.0 DESCRIPTION OF POWER PLANT

3.1 General Description

In 1969 work commenced on the construction of one unit of 200 MW and six units of 210 MW capacity each The last unit was completed by 1975 The units were designed to fire by-products and fines washings of Donetsk coal preparation and sludge (schlamm) The station has a total installed capacity of 1460 MW. The boilers operate under subcritical conditions

ENERGO SYSTEM.	DONBASSENERGO
LOCATION.	40 KM SOUTH-WEST OF DONETSK
INSTALLED CAPACITY	1460 MW 1 × 200 MW + 6 × 210 MW
COMMISSIONED	1972-1975
FUEL	LIGNITE (SCHLAMM) SUPPLEMENTED BY MAZUT

For a more detailed description of the fuel and of the following items, see the Preliminary Audit Report, issued in December 1994, Reference 1 in Appendix G

3.2 Boiler Plant

The boilers are Type TP-109 from the Taganrog Boiler Works The boiler supplies steam at a

rate of 640 tons per hour at a pressure of 140 bar gauge and live steam temperature of 535°C Steam from the high pressure turbine exhaust is directed back to the boiler for reheat and returned to the intermediate pressure cylinder at a pressure of 39 bar gauge and reheat temperature of 535°C The boiler operates on a balanced draft principle with air being supplied by two 50% forced draft fans and exhaust gas removed by two 50% induced draft fans The turbines were supplied by the Kharkov Turbine Factory

The design caloric value of the coal was 4100 kcal/kg but actual average operation caloric value is 3200 kcal/kg

3.3 Coal Handling

The coal is delivered to the station by 40 different suppliers during a typical week and is weighed by railroad car scales in the coal handling yard The coal is blended by bulldozers in the yard. The blended coal is supplied into two conveyor systems feeding all boilers and weighed on each conveyor (1 & 2) for the entire station The coal is not weighed on a per unit basis The average quality of the coal over 5 day period is determined by taking coal samples from the conveyors The coal is analyzed for caloric value, water, ash, volatility and sulfur content This is a slow process due to outdated laboratory equipment

Coal is supplied to the boiler units and held in two raw coal bunkers prior to being fed to two trains of 68 ton/hr drum ball mills. The motive air for transfer of the pulverized fuel is directed from the outlet of the air heater and is used to dry the pulverized fuel in addition to transporting it to pulverized fuel bunker The ball mill is also supplied with flue gas extracted from the precipitators to mix with the motive air and limit the oxygen content to less than 18% This minimizes the explosion risk in the coal dust system.

The mill outlet temperature is controlled to 70°C by adjustment of the rate of raw coal feed The combined air and flue gas is separated from the pulverized fuel via centrifuge separators through which all the pulverized fuel is passed prior to storage in the pulverized fuel storage bunker The storage bunker for the pulverized fuel is used to supply fuel to the sixteen burners arranged in two rows of burners in both walls of the furnace. Pulverized fuel flow to the burners is controlled via rotary feeders fitted to each outlet of the pulverized fuel storage bunker The capacity of the dust system is not sufficient for the poor quality of the coal that is actually fired in the station.

3.4 Mazut Supply

The power station units are supplemented with mazut Kourakhovska units never operate on mazut alone due to its high cost and high SO_2 emissions. The maximum mazut assistance is about 25%, but blending of coal is reducing this figure to about 10%

3.5 Gas Supply

The power station presently is not designed for firing natural gas

3.6 Boiler Efficiency Calculations

On January 5, 1994 the station produced 15409 x 10^6 KWH of electricity, consumed 11,799 tons/day of coal with a caloric value of 2136 kcal/kg and 1227 tons/day of mazut On April 29, 1994 the station produced 19229 x 10^6 KWh of electricity, consumed 14,377 tons/day of coal with a caloric value of 3759 kcal/kg and 90 tons/day of mazut. Only station efficiency can be determined The fuel consumption of each unit is not known

3.7 Process Control System

Boilers of the Kourakhovska power plant operate in a steady-state mode (turbine following the boiler) Operator manually adjusts firing rate and air flow (fixed settings for each load) and allows frequency to float There are two O_2 analyzers on each unit which are used to monitor O_2 content of exhaust gas before the economizer at 500°C. These analyzers are used by operators to remotely adjust the speed of coal feeders and the position of forced draft fan dampers The fuel to air ratio is manually adjusted based on experience and O_2 analyzer indications. There are no CO analyzers in the power station.

Hot water is supplied from each of the seven units for district heating and from two units for greenhouses. In the station the pipelines run above ground and in the city underground.

The station has an IBM 386 computer-based system for the control of steam and feedwater of Unit 6 (U8) This is a pilot unit chosen by the Ministry of the Ukraine There are 100 control points and 20 control loops. The system is not fully commissioned. The visual inspection revealed that the system resembles American-made DCS systems of 1982-83 vintage

3.8 Environmental Issues

The Electrostatic Precipitators (ESP) are reported operating very unsatisfactory This may be attributed to high specific electrical resistivity of the fly ash This affects the ESP ability to collect particles from flue gas, thus reducing ESP efficiency The station uses low NO_x burners and staged combustion to effectively reduce NO_x emissions Poor quality of fuel (both coal and mazut) increases the SO_2 air pollution and causes severe problems of boiler slagging Combustion of Polish coal results in especially high levels of SO_2 emissions

Because the stack height far exceeds the "good engineering practice" criteria, the pollutants emitted do not produce a local air quality problem, but are a concern for the atmospheric pollution

The station lacks outdoor fixed monitoring equipment for recording gaseous and dust values

3.9 Future Plans

Management of the Kourakhovska power plant is aware of the poor condition of its boilers High leakage rates are inherent in the boiler technology used for the Kourakhovska power plant and cannot be remedied at a reasonable cost. Management also understand that asbestos is not an appropriate insulating material and that considering the age of the power plant, complete replacement or major repowering are the best options Management is attracted to a number of advanced technologies, including an application of Atmospheric Circulating Fluidized Boiler (ACFB) technology, but does not have funds to pursue these options

It is Burns and Roe's judgement that once the market rates are changed and enforced (i.e consumers are disconnected for non-payment), consumption will drop significantly The future of the Kourakhovska power plant is tied to the success of the Ukrainian economy as a whole Before most of the population could afford electricity at market prices, the salaries of the general population must increase significantly Until that happens it is best to contract for good quality coal (the station already pays world market prices for coal) and maintain the existing facilities

3.10 Inspection, Assessment, Comments

- The power station is well run by experienced personnel and is well managed The staff is competent and fully cooperated in providing the requested information and assigning the hands-on audit training personnel The station is quite clean for a coal firing plant and normally dirty areas are kept clean by the plant personnel

- Considerable work of refurbishing and major component replacement on all boilers and on Unit U9 (the seventh unit) HP turbine casing has been done during the past 6 years Plans are in place for the next 6 years to continue the major component replacement on all boilers and Unit U9 IP turbine rotor

- Most of the process control systems operate on "manual" mode from the control board located in the Unit Control Room A chart is used to indicate the unit load as a function of the amount of coal and mazut cofired The controls and instrumentations are outdated, the readings are unstable and require ongoing maintenance to keep them operational

- The boilers have no burner management systems The original mechanical governors are still in operation All interlocks are of a very basic nature offering limited protection Spares are hard to find

- The coal is supplied by 40 suppliers The station presently has little input regarding the quality of the coal specified or control over fuel acquisitions

- The coal delivered to the plant does not match original boiler design requirements, thus reducing boiler efficiency and increasing maintenance requirements. In addition, the poor quality of coal increases the air pollution and causes reduction in MW output of the boilers Mazut is cofired almost all the time in order to deliver the MW output required by the system and maintain stable operation of the boilers

- The station operates in cyclic mode with two units shut down each night and the balance of units operating at minimum load (140 MW) The daily cycling mode of operation affects the equipment and results in considerable plant refurbishment and replacement.

- The efficiency can be determined per station only, not for each one of the units because the fuel consumption per each unit is not measured (no meters per unit) The power station will like to have coal flow meters to measure the input at each mill, a total of two devices per each 210 MW boiler

4.0 DESCRIPTION OF AUDIT ACTIVITIES

The audit activities included the collection of information and data from various reference sources and individuals working within the power plant The activities are of two types one for specific combustion efficiency audit measurements and calculations, and the other for information of a general natural regarding other energy conservation measures.

4.1 Specific Audit Activities

4 1 1 Scope and Methodology

Individual systems and/or equipment were identified for data collection and analysis and were selected based on several criteria

- Quantity of energy used within the system
- Potential for energy efficiency improvements
- Significance of system/component to the power plant.
- Potential for replication.

The selection of systems and equipment to audit were made after meeting with power plant specialists to discuss energy conservation priorities and a walk through the power plant

In preparation for the audit activities at the power plant, energy monitoring equipment was purchased in the United States, shipped to Kiev and delivered to the Kourakhovska power plant The equipment was purchased to make measurements of various systems that were likely to be encountered within the power plant The measurements enabled auditors to learn specific information about the systems being investigated Based on the measurements, the auditors calculated potential energy improvements that could be gained by installing energy efficiency equipment.

Economic pay backs were calculated and the items prioritized according to the shortest payback Based on estimated cost of equipment and money available, recommendations were made as to whether to implement the items studied.

The main components of the audit equipment are

- ENERAC 2000 Portable Combustion Analyzer
- Portable Laptop TI computer and Okidata printer
- Fluke AC power analyzer
- Cyclop Infrared Temperature Detector (heat spy)

The audit equipment was left behind at Kourakhovska power plant as part of the USAID boiler

efficiency improvement demonstration program Of this equipment, the most significant was ENERAC Combustion Analyzer which demonstrated an opportunity for immediate fuel saving by tuning the boilers to reduce excess combustion air.

The majority of the equipment was used extensively by the audit team personnel and as a training tool for the plant personnel assigned for hands-on audit training Typically, the audit team would take measurements while training the assigned local personnel how to use the equipment

4 1.2 General

The Kourakhovska power plant was selected by USAID/KIEV in consultation with the Ministry of Energy and Electrification The Ministry also identified the management of the power plant as receptive to this type of program and considered that the maximum benefit could be gained by auditing the Kourakhovska power plant

Management of the Kourakhovska power plant are looking forward to forthcoming privatization At the present time they are allowed to spend only 1% of the plant gross income on salaries As a result, the Kourakhovska power plant is losing its technical and maintenance personnel Technical personnel of the Ukrainian power plants are highly regarded in CIS and can increase their income significantly by working in Russia.

4.1.3 Boiler Efficiency

The specific plant audit consisted primarily of on-line flue gas emission measurements using a ENERAC 2000 portable combustion analyzer, laptop computer and printer Most of the measurements were made on Boiler #6 at maximum (200 & 180 MW) and reduced (minimum) loads of 155 and 140 MW, while firing coal and coal supplemented by mazut.

The ENERAC 2000 portable combustion analyzer is a portable instrument which has chemical cells to measure oxygen, carbon monoxide, sulfur dioxide, oxides of nitrogen content and combustible gases The unit also has a type K thermocouple incorporated in the probe to measure the temperature of the gas at the extraction point The fuel analysis of 15 various typical fuels are contained in the memory of the portable analyzer Also, custom fuel analysis can be programmed using a laptop computer ENERAC 2000 portable combustion analyzer calculates, displays and prints, boiler efficiency, excess air, CO_2 and emissions

The measurements were made at the furnace exit and at the boiler stack This was done with fixed combustion settings and essentially at the same time (the same coal and ambient temperature) The measured parameters included gas temperature, O_2, CO, combustible gases, NO_x and SO_2

Due to the high in-leakage rates in the furnace, the economizer and the air heater, an on-line calculation of the combustion efficiency by ENERAC 2000 portable combustion analyzer proved to be not feasible (see Appendix B) Direct measurements of O_2, CO, combustible gases, NO_x and SO_2 are considered to be accurate.

There were nineteen direct measurements made. A copy of the ENERAC 2000 portable analyzer print-outs can be seen in Appendix B.

For a detailed description of the Audit activities see the trip report of Team #1 (Appendix G).

Any improvement in the efficiency of the Kourakhovska power plant must come primarily from an improvement in boiler efficiency On the steam side the Kourakhovska power plant is efficient due to a significant thermal load Due to software limitations of the ENERAC 2000 portable combustion analyzer, boiler efficiency could not be calculated on-line because of high air in-leakage. For the same reason an on-line measurement of the boiler efficiency improvement achieved by reduction in the excess oxygen was not feasible

Burns and Roe estimated an incremental improvement in boiler efficiency achievable due to a reduction in excess air fed to the boilers. At full load firing coal, the excess oxygen was measured in the convection pass to be 5.6% for the normal operating condition. CO emissions were negligible BRC converted this measured excess oxygen to the excess oxygen at the burners using calculated in-leakage rates and arrived at 4.25% excess oxygen at the burners

The station reports that stable combustion with 0 3-0 5% O_2 at the burner level can be achieved due to staged combustion and low NO_x burner design The low NO_x burners are completely replaced every 4 years and are inspected, repaired or replaced on "as needed" basis every two years However, boiler operators typically add large safety margin and operate boilers at higher excess furnace oxygen that is called for by the burner design Since the burners at this plant are replaced on a regular basis, BRC very conservatively assumes that only 3% excess O_2 at burner level will be achieved using modern O_2 analyzers Excess oxygen levels higher than this provide the opportunity for a reduction in the operating levels

Based on the data collected during the visit to the plant it appears that it is possible to operate the boilers at reduced excess oxygen levels It has been shown that the potential excess oxygen reduction possible is approximately 1.25% while firing coal This would reduce the excess oxygen from 4 25% to 3.0% and improve efficiency by 0 5%.

In the future, the Kourakhovska power plant operators should be able to manually adjust the combustion air supply to determine what magnitude of reduction in excess air could be achieved within constrains imposed by CO emissions, smoke, and flame stability Therefore Burns and Roe recommends that permanent instruments be installed to measure the O_2 content of the flue gas and thus assist the operators in avoiding unsafe conditions while continually minimizing excess air

4.1 4 Boiler Plant

Present burner settings produce little CO or NO_x emissions on all fuels When firing coal, high levels of SO_2 are sometimes emitted due to an inconsistent quality of the coal Sulfur dioxide emissions could change from 4,000 mgm to 700 mgm in few hours, but tend to be in 2000-3000 mgm range when emissions are adjusted for 3% excess O_2.

Combustion of Polish coal results in especially high levels of SO_2 emissions Personnel of the plant stated that the sulfur content of the Polish coal seemed to be much higher then the Specification. They estimate a 3.5% sulfur content. Last winter the plant had critical shortages of fuel and the Polish coal deliveries saved the plant from severe blackouts. However, combustion of Polish coal resulted in furnace "puffs" and very rapid corrosion of the back end. Since all of the Kourakhovska power plant boilers are of tangent tube construction (tubes are spaced 8 mm apart with asbestos blocks behind them), and of balanced draft (negative furnace pressure), furnace "puffs" cause loss of the furnace integrity Personnel of the Kourakhovska power plant reported 21% in-leakage in the furnace alone and about 100% overall in-leakage To maintain the original design criteria of 30% overall in-leakage, they used to completely remove and reinstall furnace insulation every five years. At the present time the Kourakhovska power plant can no longer afford such overhauls

4.1 5 Boiler Controls

The combustion control is actually a manual operation Coal is usually fed to the boilers at maximum coal feeder speed, with co-firing of mazut used to bring the boiler to the required load The forced draft fan air damper positions are adjusted manually based upon a chart displayed on the control room wall, which is a function of the amount of coal and mazut being fired and the load Final air damper position adjustment is made based upon O_2 analyzer indications Thus the control of fuel and combustion air ratio is essentially a manual operation based upon maintaining a certain unit load, under constant boiler outlet steam pressure and temperature with an O_2 indication between 4 to 6%.

None of the units have CO analyzers. The TP-109 boilers have two oxygen analyzers located on the convection pass per boiler.

4 1.6 Boiler Back End Including Stack

The boilers have Ljungstrom type regenerative air heaters which are experiencing high in-leakage The electrostatic precipitators installed on all boilers have low efficiency, possibly due to the fly ash high specific electrical resistivity.

4.2 General Audit Activities

Information was gathered from existing sources, plant historical operating data and discussions with key personnel Actual audit activities consisted of taking operating data and test measurements wherever possible and performing analysis based on this data and historical information

4 2.1 Scope and Methodology

General audit activities included discussions about the entire power plant Individuals responsible for various tasks within the power plant organization were interviewed to obtain information and data on energy consumption, prices and performance They were questioned what organizational changes and controls have been implemented to manage energy conservation and efficiency In addition, the Chief Engineer was requested to provide a description of what recent measures had been taken for improvement of operational efficiency and effective fuel utilization

4.2.2 Power Plant Audits

The audit activities associated with the total power plant consisted primarily of a review of the various available publications and brochures produced by the various agencies and by the Ministry of Power and Electrification as well as from drawings and diagrams provided by the engineers at the power plant Much information and insight was also gained through the interviews related to the system specific audits at all levels Many of the personnel employed in the power plant have had experience in areas other than the one in which they currently work, and this was useful as background material.

The Cyclop infrared thermometer (heat spy) was used to find hot spots on generator buses, hot contacts on switchgear and switchyard equipment, hot spots on duct insulation, etc that all may require maintenance. Temperature readings were taken within the boiler proper where no thermocouple were installed.

The portable Fluke ac power analyzer was used to run tests on fan and pump motors to check motor power factor, and performance and quality of power supply to the relay panel, switchgear, etc

There were several audit measurements, the records can be seen in Appendix B.

5.0 FINDINGS AND RECOMMENDATIONS

5.1 Low-Cost, No-Cost Short Term Opportunities

ECO-01 ENERGY MANAGEMENT CONSERVATION PROGRAM

The chief engineer is responsible for energy conservation and efficiency improvements at the Kourakhovska power plant in addition to his other duties Because of the shortage of hard currency to pay for imported fuel the entire management of the plant is highly motivated to find ways to improve operating efficiencies in order to achieve effective fuel utilization, and all employees are aware of the need for conservation However, the existing program must be expanded and enhanced with management restructuring and new procedures to prepare for the coming privatization reforms These changes will help to prepare the plant to be commercially oriented by incorporating western management methods and procedures

The stated goals for this program, as a minimum, should be emphasized as follows:

- Conserve energy
- Reduce environmental pollution
- Improve operational efficiency
- Improve equipment reliability
- Introduce new technologies

The stated purpose for an expanded energy management program should be to provide a basis for attracting private financing and future investments for a viable enterprise having the potential for success.

As a first step, a highly visible management staff position and/or department should be established reporting to the director and having the responsibility and authority to develop, implement and monitor energy conservation, training, reliability and rehabilitation programs The primary tasks will be coordination, communication, and information The energy manager should be responsible for knowing about, reviewing and consolidating the findings and recommendations of the numerous studies and reports prepared by consultants and Institutes for the USAID, World Bank, EBRD, EC, Ministries, etc , so as to minimize duplication of work and maximize exchange of information and expertise

In addition, the energy manager should coordinate and monitor the progress and success of conservation measures implemented by the power plant staff and employees

In 1994 the Kourakhovska power plant consumed the following quantities of fuel·

Coal 4,017,027 tons	$ 85,455,000
Mazut 240,352 tons	$ 15,749,500
	$101,204,500(*)

(*)Price calculation is using 1995 cost of fuel

If only a modest savings of about 0 5 percent of this fuel expenditure is saved in the first year, $506,000 of expenditures can be justified for measures to improve fuel utilization and efficiency, improve reliability and reduce maintenance

Funds should be provided for consulting services to assist the Kourakhovska management with training and materials to establish the programs under ECO-01, ECO-02, ECO-03.

ECO-02 ENERGY CONSERVATION TRAINING PROGRAM

Many sources of energy waste and loss may seem very obvious and simplistic, and the power plant engineers and specialists are well aware of the cumulative magnitude of these losses. However, the staff needs, and should encourage, much more support from all employees in the identification and elimination of many sources of energy loss Many of the sources of waste may not be known or understood by many of the employees, and this is where the results of a formal training program can have significant energy conservation paybacks The auditors were informed that the employees already know all about energy conservation However, it is the auditors observations and measurement results as well as the observations and measurements of other studies which indicate that there are many low cost, no cost opportunities for energy savings, and this is the point of recommending a low cost, no cost energy conservation training program for all employees. The management should establish procedures, classes, more posters, incentives, rewards, competition, etc. and utilize the expertise of the engineers and specialists to reinforce the importance of energy savings If only one tenth of one percent of the annual fuel budget could be saved, this could amount to approximately $101,200!

ECO-03 FUEL QUALITY IMPROVEMENT PROGRAM

The plant must survey aggressively the available coals and take initiative in contracting directly from suppliers The plant must locate the best fuel considering boiler operational needs, design requirements, pollution control equipment performance and delivered costs The plant must consider a blending strategy of individual coals to meet the above criteria. The number of coal suppliers must be reduced to a minimum for a better control of blending process

This program must be coordinated with the requirements for burner modifications and the

resultant slagging characteristics on boiler performance as a result of the coal reactivity and ash characteristics

As a result of better coal quality and consistent ash moisture characteristics, significant savings of fuel and maintenance costs will be realized

A consideration should to be given to switch the Kourakhovska power plant to burn natural gas This will improve efficiency, reduce emissions and extend life expectancy of the Kourakhovska power plant At the present time the cost of natural gas is competitive with other fuels

ECO-04 INSITU O_2 ANALYZER

The boiler efficiency improvements can be achieved by replacing the existing extractive oxygen analyzers with in-place zirconium oxide sensor analyzers of the type used in the United States. One problem with the existing instruments installed at the plant is that they are extractive rather than in-place Therefore using extractive gas sampling instruments it is difficult to obtain a representative sample and the instruments can become fouled with acid sludge formed from moisture condensation and soot

In addition, the instruments have questionable accuracy The measurement time constant is on the order of about 1-2 minutes therefore, they cannot be used for real time excess air control United States practice typically places an oxygen sensing probe into the flue gas duct rather than extracting a sample to it This technology could be applied to the boilers at Kourakhovska power plant

It is recommended to install the new instruments on 210 MW Boiler #6 (U8)

For detailed calculations see Appendix A-1

ECO-05 VIDEO MONITORS OF THE BOTTOM ASH

There is a concern about ash slagging of the furnace from the different coals received, and the plant would like an instrument to monitor the ash fusion temperature to determine slagging process and thus have better control over boiler operation This instrument will enable excess air reductions calculated under ECO-04

It is recommended to provide one portable infrared video monitor to view bottom/ash/slag/removal for the boiler

For detailed calculations see Appendix A-1.

ECO-06 SULFUR LABORATORY ANALYZER AND TESTING SIEVE SHAKER

An accurate Sulfur laboratory analyzer should be provided to verify the Sulfur content of the received coals versus the coal specified A testing sieve shaker should be provided to verify fineness of the coal dust before combustion. These measurements will prevent deterioration of the furnace, air heaters and the duct work and thus prevent a drop in the boiler efficiency

For detailed calculations see Appendix A-1

ECO-07 FUEL METERS

The audit team learned through interviews with plant personnel that one area which has hampered the plant progress in energy improvements is the inability to accurately measure the decrease in fuel consumption due to any changes in operation or equipment motivated by efficiency improvements. This is because the plant does not have instruments to measure the fuel flow for either mazut and coal to each boiler If only modest gains in efficiency could be realized due to the incentive provided by the ability to more accurately evaluate such improvements, such flow monitoring equipment could pay to itself in a short period of time

The following instruments are recommended for metering the fuel input to the boiler

- one portable sonic type flow meter for mazut.
- instruments to measure raw coal consumption to 210 MW Boiler #6 (U8), located between raw coal bunker and mill (coal feeder)

The above portable sonic flow meter can also be used for measuring the leakages in hot water piping of the district heating lines.

For detailed calculations see Appendix A-1.

5.2 Medium and Long Term Opportunities

There are several other long term measures for improving power plant reliability, boiler efficiency and meeting environmental requirements, which require further study and large investments of capital These are listed below for future reference

- Upgrading the boilers with combustion control systems including interlocks and flame safety system Automatic control of fan dampers for combustion air and control valves for steam and fuel to meet the load demand will provide more rapid response than manual control, thus resulting in stable and efficient combustion

- Investigate lower cost SO_2/NO_x removal technologies For SO_2 removal investigate blending of coal and coal washings and lower cost sorbent technologies for flue gas conditioning For NO_x removal investigate use of burner design technology for low NO_x emissions (low cost), SNCR (selective non-catalytic reduction), and SCR (selective catalytic reduction)

- Replace the entire existing controls, instrumentation and interlocks with state-of-the-art technology for a fully automatic operation of the plant

- Upgrade the dust control system to the world performance standards, either replace the existing ESP or refurbish to meet the world standards.

- The plant has to develop short term and long term plans for boiler and air pollution control system malfunction prevention

- Install continuous opacity monitors (one per stack) to monitor the visible emissions

- Provide additional and updated analytical equipment to the chemical laboratory.

- Replace the existing water treatment plant with one using state-of-the-art technology.

- Modify the existing return air system (add air nozzles) from the coal storage bunkers to the furnace to ensure good mixing with the combustion air. The return air should arrive in the furnace as high velocity jet with the ratio of its horizontal velocity to the vertical velocity in the furnace of 6 to 1 Presently the return air rises along the furnace walls as "parasite air" and does not participate in combustion

5.3 Replicating and Expanding the Program to Other Plants

An economic benefit can be derived from expanding the demonstration program to other Ukrainian power plants. From Burns and Roe experience the Ukrainian power plants when firing coal or coal and mazut, exhibit the following characteristics

- Ukrainian power plants operate in a steady-state mode (base load),with a turbine maintaining throttle pressure, "fixed" firing rate, floating frequency and manually adjusted air flow (fixed settings for each load)

- Very high in-leakage rates (70% and higher) are typical, which make readings of any oxygen analyzer dependent on its location (distance from the furnace) They

also make impossible on-line calculation of the combustion efficiency at the back end of the boiler

- Most of the oxygen analyzers are of the extractive/paramagnetic type, with questionable accuracy and a measurement time constant on the order of about 1-2 minutes As a result, they cannot be used for real time excess air control

- Low carbon monoxide levels (10 to 100 ppm) in the flue gas in combination with 4 to 5% oxygen in locations with 850-870 degree Centigrade temperature leads to the conclusions that the boiler efficiency of the Ukrainian power plants can be improved. The improvement can be estimated on the order of 0 15% to 1%

The conclusions are as follows·

- Excess air should be reduced until at least 300-400 ppm of carbon monoxide is generated which is an indication of economic combustion

- There is room for an economic benefit because the starting point of the excess air (4 to 5% excess oxygen) is high It should not be very difficult to reduce the excess oxygen by 0.5% and achieve 0.15% improvement in the boiler efficiency even with the existing manual control of the combustion process provided that constant operator attention is achieved Such attention can be obtained via an economic inducement based on the fuel savings. Another alternative would be to invest in an expensive automatic control for the excess air system

- The benefit cannot be achieved without carbon monoxide measurements of the undiluted flue gas (850-970 degree Centigrade temperature) at different boiler loads which can be done using the portable combustion analyzer.

- Replicating and expanding the portable combustion analyzer demonstration program to the balance of twelve power plants and several other combined power and district heating plants within the Ukrainian Electrical System will provide significant improvements in boiler efficiency with low cost investments.

6 0 IMPLEMENTATION

The plant is presently in a very difficult financial position since it pays world prices for fuel but sells electrical power at the rate set by the government Both load factors and quality of coal have declined since 1995.

Typically only 2 units out of 7 are operating at 60 - 70% MCR. At the same time there is a shortage of power in the Ukraine and electrical power is being imported from Russia The answer to this paradox is that poor quality coal requires mazut or gas to support combustion which can be bought only for cash The station practically does not have cash (only 3 to 5% of its receipts are in cash) but can get some coal by trading credits. At this time the plant is overwhelmed by political and economic factors out of its control and it is a testimony to the management's efforts that the adjusted efficiency of the plant remained the same or improved since 1994

ECO-02 (energy conservation training program), and ECO-03 (fuel quality improvement program) were not implemented due to lack of funds. Salaries were not paid for 6 to 8 months and the management began layoffs. Under these circumstances implementation of the above programs would be very difficult even if the program funds were available

Some of ECO-01 (energy management conservation program) goals were realized despite the lack of funds for a formal energy management conservation program. Since 1995 the plants utilized the audit equipment that was left behind by the BREI audit team as part of the USAID boiler efficiency improvement demonstration program

ENERAC 2000

An ENERAC 2000 portable combustion analyzer is regularly used by the plant to conserve energy and reduce environmental pollution (see attached Protocol in Appendix H) An improvement in heat rate energy consumption is indicated by the plant. Some of this improvement in efficiency is due to lower excess air combustion which was made possible by timely analysis via ENERAC 2000 Plant personnel claims $25,000 to $30,000 per year in benefits due to use of a modern portable combustion analyzer (see the Protocol). So impressed was the management of DONBASENERGO by ENERAC 2000 that by the order of the Chief Engineer of DONBASENERGO this instrument was transferred from Kourakhovska to the corporation DonORGRES which tunes all power boilers in DONBASENERGO system. So now Kourakhovska' ENERAC 2000 is helping 5 TES to conserve energy and reduce environmental pollution So the overall benefit should be 5 times higher than indicated in the Protocol

The plant personnel were unwilling to quantify savings in tons of environmental pollutants or avoided environmental fines, but had no doubts that such savings took place.

An improvement in operational efficiency also took place since two technicians can perform the

measurement in 15 minutes whereas previously an inferior measurement required an effort of 4 technicians for 4 hours

CYCLOP 300AF INFRARED THERMOMETER

The plants have nothing but praise for the Cyclop 300AF infrared thermometer. It was in wide use for about 2 years The instrument is used to troubleshoot the generator stator, disconnect switches, and boiler tubes. The Protocol states $12-15,000 per year in benefits, which is conservative.

FLUKE AC POWER ANALYZER

The plant also likes the Fluke AC power analyzer. It was in constant and wide use for about 2 years. An economic benefit of 12,000 per year is claimed in the Protocol.

ZIRTEK OXYGEN ANALYZERS

ZIRTEK oxygen analyzers are being installed at the plant The reason for the delay is not known The plant have declined to estimate an economic benefit from this instrument until it gains some hands-on experience with it

TRANSPORT PT 868 PORTABLE LIQUID FLOW METER

This instrument was available to the plant for about 2 months The plant is trying to learn how to use the meter and works hard to commission it This will take some time. Future benefits are estimated by the Kourakhovska plant at $10-11,000 per year

MICRON M90 HIGH RANGE INFRARED THERMOMETER

A MICRON M90 high range infrared thermometer was available to the plant for at most 2 months The plant is trying to learn how to use the thermometer and works hard to commission it This will take some time. Future benefits are estimated by the Kourakhovska plant at $10-11,000 per year

LABORATORY SULFUR ANALYZER

A laboratory sulfur analyzer was available to the plant for at most 1 month The plant is trying to learn how to use the analyzer This will take some time However the plant has high hopes for the instrument and works hard to commission it The sulfur analyzer was provided to verify the sulfur content of the received coals versus the coal specified This would prevent deterioration of the furnace, air heaters and the duct work and thus prevent a drop in the boiler efficiency.

There also will be savings in tons of SO_2 emissions and avoided environmental fines In 1995 we estimated the economic benefit from a sulfur analyzer at $101,200 per year The plant have declined to estimate an economic benefit from this instrument until it gains some hands-on experience with it. Since the plant load is down about 50%, we estimate that under the present conditions the economic benefit will be about $50,000 per year

LABORATORY CALORIMETER

A laboratory sulfur analyzer was available to the plant for at most 1 month The plant is trying to learn how to use the analyzer and works hard to commission it This will take some time The plant have declined to estimate an economic benefit from this instrument until it gains some hands-on experience with it

APPENDIX A-1

Energy Conservation Opportunities (ECO's)

ECO-04, 05, and 07 - CALCULATIONS

INSITU OXYGEN ANALYZERS, COAL AND PORTABLE MAZUT METERS AND INFRARED BOTTOM ASH TEMPERATURE DETECTOR

1 0 INTRODUCTION

The air to fuel ratio of boiler #6 is controlled manually The existing extractive paramagnetic type oxygen analyzers are maintained and calibrated However, the instruments are prone to being fouled by moisture and acid sludge from the flue gas Also, there is a significant time lag between sample point and readout, which is aggravated by swings in excess oxygen due to fluctuations of coal feed to burners The biggest problem with the existing extractive analyzers is that the sample is taken after major air in-leakages have already occurred. Installation of in-situ zirconium oxide cells upstream of major in-leakages would improve reliability, response and accuracy of readings. However, three other instruments are necessary to actually realize a benefit from a lower excess air, namely, coal flowmeters, a portable mazut meter and an infrared bottom ash temperature detector.

2.0 ASSESSMENT OF POTENTIAL EXCESS OXYGEN REDUCTION

There is a potential to reduce the levels of excess oxygen at all Kourakhovska units, however only unit #6 is assessed in detail. This potential is based on the current levels of excess oxygen that are maintained at the burners. In order to assess this potential, it is necessary to evaluate the measured excess oxygen levels and account for air in-leakage through the various sections of the boiler.

The station reports that stable combustion with 0.3-0.5% O_2 at the burner level can be achieved due to staged combustion and low NO_x burner design. The low NO_x burners are completely replaced every 4 years and are inspected, repaired or replaced on "as needed" basis every two years. However, the existing extractive paramagnetic type oxygen analyzers are too slow and unreliable and therefore operators typically add a large safety margin and operate boilers at higher excess furnace oxygen that is called for by the burner design

In the station's judgement, the excess furnace oxygen at full load while firing coal can be reduced to 0 5% at the burner level if reliable instantaneous excess oxygen measurement becomes available to the operators Since the burners at this plant are replaced on a regular basis, BRC very conservatively assumes that only 3% excess O_2 at burner level will be achieved using modern O_2 analyzers. Excess oxygen levels higher than this provide the opportunity for a reduction in the operating levels.

2 1 Evaluation of Excess Oxygen at the Burners

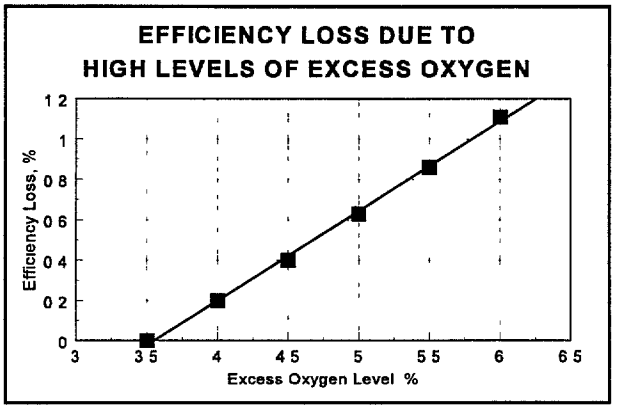
At full load firing coal, the excess oxygen was measured in the convection pass to be 5 6% for the normal operating condition CO emissions were negligible BRC converted this measured excess oxygen to the excess oxygen at the burners using calculated in-leakage rates and arrived at 4.25% excess oxygen at the burners. Accounting for the existing burner design and routine burner replacement, the minimum excess oxygen at the burner level can be assumed (very conservatively) to be 3% Thus, the potential reduction in excess oxygen at the burners would be 4 25 - 3 0 = 1.25%.

2.2 Effect of Excess Oxygen on Boiler Efficiency

Boiler efficiency is calculated based on the ASME Boiler Test Code, PTC-4 1 The losses in boiler efficiency affected by the excess oxygen levels are the dry flue gas loss and the moisture in air loss. The dry flue gas loss is the loss of heat determined by the flue gas flow and the difference in temperature of the flue gas and the ambient air. The moisture in air loss is the same loss calculated for the moisture that is contained in the air.

The reference excess oxygen was selected to be 3 5% Boiler efficiency was calculated for excess oxygen levels up to 6 5%, to account for possible operating conditions above the optimum.

A curve of the efficiency loss due to high excess oxygen is shown below.



2 3 Boiler Efficiency Improvement With Reduced Excess Oxygen Operation

Based on the data collected during the visit to the plant it appears that it is possible to operate the boilers at reduced excess oxygen levels. It has been shown that the potential excess oxygen reduction is approximately 1 25% while firing coal This would reduce the excess oxygen from 4.25% to 3.0%

Using the curve shown above, the boiler efficiency saving is extrapolated to be 0.5%. Reduction in excess oxygen from 4 25% to 3.5% will yield 0 3% efficiency improvement, reduction in excess oxygen from 3 50% to 3 0% will yield another 0 2% efficiency improvement for a total of 0 5%

3 0 COST ANALYSIS

The cost savings of a 0 5% reduction in the boiler efficiency would be realized in a fuel saving of approximately the same amount The total cost of fuel fired in 1994 for Unit #6 is estimated at $14,458,000 (see attached calculation)

BRC calculates total annual savings for Unit No 6 to be:

$14,458,000 × 0.5% = $72,290

As we mention earlier, coal flowmeters, a portable mazut meter and an infrared bottom ash temperature detector may be necessary to actually realize a benefit from a lower excess oxygen. A portable mazut meter and an infrared bottom ash temperature detector will be shared among seven boilers, therefore only 1/7 of their prices is included in per boiler payback calculations

Total equipment cost. $25,000 (high temperature oxygen analyzers) + $40,000 (two coal flow meters) + $9000 − 7 ≈ $1300 (portable mazut meter) + $4000 ÷ 7 ≈ $575 (portable infrared bottom ash temperature detector) = $66,875. We will assume cost of installation and commissioning to be $10,625, which is reasonable since installation and commissioning will be done by the plant using local labor. Therefore, total installed cost for ECO-04, 05, and 07 will be $77,500 per boiler

- <u>Payback at current fuel price for the entire package</u>·

  $77,500/$72,290=1 072 yr = 12.86 months

- <u>Payback at current fuel price for the oxygen analyzer system alone.</u>

  ($4000+$25,000)/$72,290 = 0 401 yr = 4.8 months

Note This is not recommended Unsafe operating conditions could develop if an infrared bottom ash temperature detector is not provided.

- Payback at current price for an infrared bottom ash temperature detector and the oxygen analyzer system.

  ($600+$29,000)/$72,290 =0 409 yr = 4 91 months

- Payback at current price for coal flowmeters, a portable mazut meter and the oxygen analyzer system:

  ($1,400+$46,500+$29,000)/$72,290 = 1 064 yr = 12.76 months

ECO-06 - CALCULATION

SULFUR LABORATORY ANALYZER AND TESTING SIEVE SHAKER

1.0 INTRODUCTION

A modern Sulfur Laboratory Analyzer will allow Kourakhovska Power Plant to reject shipments of coal of poor quality and unacceptably high levels of sulfur Sulfur content of Ukrainian coal even from the same mine can vary significantly. Kourakhovska Power Plant does not control back end temperature and as result SO_2 in the flue gas (as high as 6g per cubic meter) reacts with water and becomes sulfuric acid. A testing sieve shaker will allow the plant to verify fineness of the coal dust before combustion If the plant would burn coal that complies with specification, excessive corrosion and degradation of the furnace, air heaters and back end ducts can be avoided

2.0 ASSESSMENT OF POTENTIAL ECONOMIC BENEFIT

Burns and Roe assumes that prevention of excessive corrosion and degradation of the furnace, air heaters and back end ducts will result in 0 1% avoided reduction in boiler efficiency for the entire plant Given $101,204,500 as total annual cost of fuel for Kourakhovska Power Plant, the total savings in fuel cost would be **$101,204**

Payback at current price

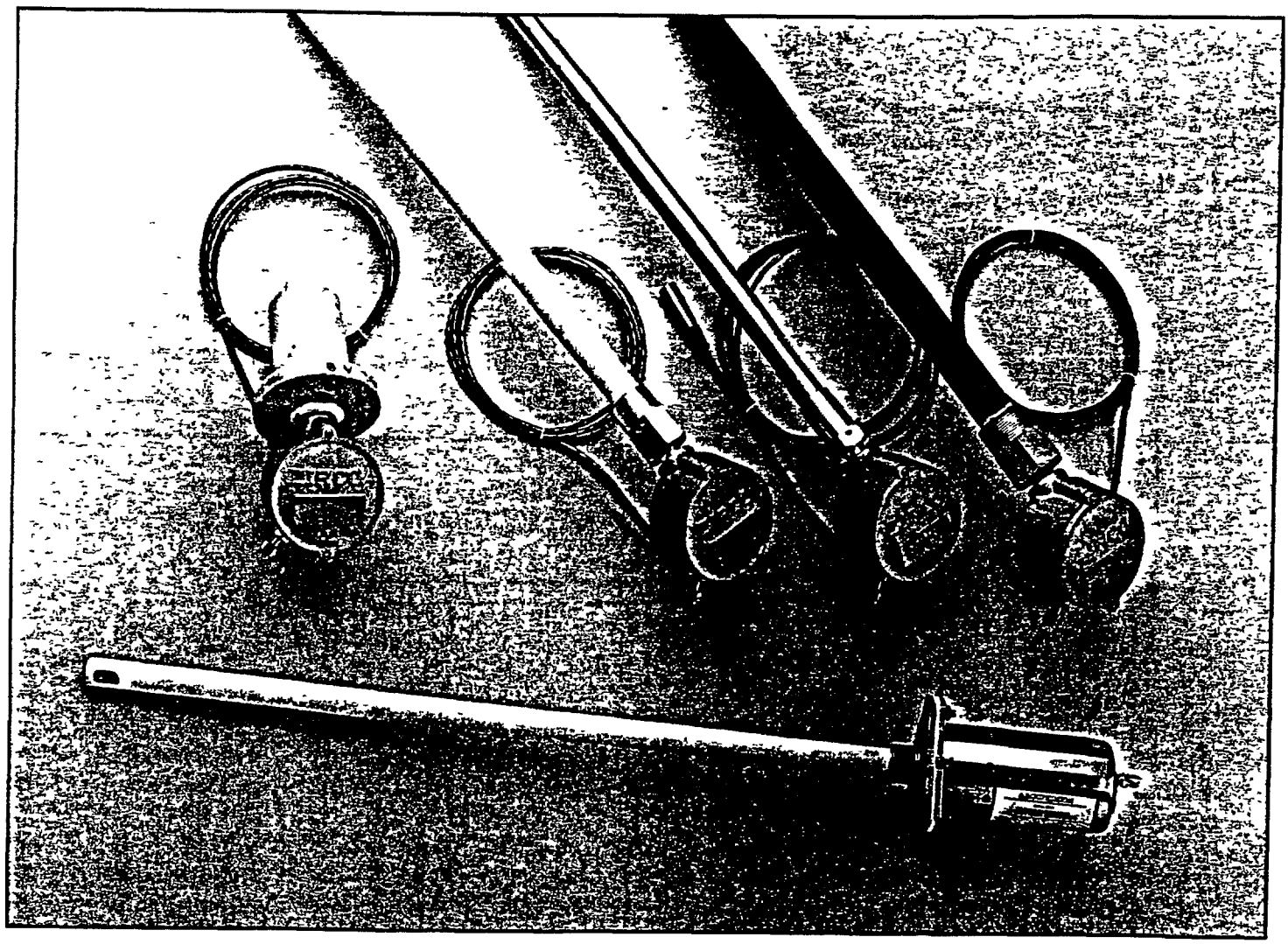
$45,000/$101,204 ≈ 0.445 yr ≈ 5 34 months

APPENDIX A-2

Vendor Information

AACC/Zircoa™

HIGH TEMPERATURE OXYGEN SENSORS



Model 8212

This sensor is designed to fulfill the special requirements of the Glass Industry. Model 8212 provides reliable O_2 measurement in positive pressure tanks, even in conditions of significant "Batch Carryover"

Model 8081

The versatility of this "workhorse" sensor is proven by its industry-wide applications around the world You can expect Model 8081 to provide dependable O_2 measurement in numerous coal, gas, oil and waste-fired environments.

Model OX

Model OX provides the critical measurements you need in a state-of-the-art rebuildable design. Available option permits use of a portable extractive device to verify oxygen readings

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Utilities

High-temp O_2 measurement improves boiler performance

Looking for ways to improve plant heat rates, Northern Indiana Public Service Co (Nipsco) has installed high-temperature O_2 sensors in the furnace and convection passes of several of its boilers, beginning with Units 7 and 8 at its Bailly generating station with good results

The problem. Units 7 and 8 are Babcock & Wilcox Co (Barberton, Ohio) coal-fired steam generators with Cyclone burners. Unit 7 is a 175-MW drum boiler. Unit 8 a 340-MW once-through boiler As with most utility units, excess-air control was achieved by determining O_2 levels at the economizer outlet Since both units are normally run under negative furnace draft, air can infiltrate through leaks in the boilers, ductwork, or expansion joints This air in-leakage can result in a bias in the excess-O_2 control circuit, giving indication of sufficient O_2 when, in fact, the opposite condition may be true

Enough air infiltration can lead to improper air-to-fuel ratios, poor combustion, and corrosive damage if a reducing atmosphere prevails Also, the O_2 probes and analyzers on Units 7 and 8 became increasingly unreliable Repairs to maintain the economizer-outlet system had become excessive and costly The result? The O_2 control system often operated with one or more probes out of service, making it more difficult for the operators to monitor and maintain excess-O_2 levels, which led to a lack of confidence in the system

To solve the problem of biased excess-air readings, Nipsco started experimenting with permanently installed high-temperature O_2 probes in the upper furnace of Unit 7 These criteria were established as a basis for the purchase of a new system·

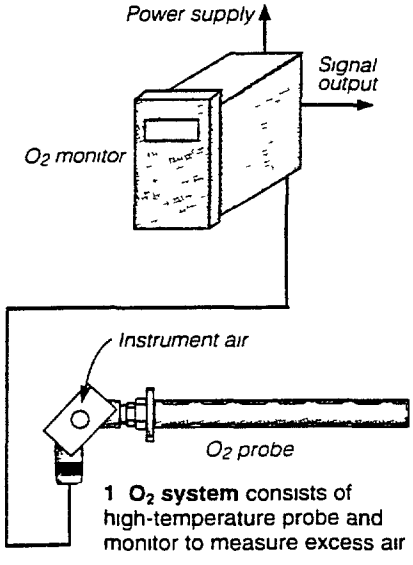
- Low maintenance requirements
- Continuous operation in the furnace section of the boiler.
- Improved probe life, with a one-year minimum desired.

A system that appeared to meet the criteria was a zirconium oxide cell mounted in a silicon carbide tube This type of probe had seen service in the glass and steel industries, but not in US utilities The probe is said to offer several advantages

- High-temperature operation, from 1200F to 2900F.
- Fast response.
- No sensor calibration required.
- No heater calibration or failure

Probe operation. The high-temperature capability of the new O_2 probes allows their permanent installation in an area of the furnace other than the economizer outlet. The high-temperature cell is exposed to a reference gas (instrument air) on one side of the cell, process gas on the other (Fig 1) Zirconia oxide cells behave as solid-state electrolyte at high temperatures in the presence of a catalyst Under isothermal conditions, and when O_2 partial pressures differ on either side of the cell, an emf inversely proportional to O_2 content in the process gas is developed.

Proper functioning of the zirconia oxide cell is achieved above a minimum recommended temperature of 1100F. Because the old probes (also zirconium oxide cells) had to operate at temperatures of 850F or less at the economizer outlet, a heater assembly and temperature controller were required to maintain cell temperatures greater than 1100F Since heaters aren t required with the new high-temperature probes, calibration requirements are eliminated



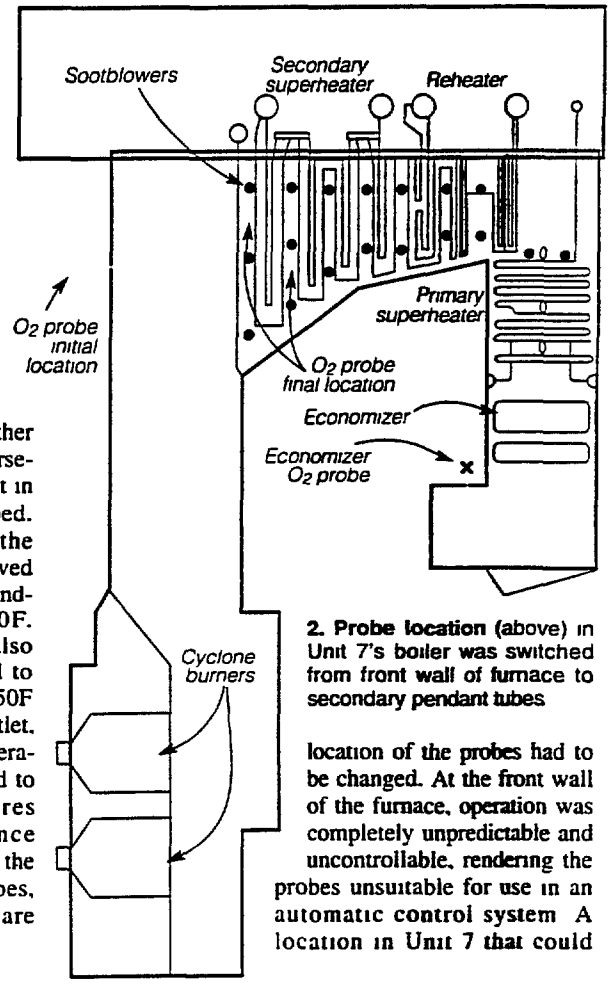
1 O_2 system consists of high-temperature probe and monitor to measure excess air

Probe testing. At Unit 7, two high-temperature O_2 probes were initially installed in the inspection ports on the front wall of the furnace (Fig 2), with a monitor for each installed at an elevation 88 ft below the probes in the burner-control cabinet room Although performance was satisfactory at first, two months later one of the probes failed, breaking off at a point beyond the inside of the front-wall tubes It was decided that excessive amounts of slag collecting on the probe had caused the failure, rather than stress caused by constant vibration experienced at this location.

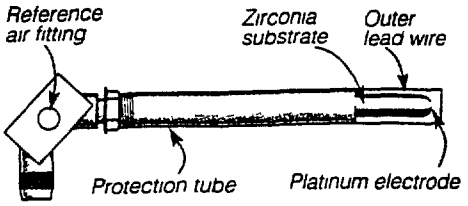
The next step was to install a probe with a stainless steel protection tube (Fig 3), instead of the standard silicon carbide tube, to see if it could better withstand the extreme conditions in the furnace After only three days of operation, this probe failed—an excessive amount of slag had accumulated on its tip. The other probe failed after four months of continuous operation The cause again appeared to be from slag

Since probe performance otherwise was satisfactory, an outer protection tube was added to increase longevity The longest achievable run with this added protection was only a probe life of three months The outer tube also had an adverse effect on the accuracy of the reading if extreme care was not taken in its installation.

Improved location. Obviously, the location of the probes had to be changed. At the front wall of the furnace, operation was completely unpredictable and uncontrollable, rendering the probes unsuitable for use in an automatic control system A location in Unit 7 that could



2. Probe location (above) in Unit 7's boiler was switched from front wall of furnace to secondary pendant tubes



3. Protection tube (right) of stainless steel is aimed at improving probe's ability to withstand extreme furnace conditions

greatly improve the service life of the high-temperature O_2 probes appeared to be in the superheater area of the boiler convection pass Rather than being exposed to harsh environmental conditions in the open area of the furnace, the probes would have maximum protection within the secondary pendant tubes (Fig 2).

Consequently, four O_2 probes were installed in the secondary superheater section of the furnace—two in each sidewall. A potential risk in putting them there was they would be close to the sootblowers. After the probes were in service, the sootblower nearest each probe was operated. It was found that sootblower operation would not damage the probes. The O_2 system could now be monitored to evaluate the performance and longevity of the probes

The bottom line. Initial trials on Unit 7's high-temperature O_2 system show that the probes have good potential for application to utility boilers The knowledge gained from these trials was put to good advantage when a high-temperature O_2 system for Unit 8 was installed, including four probes in the pendant reheat area of the convection pass After continuous operation for over a year, none of Unit 8's probes have failed.

Results to date have shown differences of O_2 measurement taken at the economizer of 0 4% to 2 5% when compared to the high-temperature probe readings Probe performance has been so successful that the economizer O_2 system will be phased out at Nipsco Also, operator confidence in O_2 measurement of flue gas has been restored.

Tom Elliott

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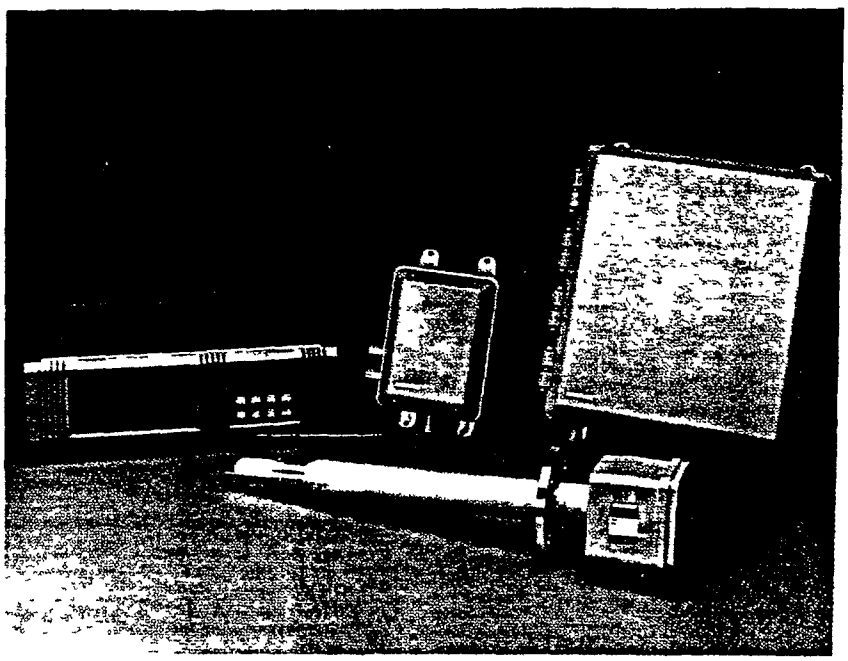
- *Flexible Electronics Configuration*
- *Control Room Electronics Module can be Integrated with up to 8 World Class 3000 Probes (16 with Master/Slave) Averages up to 8/16 World Class 3000 Probes*
- *Easy Calibration*
- *No Potentiometers to Adjust*
- *Quick Change Diffusion Element*
- *Field-Repairable Cell Design*
- *Field-Repairable Heater/ Thermocouple*
- *Flame Arrestor (Optional)*



WORLD CLASS TECHNOLOGY FROM THE WORLD LEADER

Rosemount is the leader in oxygen flue gas analyzer technology Rosemount incorporated the Hagan analyzer and combustion expertise The Hagan in situ, zirconium oxide oxygen analyzer has long been established as the industry-standard. Rosemount has combined this Hagan expertise with state-of-the-art features into one package — the World Class 3000 Oxygen Analyzer The World Class 3000 is established as the standard-of-the-industry

The World Class 3000 is totally field repairable as internal components are conveniently accessible for using in-house service personnel For example, the heater/thermocouple probe assembly can be replaced and put back into service by in-house personnel in one-half hour or less This repair is made without requiring the probe tube to be removed from the process

The Hagan zirconium oxide sensor cell incorporates a patented electronic cell-protection feature that automatically protects the sensor electrodes from reducing atmospheres often found in many combustion processes

For those applications where more than one oxygen analyzer will be installed on-site, the World Class 3000 Oxygen Analyzer together with the microprocessor-based CRE 3000 Control Room Electronics module is a cost-effective solution

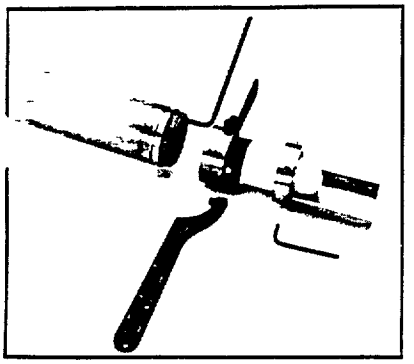
.he CRE 3000 Control Room Electronics module allows interfacing with up to eight World Class 3000 probes (16 with master/slave) via the HPS 3000 Field Interface Module This flexible, easily expanded, electronics arrangement allows the World Class 3000 probes to be linked to the Control Room Electronics module without the added cost of requiring intelligent field electronics (IFT 3000)

The CRE 3000 improves the accuracy of the combustion control process as it averages the oxygen results thereby reducing errors due to stratification Up to 4 averages of any probe combinations can be user-defined.

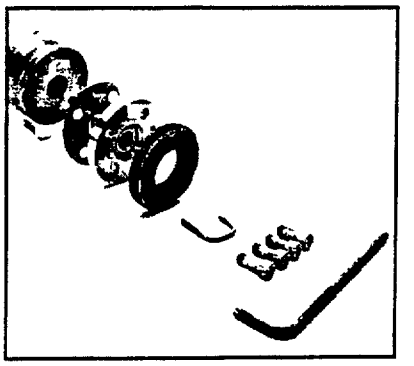
The HPS 3000 Field Interface Module provides local power to the oxygen probe. It is connected to the CRE 3000 at a distance of up to 1200 feet with low cost signal cable. The HPS 3000 module is housed in a standard NEMA 4X (IP65) enclosure for full weather and corrosion-proof protection It is also available in an optional explosion-proof Class 1, Division 1 enclosure to allow low-cost adaptability of the World Class 3000 electronics to hazardous gas areas.

Users with multiprobe applications may also choose an optional MPS 3000 Multiprobe Test Gas Sequencer. The MPS 3000 provides automatic test gas sequencing for up to four (4) World Class 3000 probes to accommodate fully automatic micro-processor-based calibration of the analyzer packages.

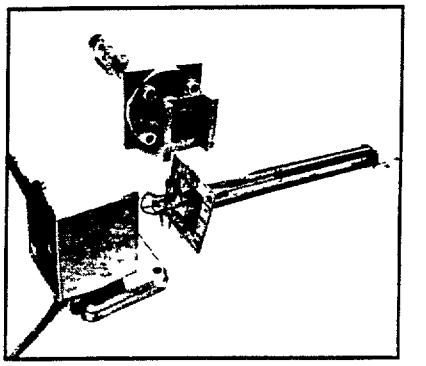
Supersedes Product Data 106-300NC,
Pages 1-8, dated March, 1992



Filter Head Assembly



Sensor Cell Assembly



Heater Thermocouple Assembly

OXYGEN SENSOR

Features	Benefits
Rapid, accurate and reliable measurement of excess oxygen with a single, in situ probe	Significant fuel savings normally pay for analyzer in less than one year Significant enhancement in safety
Electrodes are self protected by patented electronic diffusion limited current mode of operation	Provides long life for sensing element even in the presence of sulphur and reducing atmospheres
No sample system, no sample probes, no scrubbers and no pumps are necessary, test gas calibration check without disturbing probe	Low installation and low maintenance costs
High speed of response	Ideal for closed loop control
Solid zirconium oxide electrolyte	Provides high reliability
Field-replaceable cell	Ease of maintenance
Suitable for use in temperatures up to 1300°F (700°C)	May be used with any fuel Absolutely no condensation
Material of construction 316 LSS (all wetted parts)	High resistance to corrosion
Sensitivity of cell increases logarithmically when oxygen decreases	Very useful for low oxygen levels Ideal for low excess air burners

ADDITIONAL FEATURES

- Output voltage and sensitivity increase as the oxygen concentration decreases
- Use with any fuel including coal or residual fuel burners. Diffusion element keeps cell clean while the V-deflector protects the diffusion element
- Unique, patented electronic cell protection feature automatically protects sensor cell when analyzer detects reducing atmospheres
- Output suitable for use with receivers such as indicators, recorders controllers, data loggers or computers
- Optional flame arrestor
- Optional abrasive shield for extremely harsh environments, including high velocity particulates in flue stream, installation within 10 ft (3m) of soot blowers or heavy salt cake buildup Specific applications pulverized coal, recovery boilers and lime kilns

DIGITAL ELECTRONICS FEATURES

- Control Room Electronics module (CRE 3000) can interface with up to eight (8) World Class 3000 probes (16 with master/slave) Provides all necessary intelligence for controlling the probe and optional MPS 3000 Multiprobe Gas Sequencer
- CRE 3000 Electronics provides user friendly, menu-driven operator interface with context-sensitive, on-line help
- CRE 3000 Electronics averages the process data as defined by user This reduces inaccuracies due to stratification
  Remote contact initiates calibration
  HPS 3000 Field Interface Module allows interfacing of World Class 3000 probe and CRE 3000 without requiring intelligent field electronics or expensive cabling
- Optional explosion-proof HPS 3000 enclosure allows low-cost adaptability to World Class 3000 electronics in hazardous areas
- Optional MPS 3000 Multiprobe Test Gas Sequencer provides fully automatic test gas calibration and reference air for up to four (4) World Class 3000 probes MPS 3000 can be located up to 300 ft (91m) from World Class 3000 probe
- Optional stack temperature and combustion efficiency measurement Stack thermocouple required
- Probe heater over temperature protection with software disable as standard Hardware disable (line voltage relay) requires one additional twisted pair HPS/CRE cable

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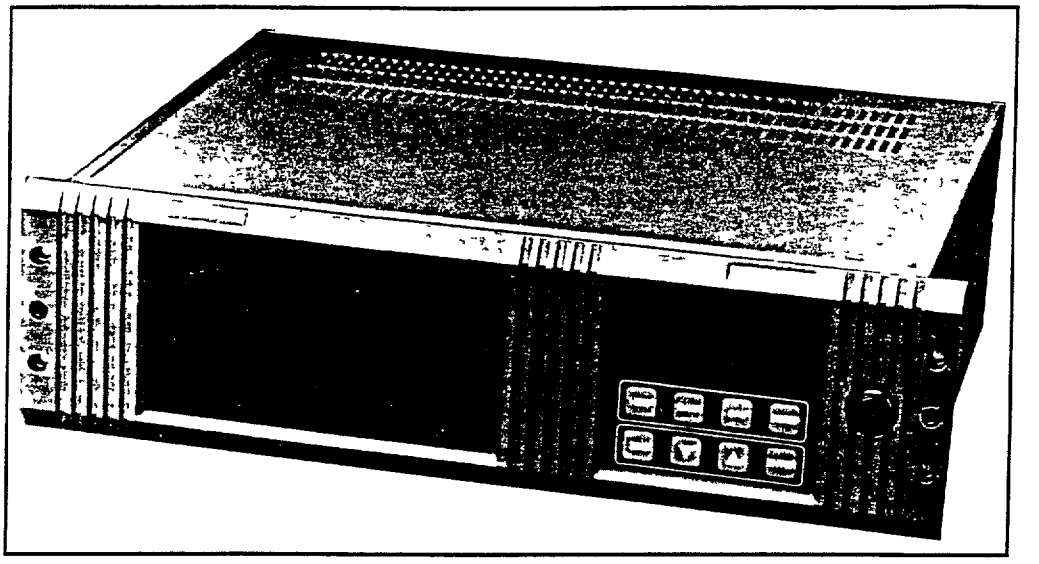
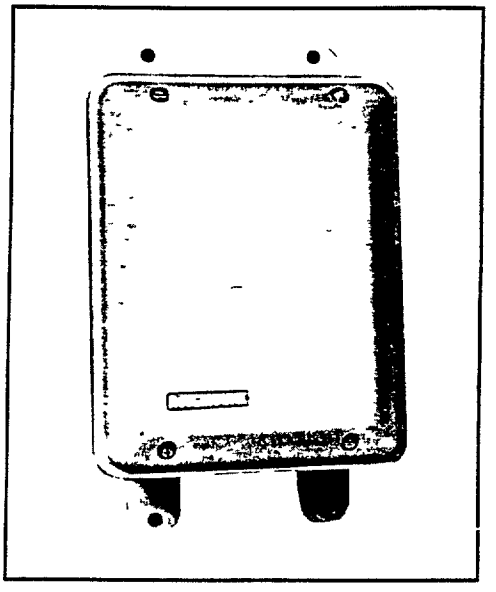
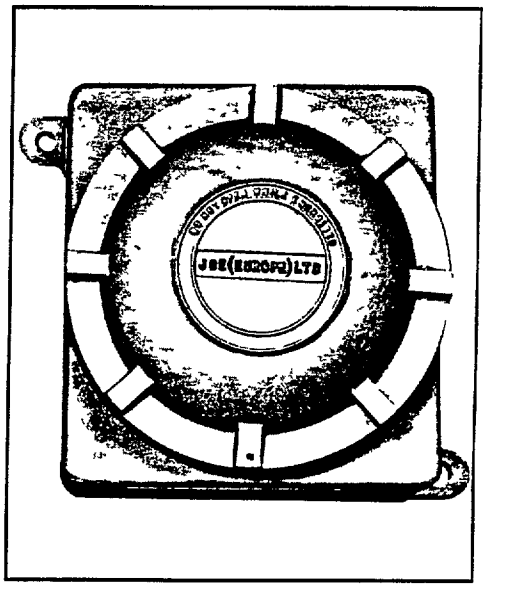
WORLD CLASS FAMILY OF ELECTRONICS



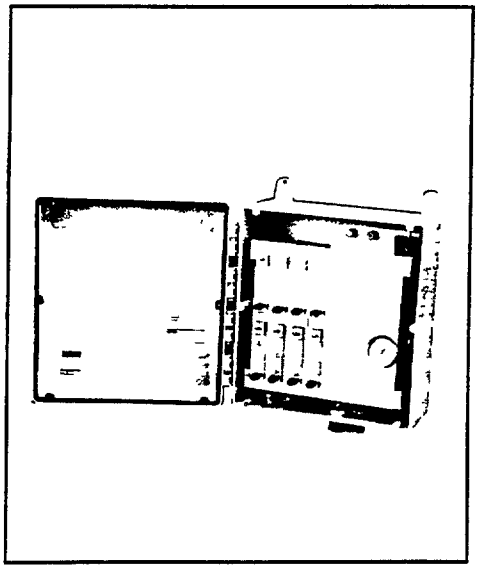
CRE 3000 Control Room Electronics Module



HPS 3000 Field Interface
(NEMA 4X Non-hazardous Enclosure)



HPS 3000 Field Interface
(Explosion-Proof Enclosure)



Optional MPS 3000 Multiprobe Test Gas Sequencer

SPECIFICATIONS①

OXYGEN SENSING EQUIPMENT

Probe lengths, nominal. 18 inches, 3 feet, 6 feet, 9 feet, 12 feet depending upon duct dimension
Probe material of construction: 316 LSS (all wetted parts)
Temperature limits for probe in process measurement area: 50 to 1300°F (10 to 700°C)
Cell speed of response: 1 millisecond
Probe reference air flow (optional): 2 SCFH clean, dry instrument quality air (20 95% O_2) Reference air set supplied as standard

Calibration gas mixtures: Rosemount Test Gas Kit Part No 6296A27G01 contains 0 4% O_2N_2 Nominal and 8% O_2N_2 Nominal Other suitable gas mixtures can be user supplied
Calibration gas flow: 5 SCFH
Approximate shipping weights:
18 inch (457 mm) package: 55 pounds (24 97 kg)
3 foot (0.91 m) package: 60 pounds (27 24 kg)
6 foot (1.83 m) package: 66 pounds (29 94 kg)
9 foot (2.74 m) package: 72 pounds (32.66 kg)
12 foot (3.66 m) package: 78 pounds (35 38 kg)

CRE 3000 CONTROL ROOM ELECTRONICS

Ambient environment requirements: Clean, Dry
Ambient temperature range: 40 to 120°F (4 to 50°C)
Vibration: Slight: 30 degree drop test
Number of probes: 8 maximum, expandable to 16 with slave CRE 3000
Communications: 1 RS 232 for communication with slave CRE 3000 (max 50 feet (15m)
Analog outputs: 2-12 isolated outputs 0-20 mADC, 4-20 mADC into 950 ohm max, 0-10 VDC into 2K ohm min
O_2 indication (analog output): ±0 1% O_2 or ±3% of reading, whichever is greater
Power supply: 110/115/220V ±10% Vac at 50/60 Hz
Power requirements: 100 VA

System speed or response (amplifier output): less than 3 seconds
Resolution sensitivity — Transmitted Signal: 0 01% O_2
O_2 range: Field Selectable (0-1%, 0-5%, 0-10%, 0-25%, 0-100%)
Programmable contact outputs: 8 available, Form-C, 48 V max, 100 mA max
Indicators: LED indicators for system failure (failure description available on LED panel)
Calibration in progress for each of 8 probes, O_2 Hi/Lo Alarm for each of 8 probes Probe failure for each of 8 probes
Programmable displays: 2 line, 0 8 inch high, 8 digit, alphanumeric LED displays for individual or averaged results.
Operator interface: 4 line by 20 character backlight LCD alphanumeric display, 8 key general purpose keyboard.
Approximate shipping weight: 35 pounds (15 88 kg)
Averaging: 4 user-definable averages of 2 to 8 probes

HPS 3000 FIELD INTERFACE

Electrical classification: NEMA 4X (IP65) Optional - Class 1, Division 1, Group B
Humidity range: 95% Relative Humidity
Ambient temperature range: -20 to 140°F (-30 to 60°C)
Vibration: 5 m/sec², 10 to 500 xyz plane
External electrical noise: Minimum Interference
Cabling distance between HPS 3000 and probe: Maximum 150 feet (45 m)
Cabling Distance between HPS 3000 and CRE 3000 Maximum 1200 feet (364 m)
Approximate shipping weight. 12 pounds (5 44 kg)
Power supply. 100/115/220V ±10% Vac at 50/60 Hz
Power requirements: 200 VA

MPS 3000 MULTIPROBE TEST GAS SEQUENCER (OPTIONAL)

Electrical classification: NEMA 4X (IP65)
Humidity range: 95% Relative Humidity
Ambient temperature range: -20 to 140°F (-30 to 71°C)
Vibration: 5 m/sec², 10 to 500 xyz plane
External electrical noise: Minimum Interference
Piping distance between MPS 3000 and probe: Maximum 300 feet (91 m)
Cabling distance between MPS 3000 and CRE 3000: Maximum 1000 feet (303 m)
Approximate shipping weight: 35 pounds (15 88 kg)
Power supply: 100/115/220V ±10% Vac at 50/60 Hz
Power requirements: 15 VA
Piping requirements: 1/4" o.d tubing, 1/4" NPT bulkhead connectors (high gas in, low gas in, ref air in, 4 x test gas out, 4 x ref air out)

① All static performance characteristics are with operating variables constant
Specifications subject to change without notice

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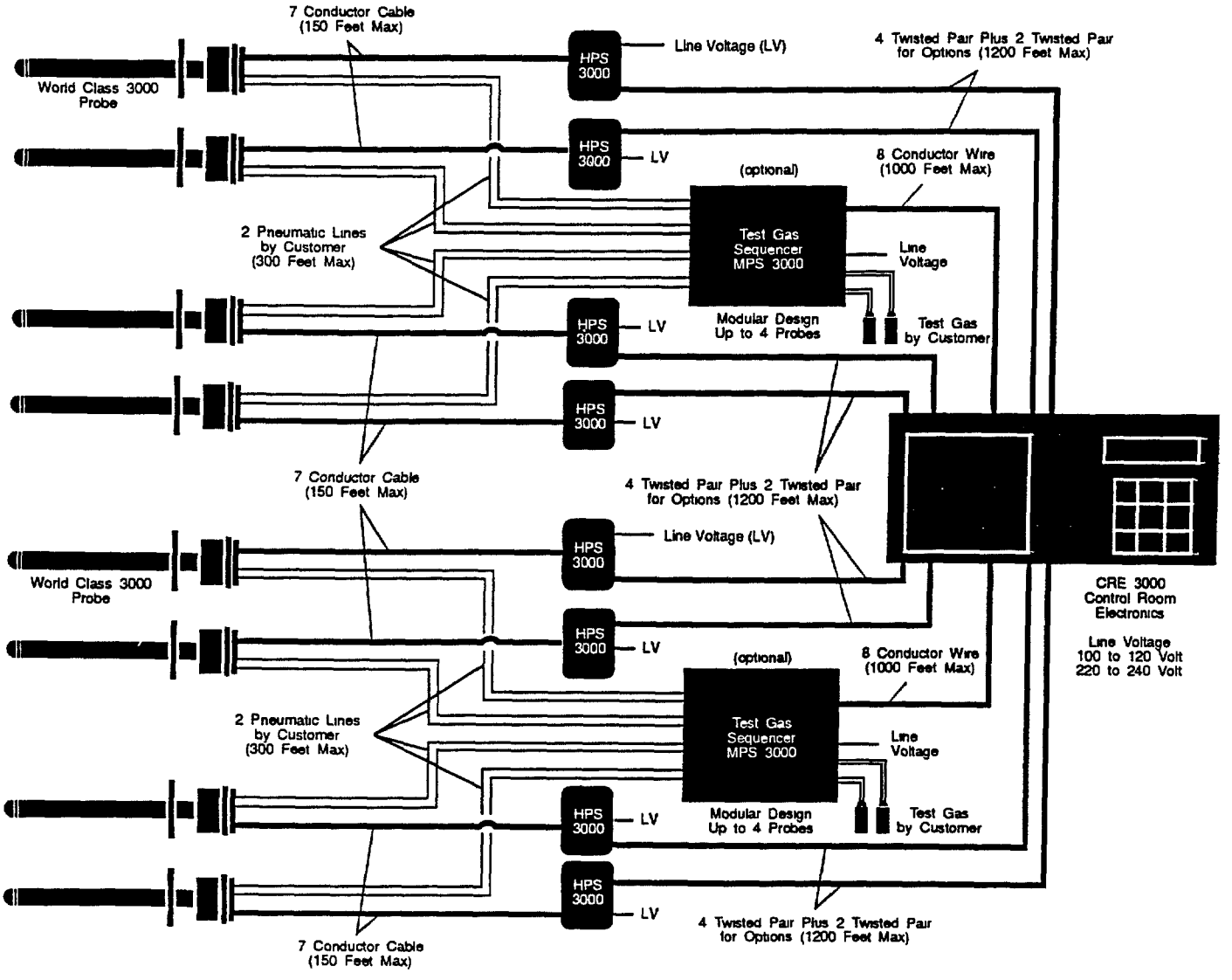
WORLD CLASS 3000 MULTIPROBE APPLICATION WITH CONTROL ROOM ELECTRONICS



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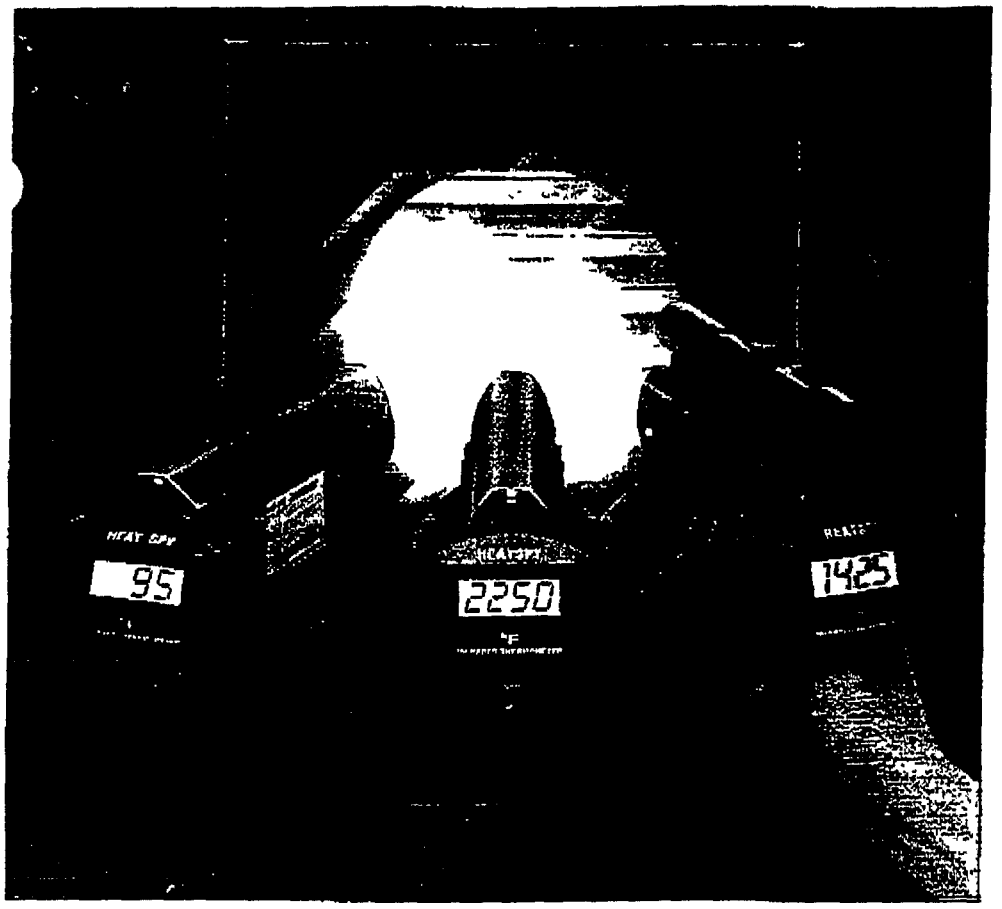


Heat Spy measures surface temperatures of glass, furnace walls and furnace tubes

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

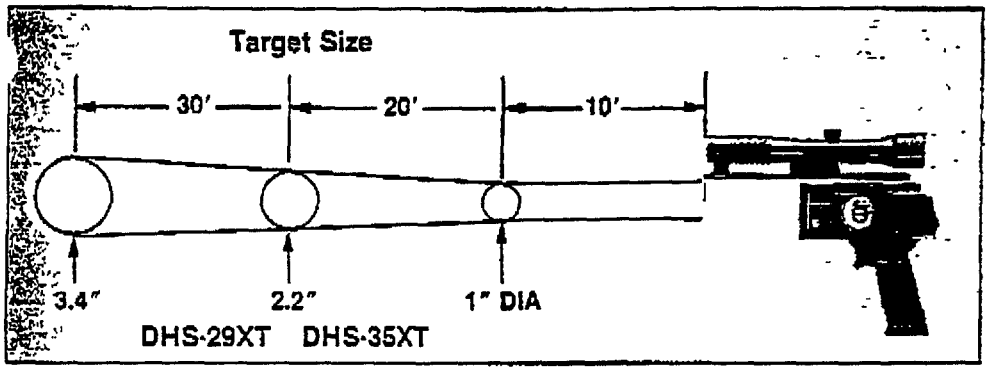
DHS-29X Standard Sight
DHS-29XT Telescopic Sight

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

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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 YEAR WARRANTY

TRACEABLE TO 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.

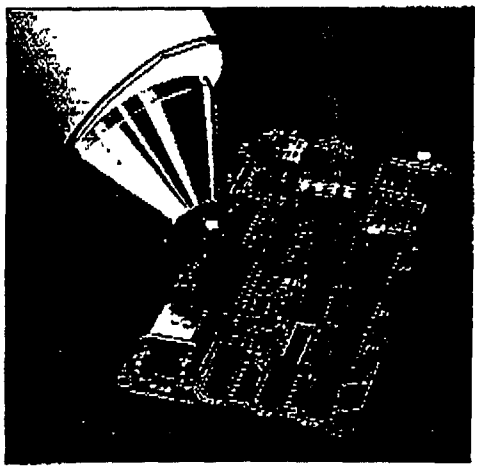
FM Approved models are dedicated °F or °C and are furnished without a connection for AC adapter, external battery pack or recorder output

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

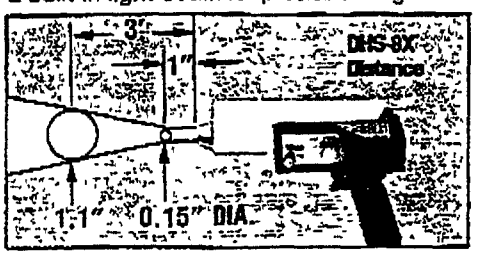
Price includes carrying case, spare battery, owners manual and trigger lock



Close Focus DHS-8X

0 to 1000°F, -20 to 550°C

For very small objects, such as electronic components, the close-focus instrument includes a built-in light beam for precise aiming.



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.

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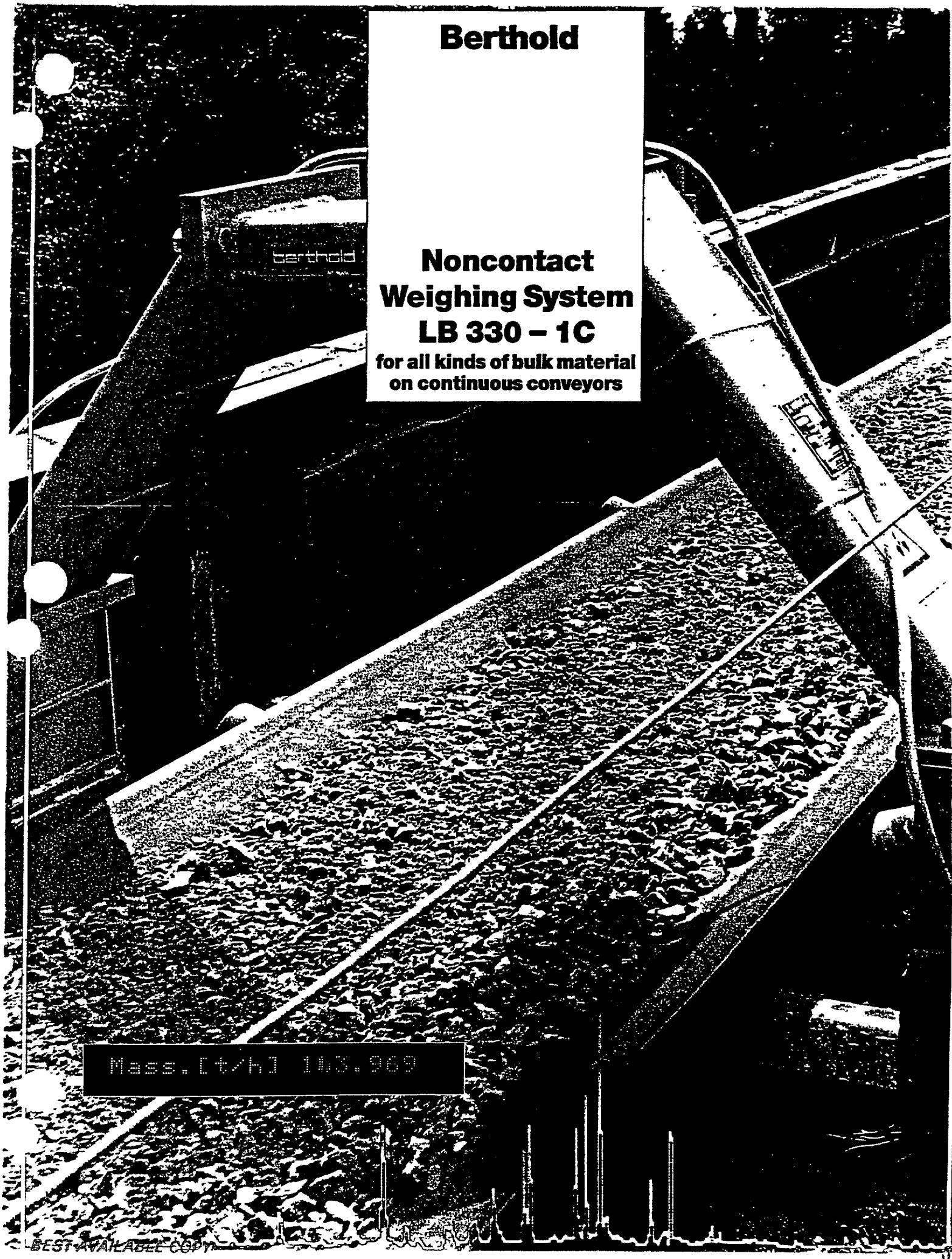
Berthold

Noncontact Weighing System LB 330 – 1C

for all kinds of bulk material on continuous conveyors



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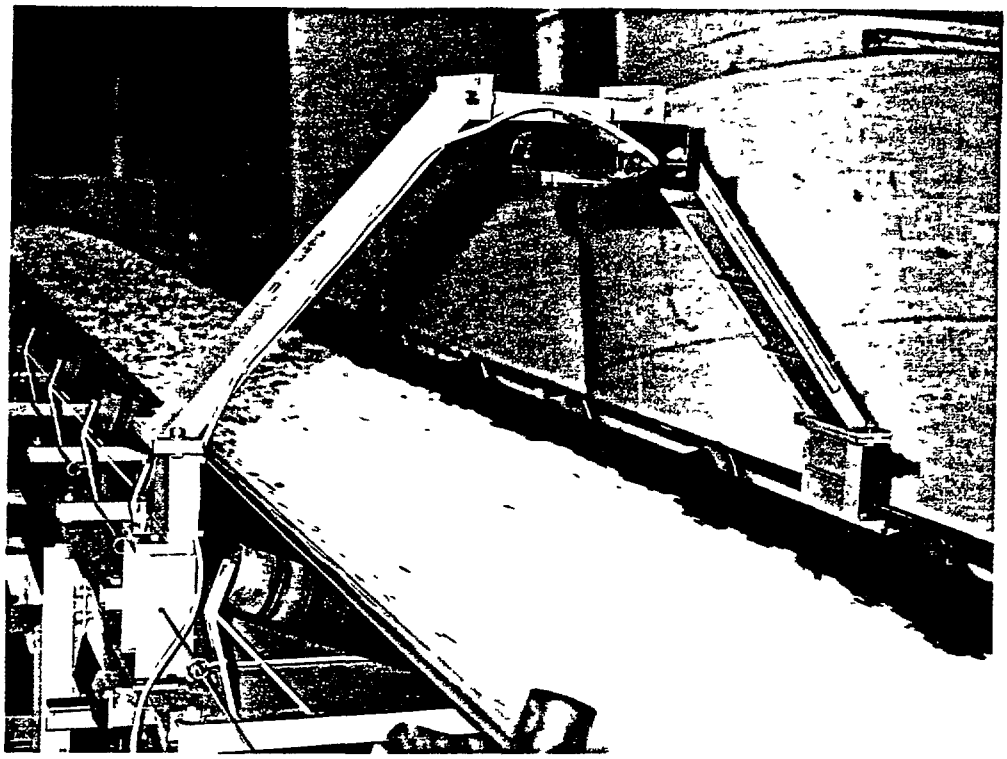
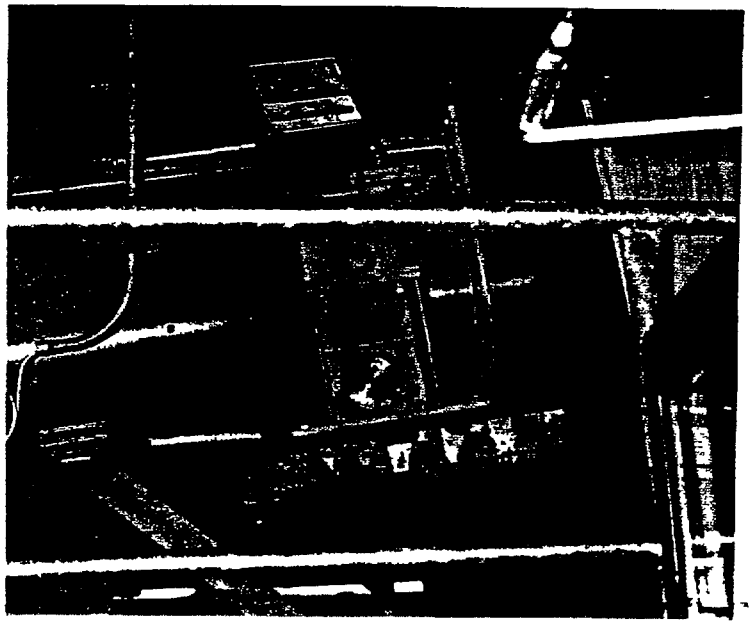
Noncontact massflow meter

The Compelling Advantages

- Noncontact massflow determination with gamma attenuation for kinds of bulk material on continuous conveyors
- No moving parts – no mechanical wear
- Installation on existing belts, screw conveyors or chain conveyors does not require any major mechanical modifications
- Little space required for frame – no relaxation section required for massflow
- Massflow determination possible during free fall
- Low source activity due to the use of highly sensitive scintillation counters
- Extreme long-term stability due to automatic drift and decay compensation
- Check of calibration on the empty conveyor system by a standard absorber
- Determination of the dry weight possible with existing moisture signal



Weighing system LB 330 – 1C installed on a rising conveyor belt



and on a screw conveyor

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Measuring principle

Design

A rod-shaped gamma source whose type, length and activity distribution is matched to the conveyor system and the material loading is installed below the massflow in a lockable shielding with a collimated radiation opening
A scintillation detector installed above the massflow detects the radiation attenuated by the material to be measured and provides a countrate dependent on area weight. From this countrate and the conveyor speed, the evaluation unit LB 330 – 1 C calculates the massflow

Accuracy

The very high stability of the measuring system is ensured by well-proven Berthold system providing automatic drift stabilization The high voltage control ensures constant amplification of the radiation pulses regardless of temperature and ageing of electronic components The accuracy obtained in practice depends on the distribution of the material on the conveyor belt, the averaging period, and the accuracy of the check weigher

With existing applications this has led to accuracies between 0.5 and 1.5 % on standard conveyor belts and up to 2.5 % on other conveyor systems, such as chain, screw or bucket conveyors

Calibration

The evaluation unit is precalibrated by the manufacturer and is immediately ready for operation, if you are willing to accept a slight decrease in accuracy. Maximum accuracy is achieved only by means of comparative weighing using calibrated weighing systems, e. g. weigh bridge
The evaluation unit automatically analyzes the resulting pairs of values (result of the radiometric system and of the comparative system) using an autocalibration program and performes an automatic self-correction. This calibration is stored as a set of constants The computer is capable of processing up to three externally selectable sets of constants for various products.
All evaluation unit functions affecting the continuous measurement are protected by a password.

Radiation Source and Shielding

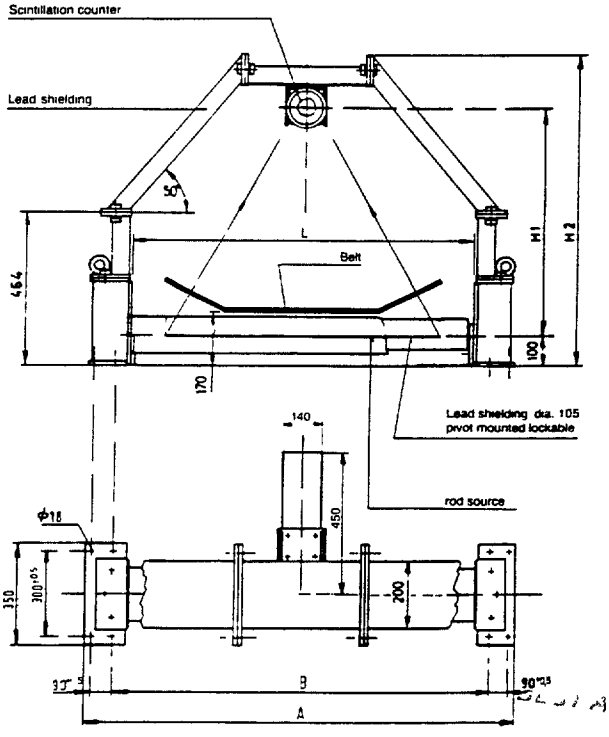
The type of gamma source used depends on the material loading With high belt loading ^{60}Co is used (half-life 5.3 years), with medium loading ^{137}Cs (half-life 30 years) and with low loading ^{241}Am rod sources (half-life 433 years)

The gamma radiation does not contaminate the product to be measured The noncontact massflow meter may therefore also be used in the food industry. The shielding is an integral part of the measuring frame which forms the outer limitation of the useful beam, and which, like the shielding, is filled with lead when ^{60}Co and ^{137}Cs is used.

This ensures that the radiation level outside the measuring frame is so low that it is well below the dose limits stipulated in the Radiation Protection Regulations.

Low doserates are guaranteed by using a sensitive detector and therefore source activities will be extremely small.

Design of Measuring Frame and Rod Source Mounting



Width mm	A	B	H1	H2	L	Weight of Measuring frame approx kg
500	1006	776	494	754	706	190
650	1156	926	584	844	856	220
800	1306	1076	674	934	1006	250
1000	1506	1276	794	1054	1206	290
1200	1706	1476	914	1174	1406	330
1400	1906	1676	1034	1294	1606	370
1600	2106	1876	1034	1294	1806	420

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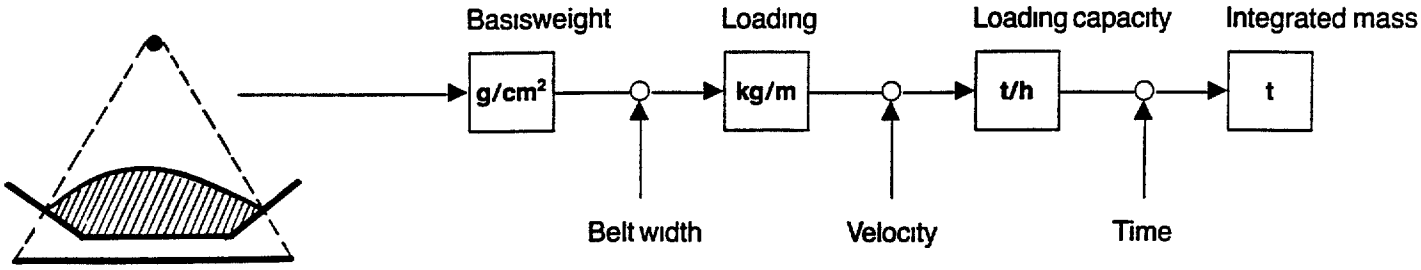
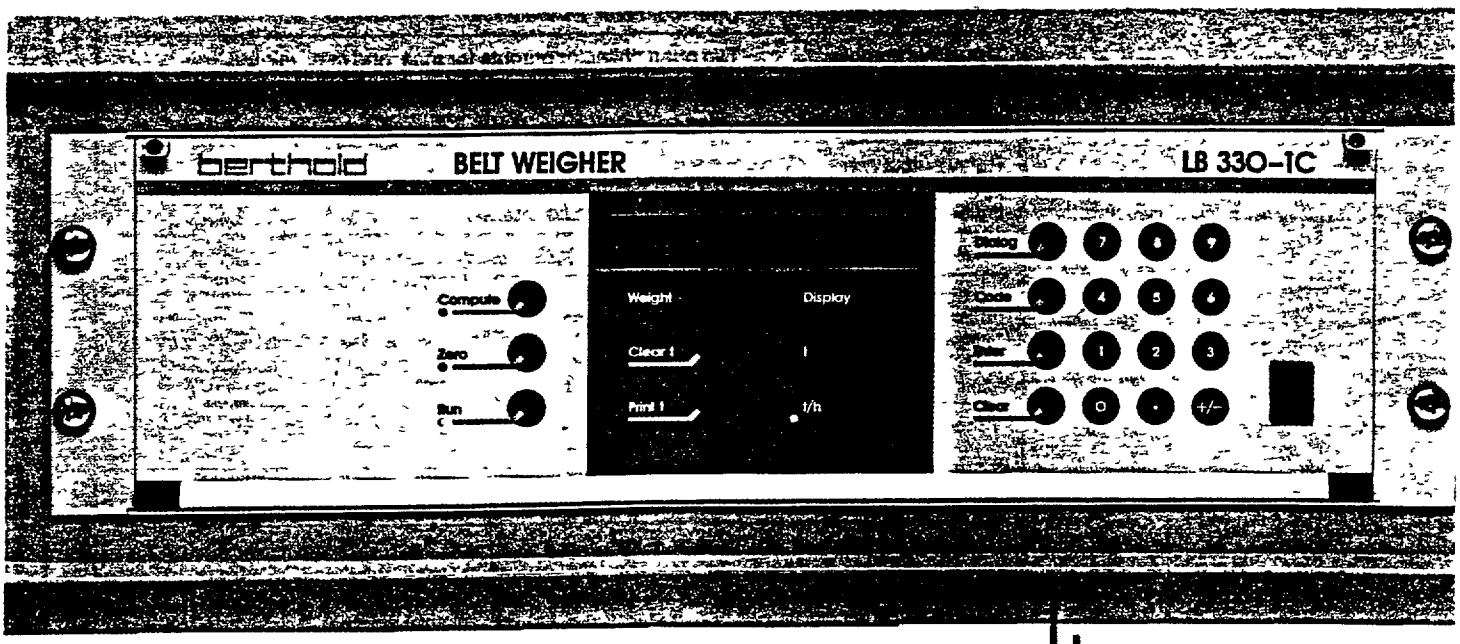
LB 330-1C – An Evaluation Unit offering Many Advantages

- wear resistant foil keypad
- easy operation via alphanumeric display
- operation mode setting via DIP-switches
- automatic decay compensation for the calibration parameters as standard, allows calibration over several days or even weeks
- two isolated current output signals is standard, range selection (0/4 – 20 mA) via DIP-switches freely selectable measuring range of both outputs
- digital inputs for conveyor stop and external menu selection, or for external clearing of the integrator, external activation of the tare measurement and also activation of the printer for protocol printout of intermediate results
- digital outputs for malfunctions indicator, set alarms, external integrator and signals when reaching a preselected batch weight
- tachometer input either as frequency or current input, selectable via DIP-switches
- input for moisture compensation is standard; when using a separate moisture measurement, the evaluation unit may therefore be used as dry-weight computer
- printer interface for parameter protocol listing and accurate documentation of the measured values Several evaluation units may be connected to one printer

Principle of data processing





Evaluation unit installed in protection housing

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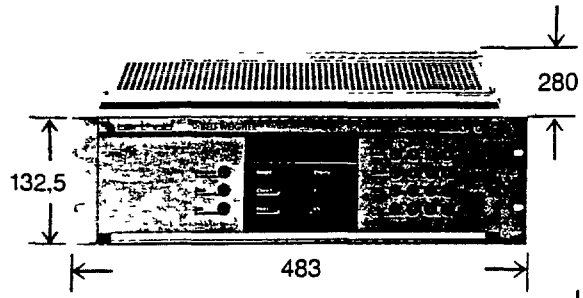
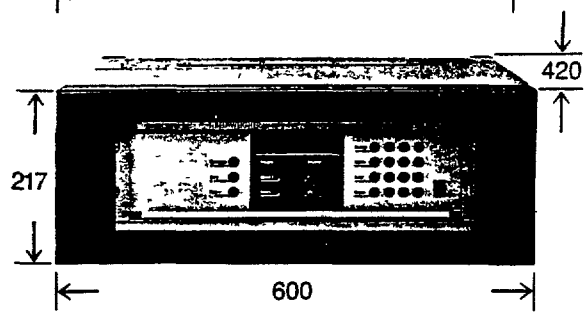
Dimensional Drawings

Dimensions in mm

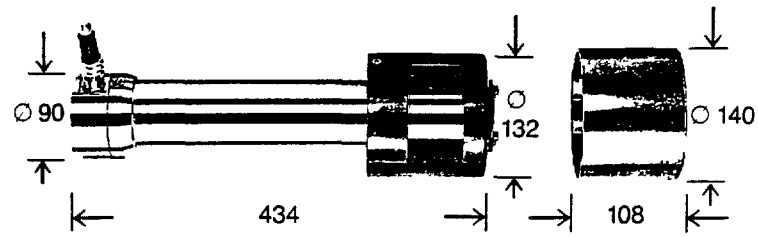
Evaluation unit
Weight approx 6 kg



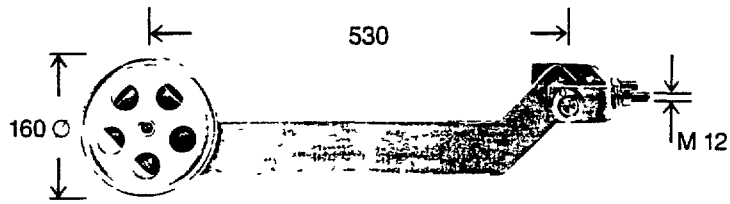
Evaluation unit in protection housing
Weight. approx 18 kg



Scintillation detector with calibration cover
Sz 5-M 1 40/35 or 50/50
Weight approx 18 kg



Tachometer with mounting bracket
Weight approx 5 kg



Your inquiries should include the following details:

- Type, width and profile section (e. g. through section) of conveyor belt
- Massflow velocity and possible alterations
- Material, bulk weight, grain size of bulk material
- Material loading or conveyor throughput
- Measuring range and accuracy required
- Approximate material profile section of material with maximum loading (sketch)
- Options required (e. g. printer)
- Proposed location of measuring system (drawing)

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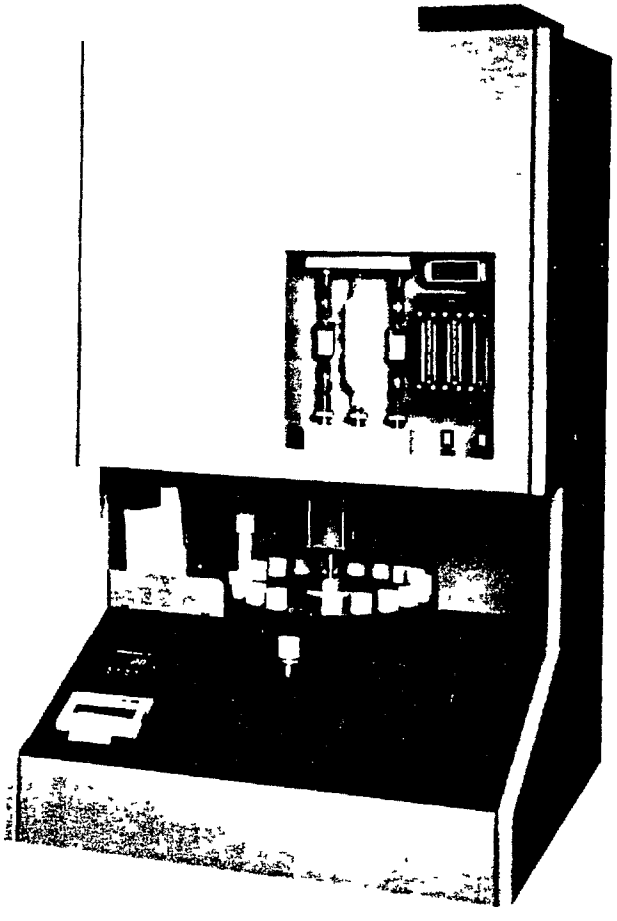
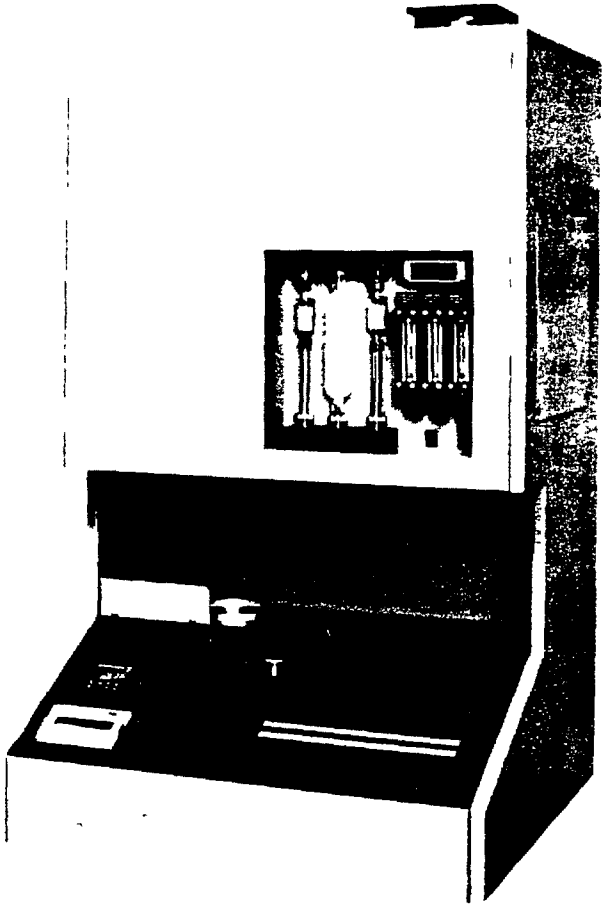
PREISER

MODEL 880 SULFUR ANALYZER



880 A



880 M

AUTOMATIC OR SEMI-AUTOMATIC OPERATION
SAMPLE SIZE IS 0.5gm FOR SAMPLES CONTAINING UP TO 4% SULFUR
SULFUR RANGE: 0.005 TO 99.99 %
TWO MINUTE ANALYSIS TIME

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MODEL 880 SULFUR ANALYZER

The Model 880 sulfur determinator uses oxidative combustion and non dispersive infrared detection to perform sulfur analysis in coal, coke as well as in other solids and heavy liquids It utilizes a micro-computer and an integral electronic balance with other automatic systems to rapidly and accurately determine the sulfur content Two models of the 880 are available· A semi- automatic model and a fully automatic model

In the automatic model, all analyzer operations are controlled by the operator through an interactive flat panel touch display This graphically based operator interface is designed to allow easy, straight forward operation of the analyzer with minimal operator training. No knowledge of a computer language is required Sample size utilized is 0 5 grams for coals containing up to 4% sulfur Coals having sulfur ranges of 0 005 to 99.99% can be analyzed. Accuracy is ±1% of the sulfur content for most samples, within the limits of ASTM D4239-85.20 samples can be weighed out by the operator at one time and then measured by the analyzer in unattended operation in approximately 40 minutes The analyzer calculates and displays the percent sulfur by weight from the SO2 reading and the initial weight of the sample. The result of the analysis is printed out on a built-in printer

The semi-automatic model differs from the automatic version in two major respects 1) It runs one sample at a time and 2) instead of the interactive touch screen, it has a 4 line LCD display and a separate, simple keypad The result of an analysis is displayed on a LCD display screen as % Sulfur and is printed out on a built-in printer.

ORDERING INFORMATION:

CATALOG NO.:	DESCRIPTION
92-1206-01	MODEL 880A AUTOMATIC SULFUR ANALYZER
92-1205-01	MODEL 880M SEMI-AUTOMATIC SULFUR ANALYZER

PREISER

PREISER SCIENTIFIC, INC.

94 OLIVER STREET • ST. ALBANS, WV 25177 • USA

Tel: 304/727-2902 • WATS: 800/624-8285 • FAX: 304-727-2932

MODEL 880 SULFUR ANALYZER

Automatic or Semi-automatic operation
Sample size is 0.5gr for samples containing up to 4% sulfur
Two minute analysis time
Sulfur range 0.005 to 00 99%
User friendly

The Model 880 sulfur determinator uses oxidative combustion and non dispersive infrared detection to perform sulfur analysis in coal, coke as well as in other solids and heavy liquids It utilizes a micro-computer and an integral electronic balance with other automatic systems to rapidly and accurately determine the sulfur content Two models of the 880 are available A semi-automatic model and a fully automatic model

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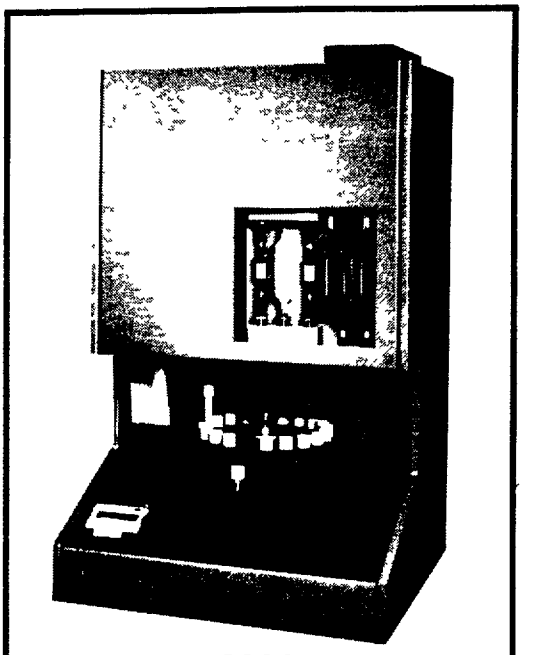
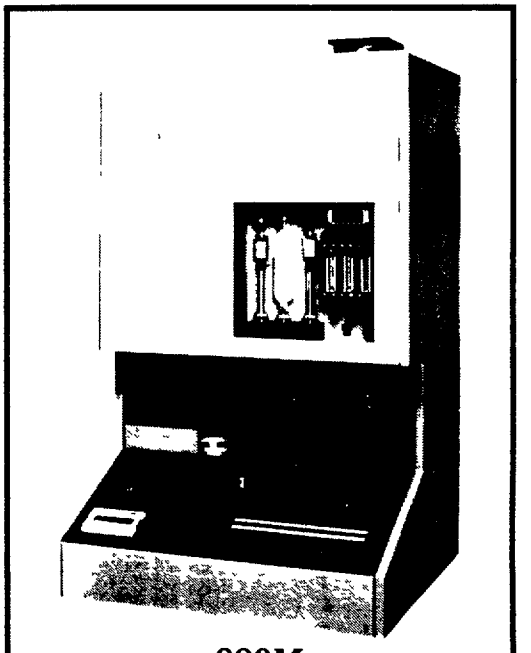
To learn more about these sulfur analyzers, call or write!



880A



880M

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P.O. BOX 1330 ST. ALBANS, WV 25177
Tel: 304/727-2902 WATS: 800/624-8285

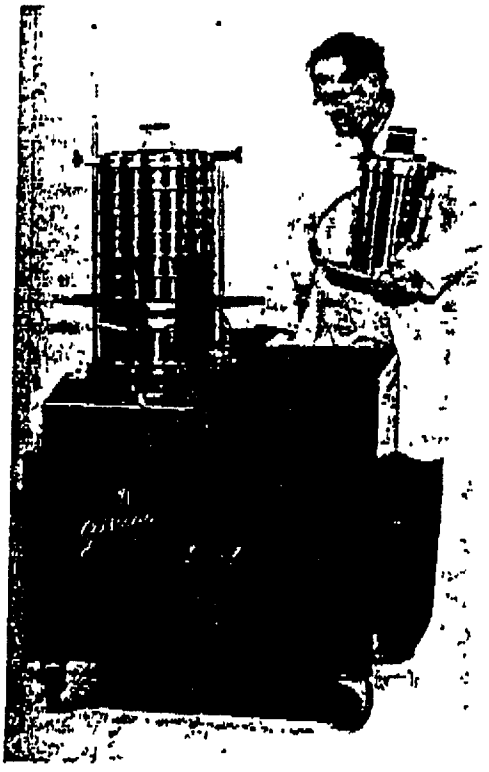
47

PREISER SCIENTIFIC, INC.
94 Oliver Street, P.O. Box 1330
St. Albans, West Virginia 25177

94 Oliver Street, P.O. Box 1330
St. Albans, West Virginia 25177

Effective Wet Sieve Tester

For Particle Size Measurement of Fine Granular Materials that Resist Dry Sieving



WV-3 can be used with 12" or 8" sieves.

Wet Sieving is used to overcome particle agglomeration, pancaking, electrostatic attraction and other problems which inhibit proper sieving of many fine materials on a dry basis. Gilson's Wet-Vac is designed to provide advantages of wet sieve testing while minimizing problems with liquid handling and fines recovery as encountered with simpler manual methods. Features include electromagnetic vibration, internal vacuum, pumped water recycle, rotating sieve spray, and filter recovery of subsieve fines. Dry sieving (with vibration only) may be performed for easy separations and is also employed prior to introduction of water and vacuum. Eight or more sieves may be used, and Wet-Vac models are available for 8 in. (203mm) and 12 in. (305mm) diameter sieves. Essential parts are stainless steel, and the entire system is housed in a cabinet on wheels.

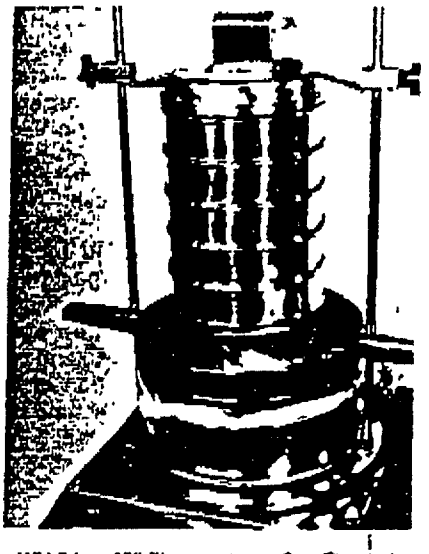
Typical Wet-Vac uses include coal and mining and mineral process design or control, investigations of soils or ocean and river sediments, control of slurries or non-soluble chemicals and powders and R&D applications. System offers control for wet-process industrial operations because tests closely approximate actual conditions. Samples may be introduced in dry, wet, or slurry form.

The 3600 vpm vibration of sieves and filter has rheostat control of amplitude and serves to disperse material on sieves and to assist passage of water by breaking water surface tension. Constant vacuum of about 2" of mercury is provided by a blower exhausting to the rear of the cabinet. Rubber gasket rings between sieves and other components seal the system. Bottom sieve nests in a sieve holder lifting ring which nests in a filter section comprised of 500mm filter paper held between a special Filter Base and Filter Holder. A See-Through Nesting Cylinder is provided for visual monitoring of water level. If filter paper blinds and needs to be changed, sieves can be raised and locked from the filter section using the lifting ring. Lifting ring and sieve cover assembly with spray bar are sized to fit 8" or 12" sieves, depending on model.

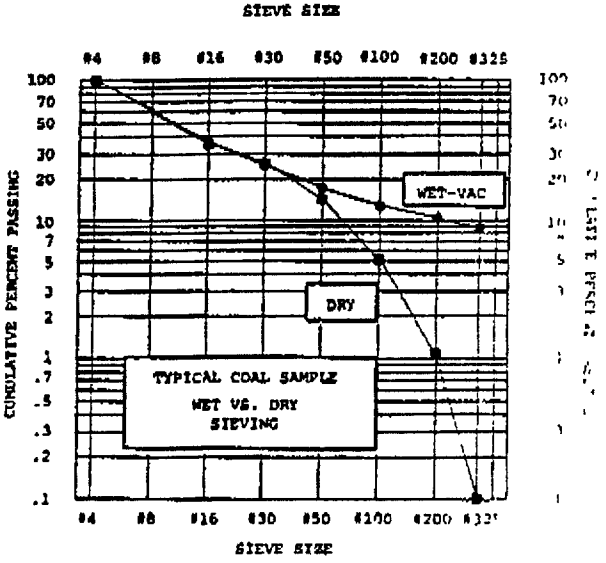
Pumped 0-35 psi recirculating water system with 7-gallon (26.5-liter) holding tank make the Wet-Vac independent of tap and drain connections. However, valves are included to permit such connections for once-through operation if desired. Water is available to the rotating spray bar above the top sieve, and also to a hose-mounted hand spray and to an upward spray in the well below the filter section. Hand spray is used to flush sieve cover, bottoms of sieves, and the upward spray clears filter paper to promote passage of water.

Stainless steel components include the sieve cover assembly, sieve holder lift ring, filter holder, instrument case, and water holding tank. The 14-gallon steel cabinet with two hinged doors has baked painted finish and houses the water tank, vacuum blower, motor, pump, and piping. An internal storage shelf, locking wheels, and durable rubber mat top work surface are included. Electrical requirement is 20 amps at 115V/60Hz. Controls include gauge and adjustment knob for water, switches for water, hand spray, vibration, and vacuum, and a vacuum indicator light. Overall Wet-Vac dimensions are 36 x 28 x 64" (914x711x1626mm) WxDxH.

- **Tests wet, dry, or in dry-wet sequence**—Samples may be introduced to WET VAC in dry, wet, or slurry form. Beginning test with dry sample permits an initial period of dry screening before adding water.
- **Recovers separated size segments**. Ability to perform physical or chemical tests on separated size segments of a sample is desirable. WET-VAC provides recovery of sample fractions permitting further testing; other methods may not.
- **Provides reproducible results**—WET-VAC's predetermined spray periods for each sieve, and operator control of vibration intensity permit uniform testing conditions for comparative and reproducible results.
- **Extends the range of sieving analysis**—Wet Sieving of fines offers an extension of normal dry sieving range. WET-VAC test results can be related directly to results of dry test-sizing in larger size ranges.
- **Suites the needs of wet-process industries**—WET-VAC offers an ideal control for wet process industrial operations because wet tests most closely approximate actual wet-processing conditions.



WV-2 has 12" filter section. See Through Nesting Cylinder is above filter section.



Typical Coal Sample—Wet vs Dry Sieving

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(Continued)

Wet-Vac may be controlled by use of a built-in circuit and control cable supplied. Cable is plugged to port in back of unit to connect a timer accessory. Gilson's Model TSA-169 Digital Timer described elsewhere is ideally suited. System tracks total "on" time even when interruptions are necessary.

Select Wet-Vac model depending on size of sieves to be employed. Model WV-3 includes cover assemblies and lifting rings to permit use of either 8" or 12" sieves. Recommended sieves of all stainless steel in No. 16 (1.18mm) to No. 635 (20μm) size range should be ordered separately. Rubber gaskets and filter papers are also ordered separately. All models require at least 4 WVA-161 gaskets; add either of 8" or 12" size depending on Wet-Vac model ordered. An extra set of Filter Holder and Filter Base is helpful in case filter paper blinds. Model WVA-168 Sieve Mesh Protector is recommended for mesh support of 12" sieves of #200 and finer when loading could cause blinding.

- Three models available for 12" (305mm) or 8" (203mm) diameter models
- Internal vacuum system always in operation during wet sieving
- Internal water recycle system provides closed circuit recycle mode or optional once-through water from external tap
- Rotating sieve spray provides efficient water distribution, always accompanied by vibration and vacuum
- Subsieve material recovery is provided by filter at base of sieve stack
- Sieve capacity: up to eight sieves of 2-1/8" (5.4cm) stacking height
- Built-in control circuit permits attaching timer accessory
- Essential components of stainless steel
- Attractive portable cabinet

WV-1 for 12" diameter sieves.

Applications

- Coal preparation plant and/or operating control
- Mining/mineral process control
- Pipeline slurry analysis and control
- EPA and other soil contamination investigation
- Ocean and river sediments
- Fine soils, ores, non-soluble chemicals and powders
- Process R&D labs

Hand spray for flushing sieve bottoms and cover.

Geared motorized spray bar in sieve cover.

Filter section removed to show Spray Head for cleaning filter.

GILSON WET-VAC® WET SIEVE TESTER

		Model	Shipping Data lb	(kg)	Cu. Ft.
WET-VAC Sieve Tester					
For 12" (305mm) Sieves,	115V/60Hz	WV-1	440	(200)	38.0
	230V/50Hz	WV-1F	465	(211)	38.0
For 8" (203mm) Sieves,	115V/60Hz	WV-2	440	(200)	38.0
	230V/50Hz	WV-2F	465	(211)	38.0
For 12" and 8" Sieves,	115V/60Hz	WV-3	460	(209)	38.0
	230V/50Hz	WV-3F	485	(220)	38.0
Required Accessories					
Rubber Gasket, 12"		WVA-150	—	—	—
Rubber Gasket, 8"		WVA-151	—	—	—
Filter Paper, 500mm, Box of 100		WVA-161	2	(1)	0.3
Optional Accessories					
Extra Filter Holder*		WVA-100	5	(2)	0.5
Extra Filter Base*		WVA-165	8	(3)	0.5
Extra See-Through 12" Cylinder*		WVA-110	2	(1)	0.5
Extra See-Through 8" Cylinder*		WVA-112	2	(1)	0.2
Sieve Mesh Protector, 12"		WVA-168	4	(2)	0.3
Digital Electronic Timer 115V		TSA-169	5	(2)	0.5

* One supplied with Wet Vac models.

WVA-168 Sieve Mesh Protector for 12" sieves with fine-mesh cloth

Tyler Laboratory Equipment

Ro-Tap Testing Sieve Shaker

The *Ro-Tap Testing Sieve Shaker* was the first mechanical sieve shaker introduced to accurately reproduce the circular and tapping motion given testing sieves in hand-sieving, but with a uniform, mechanical action assuring dependable, comparable tests Since then the Ro-Tap has become the unquestioned standard of comparison in all laboratories the world over

The Ro-Tap is built for handling 8" diameter testing sieves of different openings With the regular height sieves, one sample can be tested on a series of six sieves of different openings, while with half-height sieves, one sample can be analyzed on a series of thirteen sieves of different openings, and all with one operation of the machine

By using pans with extended rims, three different samples can be tested at one time with regular height sieves and seven different samples with half-height sieves

The Ro-Tap is operated by a vertically mounted, totally enclosed ¼ hp motor The standard Ro-Tap is furnished for operation from 110 or (220) volts, single phase current, with 1750 rpm units for 60 cycle current and 1450 rpm units for 25 or 50 cycle The Ro-Tap is actuated through its built-in timer

The dimensions of the Ro-Tap are height 25", width 28", depth 21" The net weight including the motor and timer is 200 lbs Approximate shipping weight domestic, 225 lbs, export 235 lbs

For 6" x 3" diameter sieves, adaptors are available for the standard 8" Ro-Tap For 12" diameter sieves specially built units can be supplied

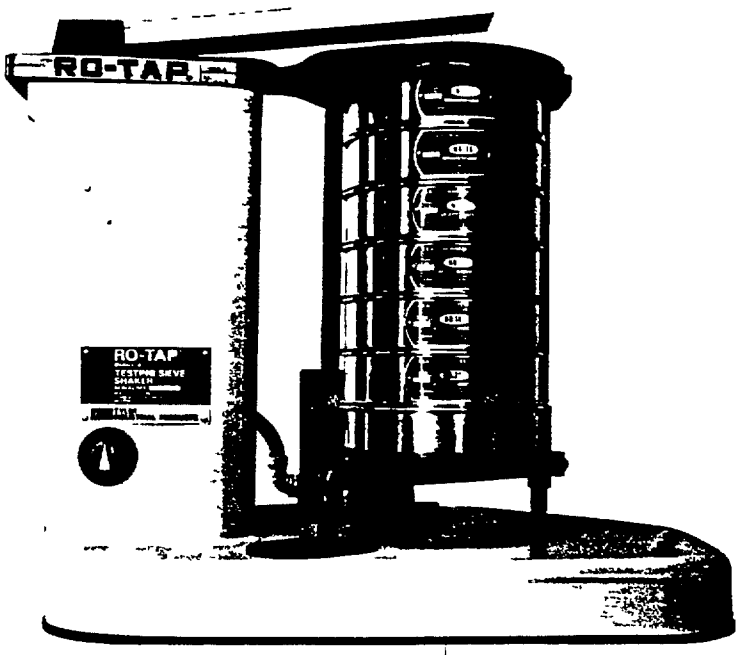
Portable Sieve Shaker

The *Tyler Portable Sieve Shaker*, as the name implies, is designed for easy transportation from one place to another for making field tests

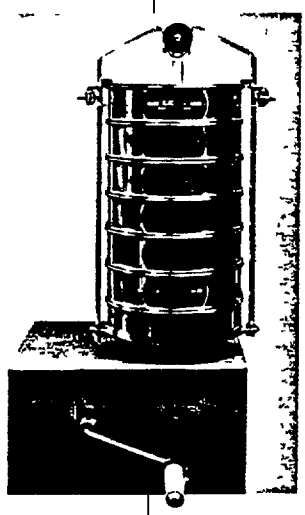
The shaker has a capacity of six full height or 13 half height eight-inch sieves with pan and cover The sieves are actuated by a specially designed mechanism to provide the correct shaking action The Shaker is ruggedly constructed and is light enough for easy handling

The *Hand Operated Sieve Shaker* is designed for use where electric current is not available By simply turning the crank at a steady speed the operator can produce rapid, positive sieving action

The *Tyler Motor Driven Portable Sieve Shaker* is also available It can be supplied with motor for 60 cycle or for 50 cycle current

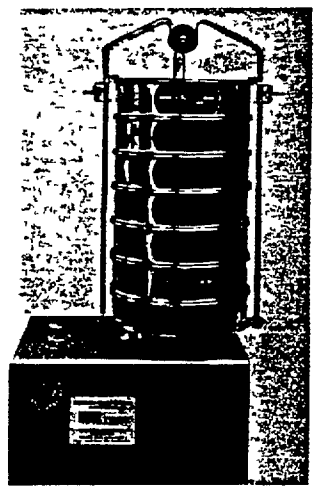


Ro-Tap with six full-height 8" diameter sieves and pan



RX-25 Hand-Operated Portable Sieve Shaker

RX-24 Motor-Driven Portable Sieve Shaker



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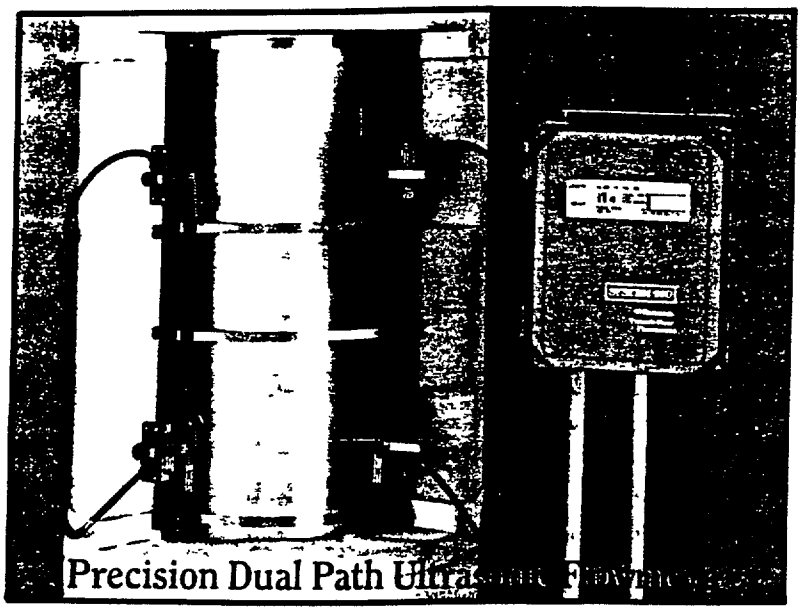
CONTROLOTRON

Models 990DBN and 990DBP

Universal Dedicated & Portable Dual Path Clamp-On Transit-Time Flowmeters



DESCRIPTION

Models 990DBN and 990DBP are precision Dual Path Universal Clamp-On Transit-Time Ultrasonic Flowmeters of NEMA 4X and Portable construction respectively They are intended for application wherever high accuracy, for either custody transfer or regulatory requirements, is demanded They maintain their high performance even when located close to elbows or other upstream disturbances Both offer field programmability for essentially any pipe size, and operate with essentially any liquid. They replace and outperform most conventional intrusive flowmeters even in their best applications and provide all industry standard analog and digital data outputs, LCD Digital or Graphics display, with integral Datalogger and Stripchart printout

Series 990DB Uniflow measures flow by means of two orthogonal ultrasonic beams, preferably operated in the reflect mode This makes the system extremely resistant to flow profile distortion, crossflow or flow swirl errors, normally caused by upstream bends, gate valves or short straight run conditions Its Clamp-On construction makes it simple to install in existing installations, or as a precision replacement for high maintenance Turbine, Venturi and Wetted Transducer 4 Path Chordal ultrasonic flowmeters

The 990 Family includes both Dedicated and Portable models Portable models can be used to quickly evaluate the performance which will be provided by the Dedicated models Dedicated NEMA 4X 990DB models are suitable for operation in almost any environment, indoors or outdoors, and at pipe temperatures up to 500°F

FUNCTIONS

Series 990D offers the following optional functions

- Industry Standard Analog and Digital Data Outputs
- Digital Flow Rate and Total Display
- Graphics Display with Stripchart and Datalogger
- RS-232 Serial I/O Data/Command Communication
- Field Programmable Status Alarms Relay Outputs
- Memorized Flow, Site and Diagnostic Data Printout

FEATURES

- Universal Applicability
- Outperforms Conventional Intrusive Flowmeters
- Lower Cost/Higher Reliability than Intrusive Flowmeters
- User Friendly Menu Driven Field Programmable Site Setup
- Non-Intrusive Universal Clamp-On Transducers
- MultiPulse® Transmission
- No Cutting of Pipe Ever Required
- Batch and Sampling Capability Built In
- Calibratable to 1/4% of Flow Rate
- Bi-Directional Flow Measurement

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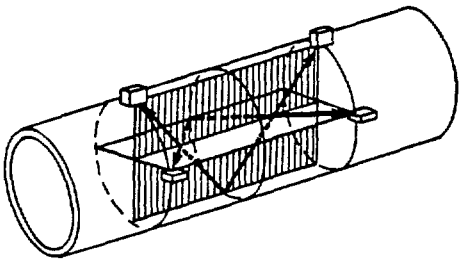
WHAT IT DOES

Models 990DBN and 990DBP measure the flow of most liquids in most pipes between 6 and 360 inch diameter, and with flow rates of ±40 ft/sec, and temperatures up to 500°F They are intended as high performance replacements for Turbine, Venturi and 4 Path Wetted Chordal ultrasonic flowmeters

HOW IT WORKS

System 990DB Dual Path transducers operate in Reflect mode to prevent crossflow error Orthogonal transducer path orientation prevents error due to distorted flow profile



WHERE TO USE

Series 990DB is intended for high precision or custody transfer applications of petroleum products, chemicals or water Dual orthogonal path Reflect Mode operation, equivalent to 4 paths, is highly resistant to distorted flow profile, crossflow and swirl conditions This makes 990DBN ideal for Nuclear Feedwater, Interstate Oil Pipeline, Hydro-Power Turbine and Irrigation Turnout flow measurement applications The 990DBP is functionally identical to the NEMA 4X 990DBN Portability facilitates use as a test device, or in applications which do not require continuous flow measurement

SPECIFICATIONS

APPLICABILITY

LIQUIDS: Any sonically conductive homogeneous fluid
LIQUID (PIPE) TEMPERATURE. −40°F to +250°F Standard
−80°F to +500°F Optional
PIPE SIZES: 6 to 360 inches OD
PIPE MATERIAL: Any sonically conductive pipe material Metal, Glass, Plastic, etc
PIPE WALL THICKNESS: 0 05 to 3 00 inches
LINER MATERIAL: Any sonically conductive material, Glass, Plastic, Cement, etc , intimately bonded to the pipe interior
LINER THICKNESS: Up to 1 inch, dependent on material
FLOW VELOCITY RANGE: ±40 fps, min , dependent on pipe OD and mounting track type

991 CLAMP-ON TRANSDUCERS

PIPE SIZE RATINGS
- Group 3. 6 to 24 inches, OD
- Group 4: 20 to 48 inches, OD
- Group 5: 36 to 360 inches, OD

RATING: Intrinsically safe. Radiation Resistant and Submersible available.
CONSTRUCTION: Aluminum, stainless steel and special alloy or plastic.
CONNECTORS: Condulet for NEMA 4, BNC for Portable

992 MOUNTING TRACKS

- Available in Direct or Reflective Mounting for all transducer sizes in standard pipe diameter ranges.
- PinStop transducer spacing standard for all models

994 FLOW COMPUTER

- POWER: 20 W, 9 to 36 VDC or internal Battery, 100/115 or 230 VAC, 1ϕ
- TEMPERATURE: −5°F to +115°F (except for Graphics Models)
- SIZE: 10.5"W, 9" D, 13" H
- WEIGHT: 12.8 pounds
- RATING: Intrinsically safe, NEMA 4X with cover closed
- MODULES: Plug-In, Interchangeable W/O special tools
- RANGES: Size 4: Transducer Sizes 3 and 4
  Size 5: Transducer Sizes 3, 4 and 5

994 PERFORMANCE (Standard Conditions)*

- SENSITIVITY: 0.001 fps at any flow rate including zero
- LINEARITY: 0.003 fps
- RESPONSE BANDWIDTH: 10 Hz (settable)
- SLEW RATE: 20 ft/sec/sec
- FLOW PROFILE COMPENSATION. Via liquid viscosity entry
- ZERO DRIFT STABILITY: 0.005 fps for transducer sizes 3 to 6

995 HAND HELD CONTROL/DISPLAY TERMINAL

- 2 Row, 32 character Liquid Crystal Display
- 30 Keys, Numeric or Function identified.

* Submit Application Information Form for estimate of performance under specific application conditions.

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HOW TO ORDER & SPECIFY SERIES 990DB

Selecting the most appropriate model and optional functions and features, offered in System 990DB, is quite simple, especially if you follow the procedure below However, feel free to call on your local Controlotron representative for assistance if needed

The Uniflow part numbering system is a guide to the process of selecting your preferred model, as well as producing the part numbers of all the system components The procedure below, gives you an opportunity to consider the many Uniflow system options offered Check with your local Controlotron representative to assure selection of compatible Dedicated model functions Note, however, that standard Portable Uniflow Systems are supplied fully loaded, with all available functions and features

System 990 Dedicated Models use a "Building Block" System This permits you to order only those functions that you actually need for your application, so as to keep your costs as low as possible If, at a later time, a new function is required, most can be added merely by plug-in of the desired Function Module into a compatible 994 Flow Computer.

Uniflow Systems include the following Components

- **Series 991 Transducers**
- **Series 992 Transducer Accessories**
- **Series 994 Flow Computer and Function Modules**
- **Series 995 Hand-Held Control Display Unit**
- **Series 996 Remote Accessories**

Specifying and ordering System 990 Uniflow equipment involves the following steps

1 Specify the Components of your selected system, choosing the component options which contain your desired features
2 Specify the desired optional plug-in Function Modules and/or Remote Accessories by part number below
3 Obtain the price and delivery of your selected components, and place your order with Controlotron either through your local Representative or Factory Direct

Listed below are the part numbers for all Uniflow system components To construct the component part number which has your desired options, replace the part number LETTERS with the appropriate CODE symbols listed below

991ABC-D TRANSDUCER	**A=MODEL** N=NEMA 4	**B=TYPE** M=Metal Body P=Plastic Body V=Sonic Velocity	**C=TEMPERATURE** S=250°F max. H=375°F max. VH=500°F max.*	**D=SIZE** 3=6" to 24" pipe OD 4=20" to 48" pipe OD 5=36" to 360" pipe OD			
992MTABCD-E MOUNTING TRACK	**A=MODEL** N=NEMA 4	**B=TYPE** D=Direct Beam R=Refelct Beam	**C=STYLE** M=Metal XDCR P=Plastic XDCR	**D=MATERIAL** A=Aluminum S=Steel SH=For VH XDRS	**E=PIPE OD RANGE (min)*** 3=6" to 24" pipe OD 5X=6' to 10' pipe OD 4=20" to 48" pipe OD 5Y=10' to 18' pipe OD 5=36" to 84" pipe OD 5Z=18' to 30' pipe OD * See 990SLECT Manual		
992CAB-C TRANSDUCER CABLE	**A=MODEL** N=NEMA 4	**B=ENVIRONMENT** S=Standard Temp W=Submersible Kit	**C=LENGTH** C=Length in ft.	**992MTM-A MAGNETIC TRACK MOUNT KIT**	**A=PIPE OD RANGE** 4=20" to 48" pipe OD 5=48" to 216" pipe OD 6=18' to 30' pipe OD		
993ABC APPLICATION FUNCTION AND CONTROL MODULE	**A=MODEL** C=Control Only Module M=Memory and Control Module		**B,C=CODES RESERVED**				
994ABCD-EF FLOW COMPUTER	**A=MODEL** DBN=NEMA 4X DBP=Portable	**B=PIPE OD RANGE** 4=6" to 48" 5=6" to 216" 6=6" to 360"	**C=DISPLAY** B=Blind G=Graphics D=Digital GL=Lighted Graphics	**D=POWER SOURCE** S=100/115 VAC M=230 VAC B=9 to 36 VDC SB=115 VAC + Battery MB=230 VAC + Battery	**E=PROGRAM LOAD** 1=Basic Data 2=Add RS-232 & Datalog 3=Add Graphics + Stripchart	**F=SPECIAL** N(n)=CC Nuclear Grade S(n)=Intrinsically Safe	
994-7 ANALOG COMPUTER	Provides Programmable Isolated 4 to 20 mA, 0 to 10 VDC and Pulse Rate Outputs one required per channel						
994-10ABC ALARM RELAY MODULE	**A=MODEL** N=NEMA 4	**B=TYPE** A=Normally Open B=Normally Closed	**C=RATING** D=Dry Reed (10 VA max) M=Mercury Wetted (50 VA max) (Not available in Portable Units or in NC" Type)				
994-11ABC LCD DISPLAY COMPUTER	**A=MODEL** D=Digital Display G=Graphics Display	**B=TYPE** D=Dual Path	**C=CODE RESERVED**				
994-12ABC RS-232 I/O MODULE	**A=MODEL** T=995 Hand Held Terminal Driver Only S=RS-232 and 995 Drivers		**B,C=CODES RESERVED**				

995T HAND-HELD CDU TERMINAL	**996P PRINTER**	**996P-5 PRINTER PAPER, 5 PACK REFILLS**	**996PSP-A PIPE SIMULATOR**	**A=XDCR SIZE** A=0, 1, 2, 3 or 4	**996DABC REMOTE DISPLAY**	**A=TYPE** D=Digital	**B=MODEL** N=NEMA 4X P=Panel Mount	**C=POWER SOURCE** S=110/115 VAC M=230 VAC

* Transducers operated above 400°F will require periodic refurbishment, with periodicity proportional to operating temperature. For extreme temperature operation, factory consultation is recommended

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TYPICAL SPECIFICATIONS

The flowmeter furnished shall be the Controlotron System 990DB Uniflow Clamp-On Dual Path Transit-Time Ultrasonic type, or approved equivalent, and shall contain the features listed below

- MultiPulse™ Flow Detection
- TransX™ Ultrasonic Transmission Optimization
- Metallic Mode Conversion Wide Beam Transducers
- Made in USA
- PinStop Universal Mounting Track (no ruler scales)
- 64 × 256 Pixel Graphics Display
- Programmable Stripchart Option for Flow, Liquid Data
- Programmable 64K Memory Datalogger Option
- All Modules Plug-In, including Power Supply
- Numeric Entry Only. Hand-Held Programming
- Full Diagnostic Data Access
- Plug-In Function Options
  - Analog Data. 0 to 10 VDC & Isolated 4 to 20 mA
  - Alarm Relay Module 8 Programmable Relays
  - Digital and Graphics Display Computer/Driver
  - RS-232 Serial Data I/O, Selectable Baud Rates
- Intrinsically Safe Construction
- Reflect or Direct Transmission Mode
- Simultaneous Individual Beam & Summed Data Display

A WORD ABOUT CONTROLOTRON

Controlotron, completing its third decade of operation, specializes in the manufacture of proprietary instruments for the measurement and control of liquids All Controlotron products are derived from Company sponsored research and development programs, the heart of our continued ability to provide new and unique instruments of outstanding value and performance characteristics, such as·

Portable System 990 UNIFLOW:
MultiPulse™ Transit-Time Flowmeter

Dedicated System 990:
MultiPulse™ Transit-Time Flowmeter

Portable System 190 Spectra:
Portable Fourier Flowmeter

Dedicated System 190 Spectra
NEMA 4X Fourier Flowmeter

Portable 990E
Thermal Energy Flowmeter

Dedicated 990E
Thermal Energy Flowmeter

Your Local Representative

RENTAL/ PURCHASE PLAN

Users who wish to familiarize themselves with Models 990DBN and 990DBP prior to purchase may avail themselves of Rental plans (where available) Advance purchase of the 990DB Field Manual will provide detailed information beyond this brochure

CUSTOMER SERVICE

Users of Controlotron instruments enjoy the benefit of worldwide customer service organizations, available on short notice for training, application, installation, demonstration, and maintenance services Contact us or your local representative for details on these services.

2 YEAR WARRANTY

System 990 carries a limited 2 year warranty, from date of shipment, against intrinsic defects

CONTROLOTRON

155 Plant Avenue, Hauppauge, New York 11788 Phone (516) 231-3600 • Fax (516) 231-3334 • Telex: 961-447

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APPENDIX B

Audit Records

AUDIT RECORDS SUMMARY
FLUE GAS MEASUREMENTS

ENERAC Ser. 11003253:
Oxy_ref=true:

Test 6	Flue Gas Measurement at the stack on coal at 180 MW blr #9
Test 8	Flue Gas Measurement at the stack on coal at 180 MW blr #6 side A
Test 9	Flue Gas Measurement at the stack on coal at 155 MW blr #6 side A
Test 10	Flue Gas Measurement at the stack on coal at 150 MW blr #6 side A
Test 11	Flue Gas Measurement at the stack on coal at 150 MW blr #6 side B
Test 12	Flue Gas Measurement at the stack on coal at 140 MW blr #6 side B
Test 13	Flue Gas Measurement at the stack on coal at 140 MW blr #6 side A
Test 14	Flue Gas Measurement at the stack on coal at 140 MW blr #6 side B
Test 15	Flue Gas Measurement at the furnace exit on coal at 140 MW blr #6
Test 16	Flue Gas Measurement at the furnace exit on coal at 140 MW blr #6
Test 17	Flue Gas Measurement at the furnace exit on coal at 140 MW blr #6
Test 18	Flue Gas Measurement at the furnace exit on coal at 180 MW blr #6
Test 19	Flue Gas Measurement at the furnace exit on coal at 180 MW blr #6
Test 20	Flue Gas Measurement at the furnace exit on coal at 200 MW blr #6
Test 21	Flue Gas Measurement at the furnace exit on coal at 200 MW blr #6
Test 22	Flue Gas Measurement at the furnace exit on coal at 200 MW blr #6
Test 23	Flue Gas Measurement at the stack on coal at 200 MW blr #6 side A
Test 24	Flue Gas Measurement at the stack on coal at 200 MW blr #6 side A
Test 25	Flue Gas Measurement at the stack on coal at 200 MW blr #6 side B

TEST 6 9

SERIAL

ENERAC MODEL 2006

COMBUSTION TEST RECORD

180 MW

FOR: BURNS & ROE

TIME: 15:17:02
DATE: 02/23/95

FUEL DESIGNCL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	166	°C
OXYGEN:	10.2	%
CARBON MONOXIDE:	14	PPM
CARBON DIOXIDE:	09.0	%
COMBUSTIBLE GASES:	0.29	%
STACK DRAFT (INCHES H20): +	7.1	
EXCESS AIR:	92	%
OXIDES of NITROGEN:	219	PPM
SULFUR DIOXIDE:	1151	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

1st A

SERIAL # 11003253

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SERIAL # 1030250
TEST 9 BOILER# 6A 175-180 MW
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:27:23
DATE: 02/24/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	39	°C
OXYGEN:	10.5	%
CARBON MONOXIDE:	53	MGM
CARBON DIOXIDE:	08.7	%
COMBUSTIBLE GASES:	0.21	%
STACK DRAFT (INCHES H20):	+ 10.8	
EXCESS AIR:	97	%
OXIDES of NITROGEN:	234	MGM
SULFUR DIOXIDE:	2142	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF=TRUE%

≈7% O2 Fan.

SERIAL # 11003253
TEST 9 BOILER# 6A 155 MW
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:39:17
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	175	°C
OXYGEN:	12.2	%
CARBON MONOXIDE:	7	MGM
CARBON DIOXIDE:	07.3	%
COMBUSTIBLE GASES:	0.33	%
STACK DRAFT (INCHES H20):	+ 6.5	
EXCESS AIR:	134	%
OXIDES of NITROGEN:	254	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM

TEST 10 B 6 A
SERIAL # 11003253 150 MW

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:40:48
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	175	°C
OXYGEN:	11.7	%
CARBON MONOXIDE:	11	PPM
CARBON DIOXIDE:	07.7	%
COMBUSTIBLE GASES:	0.41	%
STACK DRAFT (INCHES H20): +	6.7	
EXCESS AIR:	121	%
OXIDES of NITROGEN:	191	PPM
SULFUR DIOXIDE:	2046	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

TEST 11 BOILER# 6 B 150 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:45:37
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	159	°C
OXYGEN:	11.2	%
CARBON MONOXIDE:	8	PPM
CARBON DIOXIDE:	08.2	%
COMBUSTIBLE GASES:	0.41	%
STACK DRAFT (INCHES H20): +	13.7	
EXCESS AIR:	109	%
OXIDES of NITROGEN:	186	PPM
SULFUR DIOXIDE:	1972	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM

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SERIAL # 11003250
TEST .2 BOILER# 6 B 140 MW + MAZGT
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:09:15
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	152	°C
OXYGEN:	13.2	%
CARBON MONOXIDE:	10	MGM
CARBON DIOXIDE:	06.6	%
COMBUSTIBLE GASES:	0.28	%
STACK DRAFT (INCHES H20): +	8.2	
EXCESS AIR:	161	%
OXIDES of NITROGEN:	235	MGM
SULFUR DIOXIDE:	3702	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF=TRUE%

TEST .3 BOILER# 6 A
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:10:44
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	152	°C
OXYGEN:	12.3	%
CARBON MONOXIDE:	10	MGM
CARBON DIOXIDE:	07.3	%
COMBUSTIBLE GASES:	0.32	%
STACK DRAFT (INCHES H20): +	7.5	
EXCESS AIR:	135	%
OXIDES of NITROGEN:	223	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF

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TEST 14 BOILER# 6 B 170 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:16:59
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	171	°C
OXYGEN:	12.6	%
CARBON MONOXIDE:	8	PPM
CARBON DIOXIDE:	07.0	%
COMBUSTIBLE GASES:	0.37	%
STACK DRAFT (INCHES H20): +	6.5	
EXCESS AIR:	144	%
OXIDES of NITROGEN:	180	PPM
SULFUR DIOXIDE:	1471	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11003253
TEST 15 BOILER# 6
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:59:17
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	60.7	%
AMBIENT TEMPERATURE:	24	°C
STACK TEMPERATURE:	766	°C
OXYGEN.	06.2	%
CARBON MONOXIDE:	338	PPM
CARBON DIOXIDE:	12.3	%
COMBUSTIBLE GASES:	0.66	%
STACK DRAFT (INCHES H20): +	0.8	
EXCESS AIR:	41	%
OXIDES of NITROGEN:	289	PPM
SULFUR DIOXIDE:	1742	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE

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61

TEST 16 6 140 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 12:00:29
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	63.7	%
AMBIENT TEMPERATURE:	24	°C
STACK TEMPERATURE:	774	°C
OXYGEN:	05.1	%
CARBON MONOXIDE:	142	PPM
CARBON DIOXIDE:	13.3	%
COMBUSTIBLE GASES:	0.55	%
STACK DRAFT (INCHES H20): +	0.9	
EXCESS AIR:	31	%
OXIDES of NITROGEN:	292	PPM
SULFUR DIOXIDE:	1724	PPM SO_2
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

TEST 17 BOILER# 6 140 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 12:01:44
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	62.3	%
AMBIENT TEMPERATURE:	24	°C
STACK TEMPERATURE:	777	°C
OXYGEN:	05.6	%
CARBON MONOXIDE:	119	PPM
CARBON DIOXIDE:	12.9	%
COMBUSTIBLE GASES:	0.59	%
STACK DRAFT (INCHES H20): +	1.2	
EXCESS AIR:	35	%
OXIDES of NITROGEN:	289	PPM
SULFUR DIOXIDE.	1780	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

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62

SERIAL # 11003253
TEST 18 BOILER# 6 180 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 12:42:28
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	62.2	%
AMBIENT TEMPERATURE:	28	°C
STACK TEMPERATURE:	821	°C
OXYGEN:	05.0	%
CARBON MONOXIDE:	147	PPM
CARBON DIOXIDE:	13.4	%
COMBUSTIBLE GASES:	0.50	%
STACK DRAFT (INCHES H20):	+ 11.2	
EXCESS AIR:	30	%
OXIDES of NITROGEN:	297	PPM
SULFUR DIOXIDE:	1795	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

TEST 19 BOILER# 6 180 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 12:43:07
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	61.1	%
AMBIENT TEMPERATURE:	29	°C
STACK TEMPERATURE:	819	°C
OXYGEN:	05.2	%
CARBON MONOXIDE:	164	MGM
CARBON DIOXIDE:	13.2	%
COMBUSTIBLE GASES:	0.56	%
STACK DRAFT (INCHES H20):	+ 11.8	
EXCESS AIR:	32	%
OXIDES of NITROGEN:	385	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF=TRUE%

SERIAL # 11003253
TEST 20 BOILER# 6 200 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:04:00
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	59.4	%
AMBIENT TEMPERATURE:	31	°C
STACK TEMPERATURE:	824	°C
OXYGEN:	05.6	%
CARBON MONOXIDE:	140	MGM
CARBON DIOXIDE:	12.9	%
COMBUSTIBLE GASES:	0.61	%
STACK DRAFT (INCHES H20):	+ 11.7	
EXCESS AIR:	35	%
OXIDES of NITROGEN:	405	MGM
SULFUR DIOXIDE:	3656	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF=TRUE%

TEST 21 BOILER# 6 200
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:05:25
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	61.6	%
AMBIENT TEMPERATURE:	32	°C
STACK TEMPERATURE:	824	°C
OXYGEN:	05.0	%
CARBON MONOXIDE:	135	PPM
CARBON DIOXIDE:	13.4	%
COMBUSTIBLE GASES:	0.53	%
STACK DRAFT (INCHES H20):	+ 7.6	
EXCESS AIR:	30	%
OXIDES of NITROGEN:	298	PPM
SULFUR DIOXIDE:	1416	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OX\

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TEST 22 BO ... 6 200 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:06:35
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	60.8	%
AMBIENT TEMPERATURE:	32	°C
STACK TEMPERATURE:	839	°C
OXYGEN:	04.4	%
CARBON MONOXIDE:	140	PPM
CARBON DIOXIDE:	13.8	%
COMBUSTIBLE GASES:	0.60	%
STACK DRAFT (INCHES H20):	+ 23.6	
EXCESS AIR:	26	%
OXIDES of NITROGEN:	285	PPM
SULFUR DIOXIDE:	1479	PPM 4,230
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11003253
TEST 23 BOILER# 6 200 MW ID FA
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:36:54
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	30	°C
STACK TEMPERATURE:	161	°C
OXYGEN:	11.0	%
CARBON MONOXIDE:	61	PPM
CARBON DIOXIDE:	08.4	%
COMBUSTIBLE GASES:	0.35	%
STACK DRAFT (INCHES H20):	+ 10.8	
EXCESS AIR:	105	%
OXIDES of NITROGEN:	178	PPM
SULFUR DIOXIDE:	1023	PPM 2,926
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_F[illegible]

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65

TEST 2 [illegible] 6 A 200 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:44:19
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	29	°C
STACK TEMPERATURE:	180	°C
OXYGEN:	11.5	%
CARBON MONOXIDE:	13	PPM
CARBON DIOXIDE:	08.0	%
COMBUSTIBLE GASES:	0.28	%
STACK DRAFT (INCHES H20): +	9.4	
EXCESS AIR:	115	%
OXIDES of NITROGEN:	181	PPM
SULFUR DIOXIDE:	1123	PPM
CARBON MONOXIDE ALARM:	900	PPM

MODE:PPM OXY_REF=TRUE%

TEST 25 BOILER# 6 B 200 MW
SERIAL # 11003253

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:46:14
DATE: 02/26/95

FUEL PROMCOAL 7472

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	28	°C
STACK TEMPERATURE:	179	°C
OXYGEN:	11.5	%
CARBON MONOXIDE:	17	MGM
CARBON DIOXIDE:	07.9	%
COMBUSTIBLE GASES:	0.29	%
STACK DRAFT (INCHES H20): +	9.9	
EXCESS AIR:	116	%
OXIDES of NITROGEN:	243	MGM
SULFUR DIOXIDE:	3081	MGM
CARBON MONOXIDE ALARM.	900	PPM

MODE:MGM (

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AUDIT RECORDS
FLUKE AC POWER ANALYZER

GENERATOR WATER COOLING PUMP MOTOR

1) Phase A

AMPS TEXT SCREENS

Arms	=	157	Arms	=	157
Apeak	=	223	AHM	=	2
Adc	=	-3	KF	=	1 0
% THD-R	=	1.4	% THD-F	=	1.4
CF	-	1.43			

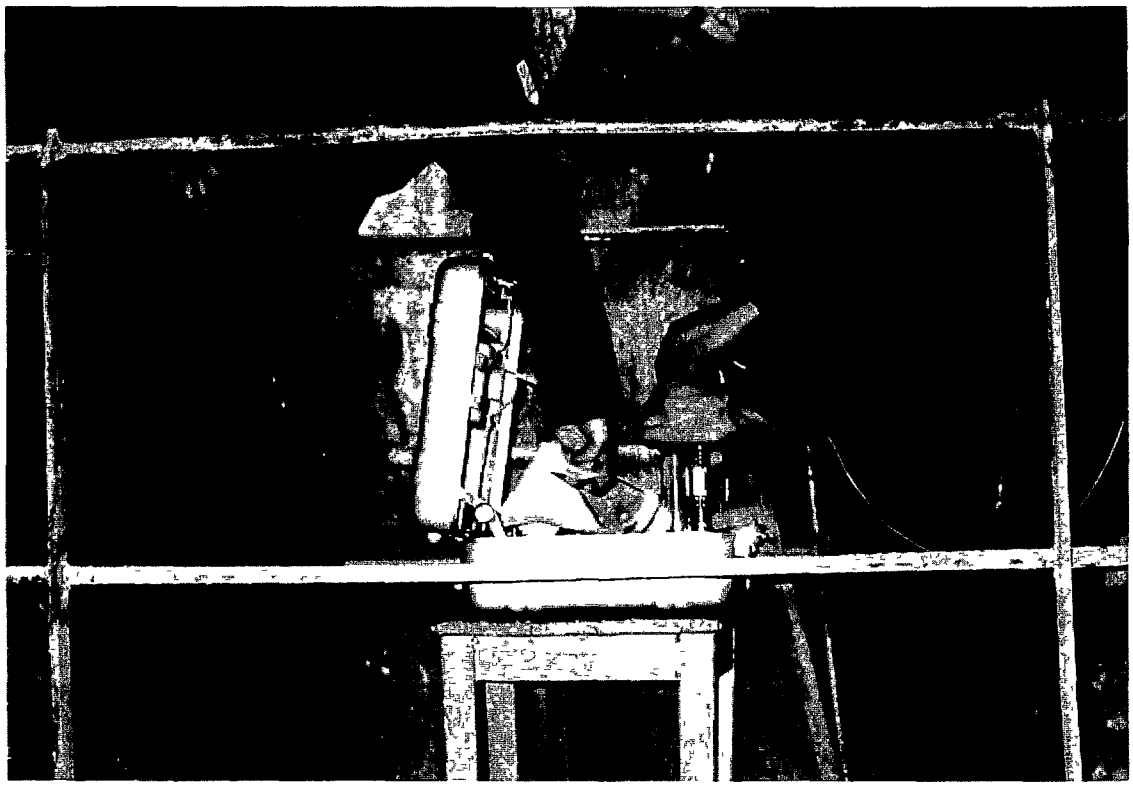
VOLTS TEXT SCREENS

Vrms	=	234	Vrms	=	234
Vpeak	=	333	VHM	=	1
Vdc	=	0	CF	=	1.42
% THD-R	=	0.4	% THD-F	=	0.4

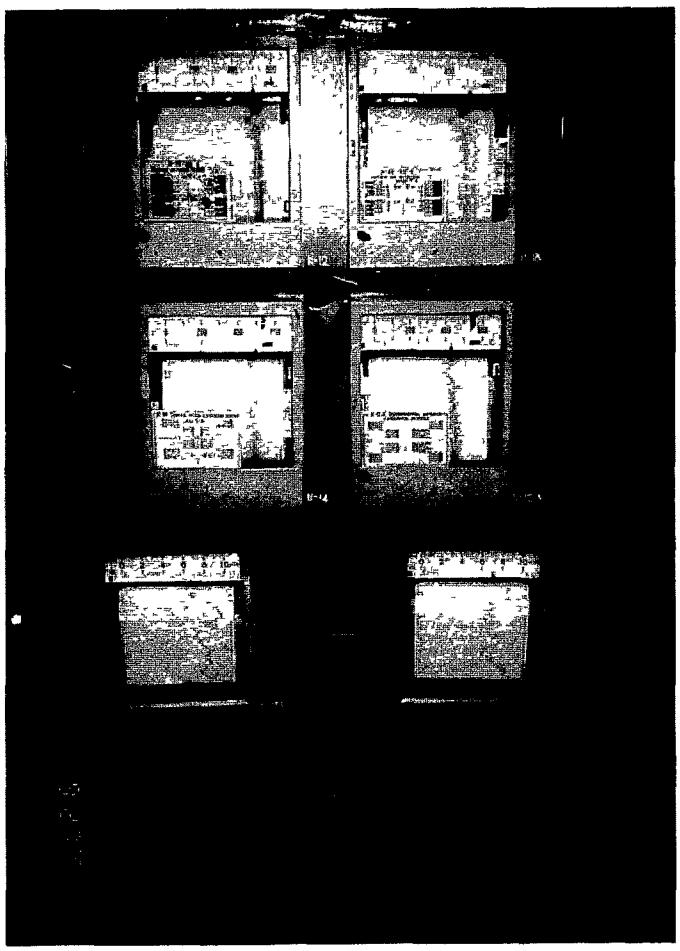
WATTS TEXT SCREENS

KW	=	32	KW	=	32
KVA	=	37	KVAR	=	18
PF	=	0.88	°ALAG	=	29
DPF	=	0.88			

5906-01/02B/UGLEG/5/8/95

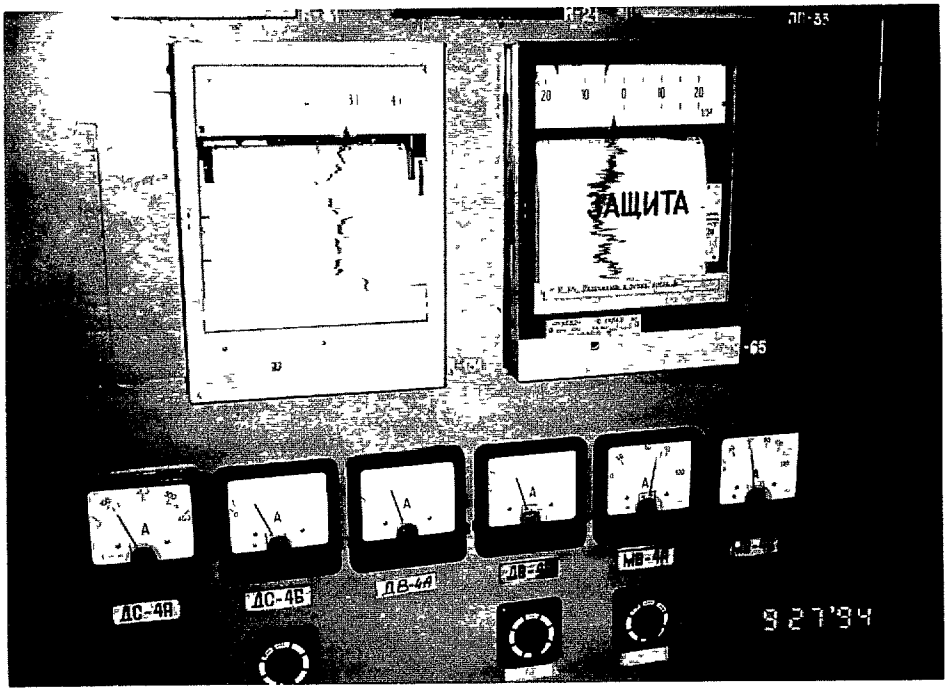


PLANT PERSONNEL AUDIT TRAINING



BOILER
O_2 ANALYZER
RECORDERS

5906-01/02B/ /5/8/95



BOILER FURNACE PRESSURE AND STEAM FLOW RECORDERS

BOILER AUTO/MANUAL CONTROL STATIONS

APPENDIX C

Power Plant Data

CALCULATIONS OF TOTAL FUEL COSTS FOR KOURAKHOVSKA STATION

The following calculations are done using available 1994 fuel consumption data and 1995 prices of fuels

1) January 5, 1994 consumption: 11,799 tons of coal @2135 kcal/kg and 1227 tons of mazut

April 29, 1994 consumption: 14,377 tons of coal @3759 kcal/kg
90 tons mazut @880 kcal/kg

The average coal consumption for two days using standard (7000 kcal/kg) fuel:

$$\left(11{,}799 \times \frac{2136}{7000} \times 14{,}377 \times \frac{3759}{7000}\right) \times 0.5 = 5{,}660 \text{ tons of standard coal}$$

2) Total annual coal consumption for the station:

$5{,}660 \times 365 =$ 2,075,900 tons of standard coal or

$2{,}065{,}900 \times \frac{7000}{3600} \simeq 4{,}017{,}000$ tons of 3600 kcal/kg coal

3) Total annual cost of coal using January 1, 1995 prices for 3600 Kcal/Kg coal

Cost per ton is: 3,191,000 c/ton @150,000 c/$ is $21.27

4,017,000 x 3,191,000/$150,000 = <u>$85,455,000</u>

4) Total annual consumption of mazut:

$\frac{1227 + 90}{2} \times 365 = 240{,}352$ tons of mazut

5) Total annual cost of mazut using January 1, 1995 prices of

9,829,000 coupons per ton at 150,000 coupons ($65.5)

$240{,}352 \times \frac{9{,}829{,}000}{150{,}000} = \$15{,}749{,}500$

5906-01/02B/CALC/5/10/95

6) Assuming that unit No. 6 consumption is 1/7 of the station consumption, the total fuel cost for Unit No. 6 is:

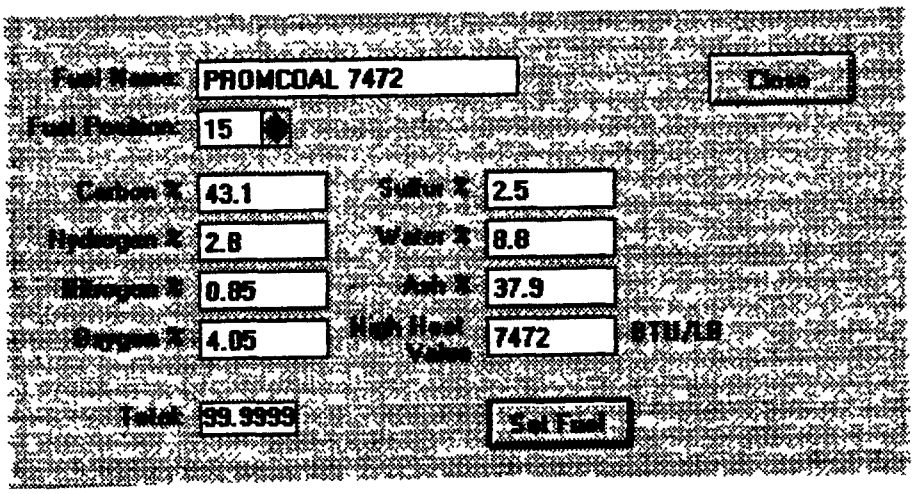
$$\frac{\$85,455,000 + \$15,749,500}{7} = \frac{\$101,204,500}{7} \simeq \$14,458,000$$

Total annual estimated cost of fuel for the entire plant is $101,204,500

Total annual estimated cost of fuel for Unit #6 (U8) is $14,458,000

5906-01/02B/CALC/5/10/95

CUSTOM FUEL CREATED FOR KOURAKHOUSKA POWER PLANT FOR DESIGN COAL



5906-01/02B/UGLEG/5/9/95

LIST OF ENERAC STANDARD FUELS

FUEL	C(%)	H_2(%)	N_2(%)	O_2(%)	S(%)	H_2O(%)	ASH (%)	HHV	SUM
#2 OIL	0.867	0 124	0.001	0	0.008	0	0	19360	1
#6 OIL	0 881	0.1	0 009	0.002	0.007	0	0	18300	0.999
NAT GAS	0 714	0.236	0.05	0	0	0	0	21870	1
ANTHRACITE	0 8436	0.0158	0 0063	0.0191	0 0089	0 028	0.0783	13300	1
BITUMINOUS	0.666	0.0428	0 01	0.063	0.03	0.0788	0.11	11700	0.9996
LIGNITE	0.451	0.03	0.009	0.148	0 012	0.293	0 057	7780	1
WOOD 50% H_2O	0.247	0.03	0 003	0.218	0	0.5	0	4320	0 998
WOOD 0% H_2O	0 495	0 06	0.006	0.435	0	0	0	8460	0.995
#4 OIL	0.875	0 11	0 004	0	0 008	0	0	18800	0 997
KEROSINE	0 851	0.143	0 003	0	0 002	0	0	19900	0.999
PROPANE	0 818	0.182	0	0	0	0	0	21677	1
BUTANE	0 828	0.172	0	0	0	0	0	21132	1
COKE OVEN GAS	0.434	0.23	0.172	0.164	0	0	0	16230	1
BLAST FURNACE	0 155	0.0025	0.554	0.286	0	0	0	1061	0 9975
SEWER GAS	0.46	0 101	0	0.416	0	0.022	0	8032	0.999

5906-01/02A/TABLE 1/4/20/95

Главный инженер КГРЭС т. Иванов С.А.
Зам. гл. инженера т. Тарасенко В. М.
Нач. ЦЛР -I т. Фоменко Н.А.
Нач. КТЦ Т. Чончиков М.М.
Группа учета

LEAKAGE REPORT

Присосы холодного воздуха в топки газоходы и пылесистемы, за январь 1995г.

№№ п/п		α за рег. ст.	Рег.ст. Ist.в/п	Ist.в/п д-с	Котел - д-с	Топка	Пылесистемы А	Пылесистемы Б
		1/2	1/3	1/4	1/5	1/6	1/7	1/8
2/1	Бл№3	I,423	46,0	I8,0	64,0	I9,0	39,0	30,0
3/1	-"-4	I,330	29,0	I5,0	44,0	I9,4	46,4	55,0
4/1	-"-5	I,348	25,5	I5,0	40,5	26,5	39,0	70,0
5/1	-"-6	I,345	20,0	I6,0	36,0	21,0	63,5	30,6
6/1	-"-7	I,335	26,0	I6,0	44,0	I9,5	42,5	39,5
7/1	-"-8	I,328	1[illegible],4	I4,3	27,5	I3,5	57,0	43,7
8/1	-"-9	I,350	24,0	12,[illegible]	36,5	I7,0	56,0	35,5
9/1	КТЦ	I,35I	26,3	I5,[illegible]	41,6	I8,6	49,2	43,4

10/1	№№	3	4	5	6	7	8	9
11/1	$\Delta\alpha$х.	I,452	1,48	I,503	1,505	I,5I5	1,462	I,475
12/1	Сшл.	3,5	2,80	3,75	4,0	3,82	3,4	3,56

Начальник ПТО В. Бурлака.

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FUEL PRICES

Цена топлива по Кураховской ГРЭС

I. Цена топлива за I994 год

Уголь: 553663 крб/тнт = I200546 крб/тут

Мазут: 2480233 крб/тнт = I83I528 крб/тут

П. Январь I995 года

Уголь: 3I907I6 крб/тнт = 6094680 крб/тут

Мазут: 9829078 крб/тнт = 730I377 крб/тут

Ш. На I марта I995 г.

Концентраты (ЖК; ДГ)

Q_p^H = 6500 ккал/кг – 7,5 млн.крб/тнт

Q_p^H = 5000 ккал/кг – 5,5 млн.крб/тнт

Газовые угли: (ГСШ; ДСШ)

Q_p^H = 4200 ккал/кг – 3,5 млн.крб/тнт

Q_p^H = 4600 ккал/кг – 3639000 крб/тнт

Q_p^H = 3600 ÷ 3800 ккал/кг – 2683000 крб/тнт

ДР, ГР

Q_p^H = 3800 ккал/кг – 2,8 млн.крб/тнт

Q_p^H = 3,683 ÷3,592 ккал/кг – 2,I50 млн.крб./тнт

Промпродукт (отходы угля после обогощения)

Q_p^H = 3600 ккал/кг – I,4 млн.крб./тнт

Q_p^H = 4270 / 3728 / 2833 / 5320 – I,469 млн.крб./тнт

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Шлам

$Q_p^н$ = 2800 ÷ 3100 ккал/кг — 0,76 млн.крб./тнт

$Q_p^н$ = 3559 / 2800 / 2610 — 0,76 млн.крб./тнт

Мазут — 12 млн.крб./тнт

Рыночный курс 1$ = 150000 крб.

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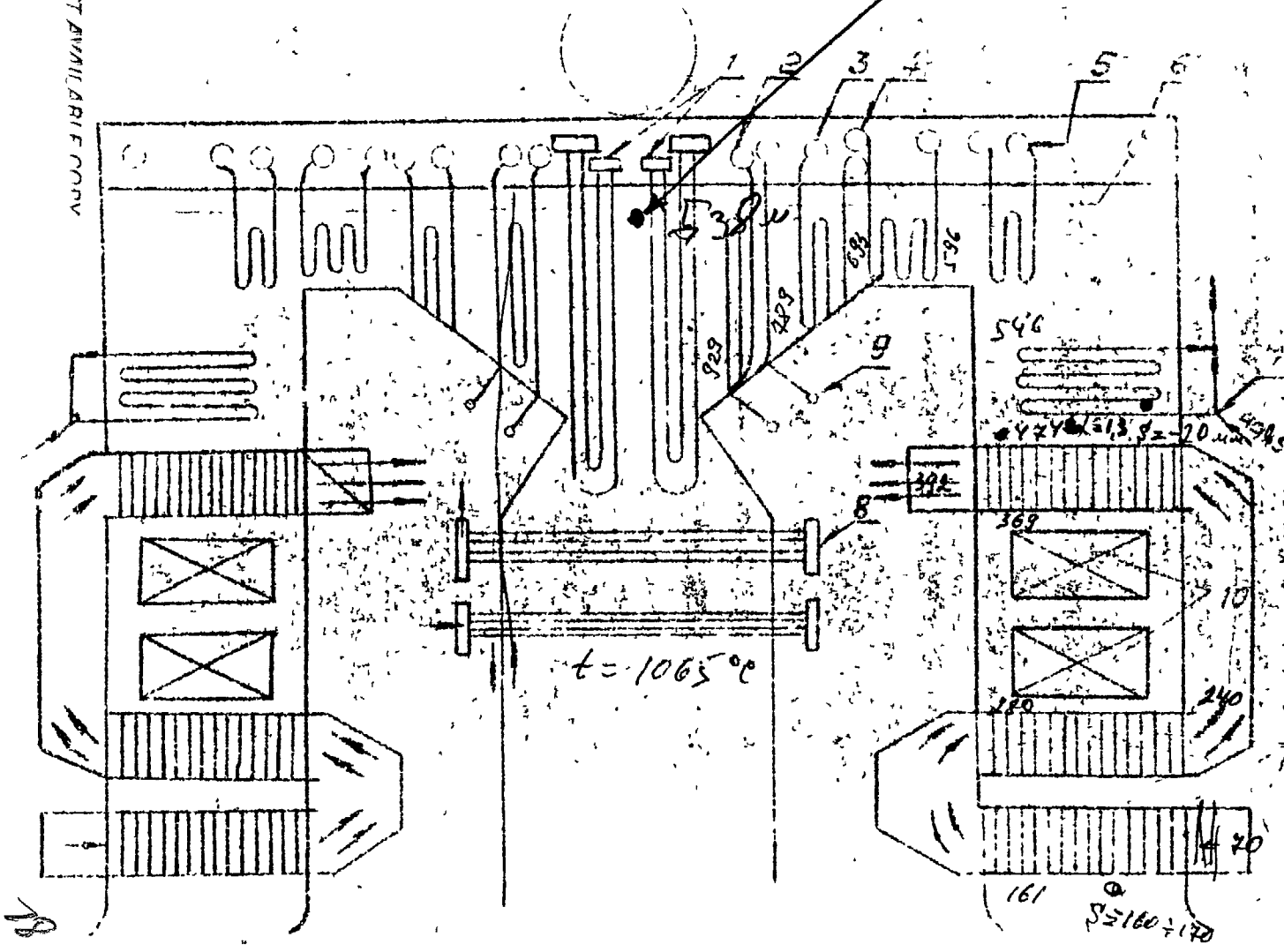
Лист К-1

Принципиальная схема котла ТГМ-99

FURNACE BLOCK DIAGRAM

PROPOSED LOCATION FOR THE O_2 PROBES

EL. 38 m., $t \cong 1000°C$



1. Ширмовый пароперегреватель
2. Средний конвективный пароперегреватель острого пара.
3. Первый конвективный пароперегреватель.
4. Холодный конвективный пароперегреватель.
5. Холодный конвективный пароперегреватель
6. Потолочный пароперегреватель
7. Регулированная отдушина
8. Настенный пароперегреватель
9. Наклонный экран
10. Водяной экономайзер
11. Воздухоподогреватель

Гл. инж. КПРЭС

Нач. СЭТО ПЭО „ДЭ" В.В. Бурк

Донтехэнергоремонт Н.В. Кирако

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WO: 05906-001

RECORD OF TELEPHONE CONVERSATIONS

DATE: April 28, 1995
TIME: 8:30 a.m. and 11:00 a.m.

Distribution: SNCorban

FROM: G. Keller P.E.
COMPANY/DEPT: BRC

TO: V.M.Tarasenko, Deputy Technical Director of Operations
COMPANY/DEPT.: Kurakhovskaya Central Power Plant
Tel. 011-380-(6212) 53-61 and 3-36-50

SUBJECT: Minimum Excess Oxygen at the Burner Level for Kurakhovskaya Unit #6.

DISCUSSION:

BRC requested station's judgement on the minimum excess oxygen at the burner level that must be maintained once the new oxygen analyzers are installed at Kurakhovskaya Unit #6 (U8)

Mr.Tarasenko asked for an hour to research the subject. When BRC called the second time, Mr Tarasenko stated that stable combustion with 0.3-0.5% O_2 at the burner level can be achieved due to staged combustion and low NO_x burner design. The low NO_x burners are completely replaced every 4 years and are inspected, repaired or replaced on "as needed" basis every two years He gave his regards to Nina (Mrs.Corban) and asked when we will be back.

C \Ukraine\Kour_tel con\May 5 1995

11

OXYGEN ANALYZER DATA FOR KOURAKHOVSKA BLR #6

The following data will be used to specify and install new high temperature oxygen analyzers:

210 MW Boiler, coal and mazut fired.

Install Probes at Elevation·	38m.
Process Temperature:	700 degrees Centigrade minimum 900 degrees Centigrade normal 1050 degrees Centigrade maximum
Ambient Temperature:	55 to 60 degrees Centigrade
Length of the cable run to the control room:	front· 100 m rear: 100 m

International Combustion Ltd

SO_2 and NOx Emissions Conversion Chart

To Convert		To: (Multiply by)								
From ↓		mg/ Nm^3	ppm NOx	ppm SO_2	g/GJ			lb/10^6 Btu		
					Coal[A]	Oil[B]	Gas[C]	Coal[A]	Oil[B]	Gas[C]
mg/Nm^3		1	0.487	0.350	0.350	0.280	0.270	8.14×10^{-4}	6.51×10^{-4}	6.28×10^{-4}
ppm NOx		2.05	1		0.718	0.575	0.554	1.67×10^{-3}	1.34×10^{-3}	1.29×10^{-3}
ppm SO_2		2.86		1	1.00	0.801	0.771	2.33×10^{-3}	1.86×10^{-3}	1.79×10^{-3}
g/GJ	Coal[A]	2.86	1.39	1.00	1			2.33×10^{-3}		
	Oil[B]	3.57	1.74	1.25		1			2.33×10^{-3}	
	Gas[C]	3.70	1.80	1.30			1			2.33×10^{-3}
lb/ 10^6 Btu	Coal[A]	1230	598	430	430			1		
	Oil[B]	1540	748	538		430			1	
	Gas[C]	1590	775	557			430			1

A :- Coal:- Flue Gas dry 6% excess O_2: Assumes 350 Nm^3/GJ – ref IEA Paper 1988.
B :- Oil :- Flue Gas dry 3% excess O_2: Assumes 280 Nm^3/GJ – ref IEA Paper 1988.
C :- Gas:- Flue Gas dry 3% excess O_2: Assumes 270 Nm^3/GJ – ref IEA Paper 1988.

APPENDIX D

List of Contacts Made During Plant Audits

LIST OF CONTACTS MADE DURING PLANT AUDITS

- Sergey A. Ivanov, Engineering Technical Director
- Veniamin N. Tarasenko, Deputy Engineering Technical Director
- Vladimir V. Burlaka, Deputy Technical Director
- Chenchikov M. Ivanovich, Chief of the Boiler and Turbine Rooms
- Egukpov G. Anatolievich, Deputy Chief of Thermal Automation Room
- Birjukov A. Anatolievich, Chief of Computer Department
- Degtjarenko V. Ivanovich, Chief Electrotechnical Laboratory
- Timoshenko V. Petrovich, Lead Engineer of the Adjustment Team
- Pilugin Y. Ivanovich, Chief of the Ecological Laboratory

APPENDIX E

Abbreviations and Unit Conversions

ABBREVIATIONS AND UNIT CONVERSIONS

AC	=	alternating current
amps	=	amperes
atm	=	atmosphere = 14.696 pounds per square inch
bar	=	100,000 pascals = 14.504 pounds per square inch
BTU	=	British thermal unit
cfm	=	cubic feet per minute
cm	=	centimeter = 0.3937 inches
cm^2	=	square centimeter = 0.155 square inches
CO	=	carbon monoxide
CO_2	=	carbon dioxide
DC	=	direct current
°C	=	degree CelsiusT[°C] = (5/9)*(T[°F] -32)
°F	=	degree Fahrenheit
°R	=	degrees RankineT[°R] = T[°F] + 460
ECO	=	Energy Conservation Opportunity
eff	=	efficiency
ex air	=	excess air
ft^2	=	square feet
ft^3	=	cubic feet
Gcal	=	gigacalorie = 1 billion calories = 3.968 million BTU
GJ	=	gigajoules = 1 billion joules
gph	=	U.S. gallons per hour
gpm	=	U.S. gallons per minute
GWh	=	gigawatt hours = 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 U.S. gallons
Hg	=	mercury
hr	=	hour
Hz	=	hertz = cycles per second
J	=	joules
kcal	=	kilocalories = 1 thousand calories = 3.968 BTU
kg	=	kilogram = 2.2046 pounds
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	=	kopec = 1/100 ruble
kPa	=	kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	=	kilovolts = 1 thousand volts
kVA	=	kilovolt-amperes
kVAr	=	kilovars = 1 thousand volt-amperes (reactive)
kW	=	kilowatt = 1 thousand watts
kWh	=	kilowatt hour = 1 thousand watt hours

lbs	=	pounds
liter	=	0.2642 U.S. gallons = 0.03531 cubic feet
m	=	meter = 39.37 inches
m^2	=	square meter = 10.76 square feet
m^3	=	cubic meter = 35.31 cubic feet
mA	=	milliampere = 0.001 amperes
MCal	=	megacalorie = 1 million calories
metric ton	=	1 thousand kilograms = 1.1023 U.S. tons
mg	=	milligrams
min	=	minute
MJ	=	megajoules
mm	=	millimeter = 0.03937 inches
MPa	=	1 million pascals = 145.04 pounds per square inch
MVA	=	megavolt-amperes
MW	=	megawatt = 1 million watts
MWh	=	megawatt hours = 1 million watt hours
NG	=	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
psi	=	pounds per square inch
psig	=	pounds per square inch (gauge)
R	=	ruble
s	=	second
SO_2	=	sulfur dioxide
sq ft	=	square feet
Tcal	=	tetracalorie = 1 trillion calories = 3.968 billion BTU
T	=	temperature
TPS	=	Thermal Power Station
V	=	volts
VA	=	volt amps
VARs	=	volt-amps reactive
yr	=	year

APPENDIX F

Letters of Receipt for Equipment
Energy Audit Items Lists

КУРАХОВСКАЯ ГРЭС

342502, г. Курахово Донецкой обл. Р/с 221001 в Марьинском отделении Агропромбанка, МФО 334196, г. Марьинка Донецкой обл. П. И. 342500, телетайп 329192 «Икар»; 115078 «Статор». Код предприятия 9537, Код ж. д. ст. Роя 481001

№ _____ February 23, 1995 199 г.

LETTER OF RECEIVING

Here is to certify that the representatives of the American Company "Burns & Roe" of New Jersey, Mrs Selisett Corban, PE and Mr George Keller, PE handed over to the Kourakhovska Thermal Power Station the equipment listed in accordance with the Attached List.

The equipment have been purchased, shipped, and handed over to the Kourakhovska Thermal Power Station under the auspices of the U.S. Agency for International Development Program "For More Efficient Operation of Ukraine Thermal Power Stations".

The equipment have been handed over to the Kourakhovska Thermal Power Station as a gift of the U.S. Government within the scope of the two-part Agreement about the U.S. technical and economical assistance to Ukraine.

USAID/KIEV Mission

Director of the Kourakhovska Thermal Power Station

Mr Pedos V.A.

Note: This document has been executed in Russian and English versions. Each version is equally accurate.

February 23, 1995

LIST OF EQUIPMENT

ITEM	DESCRIPTION	QTY	SERIAL #
1.	2 KBV ENERAC 2000 COMBUSTION ANALYZER	1	11003253
2.	SP 48-48" STACK PROBE	1	n/a
3.	SH 10-10FT HOSE FOR PROBE	1	n/a
4.	ONE CONDENSATION TRAP WITH DESECANT	1	n/a
5.	AC POWER CORD	1	n/a
6.	SMOKE CHART & 30 SMOKE PAPERS	1	n/a
7.	DISPOSABLE FILTER	1	n/a
8.	ENERAC 2000 DISKET & MANUAL	1	n/a
9.	INSTRUCTION MANUAL ENERCOMP WINDOWS & DISKET	1	n/a
10.	CYCLOPS 300AF INFRARED THERMOMETERS	1	20002073
11.	MAXELL CHARGER KB8E	1	n/a
12.	FOREIGN PLUG ADAPTOR	1	n/a
13.	220V AC POWER SUPPLY	1	n/a
14.	RECHARGEABLE AA BATTERIES	4	n/a
15.	CYCLOPS 300AF SOFT CASE	1	n/a
16.	AA SIZE BATTERIES	4	n/a
17.	LENS CAP	1	n/a
18.	EYE PIECE CAP	1	n/a
19.	2x03.5mm MINIATURE PLUGS	2	n/a
20.	INSTRUCTION MANUAL	1	n/a
21.	CYCLOPS NECK STRAP	1	n/a
22.	FLUKE #41 METER	1	n/a
23.	FLUKE #C41 - S CASE	1	n/a
24.	TL-24 TEST LEADS	2	n/a
25.	TP-20 TEST PROBES	2	n/a
26.	AC-20 TEST CLIPS	2	n/a
27.	RS-232 CABLE	1	n/a
28.	PLUG ADAPTOR	1	n/a
29.	9 PIN TO 25 PIN ADAPTOR	1	n/a
30.	COMMUNICATION SOFTWARE	1	n/a
31.	USER MANUAL	1	n/a
32.	GETTING STARTED WINDOWS	1	n/a
33.	QUICK REF. CARD	1	n/a
34.	RECHARGEABLE TYPE "C" BATTERIES	4	n/a
35.	WARRANTY REG. CARD	1	n/a
36.	80i-500S AC CURRENT PROBE	1	n/a
37.	80i-1000S AC CURRENT PROBE	1	n/a
38.	TYPE "C" BATTERIES	4	n/a
39.	MANAGING THE HARMONINGS	1	n/a
40.	Ti4000M COMPUTER	1	5010405253
41.	OKIDATA ML3380 PRINTER	1	407A0005645
42.	KEY BOARDS (RUSSIAN) & ADAPTER	1	n/a
43.	QUICK REF. CARD FLUKE 80i-1000S PROBE	1	n/a
44.	80I-1000S PROBE USER'S MANUAL & WARRANTY CARD	1	n/a
45.	WORD PERFECT 6.0 WINDOWS 6.0 LANGUAGE MODULE (RUSSIAN)	1	n/a
46.	WORD PERFECT V 6.1 FOR WINDOWS	1	n/a
47.	LOTUS 1-2-3 FOR WINDOWS	1	n/a
48.	APEX DATA DATA/FAX MODEM	1	n/a
49.	WINDOWS FOR WORKGROUPS USERS GUIDE	1	n/a
50.	PROCOMM PLUS FOR WINDOWS 2.0	1	n/a
51.	NULL MODEM ADAPTER	1	n/a
52.	DB25 CABLE 10 FT	1	n/a

КУРАХОВСКАЯ ГРЭС

342502, г. Курахово Донецкой обл. Р/с 221001 в Марьинском отделении Агропромбанка, МФО 334196, г. Марьинка Донецкой обл. П И. 342500, телетайп 329192 «Икар»; 115078 «Статор». Код предприятия 9537, Код ж. д. ст. Роя 481001

№ _____ 23 февраля 1995 199 г.

ПРИЕМО-ПЕРЕДАТОЧНЫЙ АКТ

Настоящим подтверждается, что представители американской компании "Burns & Roe" из Нью-Джерси, г-жа Селисет Корбан и г-н Джордж Кеплер передали Кураховской ГРЭС следующее оборудование согласно прилагаемому Перечню.

Приборы были закуплены, доставлены и переданы Кураховской ГРЭС в рамках Программы Агенства по международному развитию США "По повышению эффективности работы ТЭЦ Украины".

Приборы переданы Кураховской ГРЭС в качестве безвозмездной помощи Украине со стороны правительства США в рамках двусторонней Договоренности о технико-экономическом содействии Украине со стороны США.

Этот АКТ составлен на русском и английском языках и имеет равную силу.

USAID/Kiev

Директор Кураховской ГРЭС

г-н Педос В.А.

90

23 февраля 1995г.

СПИСОК ОБОРУДОВАНИЯ

Номер	ОПИСАНИЕ	Кол-во	Зав. номер
1.	2 KEV ENERAC 2000 анализатор ужигания топлива	1	11003253
2.	SP 48-48 " трубный зонд	1	отс
3.	SH 10-10FT HOSE FOR PROBE	1	отс
4.	ONE CONDENSATION TRAP WITH DESECANT	1	отс
5.	Шнур питания	1	отс
6.	Дымовые графики и бумага	1	отс
7.	Сменный фильтр	1	отс
8.	ENERAC 2000 Дискета и рук-во	1	отс
9.	Инструкция программы WINDOWS & DISKET	1	отс
10.	CYCLOPS 300AP инфракрасный термометр	1	20002073
11.	MAXELL зарядное устройство	1	отс
12.	Адаптер европейской розетки	1	отс
13.	220V источник питания	1	отс
14.	Перезаряжаемые элементы AA	4	отс
15.	CYCLOP 300AF мягкий футляр	1	отс
16.	Элементы типа AA	4	отс
17.	Крышка объектива	1	отс
18.	Крышка визира	1	отс
19.	2x03.5 mm Миниатюрные разьемы	2	отс
20.	Руководство	1	отс
21.	CYCLOPS NECK STRAP	1	отс
22.	FLUKE #41 измеритель	1	отс
23.	FLUKE #C41-5 футляр	1	отс
24.	TL-24 TECT провода	2	отс
25.	TP-20 TEST зонды	2	отс
26.	AC-20 TEST клипсы	2	отс
27.	RS-232 интерфейсный кабель	1	отс
28.	Вилочный адаптер	1	отс
29.	9 на 25 ножек адаптер	1	отс
30.	Программа связи	1	отс
31.	Руководство	1	отс
32.	Начало работы с WINDOWS	1	отс
33.	Карта быстрой ссылки	1	отс
34.	Аккумуляторы типа "C"	4	отс
35.	Карта регистрации программы	1	отс
36.	80I-500S зонд переменного тока	1	отс
37.	80I-1000S зонд переменного тока	1	отс
38.	Батарейки типа "C"	4	отс
39.	Рук-во измерения гармоник	1	отс
40.	Ti4000M COMPUTER ПЭВМ	1	5010405253
41.	OKIDATA ML3380 ПРИНТЕР	1	407A0005645
42.	Адаптер русской клавитуры	1	отс
43.	Карта быстрой ссылки 80I-1000S PROBE	1	отс
44.	80I-1000S PROBE Руководство и регистрационная карта	1	отс

ПРОГРАММНЫЕ ПАКЕТЫ С РУКОВОДСТВАМИ
(НАЗВАНИЯ ДАНЫ БЕЗ ПЕРЕВОДА)

45.	WORD PERFECT 6.0 WINDOWS 6.0 LANGUAGE MODULE (RUSSIAN)	1	отс
46.	WORD PERFECT V 6.1 FOR WINDOWS	1	отс
47.	LOTUS 1-2-3 FOR WINDOWS	1	отс
48.	APEX DATA DATA/FAX MODEM	1	отс
49.	WINDOWS FOR WORKGROUPS USERS GUIDE	1	отс
50.	PROCOMM PLUS FOR WINDOWS 2.0	1	отс
51.	NULL MODEM ADAPTER	1	отс
52.	DB25 CABLE 10 FT	1	отс

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CHECKLIST
IMPROVING COMBUSTION EFFICIENCY
UKRAINIAN POWER PLANTS

The following work will be performed at each plant, as a minimum

- Introduction and information exchange with plant management
- Discussion and presentation of the scope of work
- Identify the persons to be assigned for hands-on audit training
- Provide training and assistance to the team selected on the use of the demonstration portable instrumentation
- Perform audit tests
- Leave behind the demonstration portable instruments
- Determine physical locations for installing the stationary instruments
- Determine locations for installing the remote monitoring modules
- Determine physical characteristics related to the locations for the stationary instruments

ПЕРЕЧЕНЬ МЕРОПРИЯТИЙ ПО ПОВЫШЕНИЮ ЭФФЕКТИВНОСТИ ПРОЦЕССОВ ГОРЕНИЯ ТОПЛИВА НА УКРАИНСКИХ ЭЛЕКТРОСТАНЦИЯХ.

В качестве программы минимума на каждой станции будет произведен следующий объем работ:

- Представление и обмен информацией с администрацией станции;

- Обсуждение и представление объема работ;

- Назначение персонала для проведения аудита;

- Обучение и помощь в обучении выбранного персонала по вопросам применения портативного оборудования;

- Передача демонстративного портативного оборудования;

- Определение места для установки стационарного оборудования;

- Определение места для установки дистанционных измерительных модулей;

- Определение физических характеристик оборудования ТЭС для установки стационарных приборов;

APPENDIX G

References:

1. Preliminary Audit Report December 1994
2. Plant Audit Visit Trip Report Team #1 October 1994
3. Plant Audit Visit Trip Report Team #1 March 1995

PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

KOURAKHOVSKA POWER PLANT
(SEPT. 25 THRU SEPT. 28, 1994)

PREPARED BY: BURNS AND ROE, INC. ORADELL
SELISETT N. CORBAN, P.E.
MARC GINIGER

DECEMBER 1994

5906-02/Cover/12/9/94

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PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

KOURAKHOVSKA POWER PLANT

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PRELIMINARY AUDIT REPORT

IMPROVING COMBUSTION EFFICIENCY

KOURAKHOVSKA POWER PLANT
(Sept. 25 Thru Sept. 28, 1994)

EXECUTIVE SUMMARY

The preliminary audit activities consist of a reconnaissance visit made to the plant to meet with key plant personnel, to establish local contacts, to collect information regarding boilers, combustion process and controls, fuel management and general plant operations.

Based on the preliminary survey of this plant the following are Low-Cost, No-Cost Short Term and Medium and Long Term recommendations:

Low-Cost, No-Cost Short Term Recommendations

1) Fuel Quality Improvement Plans

The plant must survey aggressively the available coals and take initiative in contracting directly from suppliers. The plant must locate the best fuel considering boiler operational needs, design requirements, pollution control equipment performance and delivered costs. The plant must consider a blending strategy of individual coals and coal wastes to meet the above criteria. The number of coal suppliers must be reduced to a minimum for a better control of blending process.

2) Boiler Startup and Shutdown Plans

The plant must develop plans and procedures for boiler startup and shutdown to carefully monitor the furnace operation during cycling mode to limit the increase of the emissions of dust, CO, NO_x and improve boiler combustion efficiency.

3) Energy Saving Program

The energy saving program consists of providing instrumentation equipment to improve combustion efficiency of the boilers, as a first step towards the life extension of the plant. The implementation of this program is in two phases. During the first phase, in order to demonstrate the improvement of boiler's combustion efficiency, the following instruments are recommended to be installed on one boiler except as noted. Based on operation results the program may be expanded to the balance of the boilers

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in the plant. Implementation of the second phase is addressed under the Medium to Long-term Recommendations.

a) Portable combustion Analyzers

This analyzer is a very useful device to the power plant. It facilitates boiler operational adjustments to improve combustion efficiency and enable the boiler to be fine-tuned from emission point of view (CO, O_2, NO_x and SO_2).

It is recommended: one portable combustion analyzer and associated probe per station.

b) In Situ O_2 Analyzers

The combustion efficiency can be improved by replacing on one boiler the existing extractive oxygen analyzers with two in-place zirconium oxide sensor analyzers as used in USA.

It is recommended: two devices per boiler

c) Coal Meters

The following devices are recommended for metering the fuel input to the same boiler selected for the above in-situ O_2 analyzer replacement:

i) Two devices to measure raw coal consumption per boiler located between raw coal bunker and mill.

ii) Two devices to measure flow of mazut (supply and return lines).

d) Laboratory device to quickly determine caloric value and ash content of the coal as it is delivered to the station.

It is recommended: one device per station.

e) Device on conveyors to measure coal quality parameters (caloric value, ash content, water content and volatility).

It is recommended: one device per station.

f) Portable infrared temperature monitor (heat spy).

This monitor is microprocessor based-operation and gives precision spot temperature measurements without the contact with the subject being

measured.

It is recommended: one heat spy per station.

g) Portable multimeter ac power analyzer

The multimeter, microprocessor based-operation is monitoring one and three phase service recording electrical values such as volts, amps, kW, PF, Kvar, KVA, Kwh, KVarh frequency and percentage of THD.

It is recommended: one multimeter ac power analyzer and reporting software per station.

h) Laptop personal computer

This MS-DOS portable Laptop personal computer with color display is configured with reporting software necessary to meet the application.

It is recommended: one Laptop personal computer with software per station.

Medium to Long-Term Recommendations

1) Implementation of energy saving program phase two.

2) Implementation of the balance of the instrumentation per the attached station "would-like-to-have" instrument list, as a first step before replacing the entire existing instrumentation of this station.

3) Investigate lower cost SO_2/NO_x removal technologies.

For SO_2 removal for example use of coal and washings blending or lower cost sorbent technologies for flue gas conditioning. For NO_x removal use of a burner design technology for low NO_x emissions (low costs) or SNCR (selective non-catalytic reduction) or SCR (selective catalytic reduction) both expensive solutions.

4) Replace the entire existing controls, instrumentations and interlocks with state-of-the-art technology for a fully automatic operation of the station.

5) New water treatment plant.

6) Upgrade the dust control system to the world performance standards, either replace the existing ESP or refurbish to meet the world standards.

7) The plant have to develop short term and long term plans for boiler and air pollution

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control system malfunction prevention.

8) Install continuous opacity monitors one per stack to monitor the visible emissions.

9) Provide proper analytical equipment to the chemical laboratory.

10) Demonstrate the applicability of Fluidized Bed Combustion technology for this station.

The above recommendations are preliminary and subject to further review and refinement based upon completion of final audit and associated tests and measurements.

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The preliminary survey of this plant has revealed the following observations and assessments:

Observations and Assessments

- The station is quite clean for a coal firing plant and normally dirty areas are kept clean by the plant personnel.

- The station is well run by experienced personnel.

- Considerable work of refurbishing and major component replacement on all boilers and on Unit U9 (the seventh unit) HP turbine casing has been done during the past 6 years.

- Plans are in place for the next 6 years to continue the major component replacement on all boilers and Unit U9 IP turbine rotor.

- The boilers have no burner management systems.

- The station has no NO_x pollution control system.

- The original mechanical governors are still in operation.

- All interlocks are of a very basic nature offering limited protection.

- Most of the process control systems operate on "manual" mode from the Control Board located in Unit Control room.

- The design of equipment is obsolete and because of the advanced age is also significantly worn out.

- The controls and instrumentations are outdated, the readings are unstable and require ongoing maintenance to keep them operational. Spares are hard to be obtained.

- Unit U8 (the sixth unit) has a microprocessor system installed to control feedwater and steam temperature, but is not commissioned. Field instruments (primary elements) ar still not available. The visual inspection revealed that it is far from up to the-state-of-the-art technology used in USA.

- The station has no automatic synchronizing and it is not planned to install one.

- The station lacks outdoor fixed monitoring equipment for recording gaseous and dust values.

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- Because the stack hights far exceed the "good engineering practice" criteria, the pollutants emitted do not produce a local air quality problem, but it is a concern for the atmospheric pollution.

- The coal is supplied by 40 different suppliers during any given week. The station has neither input to the quality selected for the coal nor control over the fuel acquisitions.

- The coal delivered to the plant does not match original boiler design requirements, thus reducing boiler efficiency and increasing maintenance. In addition, the poor quality of fuel (coal) increases the air pollution and causes severe problems of boiler slagging. Mazut is cofired almost all times in order to deliver the MW output required by the central dispatch center.

- The Electrostatic Precipitators (ESP) are reported operating very unsatisfactory. This may be attributed to fly ash high specific electrical resistivity that affects the ability of the ESP to collect efficiently the fly ash particles from flue gas, thus reducing ESP efficiency.

- Chemical department staff is above average and competent. It is a stringent need of proper analytical equipment to perform to higher standards and in a shorter time except for fuel caloric value measurement which is adequate.

- The daily cycling mode of station operation affects the equipment and results in considerable plant refurbishment and replacement.

- The efficiency can be determined per station only, not for each one of the units because the fuel consumption per each unit is not known (no meters per unit).

INTRODUCTION

ENERGO SYSTEM:	DONBASSENERGO
LOCATION:	40 KM SOUTH-WEST OF DONETSK
INSTALLED CAPACITY:	1460 MW 1 X 200 MW + 6 X 210 MW
COMMISSIONED:	1972-1975
FUEL:	LIGNITE (SCHLAMM) SUPPLEMENTED BY MAZUT

POWER PLANT DESCRIPTION

1. In 1969 work commenced on the construction of one unit of 200 MW and six units of 210 MW capacity each. The last unit was completed by 1975. The station has a total installed capacity of 1460 MW. The boilers operate under subcritical conditions.

2. The main fuel for the station was designed to be a by-product and fines washings of Donetsk coal preparation and sludge. The poor quality of the fuel actually supplied results in the burning of fuel oil (mazut) to stabilize the boiler and supply the additional heat required for the load demand. The maximum fuel oil assistance being in the order of 25% but blending of coal is reducing this figure to approximately 10%.

3. The boilers are Type TP-109 from the Taganrog Boiler Works. The boiler supplies steam at a rate of 640 tons per hour at a pressure of 140 bar gauge and live steam temperature of 535°C. Steam from the high pressure turbine exhaust is directed back to the boiler for reheat and returned to the intermediate pressure cylinder at a pressure of 39 bar gauge and reheat temperature of 535°C. The boiler operates on a balanced draft principle with air being supplied by two 50% forced draft fans and exhaust gas removed by two 50% induced draft fans.

4. Coal is supplied to the boiler units and held in two raw coal bunkers prior to being fed to two trains of 68 ton/hr tube ball mills as shown on Attachment 1 and Reference 1 (Drawing K-205769) The motive air for transfer of the pulverized fuel is directed from the outlet of the air heater and is used to dry the pulverized fuel in addition to transporting it to pulverized fuel bunker. The ball mill is also supplied with flue gas extracted from the precipitators to mix with the motive air and limit the oxygen content to less than 18%. This minimizes the explosion risk in the coal dust system. The O_2 concentration is measured by paramagnetic oxygen meters. The mill outlet temperature is controlled to 70°C by adjustment of the rate of raw coal feed. The

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combined air and flue gas is separated from the pulverized fuel via centrifuge separators through which all the pulverized fuel is passed prior to storage in the pulverized fuel storage bunker. The storage bunker for the pulverized fuel is used to supply fuel to the sixteen burners arranged in two rows of burners in both walls of the furnace. Pulverized fuel flow to the burners is controlled via rotary feeders fitted to each outlet of the pulverized fuel storage bunker.

5. The capacity of the dust system as discussed in item 4 is not sufficient for the poor quality of the coal that is actually fired in the station.

6. Hot water is supplied from each of the seven units for district heating and from two units for greenhouses. In the station the pipelines run above ground and in the city underground.

7. The units have no gas emissions monitoring.

8. The units have manual control of forced draft fan damper positions and fan speed (two speed fan) to control combustion air flow from the Control Board located in Unit Control Room. Indications from O_2 analyzers are used to control the fuel to air ratio for the combustion.

9. The position of induced draft fan dampers is manually controlled from control board to control furnace pressure.

10. The coal as delivered to the station is weighed by scales at receiving in the coal handling yard and the mixed coal is weighed on each conveyor (1 & 2) for the entire station. The coal is not weighed on a per unit basis.

11. The design caloric value of the coal was 4100 kcal/kg. Actual operation caloric value is 3200 kcal/kg based upon an average of 5 days of sample collection and heating value determination in laboratory.

12. The station would like to have better control of coal being fired by each of the units. The station would like to have devices to quickly determine <u>caloric value</u> and <u>ash content</u> of coal as it is delivered to the station. The present laboratory facilities are old and take too long to produce results in time.

13. The station has two O_2 analyzers per unit to monitor O_2 content of exhaust gas before the economizer at 500°C. The components of each O_2 analyzer is as shown in Attachment 2. These analyzers require much maintenance and readings are not stable. The station would like to upgrade the analyzers. The station tries to maintain O_2 readings at less than 4% by manually adjusting fan dampers. The station would like to have devices to <u>automatically</u> control fan dampers and subsequently to control O_2 content of exhaust gas.

14. The station would like to have an optical burner management system.

15. The station is now developing a computer program with an IBM 386 computer for the control of steam and water cycle of Unit 6. This is a pilot unit chosen by the Ministry of Ukraine. There are 100 control points and 20 control loops. Implementation is scheduled for the end of this year. The station would like to have the instruments supplied as listed on Attachment 3 (primary elements).

BOILER PLANT

16. Boiler Coal Firing System Flow Diagram:

    a. The boiler coal firing system flow diagram has been previously discussed in items 4 and 5.

    b. The station would like to have a device on coal feeder to measure raw coal consumption to the mill. Two devices per unit or 14 devices per station. As a preferred alternate the station would like a device on the recirculation line between mill and separator, to indicate both dust weight (t/hr) and air flow (m^3/hr). Two devices per unit or 14 devices per station.

    c. The station would like to have one device on each conveyor (total of 2 for station) to measure coal quality parameters (caloric value, ash content, water content and volatility). It may be only one device switched over between conveyor 1 and 2.

    d. The station would like to have one flow meter per burner to measure coal dust flow to the burner a total of 16 flow meters per unit. The station would like to optimize combustion at each burner. If possible, to have devices to measure coal quality parameters (caloric value, ash content, water content and volatility) on each feeder (total of 16 devices per unit).

17. Boiler Design Performance:

    The original TP-109 boiler design performance is shown on Attachment 4. As stated in item 11, the design coal caloric value was 4,100 kcal/kg. The as-fired coal caloric value is 3,200 kcal/kg.

18. As-Fired Fuel Analysis:

    a. Coal:

        1. Coal is supplied by 40 different suppliers during a typical week.

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ii. Attachment 5 is a typical log of the coal supplied from September 1 to September 11, 1994. Attachment 5 lists supplier, number of order, type of fuel, total weight, water content, ash content, volatility content (measured once per 10 days for each supplier), caloric value (measured once per 10 days for each supplier). The coal is sampled on arrival.

iii. 25% of the coal in stock is schlamm, a sludge coal.

iv. Supplier certificates have different values than Attachment 5.

v. Coal is separated in the coal storage area into piles of "schlamm," "very good coal" and "low caloric value coal". The coal is proportionally mixed in the coal storage area before entering the two conveyor systems feeding the boilers.

vi. Coal is sampled every eight minutes by a mechanical device taking coal samples from each conveyor. Then after 24 hours coal samples are mixed up and analyzed for only water content. The 5 days of collected samples from both conveyors are mixed up and analyzed in detail for water, ash, volatility, sulfur content and caloric value. Attachment 6 is the result of these 5 day analyses for specific 5 day periods as noted on the attachment, and also indicates low, average and high caloric values.

b. Mazut:

Mazut is delivered by rail tanks to the plant's oil tanks for storage. A typical delivered mazut analysis is shown on Attachment 7. Typical 5 day as-fired mazut analyses are shown on Attachment 8. Mazut, heated to 100°C by steam, is delivered by pipeline to the boilers.

19. Mode of Fuel Firing:

a. Mazut is never fired alone.

b. Mazut is cofired with coal if coal caloric value is equal to or less than 3,000 kcal/kg which is virtually every day. Main steam temperature is steady. When amount of main steam decreases mazut is cofired with coal to increase main steam flow. Switchover to mazut is manual. The furnaces are equipped with infrared flame watch.

20. Section/Plan View of Boiler:

References 2, 3 and 4 (drawings 9223, K-440378-15, and K-205762-16) are section views of the type TP-109 boiler.

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PLANT OPERATION MODE

21. The units operate on cyclic mode with two units being shutdown each night and the balance of units being operated up to the minimum load of 140 MW.

22. The units operate at less than 50 hz to save fuel.

COMBUSTION CONTROLS

23. Operation is by pressure control mode. Load is changed by changing the boiler pressure setpoint. This varies the fuel flow from coal dust bunker to the burners. Actual boiler output pressure and drum pressure are compared to the pressure setpoint; the control error signal is regulating the boiler pressure controller.

CALCULATION OF BOILER EFFICIENCY

24. On January 5, 1994 the station produced 15409 x 10^6 kWh of electricity, consumed 11,799 tons/day of coal with a caloric value of 2136 kcal/kg and 1227 tons/day of mazut.

25. On April 29, 1994 the station produced 19229 x 10^6 kWh of electricity, consumed 14,377 tons/day of coal with a caloric value of 3759 kcal/kg and 90 tons/day of mazut.

26. Only efficiency per station can be determined not for each one of the units. The fuel consumption per each unit is not known.

FUTURE PLANS

27. There is a program for developing a fluidized bed boiler project at this plant but at this time is postponed. Preliminary work for construction of the auxiliary facilities has been stopped.

NOTE: See Project File for References 1, 2, 3, 4

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STATION "WOULD-LIKE-TO-HAVE" INSTRUMENT LIST

The following is a summary of the instruments that the station "would-like-to-have" provided under the energy savings program:

1. Laboratory devices to quickly determine caloric value and ash content of the coal as it is delivered to the station - one total device per station.

2. Device on conveyors to measure coal quality parameters (caloric value, ash content, water content and volatility) - one total device per station.

3. Two new in-situ O_2 analyzers per boiler - 14 total devices per station.

4. Automatic control system of forced draft fan damper positions to control O_2 content of exhaust gases - 7 total systems per station.

5. Devices to measure flow of coal dust to each burner (16 per boiler) - 112 total devices per station.

6. If possible devices to measure coal quality parameters per each rotary feeder (16 per boiler) - 112 total devices per station.

7. Optical burner management system - 7 total systems per station.

8. Devices on coal feeder to measure raw coal consumption to each mill (2 per boiler) - 14 total devices per station.

9. Alternatively devices on the recirculation line between mill and separator to measure dust weight and air flow (2 per boiler) - 14 total devices per station

10. Portable combustion analyzer - one total device per station.

11. Instruments (primary elements) as listed on Attachment 3 for Unit 6.

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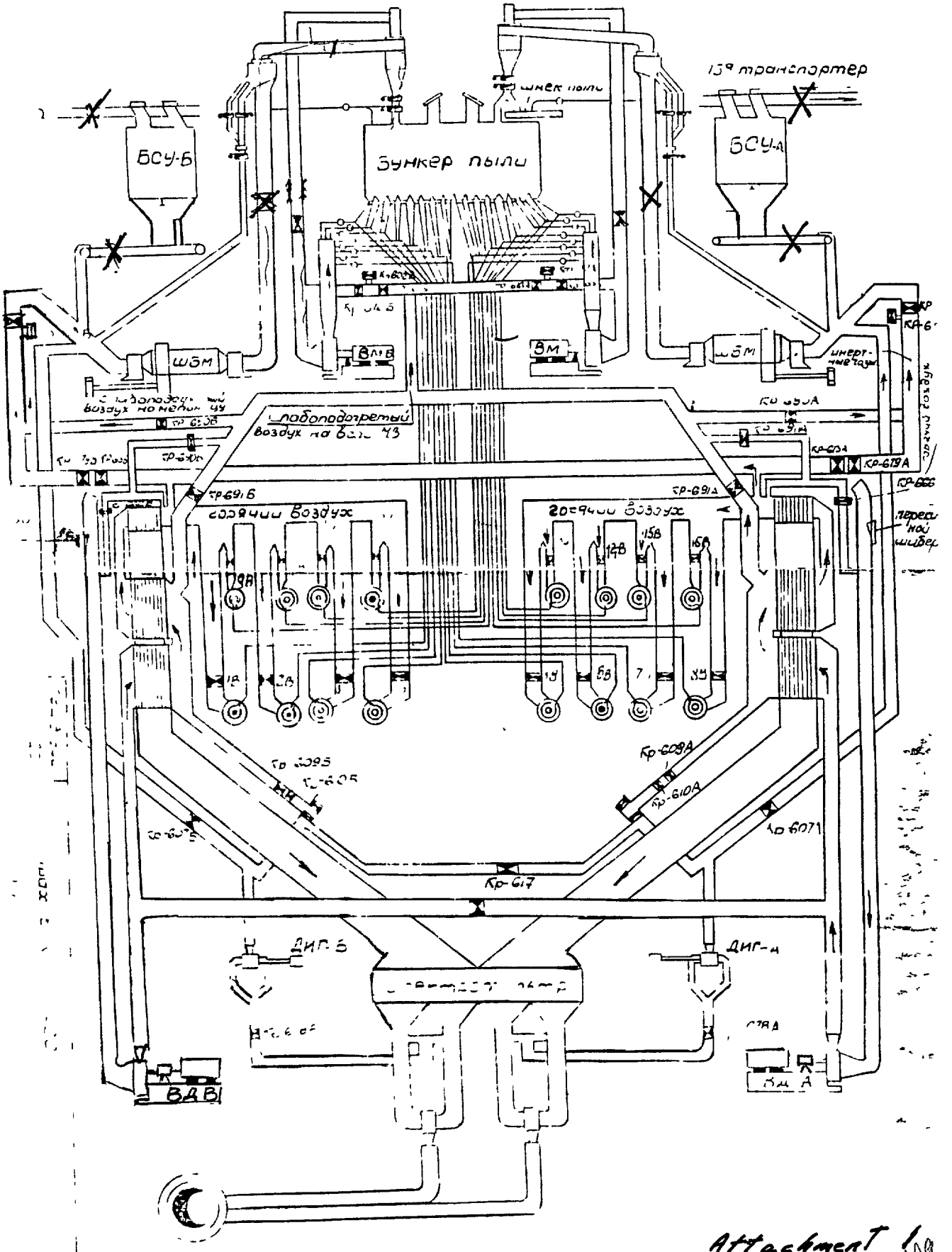
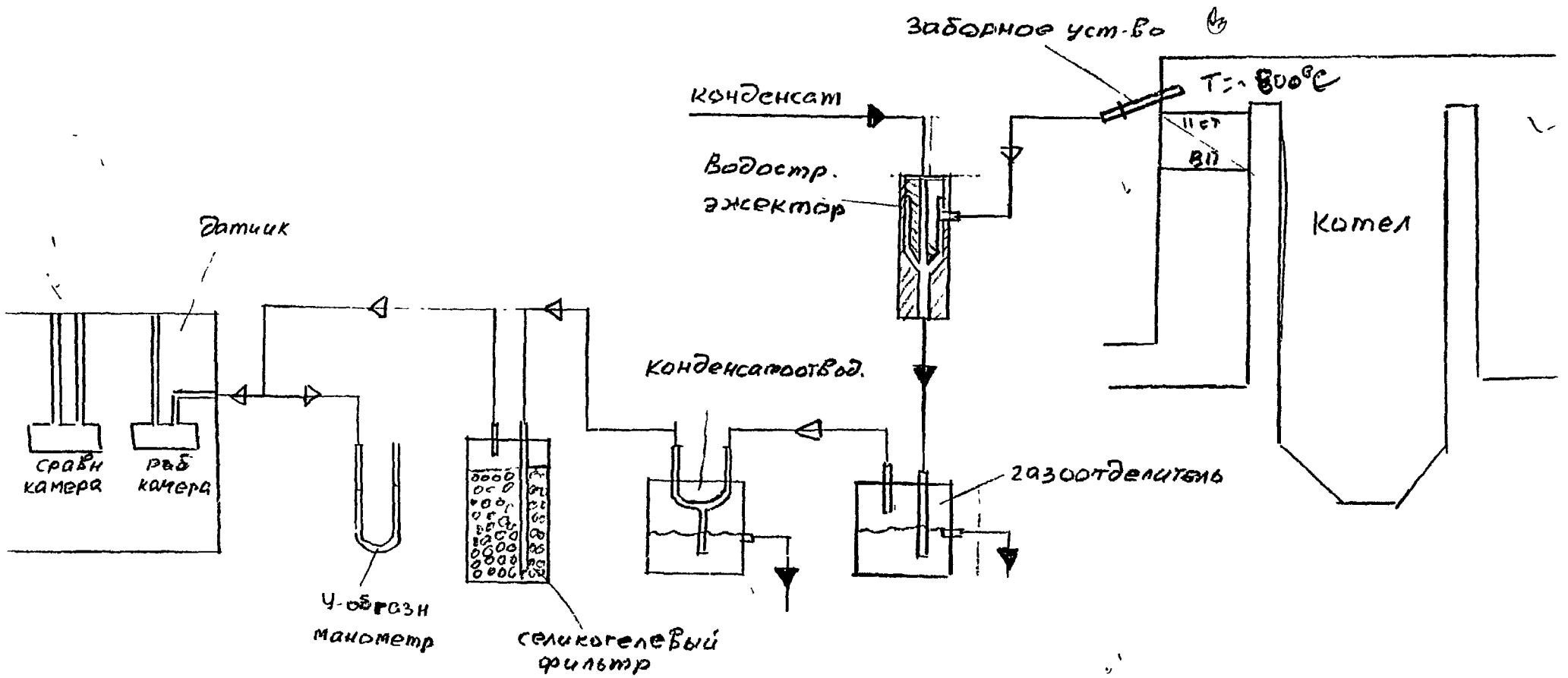


Attachment 109

Схема газоанализатора содержания кислорода в уходящих газах



Attachment 2

Attachment 3

LIST
ПЕРЕЧЕНЬ
OF THE PRIMARY INSTUMENTATION PUTTING INTO OPERATION FOR AUTOMATIC CONTROL OF THE BOILER/TURBINE
первичных приборов для вновь вводимых в работу систем автоматического регулирования котлотурбогенератора

N пп	Измеряемый параметр MEASURING PARAMETER	TECHNICAL DATA Техническая характеристика MEASUR. LIMITS предел измерения	предельно допуст. избыточ. давл. MPa MAXIMUM ALLOWABLE EXCESSIVE PRESSURE MPA	Кол-во QTY шт.
1.	BOILER DRUM LEVEL Уровень в барабане котла	6,3 KPa	40 MPa	6
2.	BOILER FEED WATER FLOW RATE Расход питательной воды к котлу	63 KPa	40 MPa	1
3.	MAIN STEAM FLOW RATE AFTER BOILER Расход острого пара за котлом	160 KPa	40 MPa	2
4.	BOILER DRUM PRESSURE Давление в барабане котла	25 MPa	–	2
5.	STEAM PRESSURE BEFORE TURBINE Давление пара перед турбиной	25 MPa	–	2
6.	WATER FLOW RATE FOR II & III INJECTION AT BOILER SUPERHEATER Расход воды на II и III впрыск в пароперегреватель котла	25 KPa	40 MPa	8
7.	WATER FLOW RATE FOR I INJECTION AT BOILER SUPERHEATER Расход воды на I впрыск в пароперегреватель котла	6,3 KPa	40 MPa	4
8.	WATER FLOW RATE FOR EMERGENCY INJECTION AT BOILER SUPERHEATER Расход воды на аварийный впрыск в пароперегреватель котла	6,3 KPa	16 MPa	4
9.	BOILER FEED WATER PRESSURE Давление питательной воды к котлу	25 MPa	–	1
10.	MAIN STEAM PRESSURE Давление острого пара за котлом AFTER BOILER	25 MPa	–	2
11.	CONTENT OF OXYGEN IN THE EXHAUST GASES Содержание кислорода в уходящих газах	10% O_2	–	14
12.	DEAERATOR LEVEL Уровень в деаэраторе	25 KPa	1 MPa	3
13.	DEAERATOR PRESSURE Давление в деаэраторе	1 MPa		2
14.	CONDENSER VACUUM Вакуум в конденсаторе	0,1 MPa	– – –	2

Примечание : Приборы по измерению кислорода в уходящих газах котла поставлять в комплекте со вторичными приборами.

NOTE INSTRUMENTATION TO MEASURE CONTENT OF OXYGEN IN THE EXHAUST GASES should be supplied WITH THE SECONDARY INSTRUMENTATIO

$1 ПА = 10^{-3} КПА = 10^{-6} МПА$

KILOPA MEGAPA

I. КОМПОНОВКА И ПАРАМЕТРЫ КОТЛОАГРЕГАТА.

Головной образец барабанного котла типа ТП-109 Таганрогского котельного завода с промежуточным пароперегревателем рассчитан на следующие параметры:

1. Производительность по первичному пару - 540 т/час.
2. Давление первичного пара за котлом - 140 ата
3. Температура первичного пара за котлом - 550°С
4. Расход пара через промперегреватель - 550 т/час.
5. Параметры пара до и после промперегревателя соответственно:

   давление - 24,0 и 21,6 ата;

   температура - 340 и 550°С;
6. Температура питательной воды - 230°С ;
7. Температура горячего воздуха - 392°С ;
8. Температура уходящих газов - 161°С ;
9. Потери тепла: с уходящими газами - 7,29% ;

   с механическим недожогом - 3,0%

   в окружающую среду - 0,3%
10. Коэффициент полезного действия котла брутто - 89,41%
11. Расчетный коэффициент избытка воздуха в топке - 1,2 ;
12. Полный расход топлива - 118,3 т/час
13. Теплонапряжение топочного объема - 118,8х10⁶ ккал/м³ час

Котельный агрегат предназначен для работы в блоке 200 Мвт с конденсационной турбиной типа К-200-130. Котел запроектирован для сжигания отходов обогащения донецких углей (промпродуктов) с сухим шлакоудалением.

Растопочным топливом служит мазут.

Расчетные характеристики промпродукта следующие:

1. Теплотворная способность $Q_н^р$ = 4100 ккал/кг ;

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2. Углерода $C^p = 43,1\%$;
3. Водорода $H^p = 2,81\%$;
4. Кислорода $O^p = 4,04\%$;
5. Азота $N^p = 0,85\%$;
6. Серы $S^p = 2,5\%$;
7. Золы $A^p = 37,9\%$;
8. Влаги $W^p = 8,8\%$.

Котельный агрегат выполнен в Т-образной компоновке.

Особенностью Т-образной компоновки является расположение топочной камеры в средней части, а хвостовых поверхностей нагрева и регулирующих поверхностей пароперегрева – в двух вертикальных опускных шахтах слева и справа от топочной камеры.

Опускные шахты связаны с топочной камерой наклонными горизонтальными газоходами, в которых расположены ширмы и конвективные поверхности нагрева первичного и вторичного пароперегревателей.

Для поддержания в чистом состоянии экранных труб (кроме двухсветного экрана) по периметру и высоте топочной камеры установлены обдувочные аппараты типа ОПР-5-58.

Для очистки поверхностей нагрева, расположенных в наклонных горизонтальных газоходах, используются аппараты типа ОГ-8, а для очистки ступени конвективного пароперегревателя высокого давления применяются высокочастотные пневматические вибраторы типа ВНП-69-ВТИ.

Очистка конвективных поверхностей нагрева, расположенных в опускных шахтах, производится при помощи дробеструйной установки, которая выполнена по напорному варианту транспорта дробя.

Удаление шлака из топочной камеры осуществляется четырьмя механизированными установками шлакового типа.

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СВОДНАЯ ТАБЛИЦА

результатов теплового расчета котла ТП-109.

1.	Производительность котла по первичному пару	670 т/час
2.	Давление первичного перегретого пара	140 кг/см²
3.	Температура перегрева первичного пара	550°С
4.	Производительность котла по вторичному пару	550 т/час
5.	Давление вторичного пара за котлом	27,3 кг/см²
6.	Температура перегрева вторичного пара	550°С
7.	Температура питательной воды	230°С
8.	Теплотворная способность топлива	4100 ккал/кг
9.	Коэффициент избытка воздуха в топке	1,2
10.	Потеря тепла с уходящими газами	7,29%
11.	Потеря тепла от химнедожога	0,03%
12.	КПД котла	89,4%
13.	Полный расход топлива	118,3 т/час
14.	Расчетный расход топлива	115,0 т/час
15.	Теплонапряжение топочного объема	118,3 ккал/м³час
16.	Лучевоспринимающая поверхность топки	2318 м²
17.	Объем топочной камеры	3960 м³
18.	Средний коэффициент загрязнения топки	0,423
19.	Теоретическая температура горения	1960°С
20.	Температура газов на выходе из топки	1065°С
21.	Температура газов за экранами	929°С
22.	Температура газов за выходн. пакетом перв. п/п	789°С
23.	Температура газов за выходн. пакетом втор. п/п.	693°С
24.	Температура газов за промежут. пакетом втор. п/п.	556°С
25.	Температура газов за холодной частью перв. п/п.	546°С
26.	Температура газов за регулир. поверх. втор. п/п	474°С
27.	Температура газов за горячей частью в. п.	369°С

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28. Температура газов за водяным экономайзером. . . . . 280°С
29. Температура уходящих газов . . . . . 161°С
30. Скорость газов в ширмовом п/п . . . . . 2,2м/сек.
31. Скорость газов в выходн.пакете первичн. п/п . . . . . 3,0 м/сек
32. Скорость газов в выходн.пакете втор. п/п. . . . . 3,9 м/сек
33. Скорость газов в промеж.части втор. п/п . . . . . 5,2 м/сек
34. -"- в холодной части первичн.п/п . . . . . 7,3 м/сек
35. -"- в регулировочной поверхн.втор.п/п. . . 8,0 м/сек
36. -"- в трубчатом воздухоподогревателе. . ,II,4/8,5м/с
37. -"- в водяном экономайзеро . . . . . 5,5 м/сек
38. Скорость воздуха в труб.воздухоподогревателе. . . 7,1/6,1м/сек
39. Температура горячего воздуха . . . . . 392°С.
40. Температура воздуха за I частью трубч. в п. . . . . 240°С
41. Температура воздуха на входе в трубч. в п. . . . . 70°С
42. Скорость пара в средних ширмах . . . . . 10,5 м/сек
43. " " в крайних ширмах . . . . . 10,9 м/сек
44. " " в выходн.пакете перв. п/п . . . . . 16,5 м/сек
45. " " в регулировочной поверхности. . . . . 15,1 м/сек
46. " " в крайних пакетах холодн.части перв.п/п 8,1 м/сек
47. " " в средних пакетах холодн.части перв.п/п 10,5 м/сек
48. " " в выходных пакетах вторич. п/п 25,7м/сек
49. " " в промежут.пакетах вторичн.п/п 22,0м/сек
50. Количество впрыскиваемого конденсата 29,3т/час

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Приложение № 2

СВОДНАЯ ТАБЛИЦА

аэродинамического расчета котла при сжигании промпродукта

РАСЧЕТ ТЯГИ

1.	Разрежение на выходе из топки	2,0 кг/м^2
2.	Сопротивление ширм и подвесных труб	2,0 кг/м^2
3.	Сопротивление выходн. пакета первичн. п/п	0,29 кг/м^2
4.	" выходн. пакета вторичн. п/п.	0,595 "
5.	" промежуточн. пакета втор. п/п	1,66 "
6.	" холодн. пакета первичн. п/п.	0,87 "
7.	" регулировочной поверхности.	17,1 "
8.	Суммарное сопротивление пароперегревателей.	24,5 "
9.	Сопротивление поворотной камеры	1,0 "
10.	" I части воздухоподогревателя.	17,3 "
11.	" водяного экономайзера	29,0 "
12.	" II части воздухоподогревателя.	27,3 "
13.	Суммарное сопротивление собственного котла.	103,2 "
14.	Сопротивление участка выход из котла-электрофильтры	38,6 "
15.	" электрофильтра ЭГ.	30 "
16.	" тракта электрофильтр-дымосос.	10,4 "
17.	Сопротивление тракта дымосос-выход в атмосферу	111,1 "
18.	Суммарное сопротивление газового тракта	310,3 "
19.	Суммарная самотяга	43,8 "
20.	Сопротивление котла с учетом самотяги	266,2 "

Выбор дымососа

21.	Производительность с запасом 5%	606000 м^3/часс
22.	Сопротивление сети	249,7 кг/м^2
23.	Температура газов у дымососа	140°С
24.	Тип дымососа	Д-25х2ШБ

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25. Число дымососов 2
26. Число оборотов (по каталогу) . . . . . 585 об/мин.
27. Графический напор . . . . . 460 кг/м²
28. Графический КПД 68%
29. Графическая мощность . . . . . 1150 квт.
30. Расчетная мощность с запасом 10% . . . . . 900 квт.
31. Напряжение сети . . . . . 6000 в
32. Тип электродвигателя . . . . . ДАВ0-19-74-10/12А.
33. Число оборотов двигателя . . . . . 600/500 об/мин
34. Мощность двигателя . . . . . 1500/800 квт.

Примечание: В связи с тем, что в дальнейшем котел будет доводиться до параметров пара 570°С и будет работать на ухудшенном топливе, дымосос выбран с большим запасом.

Расчет дутья.

35. Сопротивление всасывающего тракта хол. воз-ха . . . 25,2 кг/м²
36. " нагнетательного тракта хол. воздуха . 33,8 "
37. " калориферов . . . . . 7,3 "
38. " I ступени трубчатого в.п. . . . . 81,5 "
39. " перепускных коробов между I и II ступенями в.п. . . . . 1,8 "
40. " II ступени труб в.п. . . . . 40,5 "
41. Суммарное сопротивление труб. в.п. . . . . 123,8 "
42. Сопротивление тракта воздухоподогреватель-горелки 35,3 "
43. Сопротивление горелки по вторичному воздуху . . . 226 "
44. Суммарное сопротивление воздушного тракта без самотяги . . . . . 451,4 "
45. Разрежение в топке на уровне горелок . . . . . 23,5 "
46. Самотяга воздушного тракта . . . . . 5,8 "
47. Перепад полных давлений по воздушному тракту . . . 433,7 "

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Выбор дутьевого вентилятора.

49. Производительность с запасом 5% . . . . . 43500 м³/час
49. Сопротивление сети . . . . . 433,7 кг/м²
50. Тип вентилятора ВДН-20-II
51. Число вентиляторов . . . . . 2 шт
52. Число оборотов (по характеристике) . . . . . 740 об/мин.
53. Напор по характеристике . . . . . 400 кг/м²
54. Графическая мощность . . . . . 675 квт.
55. Графический К.П.Д. 53%
56. Расчетная мощность на валу с запасом 10% . . . 755 квт.
57. Напряжение сети . . . . . 6000 в.
58. Тип электродвигателя . . . . . ДАМО-15-69-8/10м.
59. Число оборотов двигателя . . . . . 750/600 об/мин
60. Мощность двигателя . . . . . 800/400 квт.

Расчет рециркуляции дымовых газов.

61. Процент рециркуляции 20%
62. Сопротивление ширмового п/п и подвесных труб . . . 4 кг/м²
63. " выходного пакета первичного п/п . . . 0,333 "
64. " выходного пакета вторичного п/п . . . 0,667 "
65. " промежуточного пакета вторичного п/п. 1,38 "
66. " холодного пакета первичного п/п. . . 0,99 "
67. " регулировочной ступени . . . . . 13,1 "
68. Суммарное сопротивление пароперегревателей . . . 19,9 "
69. Сопротивление поворотной камеры . . . . . 0,89 "
70. " I части воздухоподогревателя . . . . 16,9 "
71. " водяного экономайзера . . . . . 24,0 "
72. " II части воздухоподогревателя . . . . 25,0 "
73. " участка выход из котла-электрофильтр 35,6 "

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74. Сопротивление электрофильтра . . . . . 40 кг/м^2
75. Общее разрежение в месте отбора дымовых газов . . 168,2 "
76. Суммарное сопротивление всасывающего тракта . . . . 37,9 "
77. " " нагнетательного тракта . . . 97,6 "
78. Разрежение в месте ввода газов . . . . . 12,8 "
79. Суммарное сопротивление тракта . . . . . 282,2 "
80. Сопротивление тракта с учетом самотяги . . . . . 289,2 "

Выбор дымососа рециркуляции

81. Производительность с запасом 5% . . . . . 144000 м^3/час
82. Сопротивление сети . . . . . 289,2 кг/м^2
83. Тип дымососа Д12х2
84. Число дымососов . . . . . 2 шт.
85. Температура газов . . . . . 170°С
86. Число оборотов по каталогу . . . . . 730 об/мин.
87. Графический напор . . . . . 325 кг/м^2
88. Расчетная мощность . . . . . 197 квт.
89. КПД машины по характеристике 70%
90. Напряжение сети . . . . . 6000 в.
91. Тип электродвигателя ДАЗ0-72-55-2
92. Число оборотов двигателя . . . . . 730 об/мин
93. Мощность двигателя . . . . . 250 квт.

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Attachment 5

#1

Name of Vendor		Sample	Mark	Tons	Water	Ash	Volatility	Calorific V
ата !	Наименование поставщика	№ пробы	Марка	Тоннаж	Влага % рабочая	Зола A^c %	Летучие %	Каллорийнос
1	2	3	4	m 5	6	7	8	ккал/кг
I.09.94	ЦОФ Дзержинская	4237	п/п	678	5.1	40.3	33.5	4289
	ЦОФ Калининская	4238	п/п	136	4.0	52.1	25.2	3319
	ЦОФ Пролетарская	4239	п/п	204	5.5	48.8	28.1	3618
	ш.Челюскинцев	4242	ДГСШ	409	9.8	27.2	39.7	4880
	ш.Трудовская	4243	ДСШ	323	II.3	57.1	46.5	2465
	Донтехстрои	4244	шл.	599	23.0	59.7	40.6	1978
2.09.94	ш. №2	4246	ГР	1563	6.5	44.5	40.7	3648
	ш.Пионер	4248	шл.	272	2I.5	35.7	43.4	3508
	Авдеевский КХЗ	4249	п/п	134	8.4	38.2	32.3	4250
	ЦОФ Брянковская	42[illegible]	п/п	135	I.8	63.7	37.9	2427
	ЦОФ Донецкая	4256	шл.	1702	13.5	45.8	32.1	3536
	ЦОФ Донецкая	4259	п/п	748	6.0	39.9	3I.9	4333
	ЦОФ Стахановская	4260	п/п	I35	5.8	44.5	32.5	4083
3.09.94	ш.Кременная	4276	ДСШ	402	I3.7	49.6	52.9	2964
4.09.94	ш.Селидовская	428I	ДМСШ	408	II.8	50.8	49.3	2986
	ш.Абакумова	4283	ДГСШ	809	22.7	63.4	45.5	I916
	ш.Горняк	4286	ДР	400	5.8	44.3	47.0	3621
	ЦОФ Кураховская	4288	ДГСШ	1470	9.7	58.6	5I.5	2884
	ЦОФ Горская	4289	шл.	I218	20.2	46.2	35.0	2976
	Ясиновский КХЗ	4290	шл.	264	I4.7	47.0	36.8	3277
5.09.94	ш.Коротченко	4291	ДГ	269	7.7	62.I	43.2	2298
	ш. №I	4293	ГР	I36	5.7	13.2	25,9	6615
9.09.94	ш.Родинская	4380	ГЖОР	406	9.0	43.3	37.3	3732

1	2	3	4	5	6	7	8	9
	ш.Ждановская	4394	ДГР	11.7	1.7	21.5	10.6	6338
	ш.Кураховская	4397	ДР	210	9.9	45.9	41.3	3479
	ш.Матросская	4398	ДР	331	9.1	52.4	51.4	2866
	ЦОФ Колосниковская	4400	п/п	199	10.2	16.8	18.1	6068
1.09.	ш.Горняк	4429	ДР	394	11.6	38.5	45.2	3735
	ш.Абакумова	4430	ДГСШ	887	9.6	45.0	39.0	3499
	ш.Родинская	4431	ГЖОР	676	12.6	35.7	37.6	4068
	ЦОФ Краснолиманская	4432	к-т	333	9.2	32.9	38.4	4715
	Об-во Прогресс	4433	шл.	268	26.5	45.1	39.6	2774
	ЦОФ Калининская	4434	п/п	334	8.2	36.9	28.9	4467
	ЦОФ Дзержинская	4435	п/п	200	4.5	42.8	32.8	4191
	ш.Кременная	4436	ДСШ	1343	8.7	46.0	48.4	3459
	ЦОФ Кураховская	4437	ДГСШ	1284	6.8	51.1	47.8	3228
	ш.Пионер	4438	шл.	273	14.8	44.9	39.0	3216
	Донтехстрой	4441	шл.	325	22.6	60.2	42.0	1946
	ш.Черноморка	4445	ДР	1013	5.0	53.5	33.2	2917
	ЦОФ Трудовская	4449	шл.	792	8.3	64.1	42.7	1632

ATTACHMENT 6

KOURAKHOVSKA POWER PLANT

QUALITY OF COAL FOR 5 DAYS

Date	% Water	% Ash	% Volatility	% Sulfur	Lower Caloric Value (kcal/kg)	
12/29/93 to 1/3/94	9.23	36.41	33.41	1.72	3997	
1/4/94 to 1/8/94	23.41	40.8	45.37	1.36	2136	Low
1/9/94 to 1/13/94	22.13	40.66	42.78	0.8	2435	Low
1/14/94 to 1/18/94	17.63	42.3	36.88	1.52	2758	Avg
1/19/94 to 1/23/94	12.44	46.12	46.36	1.12	2779	Avg
1/24/94 to 1/28/94	13.00	45.31	40.59	0.8	2857	Avg
4/29/94 to 5/3/94	8.48	36.89	35.43	0.87	3759	High
5/4/94 to 5/8/94	8.96	41.70	30.63	0.72	3827	
5/9/94 to 5/13/94	11.03	37.49	34.07	0.88	3556	

5906-02/Attach/11/14/94

ATTACHMENT 7

KOURAKHOVSKA POWER PLANT

QUALITY OF MAZUT

PARAMETER	
Ignition Temperature in Open Crucible	163°C
Moisture Content	0.32%
Density	0.991 g/cm^3
Sulfur	3.96%
Caloric Value	941 kcal/kg

ATTACHMENT 8

KOURAKHOVSKA POWER PLANT

QUALITY OF MAZUT FOR 5 DAYS

Date	% Water	% Sulfur	Lower Caloric Value (kcal/kg)
4/29/94 to 5/3/94	14.55	1.78	8174
5/4/94 to 5/8/94	15.64	2.20	8082
5/9/94 to 5/13/94	11.5	2.29	8499
5/14/94 to 5/18/94	10.12	2.38	8742
5/19/94 5/23/95	5.37	2.34	8824
5/24/94 5/28/94	7.34	2.24	8766
7/29/94 8/3/94	7.37	2.56	8752
8/4/94 to 8/8/94	6.07	3.29	8846
8/9/94 to 8/13/94	5.94	2.53	9147
8/14/94 to 8/18/94	4.10	3.12	9045

MEMORANDUM

Burns and Roe Company

To: S.B. Gerges

From: S.N. Corban

Date: 10/26/94

Subject: Trip Report
USAID Program of Improving Combustion Efficiency of Ukrainian Power Plants
9/14 to 10/9/1994

Copies to:
R.Edelman
R.S.Gagliardo
M.Giniger
C.Crosman
J.Hallberg

This trip report is a brief summary of activities taking place during the trip to Ukraine that started on Sept. 14, 1994 thru October 9, 1994.

The activities have been related to the subject task and included as follows: selection process of the typical power plants to implement the combustion efficiency improvement program and to conduct the initial audits of those plants.

The initial audits consisted of establishing plant contacts, collecting information regarding boilers, combustion controls, fuel management and general plant operations.

Specific audit test measurements and associated calculations will be performed during the next follow-up audits of the same selected power plants.

The detailed descriptions of the findings, analyses of measurements and calculations, including recommendations will be fully covered in the audit reports that will be prepared for each selected plant.

Background:

USAID/KIEV has initiated an energy saving program by providing instrumentation equipment to combined heat and power (CHP) plants and power plant stations to improve combustion efficiency of the boilers as a first step towards life extension of these plants.

Such earlier pilot program in 1992 at Kiev No. 5 CHP station, demonstrated substantial savings in oil and gas at a low cost of installed instrumentation equipment.

Therefore, the purpose of this work has been to implement the above energy saving program at five other power plants or/and CHP plants as selected by USAID/KIEV in consultation with Ministry of Energy and Electrifications.

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Power Plant Selections

Departure from New York USA was on Sept. 14, 1994 and arrival in Kiev on Sept. 15, 1994.

Upon arrival in Kiev-Ukraine a meeting was held at the office of USAID/Ukraine Mission on Sept. 16, 1994 with Dr. Osborn of USAID/KIEV and Darian Diachock of IDEA/KIEV.

Dr. Osborn suggested selection of seven power stations located in different regions of Ukraine, that should be considered for energy saving program. This is a change from original five power stations. In addition after considerable discussions and assessment of the actual political climate of Ukraine, it was decided that during this trip all selected power stations would be visited for an initial audit. The detailed audits including the measurements and tests would have to take place later during the second trip. The selection criteria of the power stations was established as follows:

- Combination of power stations and district heating plants
- Geographical locations to encompass all Energo regions
- Power station ratings to be representative for Ukraine power sector
- Cover all types of fuels: gas, mazut, coal (lignite, high and low bituminous, anthracite)
- Types and ratings of the boilers to be representative
- Political considerations.

Kenney

A meeting with Tom Kenney of World Bank in Kiev was held to discuss the available reports, studies, and info related to power sector in Ukraine.

Performance data on power stations and CHP plants was also obtained during a meeting with Oleg Gerasimenko a local consulting engineer recommended by IDEA, Inc.

Based on the above general criteria and performance data available on Ukraine power sector, from a list of seventeen large thermal power stations and lists of other district thermal stations (CHP), an initial list of seven power stations and CHP plants had been prepared. With minor modifications the selected power plants are as shown on the Attachment 1. The concurrence to this selection was obtained from Dr. Osborn and Darian Diachock.

During a meeting with Alexey Sheberstov, First Deputy Minister of Ministry of Energy & Electrification of Ukraine, on Sept. 20, 1994, the energy saving program was explained, and the proposed selection of the power plants for this program received his concurrence and approval.

However, the final selection was reduced to six power plants due to the deletion of Simferopol CHP station located in Crimea. The travel to Crimea was restricted because of a cholera outbreak.

On Sept. 22, 1994 KIEV #5 CHP plant was visited. The purpose was to get information from the plant personnel related to the program already in place: combustion analyzer and in-situ O_2 analyzer.

Planning of Initial Audit Visits

A plant visit schedule was prepared with "Two Teams" planned to visit the selected six plants. Each team had assigned two persons.

Team #1:

Selisett N. Corban
Marc Giniger

Team #2:

John Hallberg
Cliff Crosman

Team #1 was scheduled to visit four plants all located east, south-east and southwest of the country.

Team #2 was scheduled to visit two plants, one located south the second located west of the country. This team included in its schedule the travel to visit a plant in the Republic of Moldova which is a different task activity.

An agenda entitled "Check List" of the work to be performed at each plant during this audit, was developed (see Attachment #3) and also translated in Russian. Two days were allocated for initial audit of each plant. The plant visits had to be scheduled to coincide with Dr. Osborn's visits in the areas. On Sept. 28, 1994 he was scheduled to be in Donetsk - Kourakhovska region followed up by Sept. 29-30, 1994 visit to the city of Odessa.

The plant visit schedule (see Attachment #2) together with the "Check List" were discussed and handed to Igor Lapinin, Head of Department of International Activities

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of Ministry of Energy and Electrification of Ukraine. He took care to send the documents to all six plants and associated Energo organizations for advance planning of each team's arrivals.

Arrangements for translation and car transportation services for both teams were made with a local Dutch firm called "Tebodin".

Initial Audit of the Plants

Introduction

The purpose of this initial audit work is as outlined on the attached "Check list". The information regarding power plant's operations was gathered from existing sources and discussions with key personnel. A "Punch List" (see Attachment 4) was developed and used to obtain the data at each power station.

The following trip report covers the audit activities performed by Team #1.

The Team #2 trip report is presented under a separate document.

General

The following four power stations in Ukraine were subject of initial audit activities:

1.	Kourakhovska:	1x200 + 6x210 MW
2.	Uglegorsk:	4x300 + 3x800 MW
3.	Zmiev:	6x200 + 4x300 MW
4.	Krivoi Rog:	10x300 MW

In general three types of nominal unit sizes are thru all four plants: 200 MW, 300 MW, 800 MW.

The plants are well run by experienced staff that spent almost their entire professional life at these plants.

These plants are operated like very large industrial complexes employ between 2000-3000 persons and have dedicated nearby towns for power plant personnel.

As a general comment the plants are designed for multiple fuel capabilities. Coal delivered to the plants does not match original boiler design requirements, thus reducing boiler efficiency and increasing maintenance.

For some power plants, every five years a boiler's performance is reviewed and adjusted based on the actual as-fired fuel properties. This derating is reflected in MW net output of the plant and calculations of boilers and plant's efficiencies.

In general, combustion regulation is based on maintaining constant the temperature and pressure of the main steam at the boiler outlet.

The fuel to air ratio for the combustion process is manually adjusted from the control board located in the Unit Control Room.

The O_2 analyzer's indications are used to manually control the combustion; the instrument is an old design, not reliable and requires continuous maintenance.

The fuel metering, where installed is for the entire plant, (except natural gas) thus the efficiency calculations for each boiler are extrapolated based on procedures outlined in theoretical books.

The actual instrumentation equipment of the plants is old and outdated; the operating personnel do not fully trust their indications or operations. The plants are in need of entire upgrading of the process control system.

A. <u>KURAKHOVSKA POWER PLANT (Sept. 25 thru Sept. 28)</u>

ENERGO SYSTEM:	DONBASSENERGO
LOCATION:	40 KM South-west of Donetsk
INSTALLED CAPACITY:	1460 MW
COMMISSIONED:	1972-75
BOILER TYPE:	Subcritical, Type TP-109
FUEL TYPE:	Lignite (Schlamm) supplemented by mazut when lignite caloric value is $\leq$3000 Kcal/Kg
COAL METERS:	Total per plant; extrapolated for each unit
MAZUT METERS:	None
O_2 ANALYZERS:	Old, need frequent regulations and maintenance, indications are not stable.

SERVICE DUTY:	Cyclic operating mode (two units shutdown each night and the balance of the units reduced to minimum load of 140 MW)
UNIT OPERATION:	Sliding pressure mode (Boiler pressure setpoint is changed to change the load)
BURNER MANAGEMENT:	None
POLLUTION MONITORING:	No NO_x Control

The meetings were held with the following key personnel:

- Sergey A. Ivonov, General Engineer Technical Director
- Veniamin M. Tarasenko, Deputy Technical Director of Operations
- Victor F. Larinov, Chief Engineer of Donbassenergo from Gorlovka
- Support Plant Staff

Overall assessment of technical and managerial capabilities of the plant staff is average. The staff is competent, and fully cooperated in providing the available information.

On Sept. 28, 1994, Dr. Osborn visited the plant and he was briefed on initial audit results.

B. <u>UGLEGORSK POWER PLANT</u> (Sept. 28 thru Oct. 1)

ENERGO SYSTEM:	DONBASSENERGO
LOCATION:	50 KM North-east of Donetsk
INSTALLED CAPACITY:	3600 MW
COMMISSIONED:	4x300 MW 1972-1973 (First Phase) 3x800 MW 1975-1977 (Second Phase)
BOILER TYPE:	Supercritical Type TPP-312A - First Phase Type TGMP-204 - Second Phase

FUEL TYPE:	4x300 MW; coal, gas, mazut, coal and gas or coal and mazut 3x800 MW; gas, mazut or gas and mazut
COAL METERS:	Total per plant; extrapolated for each unit
MAZUT AND GAS METERS:	Measured at each unit
O_2 ANALYZERS:	"In situ" electrochemical cells on each boiler, accurate indications if either gas or mazut is burnt, but not both.
SERVICE DUTY:	Continuously at loads required by central dispatch center.
UNIT OPERATION:	Maintain constant the temperature and pressure of the steam at the outlet of the boiler
BURNER MANAGEMENT:	None
POLLUTION MONITORING:	No NO_x Control No SO_2 Control

The 800 MW boilers have operated as a pressurized furnace with FD fans in operation only; ID fans are not provided, gases are directly exhausted into the chimney. There are high gas leakages, and vanadium corrosion.

The meetings were held with following key personnel:

- Georgy Kuryshko, Technical Director
- Fedor Tzirulnik, Deputy Chief Engineer
- Victor F. Larinov, Chief Engineer of Donbassenergo from Gorlovka
- Support plant staff

The power station is clean and appeared to be well run and managed. The staff is competent and cooperated in providing the information.

A concern was expressed in reference to available spare parts for the equipment to be installed under energy saving program. A suggestion was made for including into the program spare parts for 5 (five) years.

C. ZMIEV POWER PLANT (Oct. 3 Thru Oct. 5)

ENERGO SYSTEM:	KHARKIVENERGO
LOCATION:	30 KM South of Kharkiv
INSTALLED CAPACITY:	2400 KW
COMMISSIONED:	1960-1969
BOILER TYPE:	Subcritical TP-100 for 6x200 MW Units Supercritical TPP-210 and TPP-210 for 4x300 MW Units
FUEL TYPE:	Coal low-bituminous, anthracite and gas or mazut
COAL METERS:	Total per plant; extrapolated for each unit
MAZUT AND GAS METERS:	No meters for mazut, meters for gas
O_2 ANALYZERS:	Old, need frequent regulations and maintenance, indications are not reliable.
SERVICE DUTY:	Continuously, base load.
UNIT OPERATION:	Maintain constant the temperature and pressure of the steam at the boiler outlet.
BURNER MANAGEMENT:	None
POLLUTION MONITORING:	No NO_x Control

The meetings were held with the following key personnel:

- Oleg K. Gritsaniuck; Director

- Alexander G. Chupyra; Chief Engineer

- Valentin Kolomiets; Automation

Due to the geographic location of this power plant, the buses of this plant switchyard are used to exchange power between the Russian and Ukrainian electrical systems. The plant operates in parallel with Russian system, not with the Ukrainian grid.

Plant is old, and the control is an obsolete design of 1950's. There are several plans for improving or changing this plant. A joint venture between B&W (USA) and several Ukrainian companies works on a pilot design for a boiler to burn the local low caloric value coal, to replace in future the existing boilers.

An overall assessment of technical and managerial capabilities of the plant staff was not possible to be made fully at this time due to limited number of personnel that were assigned to work with us (one person). The cooperation was minimal. Some of the requested information was not provided.

D. KRIVOI ROG POWER PLANT (Oct. 5 Thru Oct. 8)

ENERGO SYSTEM:	DNIPROENERGO
LOCATION:	100 KM South-west of Dnipropetrovsk
INSTALLED CAPACITY:	3000 MW
COMMISSIONED:	1965-1973
BOILER TYPE:	Supercritical Type P50 - Units 1, 2, 3, 4 Type TP-210A - Units 5, 6, 7, 8, 9, 10
FUEL TYPE:	Coal low-bituminous anthracite supplemented by mazut and gas
COAL METERS:	Total per plant; extrapolated for each unit
MAZUT METERS:	None per plant
GAS METERS:	Total per plant and each boiler
O_2 ANALYZERS:	Old, indications not reliable.

SERVICE DUTY:	Base load.
UNIT OPERATION:	Maintain constant the temperature and pressure of the steam at the boiler outlet.
BURNER MANAGEMENT:	None
POLLUTION MONITORING:	No NO_x Control

The meetings were held with the following key personnel:

- Valeri M. Cebotari; Director
- Vladimir A. Lucinikov; Chief Engineer
- Victor Kabanenko; Automation
- Support plant staff

There is a program of reconstruction of this plant but because of several problems in the last years, the implementation of the program has been postponed.

The power station is well managed. The staff is competent and fully cooperated in providing the requested information.

A concern was expressed related to the availability of spare parts for the instrumentation equipment to be installed under the energy saving program.

On October 8, 1994 the Team #1 traveled from Krivoi Rog to Kiev and back to USA on October 9, 1994.

SELECTION CRITERIA

Improving Combustion Efficiency
Ukrainian Power Plants

September 19, 1994

VER PLANT	SIZE IN MWe	BOILER TYPE	FUEL TYPE	ENERGO	YEAR(s) COMMISSIONED	PLANT TYPE
AKHOVSKA	1 X 200 6 X 210	SUBCRITICAL	LIGNITE (SCHLAMM)	DONBASSENERGO	1972-1975	ELECTRIC ONLY
GORSK	4 X 300 3 X 800	SUPERCRITICAL	GAS OIL	DONBASSENERGO	1972-1973 1975-1977	ELECTRIC ONLY
ITYN	12 X 200	SUBCRITICAL	HIGH BITUMINOUS COAL	LVIVENERGO	1965-1969	ELECTRIC ONLY
DI ROG	10 X 300	SUPERCRITICAL	LOW-BITUM. ANTHRACITE	DNIPROENERGO	1965-1973	ELECTRIC ONLY
~~ROPOL~~	~~2 X 50~~	~~SUBCRITICAL~~	~~GAS~~	~~CRIMEAENERGO~~	~~1958-59~~ ~~1984-86~~	~~CHP (TETs)~~
/	6 X 200 4 X 300	SUBCRITICAL SUPERCRITICAL	LOW-BITUM. ANTHRACITE	KHARKIVENERGO	1960-69	ELECTRIC ONLY
SA	2 X 20 1 X 12 1 X 16	SUBCRITICAL	LOW-BITUM. ANTHRACITE	ODESSAENERGO	1953-57	CHP (TETs)

ATTACHMENT #1

ATTACHMENT #2

PLANT VISIT SCHEDULE

REV 9/23/94

	Team #1 (S.N. Corban)	Team #2 (J. Hallberg)
25 Sun	Travel to Kourakhovska	
26 Mon	Kourakhovska (Plant	
27 Tu	Kourakhovska (Plant)	
28 Wed	Travel to Uglegorsk	
29 Thur	Uglegorsk (Plant)	Travel to Odessa
30 Fri	Uglegorsk (Plant)	Odessa (Plant)
0-1 Sat	Travel to Kharkiv	Odessa
2 Sun	Kharkiv	Odessa
3 Mon	Zmiev (Plant)	Odessa (Plant)
4 Tues	Zmiev (Plant)	Travel to Moldova
5 Wed	Travel to Krovoi Rog	Moldova (Plant)
6 Thur	Krivoi Rog (Plant)	Moldova (Plant)
7 Fri	Krivoi Rog (Plant	Travel to Burshtyn
8 Sat	Travel to Kiev	Burshtyn
9 Sun	TRAVEL TO USA	Burshtyn
10 Mon		Burshtyn (Plant)
11 Tues		Burshtyn (Plant)
12 Wed		Travel to Kiev
13 Thur		RETURN TO USA
14 Fri		
15 Sat		
16 Sun		

ATTACHMENT # 3

CHECK LIST
IMPROVING COMBUSTION EFFICIENCY
UKRAINIAN POWER PLANTS

The following work will be performed at each plant, as a minimum:

- Introduction and information exchange with plant management
- Discussion and presentation of the scope of work
- Assess both technical and managerial capabilities
- Establish points of contacts
- Identify any local support, if available
- Identify and coordinate the work schedule
- Discussion with key personnel regarding operation of the plant
- Determine the availability of the existing sources of information and data
- Determine the plant historical operating data
- Walk through the plant to determine the requirements for selected instrumentations:

  Combustion analysers
  Fuel flow meters, gas, oil or coal
  Oxygen analyzers

- Review of existing P&ID's to determine locations of monitoring points
- Determine physical locations for installing the selected primary element
- Determine locations for installing the remote monitoring modules
- Identify the persons to be assigned for on-the-job audit training

ATTACHMENT 4

IMPROVING COMBUSTION EFFICIENCY
UKRANIAN POWER PLANTS

PUNCH LIST

A. Boiler design basis fuel analysis (coal, mazut and natural gas), design boiler performance for each fuel, parameters derated from original design, and original design fuel analysis.

B. Mode of fuel firing - only natural gas, only mazut, only coal, and combination of fuels.

C. As fired natural gas and mazut analysis, as fired best, average, worst coal analysis, where measured and frequency.

D. Boiler as fired fuel natural gas, mazut and coal performance.

E. Boiler firing system line diagram - air supply, exhaust gas, fuel feed etc.

F. Section/plan views of boiler.

G. Flow diagrams for natural gas, mazut, and coal feed and measurement of fuel feed.

H. Mode of unit operation - loading of units.

I. Copy of drawings showing combustion control scheme (functional analysis) for fuel feed and combustion air.

J. CO and O_2 monitoring.

K. Calculation of boiler efficiency for natural gas, mazut and coal firing based upon A. and C. above. Method of efficiency calculations.

TRIP REPORT

PLANT AUDIT VISITS

KOURAKHOVSKA, UGLEGORSK, AND ZMIEV TES

TEAM #1

UKRAINE

Prepared by: 3 31.95
G.Keller, P.E./date
3/31/95
S.Corban, P.E./date

March, 1995

Burns and Roe Enterprises, Inc
Oradell, New Jersey 07649

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TRIP REPORT

1.1 Introduction

USAID/ENI retained Burns & Roe Enterprises, Inc. (BREI) to perform plant audit visits to seven Ukrainian Thermal Power Plants (TES)..

The objective of these audit visits is to improve the combustion efficiency of the Ukrainian Power Plants.

Burns & Roe performed the plant audit visits during a Feb 6–Mar 7 trip to the Ukraine in accordance with the Delivery Order objectives. The following report describes the activities of Team #1 (Selisett Corban, P.E. and George Keller, P.E.), which visited Kourakhovska, Uglegorsk and Zmiev TES. A separate report describes the activities of Team #2 (John Hallberg P.E. and Prem Gupta) which visited Odessa, Simferopol, Krivoy Rog and Burshtyn.

1.2 Work Plan

The following work was planned for each plant audit visit:

- Perform introduction and information exchange with the plant management.
- Discuss and present scope of the work.
- Identify personnel to be assigned for hands-on audit training.
- Provide training and assistance to the team selected for the use of the demonstration portable instrumentation.
- Perform audit tests.
- Turn over the demonstration portable instrumentation to the plant management and sign the papers.
- Determine best location for installing stationary instruments.
- Determine best location for installing receiver instruments.
- Define process and environmental conditions as well as length of the cable runs.

1.3 Trip Report and Findings

Mon. & Tue,. Feb.6-7, 1995 -Travel to Kiev.

Feb 8 through Mar 15, 1995 - In Kiev.

The following activities took place during this time:

- Meetings and introductions at the office of USAID/Ukraine Mission with Dr. Osborn and Andrei Parinov of USAID/KIEV.
- Meetings and introductions at the office of IDEA/KIEV with Darian Diachok and his staff.
- Arrangements for expediting delivery of USAID equipment from USA to Kiev.
- Arrangements for custom clearance.
- Arrangements for delivery of USAID equipment to the office of IDEA/KIEV.
- Arrangements for safekeeping of USAID equipment.
- Inspection and check-out of the arrived USAID equipment
- Powering up and installation of the software programs for seven TI computers.
- Dry run with nine portable analyzers.
- Local procurement of the missing accessories.
- Arrangements for reliable vehicles, translators and safe travel in the Ukraine.

Thurs, Feb.16, 1995 -Travel to Uglegorsk TES.

Feb 17 through Feb 21, 1995 - In Uglegorsk.

The following activities took place during this time:

- Selisett Corban, P.E. and George Keller, P.E. met with Georgy Kuryshk, Technical Director, Fedor Tzirulnik, Deputy Chief Engineer and support staff of the Plant. After an introduction and information exchange with the plant management, Team 1 presented the scope of work and outlined the schedule and the required assistance to maintain this schedule.

  A discussion followed. Our hosts made it clear that they are pleased to see us

return to provide equipment and services. Apparently, scores of foreign companies visited the plant and promised some assistance which never materialized.

- The plant management identified those personnel to be assigned for hands-on audit training. George Keller concentrated on providing training and assistance to the team selected for the demonstration and continuous use of the portable combustion analyzer. Selisett Corban provided training to the team assigned to the infrared "Heat Spy" and Fluke power analyzer.

- Team #1 proceeded to prepare for audit tests. George Keller worked with the local computer specialists in resolving Texas Instruments (TI) PC software problems. Local computer specialists were competent and familiar with the latest PC software. We were surprised at the large number of PC's in use.

  Use of TI PC for an interface with a EES portable combustion analyzer (ENERAC) was successfully demonstrated. We obtained an absolute analysis of the local coal and successfully created a custom fuel for the portable combustion analyzer's library of fuels.

- Team #1 proceeded to perform audit tests. On the first day of the audit tests most of the measurements were performed by the BREI Team while training the assigned local personnel. On the second day the assigned team performed most of the measurements with very little assistance. Measurements were performed on different boilers, at various MW loads, at different locations on the boilers, and on two fuels (coal and natural gas). Occasionally a new access hole in the furnace or a duct was required for the analyzer probe insertion. This was accomplished by the plant personnel very expeditiously.

- Power analyses were performed by utilizing the Fluke harmonic analyzer.

- The assigned team was also trained in the use of the infrared "Heat Spy".

- We also worked on finding the best location for stationary instruments, such as oxygen analyzer and coal flowmeters. Because of the high leakage rates (up to 100% and higher), which make readings of any oxygen analyzer dependant on

its distance from the furnace, we recommended the use of high temperature oxygen analyzers for stationary purposes. After a discussion both parties agreed to use high temperature oxygen analyzer for stationary purposes. We also defined the best locations for receiver instruments, process and environmental conditions, and the length of the cable runs. Using the infrared "Heat Spy" we were able to measure ambient temperature around the future high temperature oxygen analyzer. Metal temperature at the mounting location (railing) was 57-60 Degree Centigrade.

- We also worked with the laboratory staff to define critical needs for fuel analysis.

- The Team spearheaded all necessary paper work required to turn over to the plant the portable instrumentation used for the audit test demonstration.

Wed, Feb.22, 1995 -Travel to Kourakhovska TES.

Feb 23 through Feb 27, 1995 - In Kourakhovska.

The following activities took place during this time:

- Selisett Corban, P.E. and George Keller, P.E. met with Sergey A. Ivanov, Technical Director of Operations, Benjamin M. Tarasenko, Deputy Technical Director of Operations, Vladimir V. Burlaka, Deputy Technical Director, and support staff of the Plant. After an introduction and information exchange with the plant management, Team 1 presented the scope of work and outlined the schedule and the required assistance to maintain this schedule.

  A discussion followed, very similar to the one at the previous plant. Our hosts made it clear that they are pleased to see us return to provide equipment and services. Scores of companies visited the plant and promised some assistance which never materialized.

- The plant management identified those personnel to be assigned for hands-on audit training. George Keller concentrated on providing training and assistance to the team selected for the demonstration and continuous use of the portable combustion analyzer. Selisett Corban provided training to the team assigned to the infrared "Heat Spy" and Fluke power analyzer.

- Team #1 proceeded to prepare for audit tests. George Keller worked with the local computer specialists in resolving Texas Instruments (TI) PCSsoftware problems. Local computer specialists were competent and familiar with the latest PC software. We were surprised at the large number of PC's in use.

  Use of TI PC for an interface with a EES portable combustion analyzer (ENERAC) was successfully demonstrated. We obtained an absolute analysis of the local coal and successfully created a custom fuel for the portable combustion analyzer's library of fuels.

  Team #1 proceeded to perform audit tests. On the first day of the audit tests most of the measurements were performed by the BREI Team while training the assigned local personnel. On the second day the assigned team performed most of the measurements with very little assistance.

Measurements were made on different boilers, at various MW loads, at different locations on the boilers, and on two fuels (coal and coal/mazut). Occasionally a new access hole in the furnace or a duct was required for the analyzer probe insertion. This was accomplished by the plant personnel very expeditiously.

- Power analyses were performed by utilizing the Fluke harmonic analyzer.

- The assigned team was trained in the use of the infrared "Heat Spy".

- We also worked on finding the best location for stationary instruments, such as oxygen analyzer and coal and mazut flowmeters. Because of the high leakage rates (up to 100% and higher), which make readings of any oxygen analyzer dependant on its distance from the furnace, we recommended the use of high temperature oxygen analyzer for stationary purposes. After discussion both parties agreed to use stationary high temperature oxygen analyzer and a portable mazut flowmeter. Portable mazut flowmeter can also be used to troubleshoot condensate leaks.

  We also defined the best locations for receiver instruments, process and environmental conditions, and the length of the cable runs. Using the infrared "Heat Spy" we were able to measure ambient temperature around the future high temperature oxygen analyzer. Metal temperature at the mounting location (railing) was about 55 Degree Centigrade.

- We also worked with the laboratory staff to define critical needs for fuel analysis.

- The Team spearheaded all necessary paper work required to turn over to the plant the portable instrumentation used for the audit test demonstration.

<u>Tues, Feb.28, 1995</u> -Travel to Zmiev TES

While traveling to Zmiev TES ,we stopped to visit the corporation DonORGRES in the city of Gorlovka, which we had identified as a promising I&C Contractor for commissioning stationary instruments. We met with Dr.Ostrovesky, Chief Engineer

of DonORGRES, who incidentally is a member of the American Academy of Sciences (tel.(06242)4-22-23). Dr.Ostrovesky is technically very competent and a tough negotiator. After a considerable downsizing he still has 440 people reporting to him.

DonORGRES commissioned all fossil Units at Tbilisi and Erevan TES as well as hundreds of units in Ukraine, CIS and abroad. They are prepared to do light electrical and I&C installation work but will not undertake mechanical or heavy electrical installations. All start-up men from DonORGRES are graduate engineers but will run instrument cable or will hire and supervise local labor.

We proposed that DonORGRES should become a representative for American companies that supply equipment under the USAID contract. This would simplify spare parts supply and maintenance for all Ukrainian power plants. Dr.Ostrovesky agreed to that suggestion and we since then made the necessary contacts.

We also discussed the commissioning of the stationary equipment under the USAID contract. DonORGRES implied that without their participation the equipment will not be properly commissioned. In our opinion, the power plants are capable to do the work themselves. However, if DonORGRES is reasonable in pricing the commissioning of the stationary equipment, it could be a good insurance policy.

Feb 23 through Mar 5, 1995 - In Zmiev

The following activities took place during this time:

- Selisett Corban, P.E. and George Keller, P.E. met with Alexander G. Chupyra; Chief Engineer, Valentin Kolomiets; Manager of Automation, Alexander V Ermolenko, Deputy Chief Engineer of Operations, and support staff of the Plant. After an introduction and information exchange with the plant management, Team 1 presented the scope of work and outlined the schedule and the required assistance to maintain this schedule.

- A discussion followed, very similar to the one at the previous plant. Our hosts made it clear that they are pleased to see us return to provide equipment and services. Scores of companies visited the plant and promised some assistance which never materialized.

- The plant management identified those personnel to be assigned for hands-on audit training. George Keller concentrated on providing training and assistance to the team selected for the demonstration and continuous use of the portable combustion analyzer. Selisett Corban provided training to the team assigned to the infrared "Heat Spy" and Fluke power analyzer.

- Team #1 proceeded to prepare for the audit tests. George Keller worked with the local computer specialists in resolving a hardware problem with the Texas Instruments (TI) PC. Local computer specialists were familiar with the latest software. We were unable to boot-up the TI PC. As result, we had to use a local PC for an interface with the EES portable combustion analyzer (ENERAC).

  The interface was successfully demonstrated. We have obtained an absolute analysis of the local coal and successfully created a custom fuel for the portable combustion analyzer's library of fuels.

- Team #1 proceeded to perform audit tests. On the first day of the audit tests most of the measurements were performed by the BREI Team while training the assigned local personnel. On the second day the assigned team performed most

of the measurements with very little assistance.

Measurements were performed on different boilers, at various MW loads, at different locations on the boilers, and on two fuels (coal and natural gas). Occasionally a new access hole in the furnace or a duct was required for the analyzer probe insertion. This was accomplished by the plant personnel very expeditiously.

- Power analyses were performed by utilizing the Fluke harmonic analyzer.

- The assigned team was trained in the use of the infrared "Heat Spy".

- We also worked on finding best location for stationary instruments, such as oxygen analyzer and coal flowmeters. Because of the high leakage rates (up to 100% and higher), which make readings of any oxygen analyzer dependant on its distance from the furnace, we recommended the use of high temperature oxygen analyzer for stationary purposes. After a discussion both parties agreed to use high temperature oxygen analyzer for stationary purposes. We also defined the best locations for receiver instruments, process and environmental conditions, and the length of the cable runs. Using the infrared "Heat Spy" we were able to measure ambient temperature around the future high temperature oxygen analyzer. Metal temperature at the mounting location (railing) was 48-55 Degr. Centigrade.

- We also worked with the laboratory staff to define critical needs for fuel analysis

- The Team spearheaded all necessary paper work required to turn over to the plant the portable instrumentation used for the audit test demonstration.

Suns, Mar 5, 1995 -Travel to Kiev.

Mon, Mar 6, 1995 -Kiev Debrief.

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- Participated in informal meetings with Andrei Parinov at the office of USAID/Ukraine Mission.

- Participated in informal meetings at the office of IDEA/KIEV with Darian Diachok and his staff.

- Made arrangements and moved the BRC audit sets #1&2 from the office of USAID/Ukraine Mission to a secure location in close proximity to the office of IDEA/KIEV.

Tues, Mar 7, 1995 -Travel to USA.

5.1 Preliminary Findings.

1. Ukrainian power plants operate in a steady-state mode (base loaded), with a turbine maintaining throttle pressure, "fixed" firing rate, floating frequency and manually adjusted air flow (fixed settings for each load).

   Present combustion settings produce little CO or NOx emissions on all fuels. However, when firing coal, high levels of SO_2 are emitted due to the poor quality of the coal. Combustion of Polish coal results in especially high levels of SO_2 emissions. SO_2 content of the Polish coal seems to be much higher then the Specification.

2. Very high leakage rates (100% and higher) are typical, which makes readings of any oxygen analyzer dependant on its location (distance from the furnace). They also make impossible on-line calculation of the combustion efficiency at the back end of the boiler.

3. Most of the oxygen analyzers we have seen are of the extractive/paramagnetic type, with questionable accuracy and a measurement time constant on the order of about 1-2 minutes. As a result, they cannot be used for real time excess air control.

4. Low carbon monoxide levels (10 to 100 ppm) in the flue gas in combination

with 4 to 5% oxygen in locations with 850-870 Degree Centigrade temperature lead us to believe that combustion efficiency of the Ukrainian Power Plants can be improved. In our estimation, the improvement will be no less then 0.5% and no more then 1%.

5. Ukrainian Power Plants seem to operate very well on natural gas. Emissions are low, boilers run better and will longer life expectancy. It also seems to be more economical to burn the gas at present mix of fuel prices.

6. Existing return air system from the coal storage bunkers to the furnace reduces combustion efficiency due to poor mixing with combustion air.

5.2 Preliminary Recommendations

- Excess air should be reduced until at least 300-400 ppm of carbon monoxide is generated which is indicative of economic combustion.

- There is room for a considerable economic benefit because the starting point of the excess air (4 to 5% excess oxygen) is high. It should not be very difficult to reduce the excess oxygen by 1-1.25% and achieve 0.5% improvement in combustion efficiency even with existing manual control of the combustion process provided that constant operator attention is achieved. We believe that such attention can be obtained via a small economic inducement based on the fuel savings. Another alternative would be to invest in an expensive automatic control for the excess air system.

- This benefit cannot be achieved without carbon monoxide measurements of the undiluted flue gas (850-870 Degree Centigrade temperature) at different boiler loads. Thus by extending the existing portable analyzer program to all Ukrainian power plants an improvement in combustion efficiency can be achieved at low cost.

- An accurate SO_2 laboratory analyzer should be provided for each plant to control the SO_2 content of the received coals versus the coal Specification.

- We recommend to modify the existing return air system from the coal storage

bunkers to the furnace to insure good mixing with the combustion air (add air nozzles). The return air must arrive in the furnace as high velocity jet with the ratio of its horizontal velocity to the vertical velocity in the furnace of 6 to 1. Presently the return air does not participate in combustion, but rises along the furnace walls as "parasite air".

- The best thing that can be done for improving combustion efficiency, reducing emissions and extending life expectancy of Ukrainian Power Plants is to switch them entirely to burn natural gas, which is presently cost competitive with other fuels.

Kourakhovska Power Plant

Price of coal 3,190,000 /TON @ 3,600 KKAL/Kg

Calculate payback for BLR No 6 only. 200 MW MAX
140 MW MIN

Leakages: @ plant data

Furnace:	36%
Flue Ducts	21%
A/H	31%

Assume 4% O_2 at the burner is O.K.

Flue gas temp at ID Fan ≈ 180°C

Flue gas temp to A/H	≈ 400°C
Amb air temp	18°C
A/H air temp out	≈ 340°C

Coal consumption: 600,000 T @ 3,600 KKAL/Kg

S N Corson will give you ultimate analysis at 8 a.m 4/25/95

Many thanks

4/24/95

Главный инженер КГРЭС т. Иванов С.А.
Зам. гл. инженера т. Тарасенко В. М.
Нач. ЦЭР -I т. Фоменко М.А.
Нач. ЦТД т. Ченчиков А.П.
Группа учета

Присосы холодного воздуха в топки газоходы и пылесистемы, за январь 1995г.

№№ п/п		за рег. ст.	Рег.ст. Ист.в/п	Ист.в/п д-с	котел - д-с	Топка	пылесистемы А	пылесистемы Б
		1/2	1/3	1/4	1/5	1/6	1/7	1/8
2/1	Бл№3	1,433	46,0	16,0	34,0	19,0	[illegible]	[illegible]
3/1	-"-4	1,336	[illegible]	15,0	44,0	29,4	40,4	35,0
4/1	-"-5	1,348	45,0	15,0	40,0	26,0	30,0	70,0
→ 5/1	-"-6	1,345	[illegible]	16,0	35,0	[illegible]	33,0	[illegible]
6/1	-"-7	1,335	35,0	16,0	44,0	19,0	42,5	39,0
7/1	-"-8	1,328	[illegible]	14,0	37,5	23,5	37,0	43,7
8/1	-"-9	1,350	24,0	[illegible]	35,0	17,0	36,0	35,0
9/1	КПД	1,351	35,3	15,0	[illegible]	26,0	49,2	43,4
10/1	№№	3	4	5	6	7	8	9
11/1	Дух.	1,430	[illegible]	1,43	1,515	1,515	1,430	1,475
12/1	Шл.	3,5	3,80	3,75	[illegible]	3,90	3,4	3,50

Начальник ЦТС А. С. Бурлака.

BEST AVAILABLE COPY

APPENDIX H

Data Obtained During August 1997 Visit

TRIP REPORT

PLANT AUDIT VISITS

KOURAKHOVSKA, UGLEGORSK, AND ZMIEV TES

UKRAINE

Prepared by. Aug 27, 1997
G Keller, P E./date

August 1997

Burns and Roe Enterprises, Inc
Oradell, New Jersey 07649

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TRIP REPORT

1.0 Introduction

The work described in this report has been carried out by Burns and Roe Enterprises, Inc within the framework of the U S Agency for International Development (USAID) Emergency Energy Program for the Newly Independent States (NIS), Delivery Order No 6 Energy Efficiency and Reliability - Ukraine, Technology Based Project, Energy Efficiency and Market Reform Project (EEMRP), Task 2 - Power Plants Combustion Efficiency.

U S AID/Kiev has initiated an energy savings program by providing instrumentation equipment to combined heat and power plants (CHP) and power plant stations to improve combustion efficiency of the boilers as a first step towards life extension of these plants The purpose of Task 2 is to implement this energy saving program at seven power and/or CHP plants The project team visited Ukraine September 14-October 13, 1994, to select representative plants and to gather preliminary information at the selected plants The project teams also performed combustion audits during February and March 1995.

During these audits, the project teams trained plant personnel on the use of portable combustion efficiency instrumentation. A set of portable efficiency instrumentation (ENERAC 2000 combustion analyzer, Fluke AC power analyzer, and Cyclop Infrared Temperature Detector (heat spy) was given to the Kourakhovska, Uglegorsk, and Zmiev plants in 1995 In 1997 the plants received and accepted an oxygen analyzer, high range infrared thermometer, liquid flow meter, combustion analyzer consumables, and sulfur analyzer Installation of oxygen analyzers was initiated in May - June 1997

In August 1997 Burns and Roe Enterprises, Inc representative George Keller made a follow-up visit to the Zmiev, Uglegorsk, and Kourakhovska plants The purpose of this visit was to collect data necessary for issuance of the final reports and to assist plants in commissioning of equipment received in 1997

2.0 Trip Report and Findings

Mon & Tue, Aug 4-5, 1997 -Travel to Kiev

Wed., Aug 6, 1997 -Travel to Zmiev TES

Aug 6 through Aug 7, 1997 -In Zmiev

George Keller, P.E met with the management and support staff of the plant and explained the purpose of his visit In the ensuing discussion plant technical and financial situation, impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant, and required technical assistance with commissioning of the equipment received in 1997 were brought up.

A Protocol was prepared which describes the impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant A list of questions regarding commissioning of the Sulfur Analyzer was prepared by the chemical lab and given to George Keller He will follow up on this list upon his return to USA

Fri Aug 8, 1997 -Travel to Uglegorsk TES

Aug 8 through Aug 11, 1997 -In Uglegorsk TES

George Keller, P E met with the management and support staff of the plant and explained the purpose of his visit. In the ensuing discussion the following issues were brought up plant technical and financial situation, impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant, and required technical assistance with commissioning of the equipment received in 1997

A Protocol was prepared which describes the impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant A list of questions regarding commissioning of the Laboratory Calorimeter and Sulfur Analyzer will be prepared by the chemical lab and forwarded to George Keller He will follow up on this list upon his return to USA

Aug 11, 1997 -Travel to Kourakhovska TES.

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Aug 11 through Aug 12, 1997 -In Kourakhovska.

George Keller, P.E met with the management and support staff of the plant and explained the purpose of his visit In the ensuing discussion the following issues were brought up plant technical and financial situation, impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant, and required technical assistance with commissioning of the equipment received in 1997.

A Protocol was prepared which describes the impact of AID supplied instruments on fuel efficiency and environmental improvements at the plant A list of questions regarding commissioning of the Laboratory Calorimeter and Sulfur Analyzer will be prepared by the chemical lab and forwarded to George Keller. He will follow up on this list upon his return to USA.

Tue, Aug 12, 1997 -Travel to Kiev

Tue, Aug 12, 1997 -In Kiev.

Prepared the trip report and started preparation of the Final Reports.

Thu, Aug 14, 1997 -AID Kiev Debrief and Travel to USA

3.0 Preliminary Findings

All three plants are presently in a very difficult financial position since they pay world prices for fuel but sell electrical power at the rate set by the government Both load factors and quality of coal have declined since 1995. .

Typically, on a given TES only 2 units out of 8 are operating at 60 - 70% MCR At the same time there is a shortage of power in the Ukraine and electrical power is being imported from Russia The answer to this paradox is that poor quality coal requires mazut or gas to support combustion which can be bought only for cash. The stations do not have cash but can get some coal by trading credits. At this time all three plants are overwhelmed by political and economic factors out of their control and it is a testimony to the management's efforts that the adjusted efficiency of the plants remained the same or improved since 1994.

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ECO-02 (energy conservation training program), and ECO-03 (fuel quality improvement program) were not implemented due to lack of funds Also the plants are presently in a very difficult financial position Salaries were not paid for 6 to 8 months and the management began layoffs Under this circumstances implementation of the above programs would be very difficult even if funds were available.

Some of ECO-01 (energy management conservation program) goals were realized despite the lack of funds for a formal energy management conservation program Since 1995 the plants utilized the audit equipment that was left behind by the BREI audit team as part of the USAID boiler efficiency improvement demonstration program

ENERAC 2000

ENERAC 2000 portable combustion analyzer is regularly used by plants to conserve energy and reduce environmental pollution (see attached Protocols) An improvement in heat rate energy consumption of 2 14% (1997 vs 1995, grams of nominal fuel per KWHR) is indicated by the Zmiev plant. Some of this improvement in efficiency is due to lower excess air combustion which was made possible by timely analysis via ENERAC 2000 Plant personnel considers that up to 0.4% improvement was due to the use of a modern portable combustion analyzer.

The plant personnel were unwilling to quantify savings in tons of environmental pollutants or avoided environmental fines, but had no doubts that such savings took place (see attached Protocols) Off the record I was told by the management of Uglegorsk TES that savings in environmental fines alone were about $20,000

An improvement in operational efficiency also took place since two technicians can perform the measurement in 15 minutes whereas previously an inferior measurement required an effort of 4 technicians for 4 hours

So impressed was the management of DONBASENERGO by ENERAC 2000 that by the order of the Chief Engineer of DONBASENERGO this instrument was transferred from Kourakhovska to the corporation DonORGRES which tunes all power boilers in DONBASENERGO system So now Kourakhovska' ENERAC 2000 is helping 5 TES to conserve energy and reduce environmental pollution This development does not follow to the letter the terms of the AID contract with Kourakhovska but rather to its spirit and who can argue with the leverage that was thus achieved.

INFRARED THERMOMETER CYCLOP 300AF

The plants have nothing but praise for the Infrared Thermometer Cyclop 300AF It was in wide use for about 2 years

FLUKE AC POWER ANALYZER

The plants also like the Fluke AC Power Analyzer It was in wide use for about 2 years.

OXYGEN ANALYZER ZIRTEK

Oxygen Analyzer ZIRTEK was available to the plants at most about 2 months So far they worked reliably in the Zmiev and Uglegorsk TES. The plants have high hopes for these instruments but so far not enough data to confirm their effectiveness

PORTABLE LIQUID FLOW METER TRANSPORT PT 868

This instrument was available to the plants at most about 2 months. So far attempts to use this instrument for circulating water flow measurement were not successful, seemingly due to the deposits in the circulating water lines ABB Company, acting on Zmiev request, tried to measure circulating water flow in the same pipe using their version of a portable ultrasonic meter This attempt was also without success Management of the Zmiev Plant felt that this confirms that the measurement problem is due to the deposits and therefore asked me to investigate possibility of replacing clamp-on sensors with stationary sensors, which can be cleaned without shutting down the plant If this is not done, the instrument will not find a wide application at the three plants

It is worth mentioning that originally (in 1995) this instrument was primarily specified to measure flow of mazut Since this application does not produce pipe deposits, the measurement should be successful. However by now the plants do not have much mazut to measure.

HIGH RANGE INFRARED THERMOMETER MICRON M90

High Range Infrared Thermometer MICRON M90 was available to the plants at most about 2

months. So far attempts to use this instrument for temperature measurements were either not made or not successful Management of the Zmiev Plant dislikes this instrument and would like to trade it for something more useful to them Other TES were less emphatic about it Generally it is too early to tell, it just may take some time for the plants to get used to a new instrument

LABORATORY CALORIMETER AND SULFUR ANALYZER

Laboratory Calorimeter and Sulfur Analyzer were available to the plants at most about 2 months All plants are trying to learn how to use them This will take some time The plants have high expectations for these instruments.

COMPARISON TABLE

The table below compares economic impact of the USAID supplied instrumentation at the three power plants that were visited (all numbers are from the Protocols, see Appendix H of the Final Report).

	Kourakhovska	Uglegorsk	Zmiev
Combustion Analyzer ENERAC 2000	$25 000 to $30,000 per year	$45 000 to $50,000 per year	$5,000 to 6,000/yr
Infrared Thermometer Cyclop 300AF	$12,000 to $15,000 per year	$69 000 per year	$8,000/yr
Fluke AC Power Analyzer	$12,000 to $15,000 per year	$12,500 per year	$800 to 1,000 per year
Oxygen Analyzer ZIRTEK	In commissioning	Preliminary results $30,000 per year if used with manual controls, $60,000 per year if used with automatic controls,	Expected future benefit is estimated at $12,000
Laboratory Calorimeter	In commissioning	In commissioning	N/A
Sulfur Analyzer	In commissioning	In commissioning	In commissioning
High Range Infrared Thermometer MICRON M90	In commissioning Expected future benefit is estimated at $10-11 000	In commissioning	Not in use
Portable Liquid Flow Meter TRANSPORT PT 868	In commissioning Expected future benefit is estimated at $10-11,000	In commissioning	Cannot be used with clamp-on censors If in-situ censors are provided, future benefit is estimated at $50,000

Утверждаю:

Главный инженер Кураховской ТЄС

_____А.К.Харахаш

12.08._____1997г.

г Курахово

Кураховская ТЭС

А К Т

Зам главного инженера - начальник ПТО В.В.Бурлака, начальник ЦНиИ - Е Г.Засорин , начальник ЦТАиИ В.Ф.Головащенко, начальник электороцеха - В С.Ефремов, начальник КТЦ - М.И Ченчиков, представитель фирмы Burns and Roe Enterprises, Inc Джордж Келлер составили настоящий акт об эффективности использования контрольно-измерительного оборудования, поставленного на Кураховскую ТЭС в рамках проекта "Повышение эффективности и надёжности энергетических и промышленных предприятий Украины".

За период с 1995г. по май 1997года на Кураховскую ТЭС поступило следующее оборудование:

анализатор процесса горения ENERAC 2000
инфракрасный термометр CYCLOPS 300AF/300
инфракрасный термометр MIKRON M90 B
инфракрасный термометр MIKRON M90 H
двухканальный портативный ультразвуковой расходомер жидкоси Trans Port PT868
анализатор электрических гармоник
стационарный кислородомер ZIRTEK
лабораторный калориметр
лабораторный анализатор содержания серы в топливе

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1.Газоанализатор ENERAC 2000 был получен Кураховской ТЭС и использовался в цехе наладки для определения вредных выбросов с дымовыми газами, для проверки штатных кислородомеров, для периодического контроля и наладки режима горения на котлах.

Решением главного инженера ГАЭК "Донбассэнерго" ENERAC 2000 передан в специализированную организацию "Донбассэнергоналадка" для обеспечения инструментальных замеров на всех пяти электростанциях, входящих в энергокомпанию "Донбассэнерго"

Экономический эффект от использования анализатора может быть оценен в сумму 25-30 тысяч долларов США в год.

2.Инфракрасный термометр Cyclops 300 AF/300 находится в эксплуатации в цехе наладки для контроля температуры труб поверхностей нагрева котлов, различных теплообменных аппаратов и трубопроводов. Широко используется для контроля локальных нагревов в контактных соединениях силового электротехнического оборудования станции

Прост, удобен и надежен в эксплуатации.

Экономический эффект от использования прибора на Кураховской ТЭС можно оценить в 12 - 15 тысяч долларов США.

3. Инфракрасные термометры MIKRON M90B M 90H, а также ультразвуковой расходомер жидкости передан для эксплуатации в цех наладки. В настоящее время приборы осваиваются персоналом Ожидаемый экономический эффект от их внедрения составит 20-22тысяч долларов США в год.

4. Стационарный кислородомер ZIRTEK находится в стадии монтажа на котле блок N 6.

Лабораторный калориметр и анализатор содержания серы в топливе передан в топливную лабораторию и осваивается персоналом

После освоения вышеперечисленного оборудования будет определена эффективность и информация предоставлена в агенство USAID в г. Киев.

5. Анализатор электрических гармоник.

Прибор постоянно используется в электротехнической лаборатории для диагностики коммутационного силового оборудования станции.

Экономический эффект может быть оценен на уровне 12000 долларов США

Подписи:

Зам.главного инженера- начальник ПТО	В.В.Бурлака
Начальник ЦТАИ	В.Ф. Головащенко
Начальник ЦН и Н	Е.Г Засорин
Начальник электроцеха	В.С. Ефремов
Начальник КТЦ	М.И Ченчиков
Представитель фирмы Burns and Roe Enterprises.Ins	Джордж Келлер

Approved
by Chief Engineer of Kurakhovo Heat Power Plant
A K Kharakhash
August 12, 1997

Town of Kurakhovo

Kurakhovo Heat Power Plant

PROTOCOL

Mr. V V Burlaka - Chief Engineer Deputy, Head of the Production and Technical Department, Mr Ye G. Zasorin - Head of the Adjustment and Measurements Workshop, Mr V F Golovashchenko - Head of the Heat Automation and Measurements Workshop, Mr V S Yefremov - Head of the Electric Workshop, Mr M I Chenchikov - Head of the Boiler and Heat Workshop, and Mr George Keller - the representative of *Burns & Roe Enterprises Inc* have drawn this statement on the efficiency of using the control and measurement equipment and instruments provided to Kurakhovo HPP within the frames of the project "Improvement of Efficiency and Reliability of the Energy and Industrial Enterprises in Ukraine"

Between February 1995 and May 1997 the following instruments were received at Kurakhovo HPP:

- an ENERAC 2000 combustion analyzer
- a Cyclops 300AF/300 infrared thermometer
- a MICRON M90 B infrared thermometer
- a MICRON M90 H infrared thermometer
- a TransPort PT868 two-channel portable ultrasonic liquid flow rate meter
- an electric power meter in A C circuits with the voltage up to 600 V
- an analyzer of the electric harmonics
- a ZIRTEC stationary oxygen meter
- a laboratory calorimeter
- a laboratory analyzer of the sulfur content in the fuel

1 ENERAC 2000 gas analyzer was received by Kurakhovo HPP and it was operated in the adjustment workshop to determine the unfavourable emissions with the stack gases, to verify the regular oxygen meters, to check periodically and adjust the combustion regime in the boilers.
According to the decision of the Chief Engineer of "Donbassenergo" State Association of the Energy Companies the ENERAC 2000 was transferred to the specializing organization "Donbassenergonaladka" to provide instrumental measurements at all the five power plants included into the energy company "Donbassenergo"

The economic effect of using ENERAC 2000 can be assessed as equal to $25,000 to $30,000 per year

1 Cyclops 300 AF/300 infrared thermometer is operated in the adjustment workshop and it is used to check temperatures of the boiler warmed surfaces, of the surfaces of different heat exchanging devices and pipelines The instrument is widely used to check the local warming of the contact connections of the high power electric equipment at the power plant
The instrument is suitable and simple as well as reliable in operation

The economic effect of using Cyclops 300AF/300 at Kurakhovo HPP can be assessed in $12,000 to $15,000.

3 MICRON M90 B and M90 H infrared thermometers as well as the ultrasonic liquid flow rate meter were transferred to be operated in the adjustment workshop At the present time the instruments are being mastered by the personnel The expected economic effect of their introduction will be $20,000 to $22,000 per year.

4 ZIRTEK stationary oxygen meter is being prepared for mounting it in the boiler of Unit 6.
The laboratory calorimeter and the sulfur content analyzer in the fuel were transferred to the fuel laboratory and they are being mastered by the personnel.
After mastering the above mentioned equipment by the personnel, the information concerning its efficiency will be determined and sent to Kyiv USAID Mission

5 The analyser of the electric harmonics
The instrument is permanently used in the electric laboratory for diagnostics of the commutation high-voltage equipment at the power plant
The economic effect can be estimated on the level of $12,000

Signatures·

Chief Engineer Deputy, Head of the Production and Technical Department	V.V. Burlaka
Head of the Heat Automation and Measurements Workshop	V F. Golovashchenko
Head of the Adjustment and Measurements Workshop	Ye G. Zasorin
Head of the Electric Workshop	V S. Yefremov
Head of the Boiler and Heat Department	M I.Chenchikov
Representative of *Burns & Roe Enterprises Inc*	George Keller