PN ACC-323
97223

BURNS AND ROE ENTERPRISES, INC.

Audit Report
UGLEGORSK POWER PLANT
UKRAINE

FINAL

August 1997

Submitted by:	**Burns and Roe Enterprises, Inc.**
Submitted to:	**U.S. Agency for International Development**
Contract No.:	**CCN-0002-Q-00-3154-00** **Energy Efficiency and Market Reform Project** **Delivery Order No. 6, Task 2** **Power Plants Combustion Efficiency**

W O 5906-02

Delivery Order No. 6
Energy Efficiency and Reliability - Ukraine
Task 2 - Power Plants Combustion Efficiency

Final Audit Report
Uglegorsk Power Plant

August, 1997

Prepared By G Keller, P E
Burns and Roe Enterprises, Inc
800 Kinderkamack Road
Oradell, NJ

Prepared for: U.S Agency for International Development
Washington, D.C 20523-1415

Burns and Roe Enterprises, Inc
1400 K Street, NW, Suite 1050, Washington, D C 20005
Telephone 202-408-6831 Facsimile 202-408-6835

b

COMBUSTION EFFICIENCY AUDIT REPORT
UKRAINIAN POWER PLANTS
UGLEGORSK POWER PLANT

TABLE OF CONTENTS

		PAGE
1 0	EXECUTIVE SUMMARY	1
1.1	Introduction	1
1.2	Principal Findings	1
1 3	Recommendations	2
1.4	Implementation	3
2.0	BACKGROUND	4
2 1	Objectives of Energy Saving Program	4
2 2	Purpose of the Audit	5
3 0	DESCRIPTION OF POWER PLANT	5
3.1	General Description	5
3 2	Boiler Plant	6
3 3	Coal Handling	6
3 4	Mazut Supply	6
3.5	Gas Supply	7
3 6	Boiler Efficiency Calculations	7
3 7	Process Control System	7
3 8	Environmental Issues	7
3 9	Future Plans	8
3 10	Inspection, Assessment, Comments	8
4.0	DESCRIPTION OF AUDIT ACTIVITIES	9
4 1	Specific Audit Activities	10
4 1 1	Scope and Methodology	10
4.1.2	General	11
4 1.3	Boiler Efficiency	11
4 1 4	Boiler Plant	12
4 1 5	Boiler Controls	13
4 1 6	Boiler Back End Including Stack	13

TABLE OF CONTENTS (CONTINUED)

4.2	General Audit Activities	13
	4 2 1 Scope and Methodology	13
	4.2 2 Power Plant Audits	13
5 0	FINDINGS AND RECOMMENDATIONS	14
5 1	Low-Cost, No-Cost Short Term Opportunities	14
5 2	Medium and Long-Term Opportunities	17
5 3	Replicating and Expanding the Program to Other Power Plants	18
6 0	IMPLEMENTATION	20

APPENDICES

Appendix A-1

Energy Conservation Opportunities (ECO's)

Appendix A-2

Vendor Information

Appendix B

Audit Records

Appendix C

Power Plant Data

Appendix D

List of Contacts During Plant Audits

Appendix E

Abbreviations and Units Conversions

Appendix F

Letters of Receipt for Equipment

Energy Audit Items Lists

Appendix G

References

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

Appendix H

Data Obtained during August 1997 Visit

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, 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 Uglegorsk Power Plant is presently 51% government owned The plant consists of four supercritical 300 MW units and three supercritical 800 MW units with a total of 3600 MW installed capacity. The plant was commissioned between 1972 and 1977 The coal supplied to the power station has poor quality, with caloric values of 3200 to 5000 kcal/kg and 31% ash content Typically, the plant fires coal alone, coal and mazut, coal and natural gas, or natural gas only Plans are in place for a major overhaul of all boilers and re-powering of the 800 MW units using Siemens 200 MW gas turbines However, the schedule for overhauls and re-powering is dependent upon availability of funds

1.2 Principal Findings

Several Energy Conservation Opportunities (ECO's) were identified for the Uglegorsk power plant for short term "no-cost low-cost" measures The "no-cost low-cost" measures include implementation of instruments for measuring excess air, liquid slag temperature, calorific value of the coal, and fuel consumption These measures would result in short payback periods

Combustion of high sulfur coal and mazut results in high SO_2 emissions The plant should try contracting directly from suppliers low sulfur coals and fuel oil Combustion of natural gas should also be increased as much as possible to reduce SO_2 emissions

1.3 Recommendations

Boiler efficiency can be improved, emissions reduced and the life expectancy of the Uglegorsk power plant extended based on the recommendations listed in the following Table. The Table summarizes several energy conservation opportunities with short pay back periods

An investment of $130,500 in boiler efficiency improvements (ECO-04,05,06,07) will result in an annual savings of $340,500, which corresponds to 2,100 tonnes of coal, 6,200 tonnes of natural gas and 11 tonnes 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 $968,000 which corresponds to 6,000 tonnes of coal, 17,600 tonnes of natural gas and 30 tonnes 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	$806,600	$25,000 Note 1	<1 year
02 *	Energy Conservation Training Program	$161,300	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	$179,250	$29,000	1 9 Mo
05 *	Portable Infrared Video Monitors (Bottom Ash)	Included with ECO-04	$4,600	Included with ECO-04
06 *	Calorimeter and Sulfur Laboratory Analyzer	$161,300	$40,000	3 Mo.
07 *	Coal Flow Meters - One Boiler Portable Liquid Flow Meter	Included with ECO-04	$46,500 $10,400	Included with ECO-04

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

1.4 Implementation

The plant is presently in a 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 two 300 MW units (out of 7) are operating at 60 - 70% MCR Three supercritical 800 MW units do not run at all due to lack of natural gas At this time the plant is somewhat 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 months and the management considering 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 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 paybacks

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

3.0 DESCRIPTION OF POWER PLANT

3.1 General Description

The Uglegorsk station was constructed in two phases The first phase was commissioned between December 1972 and December 1973 The second phase was commissioned between December 1975 and December 1977. Phase one consisted of 4×300 MW boilers Phase two consisted of 3×800 MW boilers In December 1977 the construction of all 7 units with a total output of 3,600 MW was completed.

ENERGO SYSTEM·	DONBASSENERGO
LOCATION.	50 KM NORTH-EAST OF DONETSK
INSTALLED CAPACITY:	3600 MW 4 × 300 MW + 3 × 800 MW
COMMISSIONED	4 × 300 MW 1972-1973 (FIRST PHASE) 3 × 800 MW 1975-1977 (SECOND PHASE)
FUEL TYPE	4 × 300 MW, COAL, GAS, MAZUT, COAL & GAS OR COAL & MAZUT 3 × 800 MW, GAS, MAZUT OR GAS & MAZUT

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

3.2 Boiler Plant

The Uglegorsk station was constructed in two phases Phase one consists of 4×300 MW boilers (TPP-312A) manufactured by Taganrog producing steam at 1000 tonnes/hr at 255 bar gauge and 545°C live steam conditions Generators and turbines were produced in Kharkov The boilers burn only coal dust, only natural gas, only mazut, coal dust and natural gas or coal dust and mazut Phase two consists of 3×800 MW boilers (TGMP-204) manufactured in Taganrog producing steam at 2680 tonnes/hr at 255 bar gauge and 545°F live steam conditions Generators and turbines were produced in Leningrad The boiler is of the suspended type with balanced draft combustion by design but currently operates as a pressurized furnace with FD fans only in operation. The ID fans were removed. The boilers burn only mazut, only natural gas or mazut and natural gas

3.3 Coal Handling

There are two conveyors (one operating, one standby), feeding type TPP-312A (300 MW) boilers for units 1,2,3 and 4 . The total weight of coal going to all four boilers is measured continuously on either one of the conveyors The coal delivered to the plant does not match original 300 MW boiler design requirements, thus reducing boiler efficiency and increasing maintenance

The 300 MW boiler (TPP-312A) has eight burners and 2 coal dust systems for each boiler There are 16 coal dust feeders Each coal dust feeder has its own pipeline, and each burner is fed from two pipelines Each pipeline has its own venturi to measure flow The amount of coal dust is a function of feeder speed which is monitored continuously via motor amperage The operator can adjust speed of feeder manually or automatically Typically 10 tonnes/hr are fed through each feeder with a normal range from 9-11 tonne/hr

Coal is supplied to the station by approximately 30 suppliers Volatility content of coal is not measured because it doesn't affect the price of coal and is taken from suppliers certificates. Average coal volatility is 35 to 45%. Coal samples are taken once per shift and then taken for five days Coal analysis is done by the station once every five days on blended samples taken for five days Coal in storage yard is blended to try to get consistent quality of coal to all boilers

3.4 Mazut Supply

Mazut is delivered in railroad tank cars Mazut samples are taken once per shift The samples are analyzed once every 30 days and then compared to the certificate.

The mazut flow measurements are available for each boiler. The flow meters are not accurate for the first 30% of the scale Uglegorsk units never operate on mazut alone due to its high cost and high SO_2 emissions.

3.5 Gas Supply

The natural gas flow is measured at each boiler The flow meters are not accurate for the first 30% of the scale.

Heating value analysis of natural gas is done once a week Heating value analysis is done immediately if consumption is increasing because of the worsening quality of natural gas

3.6 Boiler Efficiency Calculations

The methodology for the boiler efficiency calculation is shown in Attachments 13, 14, 15 and 16 of the Preliminary Audit Report (Appendix G) The calculations are done on a per unit basis The mazut and natural gas fuel quantities are measured per boiler The coal fuel quantities per boiler are extrapolated from power station data The calculation of efficiency is done once a month and the average fuel data are used for natural gas, mazut and coal These efficiencies are compared to the efficiencies calculated based upon the boiler design performance Attachment 11 of the Preliminary Audit Report (Appendix G) shows the metric tons of standard fuel (i e., 7,000 kcal/kg heating value) fired in 1993

3.7 Process Control System

Boilers of the Uglegorsk power plant operate in a steady-state mode (base load) with a turbine maintaining throttle pressure Operator manually adjusts firing rate and air flow (fixed settings for each load) and allows frequency to float.

Load is changed by manually varying the fuel flow to the boilers Basically, the combustion control scheme for coal firing is a manual operation All units have two CO analyzers per unit located after the economizer All units have two O_2 analyzers located after the economizer In addition, Unit 7 has two additional O_2 analyzers located in a higher temperature area of the convection pass 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

The station would like to locate the new O_2 analyzers in a higher temperature area of the convection pass

3.8 Environmental Issues

The four 300 MW units are provided with Electrostatic Precipitators (ESP), which are reported operating unsatisfactorily. The 800 MW are not furnished with Electrostatic Precipitators (ESP)

The station uses low NO_x burners and staged combustion to effectively reduce NO_x emissions Combustion of high sulfur coal and mazut results in high SO_2 emissions which are of great concern to the plant and the authorities The plant has to pay fines for high 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 Uglegorsk power plant is aware of the condition of its boilers High leakage rates are inherent in the boiler technology used for the Uglegorsk power plant and cannot be remedied at a reasonable cost Management also understand that major repowering is the best option Management is attracted to a number of advanced technologies, including an application of Siemens 200 MW gas turbines, 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 Uglegorsk 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 burn gas, reduce excess air whenever possible and maintain the existing facilities

3.10 Inspection, Assessment, Comments

- The power station is clean, well maintained and appeared to be well run and managed The staff is competent and experienced and fully cooperated in providing the requested information and assigning the hands-on audit training personnel This station is relatively new with the phase one commissioned 1972-1973 and the phase two 1975-1977.

- The major equipment such as boilers, turbines and generators are reported to be in good shape.

- Plans are in place to continue work of replacing heating surfaces of all boilers and to address the major problem of final stage blading erosion on both 300 MW and 800 MW turbines. At this time, due to 800 MW boiler heating surface deterioration, each unit is derated by 50 MW to a nominal rating of 750 MW

- The 800 MW boilers operate as a pressurized furnace with FD fans only in operation The ID fans and Electrostatic Precipitator (ESP) are not included in the design, therefore the gases are exhausted directly into the chimney There are high gas leakages, vanadium corrosion and high atmospheric emissions

- The plant operates continuously on base load mode, with maximum MW output during the day starting at 7 AM, and at night and weekends reduced to MW output required by central dispatch center

- The economic operation of the 300 MW boiler depends on operation with liquid slag. When high ash content coal is fired, the rate of producing the liquid slag in the bottom of the boiler is higher than the collection rate of the slag from the boiler hopper. The boiler decreases its capacity to 60% and has to be shutdown in order to manually remove the slag from its bottom Thus the boiler has to be stopped and started again after slag removal. The boiler does not have any instrumentation to monitor slag formation, its level and temperature that must be maintained at less than 1280°C.

- Most of the process control systems operate on "manual" mode from the control board located in the Unit Control Room However, the temperature and pressure of the main steam at the boiler outlet are automatically controlled Some new instrumentation including vibration monitoring equipment have been provided on 800 MW units. The boilers have no burner management systems

- The coal is supplied by 30 suppliers The station has little input regarding the quality of the coal specified or control over fuel acquisitions Both coal and oil have very high levels of sulphur content, but the station does not have any provisions for SO_2 reduction equipment.

- The coal delivered to the plant does not match original 300 MW boiler design requirements, thus reducing boiler efficiency and increasing maintenance In addition the poor quality of coal increases the air pollution and causes severe problems of boiler slagging and reduction of MW output to 240-250 MW Mazut or gas has to be cofired to deliver maximum 300 MW output if required by the central dispatch center.

- The efficiency calculations are performed on a per unit basis The mazut and natural gas fuel quantities are measured per boiler The coal fuel quantities per boiler are extrapolated from power station data These efficiencies are compared to the efficiency calculated based upon the boiler design performance recalculated in 1981

- The power station will like to have coal flow meters to measure the input at each mill, a total of two devices per 300 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 Uglegorsk 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 Uglegorsk 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 on how to use the equipment

4 1.2 General

The Uglegorsk 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 Uglegorsk Power Plant.

Management of the Uglegorsk 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 Uglegorsk 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. Measurements were made on two boilers, Boiler #3 and Boiler #7, at maximum and minimum loads, on coal and natural gas.

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 economizer 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 twenty 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 Uglegorsk power plant must come primarily from an improvement in boiler efficiency On the steam side the Uglegorsk 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 Using the ENERAC 2000 portable combustion analyzer, BRC measured about 6.1 % excess furnace oxygen in the convection pass which translates into 5% excess oxygen at the burner level while firing coal. CO emissions were negligible during the test.

In Burns and Roe's judgement the excess oxygen at the burner level can be reduced to 3 5% for a 1.5% O_2 reduction while firing coal. This translates into an incremental improvement in boiler efficiency of 0 5%

In the future, the Uglegorsk power plant operators should be able to manually adjust the 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 emitted due to an inconsistent quality of the coal Sulfur dioxide emissions were exceeding mgm scale of the instrument (4,000 mgm) As a result it was necessary to switch to ppm scale which is about 2.86 times higher Sulfur dioxide emissions were in 5000 to 6000 mgm range

Combustion of poor quality coal resulted in furnace "puffs" and very rapid corrosion of the back end Since four 300 MW boilers of the Uglegorsk power plant 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 Uglegorsk power plant reported 5% in-leakage in the furnace, about 50% in-leakage overall 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 Uglegorsk power plant can no longer afford such overhauls.

Boilers of the Uglegorsk power plant operate very well on natural gas. Emissions are low, boilers run better than on coal and, in the plant's opinion, will last longer It is also more economical to burn the gas at the present mix of fuel prices

4.1 5 Boiler Controls

The combustion control is actually a manual operation Load is changed by manually varying the fuel flow to the boilers 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 or natural gas 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%

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 300 MW 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 Uglegorsk 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 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 Uglegorsk power plant consumed the following quantities of standard fuel (7,000 Kcal per kg)

Coal:	999,464 tonnes	$51,272,500
Gas:	2,930,600 tonnes	$109,721,700
Mazut.	5,232 tonnes	$328,600
		$161,322,800(*)

(*)Price calculation is using 1995 cost of fuel

If only a modest saving of about 0 5 percent of this fuel expenditure is saved in the first year, $806,600 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 Uglegorsk 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 $161,300!

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

However, a consideration has to be given to switch to burn natural gas for the entire power plant. This will improve combustion efficiency, reduce emissions and extend life expectancy of the Uglegorsk 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 Uglegorsk Power Plant

It is recommended to install the new instruments on 300 MW Boiler #3 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 CALORIMETER AND SULFUR LABORATORY ANALYZER

An accurate Calorimeter and Sulfur laboratory analyzer should be provided to verify calorific value and the Sulfur content of the received coals versus the coal specified. This 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 coal flow to each boiler Natural gas flow meters already exist per each boiler and work well The mazut flow measurements are available for each boiler and are accurate above 30% of the scale 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 300 MW Boiler #3, 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 It is very accurate at low flows 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 combustion air and fuel flows to meet the load demand will result in stable and efficient combustion
- Investigation of lower cost SO_2/NO_x removal technologies For SO_2 removal consider use of coal and coal by-product blending or lower cost sorbent

technologies for flue gas conditioning In addition, because of the high sulfur content of mazut, an oil treatment plant should be considered as a method for reducing SO_2 emissions

For NO_x removal consider use of a burner design technology optimized for low NO_x emissions (low cost) or SNCR (selective non-catalytic reduction) or 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's or refurbish to meet the world standards.

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

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

- Provide additional and updated analytical equipment to the chemical laboratory

- 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 (50% and higher) are typical, which make readings of any oxygen analyzer dependent on its location (distance from the furnace) Because of in-leakages it is not feasible to make an 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 0.2% 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 difficult to reduce the excess oxygen by 1 to 1.25% and achieve 0 5% 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 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 10% 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 months and the management is considering 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 $45,000 to $50,000 per year in benefits (contract labor savings, avoided environmental fines, and improvement in efficiency) due to use of a modern portable combustion analyzer (see the Protocol).

The plant personnel were unwilling to quantify savings in tons of environmental pollutants 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 heat leaks, the generator stator, disconnect switches, and boiler tubes The Protocol states $69,000 per year in benefits

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 1,250 per year is claimed in the Protocol

ZIRTEK OXYGEN ANALYZERS

ZIRTEK oxygen analyzers were available to the plant at most about 2 months They worked reliably for about a month Presently the generating unit is off line The plant expects an economic benefit of $30,000 per year from the analyzers if used for manual control If the analyzers are utilized for an automatic oxygen trim control, the savings are estimeted at $60,000 per year

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. The plant have declined to estimate an economic benefit from this instrument until it gains more experience

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 already using the thermometer for bottom ash temperature measurements The plant have declined to estimate an economic benefit from this instrument until it gains more experience

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 calorimeter and a sulfur analyzer at $161,300 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 combined economic benefit will be about $80,000 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 boilers air to fuel ratio 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 has 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 Uglegorsk units, however only unit #3 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. Normal coal burner design calls for an excess oxygen level at the burners of 3 5% Since the burners at this plant are replaced on a regular basis, it is expected that an excess air level of 3.5% is achievable These are the minimum levels required for stable flames and proper combustion Excess air 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 about 6 1% for the normal operating condition, during tests 5 and 6 The air in-leakage in the boiler walls from the measured point to the burners would be 8 0% Using the curve to convert the measured excess oxygen to the excess oxygen at the burners indicates 5 0% excess oxygen at the burners

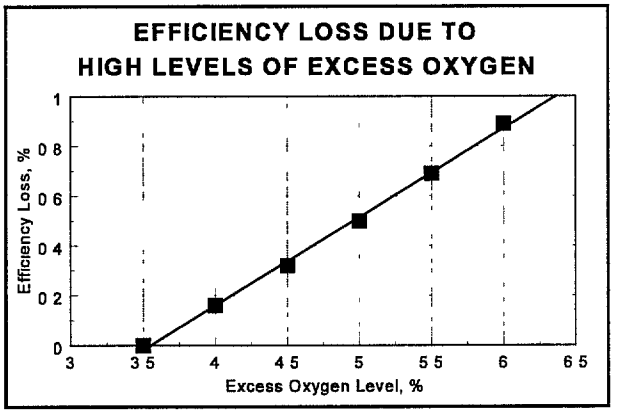
Accounting for the existing burner design and routine burner replacement, the minimum excess oxygen at the burners would be assumed to be approximately 3 5% Thus, the potential reduction in excess oxygen at the burners would be 5 0 - 3 5 = 1.5%

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 air reduction possible at the burners is approximately 1 5% while firing coal. This would reduce the excess oxygen from 5% to 3 5%. Using the curve shown above, the boiler efficiency saving would be 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 fuel fired in 1994 for Unit #3 was 698,320 metric tons of reference fuel (7000 Kcal/Kg coal) or 977,648 tons of 5000 Kcal/kg coal

The prevailing price of Ukrainian coal in January 1995 was 5,500,000 coupons per metric ton of

5000 Kcal/kg coal, which is $36 67 U.S. at 150,000 coupon per $ exchange rate The total cost of fuel per year for Unit #3 would be 977,648 × $36.67 = $35,850,352 or ≈ $35,850,000

BRC calculates total annual savings for Unit No. 3 to be

$35,850,000 × 0.5% = $179,250

NOTE. $36.67 per ton of 5000 Kcal/Kg coal is equal to or above the current world price of coal on per BTU basis

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 will be shared among seven boilers, therefore only 1/7 of its price is included in per boiler payback calculations An infrared bottom ash temperature detector will be shared among four boilers, therefore only 1/4 of its price 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 − 4 = $1000 (portable infrared bottom ash temperature detector) = $67,300 We will assume cost of installation and commissioning to be $10,850, 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 $78,150 per boiler

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

  $78,150/$179,250 = 0 436 yr = 5.23 months

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

  ($4000+$25,000)/$179,250 = 0.16 yr = 1.9 months

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

- <u>Payback at current price for an infrared bottom ash temperature detector and the oxygen analyzer system</u>

  ($1150+$29,000)/$179,250=0.168 yr = 2 months

- <u>Payback at current price for coal flowmeters, a portable mazut meter and the</u>

26

oxygen analyzer system·

($1,500+$46,500+$29,000)/$179,250 = 0 429 yr = 5 15 months

ECO-06 - CALCULATION

CALORIMETER AND SULFUR LABORATORY ANALYZER

1 0 INTRODUCTION

A modern Calorimeter and Sulfur Laboratory Analyzer will allow Uglegorsk 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 Uglegorsk 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. If the plant will 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 $161,322,800 as total annual cost of fuel for Uglegorsk Power Plant, the total savings in fuel cost would be **$161,323**.

Payback at current price

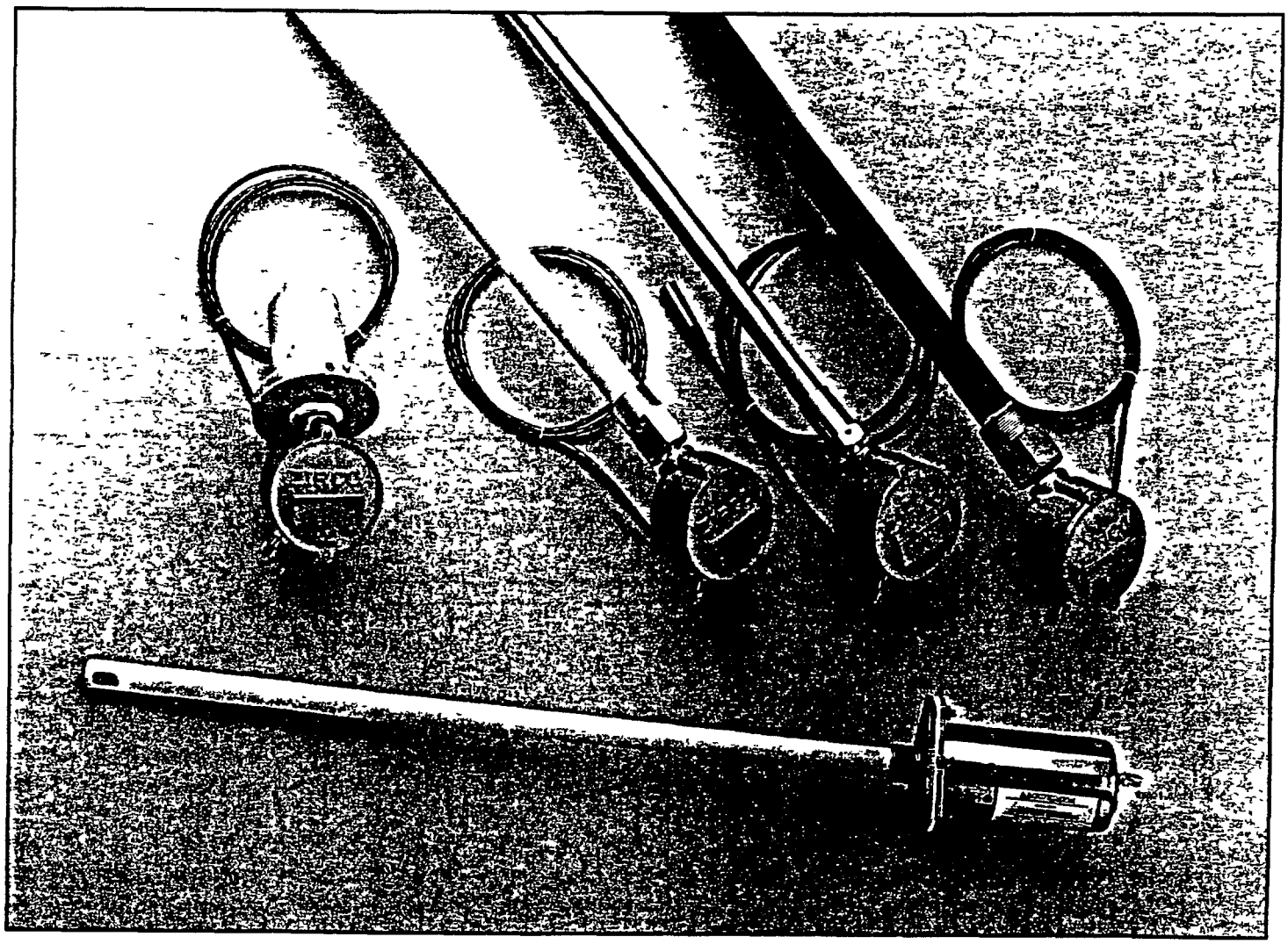
$40,000/$161,323 ≈ 0 25 yr ≈ 3 months

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

Reprinted from May 1991 issue of POWER.

Copyright 1991, McGraw-Hill, Inc. All rights reserved.

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

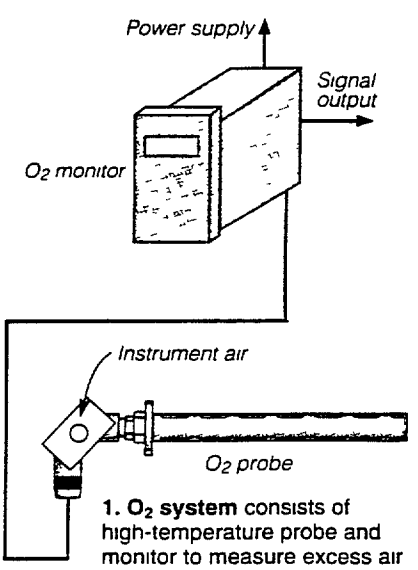
- Low maintenance requirements
- Continuous operation in the furnace section of the boiler.
- Improved probe life, with a one-year minimum desired.

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



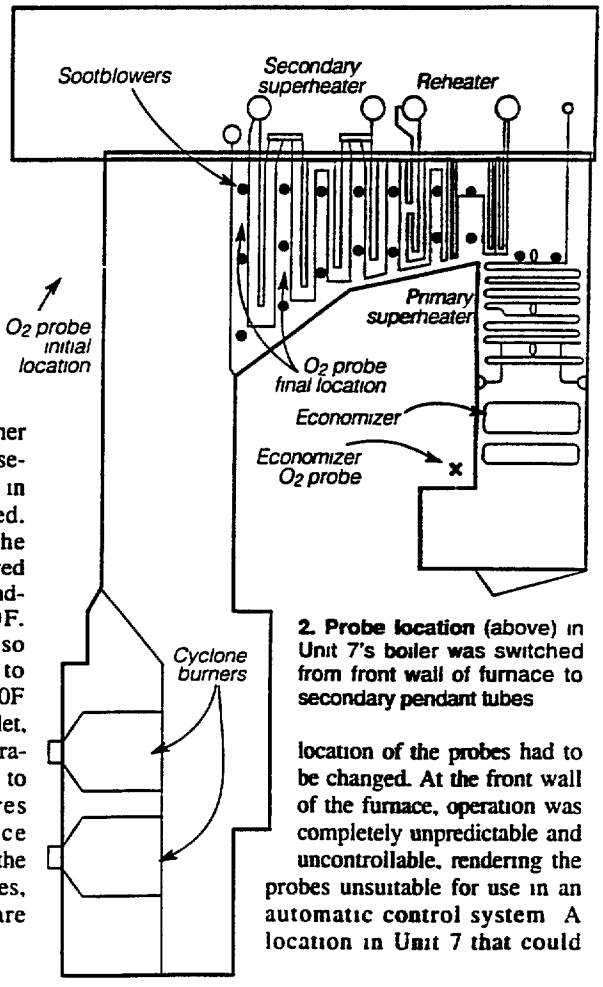
1. O_2 system consists of high-temperature probe and monitor to measure excess air

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

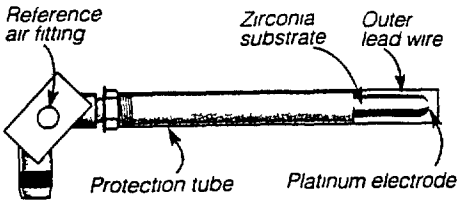
The next step was to install a probe with a stainless steel protection tube (Fig 3), instead of the standard silicon carbide tube, to see if it could better withstand the extreme conditions in the furnace. After only three days of operation, this probe failed—an excessive amount of slag had accumulated 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**

HI-TEMP CARBON AND OXYGEN SENSORS, ELECTRONICS AND ACCESSORIES.

- Simple, Cost Effective Technology
- Integral Thermocouples
- 1600°C (2900°F)
- Industry-Specific Models Available
- Matched Accessories

AACC/Zircoa™

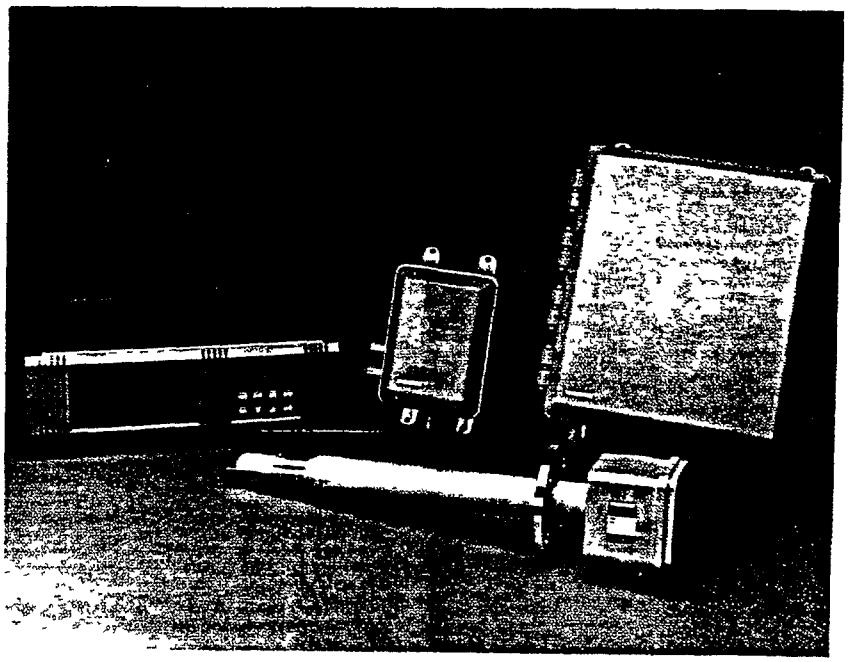
31711 Solon Rd., Solon OH 44139 Tel:(216)349-7220
FAX:(216)248-8864

WORLD CLASS 3000

OXYGEN ANALYZER WITH CONTROL ROOM ELECTRONICS

FEATURES

- *Totally Field Repairable Probe*
- *Patented Electronic Cell Protection*
- *Rugged 316 SS for all Wetted Parts*
- *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.

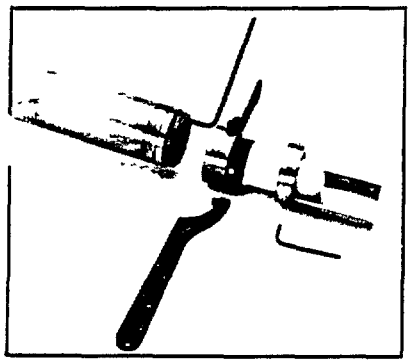
The CRE 3000 Control Room Electronics module allows interfacing with up to eight World Class 3000 probes (16 with master/slave) via the HPS 3000 Field Interface Module This flexible, easily expanded, electronics arrangement allows the World Class 3000 probes to be linked to the Control Room Electronics 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.

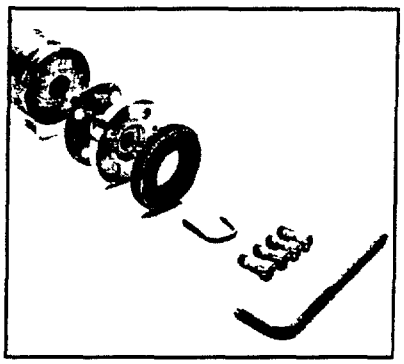
The HPS 3000 Field Interface Module provides local power to the oxygen probe. It is connected to the CRE 3000 at a distance of up to 1200 feet with low cost signal cable. The HPS 3000 module is housed in a standard NEMA 4X (IP65) enclosure for full weather and corrosion-proof protection. It is also available 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.

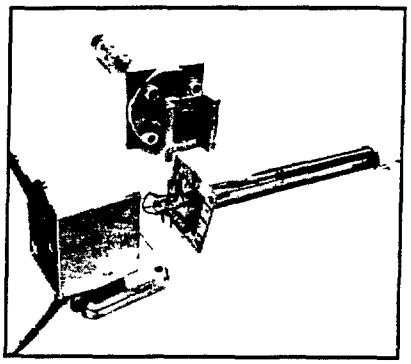
Supersedes Product Data 106-300NC,
Pages 1-8, dated March, 1992



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

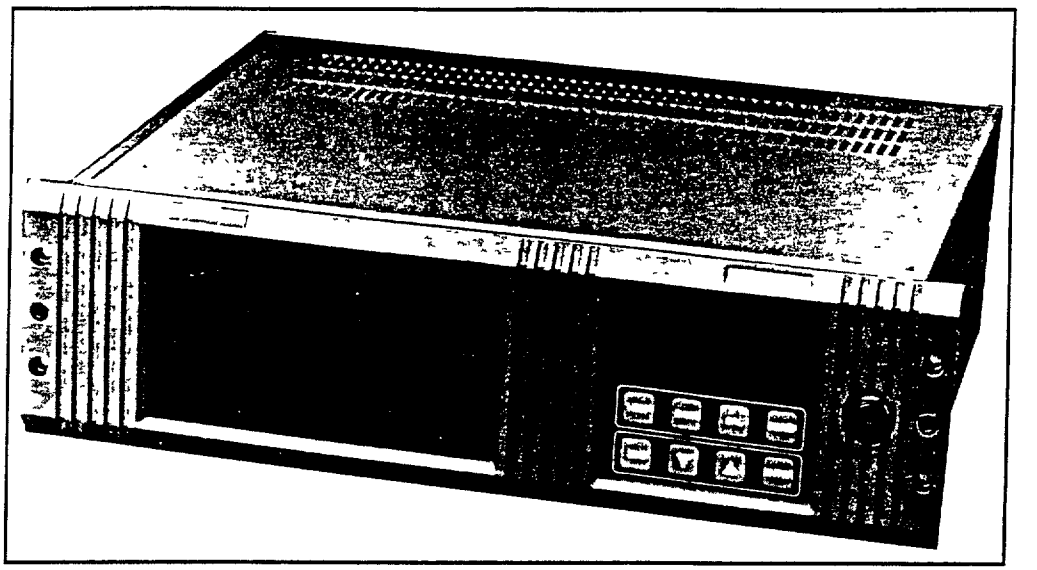
ADDITIONAL FEATURES

- 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

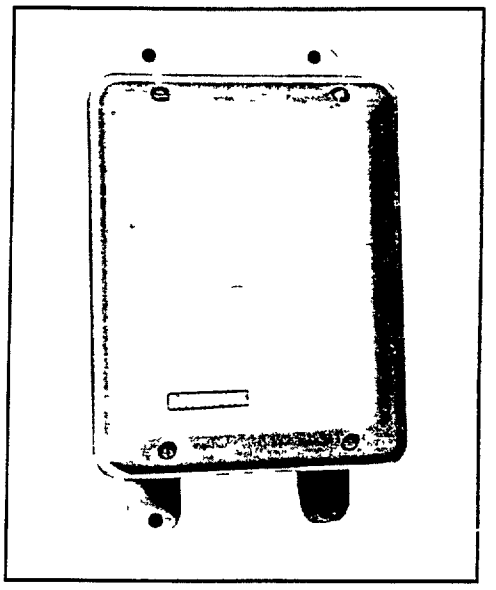
DIGITAL ELECTRONICS FEATURES

- 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

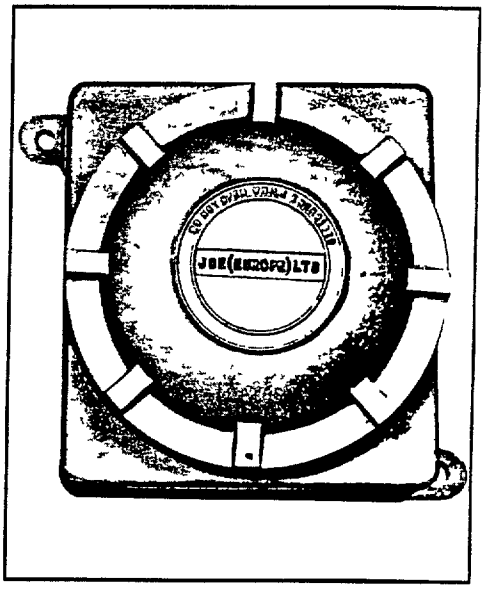
WORLD CLASS FAMILY OF ELECTRONICS



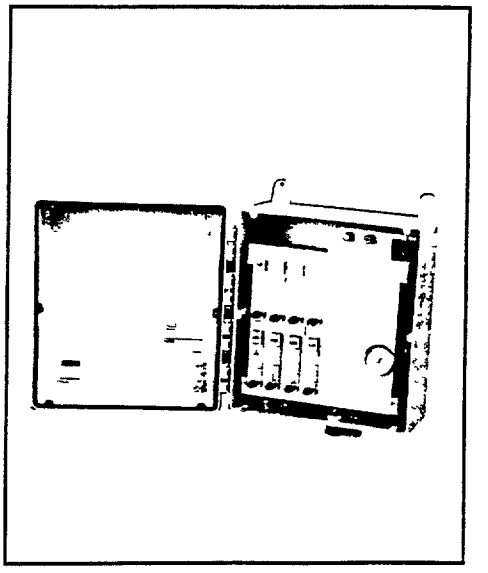
CRE 3000 Control Room Electronics Module



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

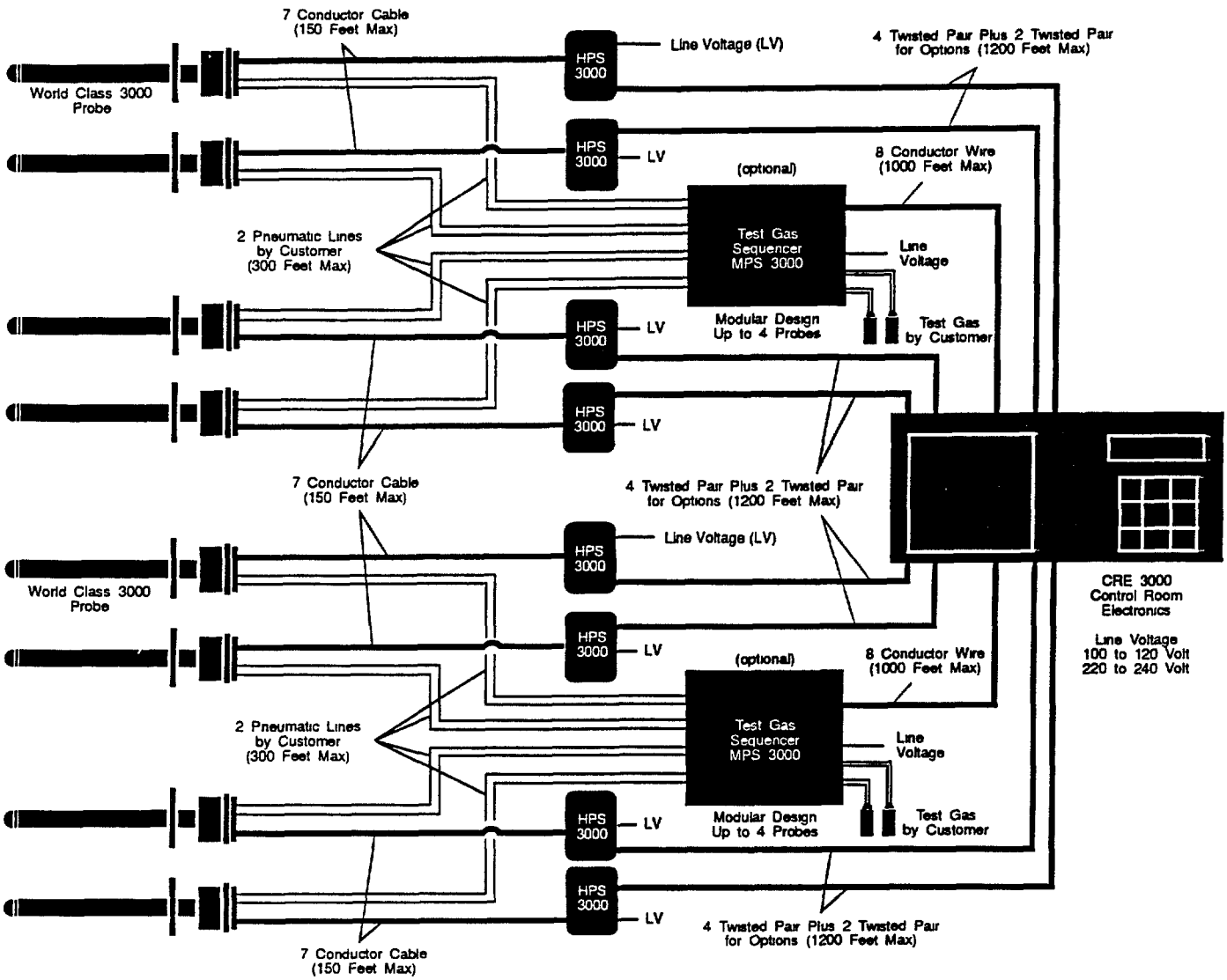
Electrical classification: NEMA 4X (IP65) Optional - Class 1, Division 1, Group B
Humidity range: 95% Relative Humidity
Ambient temperature range -20 to 140°F (-30 to 60°C)
Vibration: 5 m/sec², 10 to 500 xyz plane
External electrical noise: Minimum Interference
Cabling distance between HPS 3000 and probe: 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

WORLD CLASS 3000 MULTIPROBE APPLICATION WITH CONTROL ROOM ELECTRONICS



Recycled Paper

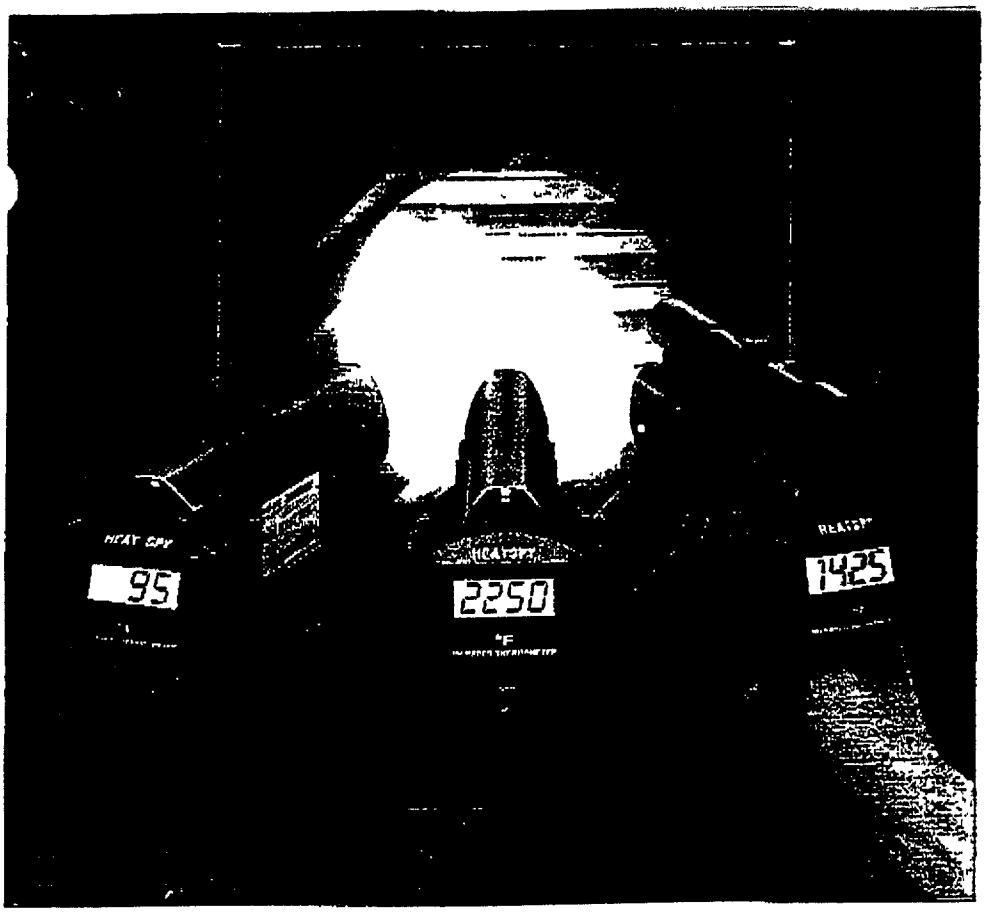
Printed in the USA
Rosemount Analytical Inc 1993

Rosemount Analytical Inc
120 North Main Street
P.O. Box 1

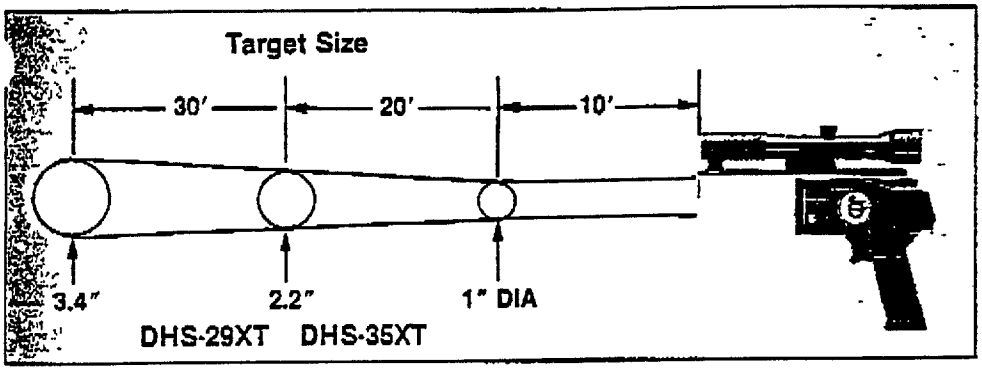
ROSEMOUNT®

Measurement
Control
Analytical
Devices

36



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



Heat Spy®

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

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

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

DHS-29X measures through glass ports
900 to 3200°F, 482 to 1760°C

Measure through glass, flames and products of combustion using the DHS-29X (2 1 - 2.5 microns) Its small target resolution and long telescopic range make the DHS-29X ideal for aiming through ports in furnace walls at refractories, glass gobs, furnace tubes, ceramics, billets, slag and annealing materials. A sapphire window protects the silicon optics from heat and contamination.

3-Year Warranty

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

DHS-35XT measures furnace tubes
800 to 3200°F, 426 to 1760°C

In the narrow spectral range of 3.5 - 4 1 microns, the DHS-35XT minimizes errors caused by reflectance from walls and flames. That makes it excellent for measuring furnace tube temperatures through open ports. It is also your best choice for high temperature general purpose applications

3-Year Warranty

DHS-35XT	Telescopic Sight

Use Laser for Tough Aiming Situations

- Available on most of our popular models: DHS-24L. -24XL. -26L. -26XL. -28XL
- Add the laser aiming option for:
  - Precise centering on target
  - Night and low-light conditions
  - Measuring in cramped and awkward areas
- Meets U.S. Federal Safety Regulations:
  - CRF 1040.10 Class II: Certified less than 1.0mW power
  - Optional CFR 1040 10 Class III-A: Certified less than 5.0mW max. power
  - Separate laser switch and indicating light
  - Laser is on only when reading temperature

How Laser Aiming Works to Your Advantage

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

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

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

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

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

RECEIVES 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.

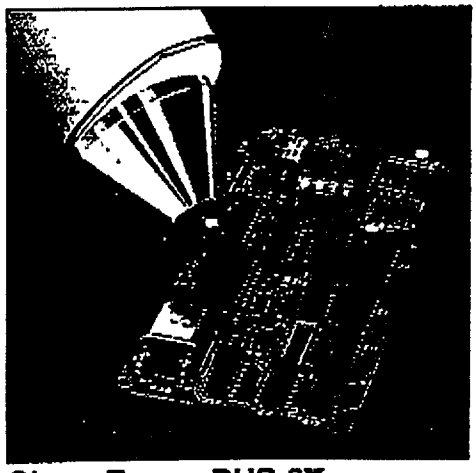
FM Approved models are dedicated °F or °C and are furnished without a connection for AC adapter, external battery pack or recorder output.

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

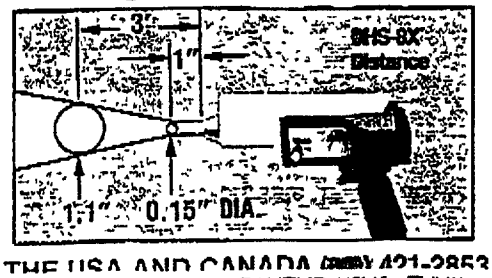
Price includes carrying case, spare battery, owners manual and trigger lock



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

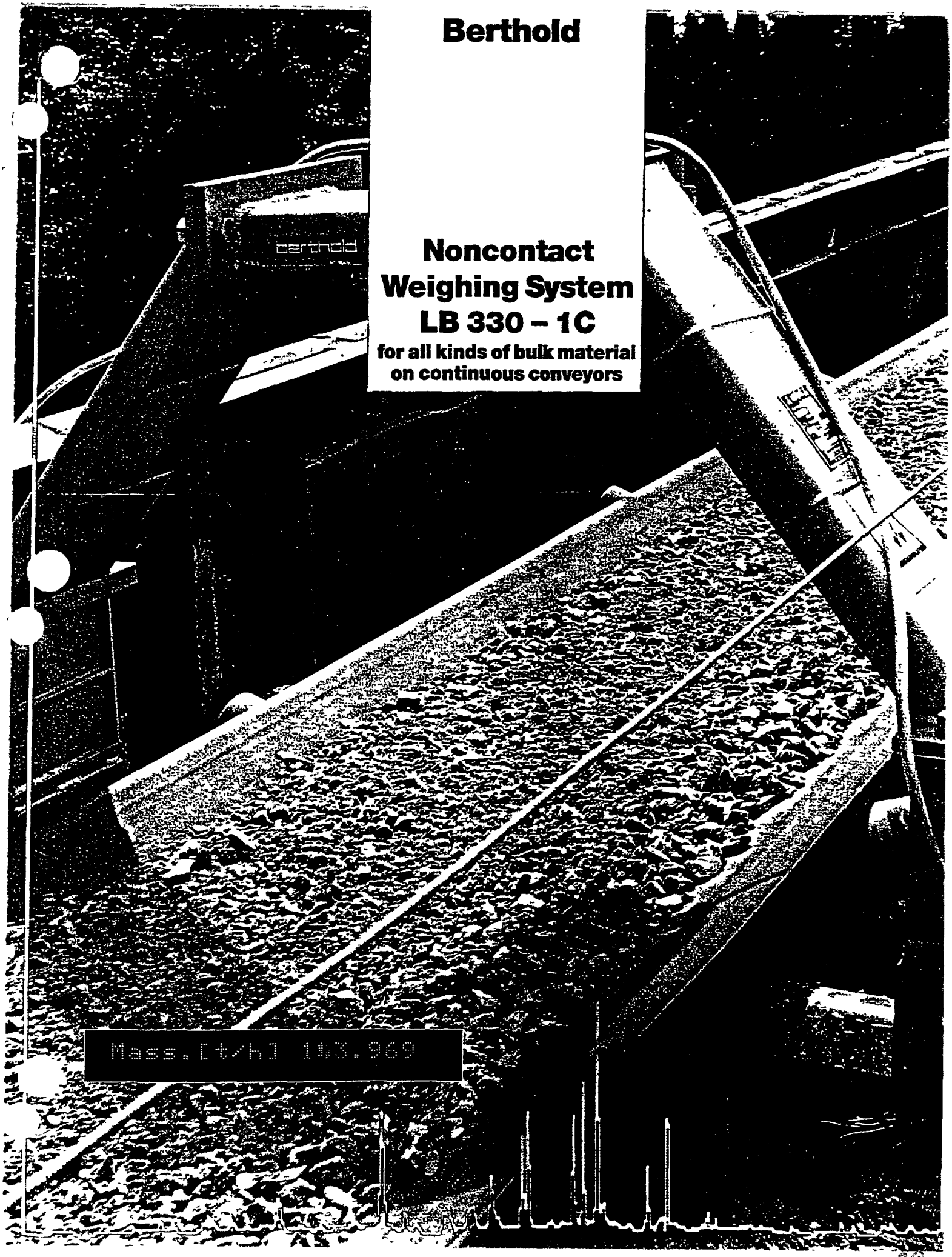
Part No.	Description
11441-1	Spare AC Adapter, 110VAC
11441-2	Spare AC Adapter, 220VAC
9852	Spare Trigger Lock
9990	Heat Spy Carrying Case
B-11	Bench Stand
CRM	Calibration/Repair Manual Specify Model/Serial No.
EP-10	Emissivity Coating Black Spray Paint
H7D	Leather Holster (except for models with telescopic 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.

Berthold

Noncontact Weighing System LB 330 – 1C

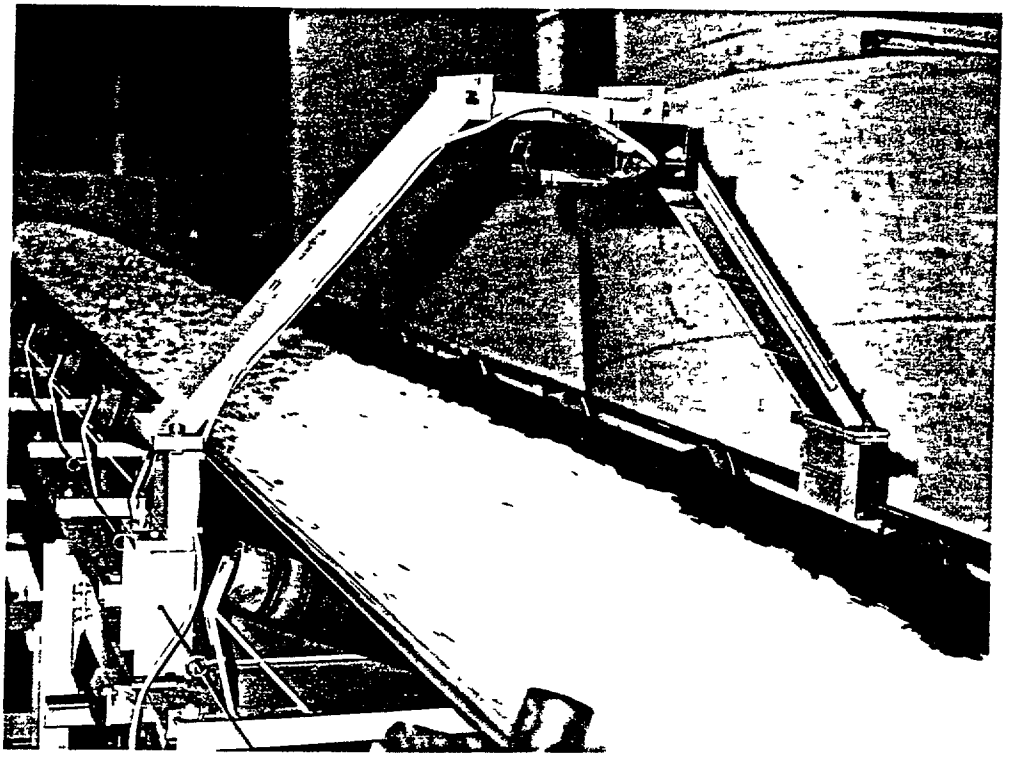
for all kinds of bulk material on continuous conveyors



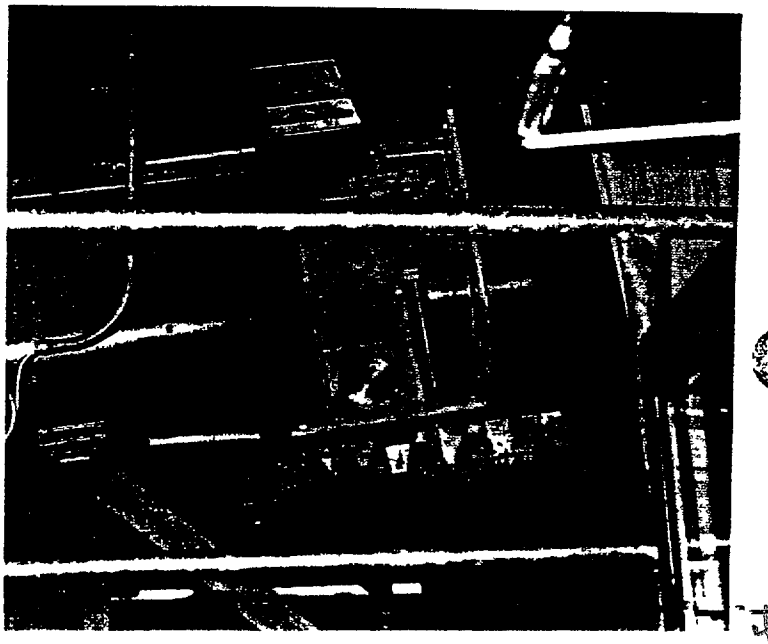
Noncontact massflow meter

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 – 1 C installed on a rising conveyor belt



and on a screw conveyor

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

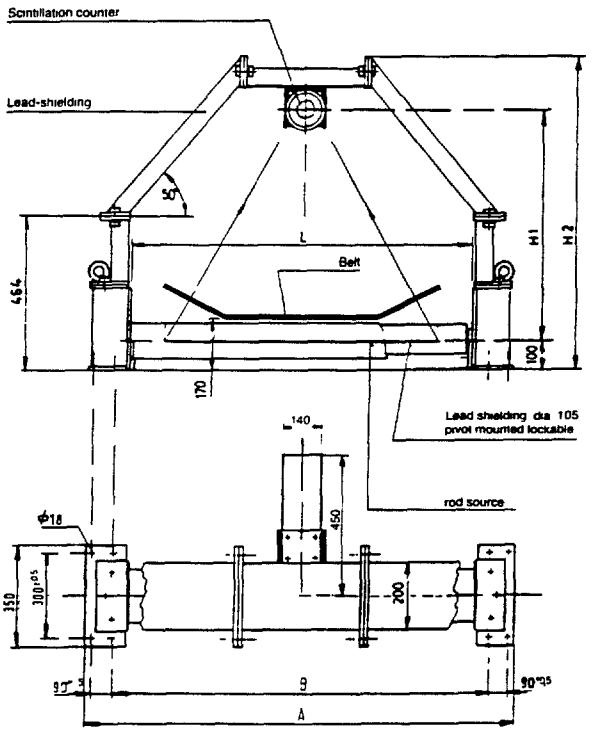
The type of gamma source used depends on the material loading With high belt loading ^{60}Co is used (half-life 5.3 years), with medium loading ^{137}Cs (half-life 30 years) and with low loading ^{241}Am rod sources (half-life 433 years)

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

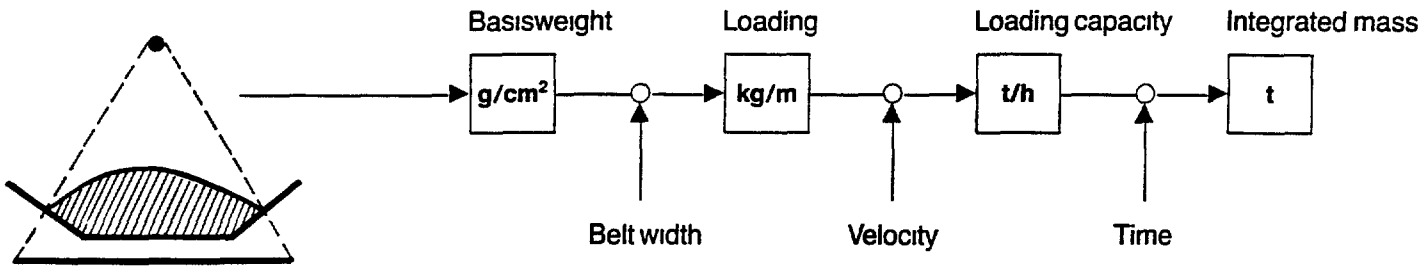


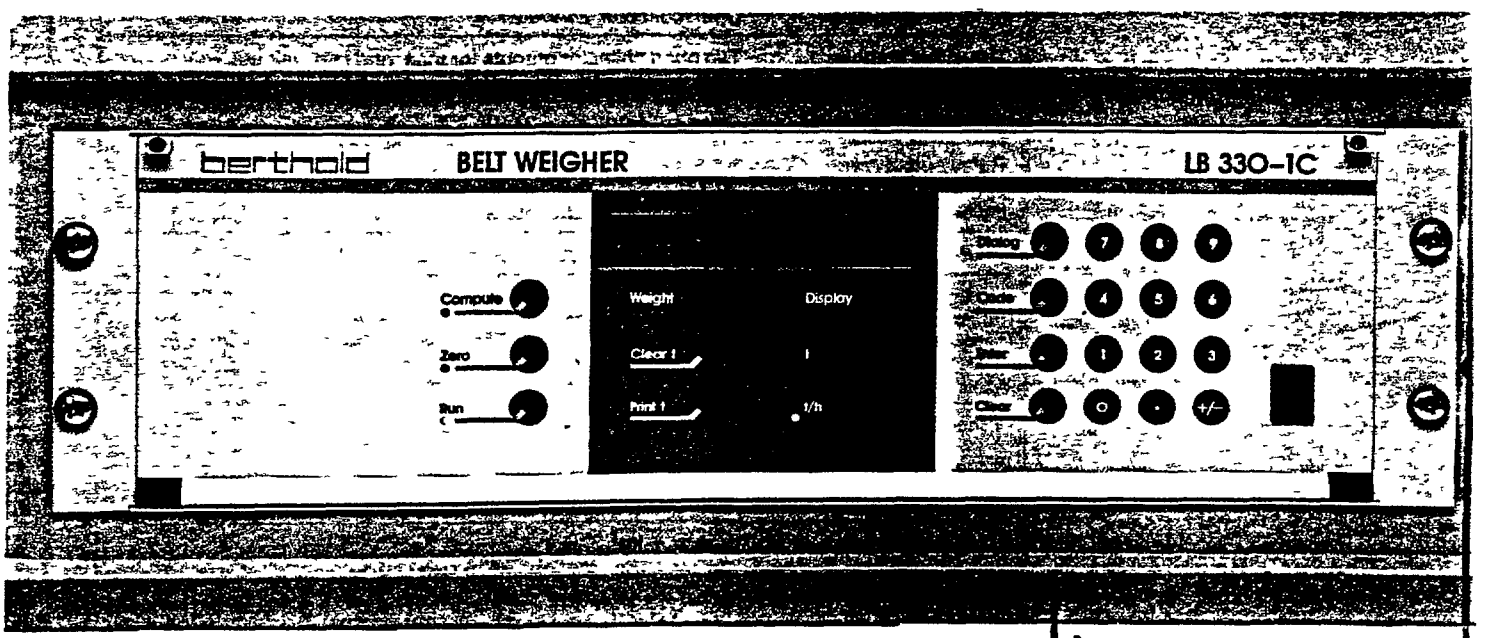
Width mm	A	B	H1	H2	L	Weight of Measuring frame approx. kg
500	1006	776	494	754	706	190
650	1156	926	584	844	856	220
800	1306	1076	674	934	1006	250
1000	1506	1276	794	1054	1206	290
1200	1706	1476	914	1174	1406	330
1400	1906	1676	1034	1294	1606	370
1600	2106	1876	1034	1294	1806	420

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



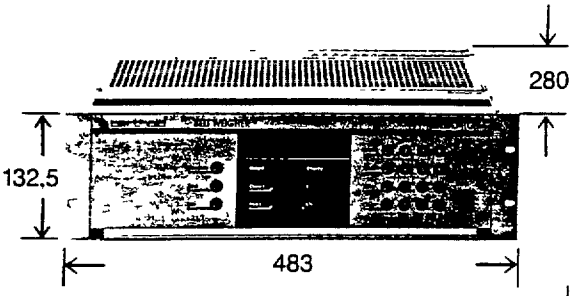


Evaluation unit installed in protection housing

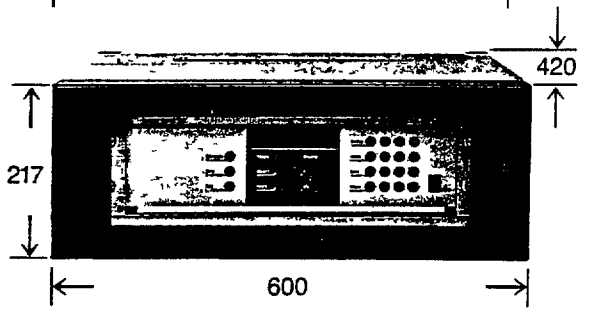
Dimensional Drawings

Dimensions in mm

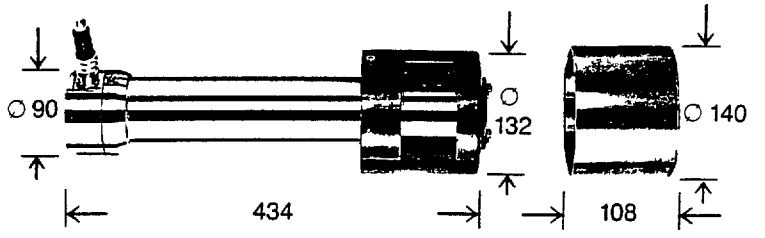
Evaluation unit
Weight approx 6 kg



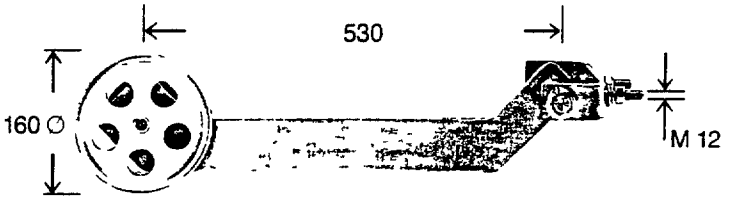
Evaluation unit in protection housing
Weight approx 18 kg



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

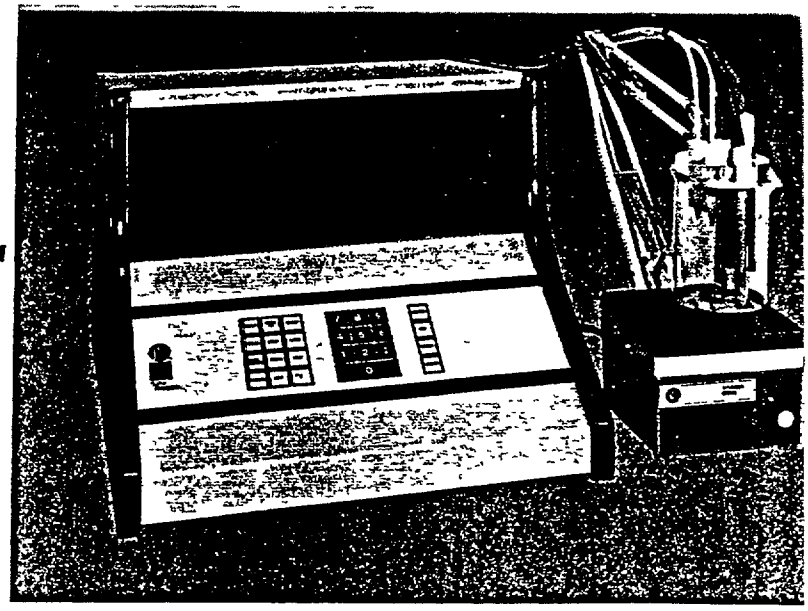


Your inquiries should include the following details:

- 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)

BERTHOLD SYSTEMS INC., 101 CORPORATION DRIVE, ALIQUIPPA, PA 15001-4863, PHONE 412-378-1900 • FAX 412-378-1926

The 1760 Sulfur Analyzer



An automatic titrimetric system for rapid sulfur determinations following combustion in a Parr oxygen bomb.

RECOMMENDED FOR

Coal mine, coal preparation plant, coal burning utility, commercial inspection and other industrial laboratories where sulfur determinations for solid or liquid fuels and combustible wastes are run daily on a routine basis, and where rapid tests with good repeatability are required. It is also an attractive, moderately priced, automatic system for laboratories where calorimetric tests are run on an intermittent basis, and where reliable results with good repeatability are required.

COMPATIBLE WITH BOMB CALORIMETRY

Although the 1760 Analyzer can be operated as a stand-alone instrument, in most installations it will be used in conjunction with a Parr oxygen bomb calorimeter. In these cases, sulfur determinations will be made using the calorimetric sample and no additional sample or weighings will be required. The operator will simply collect the washings from the bomb following a calorimetic test and place them in the Analyzer to obtain

- A complete sulfur determination in less than five minutes for samples ranging from 0 1 to 5 percent sulfur, with accuracy and precision well within ASTM test requirements.
- Automatic titration of the total acid in the bomb washings as required to calculate the calorific value of the sample.
- Full communication capabilities for automatically transferring sulfur and total acid values to a Parr Calorimeter or Calorimeter Controller, and/or to a 1750 Proximate Analyzer or computer for incorporation into calorimetric, proximate, or other complete fuel test reports.

PROVEN PROCEDURES

For more than 50 years, standard ASTM methods for determining sulfur in solid and liquid fuels have been based upon the analysis of bomb washings following combustion of a sample in an oxygen bomb. This same reliable procedure is used to prepare samples for the 1760 Analyzer, ensuring complete conversion of all sulfur to soluble sulfates in the process. But the final sulfur assay is made by a rapid titrimetric procedure instead of the tedious gravimetric method. This procedure is based upon a method described by Hicks, Fleenor and Smith* in which the soluble sulfates in the bomb washings are titrated with a lead perchlorate solution to obtain a lead precipitate. The titration is performed in a non-aqueous medium to ensure complete precipitation and a sharp end-point as determined with a lead-ion selective electrode. Titration in the 1760 Analyzer preceeds automatically under microprocessor control, determining first the total acid in the bomb washings, then bringing the solution to the proper pH for the sulfate titration and continuing to an end-point from which the Analyzer will calculate and report the sulfur content of the sample. Chloride and other ions found in many coal samples do not interfere with this ion-specific titration.

A COMPACT, AUTOMATIC TITRATION SYSTEM

Automatic titration in the 1760 Sulfur Analyzer is conducted in a 600 ml beaker held on a magnetic stir plate using a stir bar for agitation. All of the necessary electrodes and reagent discharge tubes are mounted on a non-metallic cover attached to an adjustable arm arranged so that all sensor and tubes can be lowered into the beaker and raised as a unit. Reagents used in fixed amounts are delivered from bottles with attached manually operated automatic pipets furnished with the instrument. The titrants are fed by high precision metering pumps driven by high resolution stepper motors operating under microprocessor control. All reagent concentrations have been selected to produce good precision with optimum operating speed.

SAMPLE SIZE

The 1760 Sulfur Analyzer is designed for use with one gram samples, the size usually burned in Parr oxygen bombs. This amount of sample works well for materials having sulfur contents between 0.1 and 5.0 percent. If the sulfur content runs higher, the sample size should be reduced so that the amount of sulfur in the test does not exceed 75 milligrams.

RAPID TESTS

Both the total acid and percent sulfur can be determined within five minutes after completion of the bomb process. The time required for the automatic titration will be roughly proportional to the amount of sulfur in the sample.

---

*"The Rapid Determination of Sulfur in Coal," Analytical Chemica Acta., 68, 480-3 (1974)

CONVENIENT KEYBOARD CONTROL

The Analyzer has been designed with a high degree of flexibility so that it can be adapted easily to various installations Sample weights can be entered manually from the touch panel keyboard, or picked up automatically from a 1741 Balance Interface, or from a 1261 Calorimeter or a 1720 or 1730 Calorimeter Controller, or from a 1750 Proximate Analyzer over a Smart Link network. All data entries are shown on an LED display for operator verification before they are entered into the system. In addition to its use for data entry, the keyboard serves also as a convenient means for controlling the several steps in the automatic titration and for calling up reports from the instrument.

OPERATOR PROMPTING

The microprocessor is programmed to prompt the operator with messages on the LED display showing the current status of the test and identifying the data which must be entered so that the test can continue. It also monitors the performance of the Analyzer and advises the user (1) if the sensors need cleaning, (2) if a result falls outside the optimum range, (3) if operating conditions are not correct, or (4) if the required data is not available

CALCULATIONS AND STORAGE

The Analyzer calculates the percent sulfur in the sample and reports this value together with a sample identification number, date and time of the test. Automatic storage is provided for up to 300 tests. These values can be called to the instrument display at any time or transferred to an auxiliary printer on command. Software incorporated into the Analyzer allows the operator to call up either a single report, or reports from a range of samples, or a complete memory dump. Program controls also provide for convenient memory management and for pre-formatted reports compatible with any of the printer options listed below.

PRINTED REPORTS

Printed reports can be obtained from the 1760 Analyzer using any of the following options:

1. By adding a 1722 Smart Link Board and connecting the Analyzer onto a Smart Link network, sulfur values can be included in printed reports produced by any of the following:
   (a) A 1261 Calorimeter with an attached printer,
   (b) A 1720 or 1730 Calorimeter Controller with an attached printer.
   (c) A 1750 Proximate Analyzer with an attached printer.
   (d) A laboratory or central computer connected onto the network via a 1745 or 1747 Computer Interface.

2. If the Analyzer is used as a stand alone instrument, reports can be obtained by adding a 1723 Printer Output Board and connecting the Analyzer to a Parr 1755 Printer or to any 40/80 column printer compatible with an RS232C output.

Sepor

SEPOR, INC.
718 N Fries Ave., Wilmington, CA 90748

EASY CALIBRATION

The 1760 Analyzer is usually calibrated with standard sulfate solutions, but standard coal or oil samples can be used as well. The calibration is independent of the sample size. Software in the instrument provides a curve fitting program to ensure outstanding accuracy over the entire range of the instrument. Although the Analyzer can be restandardized as often as desired, it must be restandardized only when a solution or component is changed. Up to 1500 tests can be conducted with a single bottle of titrant solution.

ACCURACY AND PRECISION PROVEN BY COMPARISON TESTS

Tests with standard samples have shown that the 1760 Analyzer can determine sulfur values within a repeatability interval approximately one-half that allowed by current ASTM/ISO test methods. The precision obtainable with the Analyzer also falls well within limits allowed by current standards but will vary with the amount of sulfur present in the sample, which is true for other accepted sulfur methods as well. The excellent results obtainable with this new procedure are best illustrated by the values listed below for tests conducted with standard coal and liquid hydrocarbon samples.

Standard Sample Number	Certified Sulfur Content Percent	Sulfur Determined with 1760 Analyzer Percent
	COAL SAMPLES	
NBS 1631A	0 553 +/- 0.027	0 539 +/- 0 006
NBS 1631B	1 99 +/- 0.05	1 97 +/- 0 01
NBS 1631C	3 04 +/- 0.07	3 04 +/- 0 03
NBS 2682	0 47 +/- 0.03	0 451 +/- 0 003
NBS 2683	1 85 +/- 0 06	1 89 +/- 0 03
NBS 2684	3.00 +/- 0.13	2 98 +/- 0 01
NBS 2685	4 62 +/- 0 18	4 61 +/- 0 01
Alpha 1700	0 33 +/- 0.03	0 33 +/- 0 03
Alpha 1704	0.95 +/- 0.03	0 94 +/- 0 01
Alpha 1708	3.01 +/- 0.04	3.02 +/- 0 01
Alpha 1711	5.02 +/- 0.05	5.02 +/- 0 05
	LIQUID HYDROCARBON SAMPLES	
Alpha 2821	0.15 +/- 0 02	0 15 +/- 0 01
Alpha 2823	0.50 +/- 0.02	0.51 +/- 0 01
Alpha 2825	1.00 +/- 0.03	1 00 +/- 0 01
Alpha 2829	3.08 +/- 0.05	3 08 +/- 0.02

ACCESSORIES

The 1760 Sulfur Analyzer is furnished as a complete operating system with titration pumps, electrodes and electrode holder, six beakers, a magnetic stir plate with stir bar, reagent bottles and two automatic pipets. A supply of lead perchlorate and 0.2N sulfuric acid is provided. The user will have to supply ammmonium hydroxide and methanol which are common reagents available in most laboratories

ORDERING INFORMATION

1760	**Sulfur Analyzer complete with accessories, 115/230 v 50/60 Hz**
1722	**Smart Link Board**
1723	**RS232C Printer Output Board**
A597E	**Smart Link cable, 25 ft.**
A643E	**Cable for RS232C output**

The 1281 Calorimeter

The 1281 Calorimeter is designed for users who want a calorimeter with all of the new technology provided in the 1271 Model but who do not require a fully automated bomb closing mechanism and a provision for expansion to a dual calorimeter. Except for these two features, the 1281 Calorimeter offers the user all of the latest developments in automatic bomb calorimetry in a single, compact unit. The choice, therefore, between the two models will depend upon the anticipated work load, the degree of automation desired, the savings in operator time and any associated budget restraints.

INTEGRATED DESIGN

In the 1281 Calorimeter all of the principal components: the combustion bomb, the bucket and jacket, the water handling system and the oxygen filling system are built into a single console which includes the calorimeter controller and the operating keyboard. The unit is 18 inches wide, 21 inches deep and 16 inches high, with a recessed area at the top for a 1756 Printer.

As with the 1271 Calorimeter, the bomb body and bucket in the 1281 Model are permanently mounted in the calorimeter, but the bomb head with its attached electrodes and sample holder must be removed for loading the sample and attaching an auxiliary cotton fuse. The loaded head is then returned to the calorimeter and the bomb is closed with a simple 23-degree turn of the twist-lock closure.

THE CALORIMETER CONTROLLER

An integral, microprocessor-based controller built into the 1281 Calorimeter provides the same operating controls, data acquisition, data processing, data reporting and communication capabilities furnished in the 1271 Model. Both instruments share the same menu driven programming and operating system with a bright, backlit liquid crystal display.

THE WATER HANDLING SYSTEM

A built-in water tank, circulating pump and temperature control system provide internal water circulation for both filling the calorimeter bucket and for maintaining true isoperibol operating conditions during the test. As with all Parr calorimeters, this is a closed loop system which conserves water and eliminates the problems caused by poor quality water supplies. The calorimeter bucket holds approximately 400mL of water in which the temperature will rise approximately 10°C during a normal test.

The 1281 Calorimeter

ADDITIONAL ACCESSORIES

A bomb wash tank to supply distilled water to wash the bomb, a cooler to remove the heat obtained from the sample, and a printer to produce calorimetric reports are furnished with the 1281 Calorimeter. These accessories are described on page 13. The air or gas required to lock the system and pressurize the bomb wash tank is best supplied from a tank of compressed air or nitrogen. A nitrogen tank pressure regulator for this purpose is furnished with the calorimeter.

THE OXYGEN BOMB

The 1136 and 1136CL oxygen bombs used in the 1281 Calorimeter are described on page 7. These are the same as the 1131 and 1131CL bombs used in the 1271 Calorimeter, but modified with extended electrodes to operate in a head-on-top configuration with manual opening and closing.

46

ORDERING GUIDE

A 1281 Calorimeter is furnished with the following parts which are easily interconnected to form a complete operating system:

- Calorimeter module with a built-in controller, an oxygen bomb with its attached water bucket, an outer water jacket and a water tank.
- Printer
- Bomb wash tank
- Water cooler
- Oxygen pressure regulator
- Nitrogen pressure regulator
- Spare parts kit.

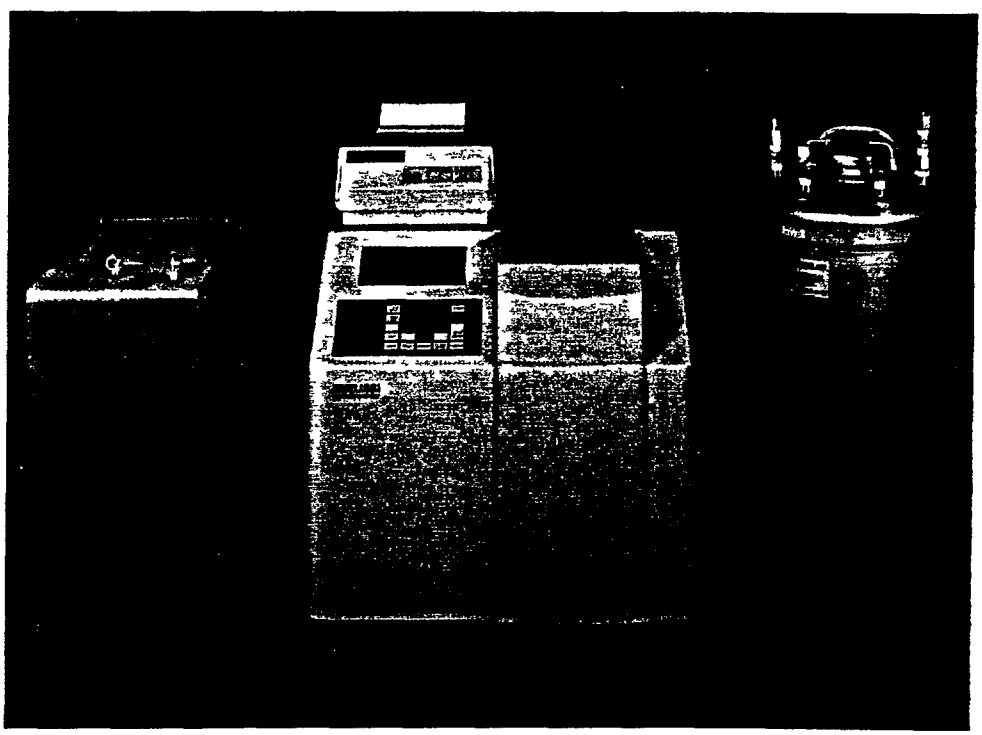
OPTIONAL ADDITIONAL ITEMS

1136 Oxygen Combustion Bomb. Although an 1136 Bomb is furnished with the 1281 Calorimeter, many users will want to have a spare bomb available to ensure continuous operation during routine servicing. This extra bomb can be either the standard 1136 stainless steel model or an 1136Cl Bomb made of a special alloy that offers best resistance to free chlorine and halogen acids.

A895DD Bomb Head Assembly. By purchasing a second head for the 1136 bomb, the user can prepare the next sample for testing before the current test is completed, thereby minimizing turnaround time and obtaining maximum thru-put from the calorimeter.

CATALOG NUMBERS

1281EA	Complete calorimeter with 1136 stainless steel bomb, for 115V 60Hz
1281EF	Complete calorimeter with 1136 stainless steel bomb, for 230V 50Hz
1281CLEA	Complete calorimeter with 1136CL bomb, for 115V 60Hz
1281CLEF	Complete calorimeter with 1136CL bomb, for 230V 50Hz
1136	Oxygen combustion bomb, stainless steel
1136CL	Oxygen combustion bomb for chlorine service
A895DD	Head assembly for 1136 bomb
A895DDCL	Head assembly for 1136CL bomb
1289	Spare parts kit for 1281 calorimeter

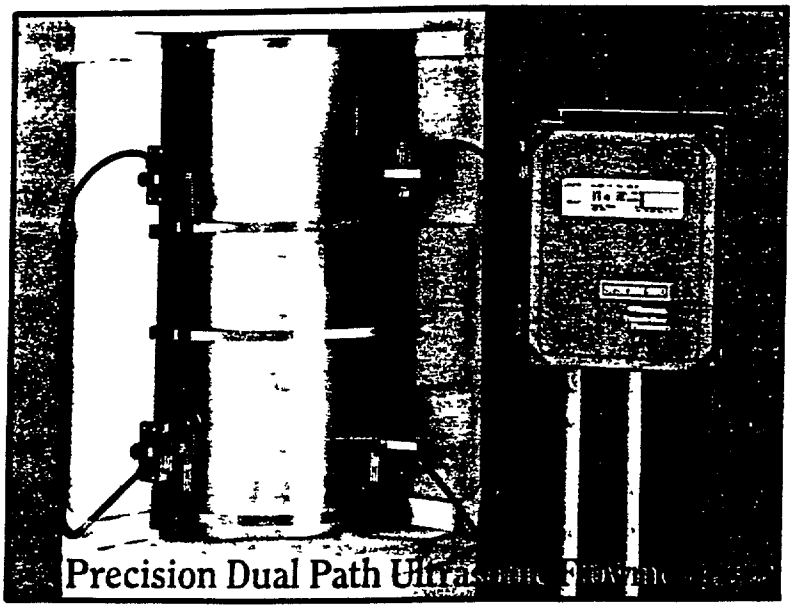


The 1281 Calorimeter System

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

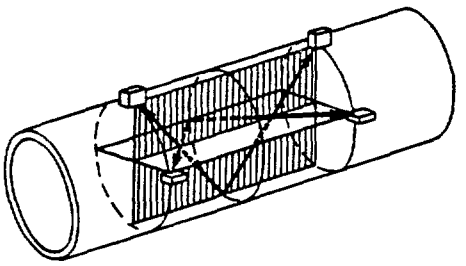
48

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.

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

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

APPENDIX B

Audit Records

AUDIT RECORDS SUMMARY
FLUE GAS MEASUREMENTS

ENERAC Ser. 11003246:
Oxy_ref=true:

Test 5	Flue Gas Measurement at convection pass on coal at 180 MW blr #3 side A
Test 6	Flue Gas Measurement at convection pass on coal at 180 MW blr #3 side B
Test 8	Flue Gas Measurement at convection pass on coal at 180 MW blr #3 side A
Test 9	Flue Gas Measurement at convection pass on coal at 180 MW blr #3 side B

ENERAC Ser. 11003251:
Oxy_ref=true:

Test 1	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test n/a	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 2	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 3	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 4	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 5	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 6	Flue Gas Measurement at the stack on gas at 550 MW blr #7
Test 7	Flue Gas Measurement at the stack on gas at 550 MW blr #7
Test 8	Flue Gas Measurement at the stack on gas at 550 MW blr #7
Test 9	Flue Gas Measurement at the stack on gas at 550 MW blr #7

ENERAC Ser. 11003246:
Oxy_ref=0:

Test 12	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 13	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 14	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 15	Flue Gas Measurement at the stack on coal at 240 MW blr #3

ENERAC Ser. 11003251:
Oxy_ref=true:

Test 13	Flue Gas Measurement at the stack on coal at 240 MW blr #3
Test 14	Flue Gas Measurement at the stack on coal at 240 MW blr #3

SIDE A

SERIAL # 11003246
TEST 5 BOILER# 3 180 MW
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:14:19
DATE: 02/20/95

FUEL GSHCOAL

COMBUSTION EFFICIENCY:	71.0	%
AMBIENT TEMPERATURE:	23	°C
STACK TEMPERATURE:	357	°C
OXYGEN:	06.2	%
CARBON MONOXIDE:	15	MGM
CARBON DIOXIDE:	12.4	%
COMBUSTIBLE GASES:	1.59	%
STACK DRAFT (INCHES H20): +	6.1	
EXCESS AIR:	40	%
OXIDES of NITROGEN:	923	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

TEST 6 BOILER# 3 180 MW
SERIAL # 11003246 SIDE B

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:17:31
DATE: 02/20/95

FUEL GSHCOAL

COMBUSTION EFFICIENCY:	67.5	%
AMBIENT TEMPERATURE:	22	°C
STACK TEMPERATURE:	366	°C
OXYGEN:	06.0	%
CARBON MONOXIDE:	25	MGM
CARBON DIOXIDE:	12.5	%
COMBUSTIBLE GASES:	1.82	%
STACK DRAFT (INCHES H20): +	5.9	
EXCESS AIR:	39	%
OXIDES of NITROGEN:	917	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

TEST [illegible] A 180 MW
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:29:27
DATE: 02/20/95

FUEL GSHCOAL

COMBUSTION EFFICIENCY:	63.4	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	386	°C
OXYGEN:	04.3	%
CARBON MONOXIDE:	33	MGM
CARBON DIOXIDE:	13.9	%
COMBUSTIBLE GASES:	2.27	%
STACK DRAFT (INCHES H20): +	6.3	
EXCESS AIR:	25	%
OXIDES of NITROGEN:	973	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

TEST 9 BOILER# 3 B 180 MW
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 13:31:21
DATE: 02/20/95

FUEL GSHCOAL

COMBUSTION EFFICIENCY:	60.7	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	386	°C
OXYGEN:	04.2	%
CARBON MONOXIDE:	43	MGM
CARBON DIOXIDE:	14.0	%
COMBUSTIBLE GASES:	2.49	%
STACK DRAFT (INCHES H20): +	6.4	
EXCESS AIR:	24	%
OXIDES of NITROGEN:	973	MGM
SULFUR DIOXIDE:	OVER	MGM
CARBON MONOXIDE ALARM:	50	PPM

E:MGM C [illegible]

SERIAL # 11003251
TEST 1 BOILER# 3 240 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: ~~04~~ 10:13:49
DATE: 02/21/95

FUEL GSCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	21	°C
STACK TEMPERATURE:	146	°C
OXYGEN:	09.2	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.8	%
COMBUSTIBLE GASES:	0.20	%
STACK DRAFT (INCHES H2O):	+ 12.9	
EXCESS AIR:	75	%
OXIDES of NITROGEN:	525	PPM
SULFUR DIOXIDE:	1995	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:15:48
DATE: 02/21/95

FUEL GSCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	21	°C
STACK TEMPERATURE:	145	°C
OXYGEN:	09.0	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	10.1	%
COMBUSTIBLE GASES:	0.22	%
STACK DRAFT (INCHES H2O):	- 12.7	
EXCESS AIR:	72	%
OXIDES of NITROGEN:	517	PPM
SULFUR DIOXIDE:	2109	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OX

TEST 2 3 240 MW

SERIAL # 11003251

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:16:03
DATE: 02/21/95

FUEL GSCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	21	°C
STACK TEMPERATURE:	145	°C
OXYGEN:	09.1	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.9	%
COMBUSTIBLE GASES:	0.22	%
STACK DRAFT (INCHES H20):	- 12.5	
EXCESS AIR:	74	%
OXIDES of NITROGEN:	488	PPM
SULFUR DIOXIDE:	2119	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11003251

ENERAC MODEL 2000

TEST 3 COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:19:03
DATE: 02/21/95

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	145	°C
OXYGEN:	09.1	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	10.2	%
COMBUSTIBLE GASES:	0.22	%
STACK DRAFT (INCHES H20):	- 12.4	
EXCESS AIR:	74	%
OXIDES of NITROGEN:	525	PPM
SULFUR DIOXIDE:	2084	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM O

TEST 4 BOILE 3 240 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:20:21
DATE: 02/21/95

FUEL NEWCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	144	°C
OXYGEN:	09.1	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.9	%
COMBUSTIBLE GASES:	0.23	%
STACK DRAFT (INCHES H20):	- 12.3	
EXCESS AIR:	74	%
OXIDES of NITROGEN:	525	PPM
SULFUR DIOXIDE:	2153	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

TEST 5 BOILER# 3 240 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:21:53
DATE: 02/21/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	144	°C
OXYGEN:	09.5	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.3	%
COMBUSTIBLE GASES:	0.23	%
STACK DRAFT (INCHES H20):	- 12.3	
EXCESS AIR:	79	%
OXIDES of NITROGEN:	524	PPM
SULFUR DIOXIDE:	2094	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:P

SERIAL # 11003251
TEST 6 BOILER# 7 GAS 550 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:50:28
DATE: 02/21/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	59	°F
STACK TEMPERATURE:	323	°F
OXYGEN:	06.0	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	06.4	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O): +	2.0	
EXCESS AIR:	36	%
OXIDES of NITROGEN:	69	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

TEST 7 BOILER# 7 550 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:52:59
DATE: 02/21/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	15	°C
STACK TEMPERATURE:	163	°C
OXYGEN:	05.9	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	08.5	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O): +	2.1	
EXCESS AIR:	35	%
OXIDES of NITROGEN:	70	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

TEST 8 BOILER# 7 550 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:54:19
DATE: 02/21/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	14	°C
STACK TEMPERATURE:	162	°C
OXYGEN:	05.9	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	08.5	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20): +	1.7	
EXCESS AIR:	35	%
OXIDES of NITROGEN:	68	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11003251
TEST 9 BOILER# 7 550 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 12:01:26
DATE: 02/21/95

FUEL ~~LIGNITE: 7780 BTU/LB~~ GAS

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	12	°C
STACK TEMPERATURE:	138	°C
OXYGEN:	05.9	%
CARBON MONOXIDE:	2	PPM
CARBON DIOXIDE:	12.2	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20): +	2.8	
EXCESS AIR:	37	%
OXIDES of NITROGEN:	67	PPM
SULFUR DIOXIDE:	6	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL #
TEST 12 BOILER# 3 ~~240 MW~~
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:12:52
DATE: 02/21/95

FUEL NEWCOAL 8528

COMBUSTION EFFICIENCY:	36.2	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	141	°C
OXYGEN:	07.8	%
CARBON MONOXIDE:	OVER	PPM
CARBON DIOXIDE:	11.0	%
COMBUSTIBLE GASES:	OVER	%
STACK DRAFT (INCHES H20): +	OVER	
EXCESS AIR:	57	%
OXIDES of NITROGEN:	546	PPM
SULFUR DIOXIDE:	2379	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF= 0%

TEST 13 BOILER# 3 240 MW
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:15:02
DATE: 02/21/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	143	°C
OXYGEN:	09.6	%
CARBON MONOXIDE:	171	PPM
CARBON DIOXIDE:	09.3	%
COMBUSTIBLE GASES:	0.59	%
STACK DRAFT (INCHES H20): +	OVER	
EXCESS AIR:	79	%
OXIDES of NITROGEN:	737	PPM
SULFUR DIOXIDE:	3271	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM

TEST 14 BOILE
SERIAL # 11003246 3 240 MW

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:17:27
DATE: 02/21/95

FUEL NEWCOAL 8528 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	143	°C
OXYGEN:	09.5	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.6	%
COMBUSTIBLE GASES:	0.83	%
STACK DRAFT (INCHES H2O):	+ OVER	
EXCESS AIR:	79	%
OXIDES of NITROGEN:	731	PPM
SULFUR DIOXIDE:	3377	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF= 0%

TEST 15 BOILER# 3 240 MW
SERIAL # 11003246

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 10:25:45
DATE: 02/21/95

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	16	°C
STACK TEMPERATURE:	143	°C
OXYGEN:	09.2	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	10.1	%
COMBUSTIBLE GASES:	1.05	%
STACK DRAFT (INCHES H2O):	+ OVER	
EXCESS AIR:	75	%
OXIDES of NITROGEN:	765	PPM
SULFUR DIOXIDE:	3152	PPM
CARBON MONOXIDE ALARM:	50	PPM

DE:PPM OXY_REF= 0%

TEST 13 BOILER# 3 240 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:30:03
DATE: 02/22/95

FUEL NEWCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	133	°C
OXYGEN	10.1	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	09.1	%
COMBUSTIBLE GASES:	0.22	%
STACK DRAFT (INCHES H2O):	+ 11.9	
EXCESS AIR:	89	%
OXIDES of NITROGEN:	519	PPM
SULFUR DIOXIDE:	1547	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE:PPM OXY_REF=TRUE%

TEST 14 BOILER# 3 240 MW
SERIAL # 11003251

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE

TIME: 11:31:04
DATE: 02/22/95

FUEL NEWCOAL 8528

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	132	°C
OXYGEN:	10.9	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	08.5	%
COMBUSTIBLE GASES:	0.17	%
STACK DRAFT (INCHES H2O):	+ 12.1	
EXCESS AIR:	103	%
OXIDES of NITROGEN:	485	PPM
SULFUR DIOXIDE:	1451	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM O>

AUDIT RECORDS
FLUKE AC POWER ANALYZER

A) MOTOR, 3 PHASE, 380V

1) Phase A 213V, 142 Amps

AMPS TEXT SCREENS

Arms	=	142	Arms	=	142
Apeak	=	205	AHM	=	2
Adc	=	-3	KF	=	1.0
% THD-R	=	1.3	% THD-F	=	1 3
CF	-	1.44			

VOLTS TEXT SCREENS

Vrms	=	213	Vrms	=	213
Vpeak	=	306	VHM	=	4
Vdc	=	0	CF	=	1.44
% THD-R	=	1.7	% THD-F	=	1.7

WATTS TEXT SCREENS

KW	=	26	KW	=	26
KVA	=	30	KVAR	=	16
PF	=	0.86	°ALAG	=	31
DPF	=	0.8			

B) GENERATOR RELAY PANEL: CT & PT LEADS

110.6V, 3.92 AMPS, 0.41 KW, 49.5 HZ

AMPS TEXT SCREENS

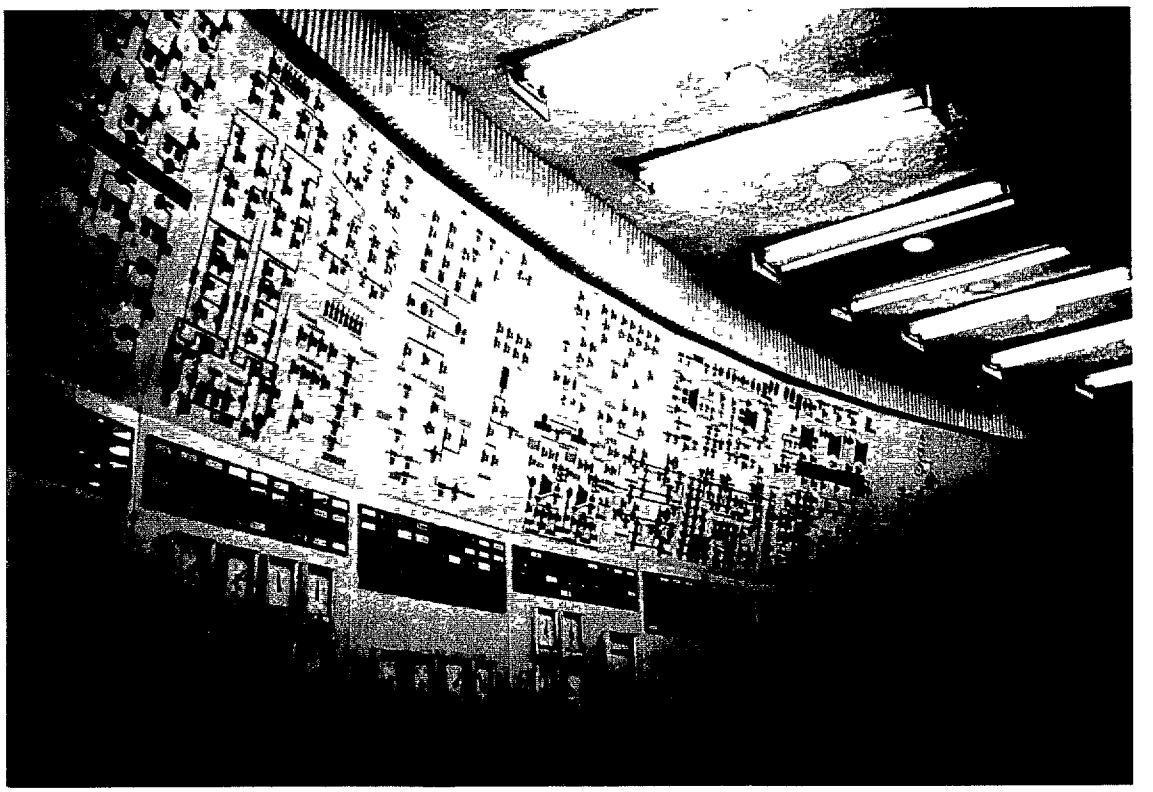
Arms	=	3.92	Arms	=	3.92
Apeak	=	5.54	AHM	=	0.04
Adc	=	-0.04	KF	=	1.0
% THD-R	=	1.0	% THD-F	=	1.0
CF	-	1.41			

VOLTS TEXT SCREENS

Vrms	=	103.4	Vrms	=	103.4
Vpeak	=	145.2	VHM	=	0.4
Vdc	=	0.2	CF	=	1.4
% THD-R	=	0.6	% THD-F	=	0.6

WATTS TEXT SCREENS

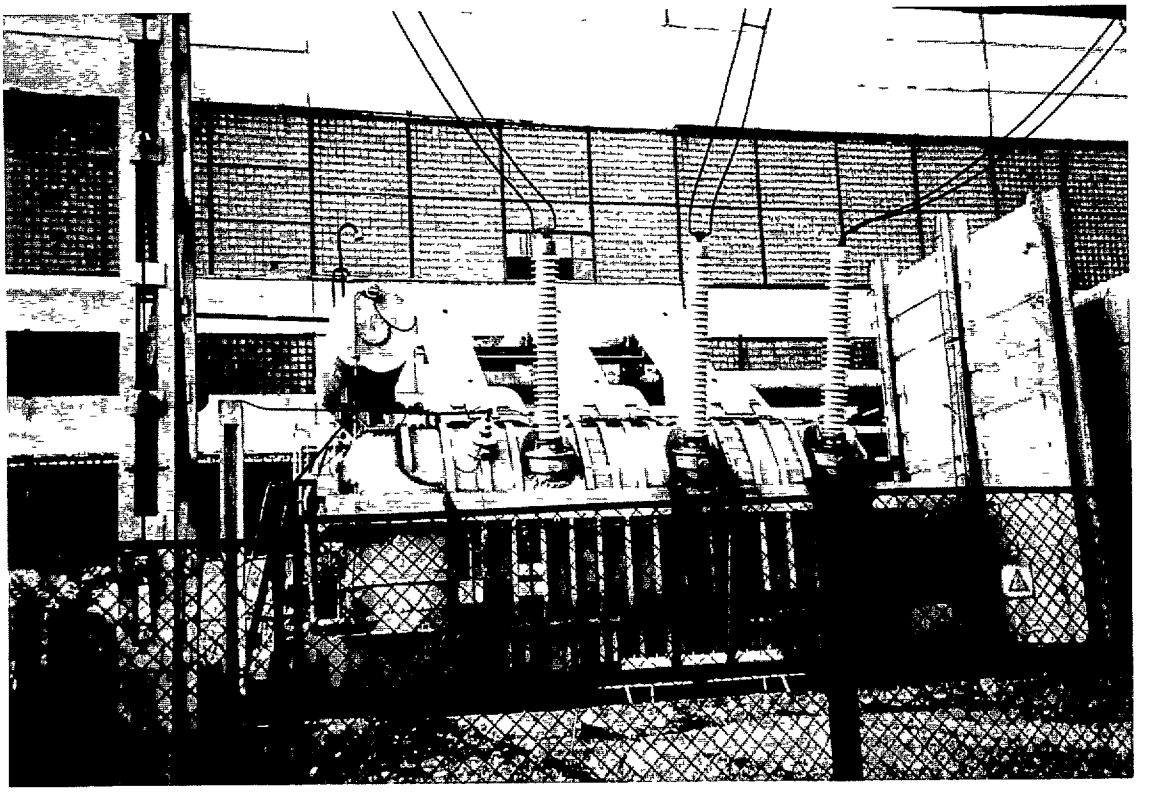
W	=	410	W	=	410
VA	=	410	VAR	=	30
PF	=	1.0	°ALAG	=	4
DPF	=	1.0			



UNIT CONTROL BOARD

BOILER
O_2 ANALYZER
RECORDERS
AND MAZUT
FLOW METERS

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



1000 MVA STEP-UP GENERATOR TRANSFORMER

BOILER
BACK-END

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

CALCULATION OF TOTAL FUEL COST FOR UGLEGORSK POWER PLANT

The following calculation is using 1994 fuel consumption and 1995 prices of fuel.

Consumption for 3 months in standard (7000 Kcal/Kg) tons

TOTAL	COAL	GAS	MAZUT
250,254	-	107,539	849
255,492	-	222,849	363
478,078	-	402,267	93
983,824	249,866	732,650	1,308

Price of coal per standard ton: (*)$36,67 x $\frac{7000}{5000}$ = $51.3

Price of natural gas per standard ton: $\frac{5,616,000c}{150,000c}$ = $37.44

Price of mazut per standard ton: $\frac{9,422,000c}{150,000c}$ = $62.81

Consumption for 12 months in standard tons and dollars

Coal:	249,866 x 4 = 999,464 x 51.3 =	$ 51,272,503
Gas:	732,650 x 4 = 2,930,600 x 37.44 =	$109,721,660
Mazut:	1,308 x 4 = 5.232 x 63.81 =	$ 328,622
	Total	$161,322,780

Total cost of fuel is estimated at $161.322,789

(*) Assumed 1995 prevailing price for one ton of coal in Ukraine = $36,67 at 5000 Kcal/Kg.

c = coupon

5906-01/02A/UGLEG/5/4/95

CALCULATION OF COST OF FUEL FOR UGLEGORSK UNIT NO.3

The following calculation is using 1994 fuel consumption and 1995 prices of fuels.

1. Total fuel consumption for 3 months:

   59,143 + 54,567 + 60,870 = 174,580 standard tons (7,000 Kcal/Kg)

2. Total fuel consumption for 12 months:

   174,580 x 4 = 698,320 S.T.

3. Total consumption of natural gas for 3 months:

   20,218 + 39,804 +_ 25,908 = 85,930 S.T.

4. Total consumption of natural gas for 12 months:

   85,930 x 4 = 343,720 S.T.

5. % gas of total fuel:

   $$\frac{343,730}{698,320} = 49.2\%$$

6. Total consumption of mazut for 3 months:

   23 +84 = 107 (S.T.)

7. Total consumption of mazut for 12 month:

   107 x 4 = 428 (S.T.)

8. % mazut of total fuel:

   $$\frac{428}{698,320} = 0.06\%$$

5906-01/02A/COST/5/3/95

9. Cost of fuel if burning only coal:

Price: 5,500,000 c/ton @5000 kcal/kg @150,000 c/$
Price for 1 ton of coal = $36,67 @ 5000 kcal/kg (*)

Total coal consumption at 5000 kcal/kg:

$$698{,}320 \times \frac{7000}{5000} = 977{,}648 \text{ tons of coal}$$

Total cost of fuel for Unit #3 in 1995 prices using 1994 fuel consumption:

977,648 x 36,67 = <u>$35,850,352</u>

10. Cost of fuel if burning present mixture of coal and gas: 50.8% coal and 49.2% gas.

Price of gas for one standard ton of fuel:

$$\frac{5{,}616{,}000c}{150{,}000c} = \$37{,}44$$

$35,840,352 x 0.508 + 343,720t x $37,44 =

18,211,978 + 12,868,876 = <u>$31,080,854</u>

Total cost of fuel for Unit No. 3 is estimated at $31,080,854.

(*)Assumed prevailing price in Ukraine
c = coupon

5906-01/02A/COST/5/3/95

№	Показатели	Обозначение	Единица измерения	Котлоагрегаты ТПП-312, 312-А, ТКЗ						ТГМП-204, ТКЗ					Всего по ГРЭС
				Станционный номер				Всего по I очереди		Станц. номера			Всего по I очереди		
				1	2	3	4	мазут / газ	перевод	5	6	7	мазут / газ	перевод	
1	Средняя нагрузка парогенератора	D_e	т/ч	759		756	654	1114043			1851	1534	1367501		2481544
	топлива	$Q_к$	Гкал/ч	482		496	445	730397			1246	1083	924783		1655180
2	Давление свежего пара за котлом	$P_к$	кГс/см²	236		249	243	233			206	193	205		
3	Температура свежего пара за котлом	$t_к$	°С	545		544	546	545			539	545	539		
4	Число часов в работе (в резерве)	$T_{раб}/T_{рез}$	час.	699 / 24	112	706 / 38	97 / 647	1502 / 621		11 / 709	678 / 66	44 / 670	763 / 1445		2265 / 2166
5	Температура воздуха: а) холодного (после калорифера)	$t_{хв}/t_{хф}$	°С	14,9 / 34,0		15,1 / 26,8	12,8 / 23,8	14,9 / 30,0			15,4 / 65	14,7 / 60	15,0 / 64		
	после воздухоподогревателя	$t_{гв}$	»	335		336	334	335			311	341	312		
6	Температура уходящих газов за последней по ходу газов нагрева котла	$t_{ух}$	»	142 / 163		142 / 150	133 / 154	142 / 156	1000		145 / 143	136 / 128	140 / 142	-377	
7	Коэффициент избытка воздуха за котлом	α	—	1,18 / 1,204		1,17 / 1,200	1,174 / 1,157	1,176 / 1,199			1,04 / 1,073	1,04 / 1,064	1,04 / 1,074		
8	Присосы воздуха на тракте котла дымососа	$\Delta\alpha$	—	0,410 / 0,377		0,410 / 0,379	0,440 / 0,385	0,411 / 0,378	-161		0,210 / 0,228	0,246 / 0,162	0,256 / 0,223	33	
9	Содержание горючих в уносе	$Г_{ун}$	%	1,24 / 0,44		1,14 / 0,58	— / —	1,22 / 0,51			— / —	— / —	— / —		
	Впрыск	$C_{впр}$	т/ч	201		246	61	508			254	254	508		
10	Теплота сгорания шлака	$R_ш/R_{шл}$	»	24,7		25,2	—	25,0			—	—	—		
11	Число растопок (в т. ч. внеочередных)	n	—	2 —		1 —	1 —	4 —	—	1 —	1 —	1 —	3 —	—	7 —
37	FUEL CONSUMPTION														
	Расход условного топлива — всего	B	т усл. топл.	53146		54567	6844	114557		635	1275	1273	140435		255492
38	в том числе газа мазута	$B_{газ}/B_{маз}$	»	35900 / 135		34804 / 84	6773 / 84	81976 / 301		614 / 21	1275 / 31	1271 / 20	140873 / 62		222849 / 363
	Потери тепла котлоагрегатами: с уходящими газами	q_2	%	8,560 / 9,451		7,904 / 8,433	7,516 / 8,583	8,190 / 8,821			6,594 / 6,743	6,162 / 5,349	6,510 / 6,065		
	с механическим недожогом	q_4	»	0,164 / 0,058		0,127 / 0,064	— / —	0,146 / 0,058			— / —	— / —	— / —		
	в окружающую среду	q_5	»	0,246 / 0,246		0,257 / 0,257	0,304 / 0,304	0,225 / 0,255			0,241 / 0,241	0,263 / 0,263	0,243 / 0,244		
	прочие	$q_{прочн}$	»	0,663 / 0,663		0,455 / 0,458	1,581 / 1,581	0,664 / 0,664			0,476 / 0,444	0,444 / 0,434	0,476 / 0,719		
39	КПД брутто на момент начала действия, брутто	$\eta_б^{нр}$	»	90,367 / 89,752		91,274 / 90,808	89,545 / 88,554	90,744 / 90,202			93,753 / 93,556	89,451 / 89,745	91,161 / 91,303		
40	Расход электроэнергии на собственные нужды: всего по котлоагрегатам	$Э^{сн}_к$	»	3,37 / 4,44		3,37 / 3,37	11,01 / 5,61	4,44 / 4,37	246		0,56 / 0,46	1,23 / 0,95	1,04 / 0,74	-166	
	в том числе: на пылеприготовление	$Э_{пл}$	кВт·ч / т усл. топл.	43,0 / 33,10		43,0 / 34,27	43,0 / 104,8	43,0 / 38,8			— / —	— / —	— / —		
	на питательные насосы	$Э_{пит}$	кВт·ч / т воды	0,94		0,97	1,70	1,19				$Э^{к}_{пит}$			
	на тягу и дутье	$Э_{тд}$	кВт·ч / т пара	6,06 / 3,90		6,01 / 5,02	6,65 / 8,11	6,07 / 3,87			0,960	0,746	0,933		
41	Удельный расход электроэнергии на питательные насосы	$Э^{уд}_{пит}$	%	3,23		3,26	3,12	3,244			3,733	3,485	3,676		
42	Расход тепла на собственные нужды	$Г^{сн}_к$	»	0,75 / 0,68		0,70 / 0,66	0,90 / 0,74	0,73 / 0,65			1,15 / 1,05	1,20 / 3,03	1,15 / 2,14		
43	КПД котлоагрегатов, нетто	$\eta^{н}_к$	»	85,87 / 84,86		84,84 / 84,76	78,36 / 80,91	85,50 / 83,39			86,54 / 86,10	83,43 / 81,63	86,65 / 86,14		
	$Q_{кф}$		Гкал	—		—	—	—			2053	1850	3903		
	$Q_{тл}$		Гкал	—		—	—	—			—	—	—		

Fuel Consumption for May 1994

Unit N°3 : 54,567 tons of fuel, including 39,804 tons of natural gas and 84 tons of mazut

TES : 255,493 tons of fuel, including 222,849 tons of natural gas and 363 tons of mazut

BEST AVAILABLE COPY

III. Показатели котлоагрегатов

№ п.п.	Показатели	Обозначение	Единица измерения	Котлоагрегаты ТПП-312, 312А, ТКЗ. Станционный номер 1	2	3	4	Всего по I очереди норма / факт	перер	ТГМП-20Н, ТКЗ. Станц. номер 5	6	7	Всего по II очереди норма / факт	перер	Всего по ГРЭС
А	Б	В	Г	1	2	3	4	5	6	7	8	9	10		
25	Средняя нагрузка. паровая	$D_{ср}$	т/ч	873	873	885	882	2046 / 447			1643		3911 / 338		2487 / 55
	тепловая	$Q_{ср}$	Гкал/ч	552	568	572	568	1317 / 902			1105		2629 / 82		1580 / 0
26	Давление свежего пара за котлом	$P_{к}$	кГс/см²	248	238	238	239	240			191		191		
27	Температура свежего пара за котлом	$t_{к}$	°С	546	546	542	546	545			542		542		
28	Число часов в работе (в резерве)	$T_{раб}/T_{рез}$	час.	475 / 191	614 / 58	642 / –	568 / 57	2309 / 312		– / 231	238 / 434	– / 672	238 / 1337		2567 / 16
29	Температура воздуха: холодного (после калориферов)	$t_{хв}/t_{пф}$	°С	-5,9 / 291	-9,1 / 282	-8,6 / 280	-9,6 / 226	-8,4 / 252			-8,4 / 62		-8,4 / 62		
	после воздухоподогревателя	$t_{гв}$	»	341	360	346	344	348			326		326		
30	Температура уходящих газов за последней поверхностью нагрева котла	$t_{ух}$	»	155 / 151	156 / 157	153 / 158	151 / 148	154 / 148	-683		139 / 143		139 / 143	88	
32	Коэффициент избытка воздуха за котлом	α	—	1,177 / 1,267	1,191 / 1,187	1,176 / 1,185	1,167 / 1,142	1,178 / 1,192			1,03 / 1,078		1,03 / 1,078		
33	Присосы воздуха на тракте котел-дымосос	$\Delta\alpha$	—	0,377 / 0,376	0,378 / 0,365	0,376 / 0,371	0,346 / 0,363	0,377 / 0,370	-61		0,28 / 0,194		0,28 / 0,194	-46	
34	Содержание горючих: в золе	$Г_{зл}$	%	0,863 / 0,20	0,863 / 0,22	0,858 / 0,44	0,859 / 0,41	0,861 / 0,33			–		–		
	В перет	$C_{пер}$	т/ч	237	1167	1520	1695	4619			4619		4619		
35	Теплота сгорания топлива	$Q_{н}^{р}/Q_{н}^{г}$	»	24,5	25,3	25,1	25,7	25,2			–		–		
36	Число рабочих (в т. ч. вынужденных)	n	—	2 / 1	1 / –	– / –	3 / 2	6 / 2	259		– / –		– / –	–	6 / 2
	Fuel Consumption														
37	Расход условного топлива — всего	B	т усл. топл.	42047	54889	59143	50213	206292			43962		43962		250254
38	в том числе газа мазута	$B_{газ}/B_{маз}$	»	11604 / 295	10366 / 149	20218 / –	18814 / 405	63592 / 849			43962 / –		43962 / –		107534 / 849
	Потери тепла котлоагрегатов: с уходящими газами	q_2	%	9,818 / 10,046	10,143 / 10,084	9,939 / 8,910	9,691 / 9,320	9,861 / 9,542			7,134 / 7,672		7,134 / 7,672		
	с механическим недожогом	q_4	»	0,30 / 0,069	0,339 / 0,086	0,274 / 0,140	0,236 / 0,142	0,287 / 0,105	9,3		0 / 0,068		0 / 0,068		
	в окружающую среду	q_5	»	0,215 / 0,215	0,205 / 0,205	0,211 / 0,211	0,215 / 0,216	0,216 / 0,216			0,248 / 0,248		0,248 / 0,248		
	прочие	$q_{прч}$	»	1,212 / 1,212	0,812 / 0,812	0,425 / 0,425	0,711 / 1,227	0,760 / 0,882			– / –		– / –		
39	Коэффициент полезного действия, брутто	$\eta_{к}^{бр}$	»	88,455 / 88,458	88,481 / 88,703	89,311 / 90,314	89,147 / 89,126	88,836 / 89,249	(89,27)		92,818 / 92,012		92,818 / 92,012	(92,30)	
41	Расход электроэнергии на собственные нужды всего по котлоагрегатам	$Э_{с.н.}^{к}$	»	4,39 / 4,61	4,36 / 4,15	4,08 / 3,63	4,12 / 3,97	4,23 / 4,04	-384		0,50 / 0,83		3,84 / 1,56	58	
	в том числе: на технологические нужды	$Э_{тех}$	кВт·ч / т пит. топл.	23,0 / 20,79	23,0 / 19,90	23,0 / 21,48	23,0 / 23,40	23,0 / 22,03			–		–		
	на технологические электроприемники	$Э_{тех}$	кВт·ч / т пара	– / 1,14	– / 0,83	– / 0,77	– / 0,79	– / 0,85			–	Эт.пер.↑	–		
	на тягу и дутье	$Э_{т.д}$	кВт·ч / т пара	6,12 / 6,66	6,13 / 6,68	6,11 / 5,77	6,11 / 6,15	6,12 / 6,25			0,798		0,798		
41	Процентный расход электроэнергии на собственные нужды котлов	$Э_{с.н.}$	%	3,54	3,69	3,66	3,63	3,64			3,49		3,49		
4	[illegible] на собственные нужды	$Г_{с.н.}^{к}$	»	1,40 / 1,751	1,55 / 1,638	1,50 / 1,589	1,55 / 1,716	1,50 / 1,665			1,80 / 12,76		1,80 / 12,76		
	[illegible]	$Y_{н}^{к}$	»	80,44 / 80,08	80,245 / 80,76	81,31 / 80,70	81,105 / 80,76	80,80 / 81,19			86,10 / 81,23		83,00 / 80,51		
	Всего		Гкал	–	–	–	–	–			0520		0520		

Fuel consumption for Unit N°3 in February 1994

59,143 tons of standard fuel, including 20,218 st of natural gas

Total fuel consumption for TES 250,254 tons of standard fuel,

including 107,534 tons of gas
849 tons of mazut

BEST AVAILABLE COPY

III. Показатели котлоагрегатов

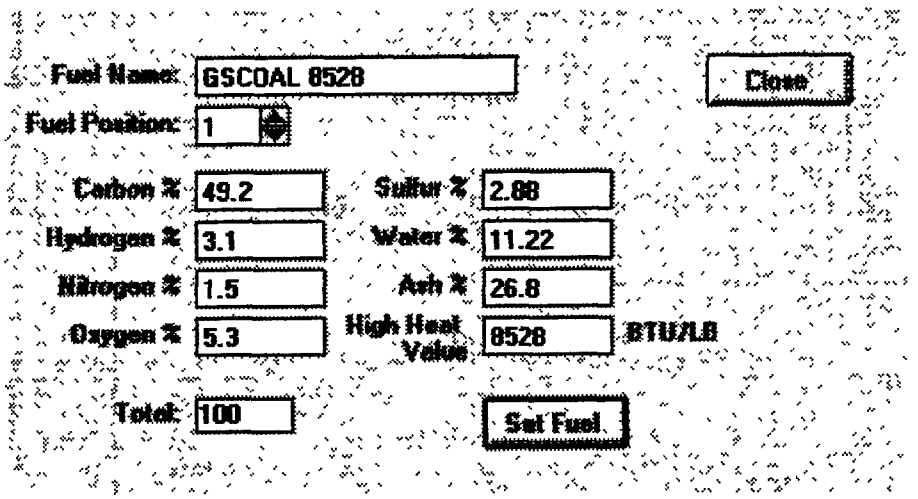
№ п/п	Показатели	Обозначение	Единица измерения	Котлоагрегаты ТПП-312, 312-А, ТКЗ: Станционный номер 1	2	3	4	Всего по I очереди: норма / факт	перер	ТГМП-204, ТКЗ: Станц. номер 5	6	7	Всего по II очереди: норма / факт	перер	Всего по ГРЭС
А	Б	В	Г	1	2	3	4	5	6	7	8	9	10		
20	Среднегодовая нагрузка пароперегревателя	$D_{пе}$	т/ч	856	845	876		1819827		1963	2050	1193	2941028		4760853
	Выработка	$W_{г}$	Гкал/ч	553	548	564		1175605		1298	1355	923	1946683		3122288
22	Давление свежего пара за котлом	$P_{п}$	кГс/см²	236	228	237		234		212	218	226	215		
23	Температура свежего пара за котлом	$t_{п}$	°С	546	540	544		543		533	538	536	536		
25	Число часов в работе (в резерве)	$T_{раб}$	час.	658 / 19	744 / —	687 / —		2119 / 19		409 / 35	744 / —	20 / 690	1173 / 725		3590 / 744
30	Температура воздуха: холодного (после калориферов)	$t_{хв}/t_{вф}$	°С	214 / 43,5	213 / 36,1	217 / 34,7		213 / 38,0		212 / 67	213 / 68	235 / 70	213 / 67,6		
	после воздухоподогревателя	$t_{гв}$	»	352	352	346		350		309	322	329	316		
31	Температура уходящих газов за последней поверхностью нагрева котла	$t_{ух}$	»	153 / 176	144 / 174	153 / 159		150 / 170	2147	147 / 133	151 / 146	146 / 148	149 / 140	-1354	
32	Коэффициент избытка воздуха за котлом	α	—	1,170 / 1,147	1,135 / 1,134	1,170 / 1,129		1,158 / 1,13		1,03 / 1,067	1,03 / 1,070	1,03 / 1,065	1,03 / 1,069		
33	Присосы воздуха на тракте котла суммарные	$\Delta\alpha$	—	0,381 / 0,406	0,328 / 0,361	0,378 / 0,377		0,369 / 0,381	-14	0,213 / 0,217	0,207 / 0,245	0,229 / 0,160	0,210 / 0,231	244	
34	Содержание горючих в золе	$Г_{зл}$	%	0,872 / 0,59	0,878 / 0,19	0,860 / 0,48		0,868 / 0,49		—	—	—	—		
	В перет	$Б_{пер}$	т/сут	—	147	108		255		127	—	128	255		
35	Топливный баланс котла	$B_{гв}/B_{мв}$	»	24,2	23,9	24,5		24,2		—	—	—	—		
36	Число растопок (в т. ч. внеплановых)	n	—	1 / —	— / —	1 / —		2 / —		1 / —	— / —	1 / —	2 / —		4 / —
37	Расход условного топлива — всего	B	т усл. топл.	60447	61413	60870		185130		137804	151423	3421	292648		478078
38	в том числе газа мазута	$B_{газ}/B_{маз}$	»	28577 / 23	55781 / —	25908 / 23		109666 / 46		137604 / 20	151423 / —	3391 / 27	292601 / 47		402267 / 93
	Потери тепла котлоагрегатами: с уходящими газами	q_{2}	%	8,004 / 9,559	7,430 / 9,137	8,413 / 8,305		7,848 / 8,997		6,291 / 5,879	6,464 / 6,689	6,286 / 6,300	6,378 / 6,302		
	с механическим недожогом	q_{4}	»	0,212 / 0,143	0,054 / 0,012	0,229 / 0,127		0,164 / 0,092	q_4 =	0 / 0,068	0 / 0,064	0 / 0,067	0 / 0,068		
	в окружающую среду	q_{5}	»	0,217 / 0,219	0,228 / 0,228	0,226 / 0,226		0,224 / 0,224		0,246 / 0,246	0,228 / 0,222	0,263 / 0,263	0,234 / 0,234		
	прочие	$q_{прочие}$	»	0,587 / 0,587	0,086 / 0,086	0,614 / 0,614		0,423 / 0,423		0,274 / 0,274	— / 0	15,468 / 15,468	0,309 / 0,309		
39	Коэффициент полезного действия, брутто	$\eta^{бр}_{к}$	»	90,98 / 89,494	92,194 / 90,514	90,818 / 90,728		91,348 / 90,264	(90,45)	93,189 / 92,533	93,314 / 93,021	93,931 / 93,902	93,087 / 93,087	(93,22)	
40	Расход электроэнергии на собственные нужды всего по котлоагрегатам	$Э^{сн}_{к}$	»	4,20 / 4,18	3,324 / 2,81	4,213 / 3,48		3,923 / 3,55	-888	0,49 / 0,56	0,43 / 0,50	19,07 / 1,79	0,66 / 0,54	-183	
	в том числе на пылеприготовление	$Э_{пр}$	тыс. квт.ч / т.квт топл.	23,0 / 20,76	23,0 / 45,0	23,0 / 20,04		23,0 / 23,30		—	—	—	—		
	на питательные электронасосы	$Э_{пит}$	кВт·ч / т воды	0,82	0,72	0,83		0,79	—		$Э^{сн}_{ПЭН}$				
	на тягу и дутье	$Э_{д}$	кВт·ч / т пара	6,17 / 7,13	6,20 / 5,60	6,14 / 4,97		6,17 / 5,89		1,07	1,10	0,60	1,08		
41	Процентный расход электроэнергии на собственные нужды по турбонососам	$\%^{сн}_{пнт}$	%	3,74	3,68	3,73		3,72		3,83	3,94	2,96	3,88		
	Расход тепла на собственные нужды	$Г^{сн}$	»	0,49 / 0,581	0,50 / 0,587	0,49 / 0,570		0,49 / 0,579		1,17 / 1,127	0,80 / 1,001	1,18 / 5,806	0,98 / 1,106		
	[illegible]	$Г^{пр}$	»	83,48 / 82,48	85,39 / 84,38	83,36 / 83,92		84,10 / 83,53		87,15 / 87,51	87,52 / 87,16	59,14 / 68,87	87,0 / 87,18		
	Экс.		Гкал	—	—	—		—		19250	21629	571	41456		

Fuel Consumption for Unit No3 in August 1994 60,870 tons of standard fuel, including 25,908 tons of natural gas and 23 tons of mazut

Fuel Consumption for TES: 478,078 tons of standard fuel, including 402,267 tons of natural gas and 93 tons of mazut

BEST AVAILABLE COPY

CUSTOM FUEL CREATED FOR UGLEGORSK POWER PLANT FOR DESIGN COAL



BEST AVAILABLE COPY

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

OXYGEN ANALYZER DATA FOR UGLEGORSK BLR #3

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

300 MW Boiler, coal, gas and mazut fired.

Install Probes at Elevation:	41m.
Process Temperature:	700 degrees Centigrade minimum 850 degrees Centigrade normal 1050 degrees Centigrade maximum
Ambient Temperature:	55 to 60 degrees Centigrade.
Length of the cable run to the control room:	front 130 m rear 130 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.

УКРАИНСКАЯ ГАЗОВАЯ КОРПОРАЦИЯ «У К Р Г А З»
ДОНЕЦКОЕ ОБЛАСТНОЕ ГОСУДАРСТВЕННОЕ ПРЕДПРИЯТИЕ ПО ГАЗОСНАБЖЕНИЮ И ГАЗИФИКАЦИИ «ДОНЕЦКОБЛГАЗ»
ДЕБАЛЬЦЕВСКОЕ УПРАВЛЕНИЕ ГАЗОВОГО ХОЗЯЙСТВА
343811, п. Мироновский, г Дебальцево Донецкой обл, тел 34-54, 35-27

21.06.94 № 13/203

НА № _____ от _____

Начальнику ПТО
Углегорской ГРЭС
Цырульнику Ф.П.

О составе газа за май 1994 г.

N_2	Азот	2,396	3,545
CO_2	Угл.газ	0,119	0,020
	Этан	1,592	2,191
PROPEN	Пропан	0,623	0,664
	И-бутан	0,074	0,115
	Н-бутан	0,096	0,201
	И-пентан	0,032	0,040
	Н-пентан	0,017	0.099
	Метан	95,051	93,125

Теплота сгорания газа = 8005; 8030 ккал/м^3

density Плотность газа: с 0605.94 г. = 0,695 кг/м^3
с23.05.94 г. = 0,716 кг/м^3

Средняя теплота сгорания газа 8012 ккал/м^3

Начальник ПТО — В.И. Савченко.

Углегорская ГРЭС
вх. № 579 лист 1
24-06-94

78

ФАКС №0045-53-59

КУРАХОВО

Данные Углегорской ГРЭС за 1994-95г.г. по цене топливо

1994 год

Цена угля -
натурального - 685971 крб/тн
условного -1094518 крб/тут

январь 1995 г.

Цена газа натурального - 6317 тыс.крб/т.м^3
условного - 5616 т.крб/тут

Мазута натурального - 12894 т.крб/тнт
условного - 9422 т.крб/тут

Январь 1995 г.

LEAKAGES → Присосы:

Топка - 5,2 %

Газоход - 21,9 %

Пылесистемы - 23,8 %

Начальник ПТО Ф.П.Цырульник

APPENDIX D

List of Contacts Made During Plant Audits

LIST OF CONTACTS MADE DURING PLANT AUDITS

- Georgy Kuryshko, Technical Director
- Isodor Tsiroulnik, Chief of Technical Department
- Mikhail Roudoy, Deputy Chief Engineer
- Nickolay Kerasy, Deputy Chief Engineer
- Alksey Voronkov, Chief of Thermal Automatics Shop
- Dimitry Fiodoraff, Chief of Computer Department
- Vladislav Dzekanovsky, Chief of Equipment Adjustment Department
- Sergey Sergeyew, Computer Department Engineer

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
Kgce	=	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

Министерство энергетики
и электрификации Украины

Производственное
энергетическое объединение
"ДОНБАССЭНЕРГО"

УГЛЕГОРСКАЯ ГРЭС

343814 г Дебальцево, г Светлодарск
Донецкая обл
Телефон 5-43-59 Телетайп 329135 "Астра"
Расчетный счет 00221303 МФО 334099
Дебальцевское отделение АК Промивестбанка

_____ № _____

На №_____ от _____

February 17, 1995

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 Uglegorskaya Thermal Power Station the equipment listed in accordance with the Attached List.

The equipment have been purchased, shipped, and handed over to the Uglegorskaya 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 Uglegorskaya 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 Uglegorskaya Thermal Power Station

Mr Panasovsky O.G.

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

86

February 17, 1995

LIST OF EQUIPMENT

ITEM	DESCRIPTION	QTY	SERIAL #
1.	2 KBV ENERAC 2000 COMBUSTION ANALYZER	1	11003251
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	20002071
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.	2xO3.5mm 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	50106404117
41.	OKIDATA ML3380 PRINTER	1	407A0005584
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 - USER'S 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

Министерство энергетики
и электрификации Украины

Производственное
энергетическое объединение
"ДОНБАССЭНЕРГО"

УГЛЕГОРСКАЯ ГРЭС

343614 г Дебальцево, г Светлодарск
Донецкая обл
Телефон 5-43-69 Телетайп 329135 "Астра"
Расчетный счет 00221303 МФО 334039
Дебальцевское отделение АК Промвестбанка

_____ № _____ ____

На №_____ ___ от _____ _____

17 февраля 1995г.

ПРИЕМО-ПЕРЕДАТОЧНЫЙ АКТ

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

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

Приборы переданы Углегорской 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/Киев

Директор Углегорской ГРЭС

г-н Панасовский О.Г.

17 февраля 1995г.

СПИСОК ОБОРУДОВАНИЯ

Номер	ОПИСАНИЕ	Кол-во	Зав. номер
1.	2 KBV ENERAC 2000 анализатор зжигания топлива	1	11003251
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 300AF инфракрасный термометр	1	20002071
11.	MAXELL зарядное устр-во	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.	2x03.5mm Миниатюрные разъемы	2	отс
20.	Руководство	1	отс
21.	CYCLOPS NECK STRAP	1	отс
22.	FLUKE #41 измеритель	1	отс
23.	FLUKE #C41-S футляр	1	отс
24.	TL-24 TECT провода	2	отс
25.	TP-20 TECT зонды	2	отс
26.	AC-20 TECT 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 программны	1	отс
36.	801-500S зонд переменного тока	1	отс
37.	801-1000Sзонд переменного тока	1	отс
38.	Батарейки типа "C"	4	отс
39.	Рук-во измерения гармоник	1	отс
40.	T14000M COMPUTER ПЭВМ	1	5010640411/
41.	OKIDATA ML3380 ПРИНТЕР	1	407A0005584
42.	Адаптер русской клавиатуры	1	отс
43.	Карта быстрой ссылки 801-1000S PROBE	1	отс
44.	801-1000S PROBE Руководство и регистрационн. 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 - USER'S 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

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;

ç

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

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

UGLEGORSK POWER PLANT
(SEPT 28 THRU OCT. 1, 1994)

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

DECEMBER 1994

5906-02/Cover/12/9/94

93

PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

UGLEGORSK POWER PLANT

TABLE OF CONTENTS

	PAGE
EXECUTIVE SUMMARY	1
INTRODUCTION	8
POWER PLANT DESCRIPTION	8
BOILER PLANT	10
FUEL SUPPLY	14
PLANT OPERATION MODE	15
COMBUSTION CONTROL	15
CALCULATION OF BOILER EFFICIENCY	16
FUTURE PLANS	16
STATION "WOULD-LIKE-TO-HAVE" INSTRUMENT LIST	17
ATTACHMENTS 1 TO 12	

PRELIMINARY AUDIT REPORT

IMPROVING COMBUSTION EFFICIENCY

UGLEGORSK POWER PLANT
(Sept. 28 Thru Oct. 1, 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 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 load swings 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

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 300 MW boiler the existing extractive oxygen analyzers with two in-place zirconium oxide sensor analyzers as used in USA.

It is recommended: two devices per 300 Mw boiler.

c) Coal Meters

The following devices are recommended for metering the coal input to the same 300 MW boiler selected for the above in-situ O_2 analyzer replacement:

Two devices to measure raw coal consumption per 300 MW boiler located between raw coal bunker and mill.

d) Devices to quickly determine the ash and water contents of the coal supplied to the mills on the same 300 MW boiler.

It is recommended: two devices per 300 MW boiler.

e) 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.

f) 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.

g) 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 blending or lower cost sorbent technologies for flue gas conditioning. In addition, because of high level sulphur content of both coal and oil, it is recommended the investigation of an oil treatment plant as a solution to reduce the SO_2 emissions. For NO_x removal use of a burner design technology for low NO_x emissions (low costs) or SCR (selective catalytic reduction) or SNCR (selective non-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) Upgrade the dust control system to the world performance standards, either replace the existing 1ESPs or refurbish to meet the world standards.

6) The plant have to develop short term and long term plans for boiler and air pollution control system malfunction prevention.

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

91

8) Provide proper analytical equipment to the chemical laboratory.

9) Demonstrate the applicability of Siemens 200 MW gas turbine prototype technology for repowering the 800 MW units.

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

98

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

Observations and Assessments

- The station is clean, well maintained and appeared to be well run and managed. The staff is competent and experienced.

- This station was constructed in two phases. The first phase consists of four units each rated 300 MW, with boilers firing coal dust, gas, mazut, gas and coal dust or coal dust and mazut. The phase two consists of three units each rated 800 MW, with boilers firing mazut, gas or mazut and gas.

- The 800 MW boilers operate as a pressurized furnace with FD fans only in operation. The ID fans and Electrostatic Precipitator (ESP) are not included, therefore the gases are exhausted directly into the chimney. There are high gas leakages, vanadium corrosion and high atmospheric emissions.

- This station is relatively new with the phase one commissioned 1972-1973 and the phase two 1975-1977.

- The station reported the major equipment such as boilers, turbines and generators in good shape.

- Plans are in place to continue work of replacing heating surfaces of all boilers and to address the major problem of final stage blading erosion on both 300 MW and 800 MW turbines. At this time, due to 800 MW boiler heating surface deterioration, each unit is derated by 50 MW to a nominal rating of 750 MW.

- The economic operation of the 300 MW boiler depends on operation with liquid slag. When high ash content coal is fired, the rate of producing the liquid slag in the bottom of the boiler is higher than the collection rate of the slag from the boiler hopper. The boiler decreases its capacity to 60% and has to be shutdown in order to manually remove the slag from the bottom of the boiler. Thus the boiler has to be stopped and started again after slag removal. The boiler does not have any instrumentation to monitor slag formation and its level, and furnace temperature for ash fusion temperature that must be maintained less than 1280°C.

- The boilers have no burner management systems.

- The station has no NO_x pollution control system.

- The plant operates continuously on base load mode, with maximum MW's output during the day starting at 7 AM, and at night and weekends reduced to MW's output required by central dispatch center.

- Most of the process control systems are operated on "manual" mode from the Control Board located in Unit Control room. However, the temperature and pressure of the main steam at the boiler outlet are automatically maintained constant.

- The station is interested in using new automatic controls for the entire plant.

- Some new instrumentation including vibration monitoring equipment have been provided on 800 MW units.

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

- Because the stack heights 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 approximately 30 suppliers. The station has little input to the quality selected for the coal or control over fuel acquisitions.

- The coal delivered to the plant does not match original 300 MW boiler design requirements, thus reducing boiler efficiency and increasing maintenance. In addition the poor quality of coal increases the air pollution and causes severe problems of boiler slagging and reduction of MW's output to 240-250 MW. Mazut or gas has to be cofired to deliver maximum MW's output if required by the central dispatch center.

- The four 300 MW units are furnished with ESP's that are reported operating unsatisfactory.

- Both coal and oil have very high levels of sulphur content, but the station does not have any provisions for SO_2 reduction equipment.

- The efficiency calculations are performed on a per unit basis. The mazut and natural gas fuel quantities are measured per boiler. The coal fuel quantities per boiler are extrapolated from power station data. These efficiencies are compared to the efficiency calculated based upon the boiler design performance recalculated in 1981.

- The station is worried about spare parts for any equipment installed under the energy saving program. The station suggests 5 year spare parts supply.

INTRODUCTION

ENERGO SYSTEM:	DONBASSENERGO
LOCATION:	50 KM NORTH-EAST OF DONETSK
INSTALLED CAPACITY:	3600 MW 4 X 300 MW + 3 X 800 MW
COMMISSIONED:	4 X 300 MW 1972-1973 (FIRST PHASE) 3 X 800 MW 1975-1977 (SECOND PHASE)
FUEL TYPE:	4 X 300 MW; COAL, GAS, MAZUT, COAL & GAS OR COAL & MAZUT 3 X 800 MW; GAS, MAZUT OR GAS & MAZUT

POWER PLANT DESCRIPTION

1. The Uglegorsk station was constructed in two phases. The first phase was commissioned between December 1972 and December 1973. The second phase was commissioned between December 1975 and December 1977. Phase one consists of 4x300 MW boilers (TPP-312A) manufactured by Taganrog producing steam at 1000 tons/hr at 255 bar gauge and 545°C live steam conditions. Generators and turbines were produced in Kharkov. The boilers burn only coal dust, only natural gas, only mazut, coal dust and natural gas or coal dust and mazut. The 300 MW boiler description is shown on Attachment 1. Phase two consists of 3x800 MW boilers (TGMP-204) manufactured in Taganrog producing steam at 2680 tons/hr at 255 bar gauge and 545°F live steam conditions. Generators and turbines were produced in Leningrad. The boiler is of the suspended type with balanced draft combustion by design but currently operates as a pressurized furnace with FD fans only in operation. The ID fans were removed. The boilers burn only mazut, only natural gas or mazut and natural gas.

2. The 800 MW boilers operate with over pressure in the fuel chamber of 400 kg/m^2. Efficiency depends on the mode of operation and ranges from 92-94%. The station is interested in control devices in order to have the possibility to operate in different modes of operation. When using alternative modes of operation efficiency drops 2-3%.

3. The station is interested in using a new system of automatic control of the whole plant. The major equipment such as boilers, turbines and generators are in good shape. The automation system should be renovated.

4. The station is worried about spare parts for any equipment we will install for improving combustion efficiency. Station proposes that within allocated funds quantity of devices to be decreased in order to have additional spare parts. Spare parts should be provided for five years. The existing station equipment was made in Ukraine and Russia.

5. The station is interested in control system for coal dust mill and to control particle size. They also would like to measure coal dust flow to burners and control automatically quality of coal for ash and water.

6. The station also wants to monitor incomplete combustion by measuring NO_x, SO_2 and O_2. The station has continuous O_2 analyzers which they think are good. They would also like to monitor hot particles in emissions (opacity monitor).

7. Since the analysis of coal takes great amount of time the station is interested in including the express analysis of coal in the low cost program.

8. At present time the station measures O_2 and CO in-situ in every boiler. They measure SO_2 and NO_x with a portable device for which only one exists in the whole of Donbassenergo system.

9. The 300 MW boiler (TPP-312A) has eight burners and 2 coal dust systems for each boiler. The volatility of the coal is 43%. The content of O_2 after the forced draft fan is 16%. The precipitator is 98.5% efficient. Temperature of air after airheater is 140°C. Exhaust gas at 140°C is directed to mill during startup. The water content of the coal is 8-16%. During normal operation of the mill, hot gases and hot air are directed to the mill. The amount of hot gases and air is based upon 16% O_2 content If the O_2 content becomes greater than 19% an explosion could occur. There is a monitoring and protection system associated with the mill. The input temperature to the mill is 400°C. The temperature output of the 100 ton/hr mill is 90°C. When output temperature of the mill is 110°C coal and gas are switched off. Output temperature of a safe operation of the mill is 70-90°C. If the output temperature is less than 70°C the coal dust becomes too dry.

   The primary air mixes with coal dust and is sent to burners There are 16 coal dust feeders. Each coal dust feeder has its own pipeline, and each burner is fed from two pipelines. Each pipeline has its own venturi to measure flow. The amount of coal dust is a function of feeder speed which is monitored continuously via motor amperage. The operator can adjust speed of feeder manually or automatically.

Typically 10 tons/hr are fed through each feeder with a normal range from 9-11 ton/hr.

The O_2 content of the exhaust gas after the water economizer and before air heater is 3%. The range of O_2 is controlled $\pm .5\%$ by changing the speed of the feeder to increase or decrease flow of coal.

10. The exhaust gas temperature before the convection pass is monitored by chromel-allumel thermocouples to be around 900°C. If the temperature is not maintained around 900°C pipes in convection pass could become sludged. The maximum allowable temperature is 950°C. This temperature is controlled by the amount of recirculating gas. It is the decision of the operator either to increase amount of the recirculation gas or decrease amount of the fuel thus to decrease the boiler capacity.

    There is stable operation of burners for: O_2 equal to 2.8 to 3.3%, and exhaust gas temperature equal to 890°C to 910°C. The operation of burners is unstable with exhaust gas temperature at 870°C and 930°C.

11. Economic operation of the boiler depends on operation with liquid slag. When coal of high ash content is burned the amount of liquid slag that is produced increases. If slag zone is full the capacity of the boiler must be decreased to 60% and the slag would be removed manually. The station would like to have <u>optical control of liquid slag</u> to be able to monitor formation of slag in boiler hopper, to avoid stop and start of the boiler for slag removal.

    When the ash content of fuel is 20% the production of slag will be 10 ton/hr which is normal. When ash content of fuel increases to 30% production of slag increases to 14 ton/hr. The boiler can still operate normally because of the capacity of slag zone If ash content of fuel is greater than 30% formation of slag will be higher than 14 ton/hr and plant load must be reduced to 240 MW to keep slag formation at 14 ton/hr. Since the time of the analysis for fuel ash content is too long (2 to 3 days), it is a need to have an optical control of slag formation and level.

    If the ash fusion temperature is less than 1280°C there is no problem. If temperature is above 1500°C there is a problem. Presently, this temperature is not monitored.

    Slag formed is cooled by water and together with precipitator flyash pumped to an ash storage pond 5 km from station. This mixture of slag and flyash can be used to produce cement or road surfaces.

<u>BOILER PLANT</u>

12. Boiler Design Performance:

a. The 1981 revised Type TPP-312A (300 MW) boiler design performance is shown on Reference 1. The original boiler design was based upon firing 5,500 kcal/kg coal. This revised calculation assumes a coal caloric value of 3,978 kcal/kg.

b. The Type TGMP-204 (800 MW) boiler design performance firing mazut is shown on Attachment 2 and Reference 2. The original boiler design was based on all mazut firing. The boilers were reconstructed to fire natural gas (only burners). Boilers were then fired on natural gas to determine the performance. The boiler performance on natural gas is shown on Reference 3.

13. Mode of Fuel Firing:

a. 300 MW Units:

i. Mazut Only or Natural Gas Only (60-100% load).

ii. Natural Gas and Coal:

1. Content of fuel - equal to or greater than 60% coal, equal or less than 40% natural gas.

2. Concerned with slag removal if ratio as discussed in a.ii.1. above is not maintained.

3. Try to burn more natural gas than coal, when available. However, if cofiring coal and natural gas must maintain the ratio as discussed in a.ii.1. above because of concern with slag removal.

b. 800 MW Units:

i. Mazut Only:

1. Mazut all 3 levels of burners (30-100% load)

ii. Natural Gas Only:

1. Natural gas first and second level of burners, third level of burners only air (30-100% load).

2. Step by step to prevent CO formation

105

iii. Natural Gas and Mazut (32-100% load):

1. Mode 1- first level natural gas, second and third level of burners mazut.

2. Mode 2 - first and second level natural gas, third level of burners mazut.

iv. Normal operation is either natural gas or mazut. Combination is not normal and only during winter time.

14. As-Fired Fuel Analysis

a. Coal:

i. Coal is supplied to the station by approximately 30 suppliers.

ii. Volatility content of coal is not measured because it doesn't affect the price of coal and is taken from suppliers certificates. Average coal volatility is 35 to 45%.

iii. Coal samples are taken once per shift and then taken for five days. Coal analysis is done by the station once every five days on mixed samples taken for five days.

iv. Coal in storage yard is mixed to try to get consistent quality of coal to all boilers.

v. Coal minimum, maximum, and average typical analysis for 1993 and 1994 is shown on Attachment 3.

c. Natural Gas:

i. Natural gas heating value analysis is done once a week If quality of natural gas gets worse increasing quantity of natural gas fired then immediately an analysis is done.

ii. Natural gas minimum, maximum and average typical analysis for 1993 and 1994 is shown on Attachment 4.

c. Mazut.

i. Mazut is delivered in railroad tank cars and samples taken and analyzed to compare to certificate.

106

ii. Mazut samples are taken once per shift with mazut analysis being done once every 30 days.

iii. Mazut minimum, maximum and average typical analysis for 1993 and 1994 is shown on Attachment 4.

15. Boiler As-Fired Fuel Performance:

a. 300 MW Units:

i. When no natural gas can be used, coal with a caloric value of greater than 4,500 kcal/kg is used to reach 300 MW.

ii. Minimum caloric value of coal delivered is 3600 kcal/kg. In this case natural gas is cofired with coal: 80% coal, and 20% natural gas to reach nominal 300 MW.

iii. If the coal's caloric value is less than 4500 kcal/kg capacity of unit is decreased. With 3,600 kcal/kg coal the capacity of unit is reduced to 240-250 MW. If dispatch asks for maximum capacity, the coal is cofired with natural gas or mazut as discussed in a.ii. above to reach nominal capacity.

iv. Natural gas cofiring is preferred if it is available. However, during the winter the natural gas is replaced by mazut for peaking load operation only. If base load operation, only coal is fired and the unit is reduced at 80% capacity, as discussed in a.iii. above. Coal and mazut are fired at the same burners.

v. When coal is 4500 kcal/kg boiler efficiency at normal capacity is 92%. When coal is 5500 kcal/kg boiler efficiency is 94%.

vi. Natural gas is basically always fired because the caloric value of the coal is usually less than 4500 kcal/kg as discussed in the as-fired fuel analysis, item 14.

vii. The boiler can reach 100% capacity when firing either natural gas or mazut.

b. The 800 MW units can produce 800 MW's firing natural gas, mazut or a combination of fuels. Since August 1993 only natural gas has been fired.

197

16. Boiler Firing System Flow Diagram

a. Units 1-4 type TPP-312A (300 MW) boilers - as shown on Attachments 5 and 6. There are eight burners and two coal dust systems per boiler. Each coal dust system consists of a raw coal bunker, one mill, one separator and one cyclone. There is one coal dust bunker for each boiler. There are sixteen coal dust feeders, with each burner being fed by two coal dust feeders. See item 9 for additional details.

b. Units 5-7 type TGMP-204 (800 MW) boilers - are mazut and natural gas fired units. Due to pressurized furnace operation with only forced draft fans operating and no precipitators the 800 MW units have a major problem with leakages, vanadium corrosion, and high atmospheric emissions. The units are derated 50 MW because of boiler heating surface deterioration.

17. Section/Plan View of Boilers:

a. References 4, 5 and 6 (drawings 08.8008001, 08.8028.014, K-593467) are the section views of the type TPP-312A (300 MW) boilers.

b. References 7 and 8 (drawings 08.8028015, 08.0918.016) are the section views of the type TGMP-204 (800 MW) boilers.

FUEL SUPPLY

18. Flow Diagrams for Fuel Supply:

a. Mazut:

i. Attachment 7 is the mazut flow diagram for the type TPP-312A (300 MW) boilers. Reference 9 is the flow diagram for the type TGMP-204 (800 MW) boilers.

ii. Attachment 8 is the mazut flow diagram associated with the mazut unloading and mazut storage tanks.

iii. The mazut fired is measured at each boiler. The flow meters are inaccurate for first 30% of the scale but the rest is accurate

b. Natural Gas:

i. Attachment 9 is the natural gas flow diagram for the type TPP-312A (300 MW) boilers. Reference 10 is the flow diagram for the type TGMP-204 (800 MW) boilers.

ii. The natural gas fired is measured at each boiler. The flow meters are inaccurate for the first 30% of the scale but the rest is accurate.

c. Coal:

There are two conveyors one operating, one standby feeding units 1 to 4 type TPP-312A (300 MW) boilers. The total weight of coal going to all four boilers is measured continuously on either one of the conveyors.

PLANT OPERATION MODE

19. 300 MW Units:

a. During day starting 7 AM all units operate at 300 MW's.

b. At night and weekends all units operate at 200 MW's.

20. 800 MW Units:

a. During day starting 7 AM all units operate at 750 MW's.

b. At night all units operate at 450 MW's.

c. During weekends all units average at 500-600 MW.

COMBUSTION CONTROL

21. Reference 11 details the combustion control scheme for mazut firing. Reference 12 details the combustion control scheme for coal firing. In principle, the temperature and pressure of the main steam at the boiler outlet is automatically maintained constant. Load is changed by manually varying the fuel flow to the boilers. Basically, the combustion control scheme for coal firing is a manual operation. The speed of coal feeders is adjusted manually from the control board. Forced draft fan dampers are manually operated from the control board to adjust fuel to air ratio. An O_2 indicating and recording instrument assists the operator in setting the correct combustion air flow rate.

22. CO and O_2 Analyzers:

a. All units have two CO analyzers per unit as shown on Attachment 10 which are located after the economizer.

b. All units have two O_2 analyzers except Unit 7 which has four. All units have two O_2 analyzers located after the economizer. In addition, Unit 7 has

additional two O_2 analyzers located in a higher temperature area of the convection pass.

c. The station would like to locate the new O_2 analyzers in a higher temperature area of the convection pass.

d. The existing O_2 analyzers with electrochemical cells are accurate with either natural gas or mazut fired but not both.

CALCULATION OF BOILER EFFICIENCY

23. The methodology for the boiler efficiency calculation is shown on References 13, 14, 15 and 16 for December 1993, and February, May and August 1994 respectively. The calculations are done on a per unit basis. The mazut and natural gas fuel quantities are measured per boiler. The coal fuel quantities per boiler are extrapolated from power station data. The calculation of efficiency is once a month and the average fuel data are used for natural gas, mazut and coal. These efficiencies are compared to the efficiencies calculated based upon the boiler design performance as discussed in item 12.

Attachment 11 shows the metric tons per standard fuel (i.e., heating value for fuel is 7,000 kcal/kg) fired in 1993.

FUTURE PLANS

24. The station has plans to install gas turbines for a repowering program of the 800 MW units. A Siemens 200 MW gas turbine prototype is under consideration

NOTE: See Project File for References 1 to 16.

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 (see Attachment 12):

1. Devices to measure consumption of coal dust and air mixture per burner Eight devices per 300 MW boiler - 32 devices total per station.

2. Devices to measure consumption of raw coal before ball mills located any place between mill and raw coal bunker. Two devices per 300 MW boiler - 8 devices total per station.

3. Temperature of furnace - continuous monitoring for 300 MW units; two per boiler (500 - 2000°C) - 8 devices total per station. Slag removal depends on this monitoring.

4. Measurements of ash and water content of coal supplied to mill. Two per 300 MW boiler - 8 devices total per station.

5. Optical device to monitor the process of liquid slag removal (video camera). Two per 300 MW boiler - 8 devices total per station.

6. Portable device for instantaneous analysis of combustion: SO_2, NO_x, CO, O_2 in ductwork going to the stack. One per station.

7. In-situ device for continuous monitoring of O_2, CO, NO_x. One per boiler - 7 devices total per station.

8. Continuous monitoring of O_2 content in boiler outlet. Two per boiler - 14 devices total per station.

9. Continuous monitoring of hard particles (dust content) after precipitator - portable, in-situ or both. Portable-one per station. In-situ two per 300 MW boiler - 8 devices total per station.

Заводская модель ТПП-312 А на закритические параметры пара спроектирован и изготовлен Таганрогским котельным заводом " Красный котельщик".

300 MW

UGLEGORSKAYA

Расчетные параметры котла:

Номинальная производительность - 1000 т/час
Давление первичного пара - 255 ати.
Температура первичного пара - 545°С.
Расход вторичного пара - 850 т/час.
Давление на выходе из промежуточного пароперегревателя- 40,5 ат
Температура пара на выходе из промежуточного пароперегревателя - 565°С.
Температура питательной воды - 265°С.
Температура горячего воздуха (при температуре воздуха перед РВП 30°С):
а) первичного - 287°С
б) вторичного - 370°С
К.П.Д. котла "брутто" - 90,65 %

Котел выполнен однокорпусным с П-образной компановкой и состоит из топочной камеры и конвективной шахты, соединенных в верхней части горизонтальным газоходом.

Топочная камера экранирована трубами радиационных поверхностей нагрева: нижней радиационной части (НРЧ), средней радиационной части I и II (СРЧ) и верхней радиационной части (ВРЧ).

В верхней части топки и в поворотной камере размещены: фронтов и потолочный пароперегреватели, ширма I и II ступени (ШПП), экран по воротной камеры (ЭПК).

Топка котла оборудована 8 горелками, расположенными на фронтовой и задней стенке в один ярус на отметке 8,9 м.

Техническая характеристика горелки:
Выходное сечение по первичному воздуха - 0,311 м^2
Выходное сечение по вторичному воздуху - 1,334 м^2
Выходное сечение по внутреннему каналу - 0,61 м^2
Выходное сечение по наружному каналу - 0,724 м^2
Выходное сечение по сбросному воздуху - 0,071 м^2
Выходное сечение по газу - 0,119 м^2.

Скорость первичного воздуха при работе на ПСШ - 32,7 м
Скорость первичного воздуха при работе на газе - 37 м
Скорость газа на выходе из горелки - 150 м/сек

BEST AVAILABLE COPY

BEST AVAILABLE COPY

ПРИЛОЖЕНИЕ 1 112

В конвективной шахте по ходу газов расположены: конвективный пароперегреватель сверхкритического давления (КПП СКД), промежуточный пароперегреватель I и II ступени (КПП НД), водяной экономайзер (ВЭ). Последняя поверхность нагрева - два регенеративных воздухоподогревателя типа РВП-98 вынесены за пределы конвективной шахты котла. Подача воздуха в котел осуществляется двумя дутьевыми вентиляторами типа ВДН-32Б расчетной производительностью 456x10^3 м^3// час и напором 630/354 кгс/м^2 каждый.

Дымовые газы из котла удаляются двумя осевыми дымососами типа ДОД-31,5 производительностью 967x10^{3}м^3/ час и напором 390 кгс/м^2 каждый.

Для снижения температуры дымовых газов вверху топки с целью снижения шлакования ширмового пароперегревателя установлены два дымососа рециркуляции дымовых газов типа ГД-200-500У. Отбор газов на рециркуляцию взят после водяного экономайзера.

Очистка дымовых газов осуществляется в двух электрофильтрах типа ЭГА-3-177. На котле выполнена гидравлическая система шлакоудаления.

Котлоагрегат оборудован двумя индивидуальными замкнутыми системами пылеприготовления, расположенными с фронта котла с одним бункером пыли.

Размол угля производится в шаровых барабанных мельницах типа Ш-50А. Производительность каждой мельницы 75,6 т/час (по ГОСТ).

Высушенный и размолотый уголь в виде пыли отсасывается мельничным вентилятором типа ВМ-180-1100 производительностью 17x10^3 м^3 / час и напором Н=1265 кгс/м^2 в бункер пыли, проходя последовательно через сепаратор ø 5500 ТКЗ-ВТИ и циклон НИИОГАЗ ø 4250 мм.
На котле 16 лопастных пылепитателей типа УЛПП - 64 - 2. К горелке пыль транспортируется через пылепроводы ø 630x10.

Регулирование температуры пара высокого давления за котлом осуществляется изменением соотношения топлива и воды, подрегулировка - с помощью впрысков.
При временном повышении температуры вторичного пара используется аварийный впрыск.

Подача газа в котельную осуществляется от 2-х ГРП производительностью 120000 нм^3/ час каждый. Подача газа к котлу в расчетном режиме осуществляется по трубопроводу Ду 400 с расчетной производительностью 20000 нм^3/час, в режиме несения нагрузки - по двум трубопроводам Ду 600 расчетной производительностью 40000 нм^3/час.

Подача газа в топку котла в каждой горелке производится через 45 труб Ду 30, установленных во внутреннем канале вторичного воздуха

BEST AVAILABLE COPY
BEST AVAILABLE COPY

I. Введение

800MW MAZUT ATTACHMENT 2

Паровой газоплотный однокорпусной котлоагрегат ПП-2650/255, типа ТПП-204, спроектирован для работы под наддувом и предназначен для работы в блоке с турбоагрегатом К-800-240-3 ЛМЗ и генератором ТВВ-800-2.

Котельный агрегат производительностью 2650 т/час расчитан на сжигание мазута с Q_p^H = 9330 Ккал/кг с параметрами:

1. Давление острого пара - 255 ата.
2. Температура острого пара - 545°С.
3. Давление вторичного пара - 36,5 ата.
4. Температура вторичного пара - 545°С.
5. Расход вторичного пара - 2180 т/час.
6. Температура питательной воды - 273°С.

Однокорпусный котельный агрегат выполнен по П-образной компоновке поверхностей нагрева и состоит из трёх газоходов: топочной камеры, горизонтального переходного газохода и конвективной шахты. Все стены газоходов котла экранированы газоплотными панелями. В горизонтальном переходном газоходе последовательно по ходу газов расположены вирны, две ступени КПП вд и одна выходная ступень КПП нд. В конвективной шахте сверху вниз последовательно по ходу газов расположены в два ярусы пакеты промежуточной и регулирующей ступени пароперегревателя и водяной экономайзер.

Газоплотное исполнение котлоагрегата, достигнутое применением цельносварных экранов, позволяет работать под наддувом и организовать сжигание мазута с избытками воздуха I,02÷ I,03 в широком диапазоне нагрузок. Существующее положение предопределяет целый ряд преимуществ: увеличения к.п.д. котла за счёт уменьшения потерь с уходящими газами, уменьшение расхода электроэнергии на собственные нужды, уменьшение коррозии поверхностей нагрева и пр.

BEST AVAILABLE COPY

При решении одной из основных задач - повышение надёжности экранов нижней части топочной камеры (НРЧ,СРЧ) применены эффективные способы снижения локальных тепловых потоков - рециркуляция дымовых газов в нижнюю часть топки (в горелочные устройства) в количестве около 15% при номинальной нагрузке и увеличение массовых скоростей среды в трубах НРЧ до 2000 кг/м²сек
Одновременно рециркуляция газов решает ряд других задач: снижает содержание окислов азота, уменьшает разность температур между сварными трубами, является одним из основных способов регулирования температуры пароперегрева, уменьшает температурную разверку по ширине котла.

Существенным отличием котлоагрегата ТПП-204 от ранее выпускаемых является создание специального горелочного устройства, в котором раздача воздуха и газов рециркуляции на форсунки осуществляется через общий короб при отсутствии какой-либо подрегулировки между отдельными горелками. На котлоагрегате установлены два горелочных короба на фронтовой и задней стенке топки,количество горелок в каждом коробе 18 шт. Расположение горелок трехярусное.

Котёл разработан без собственного несущего каркаса с подвеской всех его элементов к металлоконструкциям котельной. Для этой цели между рядами "В" и "Г" переброшены три хребтовые балки,опирающиеся на колонны здания. Усилия от наддува воспринимается специальным обвязочным каркасом.

Очистка поверхностей нагрева расположенных в горизонтальном газоходе предусмотрена с помощью глубоковыдвижных аппаратов, очистка конвективной шахты - дробеочисткой с пневмосбросом.

Наддув в котлоагрегате создаётся с помощью 2-х турбовоздуходувок типа ВНД-36х2 производительностью $155 \cdot 10^3$ м³/час в количестве резерва для работы на уравновешенной тяге.

BEST AVAILABLE COPY

115

Установлены два дымососа типа ДОД-43 производительностью 1530. 10^3 $м^3$/час.

Подача газов рециркуляции в нижнюю и верхнюю часть топочной камеры осуществляется двумя дымососами рециркуляции типа ГД-26х2 производительностью 565·10^3 $м^3$/час.

Подогрев воздуха производится в четырёх регенеративных вращающихся воздухоподогревателях типа РВП-98.

Управление котельным агрегатом осуществляется с блочного щита управления (БЩУ) как дистанционно так и автоматически, в диапазоне нагрузок по расходу питательной воды от 30% до номинальной. При работе котла в автоматическом режиме предусмотрены следующие авторегуляторы: регулятор топлива, регулятор общего воздуха, регулятор разряжения (при работе под разрежением), регулятор выравнивания температур среды по потокам, регулятор питания, регулятор температуры перегретого пара, регулятор рециркуляции дымных газов, регулятор наддува потолка, регулятор РОУ пара на обдувку. В пусковом режиме предусмотрена частичная автоматизация: регулятор распределения воды по потокам, регулятор давления перед встроенными задвижками, регулятор перепада давлений на клапанах растопочных впрысков, регулятор сброса из встроенных сепараторов, регуляторы температуры первичного и вторичного пара, регулятор расхолаживания котла.

Для расчёта технико-экономических показателей регистрации событий в аварийные периоды, контроля сигнализации и передачи информации к устройствам АСУ на энергоблоке 800 МВт выполнена информационно-вычислительная система (ИВС) "Комплекс АСВТ".

Котел ТГМП-204 спроектирован как высокоэкономичный агрегат: в диапазоне нагрузок 30 ÷ 100% $Д_{пом}$, к.п.д. котла "брутто" составляет 94 ÷ 95%.

BEST AVAILABLE COPY

116

BEST AVAILABLE COPY

К-826 6

таблица N

Основные данные теплового расчета котла ТГМП-204 на мазуте $Q_p^н = 9330$ ккал/кг

Наименование	размерн	нагрузка %			
		100	70	50	30
2	3	4	5	6	7
Расход первичного пара	т/час	2650	1850	1325	800
Температура первичного пара за котлом	°С	545	545	545	545
Температура питательной воды	—"—	273	250	230	200
Тепловосприятие первичного пара	ккал/час	$1344.35 \cdot 10^6$	$990.3 \cdot 10^6$	$739.7 \cdot 10^6$	$472.6 \cdot 10$
Расход вторичного пара	т/час	2180	1540	1100	680
Температура вторичного пара на входе	°С	291	275	268	255
Температура вторичного пара на выходе	—"—	545	545	545	520
Тепловосприятие вторичного пара	ккал/час	$317.4 \cdot 10^6$	$231 \cdot 10^6$	$164 \cdot 10^6$	$93.2 \cdot 10$
Температура холодного воздуха	°С	30	30	30	30
Температура горячего воздуха	—"—	339	312	286	251
Температура воздуха после калориферов	—"—	50	50	50	50
Температура уходящих газов	—"—	127	116	106	92
Избыток воздуха в уходящих газах		1,23	1,27	1,31	1,514

BEST AVAILABLE COPY

Продолжение таблицы

1	2	3	4	5	6	7
14	Потеря тепла с уходящими газами	%	4,68	4,24	3,85	3,62
15	Потеря тепла от химнедожога	—"—	0,5	0,5	0,5	0,5
16	Потеря тепла в окружающую среду	—"—	0,2	0,286	0,4	0,66
17	Сумма потерь	—"—	5,33	5,026	4,75	4,783
18	КПД котельного агрегата („брутто")	—"—	94,67	94,974	95,25	95,21
19	Расход топлива	т/час	185,3	136	100,1	62,6
20	Теоретическая температура горения	°С	2061	1860	1740	159
21	Температура газов на выходе из топки	—"—	1350	1225	1117	914
22	Доля рециркуляции вниз топки		0,15	0,30	0,40	0,4
23	Доля рециркуляции вверх топки		0,05	0,05	0,05	0,0
24	Температура газов рециркуляции	°С	391	357	326	28
25	Температура газов на входе в ширмы	—"—	1311	1195	1091	95
26	Температура газов на выходе из ширм	—"—	1176	1063	962	82
27	Температура газов на выходе КПП ВД (входного)	—"—	1059	960	870	75
28	Температура газов на выходе КПП ВД (выходного)	—"—	899	812	752	66

BEST AVAILABLE COPY

продолжение таблицы

1	2	3	4	5	6	7
29	Температура газов на выходе КПП НД (выходного)	°С	816	752	696	62[illegible]
30	Температура газов за поворотной камерой	—"—	767	704	652	58[illegible]
31	Температура газов за промежут. ступенью пароперегр.	—"—	592	550	519	47[illegible]
32	Температура газов за регулирующей поверхностью	—"—	523	481	440	40[illegible]
33	Температура газов за водяным экономайзером	—"—	391	357	326	28[illegible]
34	Теплонапряжение топочного объема	ккал/м³ час	197.10³	145 10³	106·10³	66,5[illegible]
35	Коэффициент избытка воздуха в топке		1.03	1.03	1,03	1.15
36	Давление в топочной камере	кг/м²	600			
37	Средняя скорость газов в ширмах	м/сек	17,2			
38	—"— —"— —"— КПП ВД (входной)	—"—	17,6	/		
39	—"— —"— —"— КПП ВД (выходной)		18,9			
40	—"— —"— —"— КПП НД (выходной)		20,7			
41	—"— —"— —"— промежуточной ступени пароперегревателя		25,3			
42	—"— —"— —"— регулирующей ступени пароперегревателя		22,1			
43	—"— —"— —"— водяном экономайзере		14,8			
44	—"— —"— —"— РВП хол/горяч.		9,7/11,6			

пл. 6 дм² Авк

ATTACHMENT 3

UGLEGORSK POWER PLANT

COAL ANALYSIS

Parameter	1993 Values*	1994 (8 mo.) Values*
Caloric Value, kcal/kg	4108 ÷ 4505 4358	3952 ÷ 4875 4380
% Ash	25.4 ÷ 33.4 30.17	25.6 ÷ 35.1 30.97
% Water	8.2 ÷ 14.5 10.63	7.0 ÷ 11.8 9.5
% Sulfur	1.29 ÷ 3.66 2.81	1.92 ÷ 4.47 3.25

*Values given are range and average.

ATTACHMENT 4

UGLEGORSK POWER PLANT

MAZUT ANALYSIS

Parameter	1993 Values*	1994 (8 mo.) Values*
Caloric Value, kcal/kg	8693 ÷ 9327 9118	
% Sulfur	2.16 ÷ 3.2 2.46	
% Water	0.03 ÷ 8.6 5.78	

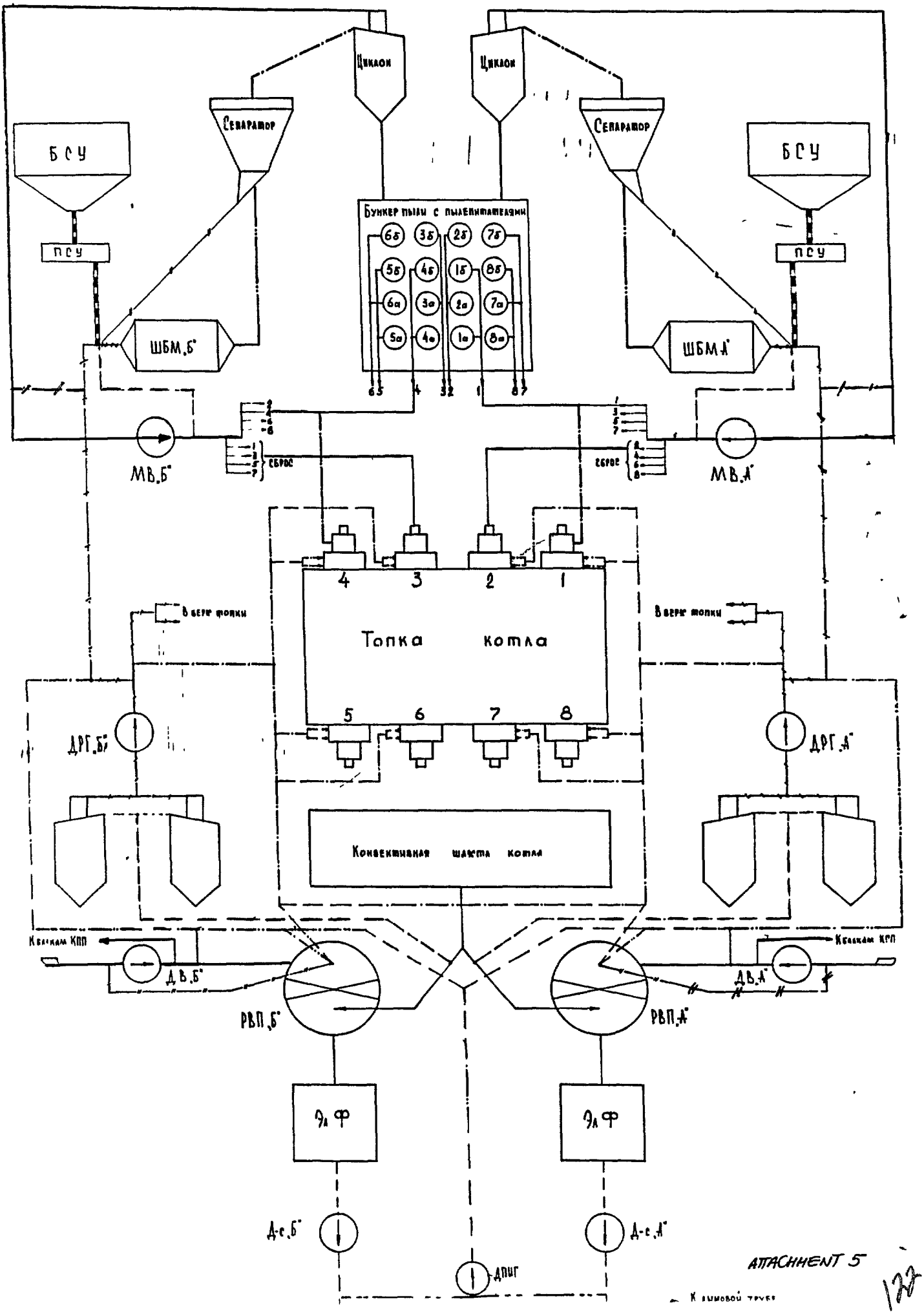
No ash content measurement

NATURAL GAS ANALYSIS

Caloric Value, kcal/kg	7892 ÷ 8102 7993	7712 ÷ 8000 7873
Density, kg/m^3	0.717	0.717

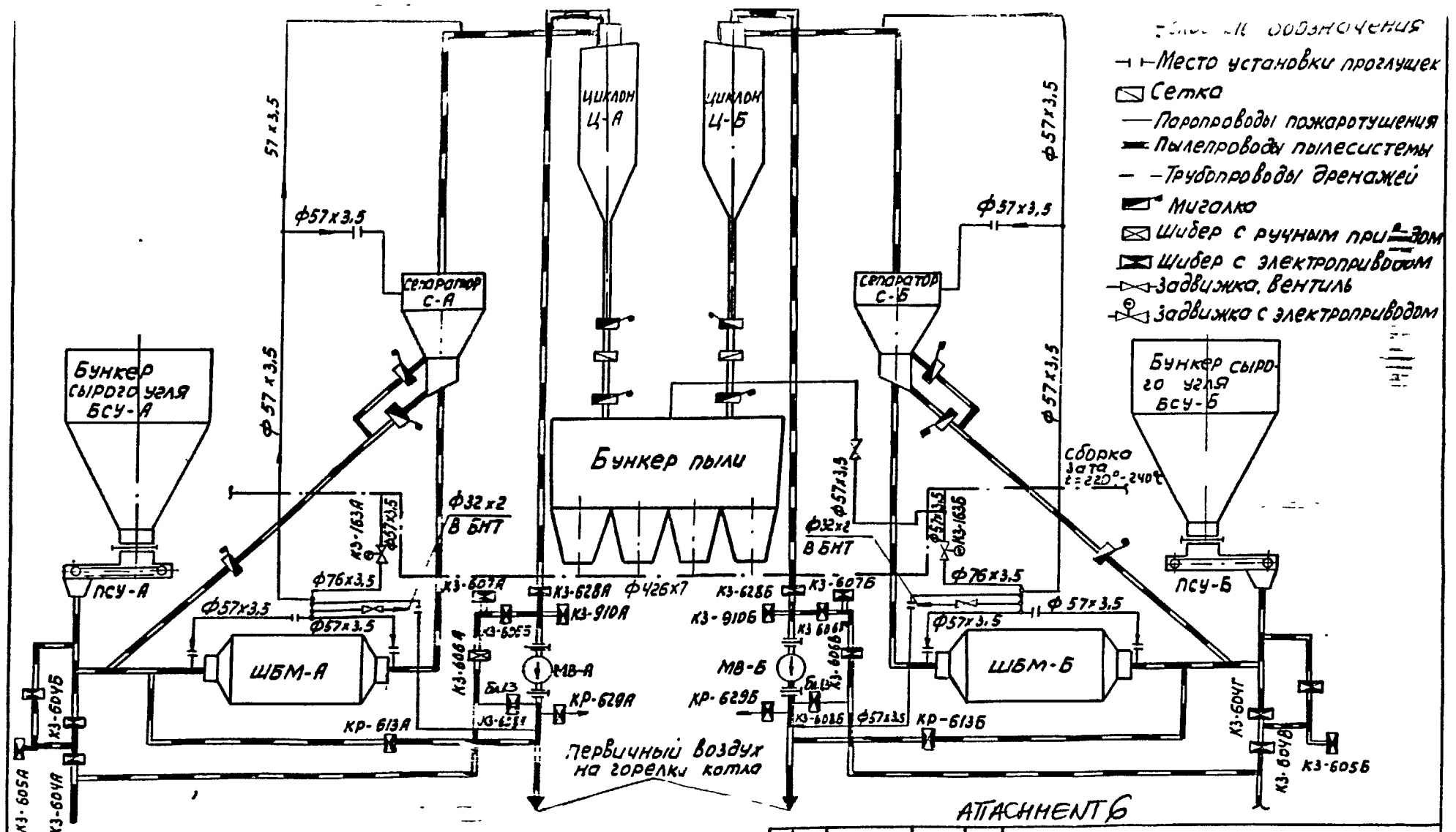
*Values given are ranges and average

Схема пылегазовоздуховодов котла ТПГ-312А



ATTACHMENT 5

127

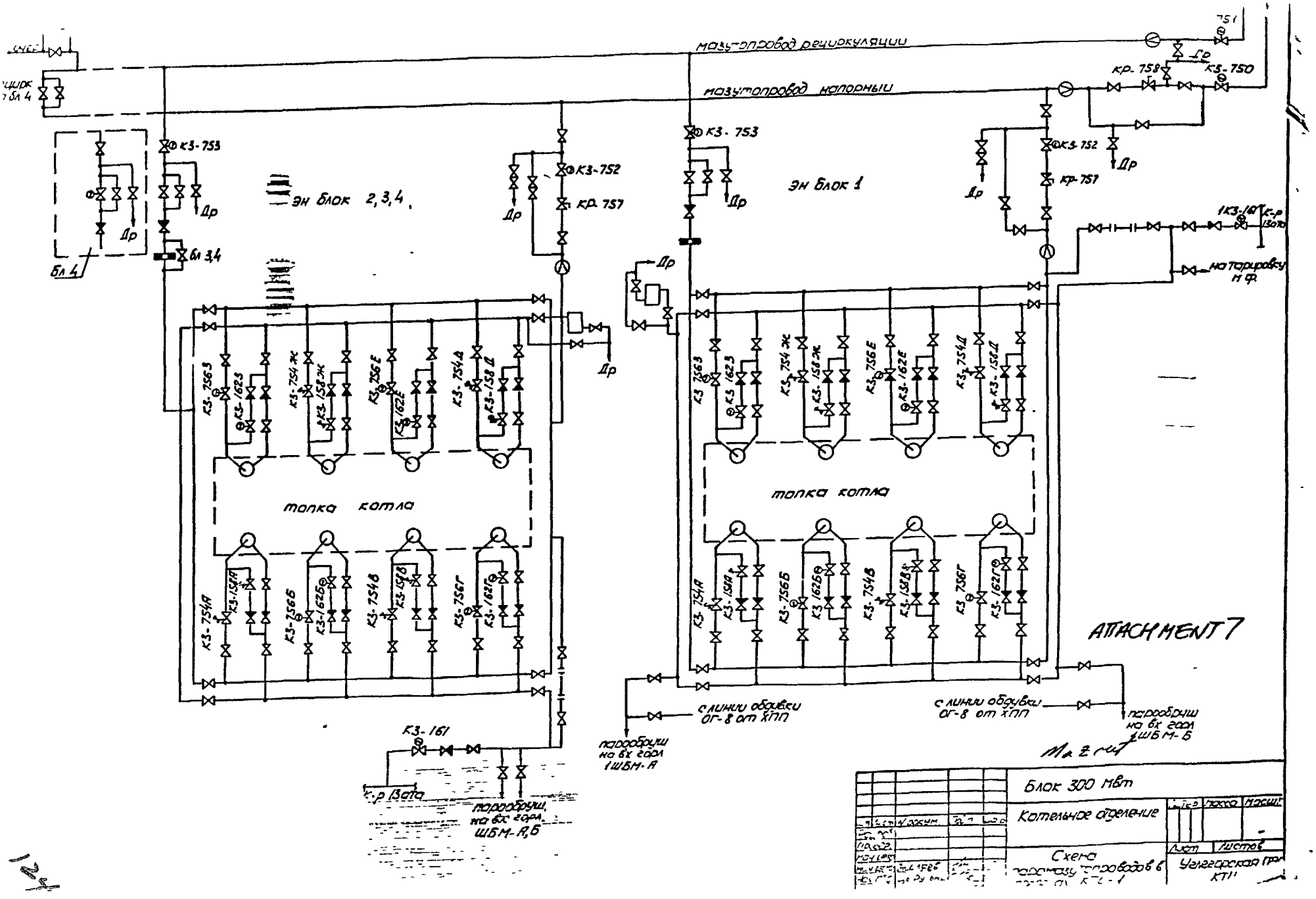


ATTACHMENT 6

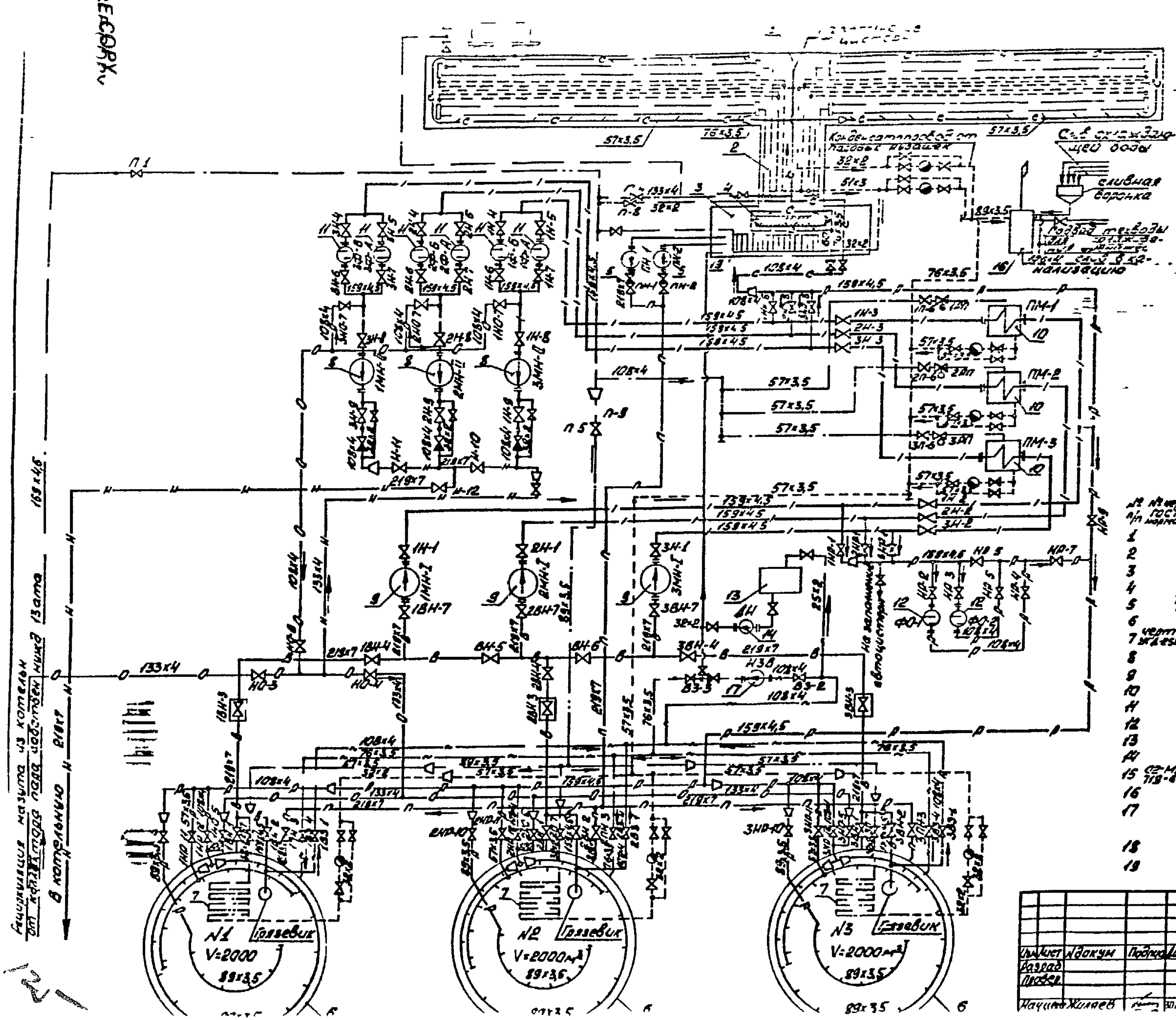
Изм.	Лист	N докум.	Подп.	Дата	Блок 300 МВт ст N 1÷4
Разраб.					Котельное отделение
Провер.					
Н.контр.					Схема

Литер	Масса	Масшт.
Лист	Листов	
Углегорская ГРЭС		

123


мазутопровод рециркуляции
мазутопровод напорный
эн блок 2,3,4
эн блок 1
топка котла
топка котла
К3-753
К3-752
К3-750
кр-758
кр-757
Др
Бл 3,4
Бл 4
К3-161
к-р 13ата
пароотбор на вх гофл ШБМ-А,Б
пароотбор на вх гофл ШБМ-А
пароотбор на вх гофл ШБМ-Б
с линии обдувки ОГ-8 от ХПП
на тарировку м ф
ATTACHMENT 7
Блок 300 МВт
Котельное отделение
Схема паромазутопроводов в б
Волгоградская ГРЭС
КТЦ

BEST AVAILABLE COPY



Условные обозначения

—п—	Напорные мазутопроводы погружных перекачивающих насосов
—б—	Всасывающие мазутопроводы насосов I подъема
—I—	Напорные мазутопроводы насосов I подъема
—Н—	Напорные мазутопроводы насосов II подъема
—о—	Рециркуляция мазута из котельной
—р—	Рециркуляция мазута насосная-мазутохранилища
—с—	Мазутопровод на разогрев мазута сливаемого мазута
—·—	Паропроводы
- - - -	Конденсатопроводы
	Дренажные трубопроводы
	Трубопроводы уплотняющей жидкости
	Направление движения потока
	Электропривод
	Сварное соединение трубопроводов
	Соединение трубопроводов отсутствует
	Фланцевое соединение трубопроводов
	Переход
	Задвижка, вентиль
	Клапан регулирующий
	Конденсатоотводчик
	Клапан обратный
	Задвижка противопожарная
	Связь с атмосферой

Перечень оборудования.

№ п/п	№ черт. ГОСТ нормаль	Наименование	Тип	Параметры	Кол-во
1		Приемно-сливное устройство на 8 цистерн			1
2		Гидрозатвор			1
3		Приемная емкость		120м³	1
4		Фильтр - сетка			1
5		Погружные перекачивающие насосы	8НД 22х6	H:54м в ст	2
6		Мазутный резервуар		V=2000м³	3
7	черт. железа	Подогреватель мазута в резервуаре	змеевиковый		3
8		Мазутонасос II подъема	5Н-5х4	Q:90м³/час H:335м в ст	3
9		Мазутонасос I подъема	8НК 9х1	Q:125м³/час H:65м в ст	3
10		Подогреватель мазута	ПМ 10-30	P:10кгс/см² Q:60м³/час	3
11		Фильтр тонкой очистки	ФМ-10-60	Q:50м³/час	6
12		Фильтр очистки резервуаров	ФМ-10-60	Q:60м³/час	2
13		Дренажный приямок			1
14		Дренажный насос	РЗ-45	Q:33м³/час H:30м в ст	1
15	СТ-МВН 119-64	Бак уплотнительной жидкости		V:4м³	1
16		Насосы уплотнительной жидкости	2,5 ЦВ 1,1М	Q:10м³/час H:190м в ст	2
17		Насос замазученной воды	4НК 5х1	Q:55м³/час H:37м в ст	1
18		Охладитель дренажей			1
19		Подогреватель мазута в приемной емкости	трубчатый		1

Блок 300 мВт

ATTACHMENT 8

Котельное отделение

Схема трубопроводов ма-

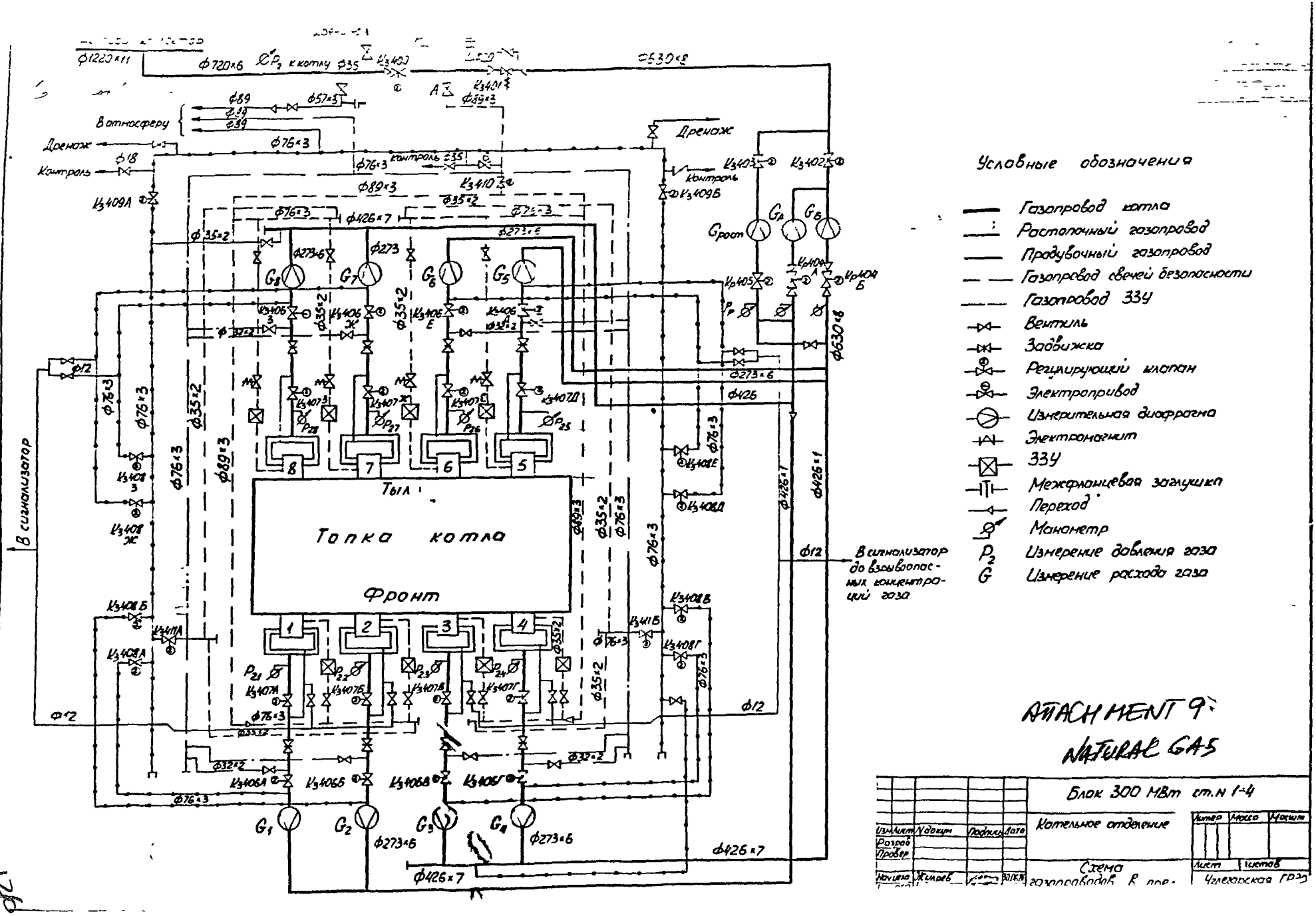
Изм.	Лист	№ докум.	Подпись	Дата
Разраб.				
Провер.				
Нач.	Жилаев			

Литер	Масса	Масштаб

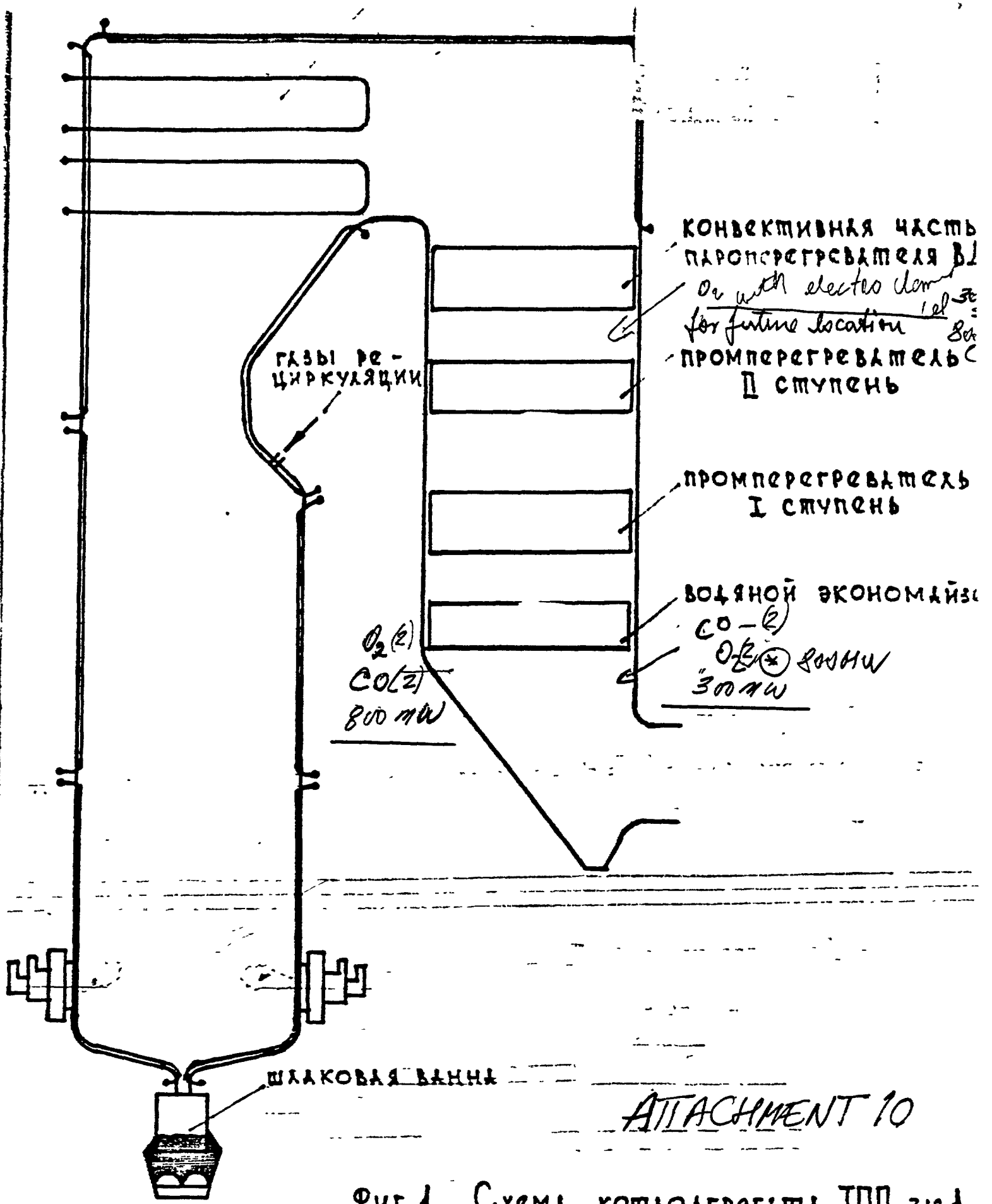
Лист | Листов

Углегорская ГРЭС

BEST AVAILABLE COPY



ATTACHMENT 9:
NATURAL GAS



ATTACHMENT 10

Фиг. 1 Схема котлоагрегата ТПП-312 А

ATTACHMENT 11

UGLEGORSK POWER PLANT

USE OF FUEL 1993

Unit	1	2	3	4	Total for 4 Units	5	6	7	Total for 3 Units	Total Plant
Total, T.Y.T.*	616837	643916	559932	271640	2092325	377950	954278	1118530	2450748	4543083
Coal, T.Y.T.	427458	463375	413242	186121	1490196	-	-	-	-	1490196
Natural Gas, T.Y.T	184884	176461	143981	82580	587906	342131	777483	782029	1901643	2489549
Mazut, T.Y.T.	4495	4080	2709	2939	14223	35819	176795	336501	549115	563338

*Tons of standard fuel at 7000 kcal/kg.

5906-02/Attach/11/14/94

128

Для Углегорской ГРЭС
для улучшения режима горения топлива
необходимо:

I. Переносной прибор для экспресс анализа состава уходящих газов - I шт.

→ 2. Прибор визуального контроля выхода жидкого шлака из летки котла - 2 шт. на I котел. Всего 8 шт.

→ 3. Приборы по измерению расхода угля (пылевоздушной смеси) на котел ТПП/3I2А - на каждую горелку - 8 шт. на I котел.
На 4 котла - 32 шт.

→4. Расход сырого угля на котел - 0-I00т/час - 2шт. на I котел Всего - 8шт.

→ 5. Приборы по измерению температуры в ядре факела от 500 до 2000°С. Всего 8 штук.

6. Прибор по измерению влажности, зольности угля поступающего на мельницу - 2 шт. на I котел. Всего 8 шт.

7. Стационарный прибор для непрерывного контроля состава уходящих газов - 7 шт.

8. Прибор непрерывного контроля O_2 на выходе из котла -I4шт.

9. Прибор запыленности газового потока уходящих газов (переносной - Iшт., стационарный - 8 шт.)

Примечание: порядковый номер соответствует приоритету.

ATTACHMENT 12

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.

130

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

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

WER 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
HTYN	12 X 200	SUBCRITICAL	HIGH BITUMINOUS COAL	LVIVENERGO	1965-1969	ELECTRIC ONLY
OI ROG	10 X 300	SUPERCRITICAL	LOW-BITUM. ANTHRACITE	DNIPROENERGO	1965-1973	ELECTRIC ONLY
~~EROPOL~~	~~2 X 50~~	~~SUBCRITICAL~~	~~GAS~~	~~CRIMEAENERGO~~	~~1958-59~~ ~~1984-86~~	~~CHP (TETs)~~
V	6 X 200 4 X 300	SUBCRITICAL SUPERCRITICAL	LOW-BITUM. ANTHRACITE	KHARKIVENERGO	1960-69	ELECTRIC ONLY
SSA	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

144

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.

145

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

146

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

147

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.

148

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

150

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.

151

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

152

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.

<u>Suns, Mar 5, 1995</u> -Travel to Kiev.

<u>Mon, Mar 6, 1995</u> -Kiev Debrief.

153

- 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

154

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

155

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.

156

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

158

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.

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.

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 Углегорской ТЭС

..... Г.И.Курышко

08.08 .....1997г.

г. Светлодарск

Углегорская ТЭС

АКТ

Начальник ЦТАИ Н.И.Губа, начальник ЦНиИ А.В.Дзекановский, начальник ПТО Ф.П.Цырульник представитель Дон ОРГРЭС В.Ф.Рухляда , представитель фирмы Burns and Roe Enterprises, Inc Джордж Келлер составили настоящий акт об эффективности использования контрольно-измерительных приборов и оборудования , поставленного на Углегорскую ТЭС в рамках проекта " Повышение эффсктивности и надежности энергетических и промышленных предприятий Украины" .

За период с февраля 1995 по май 1997 года на УТЭС поступило следующее оборудование:

- анализатор процесса горения ENERAC 2000
- инфракрасный термометр Cyclops 300AF/300
- инфракрасный термометр MIKRON M90
- двухканальный портативный ультразвуковой расходомер жидкости TransPort PT868
- прибор по измерению эл. мощности в цепях переменного тока до 600 в.
- стационарный кислородомер ZIRTEK
- лабораторный калориметр
- лабораторный анализатор содержания серы в топливе

1. Газоанализатор ENERAC 2000 находится в эксплуатации в цехе наладки и используется для контроля и корректировки процессов горения топлива , для проверки штатных кислородомеров, для периодического контроля соблюдения требований экологической инспекции, для испытаний новых контрольно-измерительных приборов газового анализа котлов.

Экономический эффект от использования прибора ENERAC 2000 за счет сокращения расходов на привлечение специалистов сторонних

организаций , за счет исключения штрафов от экологической инспекции за превышение норм вредных выбросов, за счет повышения эффективности и надежности работы основного котельного оборудования может быть оценен в сумму 45 - 50 тысяч долларов США. в год

2. Инфракрасный термометр Cyclops 300AF/300 находится в эксплуатации в цехе наладки и используется для контроля температур различных поверхностей. Особую ценность этот прибор представляет при контроле температуры поверхности тепловой изоляции паропроводов и поверхности обмуровки котлов. Периодически прибор использовался для контроля температуры выводов генераторов , изоляторов ВЛ , контактов электрооборудования под напряжением, температуры вращающихся частей механизмов. Экономический эффект от использования прибора Cyclops 300AF/300 за счет сокращения потерь тепла в окружающую среду за период эксплуатации на УТЭС можно оценить в 69 тыс. $ США. в год

3. Инфракрасный термометр MIKRON M90 находится в эксплуатации в цехе наладки и используется для периодического контроля температуры в топке котла , температур в летках при затруднениях выхода жидкого шлака , связанного с изменениями характеристик твердого топлива и возможными нарушениями топочного режима. Экономический эффект от его использования виду короткого периода эксплуатации оценить не представляется возможным.

4. Стационарный кислородомер ZIRTEK установлен и включен в работу на котле блока 1 14.07.1997 года. На протяжении 1 месяца опытной эксплуатации проводились эксплуатационные испытания кислородомеров с целью определения эффективности их промышленного внедрения для задач технологического контроля и автоматического регулирования режимов горения в топке котла. При испытаниях получены следующие результаты:

- в среднем на 10% повысилась точность определения коэффициента избытка воздуха , что по предварительным оценкам приводит к повышению КПД котла на 0,1% и к достижению экономического эффекта 30 тыс. $ США в год;
- применение кислородомеров ZIRTEK в система автоматического регулирования по предварительным оценкам позволит повысить КПД котла на 0,2% , что приводит к экономическому эффекту в 60 тыс. $ США в год.

Следует отметить , что более высокий экономический эффект на УТЭС можно получить при использовании кислородомеров ZIRTEK с принудительным разогревом чувствительного элемента.

Более точные результаты экономического эффекта можно получить только после проведения балансовых испытаний котла.

5 Прибор по измерению эл мощности в цепях переменного тока до 600 в

находится в постоянной эксплуатации в электрическом цехе. Экономический эффект от его использования может быть оценен на уровне 1250 $ США в год.

6. Двухканальный портативный ультразвуковой расходомер жидкости TransPort PT868 , лабораторный калориметр, лабораторный анализатор содержания серы в топливе в настоящее время находятся на стадии освоения и оценить экономический эффект от их внедрения не представляется возможным.

Подписи:

Начальник ЦТАИ .....Н.И.Губа

Начальник ЦНиИ ..... А.В.Дзекановский

Начальник ПТО ..... Ф.П.Цырульник

Ст. бр. инженер Дон ОРГРЭС ..... В.Ф . Рухляда

Представитель фирмы
Burns and Roe Enterprises, Inc .....Джордж Келлер

Approved
by Chief Engineer of Uglegorsk Heat Power Plant
G I Kuryshko
August 8, 1997

Town of Svetlodarsk

Uglegorsk Heat Power Plant

PROTOCOL

Mr N.I. Guba - Head of the Heat Automation and Measurements Workshop, Mr A V Dzekanovskyi - Head of the Adjustment and Measurements Workshop, Mr. F.P Tsyrulnik - Head of the Production and Technology Department, Mr V F Rukhliada - the representative of Don ORGRES, 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 Uglegorsk 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 Uglegorsk HPP·

- an ENERAC 2000 combustion analyzer
- a Cyclops 300AF/300 infrared thermometer
- a MICRON M90 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
- a ZIRTEC stationary oxygen meter
- a laboratory calorimeter
- a laboratory analyzer of the sulfur content in the fuel.

1. ENERAC 2000 gas analyzer is operated in the adjustment workshop, and it is used to check and correct the fuel combustion process, to verify the regular oxygen meters, to check periodically how the requirements of the ecological inspection are observed, to test new control and measurement instruments to be used for the gas analysis of boilers.
   The economic effect of using ENERAC 2000 resulting from a reduction of the costs to involve specialists from other organizations, from eliminating the fines set by the ecological inspection for exceeding the standard levels of the unfavourable emissions, from improvement of the efficiency and reliability of operating the main boiler equipment can be assessed as equal to $45,000 to $50,000 per year.

2 Cyclops 300 AF/300 infrared thermometer is operated in the adjustment workshop and it is used to check temperatures of various surfaces A special value of this instrument is an opportunity to check the temperatures of surfaces of the heat insulation of the steam pipelines and the temperatures of the boilers casings surfaces Periodically the instrument was used to check the temperature of the outputs of the generators, of the high-voltage line isolators, of the contacts of the electric equipment when the voltage is applied, of the temperature of the rotating parts of mechanisms The economic effect of using Cyclops 300AF/300 resulting from a reduction of the heat losses into the environment during the period of its operation at Uglegorsk HPP can be assessed in $69,000 per year

168

3 MICRON M90 infrared thermometer is operated in the adjustment workshop and it is used for a periodical checking the temperature in a boiler furnace, temperatures in the apertures in cases of any problems with letting the liquid slag out what can be related with changes of the solid fuel characteristics or with the possible breaking the furnace regimes It does not seem possible to assess the economic effect of using the instrument due to a short periods of its operation

4 ZIRTEK stationary oxygen meter was mounted and involved into operation of the boiler at Unit 1 on July 14, 1997. For a month of the experimental operation there were carried out the pilot tests of the oxygen analyzers with the aim to determine the efficiency of their industrial implementation from the point of view of the tasks of the processing control and automatic control of the combustion regimes in the boiler furnace. The following data were received after the tests

- the average rise in the precision of determination of the excessive air factor is 10 per cent, which, due to the preliminary estimations, brings to rising the boiler efficiency by 0 1 per cent and to gaining the economic effect of $30,000 per year,
- inclusion of ZIRTEK oxygen meters in the automatic control system, due to the preliminary estimations, will allow to increase the boiler efficiency by 0 2 per cent, which gives the economic effect of $60,000 per year.

There should be marked that a higher economic effect can be gained at Uglegorsk HPP providing operation of ZIRTEK oxygen meters with a forced warming-up of the sensitive element
More precise results concerning the economic effect can be available only after carrying out the balance tests of the boiler

5 The instrument for measuring the electric power in the alternating current circuits with the voltage up to 600 V is permanently operated in the electric workshop The economic effect from its using can be assessed on the level of $1,250 per year.

6 TransPort PT868 two-channel portable ultrasonic liquid flow rate meter, the laboratory calorimeter, the laboratory analyzer of the sulfur content in the fuel is being mastered now and the economic effect of its implementation does not seem to be possible to be assessed.

Signatures.

Head of the Heat Automation and Measurements Workshop	N.I Guba
Head of the Adjustment and Measurements Workshop	A V. Dzekanovskyı
Head of the Production and Technology Department	F.V. Tsyrulnık
Representative of Don ORGRES	V.F. Rukhliada
Representatıve of *Burns & Roe Enterprıses Inc*	George Keller