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BURNS AND ROE ENTERPRISES, INC.

Audit Report
ZMIEV POWER PLANT
UKRAINE

FINAL

August 1997

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Power Plants Combustion Efficiency

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

Final Audit Report
Zmiev Power Plant

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COMBUSTION EFFICIENCY AUDIT REPORT
UKRAINIAN POWER PLANTS
ZMIEV POWER PLANT

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

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

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

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

The Zmiev Power Plant is presently 51% government owned and is in the process of privatization. The plant consists of six subcritical 200 MW units and four supercritical 300 MW units with a total of 2400 MW installed capacity. The plant was commissioned between 1960 and 1969. The coal supplied to the power station has poor quality, with caloric values of 3200 to 5000 kcal/kg and 40% ash content. Typically, the plant fires coal alone, coal and mazut, coal and natural gas, or natural gas only

1.2 Principal Findings

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

Very high (by western standards) in-leakage rates in the furnace, the economizer and the air heater (total in-leakage 65% and higher) are typical These make readings of any oxygen analyzer dependent on its location (distance from the furnace), distorts any measurement of combustion air flow and makes automatic control of combustion very difficult High leakage rates inherent in the boiler technology used for the Zmiev power plant cannot be remedied at a reasonable cost

Most of the insulating material used at the plant is asbestos Considering the age of the power plant, it is recommended that longer range plans should consider complete replacement or major repowering and rehabilitation.

1.3 Recommendations

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

An investment of $143,500 in boiler efficiency improvements (ECO-04,05,06,07) will result in an annual savings of $224,400, which corresponds to 5900 tones of coal and 570 tones 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 $1,153,000 which corresponds to 30,100 tones of coal and 2,900 tones 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	$960,000	$25,000 Note 1	<1 year
02 *	Energy Conservation Training Program	$193,000	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	$31,400	$29,000	11 3 Mo

ECO#	Description	Annual Savings in US$ (1995 Prices)	Project Cost in US$ (1995 Prices)	Simple Payback
				Current Energy Prices
05 *	Portable Infrared Video Monitors (Bottom Ash)	Included with ECO-04	$4,600	Included with ECO-04
06 *	Sulfur Laboratory Analyzer	$193,000	$30,000	1 9 Mo
07 *	Coal Flow Meters - One Boiler Portable Liquid Flow Meter	Included with ECO-04	$69,500 $10,400	Included with ECO-04

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

1.4 Implementation

The plant is presently in a very difficult financial position since it pays world prices for fuel but sell electrical power at the rate set by the government Both load factors and quality of coal have declined since 1995. Typically only 2 units out of 10 are operating at 60 - 70% MCR At this time the plant is overwhelmed by political and economic factors out of its control and it is a testimony to the management's efforts that the adjusted efficiency of the plant remained the same or improved since 1994

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

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

2.0 BACKGROUND

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

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

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

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

These units often supply hot water for district heating and steam for industrial use Decreasing coal supplies and declining quality of coal supplies is affecting the ability of the Ukraine to meet its needs for electricity Also, electricity and district heating supplies are threatened because Ukraine is unable to pay for imported coal, oil and gas at 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 is 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 is 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 (1) to 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 first unit was put into operation in 1960 The unit was designed to fire natural gas which was readily available. After three units were put into the operation, the government decided in 1963 to redesign these units for coal firing along with designing the next seven units for coal firing The equipment for gas firing is still in place. In 1969 the construction of all 10 units with a total output of 2,400 MW's was completed

ENERGO SYSTEM: KHARKIVENERGO

LOCATION.	30 KM SOUTH OF KHARKIV
INSTALLED CAPACITY:	2400 MW
	6 x 200 MW + 4 x 300 MW
COMMISSIONED·	1960-1969
FUEL	Coal low-bituminous, anthracite and gas or mazut

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

3.2 Boiler Plant

The Zmiev steam power station consists of two lines of units The first line consists of six subcritical 200 MW power units These boilers were designated TP-100 and were supplied by the Taganrog Boiler Factory and the turbines were supplied by the Leningrad Metal Works The second line consists of four supercritical 300 MW power units These boilers were designated TPP-210 and TPP-210A and were supplied by the Taganrog Boiler Factory and the turbines were supplied by the Kharkov Turbine Factory The 300 MW units consist of double boilers (two subboilers) to improve reliability of operation

3.3 Coal Handling

In the 1970's the coal supplied to the power station was changed to a much poorer quality than the coal that was the basis for the plant design The ash content of the coal was up to 40% and still is, and the caloric value of the coal ranged from 3,200-5,000 kcal/kg Coal is measured in a similar manner to Uglegorsk and Kourakhovska, power plants, i.e , sampling methodology and weighing on conveyors

The speed of the coal dust feeders can be controlled from the control room Coal is supplied to the station by 44 suppliers. Lowest volatility content is 4% to 6% Initial coal quality determination is achieved by taking coal sample from each railroad car and analyzing for ash and water contents

There is coal mixing by the bulldozers in the yard The average quality of the coal over a 3 to 5 day period is determined by taking coal samples from the conveyors The coal is analyzed for caloric value, water, ash, volatility and sulfur content. This is a slow process

There are scales to weigh the coal being delivered per railroad car There are two conveyors which deliver coal to the entire power station. Each conveyor has a scale which measures the coal fired for the total power station (10 units).

3.4 Mazut Supply

The power station units are supplemented with mazut when it can be purchased Zmiev units never operate on mazut alone due to its high cost and high SO_2 emissions.

3.5 Gas Supply

The power station units are supplementally fired by natural gas when it can be purchased The units can operate at 200 and 300 MW on 100% natural gas Natural gas flow meters already exist on each boiler and work well.

3.6 Boiler Efficiency Calculations

The methodology for the boiler efficiency calculation is shown on Attachment 17 of the Preliminary Audit Report (Appendix G) The calculations are done on a per unit and per plant basis The only fuel measured directly per boiler is the natural gas All other fuel quantities per boiler are extrapolated from power station data The quality of the coal is also averaged on a 3 to 5 day basis These efficiencies are compared to the boiler design efficiencies The boiler design performance was recalculated in 1987 and 1992 as discussed in Item 16 of the above report

3.7 Process Control System

Boilers of the Zmiev power plant 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) There are four O_2 analyzers on each 300 MW unit and two O_2 analyzers on each 200 MW unit which are used to monitor furnace O_2 These analyzers are used by operators to remotely adjust the speed of coal feeders and the position of forced draft fan dampers The fuel to air ratio is manually adjusted based on experience and O_2 analyzer indications. There are no CO analyzers in the power station Approximately 140 points in the boiler are monitored by thermocouples

3.8 Environmental Issues

The six 200 MW units are furnished with wet scrubbers, while the four 300 MW units are provided with Electrostatic Precipitators (ESP) Both systems are reported operating unsatisfactorily

Because the stack heights far exceed 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

The station has no NO_x pollution control system

3.9 Future Plans

Management of the Zmiev power plant is aware of the poor condition of its boilers High leakage rates are inherent in the boiler technology used for the Zmiev power plant and cannot be remedied at a reasonable cost. They also understand that asbestos is not an appropriate insulating material and that considering the age of the power plant, complete replacement or major repowering are the best options They are attracted to a number of advanced technologies, including an application of Atmospheric Circulating Fluidized Boiler (ACFB) technology, but have no funds to pursue them

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 Zmiev 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 and maintain the existing facilities

3.10 Inspection, Assessment, Comments

- The power station is well managed. The staff is competent and fully cooperated in providing the requested information and assigning the hands-on audit training personnel

- The buses of this power station are used for exchange of power between the Russian and the Ukrainian systems Operation of this plant is in parallel with the Russian grid not the Ukrainian grid

- The units are operated base loaded without interruption and proper maintenance is often delayed. However, there is an annual maintenance outage for each unit and the regular maintenance is scheduled in accordance with the manufacturers recommendations

- Unit 1 boiler has operated over 250,000 hours and has been experienced 375 starting/shutdown cycles The operating hours are 1.5 times the design time

- Plans are in place to reconstruct this station The station would like to keep the structures and replace all the equipment step by step The new plant is expected to deliver more than the 2400 MW of existing plant installed capacity

- A joint venture is in the process of developing the design of a boiler to burn low quality coal as a part of the "pure" coal program Zmiev Unit #3 boiler will be used for testing and verifying the new design After this testing eventually the Unit #1 boiler will be replaced with the new boiler design This pilot boiler design will replace all 200 MW boilers in the rest of the Ukraine

- The station does not have a low NO_x pollution control system The existing NO_x analyzers in 300 MW units are not used because they are not reliable

- Most of the process control systems operate on "manual" mode from the control board located in the Unit Control Room A chart is used to indicate the unit load as a function of the amount of coal and mazut cofired

- The controls and instrumentation are outdated, 1950's vintage and the readings are unstable and require ongoing maintenance to keep them operational The boilers have no burner management systems The original mechanical governors are still in operation All interlocks are of a very basic nature offering limited protection Spares are hard to find

- The coal is supplied by 44 suppliers. The station has little input regarding the quality of the coal specified or control over fuel acquisitions

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

- The original boiler design performance when firing coal was revised in 1987 and 1992 and subsequently the boiler maximum MW output was reduced from 200 MW to 175 MW and from 300 MW to 275 MW Therefore, the power plant MW output is derated to 2150 MW from 2400 MW, a reduction of total 250 MW (1 42%). The main steam temperature was changed from 570°C to 540°C to increase the boiler reliability

- The units are operated on base load mode except during the weekends when two or three units are shutdown and the balance of the units operates on reduced load This operation affects the equipment.

- The efficiency calculations are performed on a per unit and per plant basis. Except for the natural gas that is measured directly per boiler, all other fuel quantities per boiler are extrapolated from power station data These efficiencies are compared to the efficiencies based upon the boiler design performances recalculated in 1987 and 1992.

- The power station will like to have coal flow meters to measure the input at each mill, a total of three devices per 200 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 Zmiev 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 paybacks 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 Zmiev Power Plant as part of the USAID boiler efficiency improvement demonstration program Of this equipment, the most significant was ENERAC Combustion Analyzer which demonstrated an opportunity for immediate fuel saving by tuning the boilers to reduce excess combustion air

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

4 1.2 General

The Zmiev 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 Zmiev Power Plant.

Management of the Zmiev 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 Zmiev 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 #1 and Boiler #8, 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 furnace exit and at the boiler stack This was done with fixed combustion settings and essentially at the same time (the same coal and ambient temperature). The measured parameters included gas temperature, O_2, CO, combustible gases, NO_x and SO_2.

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

There were twenty one 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 Zmiev power plant must come primarily from an improvement in boiler efficiency of its boilers On the steam side the Zmiev 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 in presence of high air in-leakage and an on-line measurement of the fuel saved due to reduction in excess air 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, it was measured 5-6% excess furnace oxygen at full load while firing coal and 4% excess furnace oxygen at full load while firing natural gas. CO emissions were negligible in both cases. In Burns and Roe's judgement the excess furnace oxygen at full load while firing coal can be reduced by 0.35% O_2 whereas excess furnace oxygen at full load while firing natural gas can be reduced by 1% O_2, thus an incremental improvement in boiler efficiency of 0 15% while firing coal and 0 35% while firing gas.

In the future, the Zmiev 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 and CO content of the flue gas and thus assist the operators in avoiding unsafe conditions while continually minimizing excess air

4 1 4 Boiler Plant

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

Combustion of poor quality coal resulted in furnace "puffs" and very rapid corrosion of the back end Since all of the Zmiev power plant boilers are of tangent tube construction (tubes are spaced 8 mm apart with asbestos blocks behind them), and of balanced draft (negative furnace pressure), furnace "puffs" cause loss of the furnace integrity Personnel of the Zmiev power plant reported

19% in-leakage in the furnace alone, over 65% 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 Zmiev power plant can no longer afford such overhauls.

Boilers of the Zmiev 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 Coal is usually fed to the boilers at maximum coal feeder speed, with co-firing of mazut or natural gas used to bring the boiler to the required load The forced draft fan air damper positions are adjusted manually based upon a chart displayed on the control room wall, which is a function of the amount of coal and mazut 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%

None of the units have CO analyzers As shown on Attachment 8 of the same report, the TPP-210 boilers have two oxygen analyzers per subboiler or a total of four per boiler located in the convection pass at approximately 600°C As shown on Attachment 6 of the same report, the TP-100 boilers have two oxygen analyzers located on the convection pass per boiler.

The excess O_2 at the burners is maintained at approximately 4% The station wants to maintain actual air to theoretical air at a ratio of 1 25 to account for inaccuracies in the quality and quantity of coal being fired and to compensate for inaccuracies in measurements Besides having O_2 analyzers the power station would like to measure air consumption at each burner to ensure proper combustion at each burner

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

The scrubbers installed on 200 MW boilers are wet type and operate unsatisfactorily

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 Zmiev 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 Zmiev power plant consumed the following quantities of fuel

Coal 4,997,632 tones	$171,347,500
Mazut 483,330 tones	$ 20,807,500
	$192,155,000(*)

(*)Price calculation is using 1995 cost of fuel

If only a modest savings of about 0.5 percent of this fuel expenditure is saved in the first year, $960,000 of expenditures can be justified for measures to improve fuel utilization and efficiency, improve reliability and reduce maintenance.

Funds should be provided for consulting services to assist the Zmiev 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 $193,000!

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 Zmiev 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 Zmiev Power Plant

It is recommended to install the new instruments on 200 MW Boiler #1

For detailed calculations see Appendix A-1.

ECO-05 VIDEO MONITORS OF THE BOTTOM ASH

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

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

For detailed calculations see Appendix A-1

ECO-06 SULFUR LABORATORY ANALYZER

An accurate Sulfur laboratory analyzer should be provided to verify 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 fuel flow for either mazut and coal to each boiler Natural gas flow meters already exist per each boiler and work well. 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 200 MW Boiler #1, located between raw coal bunker and mill (coal feeder)

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

For detailed calculations see Appendix A-1

5.2 Medium and Long Term Opportunities

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

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

- Investigate lower cost SO_2/NO_x removal technologies

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

- 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 scrubbers and 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 system malfunction prevention

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

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

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

5.3 Replicating and Expanding the Program to Other Plants

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

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

- Very high in-leakage rates (70% and higher) are typical, which make readings of any oxygen analyzer dependent on its location (distance from the furnace). They also make impossible on-line calculation of the combustion efficiency at the back end of the boiler.

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

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

The conclusions are as follows:

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

- There is room for an economic benefit because the starting point of the excess air (4 to 5% excess oxygen) is high It should not be very difficult to reduce the excess oxygen by 0 5% and achieve 0 15% improvement in the boiler efficiency even with the existing manual control of the combustion process provided that constant operator attention is achieved. Such attention can be obtained via an economic inducement based on the fuel savings Another alternative would be to invest in an expensive automatic control for the excess air system

- The benefit cannot be achieved without carbon monoxide measurements of the undiluted flue gas (850-970 degree Centigrade temperature) at different boiler loads

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

6 0 IMPLEMENTATION

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

Typically only 2 units out of 10 are operating at 60 - 70% MCR At the same time there is a shortage of power in the Ukraine and electrical power is being imported from Russia The answer to this paradox is that poor quality coal requires mazut or gas to support combustion which can be bought only for cash. The station practically does not have cash (only 3 to 5% of its receipts are in cash) but can get some coal by trading credits At this time the plant is overwhelmed by political and economic factors out of its control and it is a testimony to the management's efforts that the adjusted efficiency of the plant remained the same or improved since 1994

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

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

<u>ENERAC 2000</u>

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 of 2 14% (1997 vs 1995, grams of nominal fuel per KWHR) 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 considers that up to 0.4% improvement was due to use of the modern portable combustion analyzer However only $5,000 to 6,000/yr in benefits are claimed in the Protocol, which is extremely conservative

The plant personnel were also unwilling to quantify savings in tons of environmental pollutants or avoided environmental fines, but had no doubts that such savings took place (see attached Protocol in Appendix H)

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. Two high voltage accidents involving disconnect switches were prevented via use of the Cyclop 300AF The instrument is also used to troubleshoot the generator stator The Protocol states $8,000 per year in benefits, which is very conservative

FLUKE AC POWER ANALYZER

The plant also likes the Fluke AC Power Analyzer It was in wide use for about 2 years However only $800 to 1,000 per year in benefits are claimed in the Protocol, which is extremely conservative

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 $12,000 per year from this instrument

TRANSPORT PT 868 PORTABLE LIQUID FLOW METER

This instrument was available to the plant for about 2 months. So far attempts to use this meter for circulating water flow measurement have not been successful, seemingly due to the deposits in the circulating water lines The 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 plant. If in-situ sensors are provided, future benefits are estimated by the Zmiev Plant at $50,000 per year

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

MICRON M90 HIGH RANGE INFRARED THERMOMETER

A MICRON M90 high range infrared thermometer was available to the plant for at most 2 months So far attempts to use this instrument for temperature measurements have not been successful Management of the Zmiev Plant dislikes this instrument and would like to trade it for something more useful to them Generally it is too early to tell, it just may take some time for the plant to get used to a new instrument.

LABORATORY SULFUR ANALYZER

A laboratory sulfur analyzer was available to the plant for at most 1 month The plant is trying to learn how to use the analyzer This will take some time However the plant has high hopes for the instrument and works hard to commission it The sulfur analyzer was provided to verify the sulfur content of the received coals versus the coal specified. This would prevent deterioration of the furnace, air heaters and the duct work and thus prevent a drop in the boiler efficiency There also will be savings in tons of SO_2 emissions and avoided environmental fines In 1995 we estimated the economic benefit from a sulfur analyzer at $192,755 per year Since the plant load is down about 50%, we estimate that under present conditions the benefit will be under $100,000 per year.

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 monitor.

2.0 ASSESSMENT OF POTENTIAL EXCESS OXYGEN REDUCTION

There is the potential to reduce the levels of excess oxygen at all Zmiev units, however only unit #1 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%. For coal burners of this design and vintage, it would be more appropriate to assume that the excess air level would be closer to 4.0%. 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 at the stack to be 12.4% and 15.1% for an average of 13.75% (test data 1 & 2). BRC calculation indicates that this corresponds to 4.35% excess oxygen at the burners. The corresponding measured carbon monoxide levels for these tests was very low, therefore the excess oxygen at the burners can be reduced.

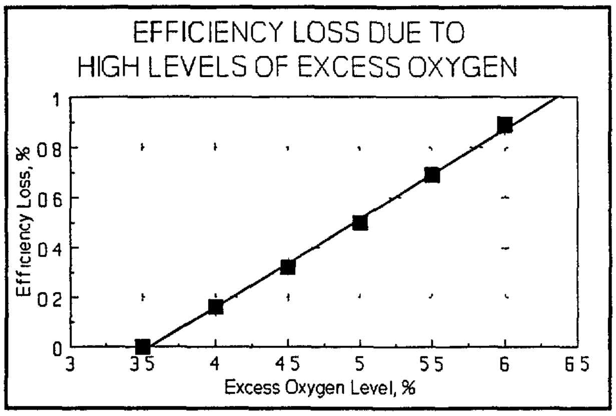
Accounting for the existing coal burner design, the minimum excess air at the burners would be assumed to be approximately 4.0%. Thus, the potential reduction in excess oxygen at the burners would be 4.35% - 4.0% = 0.35%.

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 4.0%, which is typical for coal fired burners of this design and vintage. Boiler efficiency was calculated for excess oxygen levels up to 6%, 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 0.35% at full load while firing coal. This would reduce the excess oxygen from 4.35% to 4%. Using the curve shown above, the boiler efficiency saving at full load (180 MW) would be 0.12%.

For minimum load (140 MW), we expect some additional efficiency gain since presently air flow is not reduced with the load. Thus we conservatively assume an overall efficiency gain of 0.15%. Potential savings could be higher. BRC observed that normally the boilers are run under higher excess oxygen then during the test, when plant management was making sure that operators are following the "regime" chart. The "regime" chart gives operators optimal positions of the ID fans, FD fans,and feeder speed for any given load.

3.0 COST ANALYSIS

The cost savings of a 0.15% reduction in the boiler efficiency would be realized in a fuel saving of approximately the same amount. The total fuel fired in August 1994, for all six of the 200MW units, was 0.4069 kg/kW-hr x 500,322,000 kW-hr = 203,581,022 kilograms of reference coal or 203,581 metric tons of reference fuel (7000 Kcal/Kg coal) or 293,526 tons of 4855 Kcal/kg coal.

The cost of coal in January 1995 was 4,883,748 coupons per metric ton or $35.65 U.S. per metric ton at 4855 Kcal. The total cost of coal for all six units would be 293,526 metric tons x $35.65 per ton = $10,464,200 U.S. per month or $125,570,000 per year. The total cost of fuel per year for one unit would be $125,570,000/6 = $20,928,400.

BRC calculates total annual savings for Unit No. 1 to be:

$20,928,400 x 0.15% = 31,393 $\simeq$ $31,400

NOTE: $35.65 per ton of 4855 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 monitor may be necessary to actually realize a benefit from a lower excess oxygen. A portable mazut meter and an infrared bottom ash temperature detector will be shared among ten boilers, therefore only 1/10 of their price is included in per boiler payback calculations.

Total equipment cost: $25,000 (high temperature oxygen analyzers) + $60,000 (coal flow meters) + $900 (portable mazut meter) + $400 (portable infrared bottom ash temperature detector) = $86,300. We will assume cost of installation and commissioning to be $13,700, 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 $100,000 per boiler.

- Payback at current price for the entire package:

  $100,000/$31,400 = 3.18 yr = 38.2 months

- Payback at current domestic price for the oxygen analyzer system alone:

  ($4000+$25,000)/$41,300 = 0.92 yr = 11 months

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

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

  ($460+$29,000)/$31,400 = 0.938 yr = 11.3 months

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

  ($1,040+$69,500+$29,000)/$31,400 = 3.17 yr = 38 months

ECO-06 - CALCULATION

SULFUR LABORATORY ANALYZER

1.0 INTRODUCTION

A modern Sulfur Laboratory Analyzer will allow Zmiev Power Plant to reject shipments of coal with unacceptably high levels of sulfur. Sulfur content of Ukrainian coal even from the same mine can vary significantly. Zmiev Power Plant does not control back end temperature and as result SO_2 in the flue gas (as high as 4g 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 $192,755,000 as total annual cost of fuel for Zmiev Power Plant, the total savings in fuel cost would be **$192,755** at current price of $35.65 per ton.

Payback at current price

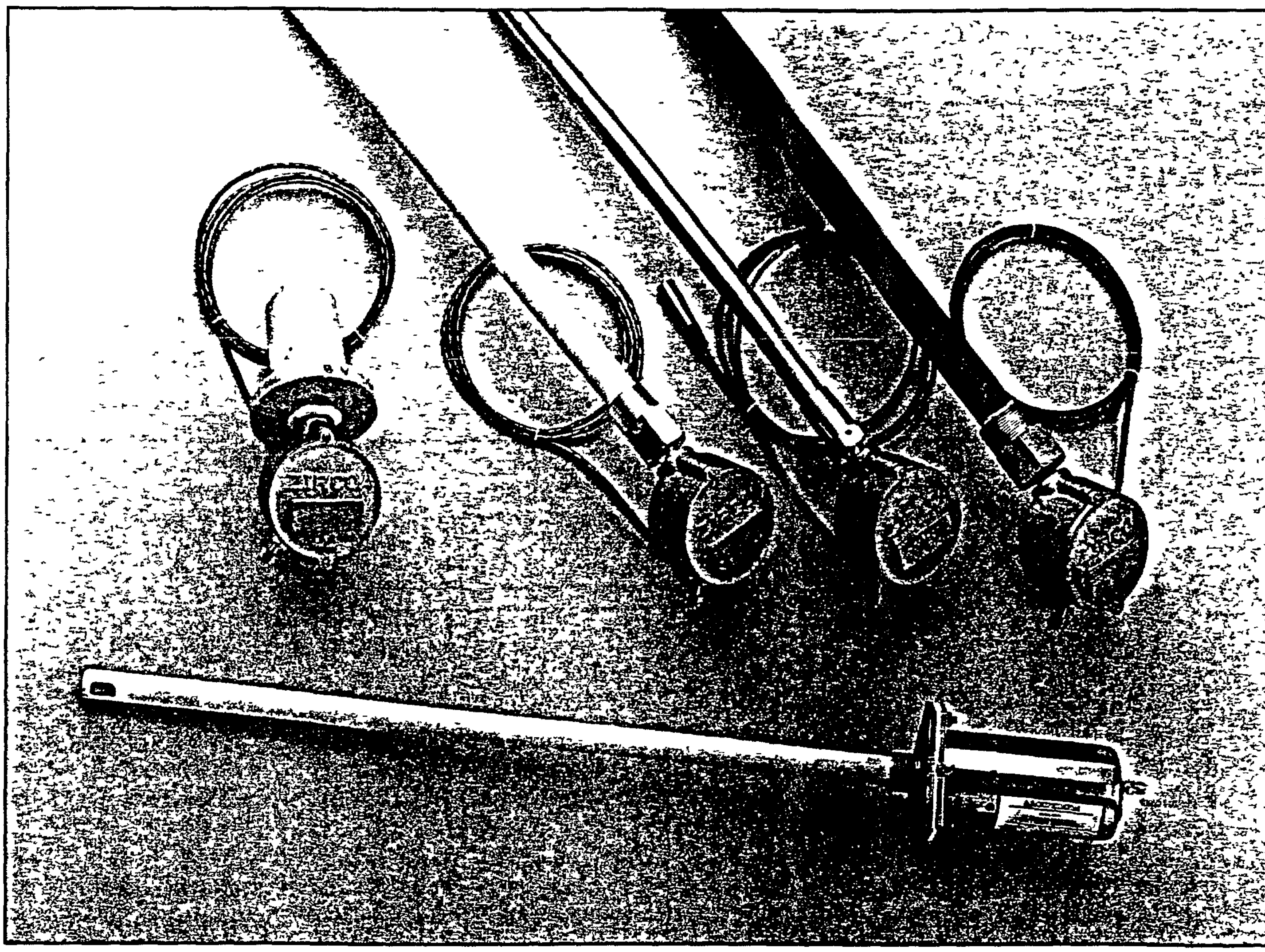
$30,000/$192,755 = 0.156 yr = 1.9 months

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

‾esign and operating advantages common to all .ACC/ZIRCOA Oxygen Sensors.

- Solid-state design.
- Integral thermocouple (B R S)
- Place directly into combustion chamber
- Operating temperature range 1200 - 2900° F (650 - 1600° C)
- Terminal head rating 300° F, (150° C) maximum.
- Responds instantly to changes in furnace atmosphere
- No sample lines to plug or leak.
- No heaters to calibrate or fail.
- Little or no maintenance required.
- Optional quick-disconnect sensor lead wire
- Installation mounting assemblies available
- Accuracy of ± 5% of the observed process variable, ie pv=2 0%±0 1%

Model 8212

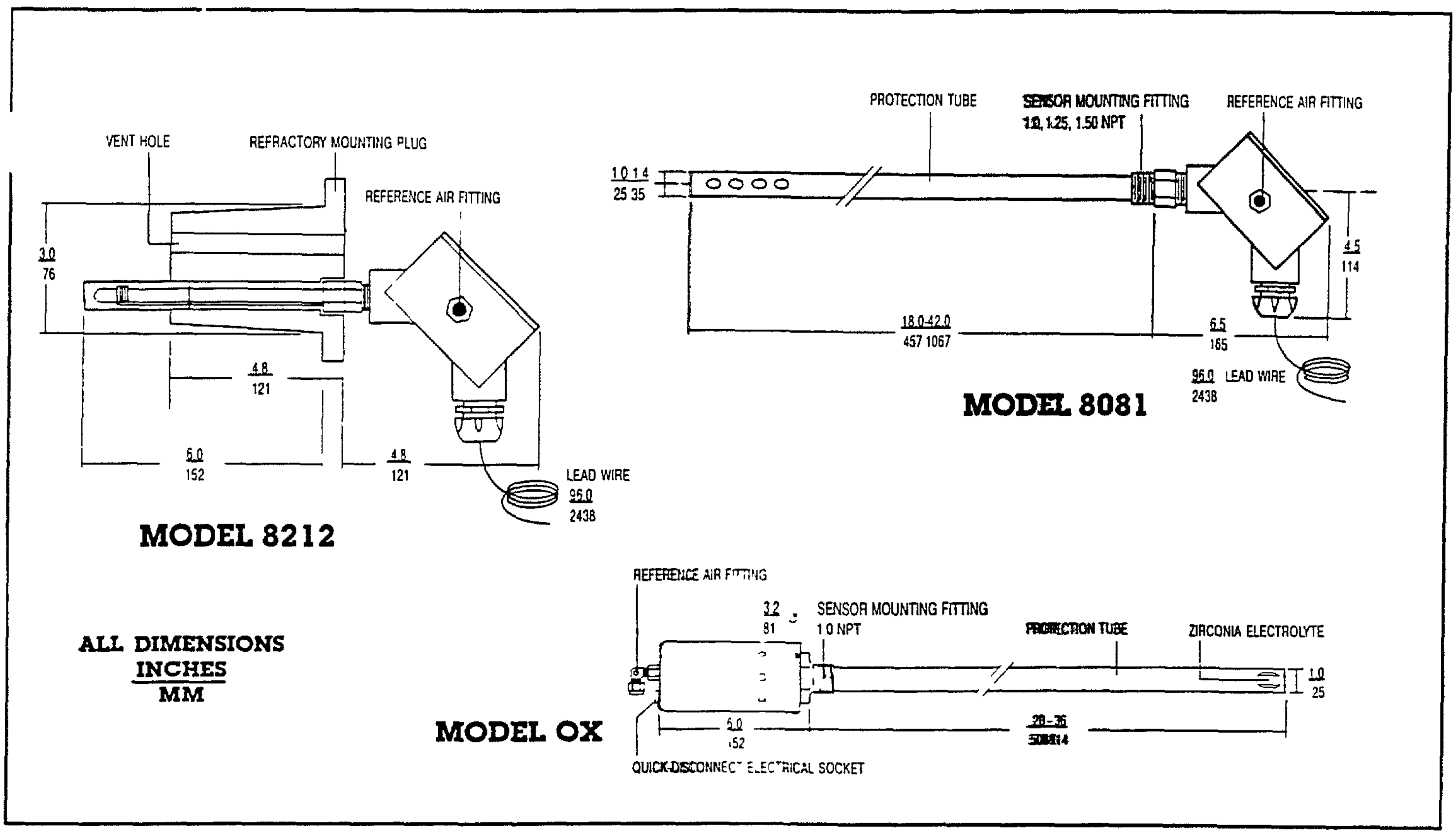
- 6" (152mm) sensor with ceramic mounting plug
- Mount in melter crown backwalls recuperator stacks regenerator crown/target walls
- Designed to withstand attack from high vapor pressure metals

Model 8081

- Patented boot protects electrode
- Alloy alumina and silicon carbide protection tubes available
- Lengths available from 18 to 42", (457 to 1067mm)

Model OX

- Optional verification port
- Lengths available from 20 to 36" (508 to 914mm)
- Rebuildable
- Alloy and alumina protection tubes available



For specific application information, please call:

Caution. Oxygen sensors should be used only to oxygen trim not direct air control. Sensors should be connected to appropriate trim or process control instruments which only allow the fine-tuning of the air/fuel mixture. Use of oxygen sensors for total independent control of combustion may result in combustion air shut-down which could lead to explosion and environmental (emissions) hazards

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Utilities

High-temp O_2 measurement improves boiler performance

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

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

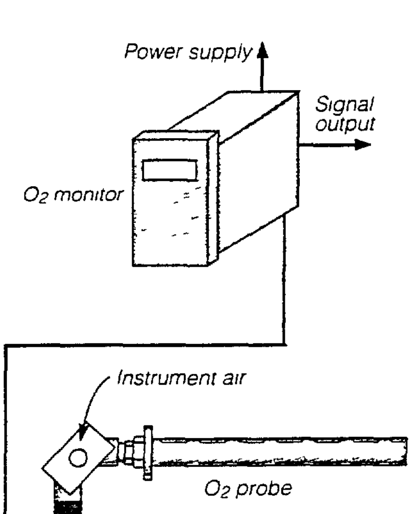
Enough air infiltration can lead to improper air-to-fuel ratios, poor combustion, and corrosive damage if a reducing atmosphere prevails Also, the O_2 probes and analyzers on Units 7 and 8 became increasingly unreliable Repairs to maintain the economizer-outlet system had become excessive and costly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

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

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

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

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



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

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

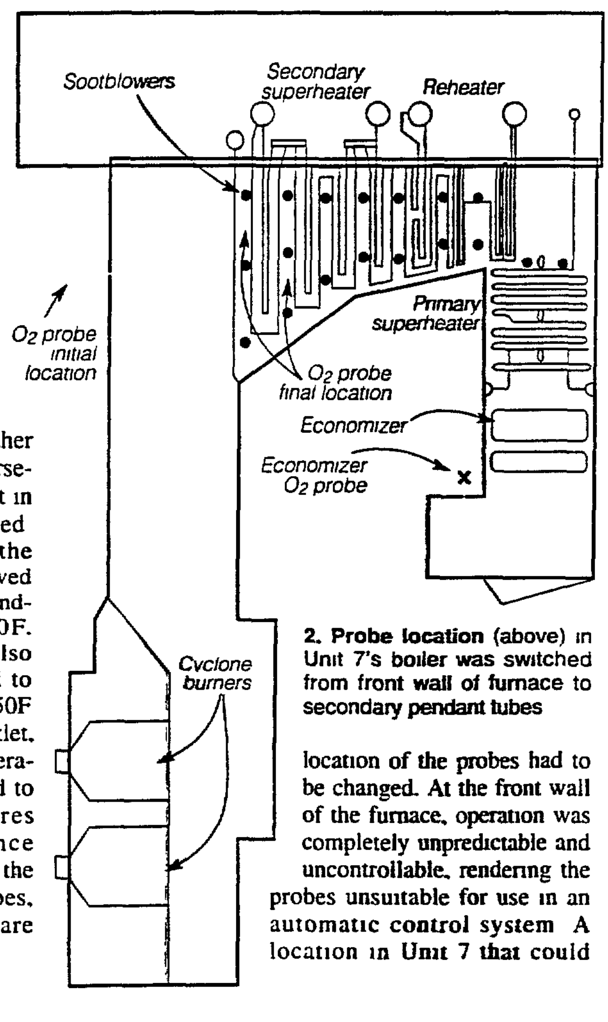
Proper functioning of the zirconia oxide cell is achieved above a minimum recommended temperature of 1100F. Because the old probes (also zirconium oxide cells) had to operate at temperatures of 850F or less at the economizer outlet, a heater assembly and temperature controller were required to maintain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

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

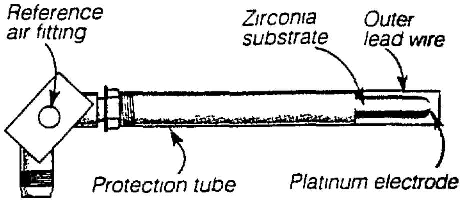
The next step was to install a probe with a stainless steel protection tube (Fig 3), instead of the standard silicon carbide tube, to see if it could better withstand the extreme conditions in the furnace After only three days of operation, this probe failed—an excessive amount of slag had accumulated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

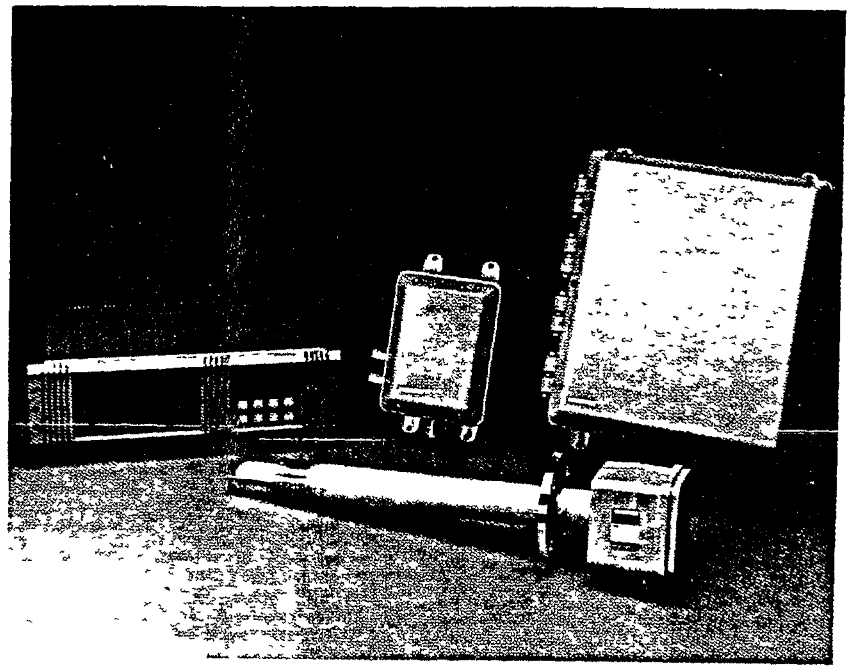
Tom Elliott

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

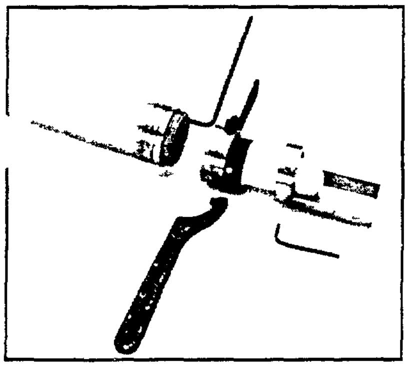
The CRE 3000 Control Room Electronics module allows interfacing with up to eight World Class 3000 probes (16 with master/slave) via the HPS 3000 Field Interface Module. This flexible, easily expanded, electronics arrangement allows the World Class 3000 probes to be linked to the Control Room Electronics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

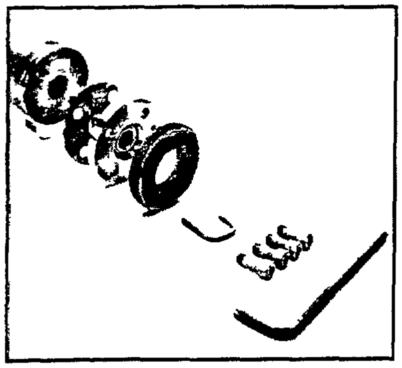
The HPS 3000 Field Interface Module provides local power to the oxygen probe. It is connected to the CRE 3000 at a distance of up to 1200 feet with low cost signal cable The HPS 3000 module is housed in a standard NEMA 4X (IP65) enclosure for full weather and corrosion-proof protection It is also available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

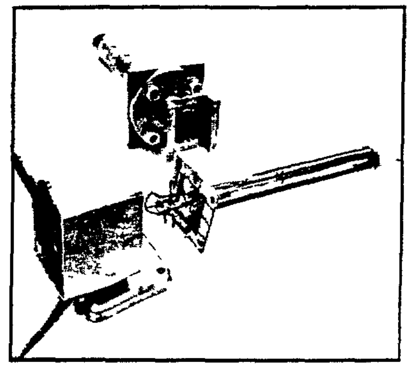
Supersedes Product Data 106-300NC,
Pages 1-8, dated March, 1992



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

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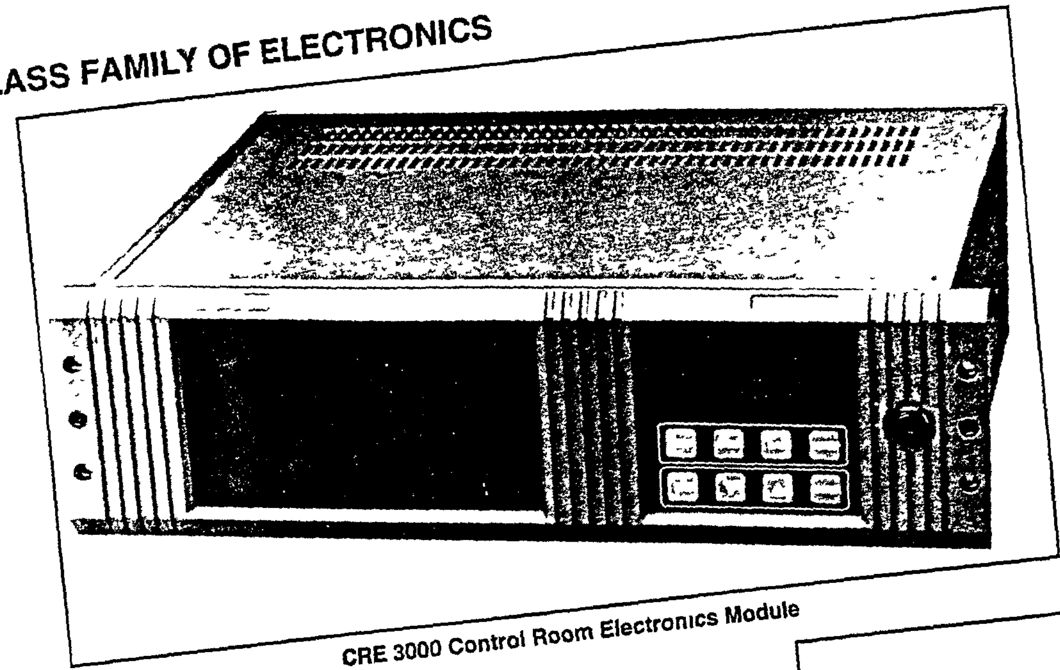
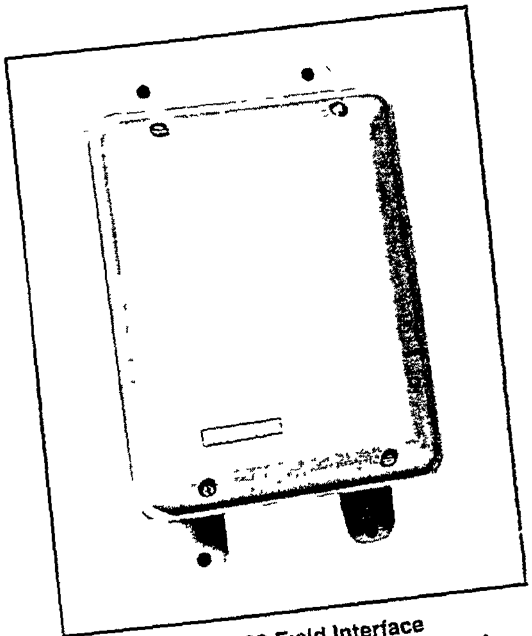
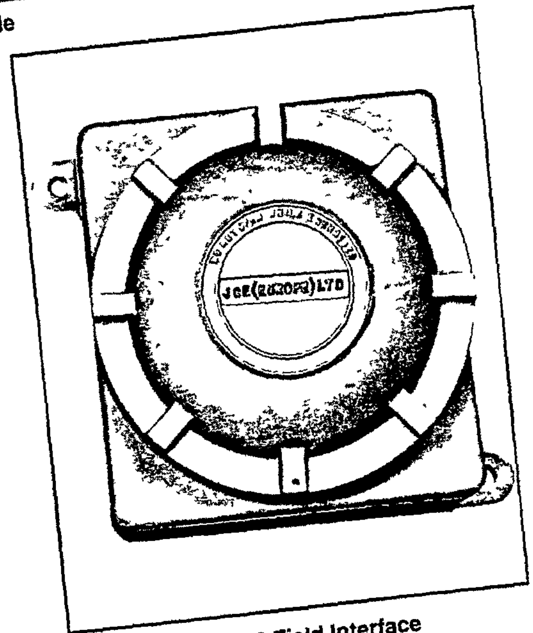
WORLD CLASS FAMILY OF ELECTRONICS



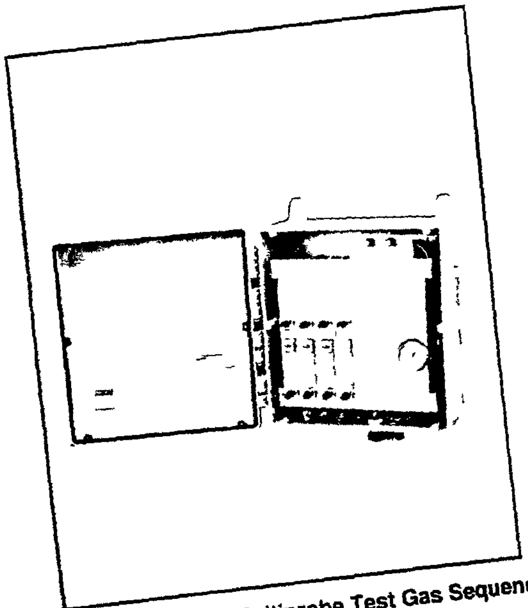
CRE 3000 Control Room Electronics Module



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



HPS 3000 Field Interface
(Explosion-Proof Enclosure)



Optional MPS 3000 Multiprobe Test Gas Sequencer

SPECIFICATIONS①

OXYGEN SENSING EQUIPMENT

robe 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

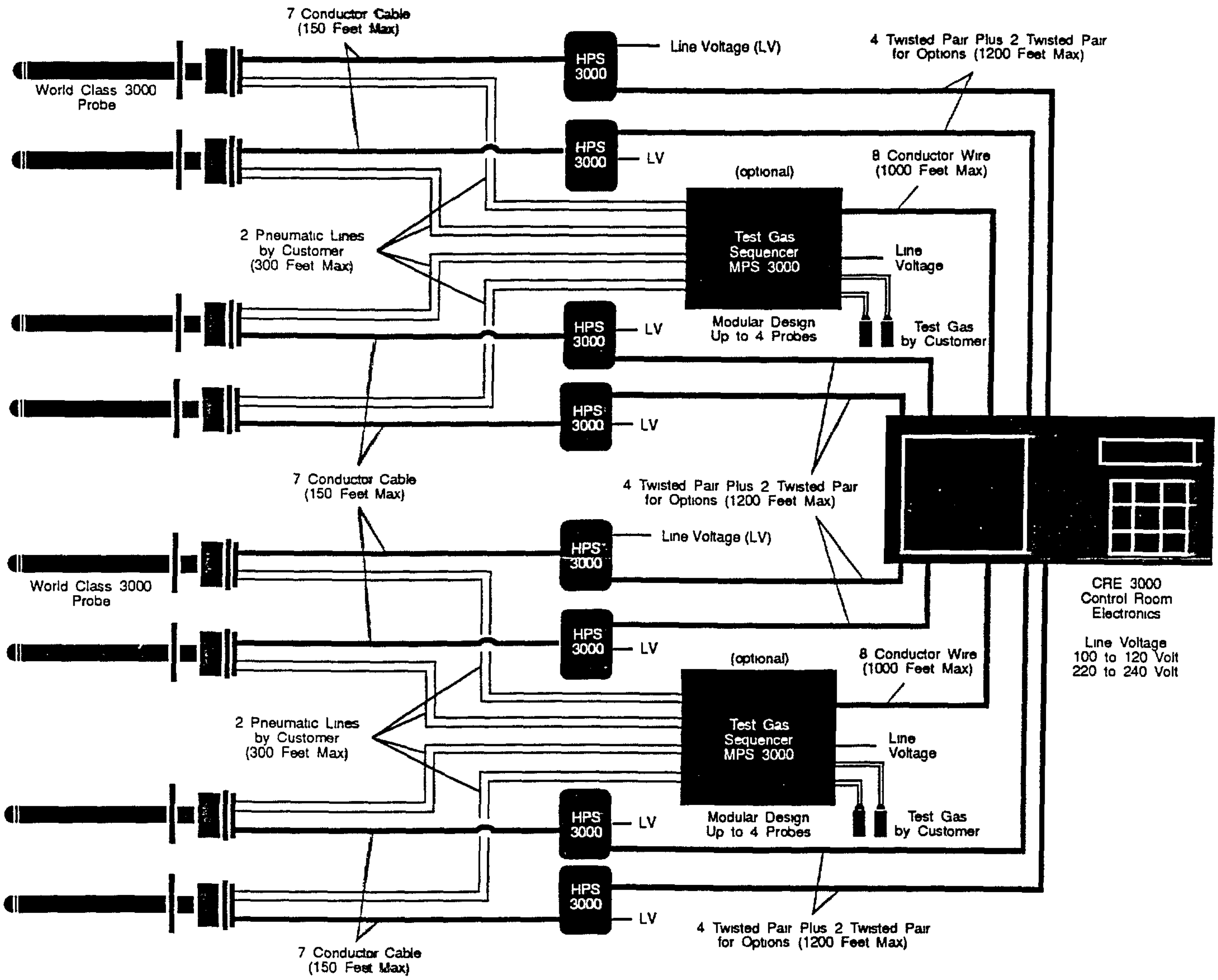
Electrical classification· NEMA 4X (IP65) Optional - Class 1, Division 1, Group B
Humidity range: 95% Relative Humidity
Ambient temperature range: -20 to 140°F (-30 to 60°C)
Vibration 5 m/sec², 10 to 500 xyz plane
External electrical noise: Minimum Interference
Cabling distance between HPS 3000 and probe: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



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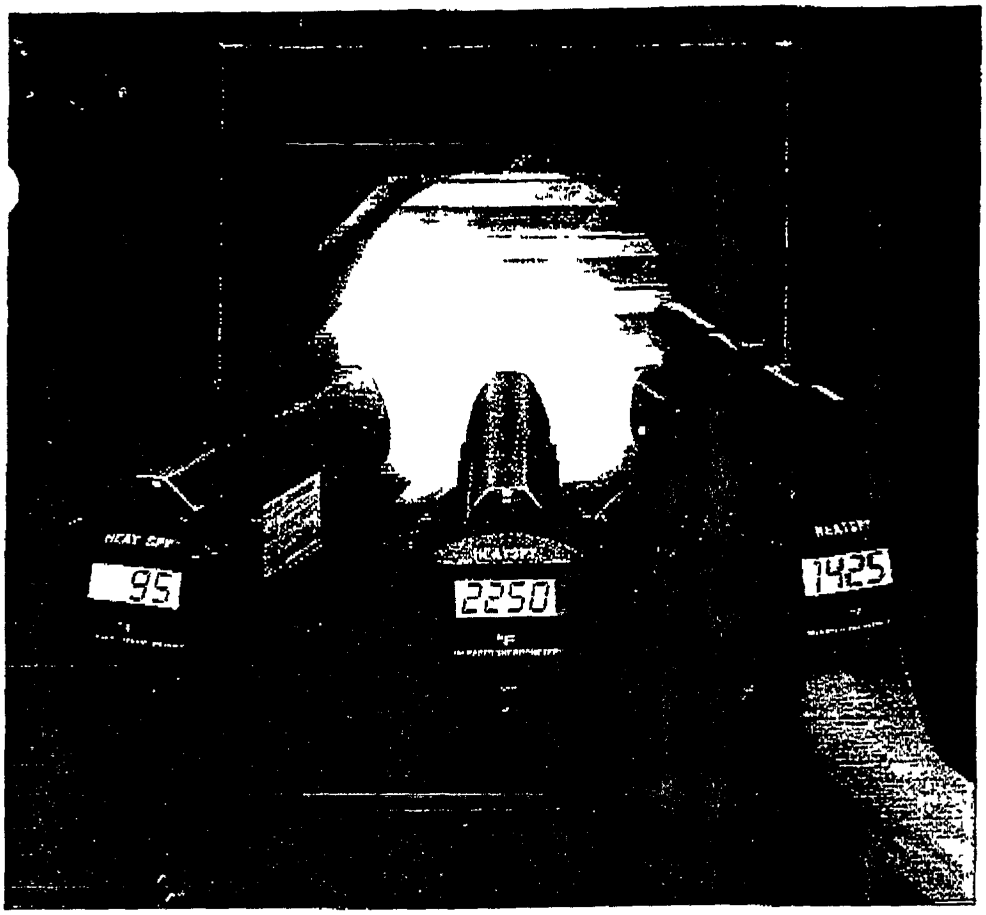
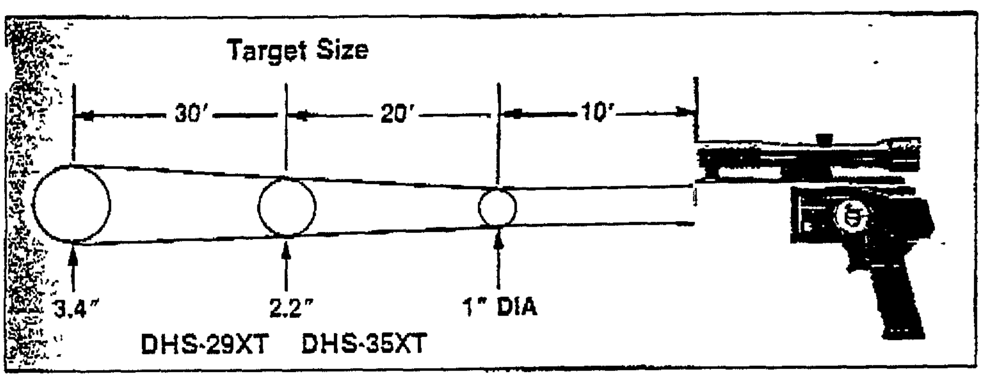
inted in the USA

Heat Spy®



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



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.

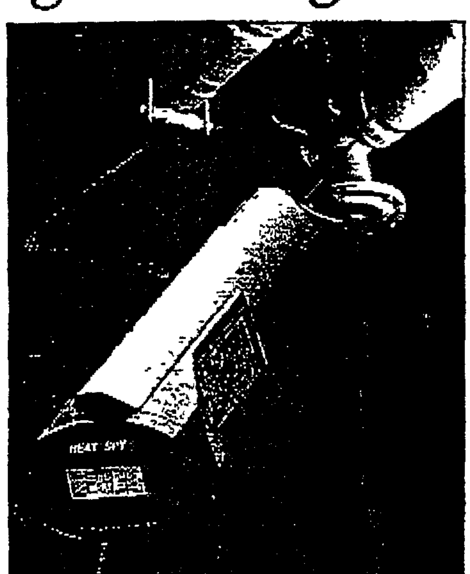
3-Year Warranty
DHS-29X Standard Sight
DHS-29XT Telescopic Sight

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

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).

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.

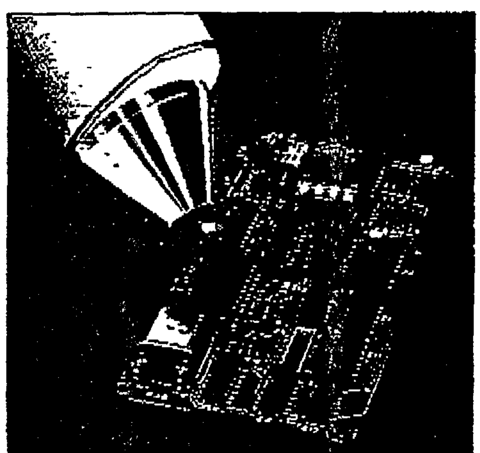
FM Approved models are dedicated °F or °C and are furnished without a connection for AC adapter, external battery pack or recorder output.

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

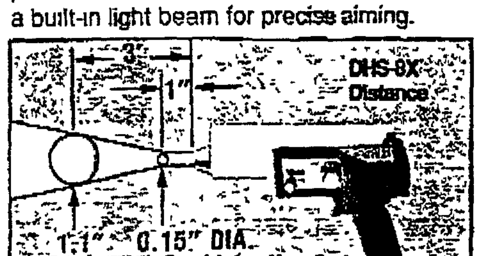
Price includes carrying case, spare battery, owners manual and trigger lock.



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

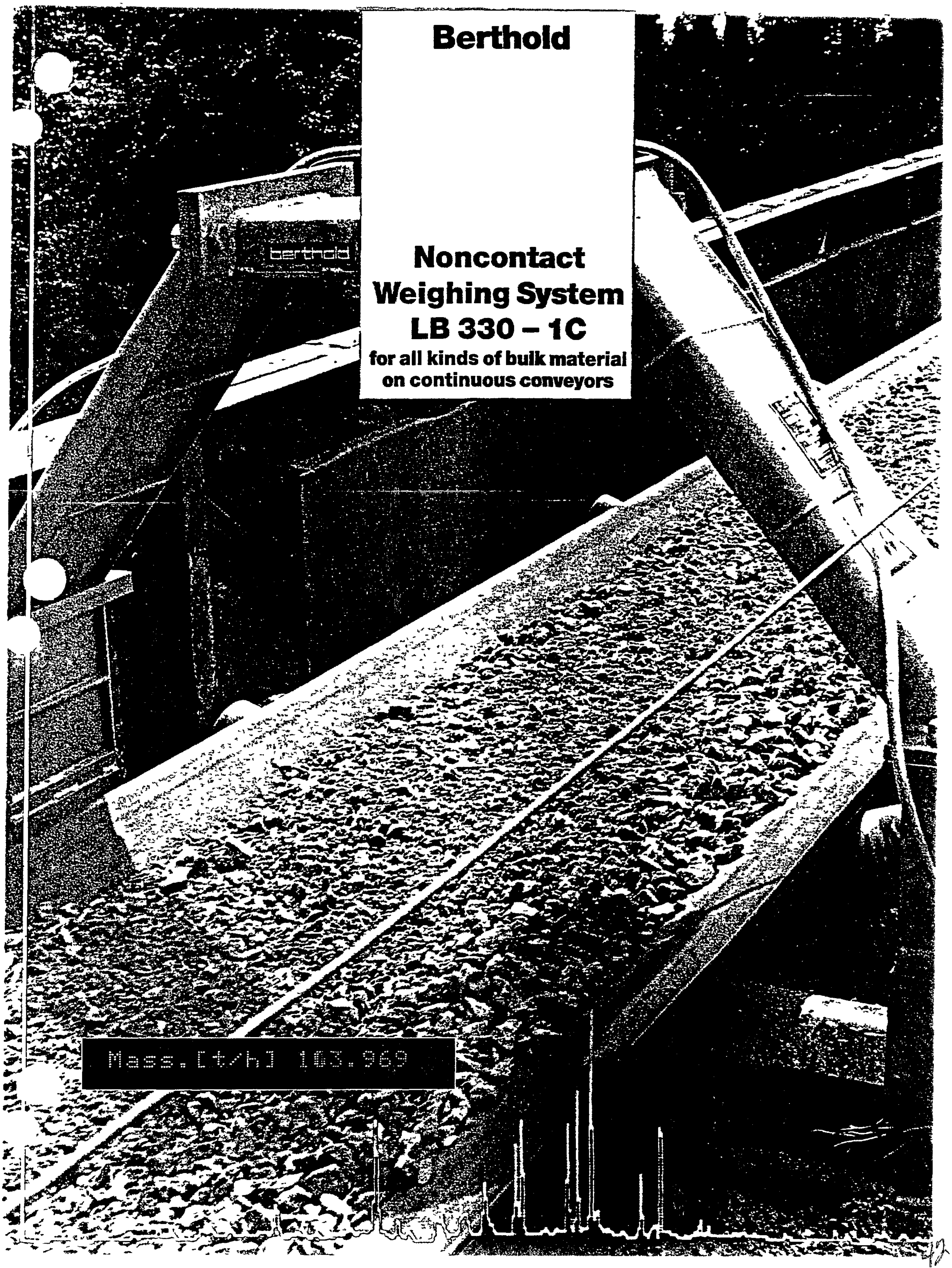
Part No.	Description
11441-1	Spare AC Adapter, 110VAC
11441-2	Spare AC Adapter, 220VAC
9852	Spare Trigger Lock
9990	Heat Spy Carrying Case
B-11	Bench Stand
CRM	Calibration/Repair Manual Specify Model/Serial No.
EP-10	Emissivity Coating Black Spray Paint
H7D	Leather Holster (except for models with telescopic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

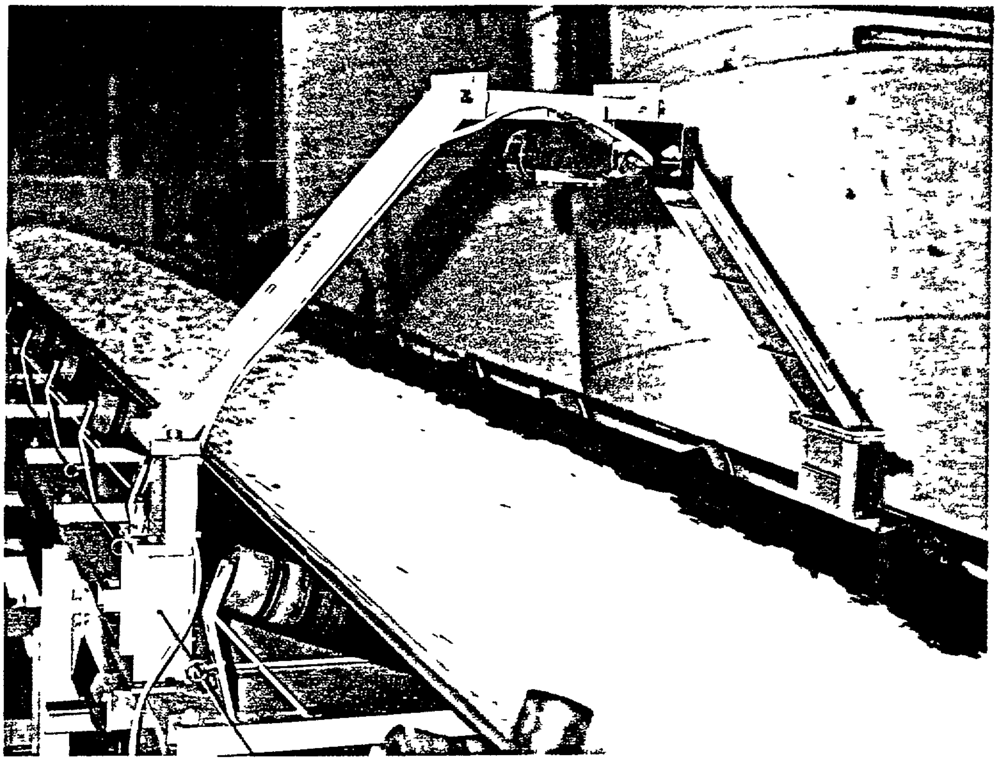
for all kinds of bulk material on continuous conveyors



Noncontact massflow meter

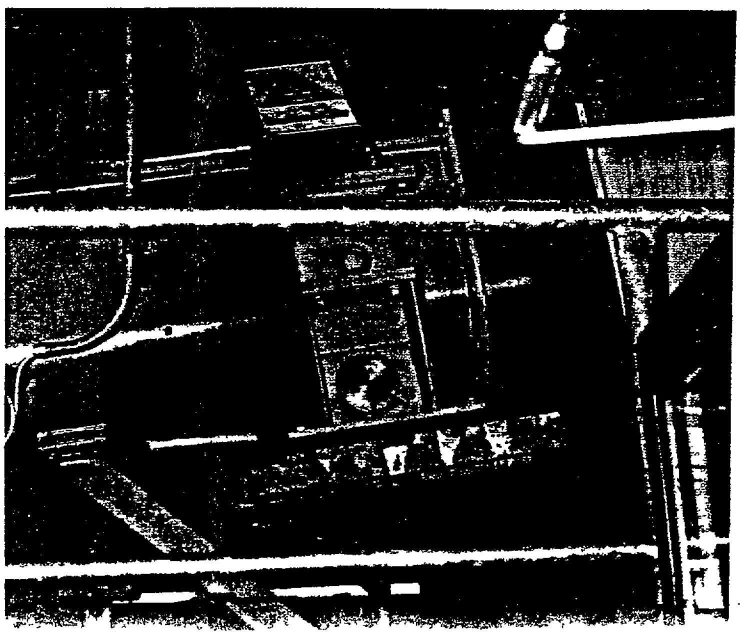
The Compelling Advantages

- 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

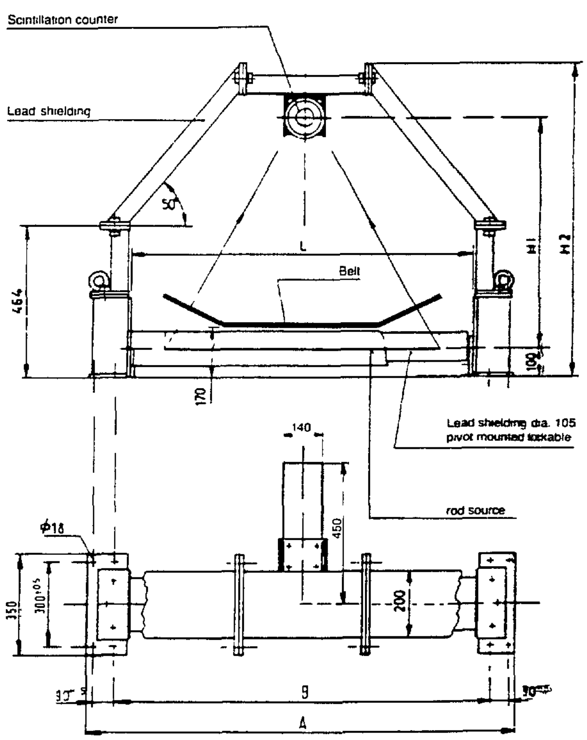
The type of gamma source used depends on the material loading. With high belt loading ^{60}Co is used (half-life 5.3 years), with medium loading ^{137}Cs (half-life 30 years) and with low loading ^{241}Am rod sources (half-life 433 years).

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

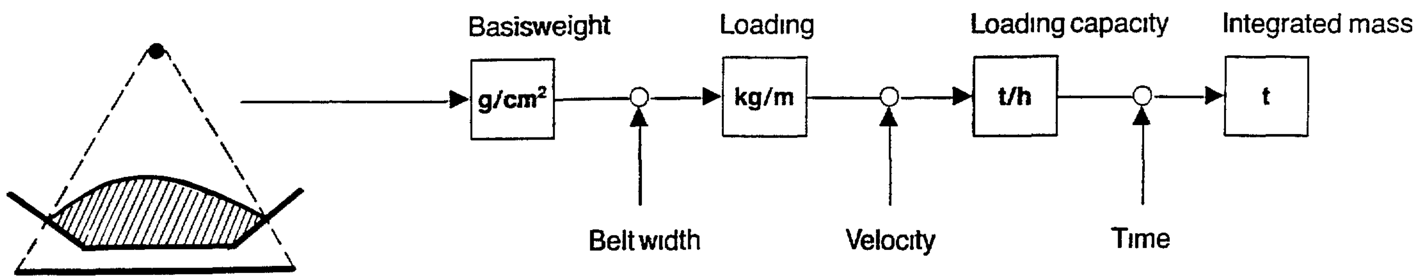


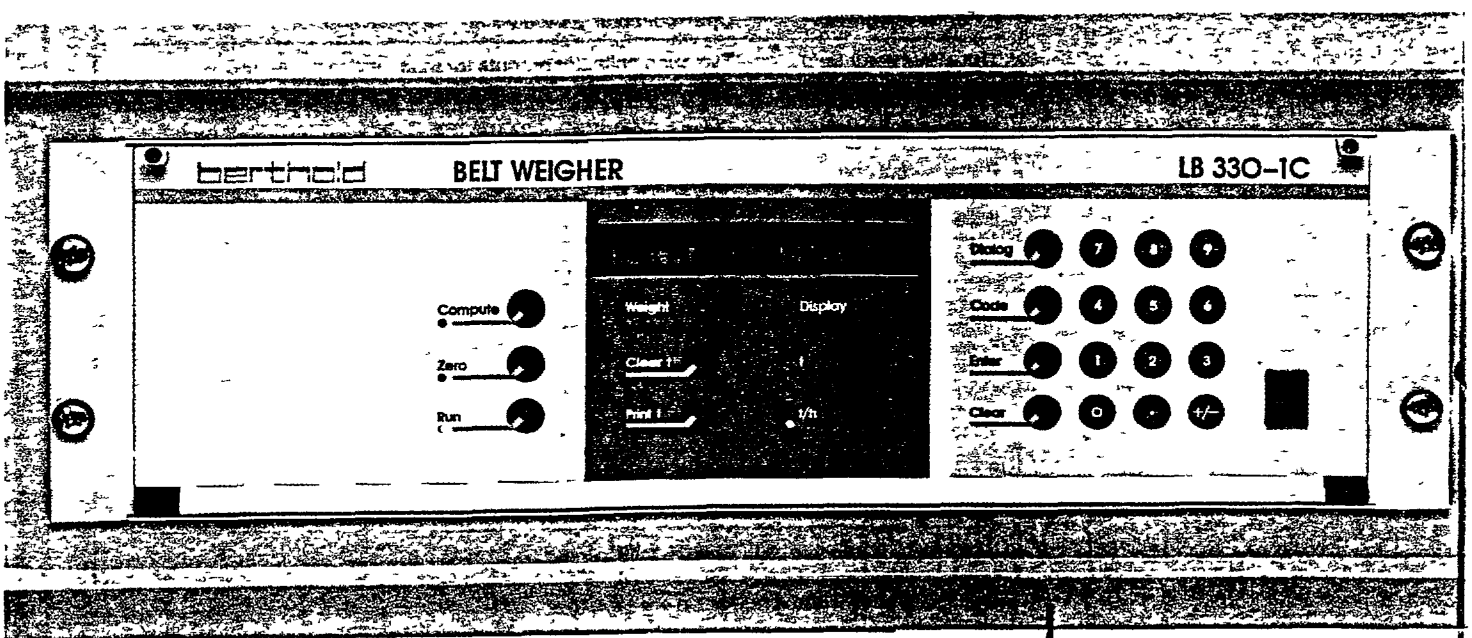
Width mm	A	B	H1	H2	L	Weight of Measuring frame approx. kg
500	1006	776	494	754	706	190
650	1156	926	584	844	856	220
800	1306	1076	674	934	1006	250
1000	1506	1276	794	1054	1206	290
1200	1706	1476	914	1174	1406	330
1400	1906	1676	1034	1294	1606	370
1600	2106	1876	1034	1294	1806	420

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



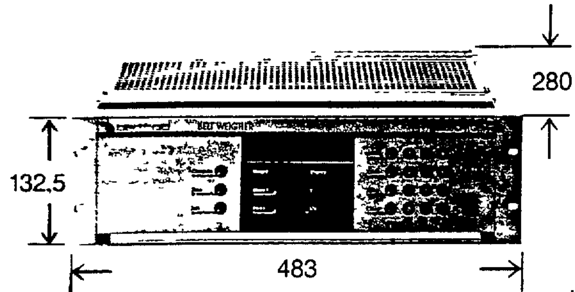


Evaluation unit installed in protection housing

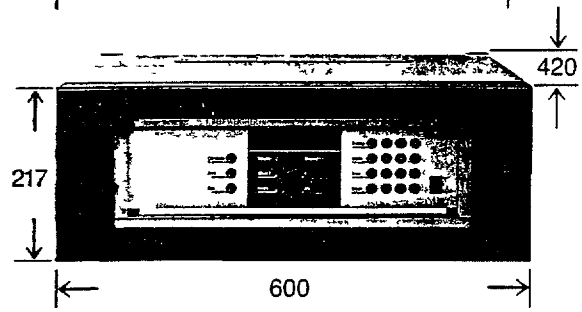
Dimensional Drawings

Dimensions in mm

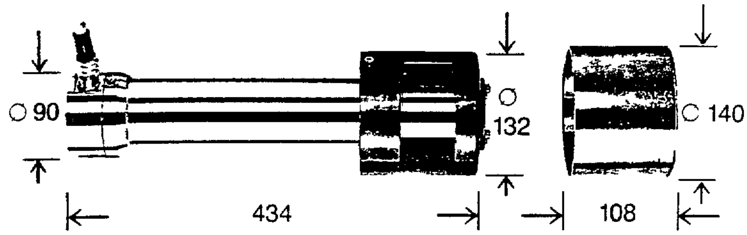
Evaluation unit
Weight approx 6 kg



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

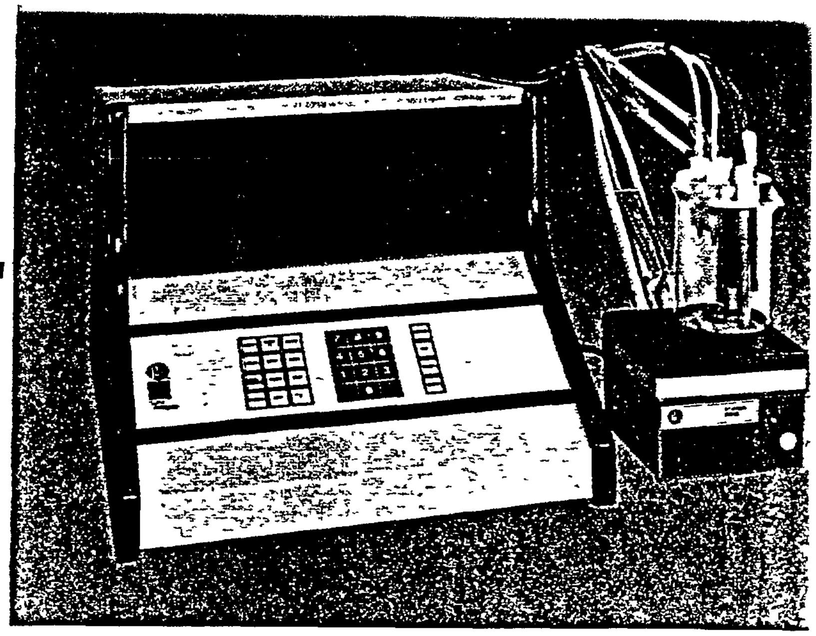
Approximate material profile section of material with maximum loading (sketch)

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)

u-1

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

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

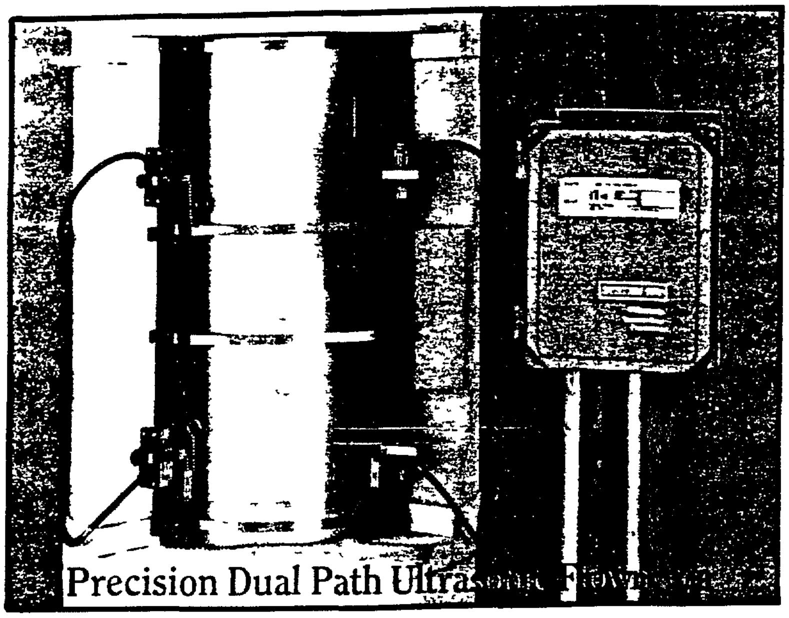
1760	**Sulfur Analyzer complete with accessories, 115/230 v 50/60 Hz**
1722	**Smart Link Board**
1723	**RS232C Printer Output Board**
A597E	**Smart Link cable, 25 ft.**
A643E	**Cable for RS232C output**

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

CONTROLOTRON

Models 990DBN and 990DBP

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



Precision Dual Path Ultra

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

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

FEATURES

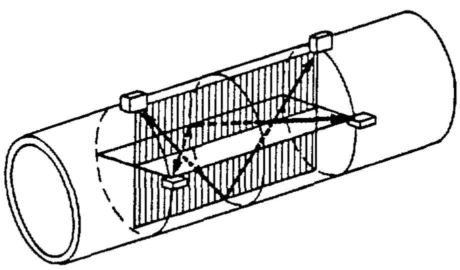
- Universal Applicability
- Outperforms Conventional Intrusive Flowmeters
- Lower Cost/Higher Reliability than Intrusive Flowmeters
- User Friendly Menu Driven Field Programmable Site Setup
- Non-Intrusive Universal Clamp-On Transducers
- MultiPulse® Transmission
- No Cutting of Pipe Ever Required
-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

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: Conduletfor 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

Oxy_ref=true:

Test 1	Flue Gas Measurement at the stack on full load (180 MW) coal for blr #1 side A
Test 2	Flue Gas Measurement at the stack on full load coal for blr #1 side B
Test 3	Flue Gas Measurement at the stack on min load (140 MW) coal for blr #1 side A
Test 4	Flue Gas Measurement at the stack on min load coal for blr #1 side B
Test 5	Flue Gas Measurement at the stack on min load coal for blr #1 side B
Test 6	Flue Gas Measurement at 476 Degr.C on min load coal for blr #1 side A
Test 7	Flue Gas Measurement at 476 Degr.C on min load coal for blr #1 side B
Test 8	Flue Gas Measurement at 466 Degr.C on full load coal for blr #1 side B
Test 9	Flue Gas Measurement at 494 Degr.C on full load coal for blr #1 side A
Test10	Flue Gas Measurement at the stack on min load gas for blr #1 side A

Oxy_ref=3%:

Test 11	Flue Gas Measurement at the stack on min load gas for blr #1 side A
Test 12	Flue Gas Measurement at the stack on min load gas for blr #1 side B
Test 13	Flue Gas Measurement at the stack on full load gas for blr #1 side B
Test 14	Flue Gas Measurement at the stack on full load gas for blr #1 side A
Test 15	Flue Gas Measurement at 479 Degr.C on full load gas for blr #1 side A
Test 16	Flue Gas Measurement at 417 Degr.C on full load gas for blr #1 side B
Test 17	Flue Gas Measurement at the stack on full load (275 MW) coal for blr #8 side A

Oxy_ref=true:

Test 18	Flue Gas Measurement at the stack on full load coal for blr #8 side B
Test 19	Flue Gas Measurement at the stack on min load (230 MW) coal for blr #8 side A

Oxy_ref=3%:

Test 20	Flue Gas Measurement at the stack on min load coal for blr #8 side B
Test 21	Flue Gas Measurement at 683 Degr.C on min load coal for blr #8 side B

SERIAL # 11003239
TEST 1 BOILER# 1A 180 MW
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 12:15:06
DATE: 03/01/95

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	92	°C
OXYGEN:	12.4	%
CARBON MONOXIDE:	21	MGM
CARBON DIOXIDE:	07.4	%
COMBUSTIBLE GASES:	0.40	%
STACK DRAFT (INCHES H20):	+ 6.6	
EXCESS AIR:	139	%
OXIDES of NITROGEN:	231	MGM
SULFUR DIOXIDE:	1308	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

TEST 2 BOILER# 1B 180MW
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 12:27:16
DATE: 03/01/95

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	90	°C
OXYGEN:	15.1	%
CARBON MONOXIDE:	14	MGM
CARBON DIOXIDE:	05.0	%
COMBUSTIBLE GASES:	0.61	%
STACK DRAFT (INCHES H20):	+ 10.1	
EXCESS AIR:	248	%
OXIDES of NITROGEN:	159	MGM
SULFUR DIOXIDE:	861	MGM
CARBON MONOXIDE ALARM:	900	PPM

MODE:MGM OXY_REF=TRUE%

1 A 140 MW

SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:43:01
DATE: 03/01/95

FUEL ~~NATURAL GAS:21870 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	19	°C
STACK TEMPERATURE:	88	°C
OXYGEN:	14.3	%
CARBON MONOXIDE:	42	MGM
CARBON DIOXIDE:	03.8	%
COMBUSTIBLE GASES:	0.26	%
STACK DRAFT (INCHES H20): +	6.2	
EXCESS AIR:	191	%
OXIDES of NITROGEN:	157	MGM
SULFUR DIOXIDE:	946	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

TEST 4 BOILER# 1 ~~A~~ B 140 MW

SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:49:04
DATE: 03/01/95

FUEL ~~NATURAL GAS:21870 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE.	19	°C
STACK TEMPERATURE:	88	°C
OXYGEN:	14.8	%
CARBON MONOXIDE:	39	MGM
CARBON DIOXIDE:	03.5	%
COMBUSTIBLE GASES:	0.37	%
STACK DRAFT (INCHES H20): +	6.6	
EXCESS AIR:	214	%
OXIDES of NITROGEN:	148	MGM
SULFUR DIOXIDE:	852	MGM
CARBON MONOXIDE ALARM:	50	PPM

DE:

TEST 5 BOILER 1 "5" 140 MW
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:56:01
DATE: 03/01/95

FUEL ~~NATURAL GAS:21070 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	17	°C
STACK TEMPERATURE:	92	°C
OXYGEN:	14.3	%
CARBON MONOXIDE:	32	MGM
CARBON DIOXIDE:	03.8	%
COMBUSTIBLE GASES:	0.12	%
STACK DRAFT (INCHES H20): +	5.9	
EXCESS AIR:	191	%
OXIDES of NITROGEN:	171	MGM
SULFUR DIOXIDE:	1008	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

140 MW

SERIAL # 11003239
TEST 6 BOILER# 1A [illegible]
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 15:23:48
DATE: 03/01/95

FUEL ~~NATURAL GAS:21070 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	74.0	%
AMBIENT TEMPERATURE:	26	°C
STACK TEMPERATURE:	476	°C
OXYGEN:	07.1	%
CARBON MONOXIDE:	54	MGM
CARBON DIOXIDE:	07.8	%
COMBUSTIBLE GASES:	0.68	%
STACK DRAFT (INCHES H20): +	0.4	
EXCESS AIR:	46	%
OXIDES of NITROGEN:	295	MGM
SULFUR DIOXIDE:	1756	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM O

"B"

140 MW

SERIAL # 11003239
TEST 7 BOILER# 1 [illegible]
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 15:39:16
DATE: 03/01/95

FUEL ~~NATURAL GAS:21870 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	71.2	%
AMBIENT TEMPERATURE:	32	°C
STACK TEMPERATURE:	425	°C
OXYGEN:	08.8	%
CARBON MONOXIDE:	86	MGM
CARBON DIOXIDE:	06.8	%
COMBUSTIBLE GASES:	0.92	%
STACK DRAFT (INCHES H20): +	0.7	
EXCESS AIR:	65	%
OXIDES of NITROGEN:	227	MGM
SULFUR DIOXIDE:	1491	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

175 MW

SERIAL # 11003239
TEST 8 BOILER# 1 [illegible] "B"
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 16:03:44
DATE: 03/01/95

FUEL ~~NATURAL GAS:21870 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	60.8	%
AMBIENT TEMPERATURE:	37	°C
STACK TEMPERATURE:	466	°C
OXYGEN:	06.7	%
CARBON MONOXIDE:	135	MGM
CARBON DIOXIDE:	08.0	%
COMBUSTIBLE GASES:	1.74	%
STACK DRAFT (INCHES H20): +	1.0	
EXCESS AIR:	42	%
OXIDES of NITROGEN:	320	MGM
SULFUR DIOXIDE:	2159	MGM
CARBON MONOXIDE ALARM:	50	PPM

[illegible]

TEST 9 BOILER# 1A 175 MW reheat ccop

SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 16:12:39
DATE: 03/01/95

FUEL ~~NATURAL GAS:21870 BTU/LB~~ COAL

COMBUSTION EFFICIENCY:	65.2	%
AMBIENT TEMPERATURE:	38	°C
STACK TEMPERATURE:	494	°C
OXYGEN:	06.0	%
CARBON MONOXIDE:	58	MGM
CARBON DIOXIDE:	08.4	%
COMBUSTIBLE GASES:	1.38	%
STACK DRAFT (INCHES H2O):	+ 0.5	
EXCESS AIR:	36	%
OXIDES of NITROGEN:	336	MGM
SULFUR DIOXIDE:	2002	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

SERIAL # 11003239

TEST 10 BOILER# 1A " 140 MW

SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 09:45:26
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	23	°C
STACK TEMPERATURE:	98	°C
OXYGEN:	10.8	%
CARBON MONOXIDE:	0	MGM
CARBON DIOXIDE:	05.7	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O):	+ 4.7	
EXCESS AIR:	94	%
OXIDES of NITROGEN:	119	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OX

TEST 11 B...... 1 1/4 A" 140 mW 20%
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 09:48:05
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	22	°C
STACK TEMPERATURE:	100	°C
OXYGEN:	10.6	%
CARBON MONOXIDE:	0	MGM
CARBON DIOXIDE:	05.8	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20): +	4.3	
EXCESS AIR:	92	%
OXIDES of NITROGEN:	224	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF= 3%

TEST 12 BOILER# 1 1/4 B" 140 mW 20%
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 09:56:53
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	27	°C
OXYGEN:	11.6	%
CARBON MONOXIDE:	0	MGM
CARBON DIOXIDE:	05.3	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20): +	3.0	
EXCESS AIR:	110	%
OXIDES of NITROGEN:	232	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE: [illegible]

SERIAL # 11003239
TEST 13 BOILER# 1 - 5" 180 MW
SERIAL # 11003239

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 10:30:58
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	16	°C
STACK TEMPERATURE:	92	°C
OXYGEN:	12.3	%
CARBON MONOXIDE:	8	MGM
CARBON DIOXIDE:	04.9	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O): +	7.0	
EXCESS AIR:	125	%
OXIDES of NITROGEN:	321	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

OXY_REF= 3%

TEST 14 BOILER# 1 - 4" 180 MW
SERIAL # 11003239

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 10:37:01
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	16	°C
STACK TEMPERATURE:	95	°C
OXYGEN:	10.4	%
CARBON MONOXIDE:	42	MGM
CARBON DIOXIDE:	06.0	%
COMBUSTIBLE GASES:	0.03	%
STACK DRAFT (INCHES H2O): +	5.6	
EXCESS AIR:	88	%
OXIDES of NITROGEN:	302	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

M OXY_RE

180 MW

~~напор регул. стор.~~ " "

SERIAL # 11003239 1 левая сторона A
TEST 15 BOILER#
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 11:01:14
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	84.5	%
AMBIENT TEMPERATURE:	22	°C
STACK TEMPERATURE:	479	°C
OXYGEN:	03.6	%
CARBON MONOXIDE:	18	MGM
CARBON DIOXIDE:	09.8	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O): +	0.7	
EXCESS AIR:	18	%
OXIDES of NITROGEN:	298	MGM
SULFUR DIOXIDE:	0	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF= 3%

напор регул. от " "

TEST 16 BOILER# 1 правая сторона 180 MW B
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 11:07:04
DATE: 03/02/95

FUEL NATURAL GAS:21870 BTU/LB

COMBUSTION EFFICIENCY:	86.3	%
AMBIENT TEMPERATURE:	26	°C
STACK TEMPERATURE:	417	°C
OXYGEN:	04.1	%
CARBON MONOXIDE:	8	MGM
CARBON DIOXIDE:	09.5	%
COMBUSTIBLE GASES:	0.03	%
S[illegible]ACK DRAFT (INCHES H2O): +	0.0	
[illegible]ESS AIR:	22	%
[illegible]ES of NITROGEN:	289	MGM
[illegible] DIOXIDE:	0	MGM
[illegible] MONOXIDE ALARM:	50	PPM

SERIAL # 11003239
TEST 17 BOILER# 8 275MW SIDE A
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:23:59
DATE: 03/02/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	23	°C
STACK TEMPERATURE:	170	°C
OXYGEN:	10.1	%
CARBON MONOXIDE:	12	MGM
CARBON DIOXIDE:	08.8	%
COMBUSTIBLE GASES:	0.19	%
STACK DRAFT (INCHES H20):	+ 7.1	
EXCESS AIR:	88	%
OXIDES of NITROGEN:	1238	MGM
SULFUR DIOXIDE:	477	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF= 3%

TEST 18 BOILER# 8 275MW SIDE B
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:25:39
DATE: 03/02/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	23	°C
STACK TEMPERATURE:	170	°C
OXYGEN:	10.7	%
CARBON MONOXIDE:	7	MGM
CARBON DIOXIDE:	08.3	%
COMBUSTIBLE GASES:	0.21	%
STACK DRAFT (INCHES H20):	+ 7.2	
EXCESS AIR:	99	%
OXIDES of NITROGEN:	708	M[illegible]
SULFUR DIOXIDE:	315	[illegible]
CARBON MON[illegible]	50	P[illegible]

MODE:MGM [illegible] TRUE

230 MW
TEST 19 BOILER 361 PBП К-е и Б

SERIAL # 11003239

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:37:49
DATE: 03/02/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	22	°C
STACK TEMPERATURE:	168	°C
OXYGEN:	10.6	%
CARBON MONOXIDE:	11	MGM
CARBON DIOXIDE:	08.4	%
COMBUSTIBLE GASES:	0.18	%
STACK DRAFT (INCHES H2O): +	5.7	
EXCESS AIR:	98	%
OXIDES of NITROGEN:	632	MGM
SULFUR DIOXIDE:	269	MGM
CARBON [illegible] M:	50	PPM

MODE: [illegible] -TRUE%

230MW

TEST 20 BOILER# 8 ?? PBП K Б[4]
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 14:39:19
DATE: 03/02/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	OVER	%
AMBIENT TEMPERATURE:	22	°C
STACK TEMPERATURE:	169	°C
OXYGEN:	10.7	%
CARBON MONOXIDE:	13	MGM
CARBON DIOXIDE:	08.3	%
COMBUSTIBLE GASES:	0.18	%
STACK DRAFT (INCHES H2O): +	5.9	
EXCESS AIR:	99	%
OXIDES of NITROGEN:	1102	MGM
SULFUR DIOXIDE:	454	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF= 3%

K-? Б[4] 230MW

SERIAL # 11003239
TEST 21 BOILER# 8 за поворотн кам
SERIAL # 11003239

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: BURNS & ROEH

TIME: 15:01:03
DATE: 03/02/95

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	37.3	%
AMBIENT TEMPERATURE:	27	°C
STACK TEMPERATURE:	683	°C
OXYGEN:	07.8	%
CARBON MONOXIDE:	1518	MGM
CARBON DIOXIDE:	10.6	%
COMBUSTIBLE GASES:	1.90	%
STACK DRAFT (INCHES H2O): +	0.7	
EXCESS AIR:	57	%
OXIDES of NITROGEN:	1018	MGM
SULFUR DIOXIDE:	680	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF= 3%

AUDIT RECORDS
FLUKE AC POWER ANALYZER

A) Transformer Cooling Fan Motor, 3 Phase 400V

1) Phase A 230V, 91.8 Amps

AMPS TEXT SCREENS

Arms	=	91.8	Arms	=	91.8
Apeak	=	131.7	AHM	=	2.7
Adc	=	-0.2	KF	=	1.1
% THD-R	=	2.9	% THD-F	=	3.0
CF	-	1.44			

VOLTS TEXT SCREENS

Vrms	=	230	Vrms	=	230
Vpeak	=	339	VHM	=	9
Vdc	=	0	CF	=	1.47
% THD-R	=	3.9	% THD-F	=	3.8

WATTS TEXT SCREENS

W	=	13.6	W	=	13.6
VA	=	21.1	VAR	=	16 1
PF	=	0.64	°ALAG	=	50
DPF	=	0.64			

2) <u>Phase B</u> 227V, 91.4 Amps

AMPS TEXT SCREENS

Arms	=	91.3	Arms	=	91.2
Apeak	=	130.4	AHM	=	2.7
Adc	=	-0.2	KF	=	1.0
% THD-R	=	2.9	% THD-F	=	3.0
CF	-	1.43			

VOLTS TEXT SCREENS

Vrms	=	226	Vrms	=	226
Vpeak	=	330	VHM	=	8
Vdc	=	0	CF	=	1 46
% THD-R	=	3.6	% THD-F	=	3.5

WATTS TEXT SCREENS

W	=	13.5	W	=	13.5
VA	=	20.7	VAR	=	15.6
PF	=	0.65	°ALAG	=	49
DPF	=	0.65			

3) <u>Phase C</u> 233V, 88.5 Amps

AMPS TEXT SCREENS

Arms	=	88.3	Arms	=	88.2
Apeak	=	126.8	AHM	=	2.7
Adc	=	-0.2	KF	=	1.0
% THD-R	=	3.1	% THD-F	=	3.1
CF	-	1.44			

VOLTS TEXT SCREENS

Vrms	=	233	Vrms	=	233
Vpeak	=	341	VHM	=	9
Vdc	=	0	CF	=	1.46
% THD-R	=	3.9	% THD-F	=	3.9

WATTS TEXT SCREENS

W	=	13.3	W	=	13.2
VA	=	20.6	VAR	=	15.7
PF	=	0.64	°ALAG	=	50°
DPF	=	0.64			

GROUND LEAKAGES

AMPS TEXT SCREENS

Arms	=	5.03
Apeak	=	7.03
Adc	=	-0.03
% ThD-R	=	3.4
CF	=	1.38

VOLTS TEXT SCREENS

Vrms	=	230V

WATTS TEXT SCREENS

W	=	0.04	W	=	0.04
VA	=	1.13	VAR	=	1.12
PF	=	0.05	°ALAG	=	88
DPF	=	0.04			

B) GENERATOR RELAY PANEL: CT & PT LEADS

110.6V, 3.05 AMPS, 0.18 KW

AMPS TEXT SCREENS

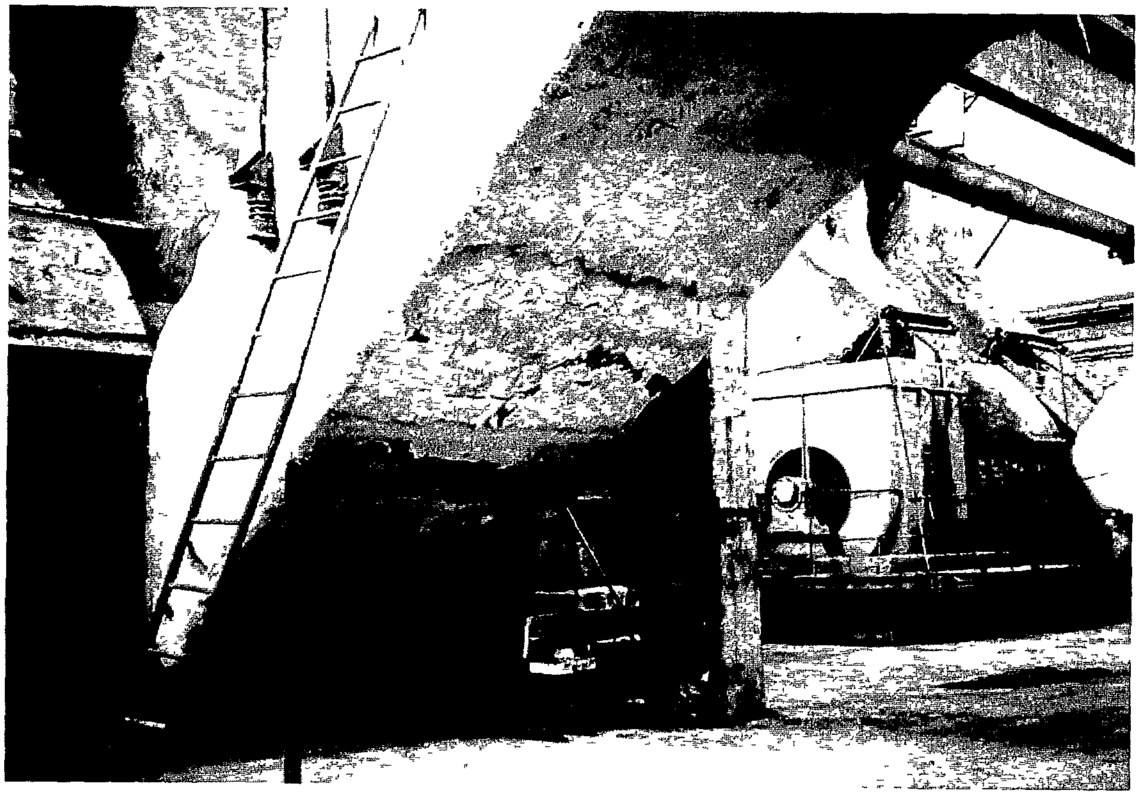
Arms	=	2.81	Arms	=	2.84
Apeak	=	3.95	AHM	=	0.04
Adc	=	0.04	KF	=	1.0
% THD-R	=	1.3	% THD-F	=	1.3
CF	=	1.4			

VOLTS TEXT SCREENS

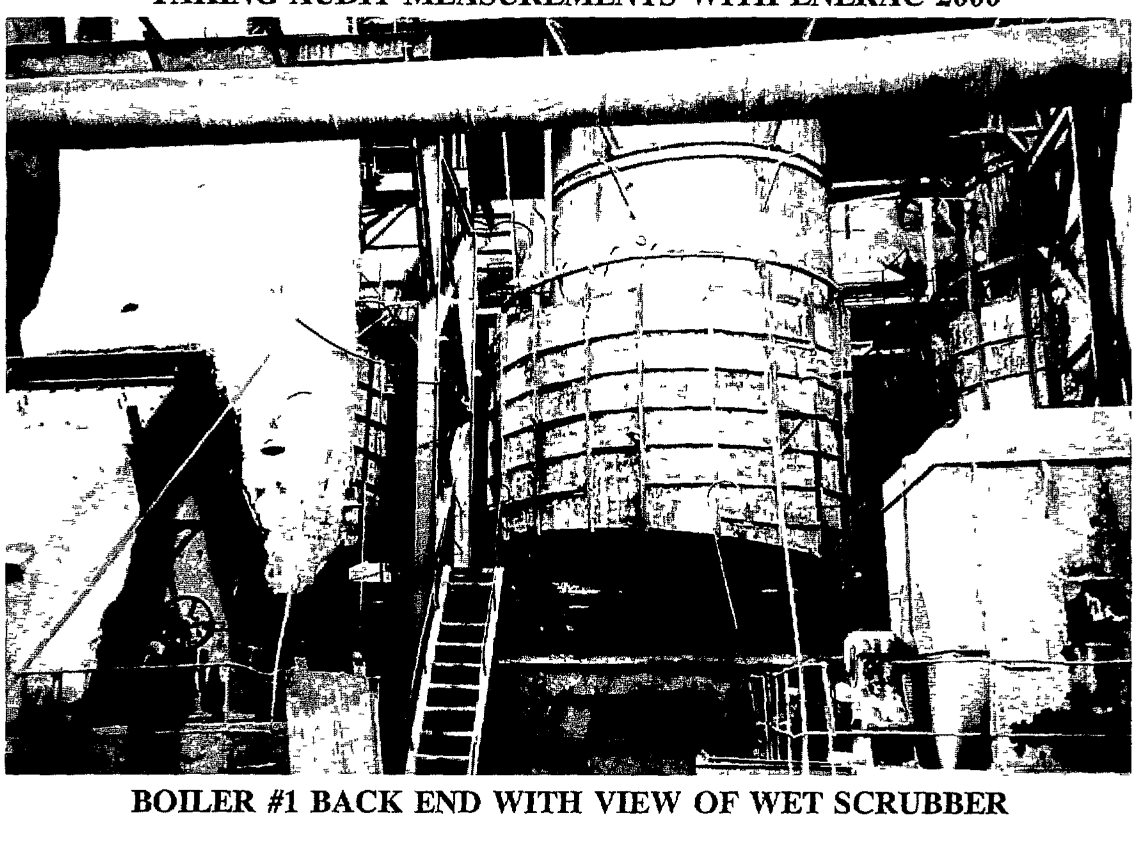
Vrms	=	110.8	Vrms	=	110 8
Vpeak	=	155.5	VHM	=	0.7
Vdc	=	-0.1	CF	=	1.4
% THD-R	=	0.6	% THD-F	=	0.6

WATTS TEXT SCREENS

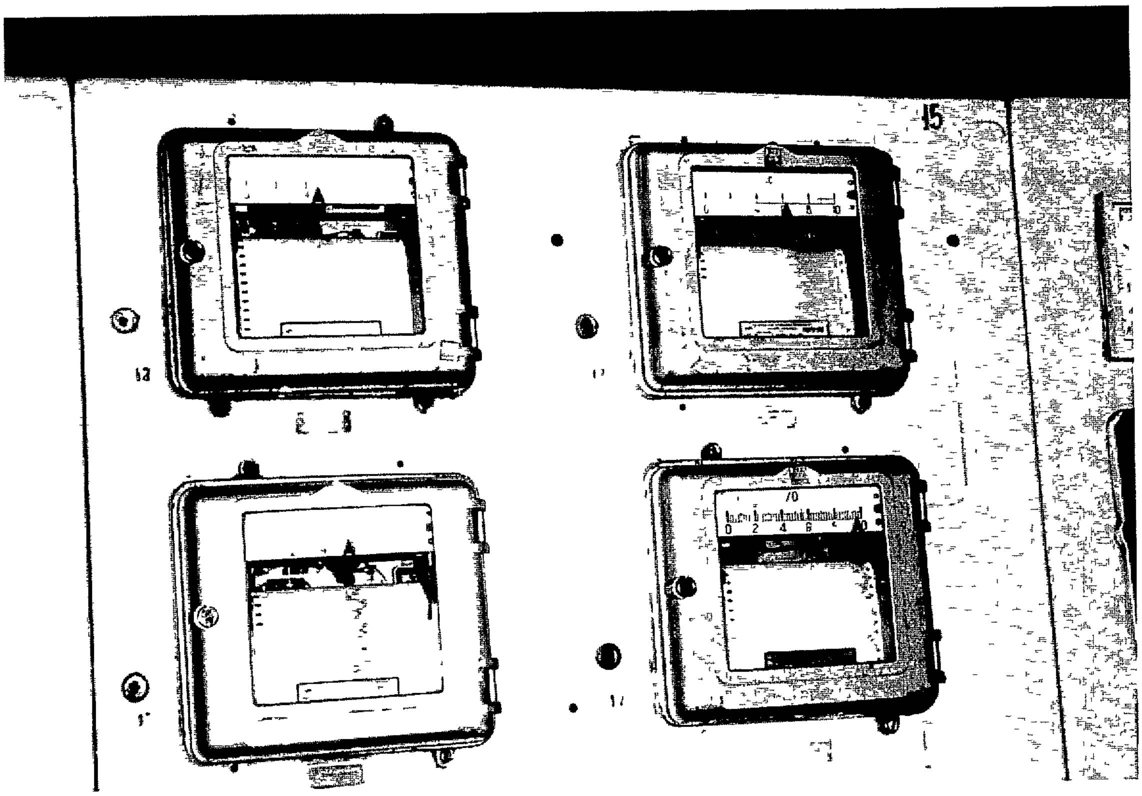
W	=	160	W	=	166
VA	=	316	VAR	=	275
PF	=	0.52	°ALAG	=	59
DPF	=	0.51			



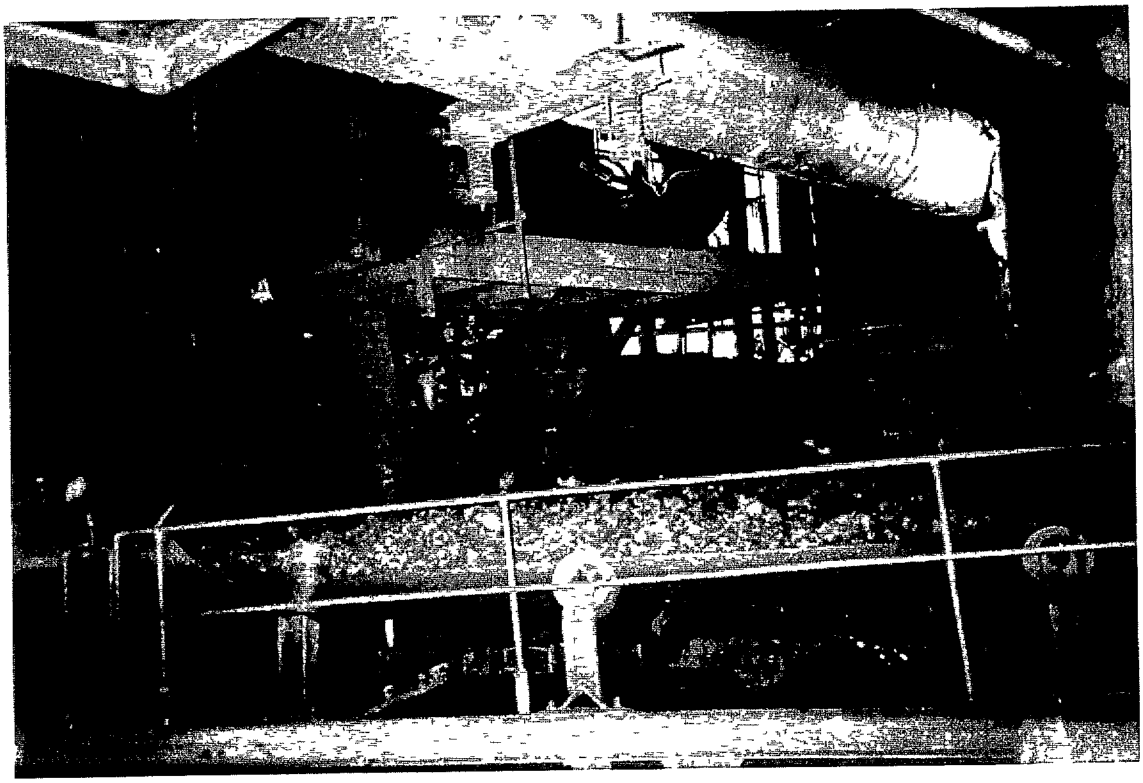
BOILER #1 BACK END
TAKING AUDIT MEASUREMENTS WITH ENERAC 2000



BOILER #1 BACK END WITH VIEW OF WET SCRUBBER



BOILER #1 - O_2 RECORDERS



BOILER #1 - COAL FEEDER

APPENDIX C

Power Plant Data

Б Л О К N 1

LEAKAGE FOR BOILER #1

Присосы по котлу N 1

Слева LEFT	Справа RIGHT
BEFORE A/H → до РВВ - 18,8%	до РВВ - 18,8%
A/H → РВВ - 20,6%	РВВ - 20,6%
ID FAN DUCT → короб ДС - 15,8%	короб ДС - 15,8%

TOTAL LEAKAGE → Общий присос - 66.3%

Цена топлива FUEL COST

Цена топлива	Уголь COAL	Газ GAS	Мазут MAZUT
за 1994 год	1055807 крб/тн	968218 крб/1000 нм^3	3557494 крб/тн
за январь 1995 г (факт) JANUARY ACTUAL	4922749 крб/тн	6257204 крб/1000 нм^3	6027082 крб/тн
за февраль 1995 г. (ожидаемая)	4900000 крб/тн	6825552 крб/1000 нм^3	6000000 крб/тн

Качество топлива за 27.02.95 г.

COAL Уголь $Q_н^р$ - 4555 ккал/кг; $A^р$ - 29,64%; $W^р$ - 9,73; $V^г$ - 9,16; S_a - 1,15

GAS Газ $Q_н^р$ - 8225 ккал/кг

MAZUT Мазут $Q_н^р$ - 9959 ккал/кг; W - 5,95%; S - 2,99%

Главный инженер /А.Г.Чупыра/

COAL ULTIMATE ANALYSES

- C = 59.4
- W_T = 7.3%
- ASH = 28.2%
- S = 2.6%
- COMB = 4.3%
- N_2 = 0.7%
- H_2 = 1.2%
- O_2 = 0.1%

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

CUSTOM FUEL CREATED FOR ZMIEV POWER PLANT FOR DESIGN COAL

Notes:		March 1, 1995
Data:		Per Power Eng. Handbook
Coal:		DON AS
C	=	59.4%
Water	=	7.3% (8.73%)
Ash	=	28.2 (29.64%)
S	=	2.6% (1.15%)
Comb	=	4.3% (9.16%)
Calorific Value:		5200 Kcal/Kg (4855 Kcal/Kg)
N	=	0.7%
H_2	=	1.2%
O_2	=	0.1%

Note: Data in parenthesis is for a lower calorific value.

<u>OXYGEN ANALYZER DATA FOR ZMIEV BLR #3</u>

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

200 MW Boiler, coal, gas and mazut fired

Install Probes at Elevation·	41m.
Process Temperature	700 degrees Centigrade minimum 900 degrees Centigrade normal 1050 degrees Centigrade maximum
Ambient Temperature.	55 to 60 degrees Centigrade.
Length of the cable run to the control room	front: 110 m rear· 125 m

International Combustion Ltd

SO_2 and NOx Emissions Conversion Chart

To Convert From ↓		To: (Multiply by) mg/Nm³	ppm NOx	ppm SO_2	g/GJ Coal[A]	g/GJ Oil[B]	g/GJ Gas[C]	lb/10^6 Btu Coal[A]	lb/10^6 Btu Oil[B]	lb/10^6 Btu Gas[C]
mg/Nm³		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}		
g/GJ	Oil[B]	3.57	1.74	1.25		1			2.33×10^{-3}	
g/GJ	Gas[C]	3.70	1.80	1.30			1			2.33×10^{-3}
lb/10^6 Btu	Coal[A]	1230	598	430	430			1		
lb/10^6 Btu	Oil[B]	1540	748	538		430			1	
lb/10^6 Btu	Gas[C]	1590	775	557			430			1

A :- Coal:- Flue Gas dry 6% excess O_2: Assumes 350 Nm³/GJ – ref IEA Paper 1988.
B :- Oil :- Flue Gas dry 3% excess O_2: Assumes 280 Nm³/GJ – ref IEA Paper 1988.
C :- Gas:- Flue Gas dry 3% excess O_2: Assumes 270 Nm³/GJ – ref IEA Paper 1988.

APPENDIX D

List of Contacts Made During Plant Audits

LIST OF CONTACTS MADE DURING PLANT AUDITS

- Oleg K. Gritsaniuck, Director
- Alexander G. Chupyra, Chief Engineer
- Ermolenko A. Bacilievich, Deputy Chief of Operation
- Kolomijets V. Ivanovich, Chief of Equipment Testing and Adjustment Department
- Babenko J. Mikhailovich, Chief of computing Center
- Ustimenko A. Andrejevich, Electrical Engineer
- Miroshnichenko N. Alexandrovich, Electrical 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
Kgcc	=	7,000 kcal = 27,776 BTU
kJ	=	Kilojoules = 1 thousand joules = 0.947813 BTU
km	=	kilometer = 0.621 miles
kN	=	kilonewton = 1 thousand newtons
kp	=	kopec = 1/100 ruble
kPa	=	kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	=	kilovolts = 1 thousand volts
kVA	=	kilovolt-amperes
kVAr	=	kilovars = 1 thousand volt-amperes (reactive)
kW	=	kilowatt = 1 thousand watts
kWh	=	kilowatt hour = 1 thousand watt hours

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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

Міністерство
енергетики та
електрифікації України
В Е О «Харківенерго»

Министерство
энергетики и
электрификации Украины
П Э О «Харьковэнерго»

З М И Е В С К А Я Г Р Э С

им. Г. М. Кржижановского

313750 Украина п Комсомольский Змиевского р-на Харьковской обл. обл код 9539, телетайп 625532 и 625545 «Сигма», телефакс 5-35-85, телефон 5-22 47, 5-22-48

отгрузочные реквизиты
д /вагонов
ст Лиман ЮЖД, код. 444002,
д / контейнеров
ст Змиев ЮЖД, код. 444303

Расчетный счет — 221504 в промстройбанке п. Комсомольский, Змиевского р-на, Харьковской обл., Украина, МФО 351210

№ ________________

На № ________________

March 1, 1995

LETTER OF RECEIVING

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

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

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

USAID/KIEV Mission

Director of the Zmiyov
Thermal Power Station

Mr. Gritsenjuk O.K.

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

LIST OF EQUIPMENT

ITEM	DESCRIPTION	QTY	SERIAL #
1.	2 KBV ENERAC 2000 COMBUSTION ANALYZER	1	11003239
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	20002115
11.	MAXELL CHARGER KB8E	1	n/a
12.	FOREGH 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.	2xϕ3.5mm 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.	NOT USED	-	-
41.	OKIDATA ML3380 PRINTER	1	407A0005649
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

Міністерство
енергетики та
електрифікації України
ВЕО «Харківенерго»

Министерство
энергетики и
электрификации Украины
ПЭО «Харьковэнерго»

ЗМИЕВСКАЯ ГРЭС

им. Г. М. Кржижановского

313750 Украина п Комсомольский Змиевского р-на Харьковской обл. обл код 9530, телетайп 625532 и 625545 «Сигма», телефакс 5-35 85, телефон 5-22 47, 5-22-48

отгрузочные реквизиты д/вагонов ст. Лиман ЮЖД, код. 444002, д/ контейнеров ст. Змиев ЮЖД, код. 444303

Расчетный счет — 221504 в промстройбанке п. Комсомольский, Змиевского р-на, Харьковской обл, Украина. МФО 351210

№ ____________

На № ____________

I марта 1995 года

ПРИЕМО-ПЕРЕДАТОЧНЫЙ АКТ

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

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

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

Этот А К Т составлен на русском и английском языках и имеет равную силу.

USAID /Киев

Директор Змиевской ГРЭС

г-н Грищенко Ю.К.

2 Тип. г. Змиев, 1991, з. 2848 т 20000

1 марта 1995г.

СПИСОК ОБОРУДОВАНИЯ

Номер	ОПИСАНИЕ	кол-во	зав.номер
1.	2 KBV ENERAC 2000 анализатор сжигания топлива	1	11003239
2.	SP 48-48" трубный зонд	1	n/a
3.	SH 10-10FT HOSE FOR PROBE	1	n/a
4.	ONE CONDENSATION TRAP WITH DESECANT	1	n/a
5.	Шнур питания	1	n/a
6.	Дымовые графики и бумага	1	n/a
7.	Стенный фильтр	1	n/a
8.	ENERAC 2000 Дискета и рук-во	1	n/a
9.	Инструкция программы ENERCOMP WINDOWS & DISKET	1	n/a
10.	CYCLOPS 300AF инфракрасный термометр	1	20002115
11.	MAXELL зарядное устройство KB8E	1	n/a
12.	Адаптер европейской розетки	1	n/a
13.	220V AC источник питания	1	n/a
14.	Перезаряжаемые элементы AA	4	n/a
15.	CYCLOPS 300AF мягкий футляр	1	n/a
16.	Элементы типа AA	4	n/a
17.	Крышка объектива	1	n/a
18.	Крышка визира	1	n/a
19.	2xФ3.5mm миниатюрные разъемы	2	n/a
20.	Руководство-инструкция	1	n/a
21.	CYCLOPS NECK STRAP	1	n/a
22.	FLUKE #41 измеритель	1	n/a
23.	FLUKE #C41-S футляр	1	n/a
24.	TL-24 ТЕСТ провода	2	n/a
25.	TP-20 ТЕСТ зонды	2	n/a
26.	AC-20 ТЕСТ клипсы	2	n/a
27.	RS-232 интерфейсный кабель	1	n/a
28.	Вилочный адаптер	1	n/a
29.	9 25 адаптер игольчатый	1	n/a
30.	Программное обеспечение для связи	1	n/a
31.	Руководство (описание)	1	n/a
32.	Начало работы с WINDOWS	1	n/a
33.	Карта быстрой ссылки	1	n/a
34.	Аккумуляторы типа "C"	4	n/a
35.	Карта регистрации программы	1	n/a
36.	80i-500S зонд переменного тока	1	n/a
37.	80i-1000S зонд переменного тока	1	n/a
38.	Батарейки типа "C"	4	n/a
39.	Руководство измерения гармоник	1	n/a
40.	Не используется	-	-
41.	OKIDATA ML3380 ПРИНТЕР	1	407A0005649
42.	Адаптер русской клавиатуры	1	n/a
43.	Карта быстрой ссылки 80i-1000S зонд	1	n/a
44.	80i-1000S зонд руководство и регистрационная карточка	1	n/a

ПРОГРАММНЫЕ ПАКЕТЫ С РУКОВОДСТВАМИ (НАЗВАНИЯ ДАНЫ БЕЗ ПЕРЕВОДА)

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.	PROF CABLE 10 FT	1	n/a

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CHECKLIST
IMPROVING COMBUSTION EFFICIENCY
UKRAINIAN POWER PLANTS

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

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

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

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

- Представление и обмен информацией с администрацией станции;

- Обсуждение и представление объема работ;

- Назначение персонала для проведения аудита;

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

- Передача демонстративного портативного оборудования;

- Определение места для установки стационарного оборудования;

- Определение места для установки дистанционных измерительных модулей;

- Определение физических характеристик оборудования ТЭС для установки стационарных приборов;

APPENDIX G

References:

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

PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

ZMIEV POWER PLANT
(OCT 3 THRU OCT. 5, 1994)

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

DECEMBER 1994

4V

PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

ZMIEV POWER PLANT

TABLE OF CONTENTS

PRELIMINARY AUDIT REPORT

IMPROVING COMBUSTION EFFICIENCY

ZMIEV POWER PLANT
(Oct. 3 Thru Oct. 5, 1994)

EXECUTIVE SUMMARY

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

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

Low-Cost, No-Cost Short Term Recommendations:

1) Fuel quality improvement Plans

The plant must survey aggressively the available coals and take initiative in contracting directly from suppliers. The plant must locate the best fuel considering boiler operational needs, design requirements, pollution control equipment performance and delivered costs. The plant must consider a blending strategy of individual coals and coal byproducts 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) 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 ans associated probe per station.

4) In Situ O_2 Analyzers

The combustion efficiency can be improved by replacing the extractive oxygen analyzers with four per 300 MW boiler in-place zirconium oxide sensor analyzers as used in USA.

It is recommended to install those new devices only on one 300 MW unit in order to demonstrate the improvement of boiler's combustion efficiency. All boilers in this station are in the program of either being replaced with a new design boiler or reconstructed in the near future.

It is recommended: total of 4 devices per station.

5) Fuel Meters

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

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

b) Two devices per 300 MW boiler to measure flow of mazut (supply and return lines) per boiler.

6) Portable infrared temperatures 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.

7) 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.

8) 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 the instrumentation per the attached station "Would-like-to-have" instrument list has to be incorporated into the program of replacing the existing boilers with the new design boilers or of boiler reconstructions.

2) Investigate lower cost SO_2/NO_x removal technologies.

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

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

4) Upgrade the dust control system to the world performance standards, either replace the existing scrubbers and ESP's or refurbish to meet the world standards.

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

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

7) Provide proper analytical equipment to the chemical laboratory.

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

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

Observations and Assessments

- The buses of this power station are used for exchange of power between the Russian and the Ukrainian systems. Operation of this plant is in parallel with the Russian grid not the Ukrainian grid.

- The units are operated as base load without interruption and proper maintenance is put off. However there is an annual maintenance outage for each unit and a regular maintenance in accordance with manufacturer's recommendations.

- This station has Unit 1 boiler operated over 250,000 hours, has been switched on/off 375 times, operation time is 1.5 times the design time operation.

- Plans are in place to reconstruct this station. The station would like to keep the structures and replace all the equipment step by step. The new plant is expected to deliver more than 2400 MW's of the existing plant installed capacity.

- A joint venture is in the process of developing a design of a boiler to burn low quality coal as a part of the "pure" coal program. Zmiev boilers will be used for testing and implementating the new design. The Unit #3 boiler will be used for testing the new design. After this testing the Unit #1 boiler will be replaced with new design boiler. This pilot boiler will replace all 200 MW boilers in the rest of the Ukraine.

- The boilers have no burner management systems.

- The station has no NO_x pollution control system. The existing NO_x analyzers in 300 MW units are not used because they are not reliable.

- The original mechanical governors are still in operation.

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

- Most of the process control systems operate on "manual" mode from the control Board located in the Unit Control room. A chart is used to indicate the unit load as a function of the amount of coal and mazut cofired.

- The design of the equipment is obsolete, all designed in the 1950's, and because of the advanced age is also significantly worn out.

- The controls and instrumentations are outdated, 1950's vintage, the readings are unstable and require ongoing maintenance to keep them operational. Spares are hard to be obtained.

- 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 44 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 boiler design requirements, thus reducing boiler efficiency and increasing maintenance. In addition, the poor quality of coal increases the air pollution and causes reduction in MW output of the boilers. Mazut or gas is cofired almost all times in order to deliver the MW's output required by the system and maintain the stable operations of the boilers.

- The original boiler design performance when firing coal was revised in 1987 and 1992 and subsequently the boiler maximum MW output was reduced from 200 MW to 175 MW and from 300 MW to 275 MW. Therefore, the power plant MW's output is derated to 2150 MW from 2400 MW, a reduction of total 250 MW (10.42%). The main steam temperature was changed from 570°C to 540°C to increase the boiler reliability.

- The six 200 MW units are furnished with wet scrubbers, while the four 300 MW units are provided with Electro Static Precipitators (ESP). Both systems are reported operating unsatisfactory.

- The units are operated on base load mode except during the weekends when two or three units are shutdown and the balance of the units operates on load reduction. This operation affects the equipment.

- The efficiency calculations are performed on a per unit and per plant basis. Except for the natural gas that is measured directly per boiler, all other fuel quantities per boiler are extrapolated from power station data. These efficiencies are compared to the efficiencies based upon the boiler design performances recalculated in 1987 and 1992.

INTRODUCTION

ENERGO SYSTEM: KHARKIVENERGO

LOCATION: 30 KM SOUTH OF KHARKIV

INSTALLED CAPACITY: 2400 MW
6 X 200 MW + 4 X 300 MW

COMMISSIONED: 1960-1969

FUEL: COAL LOW-BITUMINOUS, ANTHRACITE AND GAS OR MAZUT

POWER PLANT DESCRIPTION

1. The Zmiev steam power station consists of two lines of units. The first line consists of six subcritical 200 MW power units. The boilers were designated TP-100 and were supplied by the Taganrog Boiler Factory and the turbines were supplied by the Leningrad Metal Works. The second line consists of four supercritical 300 MW power units. The boilers were designated TPP-210 and TPP-210A and were supplied by the Taganrog Boiler Factory and the turbines were supplied by the Kharkov Turbine Factory.

2. The first unit was put into operation in 1960. The unit was designed to fire natural gas because of a supply of natural gas nearby. After three units were put into the operation, the government decided in 1963, 1964 to switch operation of these units to coal and redesign these units for coal firing along with designing the next seven units for coal firing. The equipment for gas firing is still in place. In 1969 construction of all 10 units with a total output of 2,400 MW's was completed.

3. The 300 MW units consist of double boilers (two subboilers) to improve reliability of operation.

4. In the 1970's, the coal supplied to the power station was changed to a much poorer quality than the coal that was the basis for the plant design. The ash content of the coal was up to 40% and still is, and the caloric value of the coal ranged from 3,200-5,000 kcal/kg. A special state program was started to improve the quality of the coal by reprocessing. However, when the coal was reprocessed byproducts were formed which nobody knew what to do with at that time. Nevertheless, these byproducts were delivered to the power stations to be fired. The problems firing the byproducts at this plant are greater than at Kourakhovska power station because these units were originally designed to burn natural gas.

5. The buses of this power station are used for exchange of power between the Russian and the Ukrainian systems. Operation of this plant is in parallel with the Russian grid not the Ukrainian grid.

6. These units are operated as base load without interruption. The station considers this a problem because proper maintenance is put off. Only regular maintenance in accordance with manufacturer's recommendations is performed. This is especially a concern because of poor quality of coal and the age of the plant equipment. There is an annual maintenance outage for each of the units.

7. The power station is proud of unit 1 boiler because it has operated over 250,000 hours, has been switched on/off 375 times, and actual operation time is 1.5 times the design time of operation.

8. The power station considers the units to be complicated, old and control systems obsolete, i.e., all equipment was designed in the 1950's. The power station is proud of the fact that they are able to continue to operate these old units.

9. The power station units are supplemented with either mazut or natural gas when it can be purchased.

10. Coal is measured in a similar manner to Uglegorsk and Kourakhovska, i.e., sampling methodology and weighing on conveyors.

11. The power station has a plan to reconstruct the station. The main problem is to find the correct design of these boilers for poor quality coal. They would like to replace the whole plant step by step. They would like to keep structures but replace all equipment. They would like to increase the capacity of the new plant above the nominal 2,400 MW's of existing plant. They would like to use foreign boiler manufacturer experience in the design of these boilers. At the moment, the station is developing schedules for reconstruction and building housing for workers. However, the schedule for reconstruction is dependent upon development of the new boiler.

12. A joint venture of Kharkivenergo, B&W (USA) and Bilgorod boiler plant has been formed to design a boiler to burn low quality coal. B&W and a local engineering company are responsible for design. The local engineering company would be the central design bureau. Kharkivenergo and B&W are part of the pure coal program. Pure coal is the name of a special program to find an optimal technology for the boiler design. Zmiev boilers will be used for testing the new design. The unit 3 boiler will be tested in a special center for pure coal. After testing, the unit 1 boiler will be replaced with a new design boiler. The results of activities of the joint venture will be a pilot boiler to be used for 200 MW units that will replace all 200 MW units in the rest of the Ukraine.

13. When all units of the power station are operating they can produce a maximum output of 2,200 MW's with an average coal of 4,500 kcal/kg. With mazut or natural gas cofiring the power station can produce 2,400 MW's.

14. The speed of the coal dust feeders can be controlled from the control room. In principal they have schemes to interlock the coal dust feeders and forced draft fan dampers but don't work and don't use. Forced draft fans always operate at full capacity.

15. There are four O_2 analyzers per unit which are used to monitor O_2 contents in boiler combustion process. These analyzers are used to remote manually adjust from the Control Room the speed of coal feeders and position of forced draft fan dampers. Limits of O_2 content are 4% to 6%. The fuel to air ratio is manually adjusted based on experience and O_2 analyzer indications. There are no CO analyzers in the power station. Approximately 140 points in boiler are monitored by thermocouples. Electrical signals go to the Control Room. Station said they had NO_x analyzers in 300 MW units but did not use because they are not reliable.

BOILER PLANT

16. Boiler Design Performance:

    a. The 1987 revised type TP-100 and type TPP-210 boiler design performances are shown on References 1 and 2.

        i. The boiler performances are based upon coal and mazut or coal and natural gas cofiring with mazut being maximum 15% of the total heat input. Never mazut alone.

        ii. The main steam temperature was lowered from 570°C to 540°C.

        iii. The original boiler design performance calculations were based upon a coal caloric value of 6430 kcal/kg, ash content of 18% and water of 6%.

        iv. The 1987 boiler performances are based upon a coal caloric value of 4900 kcal/kg, ash content of 27% and water of 10%; gas of 8221 kcal/kg and mazut of 9316 kcal/kg.

    b. Excerpts from the 1992 revised type TP-100 and type TPP-210 boiler design performances are shown on Attachments 1 and 2 respectively. The TP-100 boiler was derated from 200 to 175 MW output and the TP-210 boiler was derated from 300 to 275 MW output.

17. Mode of Fuel Firing:

a. Mazut Only - units never operate on mazut alone.

b. Natural Gas Only - units can operate at 200 and 300 MW on natural gas only.

c. Coal - can operate with coal firing alone, coal firing with mazut cofiring, and coal firing with natural gas cofiring.

18. As Fired Fuel Analysis:

a. The as-fired fuel analysis for coal, natural gas and mazut is shown on Attachment 3. The fuel analysis for the schlamm is also shown on Attachment 3.

b. Coal:

i. Coal is supplied to the station by 44 suppliers. Lowest volatility content is 4 to 6%.

ii. Initial coal quality determination is achieved by taking coal sample from each railroad car and analyzing for ash and water contents.

iii. There is coal mixing by the bulldozers in the yard.

iv. The average quality of the coal over a 3 to 5 day period is determined by taking coal samples from the conveyors. The coal is analyzed for caloric value, water, ash, volatility and sulfur content. This is a slow process.

v. The power station would like to have devices to measure coal quality feeding each mill (2 devices per boiler) and after each cyclone (2 devices per boiler) for the TP-100 boilers. They want the same arrangement for the TPP-210 boilers except 3 devices per boiler because each boiler has 3 mill systems. The location of these devices for the TP-100 boiler is shown on Attachment 4.

19. Boiler Firing System Flow Diagram:

a. Units 1-6 (TP-100 boilers) - as shown on Attachment 4; there are two rows of eight burners (16 burners total), and two raw coal bunkers, two mills, two separators, two cyclones and one coal dust bunker per boiler.

i. The power station would like to have coal flow meters to measure the input to each mill (2 devices per boiler) for mill efficiency improvement.

ii. Each burner has a 5 ton/hr capacity for coal dust.

iii. Each coal dust feeder (16 total per boiler) can revolve from 500-1500 rev/min.

iv. Speed of rotation of each coal dust feeder is based upon main steam pressure and temperature at the boiler outlet. This is the automatic system of controlling combustion. Good and fast but adjustment is not made correctly for all coal dust feeders as discussed below.

v. However, because of wear and tear of coal dust feeders the actual flow of coal dust through each feeder ranges from 5-7 tons/hr causing local problems at each burner and excess combustion of fuel. In addition, the speed of eight coal dust feeders are adjusted at one time.

vi. The power station would like to have individual coal dust flow meters on each pipeline feeding the burners (16 total per boiler) and be able to individually and manually adjust the coal dust flow to each burner, thus to control combustion at each burner.

vii. The design capacity of the coal dust feed system is 79 tons/hr. Now the system is feeding 100 tons/hr of poor quality coal dust to each boiler.

b. Units 4-10 (TPP-210 boilers) - A boiler firing system flow diagram was not provided for the TPP-210 boilers. The boiler consists of two subboilers of 475 tons/hr each. The unit can operate with one subboiler, but firing actual coal requires two subboilers to maintain nominal steam flow. Each subboiler has 12 burners on two rows for a total of 24 burners per boiler. Each boiler has three mill systems of 50 ton/hr capacity instead of two as discussed for the TP-100 boilers. Three cyclones output to one coal dust bunker for two sub-boilers.

i. The power station would like to have coal flow meters to measure the input to each mill (3 devices per boiler) for mill efficiency improvement.

ii. The power station would like to have individual coal dust flow meters on each pipeline feeding the burners (24 total per boiler) from coal dust bunker and be able to individually and manually adjust the coal dust flow to each burner.

20. Section/Plan View of Boiler:

a. Attachments 5 and 6 are section views of the TP-100 boiler. Attachment 7 is a plan view of the TP-100 boilers.

b. Attachments 8 and 9 are section views of the TPP-210 boiler.

FUEL SUPPLY

21. Flow Diagrams for Fuel Supply:

a. Mazut:

i. Attachment 10 is the mazut flow diagram for the TP-100 boilers. The flow diagram shows the mazut being fed to eight of the sixteen burners. A similar flow diagram exists for the TPP-210 boilers.

ii. The amount of mazut fired for the total power station is determined by measuring the level of the mazut storage tanks.

iii. The power station would like to have the capability to measure the flow of mazut to each boiler.

b. Natural Gas:

Attachment 11 is the natural gas flow diagram for the TP-100 boilers. A similar flow diagram exists for the TPP-210 boilers. Natural gas flow meters already exist per boiler and work well.

c. Coal:

i. There are scales to weigh the coal being delivered per railroad car.

ii. There are two conveyors which deliver coal to the entire power station. Each conveyor has a scale which measures the coal fired for the total power station (10 units)

PLANT OPERATION MODE

22. The mode of unit operations during summer or winter is the same and it is as follows:

	TP-100 (200 MW) Boiler	TPP-210 (300 MW) Boiler
Night Load:	140 MW	230 MW
Day Load:	175 MW	275 MW
Weekend:	Four or five units each operating at 140 MW	Two or three units each operating at 230 MW

COMBUSTION CONTROLS

23. Attachments 12 and 13 detail the combustion control scheme for the 200 MW (TP-100) boiler. Attachments 14 to 16 detail the combustion control scheme for the 300 MW (TPP-210 boiler). However, the combustion control is actually a manual operation. Coal is usually fed to the boilers at maximum coal feeder speed, with cofiring of mazut or natural gas used to bring the boiler to the required load. The forced draft fan air damper positions are adjusted manually based upon a chart displayed on the Control Room wall, which is a function of the amount of coal and mazut or natural gas firing and 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%.

24. CO and O_2 Analyzers:

a. None of the units have CO analyzers.

b. As shown on Attachment 8 the TPP-210 boilers have two oxygen analyzers per subboiler or a total of four per boiler located in the convection pass at approximately 600°C. As shown on Attachment 6 the TP-100 boilers have two oxygen analyzers located on the convection pass per boiler.

c. The excess O_2 is maintained at approximately 4%. The station wants to maintain actual air to theoretical air at a ratio of 1.25 to account for inaccuracies in the quality and quantity of coal being fired and to compensate for inaccuracies in measurements.

d. Besides having O_2 analyzers the power station would like to measure air consumption at each burner to ensure proper combustion at each burner. Adjustment of fuel to air ratio at each burner would be manual from the

Control Board in Unit Control Room.

CALCULATION OF BOILER EFFICIENCY

25. The methodology for the boiler efficiency calculation is shown on Attachment 17 for August 1994. The calculations are done on a per unit and per plant basis. The only fuel measured directly per boiler is the natural gas. All other fuel quantities per boiler are extrapolated from power station data. The quality of the coal is also averaged on a 3 to 5 day basis. These efficiencies are compared to the efficiencies calculated based upon the boiler design performance. The boiler design performance was recalculated in 1987 and 1992 as discussed in item 16.

NOTE: See Project File for References 1 and 2.

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

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

1. Devices to measure coal quality feeding each mill (2 devices per TP-100 boiler, 3 devices per TPP-210 boiler) - 24 total devices per station.

2. Devices to measure coal quality after each cyclone (2 devices per TP-100 boiler, 3 devices per TPP-210 boiler) - 24 total devices per station.

3. Devices to measure coal flow feeding each mill (2 devices per TP-100 boiler, 3 devices per TPP-210 boiler) - 24 total devices per station.

4. Devices to measure flow of coal dust to each burner (16 devices per TP-100, 24 devices per TP-210 boiler) - 192 total devices per station.

5. Devices to measure flow of mazut to each boiler (2 devices per boiler) - 20 total devices per station.

6. New devices to measure O_2 content of exhaust gases in convection pass (2 devices per TP-100 boiler, 4 devices per TP-210 boiler) - 28 total devices per station.

7. Devices to measure air consumption at each burner (16 devices per TP-100 boiler, 24 devices per TP-210 boiler) - 192 total devices per station.

8. Video monitors to view bottom ash (slag) removal for each boiler (1 device per TP-100 boiler, 2 devices per TP-210 boiler) - 14 total monitors per station.

9. Furnace flame detection system for each boiler (1 device per TP-100 boiler, 2 devices per TP-210 boiler) - 14 total systems per station.

10. Portable combustion analyzer - one per station.

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Исходно-нормативный удельный расход условного топлива на отпущенную электроэнергию энергоблока 175 МВт Змиевской ГРЭС при сжигании смеси „АШ + мазут"

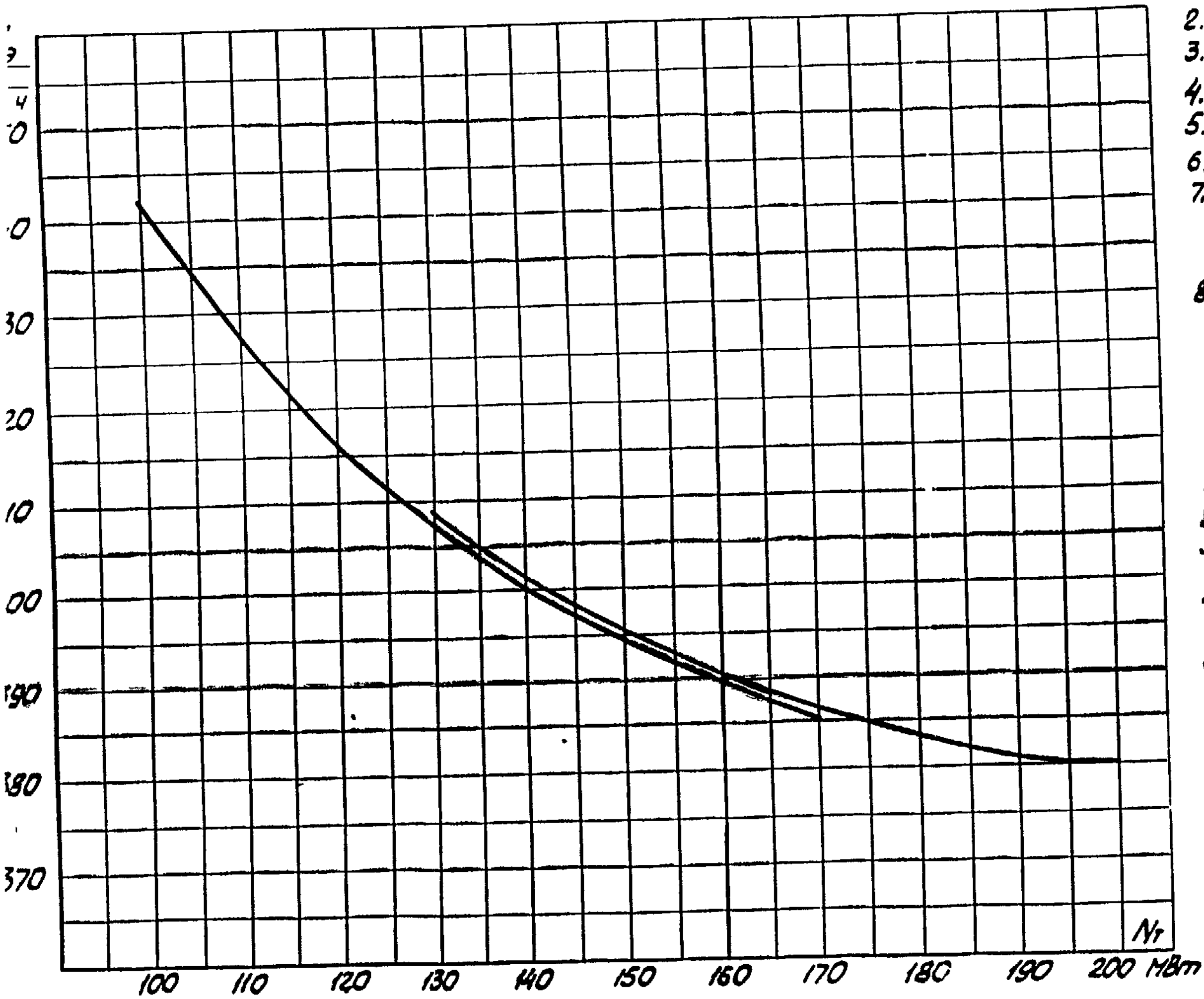

Рис 26

Условия построения графика

1. Топливо: АШ-$Q_н^р$=4900 $\frac{ккал}{кг}$, $A^р$=27%, $W^р$=10%
   мазут-$Q_н^р$=9300 $\frac{ккал}{кг}$ (доля по теплу 15%)
2. Давление свежего пара $-P_o$ =130 $\frac{кгс}{см^2}$
3. Температура свежего пара $-t_o$ =540°С
4. Температура пара промперегрева $-t_{пп}$ =540°С
5. Давление отработавшего пара $-P_2$ =0,035 $\frac{кгс}{см^2}$
6. Температура холодного воздуха $-t_{хв}$ =20°С
7. Температура воздуха на входе в воздухоподогреватель $-t'_{вп}$ =30°С (подогрев осуществляется рециркуляцией)
8. Наработка с начала эксплуатации на 01.01.92 - 217856 ч.

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Поправки:

1. На изменение зольности топлива на ±1% -Δв=±0,36%
2. На изменение влажности топлива на ±1% -Δв=±0,08%
3. На изменение температуры холодного воздуха на ±10°С Δв=∓0,63%
4. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°С -Δв=±0,09%
5. На отпуск 10 Гкал/ч из отборов:
   II -Δв=-0,7%   IV -Δв=-1,2%
   V -Δв=-1,7%
6. На изменение давления отработавшего пара на +0,01 $\frac{кгс}{см^2}$ -Δв=+1,12 %
   -0,01 $\frac{кгс}{см^2}$ -Δв=-0,5%.

На изменение доли мазута, сжигаемого раздельно на ±10%

Затраты топлива на пуск блока

Хол. сост.	88,1	тут
50 - 60 ч.	86,5	тут
30 - 35 ч.	75,8	тут
15 - 20 ч.	70,1	тут
6 - 10 ч.	60,7	тут

Кр = 0,0024

Attachment 1

На старение оборудования
$Δв = (0,0085 \cdot 10^{-2} + \frac{0,0055}{τ_{бр}})(τ_{нар} - 217856) \cdot 10^{-1}$, %

Гл инженер ПЭО „Харьковэнерго" [подпись] Е.М. Олейник
Гл инженер Змиевской ГРЭС [подпись] А.Г. Чупыра
Гл инженер ДонОРГРЭС [подпись] 10.12.92 Р.М. Островецкий

108

Зам Мин
электр

...эно - нормативный удельный расход условного топлива
отпущенную электроэнергию энергоблока 175 МВт
...иевской ГРЭС при сжигании природного газа ← 200 МВт

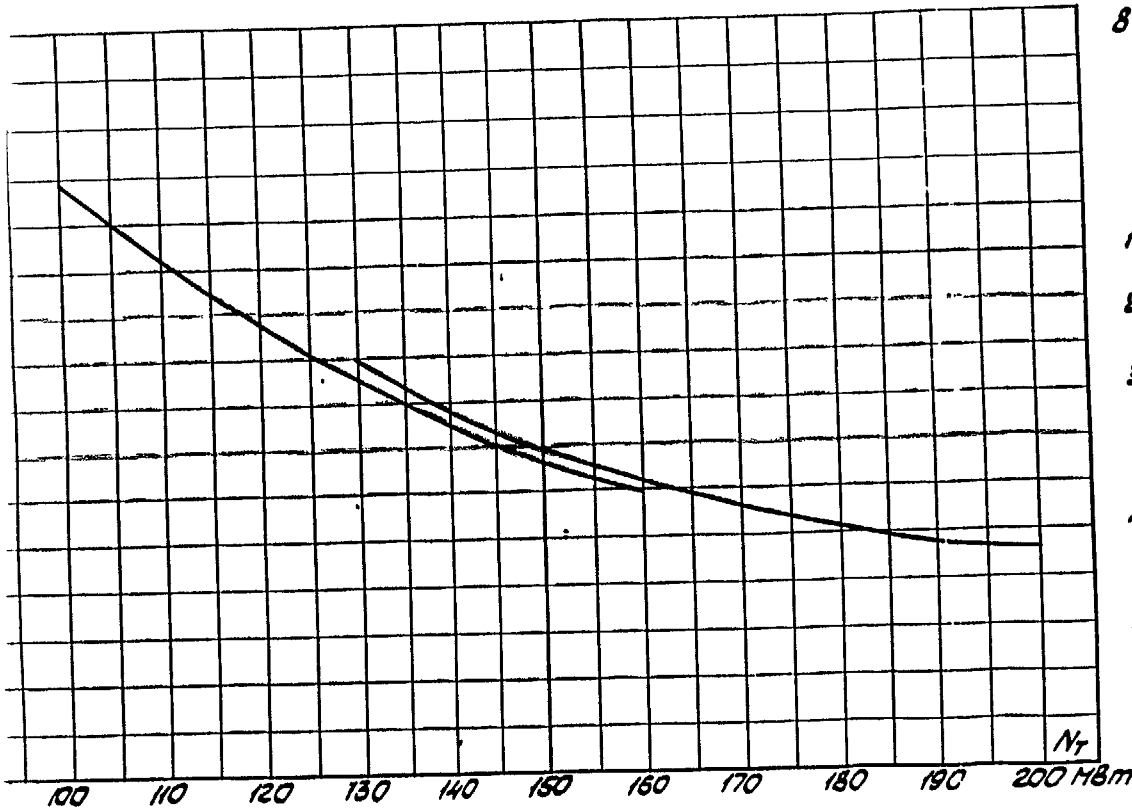

Рис. 27

Условия построения графика

1. Топливо: природный газ $- Q_н^р = 8200 \frac{ккал}{м^3}$
2. Давление свежего пара $- P_0 = 130 \frac{кгс}{см^2}$
3. Температура свежего пара $- t_0 = 540°C$
4. Температура пара промперегрева $- t_{пп} = 540°C$
5. Давление отработавшего пара $- P_2 = 0{,}035 \frac{кгс}{см^2}$
6. Температура холодного воздуха $- t_{хв} = 20°C$
7. Температура воздуха на входе в ВП $- t'_{вп} = 30°C$
8. Наработка с начала эксплуатации на 01.01.92 - 217856 ч.

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и ...

Поправки

1. На изменение температуры холодного воздуха на ±10°C $- \Delta b = \mp 0{,}56\%$
2. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°C $- \Delta b = \pm 0{,}1\%$
3. На изменение давления отработавшего пара
   на $+0{,}01 \frac{кгс}{см^2}$ $- \Delta b = +1{,}12\%$
   на $-0{,}01 \frac{кгс}{см^2}$ $- \Delta b = -0{,}5\%$
4. На отпуск $10 \frac{Гкал}{ч}$ из отборов
   II $- \Delta b = -0{,}7\%$ IV $- \Delta b = -1{,}2\%$
   V $- \Delta b = -1{,}7\%$
5. Затраты топлива на пуск блока

Хол. сост.	74,9 тут
50-60 ч.	70,7 тут
30-35 ч	61,2 тут
15-20 ч.	57,0 тут
6-10 ч.	48,5 тут

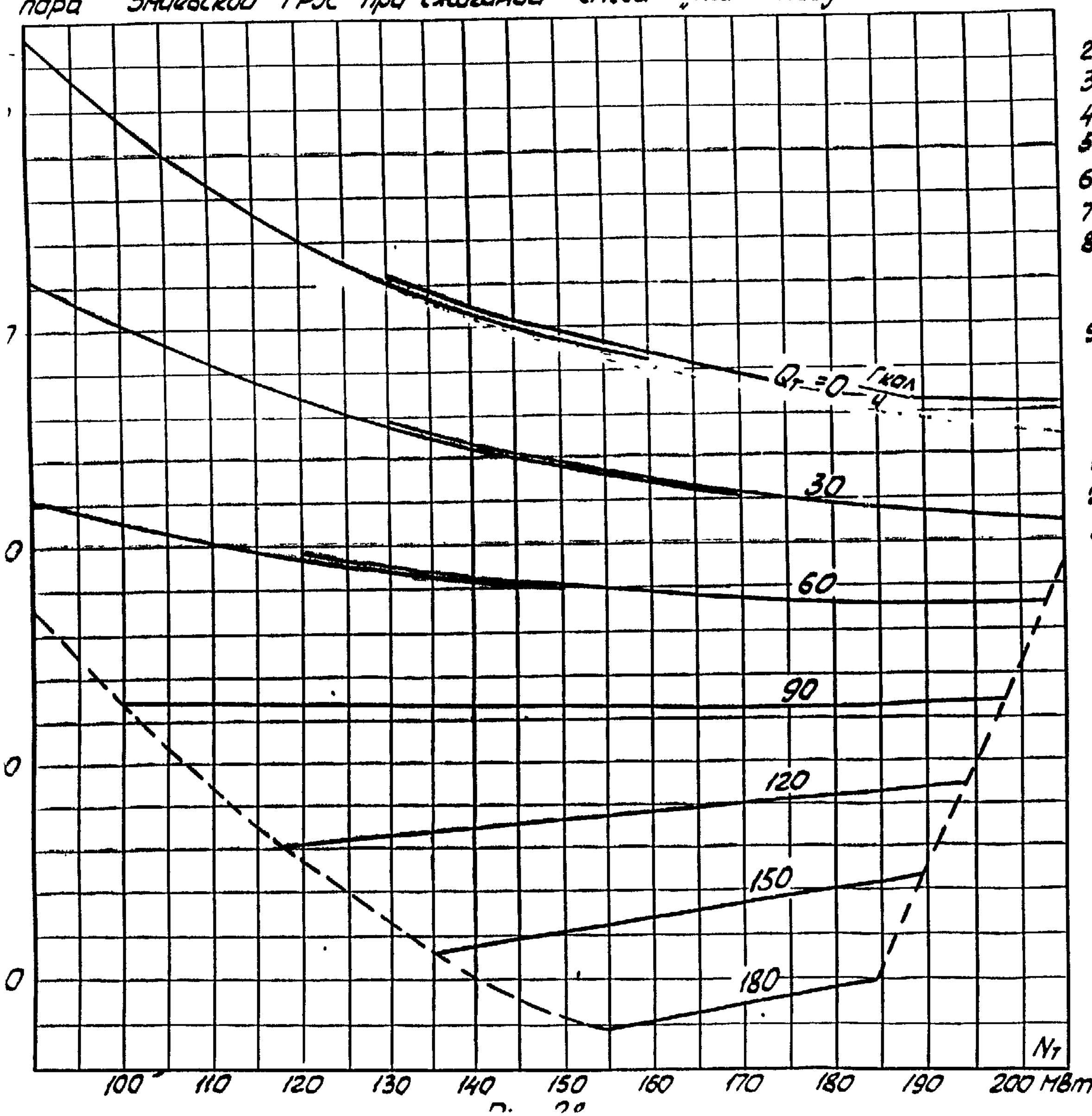
6. На старение оборудования

$$\Delta b = \left(0{,}0085 \cdot 10^{-2} + \frac{0{,}0055}{\tau_к^{бр}}\right)(\tau_{нар} - 217856) \cdot 10^{-1}, \%$$

$K_р = 0.0024$

Гл инженер ПЭО „Харьковэнерго" Е-М Олейник
Гл инженер Змиевской ГРЭС А Г Чулыра
Гл инженер ДонОРГРЭС 10.12.92 Р М Островецкий

Исходно-нормативный удельный расход условного топлива на отпущенную электроэнергию энергоблока 175 МВт с регулируемым отбором пара Змиевской ГРЭС при сжигании смеси „АШ + мазут"



Условия построения графика

1. Топливо: АШ - $Q_н^р = 4900 \frac{ккал}{кг}$; $A^р = 27\%$, $W^р = 10\%$
   мазут - $Q_н^р = 9300 \frac{ккал}{кг}$ (доля по теплу - 15%)
2. Давление свежего пара - $P_0 = 130 \frac{кгс}{см^2}$
3. Температура свежего пара - $t_0 = 540°C$
4. Температура пара промперегрева - $t_{пп} = 540°C$
5. Давление отработавшего пара - $P_2 = 0{,}035 \frac{кгс}{см^2}$
6. Давление пара в Т-отборе - $P_T = 1{,}2 \frac{кгс}{см^2}$
7. Температура холодного воздуха - $t_{хв} = 20°C$
8. Температура воздуха на входе в воздухоподогреватель - $t'_{вп} = 30°C$
   (подогрев осуществляется рециркуляцией)
9. Наработка с начала эксплуатации на 01.01.92 г. - 217856 ч.

Поправки

1. На изменение зольности топлива на ±1% - $\Delta b = \pm 0{,}36\%$
2. На изменение влажности топлива на ±1% - $\Delta b = \pm 0{,}08\%$
3. На изменение температуры холодного воздуха на ±10°С - $\Delta b = \mp 0{,}63\%$
4. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°С - $\Delta b = \pm 0{,}09$
5. На изменение давления отработавшего пара на +0,01 $\frac{кгс}{см^2}$ - $\Delta b = +1{,}12\%$
   на -0,01 $\frac{кгс}{см^2}$ - $\Delta b = -0{,}5\%$
6. На изменение доли мазута, сжигаемого раздельно на ±10% - $\Delta b = \mp 0{,}98\%$.
7. Затраты топлива на пуск блока

Хол. сост.	88,1 тут
50-60 ч	86,5 тут
30-35 ч	75,8 тут
15-20 ч	70,1 тут
6-10 ч	60,7 тут

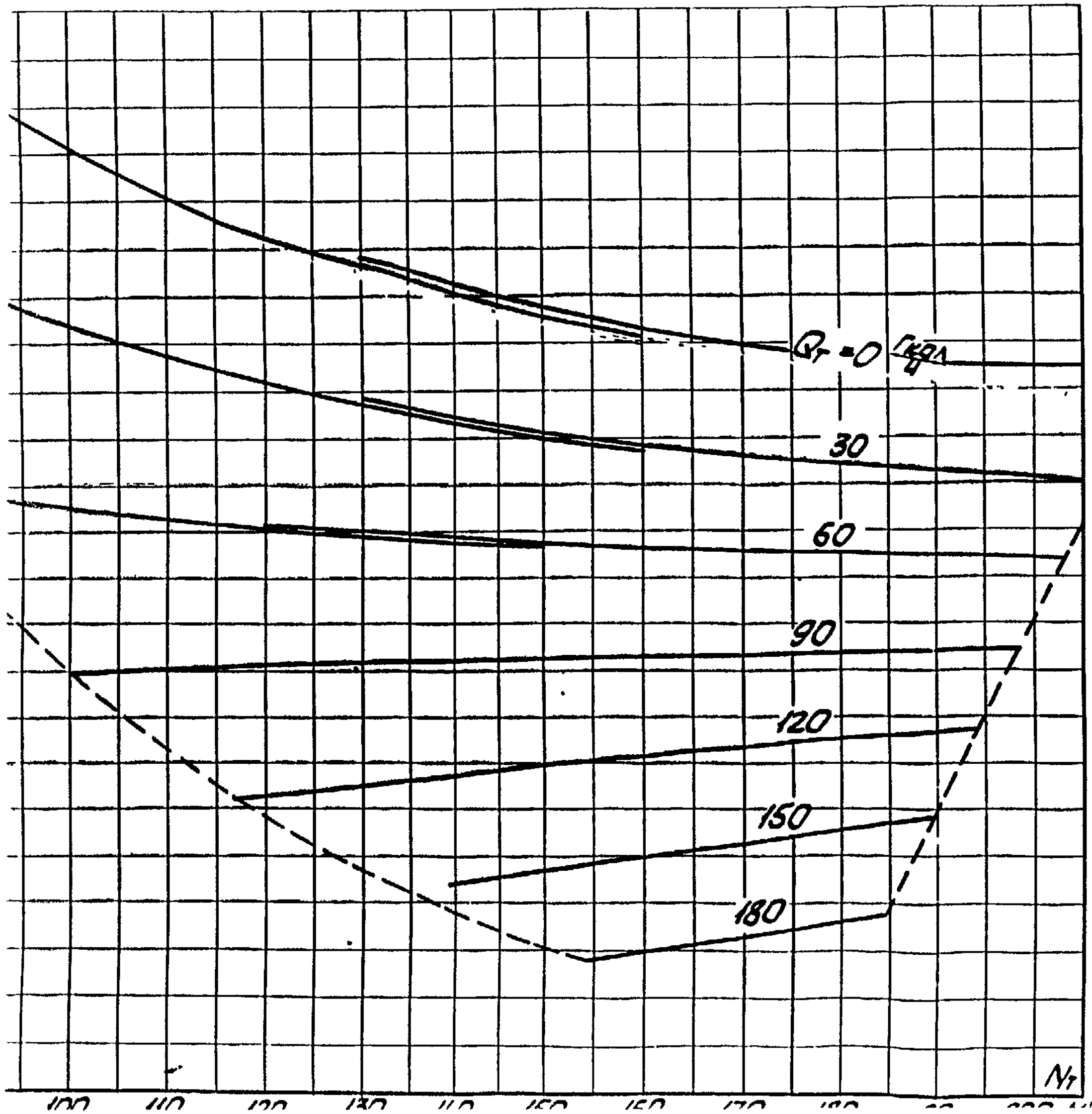
8. На старение оборудования

$$\Delta b = (0{,}0085 \cdot 10^{-2} + \frac{0{,}0055}{n_{бр}})(\tau_{нар} - 217856)10^{-1}, \%$$

Гл инженер ПЭО...
Гл инженер Змие...
Гл инженер ДонО...

Зат...
эле...
Кр

дно-нормативный удельный расход условного топлива на
щенную электроэнергию энергоблока 175 МВт с регулируемым отбором
Змиевской ГРЭС при сжигании природного газа



Условия построения графика

1. Топливо: природный газ $-Q_н^р = 8200\ \frac{ккал}{м^3}$
2. Давление свежего пара $-P_o = 130\ \frac{кгс}{см^2}$
3. Температура свежего пара $-t_o = 540\,°C$
4. Температура пара промперегрева $-t_{пп} = 540\,°C$
5. Давление отработавшего пара $-P_2 = 0{,}035\ \frac{кгс}{см^2}$
6. Давление пара в Т-отборе $-P_т = 1{,}2\ \frac{кгс}{см^2}$
7. Температура холодного воздуха $-t_{хв} = 20\,°C$
8. Температура воздуха на входе в воздухоподогреватель $-t'_{вп} = 30\,°C$ (подогрев осуществляется рециркуляцией)
9. Наработка с начала эксплуатации на 01.01.92 г. - 217856 ч.

Зам. элекп

Начальн электри тепловы

Поправки

1. На изменение температуры холодного воздуха на ±10°C - $\Delta b = \pm 0{,}56\,\%$.
2. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°C - $\Delta b = \pm 0{,}1\,\%$
3. На изменение давления отработавшего пара на $+0{,}01\ \frac{кгс}{см^2}$ - $\Delta b = +1{,}12\,\%$
   $-0{,}01\ \frac{кгс}{см^2}$ - $\Delta b = -0{,}5\,\%$.
4. Затраты топлива на пуск блока

Хол. сост.	74,9 тут
50-60 ч.	70,7 тут
30-35 ч.	61,2 тут
15-20 ч.	57,0 тут
6-10 ч.	48,5 тут

Гл инженер ПЭО.Ха

Гл инженер Змиевс.

Гл инженер Дон ОРГР

На старение оборудования

$$\Delta b = (0{,}0085 \cdot 10^{-2} + \frac{0{,}0055}{\eta^{бр}_к})(\tau_{нар} - 217856)\,10^{-1},\ \%$$

Кр = 0 0024

Согласовано
Начальник Управления электрических станций и тепловых сетей
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„__" ______ 199 г

Утверждаю
Зам Министра энергетики и электрификации Украины
„16" ____ 199 г

Исходно-нормативный удельный расход условного топлива на отпущенную теплоту с паром котла ТП-100 Змиевской ГРЭС на смеси „АШ+мазут"

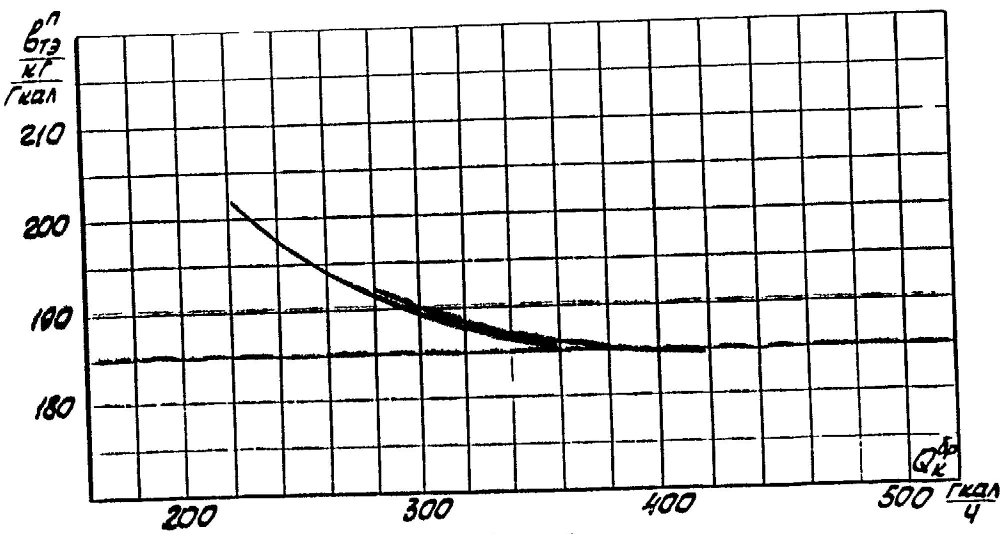

Рис. 30

Условия построения графика

1. Топливо: АШ - $Q_н^р = 4900 \frac{ккал}{кг}$; $A^р = 27\%$; $W^р = 10\%$
   мазут - $Q_н^р = 9300 \frac{ккал}{кг}$ (доля по теплу -15%)
2. Температура холодного воздуха - $t_{хв} = 20°C$
3. Температура воздуха на входе в ВП - $t'_{вп} = 30°C$ (подогрев осуществляется рециркуляцией)
4. Коэффициент потерь с отпуском теплоты - 1%
5. Наработка с начала эксплуатации на 01.01.92 - 217856 ч

Поправки

1. На изменение зольности топлива на ±1% - $\Delta b = \pm 0{,}36\%$
2. На изменение влажности топлива на ±1% - $\Delta b = \pm 0{,}08\%$
3. На изменение температуры холодного воздуха на ±10°С - $\Delta b = \mp 0{,}63\%$
4. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°С - $\Delta b = \pm 0{,}09\%$
5. На долю отпуска теплоты с горячей водой
$$\Delta b = \alpha_{гв} \cdot Э_{тепл} \cdot b_э \cdot 10^{-3}, \ кг/Гкал$$
6. На старение оборудования
$$\Delta b = \frac{0{,}0055 \cdot (\tau_{нар} - 217856) \cdot 10^{-1}}{Q_к^{бр}}, \ \%$$
7. Затраты топлива на пуск котла

Хол. сост.	58,0 тут
50-60 ч.	50,2 тут
30-35 ч.	47,7 тут
15-20 ч.	40,3 тут

Кр=0

Гл инженер ПЭО „Харьковэнерго" Е М Олейник
Гл инженер Змиевской ГРЭС А Г Чупыра
Гл инженер ДонОРГРЭС Р М Островецкий
16.12.92

117

Согласовано
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Зам Министра энергетики и электрификации Украины
"__" ______ 199_ г

Исходно-нормативный удельный расход условного топлива на отпущенную теплоту с паром котла ТП-100 Змиевской ГРЭС на природном газе

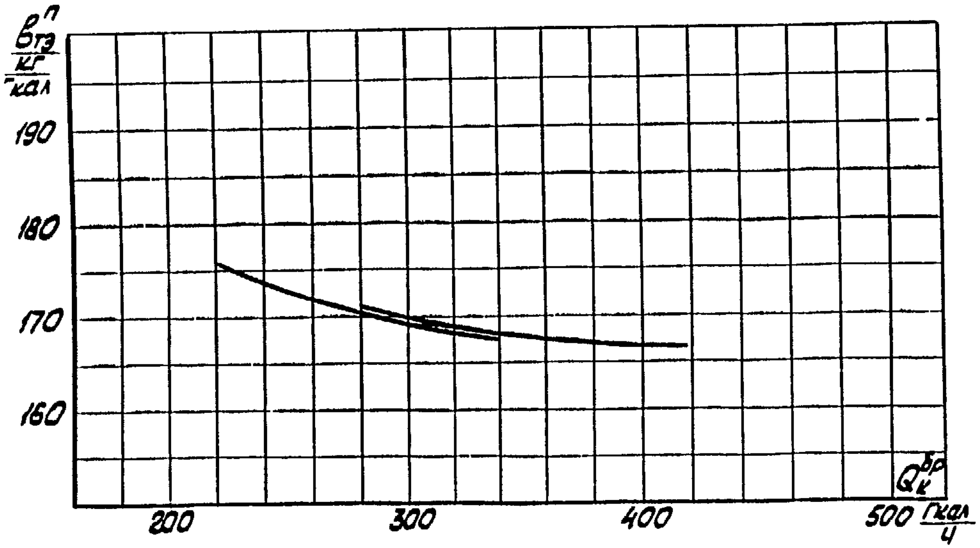

Рис. 31

Гл инженер ПЭО "Харьковэнерго" Е М Олейник
Гл инженер Змиевской ГРЭС А Г Чупыра
Гл инженер ДонОРГРЭС Р М Островецкий
10.12.92

Условия построения графика

1. Топливо: природный газ $- Q_н^р = 8200 \frac{ккал}{м^3}$
2. Температура холодного воздуха $- t_{хв} = 20°C$
3. Температура воздуха на входе в ВП $- t'_{вп} = 30°C$ (подогрев осуществляется рециркуляцией)
4. Коэффициент потерь с отпуском теплоты $- 1\%$
5. Наработка с начала эксплуатации на 01.01.92 $- 217856$ ч.

Поправки

1. На изменение температуры холодного воздуха на ±10°С $- \Delta b = \mp 0{,}56\%$
2. На изменение температуры воздуха на входе в воздухоподогреватель на ±10°С $- \Delta b = \pm 0{,}1\%$
3. На долю отпуска теплоты с горячей водой

$$\Delta b = \alpha_{гв} \cdot Э_{тепл} \cdot b_э \cdot 10^{-3},\ кг/Гкал$$

4. На старение оборудования

$$\Delta b = \frac{0{,}0055(\tau_{нар} - 217856) \cdot 10^{-1}}{Q_к^{бр}},\ \%$$

5. Затраты топлива на пуск котла

Хол. сост.	44,8 тут
50-60 ч	36,8 тут
30-35 ч	35,5 тут
15-20 ч	37,4 тут
6-10 ч	35,6 тут

$К_р = 0$

Согласовано
...чальник Управления электрических станций и тепловых сетей
Н Э Турас

...л инженер ПЭО „Харьковэнерго" [signature] Е М Олейник
...л инженер Змиевской ГРЭС [signature] А Г Чупыра
...л инженер Дон ОРГРЭС [signature] ...92 Р М Островецкий

Утверждаю
Зам Министра энергетики и электрификации Украины
[signature]
„26" ...... 199.. г

Исходно-нормативный удельный расход условного топлива на отпущенную электроэнергию энергоблока 275 МВт Змиевской ГРЭС при сжигании смеси „АШ+мазут"

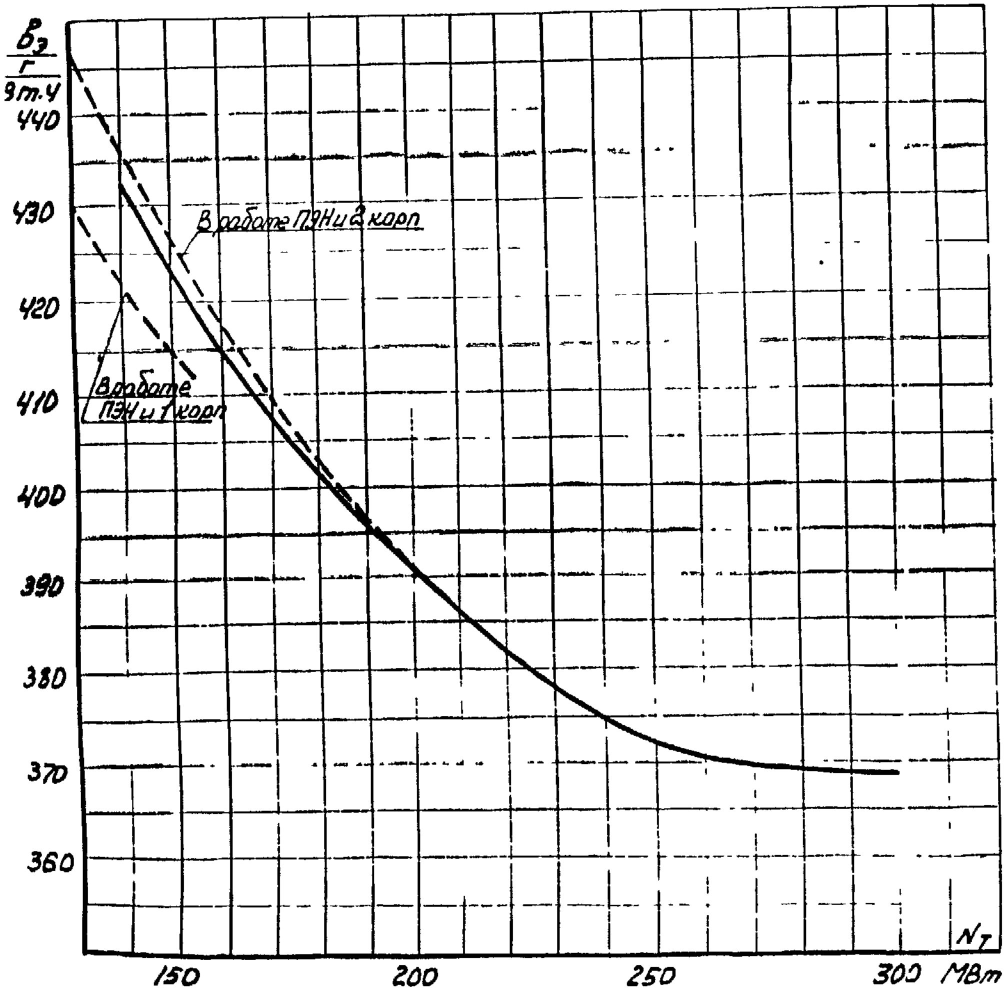

Рис. 46 $K_p = 0{,}0003$

Условие построения графика

1 Топлива: АШ – $Q_н^р = 4900 \frac{ккал}{кг}$; $A^р = 27\%$; $W^р = 10\%$
мазут – $Q_н^р = 9300 \frac{ккал}{кг}$ (доля по теплу – 15%)
2 Давление свежего пара – $P_0 = 240 \frac{кгс}{см^2}$
3 Температура пара: свежего – $t_0 = 540\,°C$
промперегрева – $t_{пп} = 540\,°C$
4 Давление отработавшего пара – $P_2 = 0{,}035 \frac{кгс}{см^2}$
5 Температура холодного воздуха – $t_{хв} = 20\,°C$
6 Температура воздуха на входе в воздухоподогреватель – $t'_{вп} = 30\,°C$ (подогрев осуществляется рециркуляцией)
7 Наработка с начала эксплуатации на 01.01.92 – 175409 ч

Поправки

1 На изменение зольности топлива на ±1% – $\Delta b = \pm 0{,}40\%$
2 На изменение влажности топлива на ±1% – $\Delta b = \pm 0{,}08\%$
3 На изменение температуры холодного воздуха на ±10°C $\Delta b = \mp 0{,}63\%$
4 На изменение температуры воздуха на входе в воздухоподогреватель на ±10°C – $\Delta b = \pm 0{,}1\%$
5 На отпуск 10 $\frac{Гкал}{ч}$ из отборов:
II – $\Delta b = -0{,}5\%$ IV – $\Delta b = -0{,}9\%$
VI – $\Delta b = -1{,}1\%$
6 На изменение давления отработавшего пара
на +0,01 $\frac{кгс}{см^2}$ – $\Delta b = +1{,}33\%$
на –0,01 $\frac{кгс}{см^2}$ – $\Delta b = -0{,}9\%$
7 На изменение доли мазута сжигаемого раздельно на ±10% – $\Delta b = \mp 1{,}09\%$
8 Затраты топлива на пуск корпуса / двух корпусов, тут

Хол. сост	187,7 / 215,7
50 - 60 ч	154,8 / 202,8
30 - 35 ч	134,4 / 182,4
15 - 20 ч	126,9 / 170,2
6 - 10 ч	87,2 / 119,5

9 На старение оборудования
Δb = (0,0085 10^{-2} + $\frac{0{,}0055}{...}$) ...

Attachment 2

114

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26 ... 199_ г

Гл инженер ПЭО Харьковэнерго Е М Олейник
Гл инженер Змиевской ГРЭС А Г Чупыра
Гл инженер Дон ОРГРЭС Ф М Островецкий

Исходно-нормативный удельный расход условного топлива на отпущенную электроэнергию энергоблока 275 МВт Змиевской ГРЭС при сжигании природного газа

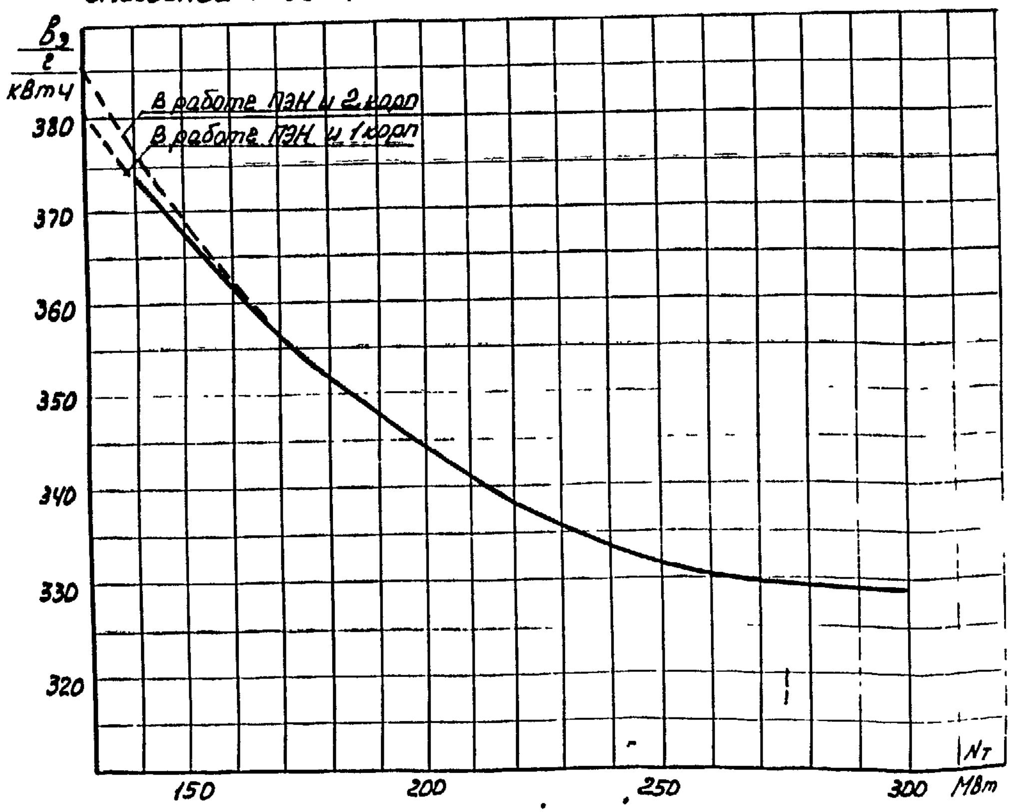

Рис 47

Условия построения графика

1 Топливо природный газ $- Q_н^р = 8200 \frac{ккал}{м3}$
2 Давление свежего пара $- P_0 = 240 \frac{кгс}{см2}$
3 Температура пара: свежего $- t_0 = 540°C$
промперегрева $- t_{пп} = 540°C$
4 Давление отработавшего пара $- P_2 = 0{,}035 \frac{кгс}{см^2}$
5 Температура холодного воздуха $- t_{хв} = 20°C$
6 Температура воздуха на входе в воздухоподогреватель $- t'_{вп} = 30°C$ (подогрев осуществляется рециркуляцией)
7 Наработка с начала эксплуатации на 01.01.92 — 175409 ч

Поправки

1 На изменение температуры холодного воздуха на ± 10°С — $\Delta B = \mp 0{,}53\%$
2 На изменение температуры воздуха на входе в воздухоподогреватель на ± 10°С $- \Delta B = \pm 0{,}09\%$
3 На изменение давления отработавшего пара
на $+0{,}01 \frac{кгс}{см2}$ $- \Delta B = +1{,}33\%$
на $-0{,}01 \frac{кгс}{см2}$ $- \Delta B = -0{,}9\%$
4 На отпуск 10 $\frac{Гкал}{ч}$ из отборов
II $- \Delta B = -0{,}5\%$
IV $- \Delta B = -0{,}9\%$
VI $- \Delta B = -1{,}1\%$
5 Затраты топлива на пуск корпуса/двух корпусов, тут

Хол. сост	147,5 / 195,5
50 - 60ч	130,7 / 178,7
30 - 35ч	111,6 / 159,6
15 - 20ч	106,2 / 149,5
6 - 10ч	67,5 / 90,8

6 На старение оборудования

$$\Delta B = \left(0{,}0085 \cdot 10^{-2} + \frac{0{,}0055}{\eta_к^{бр}}\right)(\tau_{нар} - 175409)\, 10^{-1}, \%$$

$K_р = 0{,}0003$

115

Согласовано
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«—» ——— 199 г

Утверждаю
Зам Министра энергетики и электрификации Украины
«26» февр. 1993 г

Исходно-нормативный удельный расход условного топлива на отпущенную теплоту с паром котла ТПП-210 Змиевской ГРЭС на смеси „АШ + мазут"

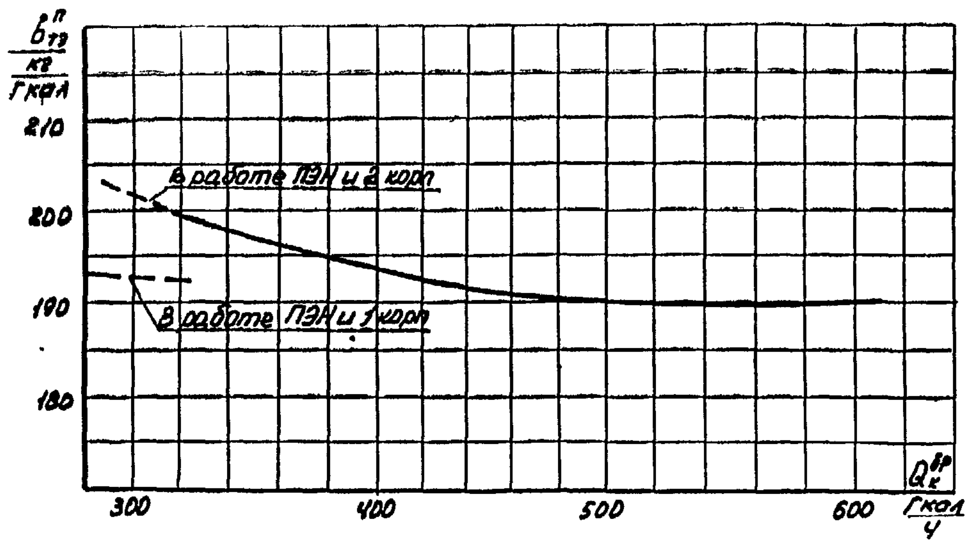

Рис. 48

Гл инженер ПЭО „Харьковэнерго" Е М Олейник
Гл инженер Змиевской ГРЭС А Г Чупыра
Гл инженер Дон ОРГРЭС Р М Островецкий
10.12.92

Условия построения графика

1 Топливо: АШ – $Q^р_н = 4900$ ккал/кг, $A^р = 27\%$, $W^р = 10\%$
Мазут – $Q^р_н = 9300$ ккал/кг (доля по теплу 15%)
2 Температура холодного воздуха – $t_{хв} = 20°C$
3 Температура воздуха на входе в воздухоподогреватель $t'_{вп} = 30°C$ (подогрев осуществляется рециркуляцией)
4 Температура питательной воды – рис.
5 Коэффициент потерь с отпуском теплоты – 1%
6 Наработка с начала эксплуатации на 01.01.92 – 175409 ч

Поправки

1 На изменение зольности топлива на ±1% – $\Delta b = \pm 0{,}4\%$
2 На изменение влажности топлива на ±1% – $\Delta b = \pm 0{,}08\%$
3 На изменение температуры холодного воздуха на ±10°C – $\Delta b = \mp 0{,}63\%$
4 На изменение температуры воздуха на входе в воздухоподогреватель на ±10°C – $\Delta b = \pm 0{,}1\%$
5 На долю отпуска теплоты с горячей водой

$$\Delta b = \alpha_{гв}\, Э_{тепл}\, b_э \cdot 10^{-3},\ кг/Гкал$$

6 На старение оборудования

$$\Delta b = \frac{0{,}0055\,(\tau_{нар} - 175409)\cdot 10^{-1}}{\eta^{бр}_к},\ \%$$

7 Затраты топлива на пуск корпуса/двух корпусов, тут

Хол. сост	101,0 / 141,5
50 - 60 ч	79,6 / 120,3
30 - 35 ч	72,9 / 113,9
15 - 20 ч	74,3 / 111,1
6 - 10 ч	56,2 / 84,4

Кр = 0

116

Согласовано
Начальник Управления электрических и тепловых сетей
станций
А.Э Турос
"__" ________ 199 г

Утверждаю
Зам Министра энергетики и электрификации Украины
"__" ________ 1993 г

Исходно-нормативный удельный расход условного топлива на отпущенную теплоту с паром котла ТПП-210 Змиевской ГРЭС на природном газе

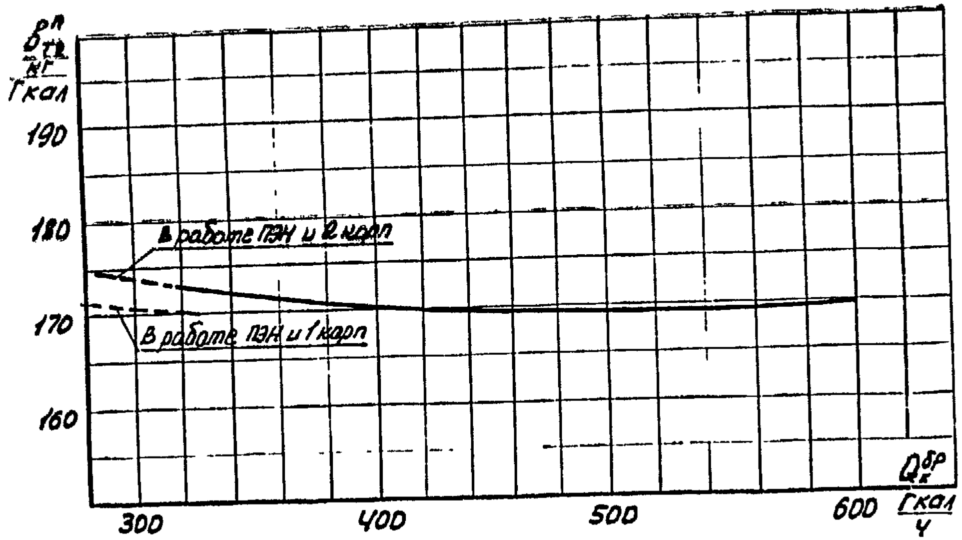

Рис. 49

Условия построения графика

1 Топлива: природный газ $-Q_н^р = 8200\ \frac{ккал}{м^3}$
2 Температура холодного воздуха $- t_{хв} = 20°C$
3 Температура воздуха на входе в воздухоподогреватель $- t'_{вп} = 30°C$ (подогрев осуществляется рециркуляцией)
4 Коэффициент потерь с отпуском теплоты $- 1\%$
5 Наработка с начала эксплуатации на 01.01.92 – 175409ч

Поправки

1 На изменение температуры холодного воздуха на $\pm 10°C - \Delta b = \mp 0{,}53\%$
2 На изменение температуры воздуха на входе в воздухоподогреватель на $\pm 10°C - \Delta b = \pm 0{,}09\%$
3 На долю отпуска теплоты с горячей водой

$$\Delta b = \alpha_{гв} \cdot Э_{тепл} \cdot b_э \cdot 10^{-3},\ кг/Гкал$$

4 На старение оборудования

$$\Delta b = \frac{0{,}0055\,(\tau_{нар} - 175409) \cdot 10^{-1}}{\eta_к^{бр}},\ \%$$

5 Затраты топлива на пуск корпуса/двух корпусов, тут

Хол. сост	80,8 / 121,3
50 - 60ч	59,7 / 100,4
30 - 35ч	54,3 / 95,3
15 - 20ч	55,7 / 92,5
6 - 10ч	38,2 / 60,4

$K_р = 0$

Гл инженер ПЭО "Харьковэнерго" Е М Олейник
Гл инженер Змиевской ГРЭС А Г Чупыра
Гл инженер Дон ОРГРЭС Р М Островецкий
19.12.92

Attachment 3

[illegible] ГРЭС Natural Gas

Сведения по топливу

[Кому] ПТО Газ 22/VII-94г

Число месяца	Марка	Место отбора	I см	II см	III см	Примеч.

$Q_н^р$ – 8270 ккал/нм³

Анализ произвел
нач. хим. цеха
нач. цеха наладки

Змиевская ГРЭС Schlamm Хим. цех

Сведения по топливу

Кому ПТО Уголь с вагонов АР июнь
N 1527

Число месяца	Марка	Место отбора	I см	II см	III см	Примеч.
			W^р %	A^р %	S %	
			6,1	42,0	1,87	

S_p^a – 1,39%

$Q_н^р$ – 3862 ккал/кг

Анализ произвел
нач. хим. цеха
нач. цеха наладки

…вская ГРЭС Schlamm

Сведения по топливу

ПТО Ср. пр. уголь „шлам" 11/IX-20/IX

Число месяц	Марка	Место отбора	W^p_{cm}%	A^p_{cm}%	$V^{г}_{cm}$%	примеч.
			11,49	36,81	9,93	

S_{δ}^{a} – 0,87%

$Q_н^р$ – 3768 ккал/кг.

Анализ произвел

Нач хим цеха

Нач цеха наладки

… ГРЭС Coal Химцех

Сведения по топливу

Кому ПТО Ср. пр. угля м-ть 28/VIII-30/VIII 94

Число месяц	Марка	Место отбора	W^{p}_{cm}%	A^{p}_{cm}%	$V^{г}_{cm}$%	Примеч.
28/VIII			7,15	27,66		
29/VIII			6,35	28,19		
30/VIII			7,48	27,01		
Ср. пр.			6,98	27,6	6,71	

S_{δ}^{a} – 0,87%

$Q_н^р$ – 5043 ккал/кг

Анализ произвел

Нач. хим. цеха

Нач цеха наладки

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...ская ГРЭС *Coal* ... Химцех

Сведения по топливу
ПТО Ср. пр. м-ков 5/II-9/II-94г

...	Марка	Место отбора	W^p%	A^p%	S^p%	Примеч.
5/II			8,0	23,85		
.../II			9,36	27,02		
7/II			8,94	26,57		
8/II			8,09	26,28		
9/II			9,62	32,98		
Ср. пр.			8,83	27,57	6,05	

S_d^a – 1,31%

$Q_н^p$ – 4855 ккал/кг

Анализ произвел ...
/нач. хим. цеха
Нач. цеха наладки

...ая ГРЭС *Mazout* Хим. цех

Сведения по топливу
ПТО Мазут от 31/I-9/II-94г

...	Место отбора	... см	... см	III см	Примеч.

W^p – 8,34%

S_d^c – 3,43%

ml – 0,975 г/см³

$Q_н^p$ – 8639 ккал/кг

...
/ ...

120

...ская ГРЭС Natural Gas хим. цех

Сведения по топливу

ППО Газ Шебелинский 21/IX 94г

Марка	Место отбора	I см	II см	III см	Примеч.

$Q_н^с$ – 8267 ккал/нм³

Анализ произвел

Нач. хим цеха

Нач цеха наладки

...

Змиевская ... Coal

Сведения по топливу

ППО Ср. пр. угля м-ябь 20/IX-24/IX 94

Число месяц	Марка	Место отбора	$W^р$%	$A^с$%	$V^с$%	Примеч.
20/IX			9,15	30,03		
21/IX			8,64	31,57		
22/IX			7,70	32,01		
23/IX			7,2	29,56		
24/IX			6,59	29,99		
Ср. пр.			8,0	30,5	7,0	

$S_о^а$ – 0,73%

$Q_н^р$ – 4680 ккал/кг

...ская ГРЭС Mazout

Сведения по топливу

ПТО Ср. пр. мазута 14/IX-23/IX 94 г.

Марка	Место отбора	I см	II см	III см	Пр.

W^p %	$S_б^a$	уд.в.
5,63	3,09	0,978 г/см³

$Q_н^p$ – 8921 ккал/кг

Нач. ... / нач. хим. цеха / нач. цеха наладки

хим. цех

Coal

Сведения по топливу

ПТО Ср. пр. угля м-ков 15-19/IX-94 г.

	Место отбора	W^p %	A^p %	$V^г$ %	Примеч.
15/IX		5,51	32,25		
16/IX		6,74	33,83		
17/IX		9,89	31,91		
18/IX		10,18	33,44		
19/IX		6,03	34,54		
Ср. пр.		8,48	32,40	8,57	

$S_б^a$ – 1,02 %

$Q_н^p$ – 4543 ккал/кг

Нач. ... / нач. хим. цеха / нач. цеха наладки

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Mazout

Сведения по топливу

ТПО Ср. пр. мазута 10/II-19/II-94 г.

Марка	Место отбора	I см	II см	III см	Примеч
	W^{P}%		S_{δ}^{a}%		пл.
	8,48		3,18		0,974 г/см³

$Q_н^P$ = 8812 ккал/кг

Анализ произвел [signature]

Нач. хим. цеха [signature]

Нач. цеха наладки

Coal

Сведения по топливу

ТПО Ср. пр. угля м-ль 13/VIII-17/VIII

Дата	Марка	Место отбора	W^P%	A^P%	S^P%	Примеч
13/VIII			7,44	33,09		
14/VIII			6,03	31,63		
15/VIII			6,18	33,99		
16/VIII			5,15	46,32		
17/VIII			5,38	39,15		
Ср. пр.			5,94	37,08	8,37	

S_{δ}^{a} – 0,89%

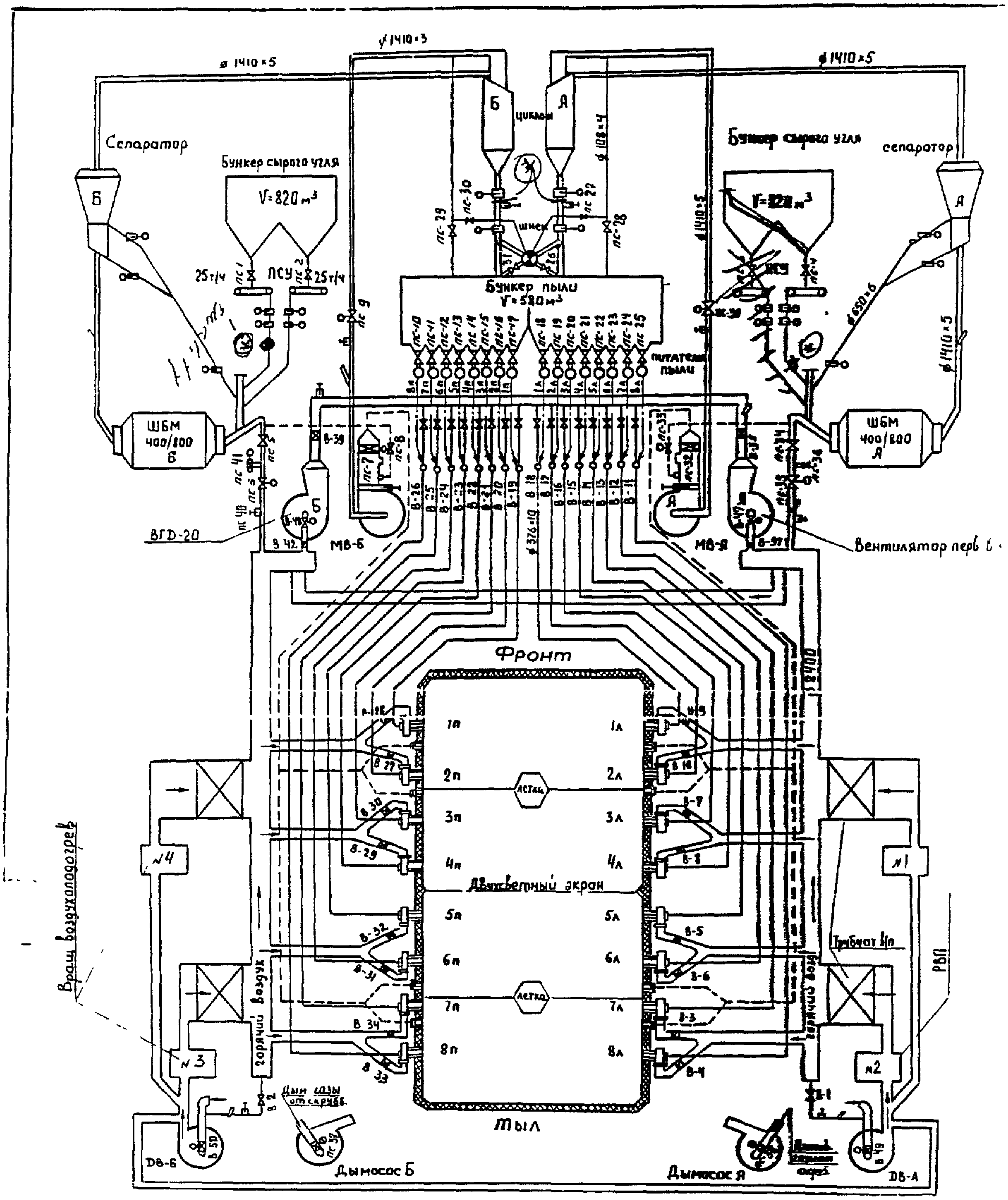
$Q_н^P$ – 4240 ккал/кг

Анализ произвел [signature]

Нач. хим. цеха

Нач. цеха наладки

23



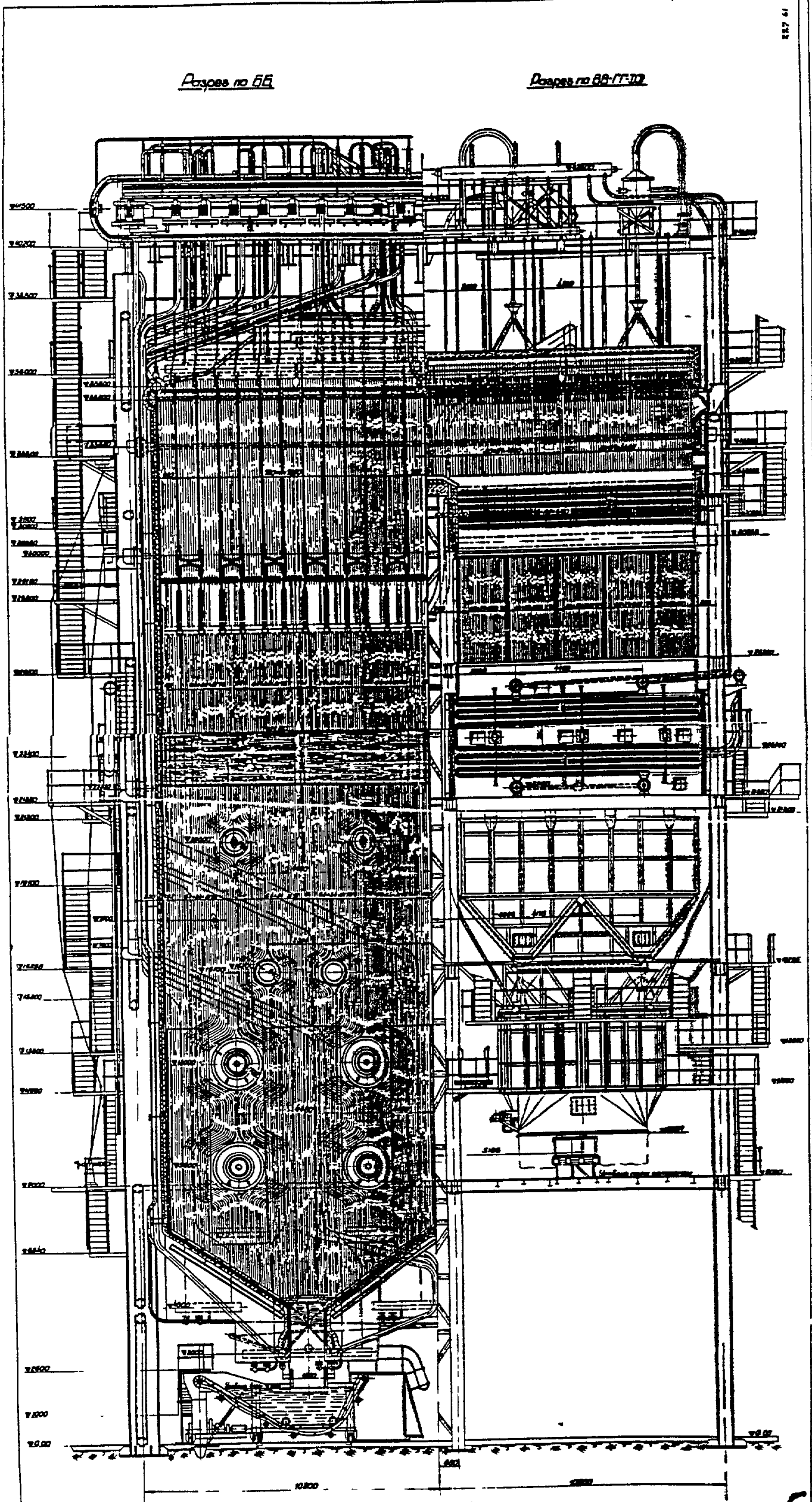
Условные обозначения

- шибер
- мигалка
- направляющий аппарат
- перекидной шибер

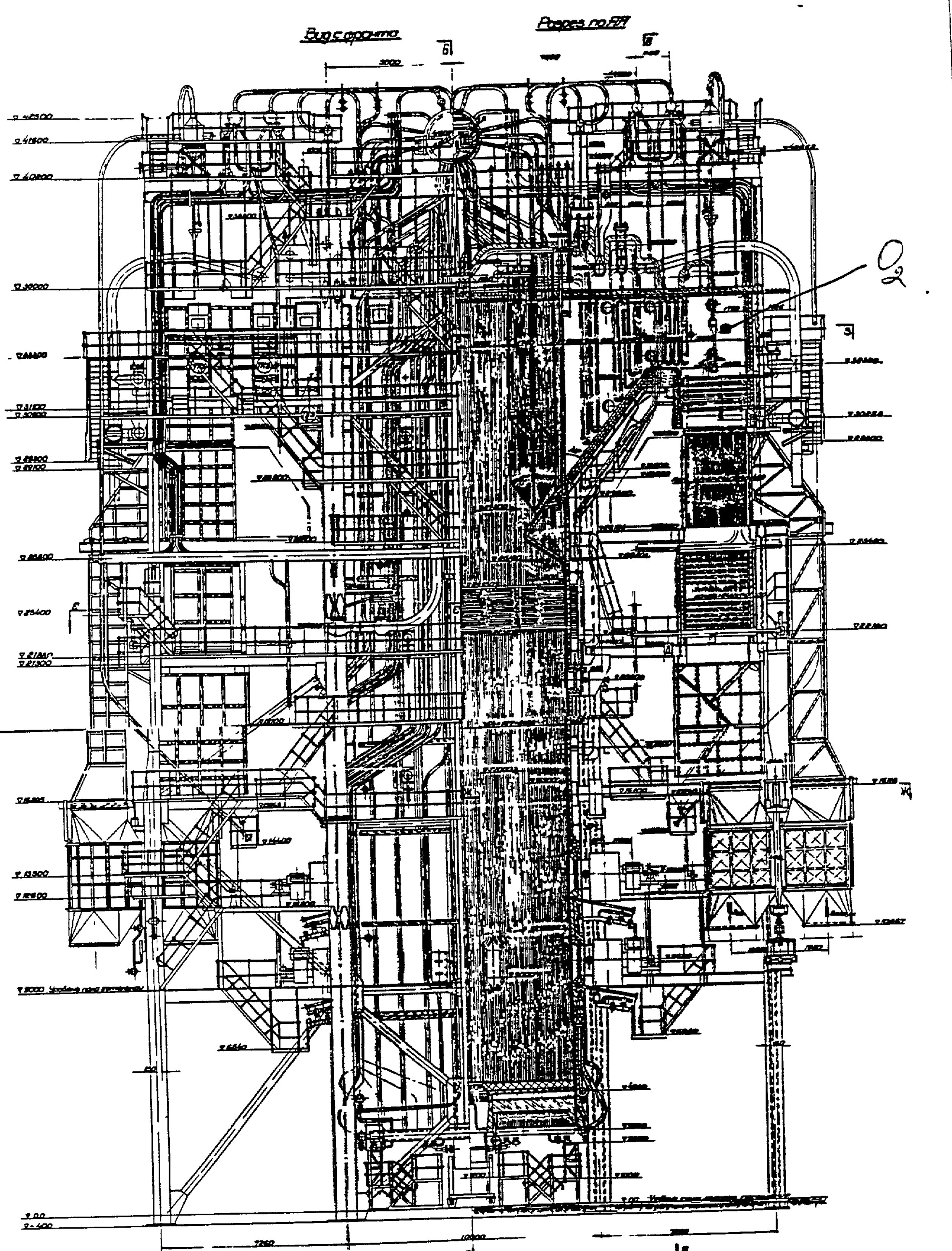
Attachment 4

TYPE TP-100

СК-27	Змиевская ГРЭС	Схема пылесистемы кот
	издание	внесение изменен
Дата	25.01.93г	
Гл. инженер	Чупыра	
Нач. ПТО	Жалов	
Нач. КТЦ-1	Савченко	
Исполнит	Шконда	



Attachment 5



Основные данные по котлу

1. Паропроизводительность котла 640 т/час
2. Давление в барабане котла 155 кг/см² [illegible]
3. Тем-ра перегретого пара 570°C
4. — — питательной воды 235°C
5. Поверхность нагрева первичного радиац. [illegible] 116 м²
6. ширмового пароперегревателя 1764 м²
7. I и II ч первичного пароперегревателя 4550 м²
8. I и II ч вторичного пароперегревателя 5160 м²
9. регулировочного пакета 2750 м²
10. водяного экономайзера 4150 м²
11. I ч воздухоподогревателя 14300 м²
12. регенератив воздухоподогревателя 16300 м²
13. Топливо - антрацитовый штыб и естественный газ

Примечание:

1. Продольный разрез котла см. черт. № К-198660
2. План и горизонтальные разрезы котла см. черт. №№ К-198662, К-198663

Attachment 6

Копия чертежа № К 198661 ТКЗ

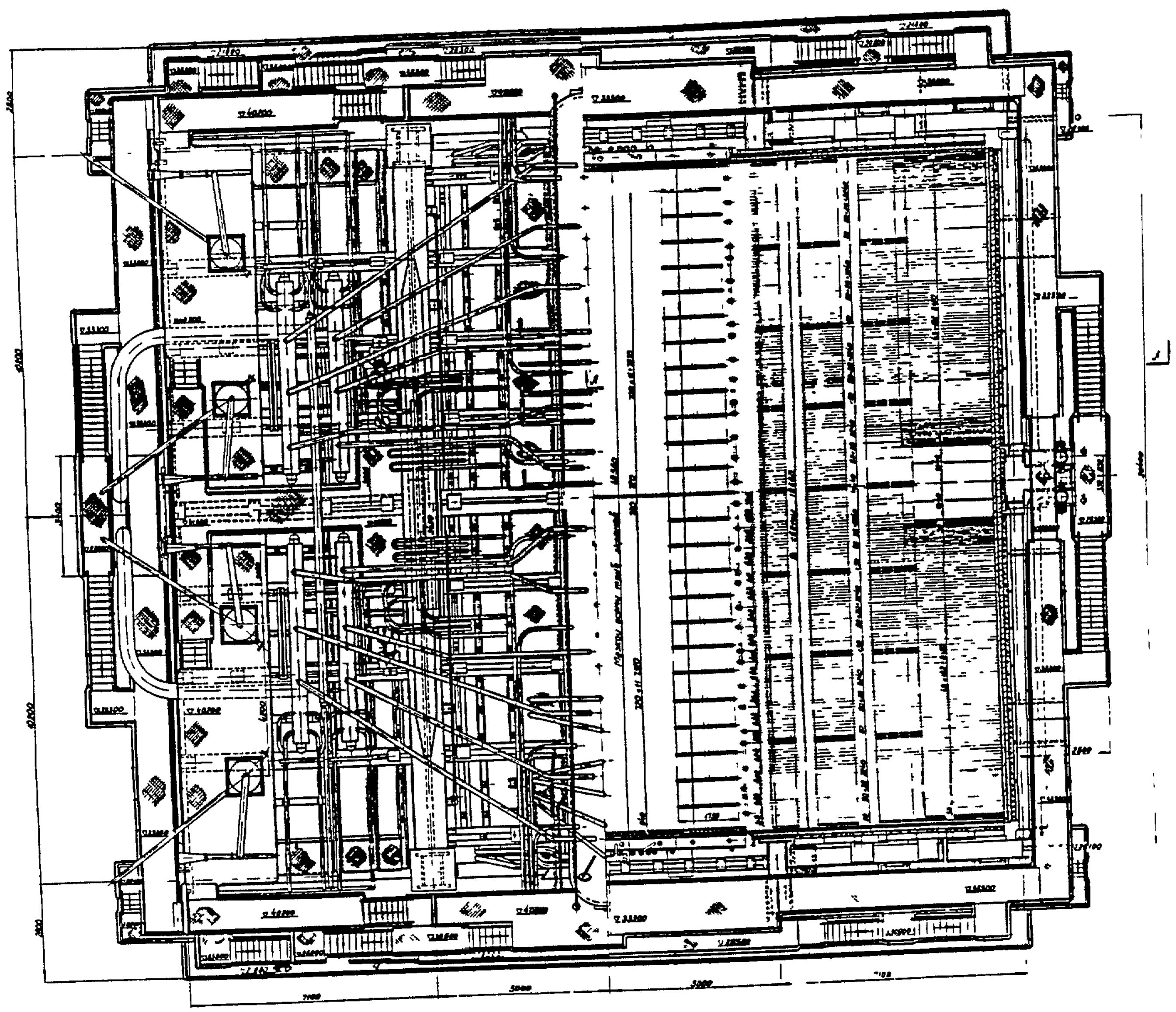
Котел ТП-100 Д=640 т/час Рп 155 кг/см² tпп=570/570°C

200 MW

126

Вид сверху

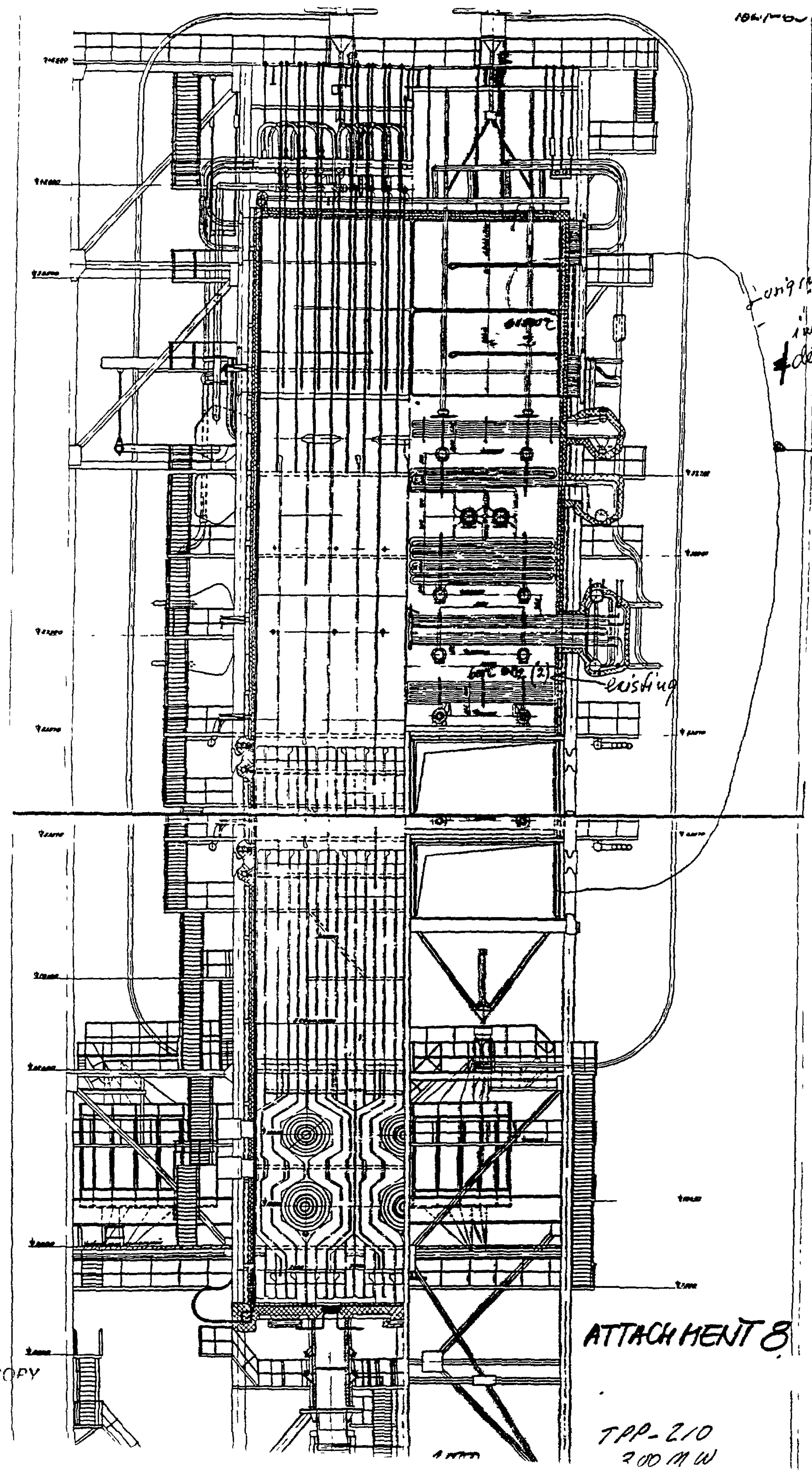
Разрез по 33



Attachment 7

200 MW

225 61



ATTACHMENT 8

TPP-210
200 MW

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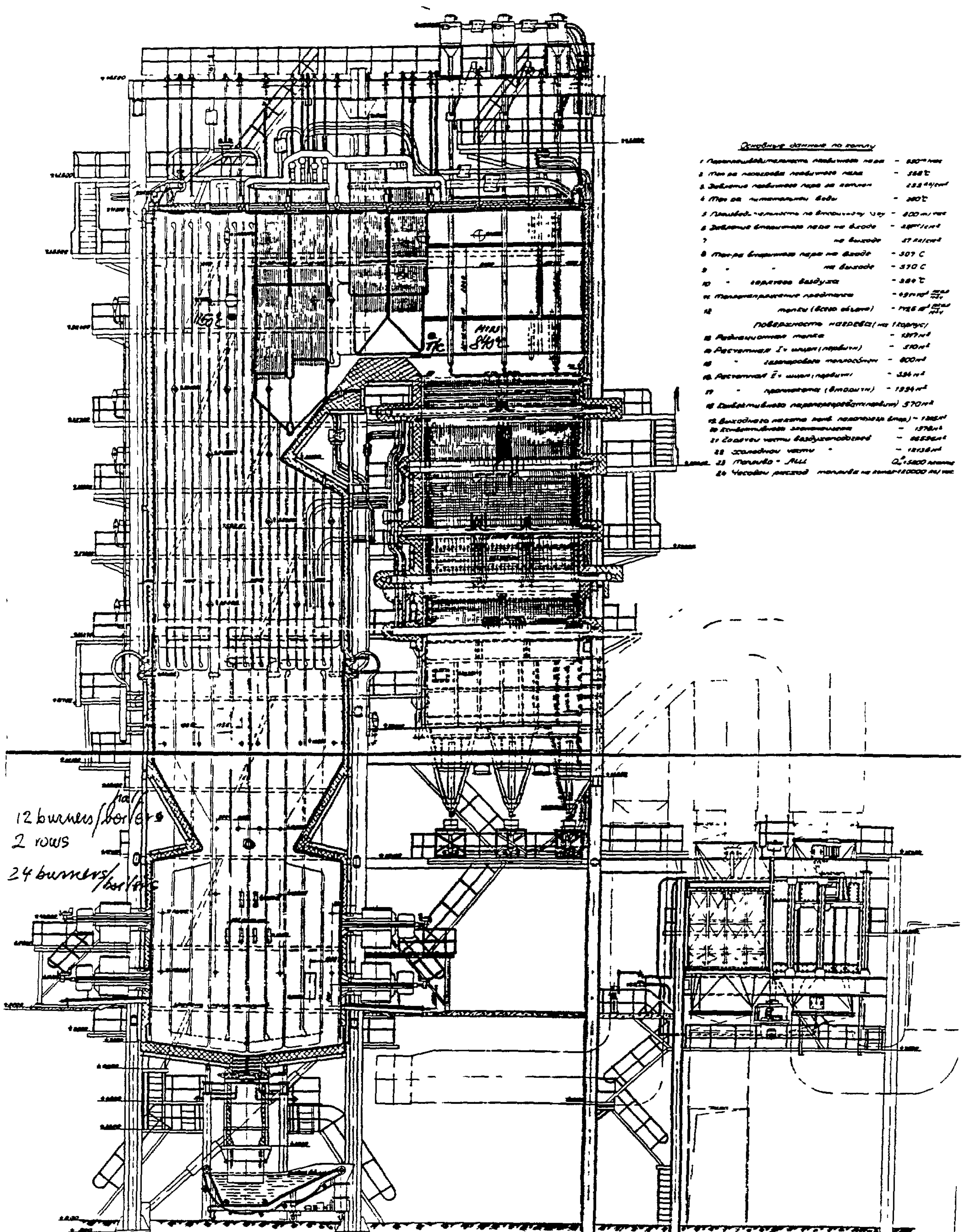
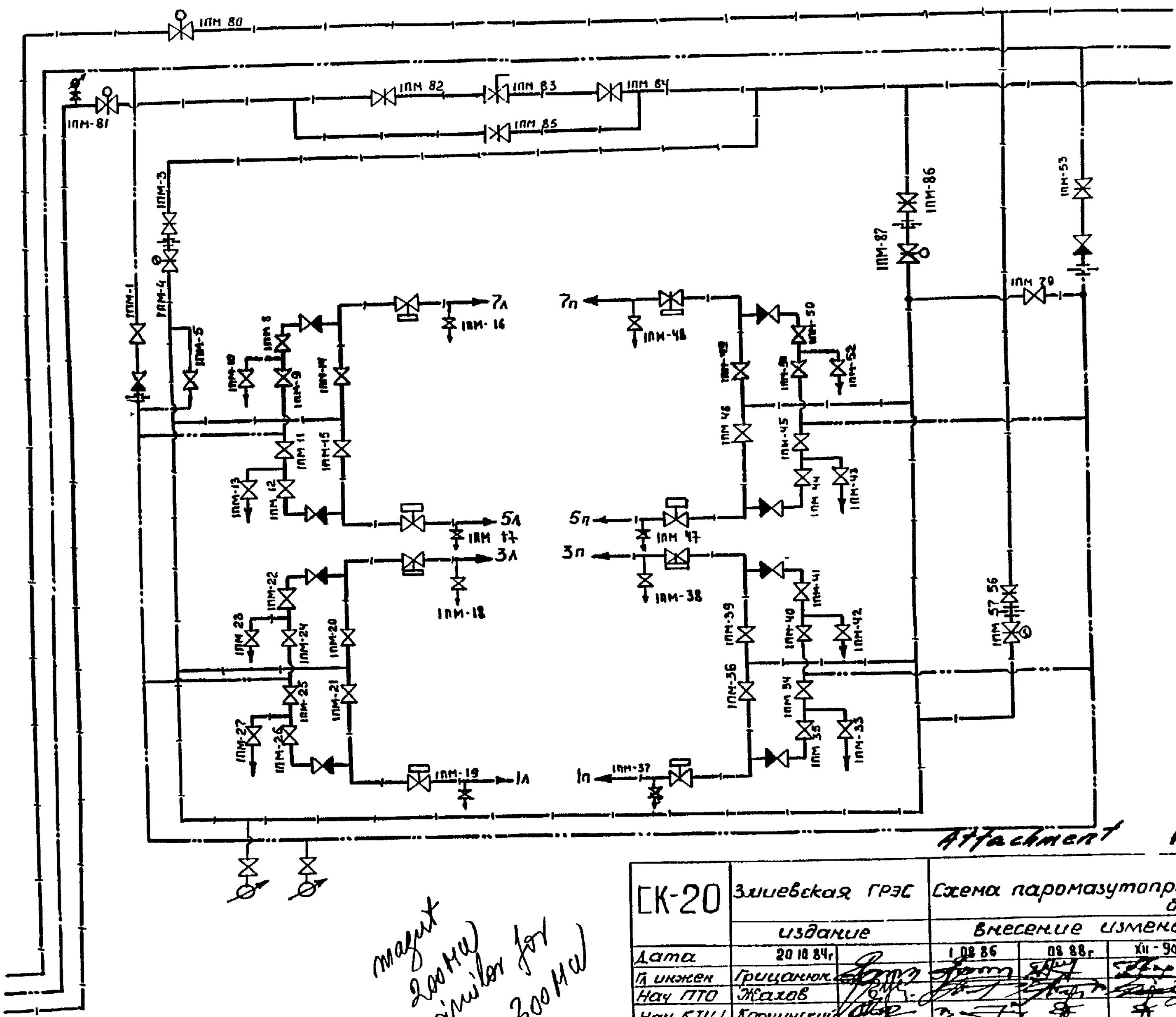


BEST AVAILABLE COPY

TPP-210

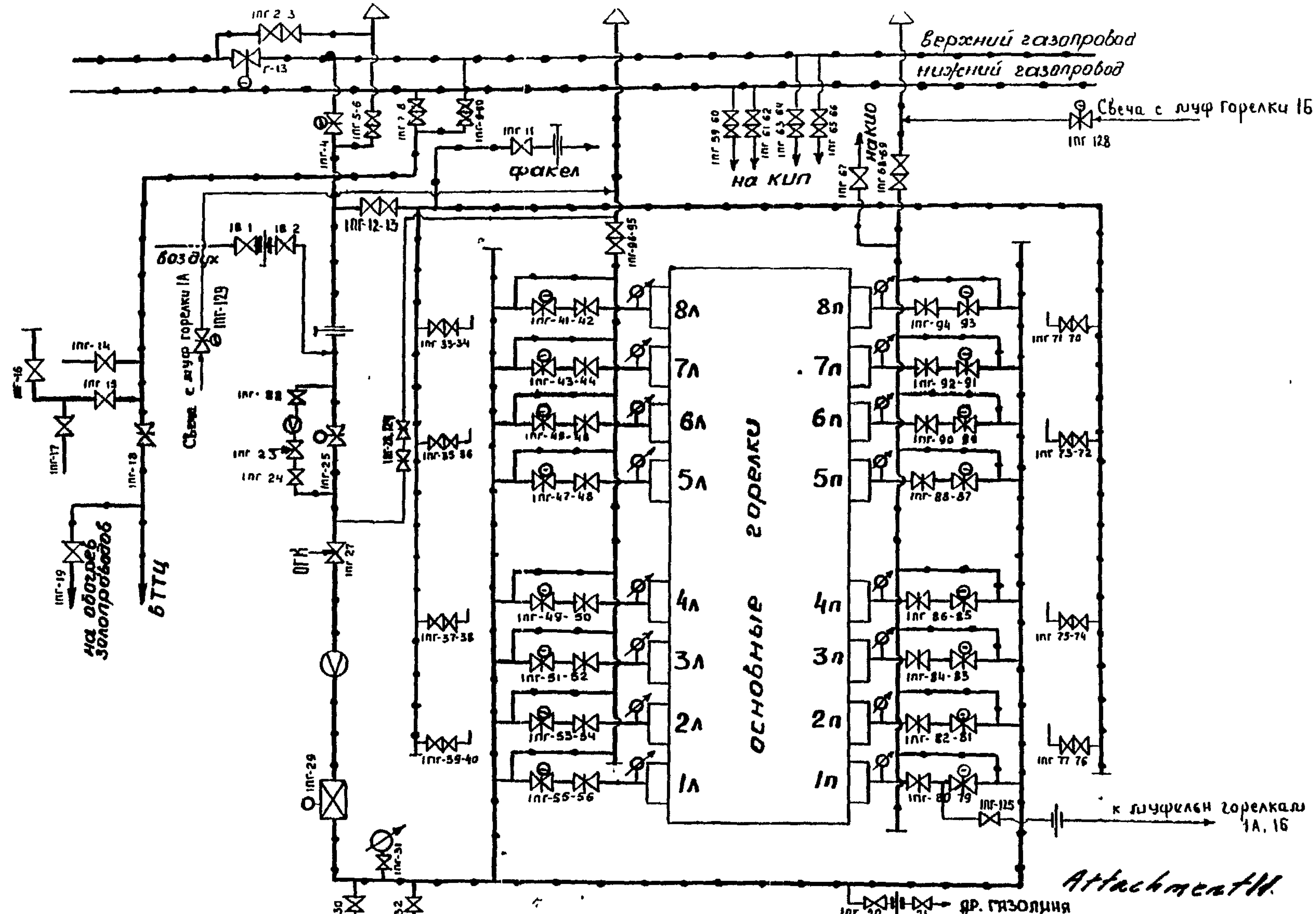


Attachment 10

ЕК-20	Змиевская ГРЭС		Схема паромазутопроводов бл №1			
	издание		внесение изменений			
Дата	20 10 84г		1 08 86	08 88г	XII - 90г	25 01 9[illegible]
Гл инжен	Грицанюк					
Нач ПТО	Жахов					
Нач КТЦ I	Корчинский					

mazut 200 MW similar for 300 MW

130

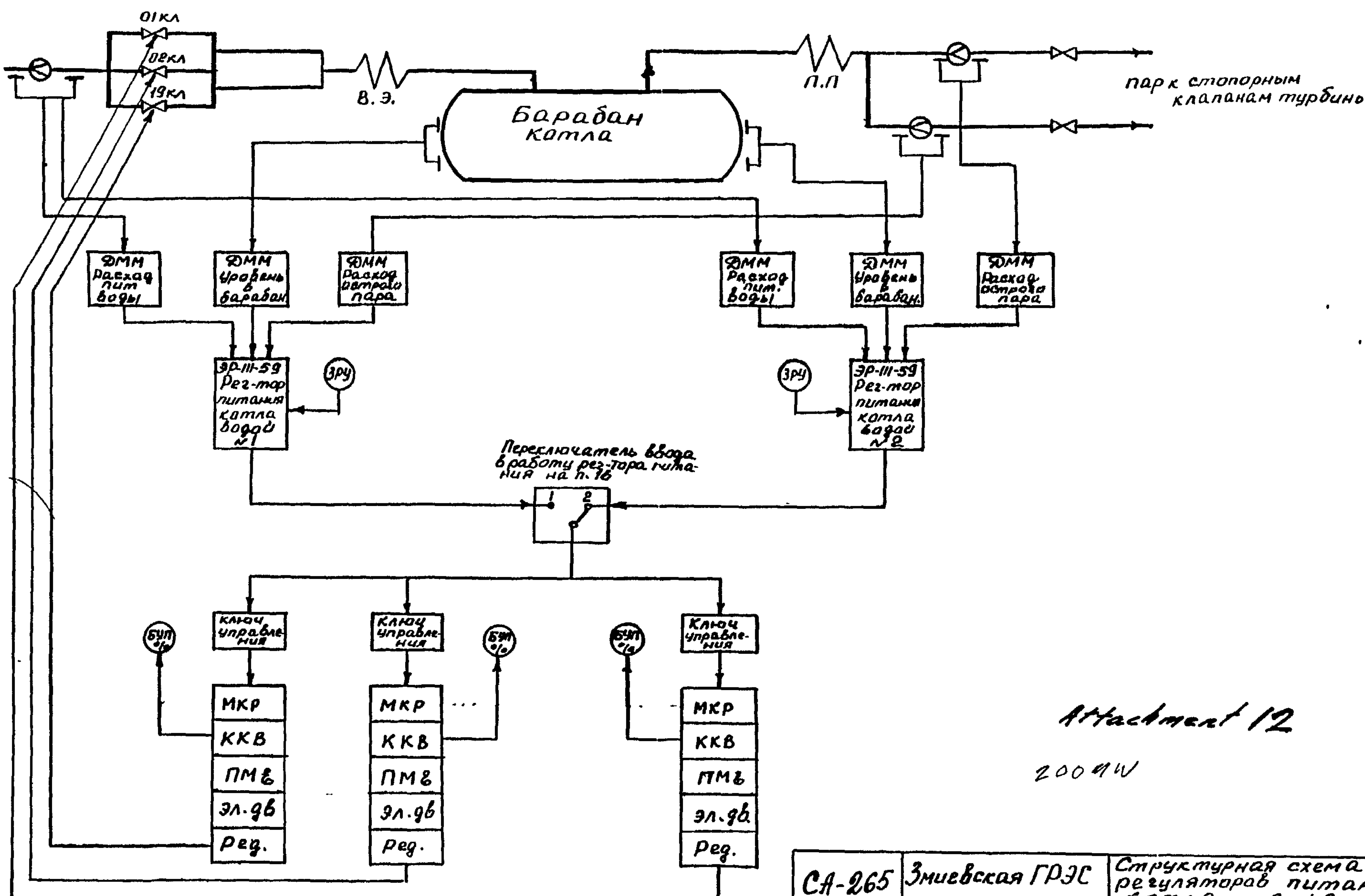


Attachment W.

700 MW gas.

СК-15	Змиевская ГРЭС		Схема природного газа блока №1		
	издание		Внесение изменений		
Дата		25 01 93г			
Гл инженер	Чупыра	[signature]			
Нач ПТО	Э.Салов	[signature]			
Нач КТЦ-1	Савченко	[signature]			
Исполнитель	Заец	Заец			

103



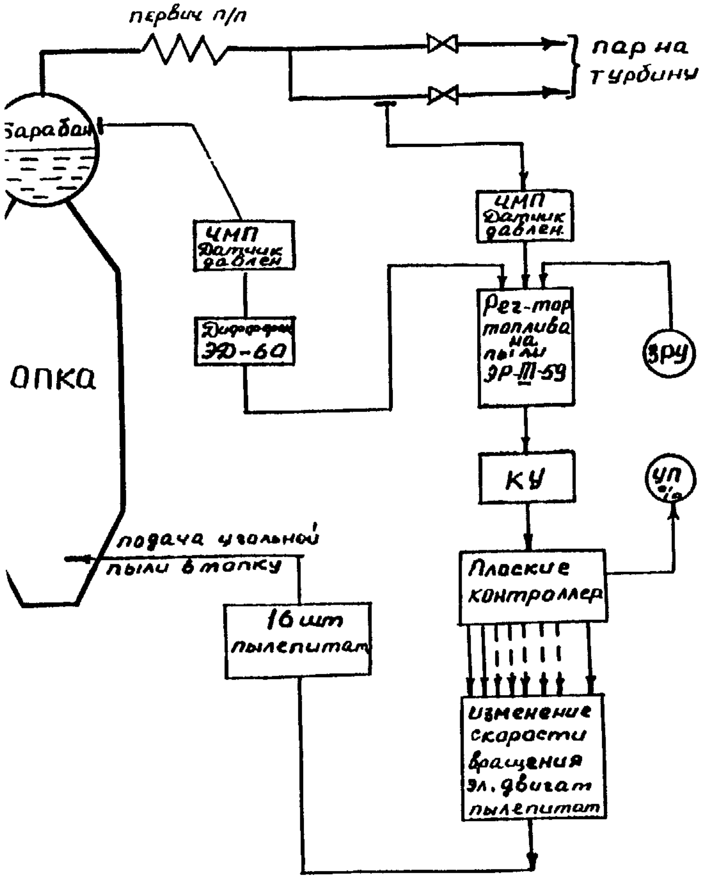
Attachment 12

200 MW

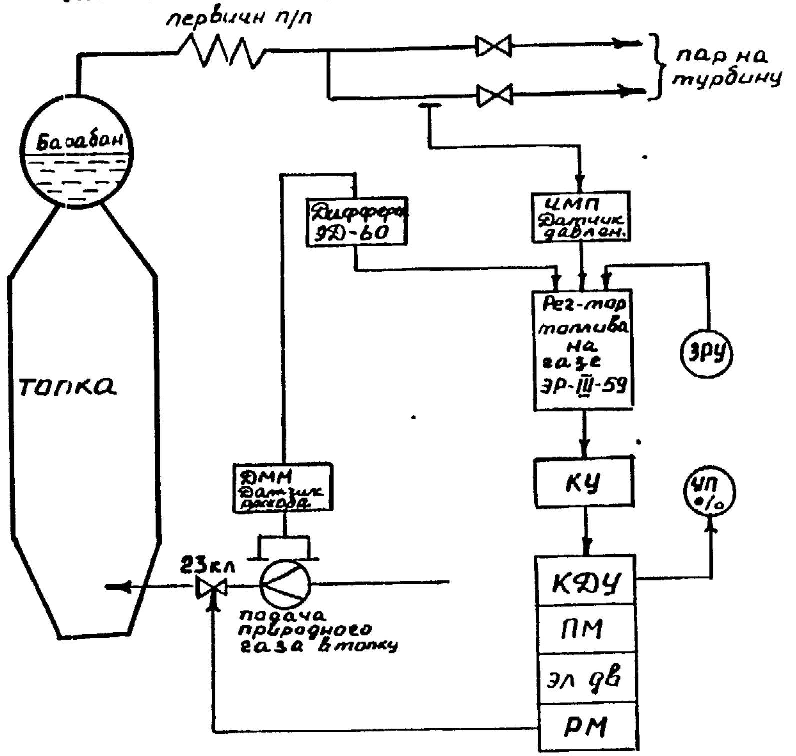
СА-265	Змиевская ГРЭС		Структурная схема регуляторов питания котла Бл. 1-2
	Издание		Внесение изменений
Дата		19.03.83	02.04.87
Гл. инженер	Грицаненко А.К.		
Нач ПТО	Жалов Г.Е.		
Нач цеха	Захарченко		

Схема пересмотрена 14.03.85
Нач цеха

Регулирование давления пара перед турбиной при работе блока на пыли (рег-тор топлива на пыли)



Регулирование давления пара перед турбиной при работе блока на газе (рег-тор топлива на газе)



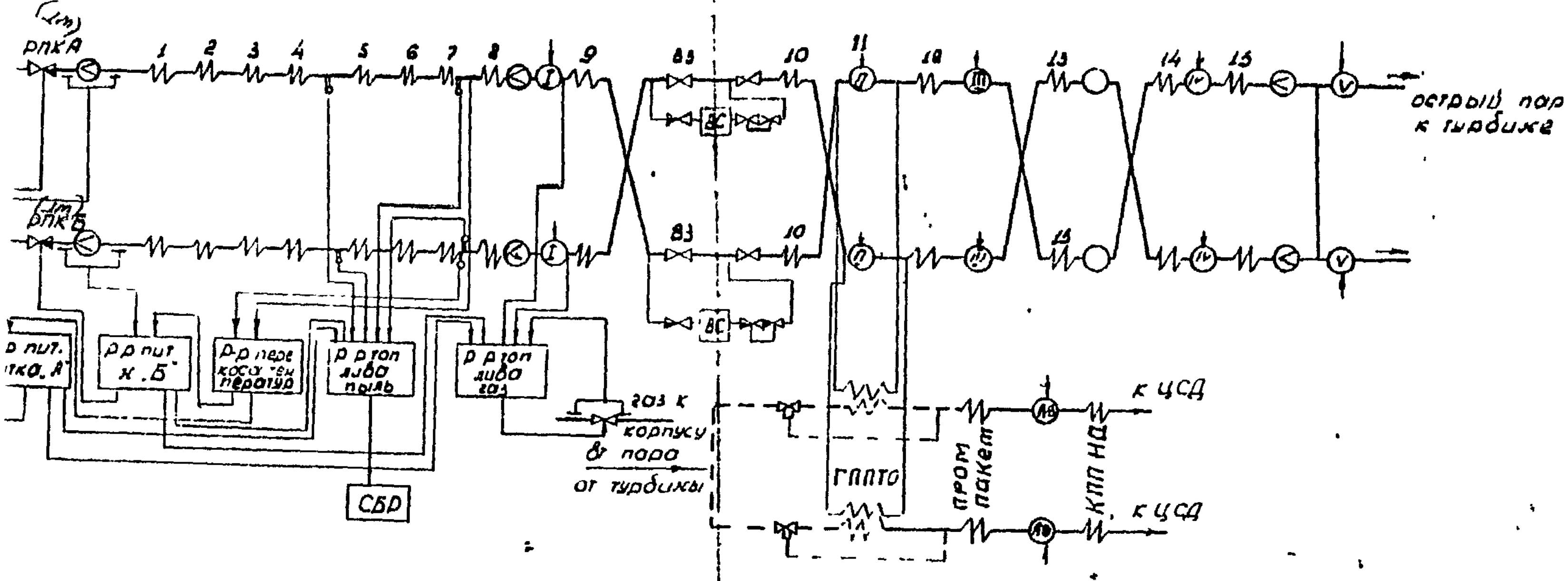
Attachment 13

Схема пересмотрена 14.03.85
Нач цеха Захарченко
Мастер Хамуза

200 MW

СА-261	Змиевская ГРЭС		Структурные схемы регуляторов топлива на пыли и газе. Бл 1-2		
	издание		Внесение изменений		
Дата		14.03.83	02.04.87		
Гл инженер	Гриценюк О.К.				
Нач ПТО	Жалов Г.Е.				
Нач. цеха	Захарченко А.Г.				

Схема регулирования питания и топлива котла ТПП 210 бл 7



условные обозначения

ПКА, РПКБ - регулирующий питательный клапан нитки А и Б
термопара
З - встроенная задвижка
С - встроенный сепаратор
блок водяного экономайзера
водяной экран НРЧ
боковой экран НРЧ
фронтовой экран НРЧ
фронтовой экран ВРЧ
боковой экран ВРЧ

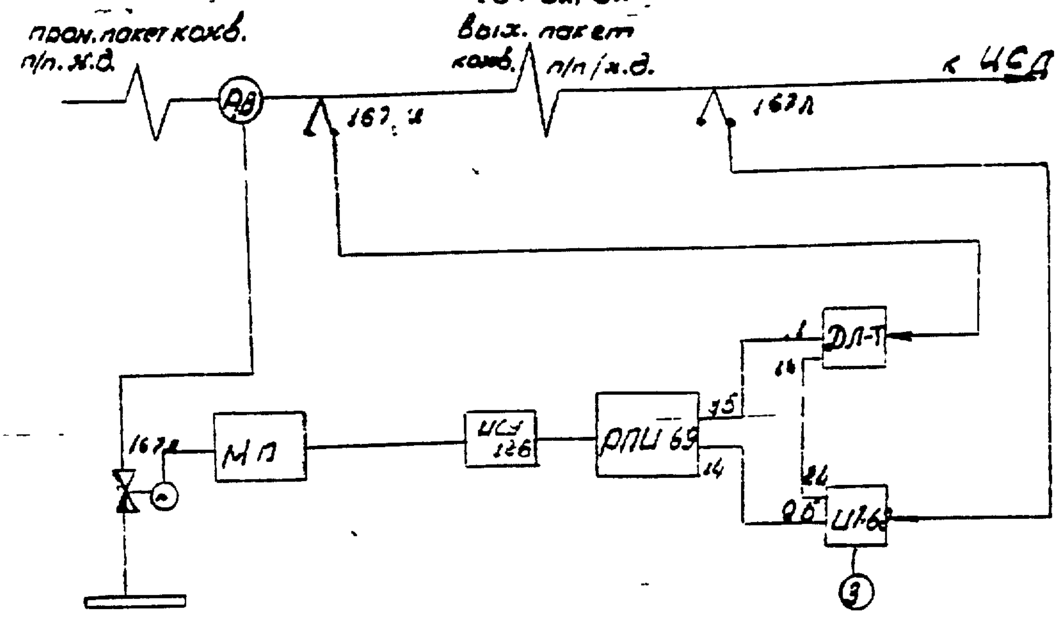
7 задний экран ВРЧ
8 экран сепаратный
9 Экраны потолочного пароперегр
10 ширмы I ступени входные
11 теплообменник
12 ширмы I ступени выходные
13 ширмы II ступени входные
14 ширмы II ступени выходные
15 КПП. В.Д

300 MW

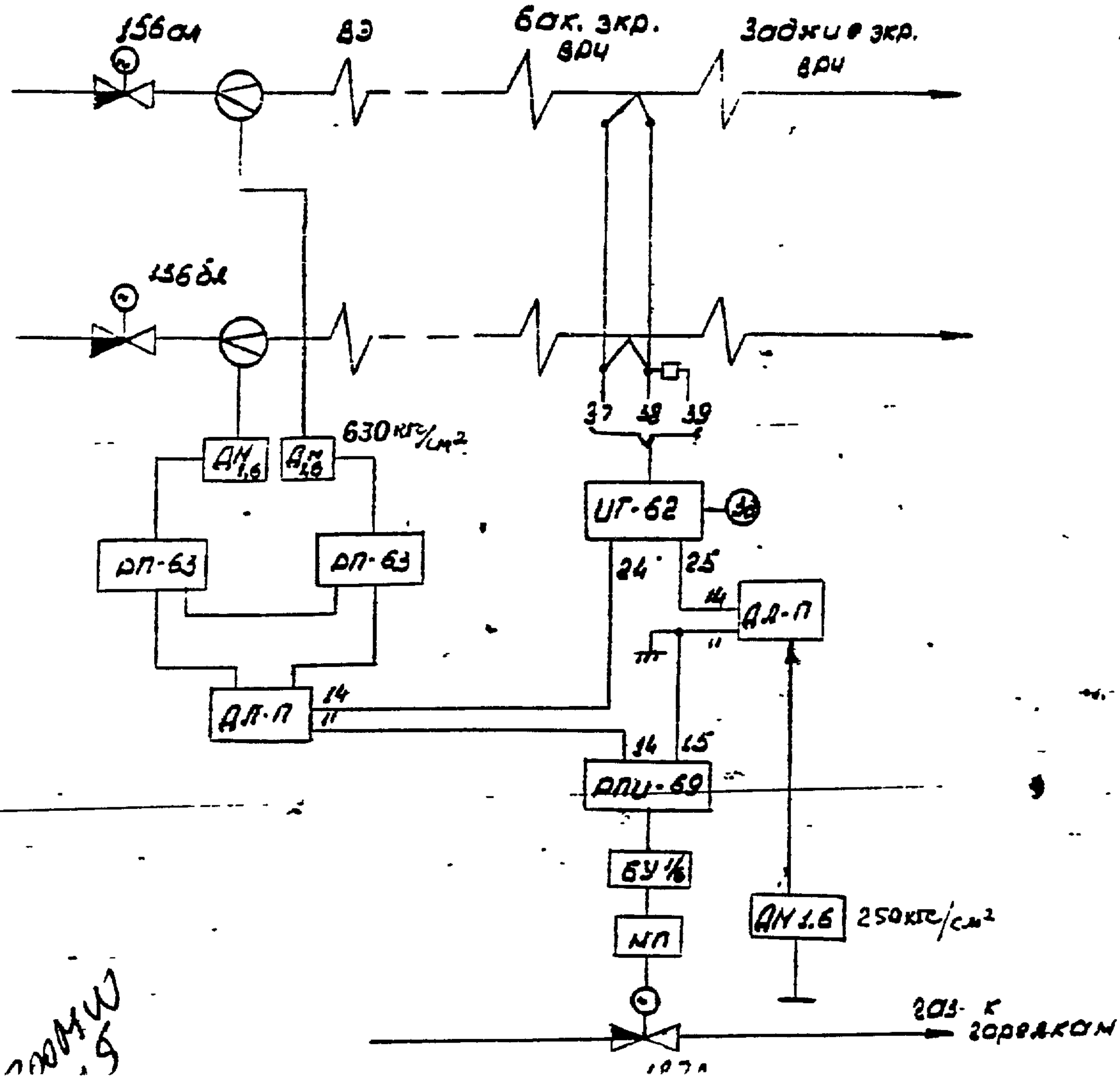
Attachment 14

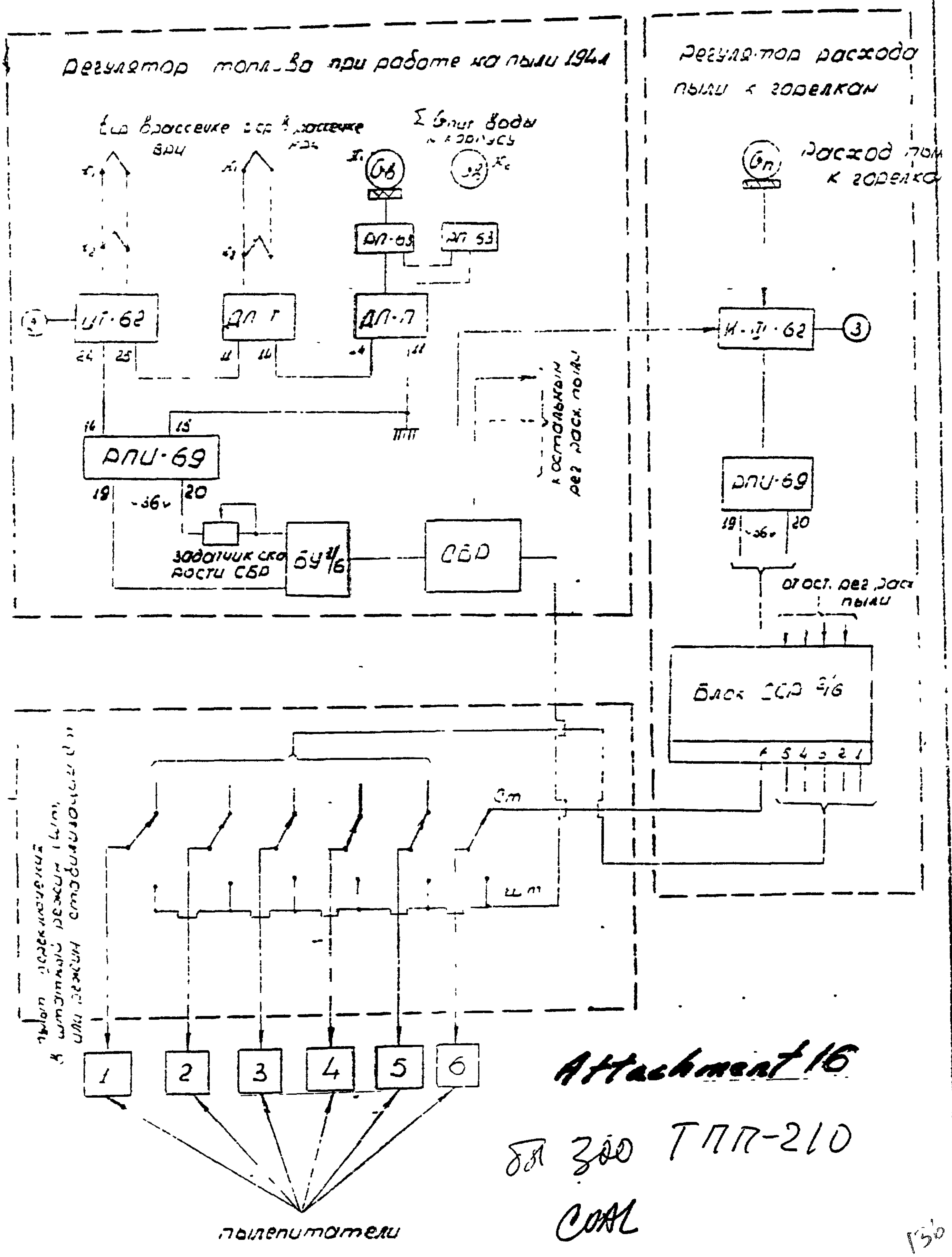
Регулятор t° вторичного пара (аварийный впрыск)

167 ал, бл



Регулятор топлива при работе на газе №187л





Attachment 16

бл 300 ТПП-210

COAL

Кому высылается ____________

адрес получателя

0821033							
1	2	3	4	5	6	7	8
формы документа по ОКУД	организации составителя документа по ОКПО	отрасли	территории	министерства (ведомства)	промышленного объединения главного управления (управления) треста	производственного объединения (комбината) предприятия	

КОДЫ

Форма № 3-тех (энерго)

Утверждена приказом ЦСУ СССР от 25 V 1982 г № 280

Почтовая — квартальная

Высылают все тепловые электростанции мощностью от 50 тыс. кВт и выше согласно подчиненности 15 го числа после отчетного периода районному энергоуправлению, главному производственному управлению энергетики и электрификации союзной республики, Минэнерго Узбекской ССР

Районные энергоуправления, а где их нет — Главные производственные управления энергетики и электрификации республик и Минэнерго Узбекской ССР — 20 числа после отчетного периода соответствующим Главным эксплуатационным управлениям министерствам энергетики и электрификации Украинской и Казахской ССР, производственному объединению «Союзтехэнерго»

Министерство (ведомство) энергетики и электрификации УССР

Промышленное объединение, главное управление (управление), трест ПЭО Харьковэнерго

Производственное объединение (комбинат), предприятие Змиевская ГРЭС

Адрес п. Комсомольский, Харьковской обл.

ТЕХНИЧЕСКИЙ ОТЧЕТ

по эксплуатации тепловой электростанции

за август 1994 г.

I. Общие показатели электростанции

Показатели	Блоки 200 МВт							Блоки 300 МВт					Всего по станции
	1	2	3	4	5	6	Всего	7	8	9	10	Всего	
Выработано электроэнергии (т кВт·ч)	67112	113583	43091	90326	98990	87220	500322	140312	–	107760	174816	422888	923210
Отпуск электроэнергии с шин (–"–)	61893	103662	38250	81983	90074	79740	455602	126236	–	100681	165491	392408	848010
Отпуск теплоэнергии — всего (Гкал)	56	92	34	72	80	70	150	3568	–	–	1328	4896	5300
в том числе отработанным паром турбин (%)							100					100	100
с горячей водой (%)							0					46,63	43,08
Удельный расход условного топлива на отпущенную электроэнергию план (г/кВт·ч)							406,89					390,96	399,52
фактически (г/Гкал)	397,8	385,5	428,1	414,9	417,1	411,8	406,9	411,8	–	396,8	371,5	391,0	399,5
отпущенную теплоэнергию план (кг/Гкал)							180,69					195,35	194,15
фактически (–"–)							180,69					195,4	194,15
Фактический расход электроэнергии на выработку электроэнергии (%)	7,72	8,73	11,23	9,23	9,0	8,57	8,93	9,85	–	6,57	5,28	7,12	8,10
на отпуск теплоэнергии (кВт·ч/Гкал)							66,83					72,71	72,26

Attachment 17

Доверенное отделение ВГО [illegible]

137

II. Показатели турбоагрегатов

Показатели	Код строки	Обозначение	Единица измерения	I очередь К-200-130						По очереди			
				1	2	3	4	5	6	норм	факт	р-вы экон.	
А	Б	В	Г	1	2	3	4	5	6	7	8	9	10
работано электроэнергии	12	Э	тыс кВт·ч	67112	113583	43091	90326	98990	87220	—	500322		
едняя электрическая нагрузка	13	N ср	МВт	147	153	138	146	142	159	—	148		
Средняя тепловая нагрузка суммарная	14	Q ср	Гкал/ч	181	296	2140	963	1364	953	—	5897		
производственного отбора	15	Q по	»	—	—	—	—	—	—	—	—		
теплофикационного отбора	16	Q то	»	—	—	—	—	—	—	—	—		
за счет ухудшенного вакуума (встроенного пучка)	17	Q вр	»	—	—	—	—	—	—	—	—		
Число часов в работе/в резерве	18	$T_{раб}$ | $T_{рез}$	час	455/389	744/—	313/386	617/127	695/39	549/195	—	3373/1036		
Число часов работы на одном корпусе котла (для дубль блоков)	19	Тт	»	—	—	—	—	—	—	—	—		
Выработано электроэнергии по теплофикационному циклу	20	Э тф	тыс кВт·ч	24	40	385	126	184	121	—	780		
	21		%	0,086	0,035	0,661	0,139	0,186	0,139	—	0,156		
Коэффициент использования электрической/тепловой мощности	22	К	»	51,5	87,2	33,1	69,2	76,0	67,0	—	64,0		
Число пусков (в том числе внеплановых)	23	n		—	—	3/-	1/-	2/1	1/-	—	7/1		
Давление пара у турбины: свежего	24	P_0	кГс/см²	130	130,8	130	130	130,1	131,2	130	130,4	-31	
~~производственного отбора~~ на промперегрев	25	$P_{по}$	»	19,3	19,8	16,9	17,6	18,5	18,9	—	18,7		
~~теплофикационного отбора~~ после промперегрева	26	P то	»	16,3	17,5	13,9	14,8	15,5	16,2	—	15,9		
противодавления	27	P пр	»	0,0825	0,0791	0,0586	0,0677	0,0639	0,0654	0,0662	0,0704		
Температура пара у турбины: свежего	28	t_0	°С	537	540	538	537	540	532	540	537,6	121	
[illegible] промперегрева	29	$t''_{пп}$	»	313/545	305/537	305/537	256/544	304/540	309/538	—/540	304,9/539,8	5	
Вакуум Н/ф	30	V	%	92,92/91,35	93,3/93,06	94,03/93,14	93,32/93,23	93,55/93,61	93,58/93,46	93,38	92,86	845	
Температура охлаждающей воды на входе/выходе из конденсатора	31	t_1/t_2	°С	27,25/33,4	25,83/31,49	26,6/30,81	16,83/32,98	25,94/32,9	25,40/31,06	26,0/32,1	26,0/32,1		
Температурный напор в конденсаторе Н/ф	32	δt	»	5,5/8,4	6,3/9,5	2,7/4,5	4,8/5,0	4,8/4,6	6,5/6,3	5,5	6,7		
Присосы воздуха в вакуумную систему	33	—	кг/ч	50	27	30	37	40	45	20	37,9		
Температура питательной воды перед деаэратором (за П и Д) Н/ф	34	$t_{пв}$	°С	225,0/216,0	232,4/227,8	233,3/220,2	226,7/218,9	224,8/224,9	232,6/224,8	226,5	224,2	126	
Удельный расход тепла брутто на турбину	35	$q_т$	ккал/кВт·ч	2183,34/2181,52	2174,11/2174,8	2183,42/2179,41	2185,4/2185,4	2207,88/2207,9	2230,78/2230,8	2194,95	2195,0		
Расход тепла на собственные нужды	36	$q_т^{сн}$	%	0,403/0,05	0,330/0,04	0,464/0,464	0,413/0,413	0,419/0,419	0,384/0,284	0,407	0,281	-242	
Расход электроэнергии на собственные нужды	37	$Э_т^{сн}$	»	1,461/1,36	1,416/1,28	1,554/1,42	1,414/1,37	1,415/1,36	1,271/1,33	1,421	1,34	-156	
в том числе на ~~циркуляционные насосы~~	38	Эпн	»	1,178/0,921	1,139/0,883	1,368/0,986	1,183/0,928	1,321/0,930	1,097/0,855	1,172	0,916	-586	
Удельный расход тепла нетто на турбоустановку	39	$q_т^н$	ккал/кВт·ч	2218,34/2218,6	2213,94/2203,35	2234,69/2230,97	2237,36/2224,91	2248,95/2247,81	2268,19/2269,44	2235,67	2231,10		
Расход электроэнергии на теплофикационную установку	40	Э тепл	кВт·ч/Гкал	—	—	66,58	—	—	—	66,58	66,58		

III. Показатели котлоагрегатов

Показатели	Код строки	Обозначение	Единица измерения	I очередь ТП-100						По очереди			
				1	2	3	4	5	6	норм	факт	р-вы экон	
А	Б	В	Г	1	2	3	4	5	6	7	8	9	10
Средняя нагрузка паровая	41	Dк	т/ч	454,4	463,9	425,8	438,8	436,2	449,1	–	1505646		
тепловая	42	Qк	Гкал/ч	326,7	336,1	314,0	325,7	320,9	360,6	–	1118894		
Давление свежего пара за котлом	43	Pк	кГс/см²	137	137,8	137	137	137,1	138,7	–	137,4		
Температура свежего пара за котлом	44	tк	°C	542	545	543	542	545	537	–	542,6		
Число часов в работе/в резерве	45	Траб Трез	час	455/189	449/–	313/386	617/127	695/39	549/195	–	3573/1036		
Температура воздуха холодного/после калорифера	46	tхв/tкф	°C	42,2/47,3	43,4/44,3	36,1/43,5	42,8/48,8	40,6/45,3	40,0/44,7	20/–	41,1/45,7		
после воздухоподогревателя	47	tгв	»	344,3	353,2	322,2	340,2	338,2	337,7	–	341,1		
Температура уходящих газов за последней поверхностью нагрева котла н/ф	48	tух	»	141,2/141,8	143,2/149,3	139,1/144,6	142,8/138,7	144,9/144,0	144,2/143,1	142,4	143,8	178	
Коэффициент избытка воздуха за котлом	49	α	—	1,572/1,975	1,653/1,865	1,604/2,055	1,579/1,998	1,589/1,939	1,571/1,824	1,575	1,929	2681	
Присосы воздуха на тракте котел дымосос	50	Δα	—	0,8955	0,7817	0,9527	0,9099	0,8177	0,7337	0,3832	0,8342		
Содержание горючих в уносе	51	Гун	%	22,32	14,26	19,1	18,6	18,72	14,62	15,43	17,25		
в шлаке	52	Гшл	»	–	–	–	–	–	–	–	–		
Тонкость помола пыли	53	R90/R200		10,33	8,5	6,9	8,1	8,2	9,8	8,6	8,6		
Число растопок/в т. ч. вынужденных	54	n	—	–	–	3/–	1/–	2/1	1/–	–	7/1	63	
Расход условного топлива — всего	55	B	т/усл.топ.	24631	39981	16382	34027	37581	32851	–	185453		
в том числе газа мазута	56	Bгаз/Bмаз	»	13160/–	16490/–	9016/–	11483/–	15545/–	8402/–	–	44096/–		
Потери тепла котлоагрегатом: с уходящими газами	57	q₂	%	5,38/7,22	5,17/7,66	5,74/8,14	5,09/7,67	5,34/8,07	5,16/7,24	5,26	7,67		
с механическим недожогом	58	q₄	»	5,06/7,87	6,24/5,75	4,98/6,24	7,11/8,91	6,36/7,93	7,88/7,49	6,44	7,39	2023	
с химическим недожогом	59	q₃	»	0,57/0,57	0,55/0,55	0,58/0,58	0,55/0,55	0,56/0,56	0,54/0,54	0,55	0,55	264	
прочие	60	q₅+q₆	»	0,16/0,22	0,21/0,28	1,24/1,4	0,41/0,52	0,35/0,59	0,45/0,57	0,4	0,52		
Коэффициент полезного действия, брутто н/ф	61	$\eta_к^{бр}$	»	88,83/84,12	87,83/85,76	87,46/83,64	86,84/82,35	87,29/82,85	85,97/84,12	87,35	83,87		
Расход электроэнергии на собственные нужды всего по котлоагрегатам	62	$Э_к^{сн}$	»	7,46/6,41	7,54/7,45	7,61/9,81	7,9/7,86	7,38/7,64	7,05/7,24	7,73	7,59	-290	
в том числе: на пылеприготовление	63	Эпп	кВт·ч/т нат. топл.	33,2	55,23	62,39	41,5	46,09	44,0	40	46,38	451	
на питательные электронасосы	64	Эпэн	кВт·ч/т воды	9,57/8,13	9,05/7,5	10,07/8,62	9,29/8,61	9,58/8,55	9,01/8,44	9,35	8,25	-472	
на тягу и дутье	65	Этд	кВт·ч/т пара	8,92/9,62	8,89/7,26	8,16/9,48	9,21/9,51	9,2/8,8	9,22/8,61	9,09	8,72	-220	
Приведенный расход электроэнергии на питательные турбонасосы	66	Этпн	%	–	–	–	–	–	–	–	–		
Расход тепла на собственные нужды	67	$P_к^{сн}$	»	0,61/0,04	0,64/0,04	0,69/1,7	0,67/0,04	0,65/0,17	0,69/0,07	0,66	0,22	-825	
Коэффициент полезного действия, нетто	68	$\eta_к^н$	»	81,61/80,58	80,6/82,57	80,11/75,87	78,34/77,61	79,22/78,09	78,41/79,72	79,96	79,39		

II. Показатели турбоагрегатов

Показатели	Код строки	Обозначение	Единица измерения	II очередь К-300-240: 7	8	9	10	По очереди: норм	факт	р-ты экон	Всего по станции: норм	факт	р-ты экон
А	Б	В	Г	1	2	3	4	5	6	7	8	9	10
Выработано электроэнергии	12	Э	тыс кВт·ч	140312	–	104760	144816	–	422888		–	923210	
Средняя электрическая нагрузка	13	N ср	МВт	189	–	185	235	–	204		–	–	
Средняя тепловая нагрузка: суммарная	14	Q ср	Гкал/ч	5969	–	3154	2977	–	12100		–	17997	
производственного отбора	15	Q по	»	–	–	–	–	–	–		–	–	
теплофикационного отбора	16	Q то	»	–	–	–	–	–	–		–	–	
за счёт ухудшенного вакуума (встроенного пучка)	17	Q вп	»	–	–	–	–	–	–		–	–	
Число часов в работе/в резерве	18	τраб / τрез	час	744 / –	–	582 / 162	744 / –	–	2070 / 162		–	7967 / 1198	
Число часов работы на одном корпусе котла (для дубль блоков)	19	τт	»	205	–	238	–	–	443		–	443	
Выработано электроэнергии по теплофикационному циклу	20	Э тф	тыс. кВт·ч	610	–	291	346	–	1247		–	2027	
Коэффициент использования электрической/тепловой мощности	21	[illegible]	%	0,435	–	0,270	0,198	–	0,295		–	0,22	
	22	[illegible]		68,6	–	52,7	85,4	–	51,7		–	57,7	
Число пусков (в том числе внеплановых)	23	n		–	–	1/–	–	–	1/–		–	8/1	
Давление пара у турбины свежего	24	P_0	кГс/см²	237,2	–	236,2	235,9	240	236,4	83	180,4	178,96	52
производственного отбора	25	Pпо	»	33,9	–	32,8	35,5	–	33,9		–	25,7	
теплофикационного отбора	26	Pто	»	29,9	–	29,8	32,5	–	30,9		–	22,8	
противодавления	27	Pпр	»	0,0654	–	0,0627	0,0666	0,0622	0,0652		0,0644	0,068	
Температура пара у турбины свежего	28	t_0	°C	540	–	542	543	540	541,9	-116	540	539,5	11
после промперегрева	29	tпп	»	297 / 540	–	302 / 539	304 / 541	540	301,7 / 540,1	-1	540	303,9 / 539,9	4
Вакуум	30	V	%	93,31 / 93,46	–	94,27 / 93,76	94,31 / 93,34	93,78	93,48	626	93,56	93,2	1471
Температура охлаждающей воды на входе/выходе из конденсатора	31	t1в/t2в	°C	25,65 / 33,06	–	25,51 / 31,33	25,14 / 34,22	25,7 / 33,1	25,7 / 33,1		25,9 / 32,6	25,9 / 32,6	
Температурный напор в конденсаторе	32	δt	»	30 / 4,3	–	33 / 5,3	36 / 3,5	3,4	4,2		4,5	5,5	
Присосы воздуха в вакуумную систему	33	—	кг/ч	60	–	60	35	30	49,7		25	43,3	
Температура питательной воды перед деаэратором (за п. в. д.)	34	tпв	°C	247,0 / 247,0	–	247,5 / 247,5	260,3 / 260,3	252,6	252,6	–	238,4	237,2	126
Удельный расход тепла брутто на турбину	35	qт	ккал/кВт·ч	2094,66 / 2108,16	–	2093,96 / 2122,49	2037,68 / 2037,69	2070,93	2082,0		2138,1	2143,2	
Расход тепла на собственные нужды	36	$q_т^{сн}$	%	0,155 / 0,155	–	0,185 / 0,185	0,128 / 0,128	0,152	0,152	–	0,234	0,223	-242
Расход электроэнергии на собственные нужды	37	$Э_т^{сн}$	»	2,113 / 1,54	–	2,161 / 1,66	1,821 / 1,30	2,01	1,47	-875	1,69	1,40	-1031
в том числе на циркуляционные насосы	38	Эцн	»	1,186 / 1,025	–	1,208 / 1,094	0,953 / 0,825	1095	0,946	-247	1,137	0,93	-773
Удельный расход тепла нетто на турбоустановку	39	$q_т^{н}$	ккал/кВт·ч	2143,20 / 2142,49	–	2144,18 / 2162,42	2088,15 / 2064,34	2116,56	2116,30		2183,67	2179,3	
Расход электроэнергии на теплофикационную установку	40	Э тепл	кВт·ч/Гкал	←	←	66,58	→	66,58	66,58		66,58	66,58	—

III. Показатели котлоагрегатов

Показатели	Код строки	Обозначение	Единица измерения	II очередь ТП-210, 210А												По очереди			Всего по станции			
				7а	7б		8а	8б		9а	9б		10а	10б		норм	факт	р-вы экон	норм	факт	р-вы экон	
А	Б	В	Г	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10
Средняя нагрузка паровая	41	Dк	т/ч			633,02			—			644,9			786,2	—	1430502		—	2936148		
тепловая	42	Qк	Гкал/ч			413,4			—			419,1			504,2	—	926618		—	2046512		
Давление свежего пара за котлом	43	Pк	кГс/см²			242,2			—			241,2			240,9	—	241,4		—	185,0		
Температура свежего пара за котлом	44	tк	°C			545			—			547			548	—	546,9		—	544,5		
Число часов в работе/в резерве	45	Траб Трез	час	678	605/68		—	—		344/272	582/162		744	744		—	3697/502		—	7070/1538		
Температура воздуха холодного/после калорифера	46	tхв/tкф	°C	34,44/43,2	27,1/39,6	30,8/41,4	—	—	—	41,6/44,6	40,9/46,9	41,3/45,7	32,9/40,2	40,5/43,7	36,7/42,0	20/—	35,9/42,8		20/—	38,7/44,4		
после воздухоподогревателя	47	tгв	»	322,2	341,4	331,8	—	—	—	344,9	353,2	349,1	362	346,4	354,2	—	345,2		—	343,0		
Температура уходящих газов за последней поверхностью нагрева котла Н/фо	48	tух	»	165,3	164,5	154,7/164,9	—	—	—	170,8	167,6	154,7/162,2	161,2	169,3	164,5/168,8	152,0	167,6	915	149,8	154,6	1093	
Коэффициент избытка воздуха за котлом	49	α	—			1,58/1,416			—			1,51/1,647			1,471/1,588	1,517	1,651	908	1,548	1,802	3079	
Присосы воздуха на тракте котел дымосос	50	Δα	—	0,6142	0,5966	0,4743/0,6054	—	—	—	0,6109	0,5753	0,4836/0,5931	0,5687	0,5141	0,4293/0,5384	0,4604	0,5754		0,4183	0,7166		
Содержание горючих в уносе	51	Гун	%	17,54	18,61	18,08	—	—	—	14,88	17,4	16,14	15,49	16,55	16,69	16,72	16,89		15,96	17,1		
в шлаке	52	Гшл	»	—	—	—	—	—	—	-	-		—	—	—	—	—		—	—		
Тонкость помола пыли	53	R90/R200	»			8,6			—			11,5			8,1	9,4	3,4		9,0	3,0		
Число растопок/в т. ч. внеплановых	54	n	—	1/1	2/1				—	4/1	1/-					—	8/3	16,5	—	15/4	128	
Расход условного топлива — всего	55	B	т/усл.топ.			52646/20831			—			39949/35626			61748/30774	—	154372/77331		—	339825/151432		
в том числе газа мазута	56	Вгаз/Вмаз	»			—			—			—			—	—	—		—	—		
Потери тепла котлоагрегатом с уходящими газами	57	q2	%	9,01	9,61	6,41/9,3	—	—	—	9,05	8,76	6,11/8,9	5,85	8,59	6,46/8,73	6,35	8,94		5,75	8,45		
с механическим недожогом	58	q4	»	7,53	8,1	7,36/7,82			—	3,68	4,44	4,36/4,06	5,41	5,85	5,68/5,53	5,89	5,94	109	6,13	6,73	2132	
…ическим недожогом	59	q5	»			0,64/0,64			—			0,65/0,55			0,51/0,51	0,59	0,51	391	[illegible]	[illegible]	655	
прочие	60	q прочие	»			0,32/0,67			—			0,76/1,06			0,18/0,24	0,38	0,6		0,33	0,56		
Коэффициент полезного действия, брутто Н/фо	61	ηбр	»			85,47/81,57			—			88,12/83,43			87,12/84,8	86,79	83,43		87,1	83,37		
Расход электроэнергии на собственные нужды всего по котлоагрегатам.	62	Эсн				7,05/8,31			—			3,85/4,91			3,73/3,98	4,86	[illegible]	1322	6,42	5,7	1032	
в том числе, на пылеприготовление	63	Эпп	кВт·ч/т нат топл.			48,07			—			49,33			51,99	46	[illegible]	[illegible]	46	[illegible]	922	
на питательные электронасосы	64	Эпэн	кВт·ч/т воды			—			—			—			—	—	—		—	—		
на тягу и дутье	65	Этд	кВт·ч/т пара			6,89/6,47			—			6,27/6,21			5,74/5,86	6,26	6,39	186	7,71	7,55	-34	
Приведенный расход электроэнергии на питательные турбонасосы	66	Этпн	%			3,56/0,83			—			3,56/3,45			3,53/3,57	3,56	2,63		1,63	1,21	-838	
Расход тепла на собственные нужды Qнтн	67	qсн	»			0,65/0,63 0,8			—			0,66/1,12 3,25			0,69/0,38 3,32	0,67 3,37	0,63 2,49	-13	1,63 1,56	1,21 1,13		
Коэффициент полезного действия, нетто	68	ηнетто	»			75,75/75,37			—			81,02/79,22			80,36/80,21	79,0	78,34		79,53	78,94		

IV. Потери конденсата

Показатели	Код строки	Обозначение	Единица измерения	По группе бл. 200: абсолютные величины	По группе бл. 200: %	По группе бл. 300: абсолютные величины	По группе бл. 300: %	По группе: абсолютные величины	По группе: %	По электростанции: абсолютные величины	По электростанции: %
А	Б	В	Г	1	2	3	4	5	6	7	8
Расход питательной воды	69	$G_{пв}$	тыс. т	1514,180	100	1430,502	100		100	2944682	100
Добавок химически очищенной воды и дистиллята	70	$G_{доб}$	»	40,470		61,578				102,048	
Невозврат конденсата от тепловых потребителей	71	$G_{невозв}$	»	0,553		3,579				4,132	
Внутристанционные потери конденсата нормы	72	$G_{пот}$	»	42,548	2,81	37,908	2,65			80,456	2,73
фактически	73	$G_{пот}$	»	31,915	2,07	51,070	3,57			82,485	2,8
перерасход	74		т усл. топл.	- 434		513				59	
в том числе потери с продувкой котлов, нормы	75	$G_{пот\ прод}$	тыс. т	0,7528	0,05	—	—			0,7528	0,025
фактически	76	$G_{пот\ прод}$	»	4,7528	0,05	—	—			0,7528	0,025
Коэффициент теплового потока	77	[illegible]	%		98,66		98,7				98,69

V. Отклонение расхода топлива от расчетного

Показатели	Код строки	Обозначение	Единица измерения	По группе бл. 200	По группе бл. 300	По группе	По электростанции
А	Б	В	Г	1	2	3	4
Расчетный удельный расход топлива на отпущенную электроэнергию	78	$в^{от}_{э(н)}$	г/кВт. ч	406,89	390,96		399,52
Расчетный удельный расход топлива на отпущенную теплоэнергию	79	$в^{от}_{тэ(н)}$	кг/Гкал	180,69	195,35		194,15
Отклонение фактического расхода топлива от расчетного	80	ΔB	т усл. топл.	—	—		—
в том числе: по отпуску электроэнергии	81	$\Delta B^{от}_{тэ}$	г/кВт ч	—	—		—
	82	$\Delta в$	т усл. топл.	—	—		—
по отпуску теплоэнергии	83	$\Delta B^{от}_{тэ}$	кг/Гкал	—	—		—
	84	$\Delta в_{тэ}$	т усл. топл.	—	—		—

15. сентября 1994 г.

Главный инженер

НРД 3642

MEMORANDUM

Burns and Roe Company

To: S.B. Gerges

From: S.N. Corban

Date: 10/26/94

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

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

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

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

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

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

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

Background:

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

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

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

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Power Plant Selections

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

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

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

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

Kearney

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. UGLEGORSK POWER PLANT (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. <u>KRIVOI ROG POWER PLANT (Oct. 5 Thru Oct. 8)</u>

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.

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		

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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.

SELECTION CRITERIA

Improving Combustion Efficiency
Ukrainian Power Plants

September 19, 1994

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

ATTACHMENT #1

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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

TRIP REPORT

1.1 Introduction

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

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

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

1.2 Work Plan

The following work was planned for each plant audit visit:

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

1.3 Trip Report and Findings

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

Feb 8 through Mar 15, 1995 - In Kiev.

The following activities took place during this time:

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

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

Feb 17 through Feb 21, 1995 - In Uglegorsk.

The following activities took place during this time:

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

  A discussion followed. Our hosts made it clear that they are pleased to see us return to provide equipment and services. Apparently, scores of foreign companies visited the plant and promised some assistance which never materialized.

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

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

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

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

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

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

- We also worked on finding the best location for stationary instruments, such as oxygen analyzer and coal flowmeters. Because of the high leakage rates (up to 100% and higher), which make readings of any oxygen analyzer dependant on its distance from the furnace, we recommended the use of high temperature oxygen analyzers for stationary purposes. After a discussion both parties agreed to use high temperature oxygen analyzer for stationary purposes. We also defined the best locations for receiver instruments, process and environmental conditions, and the length of the cable runs. Using the infrared "Heat Spy" we were able to measure ambient temperature around the future high temperature oxygen analyzer. Metal temperature at the mounting location (railing) was 57-60 Degree Centigrade.

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

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

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

Feb 23 through Feb 27, 1995 - In Kourakhovska.

The following activities took place during this time:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

While traveling to Zmiev TES ,we stopped to visit the corporation DonORGRES in the city of Gorlovka, which we had identified as a promising I&C Contractor for commissioning stationary instruments. We met with Dr.Ostrovesky, Chief Engineer of DonORGRES, who incidentally is a member of the American Academy of Sciences (tel.(06242)4-22-23). Dr.Ostrovesky is technically very competent and a tough negotiator After a considerable downsizing he still has 440 people reporting to him.

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

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

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

Feb 23 through Mar 5, 1995 - In Zmiev

The following activities took place during this time:

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

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

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

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

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

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

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of the measurements with very little assistance.

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

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

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

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

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

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

Suns, Mar 5, 1995 -Travel to Kiev.

Mon, Mar 6, 1995 -Kiev Debrief.

- 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

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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

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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.

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

TRIP REPORT

1 0 Introduction

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

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

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

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

2.0 Trip Report and Findings

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

Wed , Aug 6, 1997 -Travel to Zmiev TES

Aug 6 through Aug 7, 1997 -In Zmiev

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

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

Fri Aug 8, 1997 -Travel to Uglegorsk TES

Aug 8 through Aug 11, 1997 -In Uglegorsk TES.

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

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

Aug 11, 1997 -Travel to Kourakhovska TES

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Aug 11 through Aug 12, 1997 -In Kourakhovska

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

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

Tue, Aug 12, 1997 -Travel to Kiev

Tue, Aug 12, 1997 -In Kiev

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

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

3 0 Preliminary Findings

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

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

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

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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

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"УТВЕРЖДАЮ"
Главный инженер Змиевской ТЭС
Чупыра
"__" ______ 1997 г.

п.Комсомольский   Змиевская ТЭС

А К Т

Начальник ПТО Жалов Г.Е., заместитель начальника ЦНиИ Сосков Б.Ф заместитель начальника ЦАТИ Мамницкий В.В., начальник химлаборатории Ильченко Л.Я., представитель фирмы Бернз энд РОУ Джордж Келлер составили настоящий акт об эффективности использования контрольного оборудования, поставленного с 1995 по 1997г. на Змиевскую ТЭС в рамках проекта "Повышение эффективности и надежности энергетических и промышленных предприятий Украины".

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

- анализатор процесса горения ENERAC 2000
- инфракрасный термометр Cyclops 300 AF
- инфракрасный термометр MIK RON M90
- двухканальный портативный ультразвуковой расходомер жидкости Trans Port PT 868-2
- прибор для измерения электрической мощности в цепях переменного тока до 600 вольт
- стационарный анализатор кислорода (кислородомер) ZIRTEK
- лабораторный анализатор содержания серы в топливе Parr 1750 EF.

1. Газоанализатор ENERAC 2000 находится в эксплуатации в цехе наладки и используется для контроля и корректировки процессов горения топлива, для проверки штатных кислородомеров, для определения вредных выбросов с дымовыми газами (контроль соблюдения требований экологической инспекции).

Экономический эффект от использования прибора за счет повышения экономичности и надежности работы основного котельного оборудования, за счет отказа от привлечения специалистов сторонних организаций, за счет исключения штрафов от экологической инспекции за превышение норм выбросов вредных веществ может быть оценен в сумму 5÷6 тысяч долларов США в год.

2. Инфракрасный термометр CYCLOPS 300 AF находится в эксплуатации в цехе наладки и используется для контроля температуры различных поверхностей: температуры поверхности тепловой изоляции трубопроводов пара горячей воды и различных теплообменных аппаратов, поверхностей обмуровки котлов. Особенно незаменим для контроля температуры электротехнического оборудования, находящегося под напряжением, вращающихся частей механизмов.

Экономический эффект от использования прибора CYCLOPS 300 AF за счет сокращения потерь тепла в окружающую среду, предотвращения повреждений электрооборудования можно оценить в 8 тыс. долларов США в год.

3. Инфракрасный термометр MIKRON M90 на Змиевской ТЭС практически не использовался из-за наличия особых условий измерений, заложенных в самом приборе, невозможности измерения температуры газовой среды (температуры факела в топке, дымовых газов в тракте котла).

Измерение температуры расплавленного шлака или твердых тел легче производить с использованием более простых в применении приборов, как оптический пирометр, CYCLOPS 300 AF.

Оценить экономический эффект от использования прибора MIKRON M90 в виду его ограниченного применения не представляется возможным.

4. Стационарный кислородомер ZIRTEK установлен на корпусе 8-А бл.8 и включен в работу 05.07.97г.

Во время работы энергоблока с 05.07.97г. по 02.08.97г. кислородоме работал без замечаний, давал реальные показания содержания кислорода непосредственно на выходе из топки, что очень важно для корректировки и контроля режима горения топлива в котле.

Точность определения коэффициента избытка воздуха за топкой котла повысилась, что по предварительным оценкам приводит к повышению КПД котла на 0,1% и получению экономического эффекта в 12 тыс. долларов США в год.

Более точные результаты экономического эффекта можно получить только после оснащения кислородомерами ZIRTEK обоих корпусов котла энергоблока № 8 и проведения балансовых испытаний.

5. Двухканальный портативный ультразвуковой расходомер жидкости РТ 868-2 в настоящее время находится в стадии освоения.

Первые опыты по измерению расхода жидкости с использованием накладных преобразователей не дали результатов.

По нашему мнению и мнению специалистов фирмы SIEMENS измерение расхода жидкости в трубопроводах, имеющих значительные отложения в виде накипи, ржавчины на внутренней поверхности трубы, не представляется возможным с использованием накладных преобразователей (об этом имеется информация и в Инструкции Пользователя 910-122AI,Диагностика и неисправности,стр.10-11).

В случае оснащения расходомера жидкости РТ 868-2 стационарными преобразователями в количестве 4 штук для измерения и корректировки расхода циркуляционной воды на конденсаторы возможно улучшение вакуума в конденсаторах турбин на 0,05÷0,1% и получение экономического эффекта оценочно в 50 тыс.долларов США в год.

6.Прибор по измерению эл.мощности в цепях переменного тока до 600вольт находится в эксплуатации в электрической лаборатории.Экономический эффект от его использования можно оценить на уровне 800÷1000 долларов США в год.

7. Лабораторный анализатор содержания серы в топливе Parr 1760 EF в настоящее время находится в стадии освоения.

При оснащении (дополнении) этого прибора лабораторным калориметром возможен экономический эффект за счет повышения производительности труда в 1,5÷2 раза.

В настоящее время оценить экономический эффект не представляется возможным.

Подписи:	Начальник ПТО	Г.Е.Малов
	Зам.нач.ЦНиИ	Б.Ф.Сосков
	Зам.начальника ЦАТИ	В.В.Мамницкий
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	Представитель фирмы Бэрнз энд РОУ	Джордж Келлер

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Approved
by Chief Engineer of Zmiyev Heat Power Plant
A G Chupyra
August , 1997

Town of Komsomolskoy

Zmiyev Heat Power Plant

PROTOCOL

Mr G Ye Zhalov - Head of the Production and Technical Department, Mr V F Soskov - Assistant of the Head of the Adjustment and Measurements Workshop, Mr V.V Mamnitskyi - Assistant of the Head of the Automation and Technical Measurements, Mr L Ya. Ilchenko - Head of the Chemical Laboratory, and Mr George Keller - the representative of *Burns & Roe Enterprises Inc* have drawn this statement on the efficiency of using the control and measurement equipment and instruments provided to Zmiyev HPP between 1995 and 1997 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 Zmiyev 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 analyzer (oxygen meter)
- a Parr 1750 EF 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 determine the unfavourable emissions with the stack gases (checking how the requirements of the ecological inspection are observed) The economic effect of using ENERAC 2000 resulting from improvement of the efficiency and reliability of operating the main boiler equipment, from stopping to involve specialists from other organizations, from eliminating the fines set by the ecological inspection for exceeding the standard levels of the unfavourable emissions can be assessed as equal to $5,000 to $6,000 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 the temperatures of the surfaces of the heat insulation of the steam pipelines, hot water pipelines and the temperatures of the surfaces of different heat exchanging devices Especially valuable the instrument is to check the temperature of the electric and mechanical equipment that is under voltage as well as that 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 and from eliminating failures of the electric equipment can be assessed in $8,000 per year

1 MICRON M90 infrared thermometer has not been practically operated at Zmiyev HPP due to specific measurement conditions required by the instrument itself, improbability to measure the

temperature of a gas medium (the temperature of the flame in a furnace, that of the stack gases in the volume of a boiler)

It is easier to measure the temperature of the melted slag or that of the solid bodies by using instruments that are simpler in operation, for example, the optical pyrometer CYCLOPS 300 AF

It does not seem possible to estimate the economic effect due to the short period of its operation

2. ZIRTEK stationary oxygen meter was mounted at 6-A Body of Unit 8 and it was involved into operation on July 6, 1997

While the energy unit was being operated between July 5, 1997 and August 2, 1997 the oxygen meter was functioning with no failures, it gave readings of the real oxygen content directly at the output from the furnace, which is very critical for correcting and checking the process of burning the fuel in the boiler

The precision of determination of the factor of the excessive air content after the furnace has been increased, which, according to the preliminary estimations, brings to gaining the economic effect of $12,000 per year.

More precise results concerning the economic effect can be available only after providing ZIRTEK oxygen meters at both bodies of the boiler at Unit 8 and carrying out the balance tests

5. PT 868-2 two-channel portable ultrasonic liquid flow-rate meter is at the moment under mastering. The first experiments aimed at measuring the flow rate of a liquid with applied transducers were of no use.

The specialists from *Siemens Company* and we do not think that there are possible measurements of the liquid flow rate in the pipelines having significant deposits of sediments in form of scale and rust on the internal surface of the pipe (information relating to that there is also in the manual operation for the user 910-122AI ("Diagnostics and Failures", pp 10-11)

On condition of equipping the PT 868-2 liquid flow meter with stationary transducers (4 units) to measure and correct the flow rate of the circulating water on the condensers, it is possible to improve the vacuum in the turbine condensers by 0.05 to 0 1 per cent and to have the approximately estimated economic effect of $50,000 per year

6 The instrument for measuring the electric power in the alternating current circuits with the voltage up to 600 V is operated in the electric workshop. The economic effect from its using can be assessed on the level of $800 to 1,000 per year.

7. Parr 1750 EP laboratory analyzer of the sulfur content is now under mastering

On condition of equipping this instrument (in addition) with a laboratory calorimeter, there is possible to gain the economic effect due to 1 5 to 2 times improvement of the labour production

It does not seem possible to estimate the economic effect

Signatures

Head of the Production and Technical Department	G Ye Zhalov
Assistant of Head of the Adjustment and Measurements Workshop	B F. Soskov
Assistant of Automation and Technical Measurements Workshop	V V. Mamnitskyi
Representative of *Burns & Roe Enterprises Inc*	George Keller