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BURNS AND ROE ENTERPRISES, INC.

Audit Report
KRIVOI ROG POWER PLANT
UKRAINE

FINAL

August 1997

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

Final Audit Report
Krivoi Rog Power Plant

August 1997

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COMBUSTION EFFICIENCY AUDIT REPORT
UKRAINIAN POWER PLANTS
KRIVOI ROG POWER PLANT

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4. Follow-up Audit Trip Report, July-August 1997

1.0 EXECUTIVE SUMMARY

1.1 Introduction

The audit team of John Hallberg and Prem Gupta spent four days, February 26 through March 1, 1995 at the Krivoi Rog power plant, about 45 Km SE of Krivoi Rog city. They performed the following energy audit as representatives of Burns and Roe Enterprises, Inc of Oradell, New Jersey.

The Krivoi Rog power plant is presently 100% government owned, but is in the process of reorganization for privatization with the governments change to a free market economy. The plant consists of ten supercritical 300 MW units. The plant was commissioned between 1965 and 1973 and was built in three stages.

The coal the station burns is from the Donetsk region types T, TP and TK. Because of the poor quality of coal, the plant has to co-fire expensive imported mazut and natural gas to support combustion and to reach rated boiler performance. Typically the station fires 80% coal, 10% natural gas, and 10% mazut.

Operational life of a unit is considered to be 200,000 hours. The first unit has been in operation for about 30 years and has undergone extensive renovation at about 200,000 hours for an estimated life extension of 25 years. Units 2 and 3 have operated 23 years and 25 years, Unit 6 for 22 years and the other units less time. Unit 5 was reconstructed about 5 years ago. Unit 6 is presently being rehabilitated to replace boiler pressure parts, overhaul turbine/generator and other equipment and upgrade instrumentation. There are plans to rebuild other units.

1.2 Principal Findings

Several Energy Conservation Opportunities (ECO's) for the power plant were identified for short term low cost measures and for longer term higher cost measures for large energy savings The low cost measures include instrumentation for measuring fuel consumption and heating values and for controlling combustion efficiency which would result in simple short payback periods. Larger cost long term measures include major combustion control system upgrades, including interlocks and flame safeguard systems, coal, ash and laboratory instruments, and would result in payback periods of about one to three years.

Rehabilitation and reconstruction studies have been completed on this power plant to evaluate the options: (1) life extension of existing units, (2) complete replacement with new power plant, or (3) a mix of life extension presently being done with addition of new units The objectives are to be able to cleanly burn the existing poor quality coals, remove SO_2 and minimize NO_x formation and increase boiler efficiency and reliability. One proposed option is reconstruction with atmospheric circulating fluidized bed (ACFB) boilers.

1.3 Recommendations

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

An investment of $166,000 in boiler efficiency improvements (ECO-04, 05, 06, 07, 08) will result in an annual savings of $1,006,000, which corresponds to 16,570 tonnes of coal, 2,798,690 Nm^3 of natural gas and 919 tonnes of mazut. An additional investment of $25,000 in energy conservation programs (ECO-01, 02, 03) may result in an annual savings up to $144,700 which corresponds to 23,833 tonnes of coal, 4,025,554 Nm^3 of natural gas and 1322 tonnes of mazut.

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

Summary of Energy Conservation Opportunities (ECOs)

ECO#	Description	Annual Savings in US$ (1995 Prices)	Project Cost in US$ (1995 Prices)	Simple Payback
				Current Energy Prices
01*	Energy Conservation Management Program	$1,200,000	$25,000 Note 1	< 1 year
02*	Energy Conservation Training Program	$247,000	Note 1	< 1 year
03*	Fuel Quality Improvement Program	See ECO-05	Note 1	< 1 year
04*	In-Situ Oxygen Analyzer One Unit - 4 Probes	$204,000	$40,000	2.4 Mo
05*	Laboratory calorimeter with Proximate Analyzer, Sulfur Analyzer and accessories	$212,000	$35,000	2.0 Mo.
06	Mazut Sonic Flow Meters (4 Req'd)	Included with ECO-04	$16,000	Included with ECO-04
07	On-Line gas calorimeter	$590,000	$35,000	0.7 Mo.
08	Coal Flow Meters	Included with ECO-04	$40,000	Included with ECO-04

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

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 supports 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 lack of hard currency exchange 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 to district heating and steam for industrial use. Decreasing coal supplies and declining quality of coal supplies is affecting the ability of Ukraine to meet its needs for electricity. Also, electricity and district heating supplies are threatened because Ukraine is unable to pay for imported coal, oil and gas at prices approaching world fuel prices

2.1 Objectives of Energy Saving Program

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

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

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

2.2 Purpose of the Audit

The purpose of the audit was to:

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

- Identify short-term no-cost/low-cost efficiency measures with savings potential and paybacks.

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

3.0 DESCRIPTION OF POWER PLANT

3.1 General Description

The Krivoi Rog Steam Power Station consists of ten supercritical 300 MW units firing coal. The station was commissioned between 1965 and 1973. The station was constructed in three stages. The first stage (units 1-4) consists of boilers from Podolsk and turbines from Kharkov, the second stage (units 5-8) consists of boilers from Taganrog and turbines from Kharkov, and the third stage (units 9-10) consists of boilers from Taganrog and turbines from Kharkov.

ENERGO SYSTEM:	DNIPROENERGO
LOCATION:	45 Km SOUTHEAST OF KRIVOI ROG
INSTALLED CAPACITY:	3000 MW
	10 x 300 MW
COMMISSIONED:	1965-1973
FUEL:	Coal low-bituminous supplemented by mazut and gas

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

3.2 Boiler Plant

The Podolsk boilers are type P-50 of Russian manufacture from the Podolsk Machine Building Plant. The layout is of two identical boiler blocks coupled together to supply the required steam rate of 950 tons per hour. Each boiler is supercritical and capable of supplying steam at a rate of 475 tons per hour at a pressure of 255 bar gauge and live steam temperature of 545°C Reheat steam is also produced at a temperature of 545°C. The boiler operates in a balanced

draft mode. Coal is supplied to the boiler unit and held in raw coal bunkers prior to being fed to the ball mills. The motive air for transfer of the pulverized fuel is directed from the outlet of the air heaters and is used to dry the pulverized fuel in addition to transporting it to pulverized fuel storage bunkers. The contained air is returned back to the primary air system via centrifuge separators through which all the pulverized fuel is passed prior to storage in the pulverized fuel storage bunkers. The pulverized fuel storage bunkers supply pulverized fuel flow to the burners via individual bunker outlets feeding to rotary feeders which control the flow to the burners. The fuel flow is controlled manually from the Unit Control room. The Taganrog boilers are type TPP-210A of Russian manufacture from the Taganrog Boiler Works. The characteristics of the Taganrog boilers are similar to those discussed previously for the Podolsk boilers.

3.3 Coal Handling

Coal is supplied to the station from more than 30 suppliers. The coal can go either of two ways. from railroad direct to the coal storage or from railroad direct to station's two conveyors (one plus one reserve). There is a special scale in the railroad track to weigh as-received coal to $\pm .5\%$ accuracy. Coal in storage is not blended. Usually as-delivered coal bypasses storage and goes directly from coal train to raw coal bunkers. Mechanical coal samples are taken from the two conveyors and collected every 5 minutes and mixed for 24 hours and analyzed Coal is then collected for 5 days, mixed and a more detailed analysis completed.

3.4 Mazut Supply

Mazut is sampled from one railroad tanker car at delivery and from the pipelines feeding boilers The amount of mazut fired for the total power station is determined by measuring the level of the mazut storage tanks once per shift.

3.5 Gas Supply

The power station units are supplemented by natural gas when it can be purchased Natural gas flow meters already exist per boiler and work well.

3.6 Boiler Efficiency Calculations

The methodology for the boiler efficiency calculation is similar to Zmiev, Uglegorsk, Khourakhuvska, Burshtyn and other power plants in Ukrainian Power System. The calculations are done on a per unit 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 5 day basis. These efficiencies are compared to the efficiencies calculated based upon the boiler design performance as discussed in item 10 of the Preliminary Audit Report Reference 2 in Appendix G.

3.7 Process Control System

Boilers of the Krivoi Rog 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 leach load). There are four O_2 analyzers per unit which are used to

monitor furnace O_2. These analyzers are used by operators to remotely adjust speed of coal feeders and 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.

3.8 Environmental Issues

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

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 are a concern for the atmospheric pollution.

The station has no NO_x or SO_2 pollution control system.

3.9 Future Plans

The first unit has been in operation for approximately 30 years and has undergone considerable renovation. Starting in 1987 the cylinders of the high and medium pressure sections of the turbines in units 1 to 5 have been replaced. Some steam pipelines interconnecting the boiler and turbine have been replaced. Various heating surfaces have been replaced in the boilers. Some parts of the control system have been replaced. It is considered that these measures would prolong a unit's life another 25 years. There are plans to do the same kind of work on the other units. However, the financial condition of the Ukraine is an obstacle to completing these plans, and schedules are being delayed.

Operational life of a unit is considered to be 200,000 hours of operation. The units of stages 2 and 3 have an operational life of 5 to 7 years. Unit 6 has operated 180,000 hours with the rest of units less. Units are operated on the order of 6,000 to 8,000 hours per year.

A reconstruction study is being completed by a special agency and consists of three options·

a. Reconstruction of equipment within existing structures.

b. Construct similar power plant nearby.

c. Reconstruction of four units in existing structures and construction of six new units nearby.

The objectives are to use presently available coal, increase reliability of the boilers, remove SO_2, NO_x, and gas emissions cleanup. The station would prefer the third option. There is much interest in application of Atmospheric Circulating Fluidized Boiler (ACFB) technology to achieve these goals. The financial condition of Ukraine is an obstacle to implementing the program The station is now replacing the existing equipment step by step.

The emissions from 300 MW units are now on the agenda in Ukraine. The station is interested in improving combustion efficiency to reduce emissions.

3.10 Inspection, Assessment, Comments

- The station is well managed by experienced personnel The engineering staff is competent. There is a need for proper analytical equipment to perform to higher standards in a short time.

- The power station typically operates with 5-6 units at base load, 2-3 units in reserve and 1 unit undergoing overhaul.

- The plant design is a base load plant. The plant capacity may go down to 30% when operating, but a unit capacity cannot go less than 210 MW; operating range of a unit is 210 to 290 MW.

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

- The station expressed concern about adequate spare parts available for the equipment provided to improve combustion efficiency.

- The total station operating and maintenance personnel is 2,500 plus 1,000 for social programs. In addition, there are 500 contracted maintenance personnel. There are workshops for repairing turbine and boiler components and a special workshop for automation.

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

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

- 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 Each burner has a 5 ton/hr capacity for coal dust Each coal dust feeder (16 total per boiler) can revolve from 500-1500 rev/min. Speed of rotation of each coal dust feeder is based upon main steam pressure and temperature at the boiler outlet.

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, including:

- 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, technical energy monitoring equipment was purchased in the United States, shipped to Kiev and delivered to the power plant. The equipment was purchased to monitor and 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 boiler efficiency and potential energy improvements that could be gained by installing energy efficiency equipment. Economic paybacks were calculated and the priority of items established according to the shortest payback. Based on estimated cost of equipment and money available, recommendations were then made as to whether to implement the items studied.

The main components of the equipment are:

- Enerac combustion analyzer
- Portable computer and printer
- Fluke power analyzer
- "Heat Spy" Infrared temperature detector/indicator

Of this equipment, the most significant was the Enerac Combustion Analyzer which showed a potential immediate fuel savings by tuning the boilers to reduce excess combustion air and increase boiler efficiency.

The majority of the equipment was used extensively by the audit team and as a training tool for the plant personnel. Typically, the audit team would separate during the day, with each member responsible for data collection, etc. Each member would usually be accompanied by three to six specialists, for the purpose of observing and answering questions, etc.

4.1.2 General

The Krivoi Rog power plant was selected by USAID/KIEV in consultation with the Ministry of Energy and Electrification. The Ministry also identified the management of the facility as receptive to this type of program and felt that the maximum benefit could be gained by working at Krivoi Rog.

4.1.3 Boiler Efficiency

The specific plant audit consisted primarily of on-line flue gas emission measurements using Enerac 2000 portable combustion analyzer, laptop computer and printer. Measurements were made on Boiler #5 burning coal and natural gas.

The Enerac 2000 portable combustion analyzer is an 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 through the center thermocouple insertion point ahead of each regenerative air heater. 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. The efficiency calculated is actually overall boiler efficiency as shown on the printout. Direct measurements of O_2, CO, combustible gases, NO_x and SO_2 appeared to be accurate. Any improvement in the efficiency of the Krivoi Rog power plant must come primarily from an improvement in overall efficiency of its boilers. On the steam side the Krivoi Rog power plant is efficient due to a significant thermal load. A copy of the Enerac 2000 portable analzyer print-outs can be seen in Appendix B.

For a detailed description of the Audit activities see the trip report in Appendix G

Burns and Roe engineers estimated an incremental improvement in boiler efficiency achievable due to a reduction in excess air fed to the boilers. Using a portable combustion analyzer, 5-7% excess furnace oxygen was measured at full load while firing coal and natural gas. CO emissions were negligible in all tests. Based on calculations, the excess furnace oxygen at full load while firing coal can be reduced by 1.2%, resulting in an incremental improvement in boiler efficiency of at least 0.33%.

In future the Krivoi Rog 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, it is recommended 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

Boiler No. 5 was tested by the boiler department specialist using the Enerac 2000 portable combustion analyzer. Unit 5 was reconstructed about five years ago. Unit 6 is presently disassembled and undergoing reconstruction after five years of operation There is a lot of

fireside deposits on furnace wall tubes and convection back pass tubes which results in loss of boiler efficiency. There is a concern about ash slagging on the superheaters and reheaters from the different coals they receive, and the plant staff would like to get a laboratory instrument for determining ash fusion temperature to determine slagging characteristics and thus have better control over the fuel mix and boiler operation.

4.1.5 Boiler Controls

The boilers have no burner management system and all interlocks are of a very basic design offering limited protection. Most control functions are single loop manual control from the control board located in the control room. On the older units, the controls and instruments are obsolete, readings are unstable and require ongoing maintenance to keep operational Spare parts are difficult to obtain.

Unit 5 control room instruments were all replaced in 1990 during life extension reconstruction. Unit 6 control boards were stripped of original instruments and technicians were in the process of replacement.

4.1.6 Boiler Back End Including Stack

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

4.2 General Audit Activities

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

4.2.1 Scope and Methodology

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

4.2.2 Power Plant Audits

The audit activities associated with the total power plant consisted primarily of a review of the various available publications and brochures produced by the various agencies and by the Ministry of Power and Electrification as well as from drawings and diagrams provided by the engineers at the power plant. Much information and insight was also gained through the interviews related to the system specific audits at all levels. Many of the personnel employed

in the power plant have had experience in areas other than the one in which they currently work, and this was useful as background material.

The Cyclop infrared thermometer (heat spy) was used to find hot spots on generator buses and switchgear contacts, etc. which may need maintenance.

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

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

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

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

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

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

In 1994 the Krivoi Rog power plant consumed the following quantities of fuel:

		1994 Prices		1995 World Prices
Coal 4,062,902 tonnes	($11.09/tonne)	$40,993,064	($45/tonne)	$182,830,590
Gas 686,447,000 Nm^3	($15.88/1000 Nm^3)	$10,901,642	($50/1000 Nm^3)	$34,322,350
Mazut 225,517 tonnes	($35.87/tonne)	$ 8,088,935	($131/tonne)	$29,542,727
		$59,983,641		$246,695,670

If only a modest savings of about 0.5 percent of this fuel expenditure is saved in the first year, $1,200,000 of expenditures can be justified for measures to improve fuel utilization and efficiency, improve reliability and reduce maintenance.

Some funds should be provided for consulting services to assist the Krivoi Rog management with training and materials to establish this program 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. 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 can be saved in the first year, $247,000 can be provided for training material

ECO-03 FUEL QUALITY IMPROVEMENT PROGRAM

The plant must aggressively survey 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 an moisture characteristics, significant savings of fuel and maintenance costs will be realized.

ECO-04 IN-SITU O_2 ANALYZERS

The boiler efficiency improvements can be addressed 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 are that they are extractive rather than in-place. It is difficult to obtain a representative sample by using extractive type analyzer. Also, the instrument can become fouled with acid sludge formed from moisture condensation and soot. United States practice typically places an oxygen sensing probe into the flue gas duct. This technology could be applied to the boilers at Krivoi Rog.

It is recommended to install in-situ zirconium oxide oxygen probes on at least one unit, two furnaces, two per furnace, four required For detailed calculation of payback savings, see Appendix A-1.

ECO-05 LABORATORY CALORIMETER WITH PROXIMATE ANALYZER, SULFUR ANALYZER AND ACCESSORIES

The existing sampling and analysis system and procedure is typical of other coal fired plants. There are four main 48" reclaim belts feeding to boiler house. A continuous auger sampler takes a coal sample from each operating belt to a 1 m^3 sample bunker. Every 24 hours a sample composite is taken to the laboratory for testing for ash and moisture, and every five days the heat content in Kcal/Kg is tested. They have the capability to measure sulfur by the titrametric method on the calorimeter ash residue.

They also sample every third car at the car dumper to test ash and moisture content of coal deliveries from the mines. It takes 24 hours to run all of these samples and the laboratory is a continuous operation. They need a new, modern calorimeter which will speed up the analyses of coal and mazut for heat content, providing automatic control of operation and computer interface for data storage, with better accuracy than the old manual operated calorimeters. These modern calorimeters can run a sample in 10 to 20 minutes and would free up at least one laboratory specialist to work on other tasks.

They could see the advantages of having nuclear dual gamma ash gage on the coal conveyors going to the boilers. This instrument could give real time readouts of percentage ash and moisture, which would allow the operators to choose the mode of operation of boilers to adjust for changes in moisture, ash content and volatiles. Considering the cost, it is recommended to furnish fuel laboratory instruments to determine proximate analyses (fixed carbon, volatiles, ash, moisture, sulfur), heating value and ash fusion temperature. If they can register these instruments with the National Standardization committee, they will be able to improve testing of coal deliveries to substantiate claims to suppliers for deficiencies in quality.

Fines for emissions are based on the delivery analyses of sulfur in coal and mazut and then calculating SO_2 and SO_3 concentrations in mass flow of flue gas based on boiler loads. The fines for thermal power plants are only ten percent of the fines levied on industrial emitters. The calculated results are only educated estimates at best based on the accuracy of sulfur contents variations over time and estimates of the tons of coal burned. More accurate and frequent analyses would help to improve the data requried for calculating emissions from the boilers used in determining fines.

These instruments would result in improved control of fuel procurement, coal yard management for blending and quality control and more consistent ash and moisture contents going to the boilers. The savings are difficult to estimate, but would be realized in improvements to boiler efficiency, reduced emissions and more stable boiler operation which will reduce maintenance and extend boiler life.

If only one tenth of one percent of the annual fuel (coal and mazut) budget can be saved (i.e. $212,000) the payback will be two months based on 1995 world fuel cost.

ECO-06 MAZUT SONIC FLOW METERS

The audit team learned through interviews with station personnel that one area which has hampered the stations 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 improvement. This is because the existing fuel flow instruments in place at the station are inaccurate or don't work. 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 for itself in a very short period.

Line sizes and design information were obtained for specifying sonic flow meters for two supply and two return mazut lines serving the boilers.

ECO-07 ON-LINE NATURAL GAS CALORIMETER

The most important concern and priority at Krivoi Rog was the urgent need for analytical instruments for monitoring fuel quality (coal, mazut, gas). The data indicates that the plants are paying large sums of money for fuel energy content (heating value) which they do not receive. Instruments for measuring the fuel heat value in Kcal/Kg and other parameters would provide the documentation necessary for making claims against suppliers.

They urgently need an on-line gas calorimeter to verify the heat content supplied by Gasprom. Their laboratory calorimeter is not commercial (certified), the tests are not continuous so they cannot make a claim for credits. The plant claims losses of about 71 x 10^9 Kcal (2.8 x 10^{11} BTU's) which results in $590,000 loss per year. Although this loss of expensive gas fuel heating value has nothing directly to do with "combustion" efficiency, this is also a priority in reducing the large sums of hard currency they must pay for fuel gas. For detailed calculation of payback savings, see Appendix A-1.

ECO-08 COAL FLOW 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. Instruments to measure raw

coal consumption to 300 MW Unit #6 on belt conveyors, located between raw coal bunkers and mills (coal feeder) are recommended

For detailed calculations see Appendix A-1

5.2 Medium and Long Term Opportunities

COMBUSTION IMPROVEMENT PROGRAM

This is a longer range energy conservation program requiring larger investments of capital which will accomplish larger fuel savings, improvements in efficiency and reliability and life extension of the boilers. It is beyond the scope of this audit to provide details other than enumerate measures which could reduce mazut and gas co-firing by as much as 10-30% and possibly achieve some reduction of NO_x, reduce SO_2 and particulate:

- Improve burner design and combustion air flow configuration and temperature profiles.
- Improve pulverized coal flow to minimize pulsation and excess oxygen variations.
- Repair boiler air leaks.
- Develop new procedures for startup and shutdown cycling based on results of metallurgical testing for creep and fatigue life
- Continue rehabilitation upgrading of precipitators (electrofilters).
- Consider lime or limestone injection technology for reduction of SO_2, consistent with fuel quality improvement program.
- Upgrade instrumentation for load control, fuel control, combustion air and boiler pressure control.
- Repair and/or replace (asbestos) insulation on boilers.

There are other studies which have been done or are being done, and it is recommended that the results and recommendations be coordinated to prevent overlap or conflicting tasks.

MEASURES FOR IMPROVEMENT OF RELIABILITY

The chief engineer asked about analytical instrumentation for performing waveform analysis to determine vibration harmonics in balancing turbine generators. They do not have the technology to balance rotors adequately after overhaul and repairs, and have sustained large economic losses to maintenance and operation from damage to bearings and blading. Turbine reliability will be improved with portable Fast Fourier Transform (FFT) waveform harmonic analyzer and orbit vector plotter with associated computer interface equipment, transducers, fittings, cables, etc This equipment cannot improve combustion efficiency, however, unit efficiency would be zero if the turbine is out of service because of vibration. Approximately $30,000 would provide a

complete set of equipment and accessories which could be used at several power plants within an Energo system. Payback for one 300 MW turbine-generator balancing based on lost production at $0.03 per Kwh would be about 3.5 hours

They also want to learn about U.S. technology for identifying hidden cracks in weld joints in complex shapes and sections in supercritical steam service. They have dye penetrant, eddy current magnetic particle, ultrasonic and X-ray NDT, but their X-ray equipment does not have the needed energy level film resolution. This could be a repeat of the information technology transfer provided to Kyrghystan in February, 1995 as well as information on the Integrated Diagnostic Measurement Corp. (IDM) subsidiary of Arkwright Mutual Insurance co., new Integrated Real-Time Inspection System (IRIS) using the new three dimensional Computed Tomography (CT).

Additional equipment items which were requested by the chief engineer and his specialists which are ungently needed for maintaining reliability of the boilers and power plant are listed below:

	DESCRIPTION	COST
1.	Infrared Temperature "Heat Spy" used for locating sources of heat loss. also useful for locating "hot spots" which could lead to equipment failure, such as bearings,motor and generator windings, switchgear contacts, iso-phase bus bar bolting, etc.	$4,000
2.	Silica Analyzer necessary for measuring demineralizer performance and quality of water being fed to boilers. Silica in steam going to turbines will cause serious damage to blades.	$9,000
3.	Oil Analyzer (laboratory) used for detecting organics breakthrough from makeup water treatment carbon filters before demineralizers. Hydrocarbon contamination of demineralizer resins can cause irreparable damage and reduction of capacity required for boiler feedwater makeup.	$8,000
4.	Dissolved Oxygen Probes (feedwater) a specific ion oxygen probe analyzer is needed for continuous monitoring for control of dissolved oxygen in feedwater to each boiler between 50-250 ppb. ($2,200 each x 10)	$22,000
5.	Oxygen Analyzer (laboratory) as a lower cost alternate to online monitoring, a modern portable oxygen analyzer can be used manually to obtain faster and more accurate readings than present.	$2,500

Note: $1995 US equipment/instrument prices

5.3 Replicating and Expanding the Program to Other Power Plants

An economic benefit can be derived from extending 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 typical 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 (up to 100%) 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. What is calculated by the Enerac is boiler efficiency.

- 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 us to believe that combustion efficiency of the Ukrainian Power Plants can be improved. In our estimation, the improvement will be on the order of 0.5% to 1%.

The conclusions are as follows:

- Excess air can be reduced until a maximum of 300-400 ppm of carbon monoxide is generated which is indicative of efficient coal combustion.

- Considerable economic benefit can be realized by reducing the excess oxygen by 1-1.25% and achieve 0.5% improvement in combustion efficiency even with existing manual control of the combustion process. It is important that constant operator attention is maintained. Such attention can be obtained by way of operator incentives based on the fuel savings. Another alternative would be to invest in expensive automatic control for the excess air system.

- Savings can be achieved more easily with carbon monoxide measurements of the undiluted flue gas at different boiler loads.

- Improvements in boiler efficiencies and reductions in fuel consumption can be further demonstrated by replicating and expanding the portable combustion analyzer program to other Ukrainian power plants.

6.0 IMPLEMENTATION PHASE (Follow-up Visit)

Burns and Roe engineers conducted follow-up visits and training during July 22 - August 16 in Ukraine in accordance with the Delivery Order objectives The following report describes the activities of John E Hallberg, P E and Alexander Filippov who visited Krivoi Rog TPP

6.1 Introduction

WORK PLAN

For the power plant

1 Review the steps taken by the plant for implementation of recommendations and assist in completion
2 Provide additional training and assistance on installation and use of the equipment
3 Refine and finalize the audit report and the recommendations for short and long term actions based on follow-up discussions with power plant personnel and minor additional audit work, if necessary
4 Measure actual energy savings based on audit recommendations and equipment installation, if measurements are not possible, estimate and provide the rationale of the method that is used for estimation

PERSONS MET DURING MEETINGS

Vladimir F Soroka - Chief Engineer (new)
Peter Solovey - Chief of Maintenance Department
Rjabokon Nikolay - Deputy Chief of Automation
Vladimir Pachura - SeniorMaster, Head of Automation Department
Anatolij Propopenko - Electrical Specialist
Vasily Bokiy - Infrared Thermometer
Andrey Kolobayev - Fluke power analyzer, Ultrasonic flow meter

INSTRUMENTS SUPPLIED TO KRIVOI ROG TPP (April - May, 1997)

Zirtek oxygen analyzers, 4 probes for 2 boilers, 2-two channel analyzers
Panametrics two channel ultrasonic flow meter
Instromet natural gas chromatograph, display unit and accessories
Oxygen cell and consumables for Enerac

During February - March of 1995, the plant was provided with an Enerac combustion analyzer, a laptop computer and printer, an infrared thermometer and a Fluke power analyzer

6.2 Results and Benefits

Enerac Combustion Analyzer

They find the Enerac combustion analyzer to be very good compared to other instruments However, they do not see any advantages to use it effectively in this plant on the supercritical boilers, as there are no appropriate measuring ports They claim that the instrument is expensive to maintain, requiring calibration every three months, with a calibration gas kit which they do not have Also, the oxygen sensor must be replaced every year They recently received a new sensor, but haven't installed it yet because they cannot calibrate it (A supplemental calibration gas kit has since been ordered and sent to the plant)

Infrared Thermometer

The infrared thermometer is used a lot in the Electrical Department for checking contacts Mechanical technicians use it on generator and turbine where they cannot measure direct It is used for routine maintenance measuring hot spots on bus connections, at distribution substation, on motors, bearings, transformer bushings, insulators, etc They now use the infrared thermometer in place of manual hand test for rotor and stator "hot spots" They also use it on heat exchangers to find scale and sludge build-up in heat exchangers

Sometimes the technical people will not believe the instruments, but will trust their experience or hand or senses An example is for coal mill bearings where many have been destroyed, but the infrared thermometer can find hot spots quickly and save a lot of money It would be very useful for operations to have this instrument, everybody who needs it, instead of one man It would be best for each control room to have one

Fluke Power Harmonics Analyzer

We did not get information on results from using the Fluke power analyzer as the specialist was said to be on vacation However, we know from previous audit that the electrical department uses it extensively for testing and analyzing power circuit phase load balance, phase angle and motor losses, etc

Panametrics Ultrasonic Flow Meter

They started using the Panametrics ultrasonic flow meter to measure cooling water flow to condensers Next they plan to measure boiler feedwater and district heating water flow rates They recognize many opportunities for using this instrument to save energy The most important use is for balancing the district heating demand load

A practical example we observed was to measure the flow rates of 25 cu m/sec through

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a filter with new media installed The chemists said flow rate would decrease due to increased pressure drop, but there was no way to check it In a matter of a few minutes, the specialist confirmed the flow rate with the ultrasonic flow meter

Another example is where they plan to check mazut flow to quantify measurement differences and losses One morning they could not account for 80 tonnes of mazut burned in three boilers, how much per boiler and why Was it easier to burn the mazut than poor coal in one of the boilers, or was the coal unusually bad that night?

They requested technical literature on doppler ultrasonic flow meters for use in open channel flow measurements in cooling water flumes

Boiler Oxygen Analyzer

They installed oxygen analyzer probes on base loaded Unit 1 dual boilers, two probes per boiler with signals to two dual channel analyzers installed in control room behind main panel Jerry Harger from Zirtek commissioned the instruments in June and trained the personnel.

During startup, one electronic board failed and Zirtek replaced it Out of 8 probes, (4 spare), four were damaged, the ceramic broken One analog output for plotter failed after Zirtek left The analog outputs are connected to their strip recorders They plan to move the analyzers (display) to the front panel as operators become confident in readings The oxygen readings were averaging about 4%, temperature about 700°C Air heater temperature is about 500°C +

Reference air for the probes is temporarily supplied from compressed air cylinders, good for one week The only compressed air available is plant air which is wet and dirty with oil They plan to install a coalescer and filters

Positive advantage of the zirconium oxide probes is that they are "ten times less maintenance" and very stable Two maintenance technicians work full time on the Soviet made paramagnetic oxygen analyzers to repair and adjust them Every morning they have to blow down, clean and adjust them on all the boilers, and whenever operators call them to check on erratic readings

Instromet Encal Gas Chromatograph

The Instromet Encal Gas Chromatograph was received in May and they had not yet installed it We looked at the instrument in the shop and answered questions about connections They have been studying the Russian language manuals

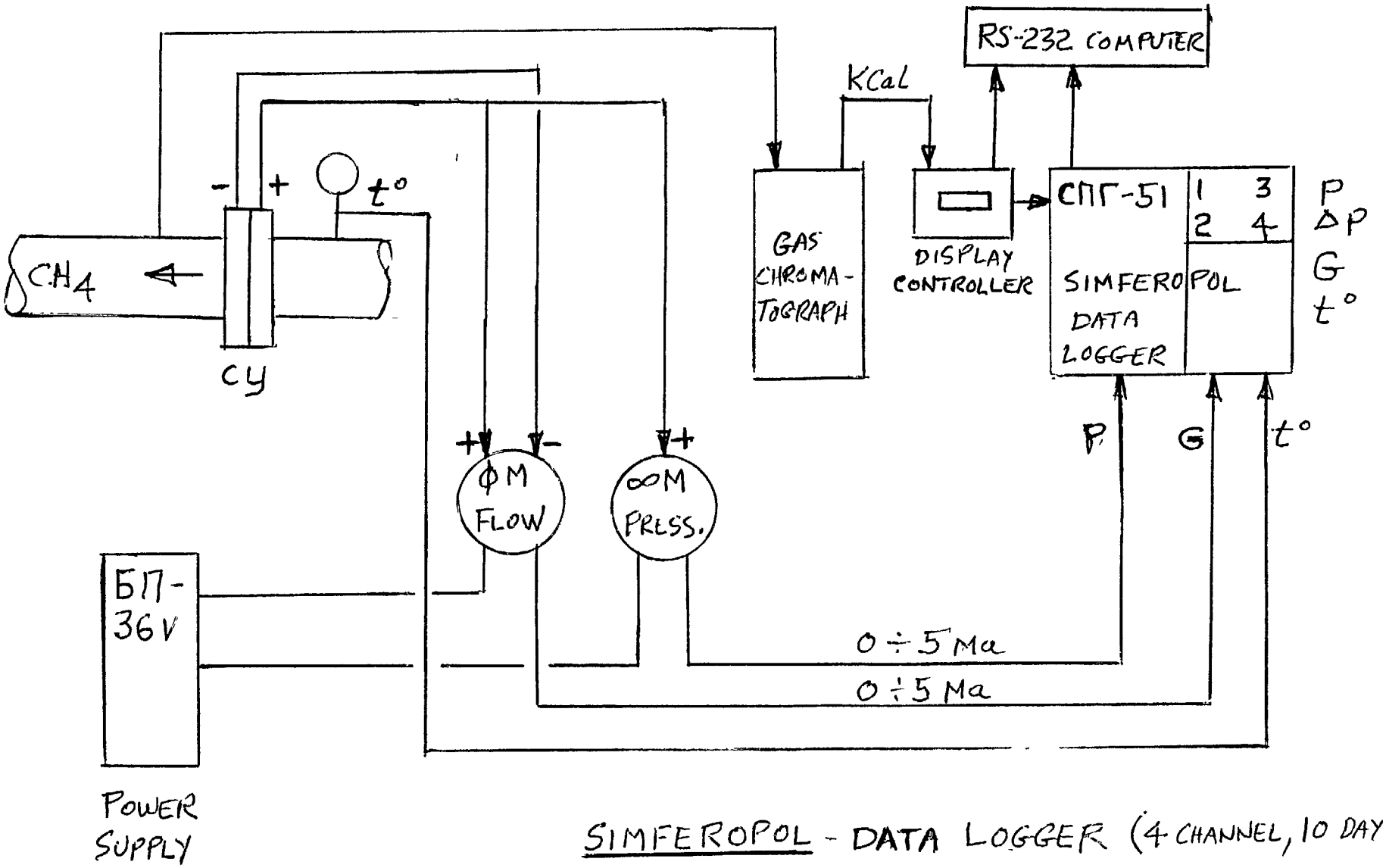
We went to the natural gas metering substation to look at where they planned to install the

chromatograph They believe the control house is too small and want to build a new 3m x 3m brick building, but have no money They are concerned about regulations, safety and maintenance They will take the sample line off of main before orifice run They are planning to install display control unit in laboratory After much discussion, they think they can clean up the control house and install GC in there by August 8

6.3 Conclusions

The employees haven't been paid until today, 25 August, 30% of their December 1996 salary The plant could not even find enough money to buy milk for the kindergarten children They need money to buy freon for the turbine building overhead crane cab air conditioner, where temperature reaches 120°F

It is hard to get people motivated, even though they are highly skilled and experienced The plant still generates power when they can get enough fuel, and do not get paid for the power It is a catch-22 situation where they know they need modern instruments to measure and analyze fuels to save large sums of money and energy, but no money to even buy spare parts and supplies.



SIMFEROPOL - DATA LOGGER (4 CHANNEL, 10 DAY MEMORY)
ODESSA - PENTIUM COMPUTER

PANAMETRICS ULTRASONIC
TRANSIT TIME FLOW METER

KRIVOI ROG

Location: Krivoy Rog Power Plant
Date: June 24, 1997

Re) Trip Status

We arrived at the plant hotel on the evening of 6/23. Plant Director escorted us to the hotel.

Work began with a meeting at the plant at 9:00 AM on the morning of the 24th. Initial meeting was with the Chief engineer. We adjourned and began discussions with key supervision. Primary interest was how to proceed with work and several questions about the analyzer operating principles. One specific concern was about the 6-12 inch extension of the probe tip into the gas stream.

I suggested that we go look at the equipment installation. The electronic panels were installed in the instrument cabinets located behind the operators control panels. Each panel has been installed behind a lockable, clear door. The workmanship was very good on the installation of probes, wiring, electronics and reference air cabinet. The reference air is supplied from compressed air cylinders

The 2 systems (4 analyzers) are installed on power unit #1, boilers A & B The probes are in the inside wall of the flue gas downcomer above the air preheater. Each boiler has two probes spaced at approximately the 1/4 points (horizontally). The reference air cabinets are at about the same elevation over at the side of the boiler. The 42 inch probes have a long pipe nozzle stand-off welded to the pipe mounting supplied by Zirtek. It is unfortunate that some mis-understanding occurred over the generally suggested 6 - 12 inch entry into the gas stream. The plant understood this to be an actual limit. Therefore the stand-off nozzle was installed and creates no particular mechanical problem. However, the probe could be extending an additional 18-24 inches into the gas stream if mounted as expected Hopefully the measurement cell at the probe tip is not "seeing" any non-combustion air (in-leakage) that maybe in a boundary layer along the wall. The plant personnel were very careful to follow the instructions as they understood them and should be commended for the engineering adaptation.

The system for boiler A was not completely installed. The boiler B system was completely installed and ready for comississioning. The reference air panel was started at the proper flows and the power switch was engaged at the electronics' panels. Both analyzers began operating correctly immediately. This activity included considerable training through question and answers as well as hands on operation. We broke for lunch.

After lunch several questions were addressed and then word came that analyzer #1 on boiler B had faulted The display had gone blank. To troubleshoot the fault, we switched the electronics for analyzer #1 between boiler A & B Analyzer #1 on boiler B began operating properly. The 4 - 20 mA analog outputs were scaled 0 - 20% O2 when shipped. The plant wanted them scaled 0 - 10%. This was done. (See Note on Zmiev - they may still need the 0 - 5 mA setup) I took the faulted electronics to the hotel for further investigation.

The plant asked if I would look at the EnCal 2000 chromatograph. They did not understand (and did not find documentation on) how to install the loose regulators, sample probe, filter, etc. The discussion went very well and they seemed gain a proper understanding of how the parts were related. We ended the day.

We met on 6/25 at 9:00 AM. The day began with an inspection of the spare probes. All four spare probes had vibrated (or bounced) hard enough in shipment to crush the "boot" that surrounds the cell at the probe tip On two of the probes, the outer cell leads had severed near the cell connection. They can not be used until they are repaired. The location of the damage will require repair at the Zirtek plant. The remaining two spares appear to be functional The "boot" is not required for normal operation. Limited electrical checks can be (and were) made on the two "good" spares. A full evaluation requires that the probe be heated to at least 650 Deg. C.

The plant attempted to start up the good analyzer on boiler A from what they had learned. It was not successful but provided an excellent training opportunity. We installed a spare electronics set to replace the unit "borrowed" from boiler A the day before They were able to correct their mistakes made during the attempted startup with my assistance. Both analyzers on boiler A became operational with out further difficulty. At this point all four analyzers were online. The plant seemed quite pleased.

Typical readings observed on the oxygen analyzer display were:

A	100	5.75	666	Analyzer #1
		5.60	661	" #2
B	80	4.70	648	" #1
		4.50	645	" #2

[illegible] were not able to get started up. We reviewed the unit in the office The portable meter was passing all basic self tests. However, they could not get beyond an error indication that there was low signal strength from the transducers. We discussed their attempts in some detail. I'm satisfied that the plant personnel had made every reasonable attempt at a proper installation on the actual water line. They had all the right entries for pipe material, pipe size, pipe contents, etc. They had followed all the manual's trouble shooting tips for low signal strength including repositioning the transducers and trying the spare transducers. There were two parameters out of the accepted range that can be checked off-line as well as on-line. This was demonstrated in my presence. There was no obvious remedy in the manual. Perhaps this is part of the problem. The only help I may have been was to verify that they had used a correct and logical approach to solving the problem They had contacted Alexander Filippov for help. I agreed that this seemed appropriate.

The installation and training was finished in the early afternoon. We will travel to Simferopol on the 26th.

Personnel Contacts

Mr. Chebotar'	Plant Director
Mr. Soroka	Head of Automatic measurement (Yegor Nikolayevich Sysoyev?)
Mr. Terenchuk	Ass't Head of Operation (Viktor)
Mr Pachura	Sr. Foreman for I&C Equipment (Vladimir)
Mr. Kuriat	Foreman of Chemical Gas analyzers Vanliy)
Mr. Kozhurhkv	Electric & Metal Worker (Alexander)
Mr. Ksrokhov	" " " (Viacherlav)

Recommended Action:

1 The two damaged spare probes. Ser#189-18 & 189-10 should be sent back to Zirtek for repair.

2. The plant is quite concerned about not having access to a spare set of electronics I think there should be a unit available in the Ukraine if not at each plant.

APPENDIX A-1

Energy Conservation Opportunities (ECO's)

ECO-04, ECO-06, AND ECO-08 CALCULATIONS

IN-SITU OXYGEN ANALYZERS, MAZUT FLOW METERS AND COAL FLOW METERS

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.

2.0 ASSESSMENT OF POTENTIAL EXCESS OXYGEN REDUCTION

There is the potential to reduce the levels of excess oxygen at the Krivoi Rog units 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 burner design calls for an excess oxygen level at the burners of 3.5%. For burners of this design and vintage, it would be more appropriate to assume that the excess oxygen level would be closer to 4 0%. These are the minimum levels required for stable flame and proper combustion. Excess oxygen levels higher than this provide the opportunity for a reduction in the operating levels.

2.1 Evaluation of Excess Oxygen at the Burners

At full load firing coal, the excess oxygen was measured in the convection pass and ahead of the air heaters. The excess oxygen measured was a maximum of 7.2%. BRC calculation indicates that the corresponding excess oxygen at the burner is about 5.2%.

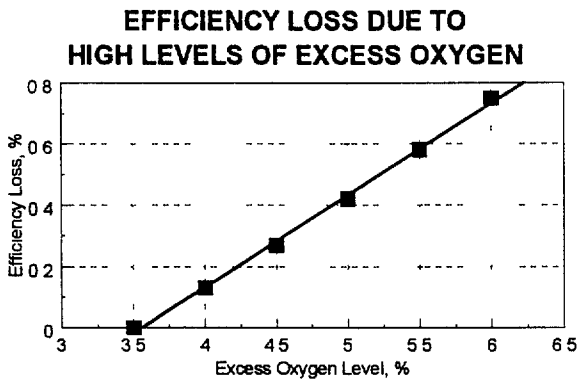
Accounting for the existing burner design, the minimum excess oxygen at the burners would be assumed to be approximately 4.0%. Thus, the potential reduction in excess oxygen at the burners would be 5 2 - 4 0 = 1.2%.

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 oxygen reduction possible at the burners is approximately 1 2% This would reduce the excess oxygen from 5 2% to 4% Using the curve shown above, the boiler efficiency improvement would be 0 33%

3 0 COST ANALYSIS

Fuel savings can be realized by replacing existing extractive oxygen analyzers with zirconium oxide sensor probes placed directly into the flue gas path to be able to better control excess air for combustion In addition, mazut flow meters and coal flow meters are required to realize benefit from lower excess air

Equipment Cost

ECO-04	Oxygen analyzers, 1 unit, 2 probes	$40,000
ECO-06	Mazut sonic flow meters, 4 required	$16,000
ECO-08·	Coal flow meters	$40,000
	Installation and commissioning	$15,000
		$111,000

Based on test results, it is estimated that a modest 0 33% increase in boiler efficiency can be achieved from better control and reduction of excess air required for combustion, which will result in a 0 33% decrease in fuel costs,

Plant generating capacity = 10 units x 300 MW (282 MW derated) = 2820 MW
1994 power generation = 9,896, 612,000 KWH/8760 hrs = 1130 MW
≈ 4 units at full load
(1130 MW/282 MW)

Simple Payback for O_2 Analyzers - 1994 Prices

Fuel cost per unit per year = $59,983,641 total/4 units = $14,995,910
Savings per year due to boiler efficiency improvement = 0 0033 x $14,995,910 = $49,487
Payback = $40,000/49,487 = 0 81 year = 9 7 months

Simple Payback for O_2 Analyzers - World Prices

Fuel cost per unit per year = $246,695,670 total/4 units = $61,673,918
Savings per year due to boiler efficiency improvement = 0 0033 x $61,673,918 = $203,524
Payback = $40,000/203,524 = 0 20 year = 2 4 months

Simple Payback for O_2 Analyzers and Sonic Flow Meters - 1994 Prices

($40,000 + $16,000)/$49,487 = 1 13 years = 13 6 months

Simple Payback for O_2 Analyzers and Sonic Flow Meters - World Prices

($40,000 + $16,000)/$203,524 = 0.27 year = 3 3 months

Simple Payback for Entire Package - 1994 Prices

$111,000/$49,487 = 2 24 years = 26 9 months

Simple Payback for Entire Package - World Prices

$111,000/$203,524 = 0.55 year = 6 5 months

ECO-07 - Calculation

Online Gas Calorimeter

Reported heating value specification for Russian natural gas is 8116 Kcal/Kg. However, the technical specialists complain that the delivered heating value runs low by as much as 143 Kcal/Kg when the plant is paying for gas on a volumetric basis. They want to be able to measure the gas deliveries on the basis of heat content. An online gas calorimeter measuring and recording Kcal/Kg and Sp. Gr. costs about $35,000.

Delivered Natural Gas

686,447,000 Nm^3/Yr x 0.7207 Kg/Nm^3 = 494,722,350 Kg/Yr

494,722,350 Kg/Yr x 143 Kcal/Kg = 7.075 x 10^{10} Kcal/Yr

7.075 x 10^{10} Kcal/Yr x 3.9685 BTU/Kcal = 2.808 x 10^{11} BTU/Yr

Simple Payback - Domestic Price

2.808 x 10^{11} BTU/Yr x $0.715/$10^6$ BTU = $200,722/Yr

$35,000/$200,772 = 0.17 Yr = 2.1 months

Simple Payback - World Price

2.808 x 10^{11} BTU/Yr x $2.10/$10^6$ BTU = $589,680 Yr

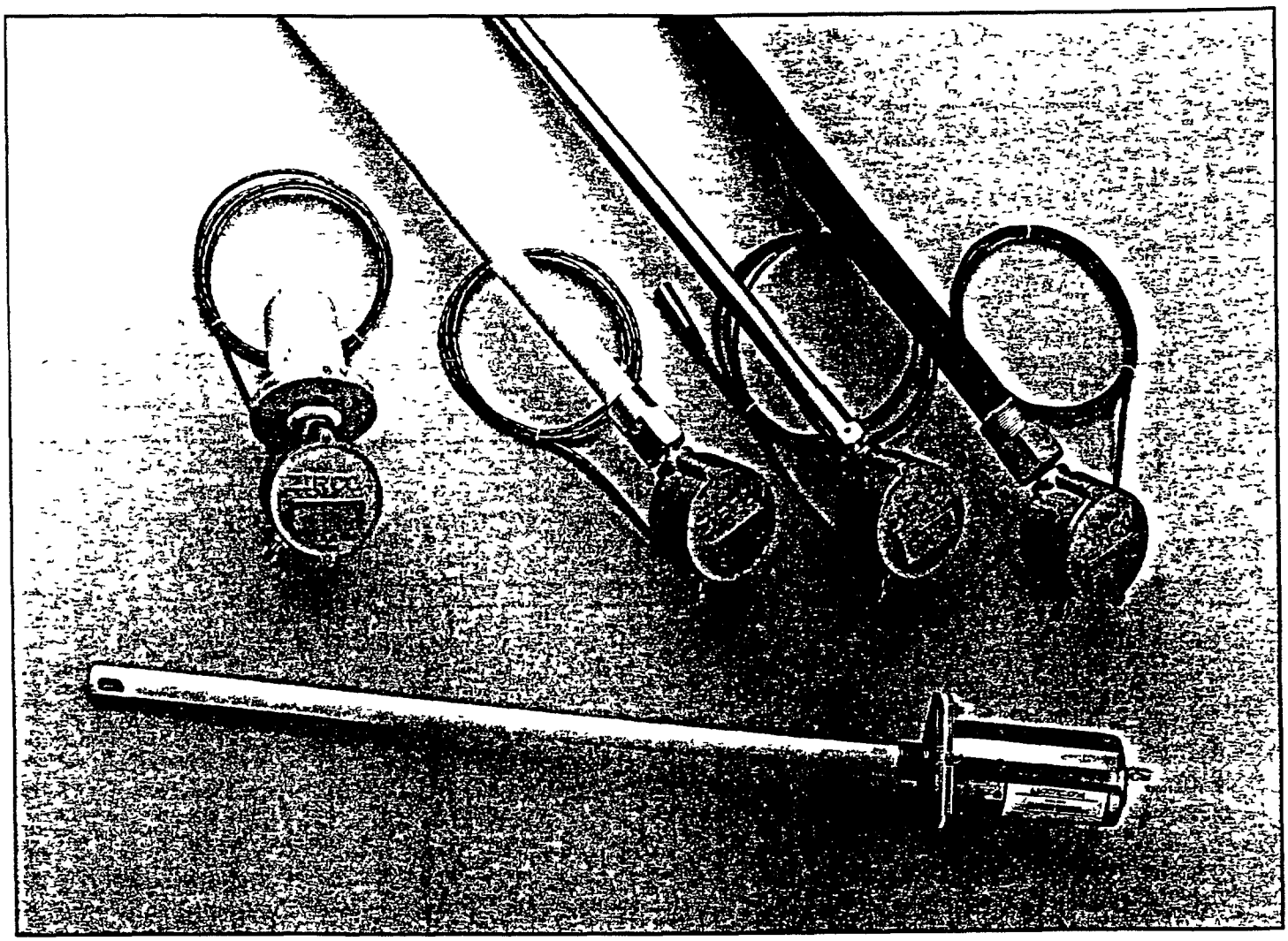
$35,000/$589,680 = 0 06 Yr = 0.7 months

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

Design and operating advantages common to all AACC/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

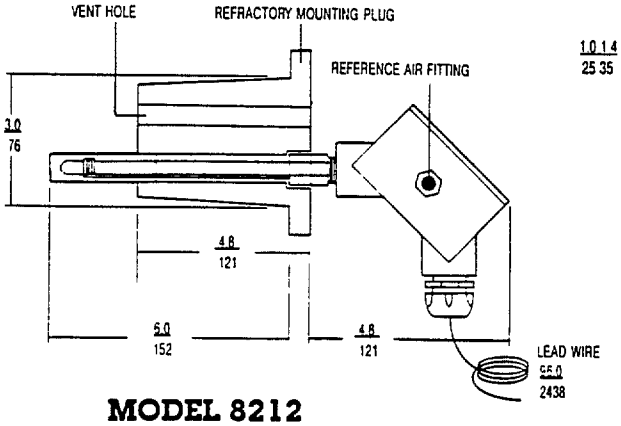
- 6" (152mm) sensor with ceramic mounting plug
- Mount in melter crown backwalls recuperator stacks regenerator crown/target walls
- Designed to withstand attack from high vapor pressure metals

Model 8081

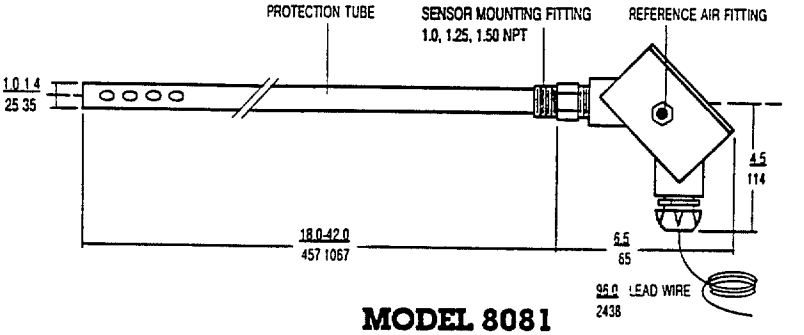
- Patented boot protects electrode
- Alloy alumina and silicon carbide protection tubes available
- Lengths available from 18 to 42" (457 to 1067mm)

Model OX

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

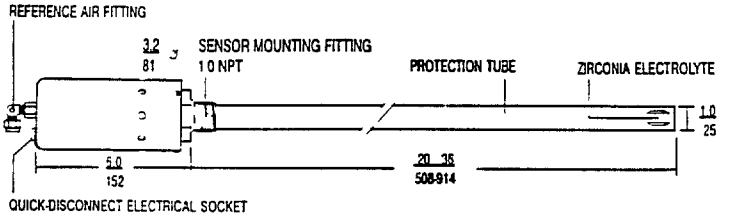


MODEL 8212



MODEL 8081

ALL DIMENSIONS
INCHES
MM



MODEL OX

For specific application information, please call:

Caution. Oxygen sensors should be used only for 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.

AACC/Zircoa
DIVISION OF ZIRCOA, INC
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SOLON OHIO 44139
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Utilities

High-temp O_2 measurement improves boiler performance

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

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

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

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

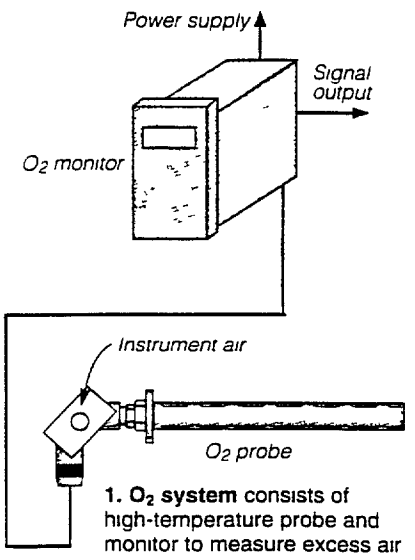
- Low maintenance requirements
- Continuous operation in the furnace section of the boiler.
- Improved probe life, with a one-year minimum desired.

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

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

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

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



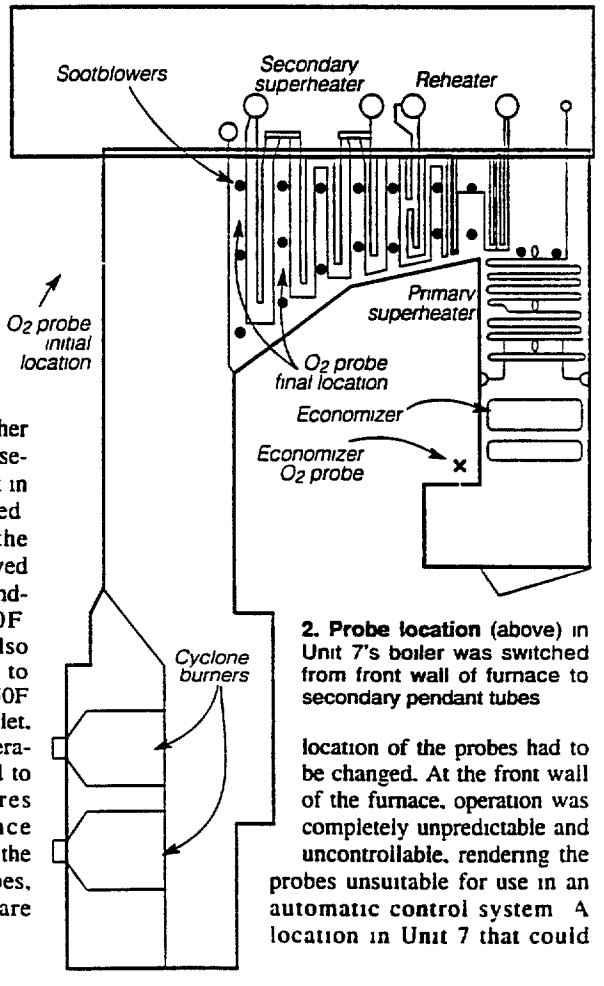
1. O_2 system consists of high-temperature probe and monitor to measure excess air

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

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

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

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



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

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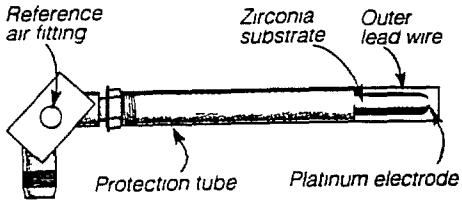

3. Protection tube (right) of stainless steel is aimed at improving probe's ability to withstand extreme furnace conditions

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

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

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

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

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

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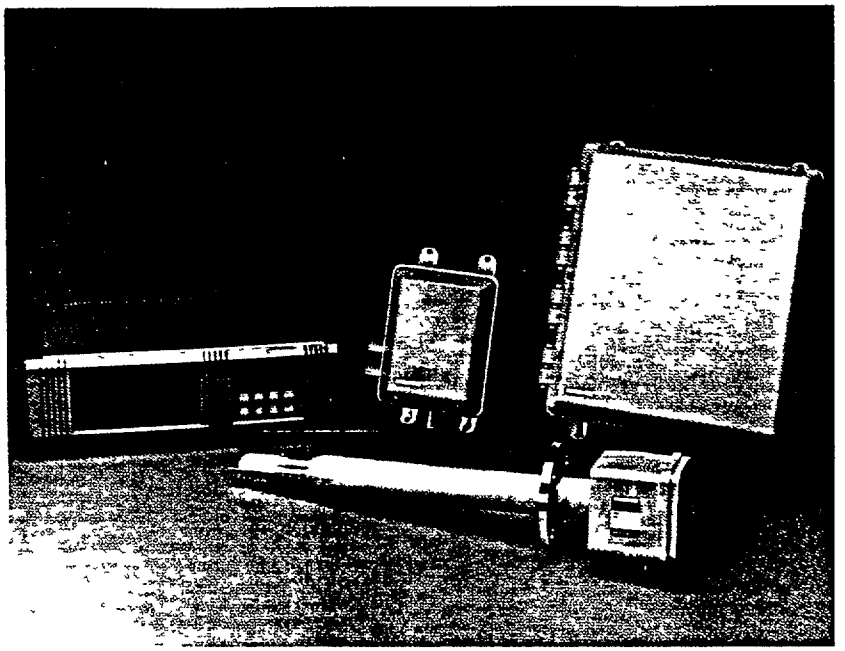
WORLD CLASS 3000

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

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

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

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

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

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

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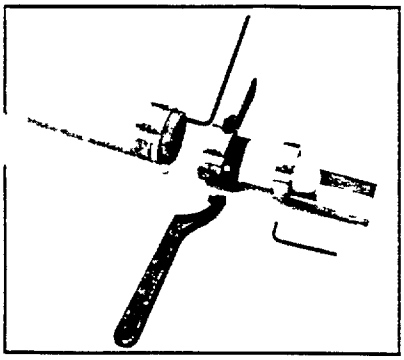
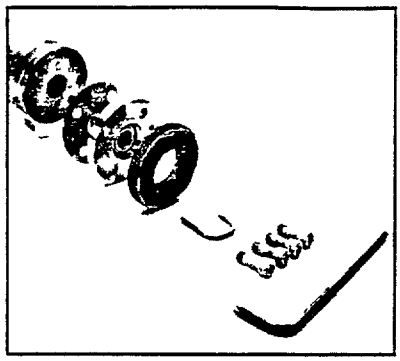
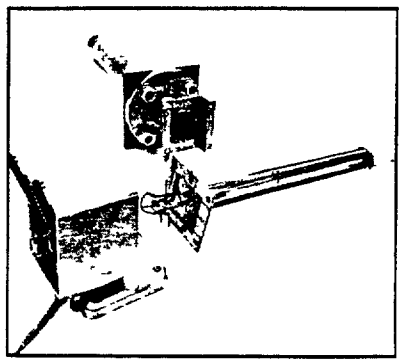


Filter Head Assembly



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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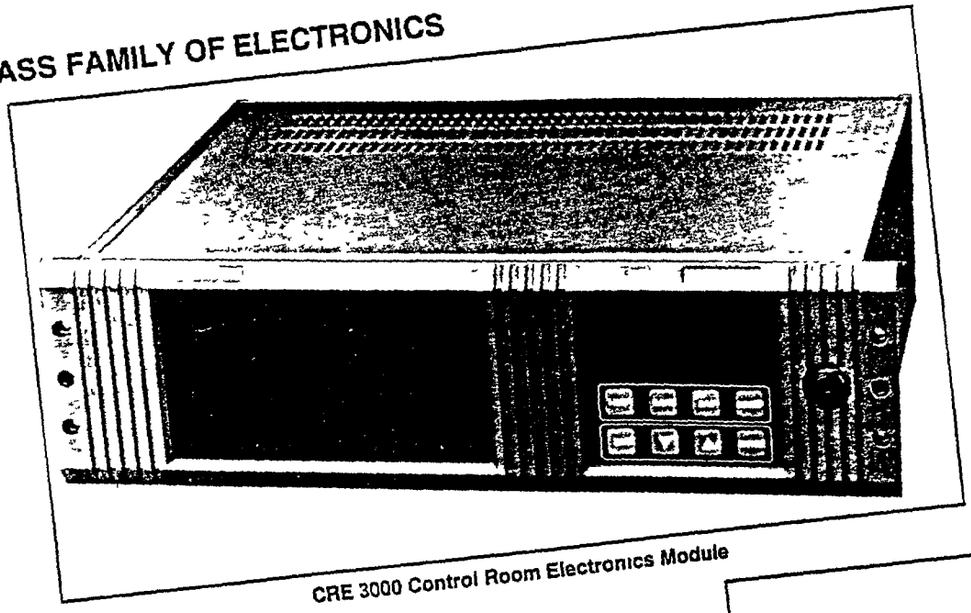
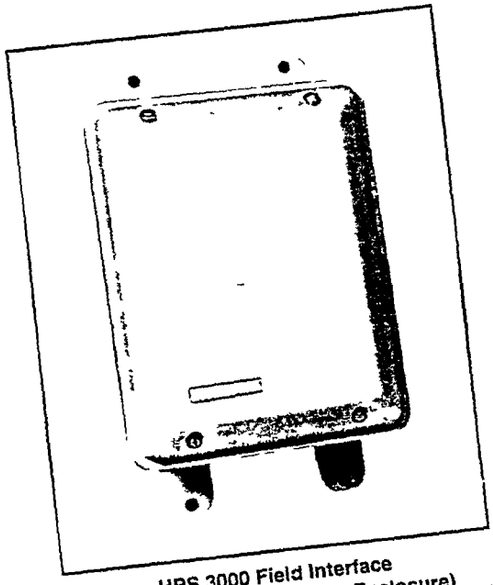
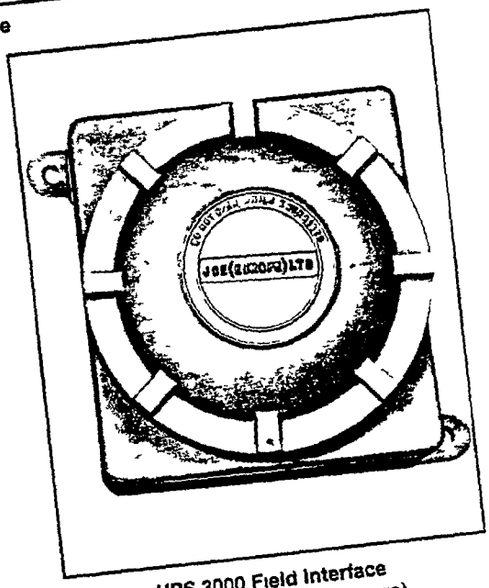
WORLD CLASS FAMILY OF ELECTRONICS



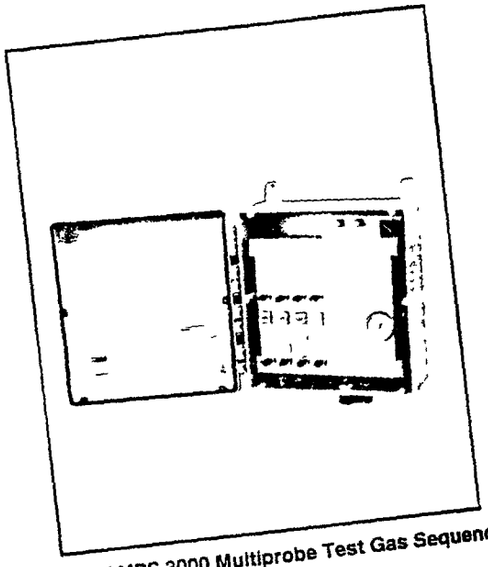
CRE 3000 Control Room Electronics Module



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

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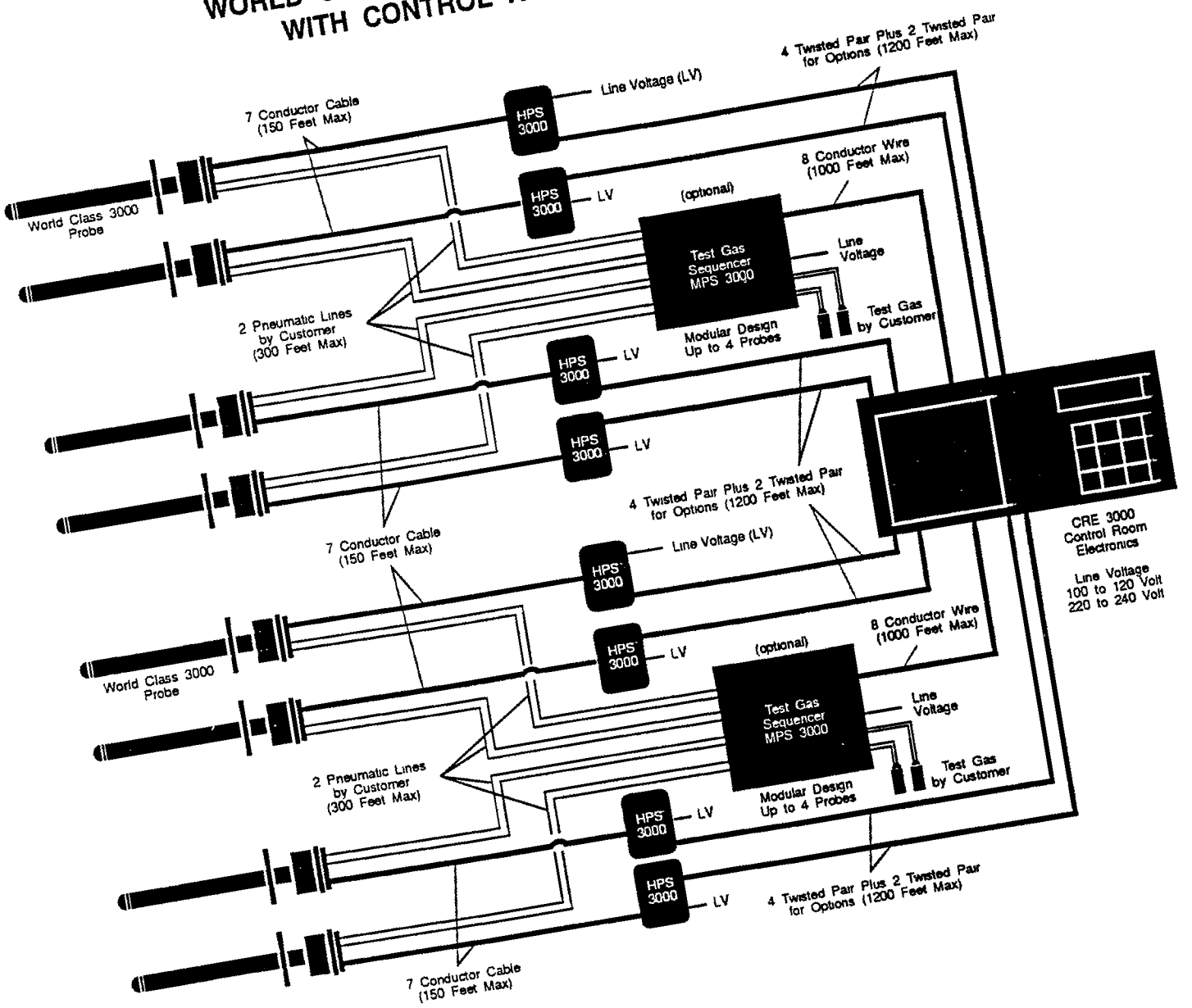
WORLD CLASS 3000 MULTIPROBE APPLICATION WITH CONTROL ROOM ELECTRONICS



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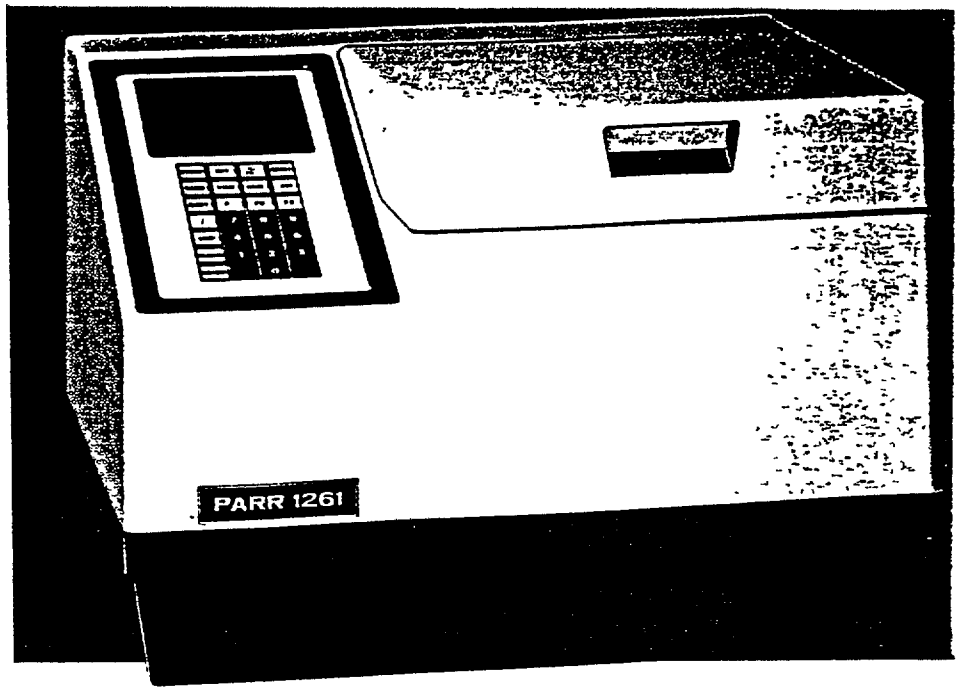
The 1261 Calorimeter

A self-contained oxygen bomb calorimeter with automatic microprocessor control for rapid and precise calorific tests with minimal operator attention.



RECOMMENDED FOR

Coal mine, coal preparation plant, commercial inspection, coal burning utility and other industrial laboratories where calorific tests of solid, liquid or refuse-derived fuels are run daily on a routine basis, and where rapid tests with good repeatability are required. Although principal uses for the 1261 Calorimeter are found in coal laboratories, it has equally important applications for determining the calorific value of other solid and liquid fuels. Firms involved in waste disposal management find the 1261 Calorimeter a reliable means for monitoring the energy content of refuse fuels. Equally important applications are found in food laboratories for determining calorific values for foodstuffs and animal feed mixtures, in university laboratories for teaching purposes and for high precision energy research projects.

A COMPLETE, SELF-CONTAINED OPERATING UNIT

All sensors, controls and jacketing in the new Parr 1261 Isoperibol Calorimeter are built into a single, compact cabinet to provide a self-contained operating unit consisting of:

- A temperature-controlled, insulating water jacket with a built-in circulating system and an electric heater.
- An oval calorimeter chamber and bucket.
- An 1108 oxygen combustion bomb
- A built-in automatic system for charging the bomb with oxygen.
- A high precision electronic thermometer.
- A sealed, touch-panel keyboard for data entry and operation control.
- A bright, LED display for operator prompting, status indication, data verification and report review.

FULLY INTEGRATED MICROPROCESSOR CONTROL

All steps in the test procedure are managed by a microprocessor control system using third generation hardware and software pre-programmed to:

- Operate the calorimeter in either the conventional isoperibol/equilibrium mode or in a faster isoperibol/dynamic mode.
- Monitor and control the jacket temperature.
- Ascertain equilibrium, fire the bomb, confirm that ignition has occurred and monitor the temperature rise.
- Terminate the test within operating parameters selected by the user and check for errors.

A BUILT-IN MICROCOMPUTER

All data involved in a calorific test is handled automatically by a dedicated microcomputer which will:

- Accept and store all sample weights and temperature data.
- Apply all necessary corrections for acid, sulfur and fuse.
- Compensate for any added combustion aid or "spiking".
- Compute and report the heat of combustion in units selected by the user.
- Transmit test results to an alpha numeric printer (not included with the calorimeter).
- Accept sample weights directly from an analytical balance using an appropriate interface.
- Communicate with and transmit calorific data to a central computer and/or other instrumentation in a Smart Link network.

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Isoperibol Calorimetry

A classical method—improved with automatic control.

Provides rapid tests in the 1261 Calorimeter with excellent repeatability, using either the CLASSICAL EQUILIBRIUM METHOD or a RAPID DYNAMIC METHOD which cuts the time for an individual test almost in half.

THE ISOPERIBOL/EQUILIBRIUM METHOD

The excellent jacket temperature control provided in the 1261 Calorimeter is ideal for test runs using the classical isoperibol method. In this procedure the jacket temperature is held constant throughout the test while the controller continuously monitors the temperatures in the jacket and in the bucket and performs the integration needed to account for any heat leak resulting from any differences between bucket and jacket temperatures during the run The test continues until the controller determines that equilibrium has been reached, usually within 8 to 10 minutes after firing, at which point it signals the operator to return to the calorimeter to remove the bomb and prepare it for the next test.

The operator does not have to wait for the jacket temperature to cool before starting another run. A new test can be started immediately. The jacket temperature is controlled automatically and is usually set slightly higher than room temperature, although any temperature preferred by the operator can be used. Obviously, for best results all tests should be conducted within the same operating range.

THE ISOPERIBOL/DYNAMIC METHOD

As an alternative to the equilibrium method, Parr has developed an Isoperibol/Dynamic method for use in the 1261 Calorimeter which cuts the time required for an individual test almost in half. Using this procedure the test is run in the same manner as described above for the equilibrium method, but with the controller instructed to employ a sophisticated curve matching technique to compare the temperature rise with a known thermal curve for the system. Using this comparison, the controller can extrapolate and predict the final temperature without waiting for it to develop, making it possible to terminate the test and compute the calorific value of the sample in periods as short as 3 to 4 minutes after firing. The savings in operating time with this method will become particularly significant when running multiple samples.

ATTAINABLE PRECISION

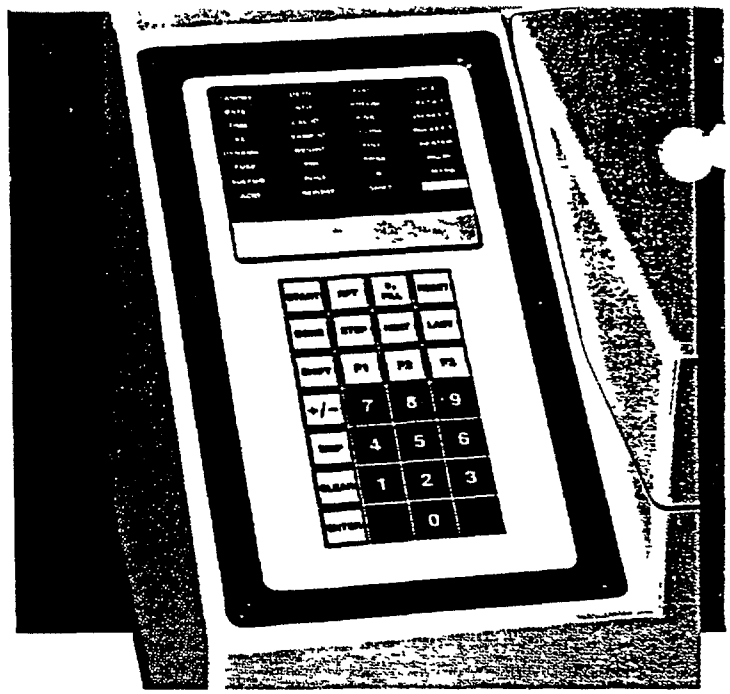
The precision attainable with the rapid Isoperibol/Dynamic method is fully comparable to results obtained with the Equilibrium method. Routine comparison tests with standard samples have shown standard deviations of 0.05 to 0.08 percent of the determined value for both the Isoperibol/Dynamic and the Isoperibol/Equilibrium methods. It should be noted, of course, that in comparison tests with a non-homogenous material such as coal, the results may show a wider spread than tests with a uniform sample such as benzoic acid. Nevertheless, all results obtained with the 1261 Calorimeter should fall well within approximately one-half of the 50 Btu/lb repeatability limits specified in standard ASTM/ANSI test methods. Replicate tests with a bituminous coal sample will seldom differ by more than 30 Btu/lb.

COMPARATIVE OPERATING SPEEDS

1261 Calorimeter	Operating Mode	
	Isoperibol/ Equilibrium	Isoperibol/ Dynamic
Time for a single test	10 to 12 min	6 to 8 min
Complete tests per hour	5 to 6	8 to 10

The 1261 Calorimeter

Convenient touch-panel keyboard operation with many options



MANY UNIQUE FEATURES

All steps in the operation of a 1261 Calorimeter are controlled from a sealed, touch-panel keyboard mounted on the calorimeter together with a bright LED display for data verification and prompting. From this keyboard the operator can control all operations involved in a calorific test, using the many unique features built into this automatic system, including:

Selectable procedures. The operator can choose either the conventional Isoperibol/Equilibrium test method or a faster Isoperibol/Dynamic procedure, depending upon the speed desired for his particular application.

Automatic control. The microprocessor will (a) continuously monitor and control the jacket temperature, (b) detect equilibrium, fire the bomb, confirm that ignition has occurred and monitor the temperature rise, and (c) terminate the test within operating parameters selected by the user and check for errors.

Automatic computation. The microcomputer will not only collect and evaluate all data, but it will also (a) apply the necessary correction for heat loss, (b) calculate and apply the appropriate corrections for acid, sulfur and fuse, and (c) compute and report the heat of combustion in units selected by the user.

Data acquisition and storage. All sample weights and temperature data are accepted and retained by the calorimeter.

Large memory capacity. Data for up to 175 tests can be retained in the memory until called up by the operator.

Back-up power supply. Battery back-up is provided to protect the memory so that no data will be lost if the power should fail.

Operator prompting. Clear, LED actuated messages describe the current status of the test and identify the specific data which must be entered so that a test or reporting procedure can continue.

Menu driven setup program. When operated with a 1755 Printer, the calorimeter may be configured automatically using a menu driven, conversational program provided in the calorimeter firmware. This setup program is available at any time to set, change or view the commonly used operating parameters.

Diagnostic tests. The controller will make extensive diagnostic tests to ensure that the calorimeter is functioning properly and to identify any errors or problems.

AUTOMATIC STANDARDIZATION

The 1261 Calorimeter will automatically generate its energy equivalent (EE value) from a series of standardization tests, calculating a mean value from either (a) all standardization tests, or (b) from the last 10 tests for each bomb/bucket combination. The user can enter the maximum relative standard deviation he will accept for a series of standardization tests and the calorimeter will advise him if his standardization fails to meet this criteria. Energy equivalent values for up to eight bomb/bucket combinations can be stored in the computer.

MAINTAINS STANDARDIZATION

One of the most important characteristics of the 1261 Calorimeter is its ability to maintain a constant standardization. There should be no annoying fluctuations in the energy equivalent from morning to afternoon, or from winter to summer. This can be attributed largely to an effective water jacket which isolates the calorimeter from temperature changes in the laboratory and to a system with no paths for significant heat leaks. Also, any change in pressure in the water supply line will not affect calorimeter operations or change the energy equivalent since the calorimeter does not require a pressurized water supply for its operation. Features introduced when the calorimeter is operated with the recommended 1563 Water Handling System add further to its ability to maintain constant standardization, since the 1563 System ensures that the bucket will always be filled with water at a constant temperature within +/−0.5° C, and the volume of water placed in the bucket will always be the same when delivered from an automatic pipet.

Options and Specifications

MANY USER OPTIONS

Although specific procedures are recommended, various options are available to the user.

- Program parameters can be adjusted to accommodate unusual sample sizes, burning rates and precision requirements.
- The calorimeter can be programmed to accommodate any reagent concentrations selected by the user.
- Calorific values can be reported in any of several measurement units.
- The calorimeter program can be adjusted to compensate for the subtle differences in the way acid correction values are handled in ASTM, BS and ANSI Methods.
- Programmable function keys are available for operating convenience.
- Program controls can be password protected, if desired.
- User selectable default parameters.
- A bomb usage tally can be maintained to notify the user when each bomb should be serviced.
- Program parameters can be selected to support all currently manufactured Parr combustion calorimeter bombs.

PRINTED REPORTS

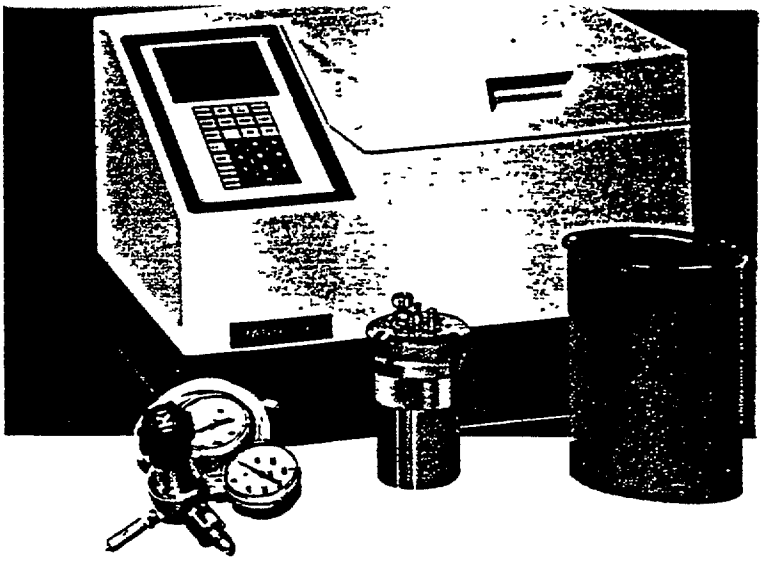
A printed record of all essential data and results from each test, including detailed error and diagnostic messages, can be obtained by connecting the calorimeter to a Parr 1755 Printer described on page 9, or to any 40/80 column commercial printer compatible with an RS232C output.

AUTOMATIC DATA TRANSFER

The calorimeter is Smart Link ready for use with any of the balance, sulfur or computer interfaces designed for this system, as described on pages 11 & 16.

COMPATIBLE MODULAR DESIGN

The 1261 Calorimeter is fully compatible with existing Parr bombs, calorimeter controllers, closed-circuit water handling systems and all Parr Smart Link devices, making it easy to fit the instrument into an existing laboratory set-up. Modular design with all electronics assembled in a removable chassis simplifies trouble shooting problems Also, the calorimeter is equipped so that it can be connected through a phone modem direct to the Parr Instrument Company factory computer for trouble shooting or for program parameter up-dates.



SPECIFICATIONS

Available Test Procedures	Isoperibol/Equilibrium Isoperibol/Dynamic Determination Standardization
Stored Energy Equivalent EE Values	8
Corrections for Acid, Sulfur and Fuse	Automatically from Sulfur Analyzer, by Operator Entry, or by Fixed Corrections
Data Display	LED
Operator Prompting	LED
Diagnostics	LED with printed error and diagnostic messages
Storage Capacity, normal	175 Tests
Electrical	Separate Models: 110-125 v 60 Hz 210-250 v 50 Hz
Power Requirements	1000 watts, maximum
Dimensions	20" wide, 15" deep, 14" high

ACCESSORIES

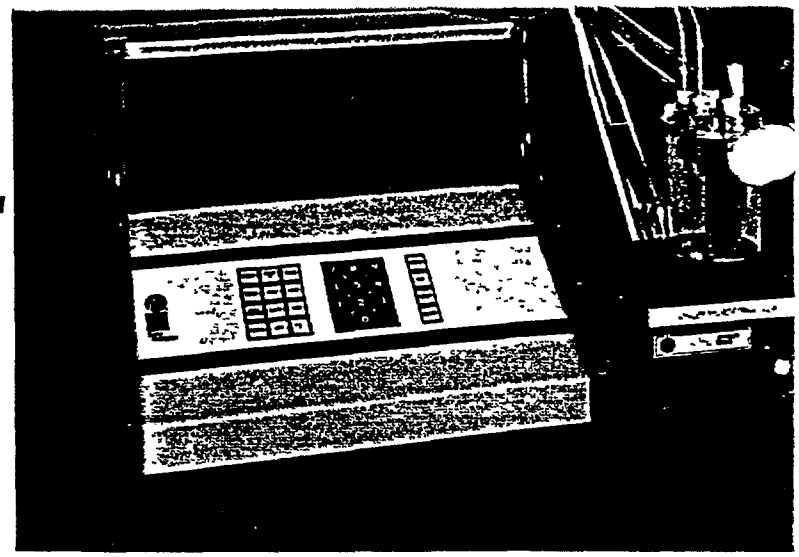
Six fuel capsules, fuse wire for 500 tests and a stand for holding the bomb head during assembly are furnished with each calorimeter, also a bottle of 100 benzoic acid pellets for standardizing the calorimeter and complete operating instructions.

ORDERING INFORMATION

1261EA **Isoperibol oxygen bomb calorimeter with 1108 oxygen bomb, 115 v 60 Hz.**
(For 230 v 50 Hz, use Cat.No. 1261EF)

4

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)

USE WITH EXISTING EQUIPMENT

The 1750 Analyzer does not require a special oven, furnace or analytical balance. Existing procedures do not have to be changed. All drying and ashing operations are performed in the same oven and furnace normally used for standard ASTM proximate analyses. The Analyzer can be programmed to communicate with any of the commonly used digital analytical balances. Samples can be weighed and treated in any order with the Analyzer accepting data from a balance as generated, organizing and storing it in the correct order under operator assigned sample numbers. The operator can override the automatic data system at any time to enter weights manually, if necessary. Weights taken on a non-digital trip balance or scale to determine air-dry loss (ADL) can be entered manually, or the ADL value can be calculated and entered separately. ADL values can also be determined automatically using a 1750A Air-dry Loss Interface connected to a top loading balance. With this arrangement the 1750 Analyzer can be instructed to obtain ADL/total moisture values direct from the 1750A Interface.

CONVENIENT KEYBOARD OPERATION

With the 1750 Analyzer connected to a digital analytical balance, each weighing will be shown on the LED display on the Analyzer for confirmation before it is entered into memory. The operator will then use the touch panel keyboard to identify each entry as to the test (moisture, ash, volatile matter or air-dry loss) and the function (tare, gross or final weight) to which the data applies. The Analyzer will also prompt the operator to identify the data with a valid sample number before it is entered.

PROXIMATE ANALYZER REVISION 50.33E

SAMPLE ID: 25 FINAL REPORT

	ADL	MOIST	ASH	VM
TARE	2218.	15.6908	17.6908	16.7701
GROSS	6711.	16.6925	18.6741	17.7709
FINAL(%)	6577.	16.6741	17.8542	17.4792
AS RECD	2.98	4.76	16.12	26.50
AS DETR		1.84	16.62	27.31
DRY			16.93	27.82
DAF				33.49

	FC	SULFUR	BTU
AS RECD	52.62	2.18	12122.9
AS DETR	54.24	2.25	12495.2
DRY	55.25	2.29	12729.9
DAF	66.51	2.76	15322.7

Printout from 40-Column Printer

SELECTABLE REPORTS

The user can select from a variety of preprogrammed options when obtaining final reports from the Analyzer. Proximate analyses can be obtained for an individual sample or from a full range of tests. All supporting raw data can be included in the report, or the report can be condensed to show only final values.

AIR-DRY LOSS INTERFACE

Air-dry loss determinations are usually made using large (1000 gram) samples on a top-loading balance, often located in a facility outside of the laboratory where other coal tests are performed. To facilitate the transfer of ADL test data to the Proximate Analyzer, Parr offers the **1750A Air-Dry Loss Interface** which can be connected directly to a digital top-loading balance at the location where ADL weighings are performed. Tare, gross and final weights can then be collected automatically in the 1750A Interface and transmitted to the 1750 Proximate Analyzer over a Smart Link for incorporation into the final proximate analysis report. Without this arrangement, ADL weighings must be entered into the Analyzer through the keyboard.

The 1750A Interface looks and works exactly like the 1750 Proximate Analyzer, but it will be instructed to gather and transmit only ADL data. Again, the user must specify the make and model of his balance when ordering the 1750A Interface so that the proper communications protocols and cables can be furnished.

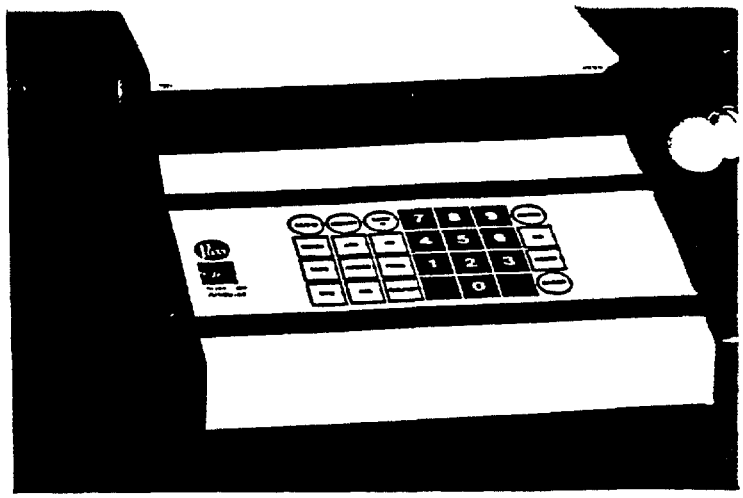
INSTALLATION ASSISTANCE

Installation and operation of the 1750 Proximate Analyzer should proceed smoothly with little difficulty using the detailed instructions furnished with each instrument. But, since each installation is unique, users are urged to call the Parr Instrument Company direct (309/762-7716) for assistance in adapting peripheral devices to a 1750 Proximate Analysis System.

ORDERING INFORMATION

1750	**Proximate analyzer** with connecting cable to an analytical balance (specified by the user) 115/230v, 50/60 Hz.
1750A	**Air-dry loss interface,** 115/230v, 50/60 Hz.
A597E	**Smart link cable,** 25 ft

The 1750 Proximate Analyzer



A rapid data processing system for calculating and reporting the proximate analysis of coal.

RECOMMENDED FOR

Assembling data, calculating and reporting the proximate analysis of coal, coke and related fuel samples as tested in coal mine, coal preparation plant, coal burning utility, commercial inspection and other industrial laboratories where coal samples are tested daily on a routine basis.

A FULLY INTEGRATED DATA PROCESSING SYSTEM

The proximate analysis of a coal sample is a tedious procedure involving several separate weighings and producing considerable data as needed to calculate:

Air-dry moisture **Volatile matter**
Total moisture **Fixed carbon**
Ash

There is no way to avoid the individual weighings and heatings involved in these separate determinations, but the data entry, data processing and reporting functions can be speeded and simplified considerably using the convenient microprocessor system provided by a Parr 1750 Proximate Analyzer.

Operating in conjunction with a moisture oven, furnace and analytical balance already on hand in a user's laboratory, the 1750 Proximate Analyzer will:

- **Accept and retain all individual weighings** obtained during the series of steps required to determine air-dry moisture, total moisture, volatile matter, fixed carbon and ash.
- **Organize and store all test data** for up to 100 samples, accepting the data as it becomes available from a digital balance. Samples can be weighed and treated in any order with the Analyzer accepting the data as generated, organizing and storing it in proper sequence under operator assigned sample numbers.
- **Collect and store sample weights for calorimetric determinations.** If a 1750 Proximate Analyzer is used with a 1261 Calorimeter (or with a 1241 Calorimeter equipped with a 1720 or 1730 Controller) the 1750 Analyzer will provide all of the functions of a 1741 Balance Interface, and a separate Balance Interface will not be required. Each weighing will be shown on an LED display before it is entered into memory, with the Analyzer prompting the operator to identify each entry with a valid sample number. Weights can also be entered from a keyboard. The Analyzer will collect and hold all sample weights for calorimetric determination until called up by the calorimeter.
- **Collect and store sulfur values** from a 1760 Sulfur Analyzer to be included in a consolidated proximate analysis report.
- **Calculate air-dry moisture, total moisture, volatile matter, fixed carbon and ash** for each sample on any of four reference bases:

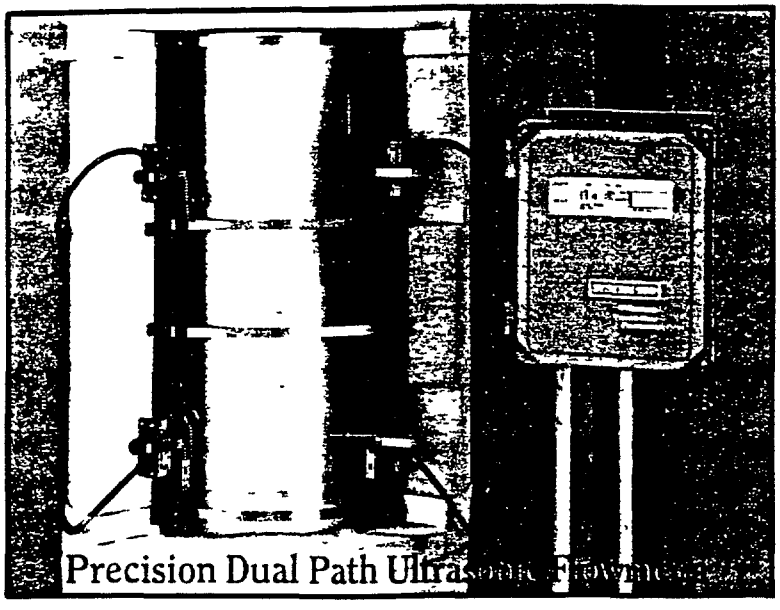
As-received	**(AR)**	**Dry**	**(DRY)**
As-determined	**(AD)**	**Dry, ash-free**	**(DAF)**

- **Convert calorific and sulfur values** to any of the moisture reference bases listed above.
- **Produce a consolidated proximate analyses report** for each valid sample (including calorific value and sulfur) by feeding all collected reports to any of the following:
  A Parr 1755, 40-column printer or an 80-column commercial printer.
  A 1261 Calorimeter with a Parr 1755 Printer.
  A central computer.
  A laboratory or personal computer connected on a Parr Smart Link.
- **Produce full or partial reports** at any time for an individual sample or for a full range of tests. Reports can include all supporting raw data or can be condensed to show only final values.

CONTROLOTRON

Models 990DBN
and 990DBP

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



DESCRIPTION

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

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

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

FUNCTIONS

Series 990D offers the following optional functions

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

FEATURES

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

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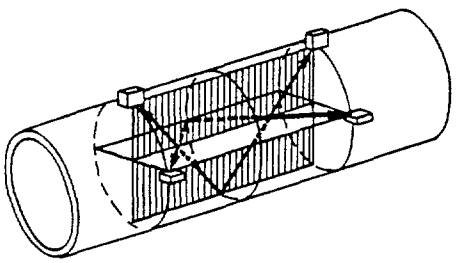
WHAT IT DOES

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

HOW IT WORKS

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



WHERE TO USE

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

SPECIFICATIONS

APPLICABILITY

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

991 CLAMP-ON TRANSDUCERS

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

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

992 MOUNTING TRACKS

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

994 FLOW COMPUTER

- POWER: 20 W, 9 to 36 VDC or internal Battery, 100/115 or 230 VAC, 1ϕ
- TEMPERATURE: −5°F to +115°F (except for Graphics Models)
- SIZE. 10.5"W, 9" D, 13" H
- WEIGHT: 12 8 pounds
- RATING. Intrinsically safe, NEMA 4X with cover closed
- MODULES. Plug-In, Interchangeable W/O special tools
- RANGES. Size 4: Transducer Sizes 3 and 4
  Size 5: Transducer Sizes 3, 4 and 5

994 PERFORMANCE (Standard Conditions)*

- SENSITIVITY: 0.001 fps at any flow rate including zero
- LINEARITY· 0.003 fps
- RESPONSE BANDWIDTH: 10 Hz (settable)
- SLEW RATE. 20 ft/sec/sec
- FLOW PROFILE COMPENSATION: Via liquid viscosity entry
- ZERO DRIFT STABILITY: 0 005 fps for transducer sizes 3 to 6

995 HAND HELD CONTROL/DISPLAY TERMINAL

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

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

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

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

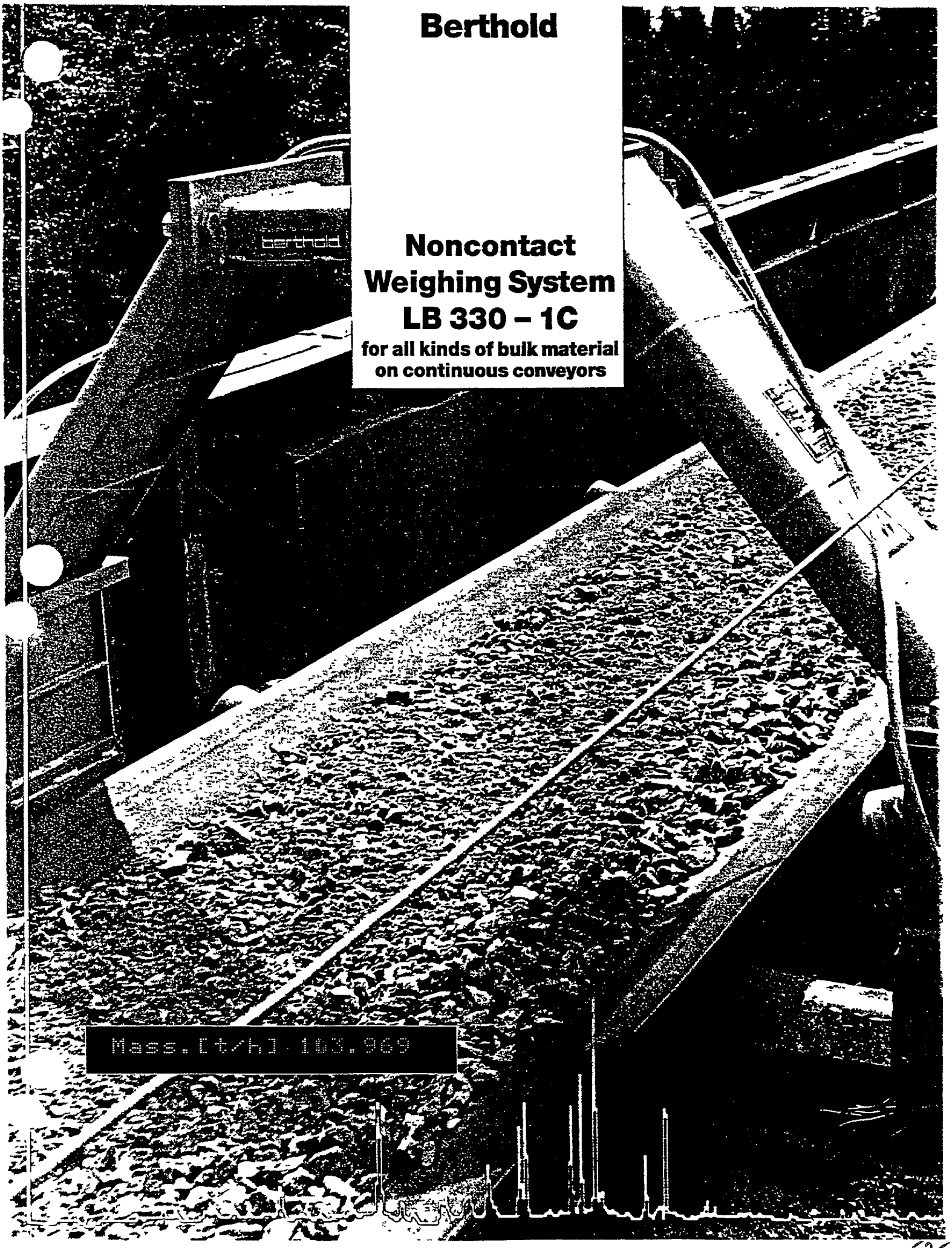
* Transducers operated above 400°F will require periodic refurbishment with periodicity proportional to operating temperature For extreme temperature operation, factory consultation is recommended

5

Berthold

Noncontact Weighing System LB 330 – 1C

for all kinds of bulk material on continuous conveyors



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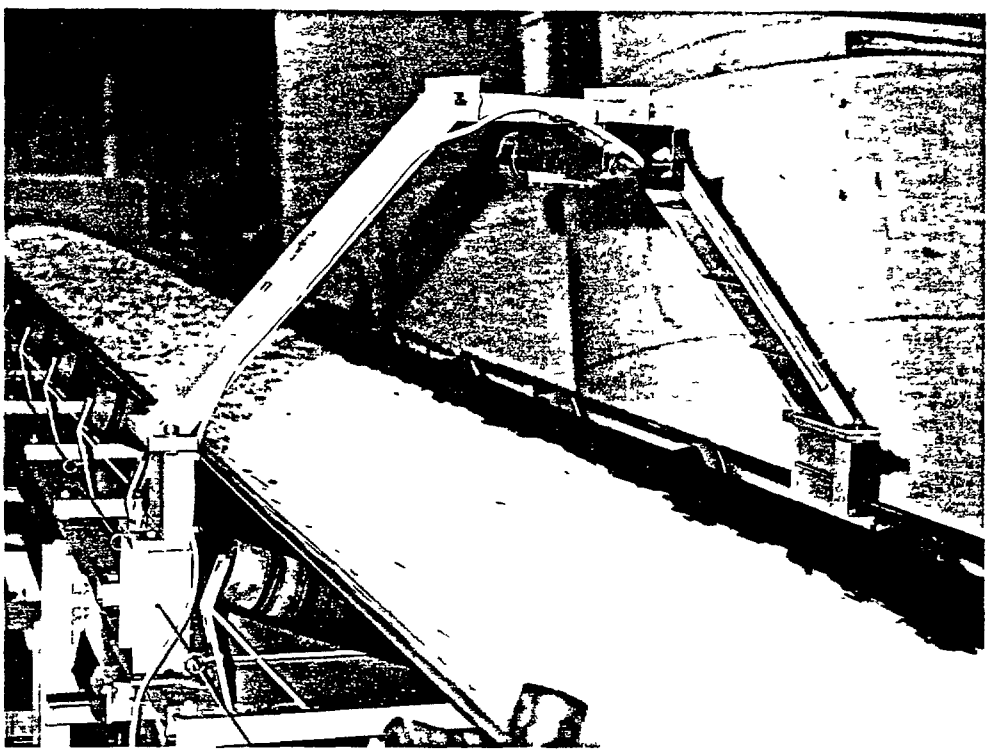
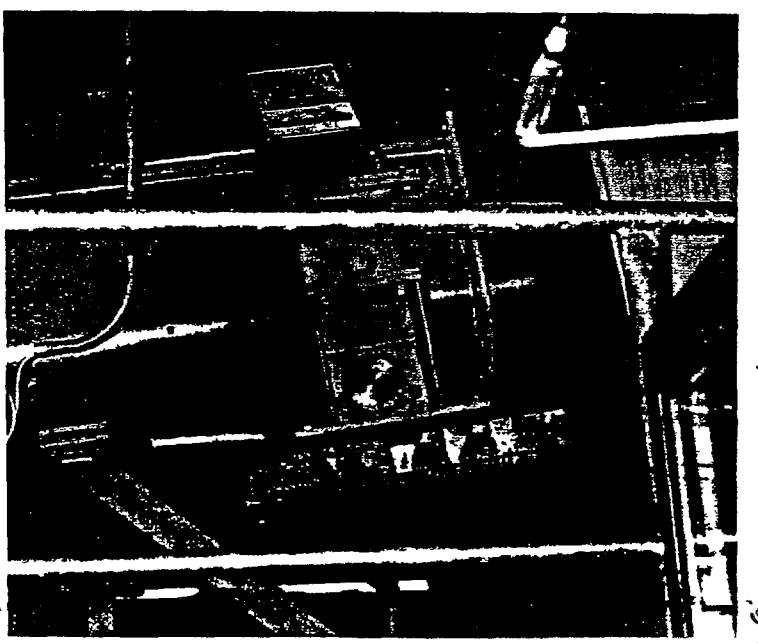
Noncontact massflow meter

The Compelling Advantages

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



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



and on a screw conveyor

BEST AVAILABLE COPY

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

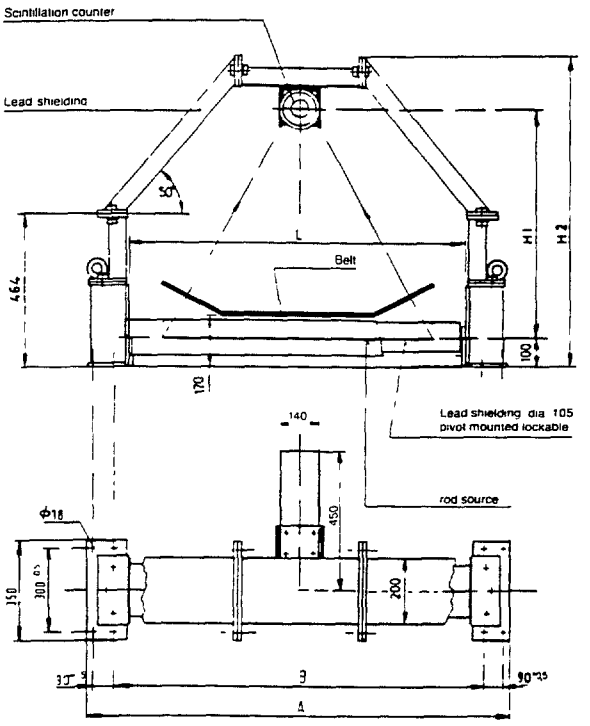
The type of gamma source used depends on the material loading With high belt loading ^{60}Co is used (half-life 5.3 years), with medium loading ^{137}Cs (half-life 30 years) and with low loading ^{241}Am rod sources (half-life 433 years)

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

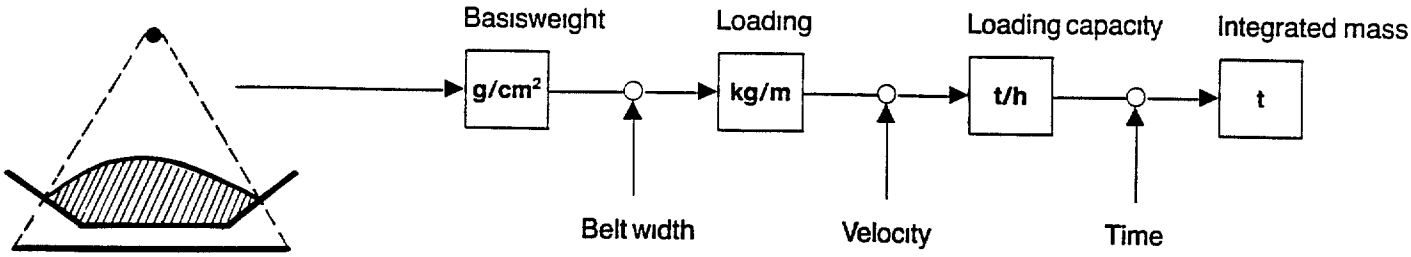


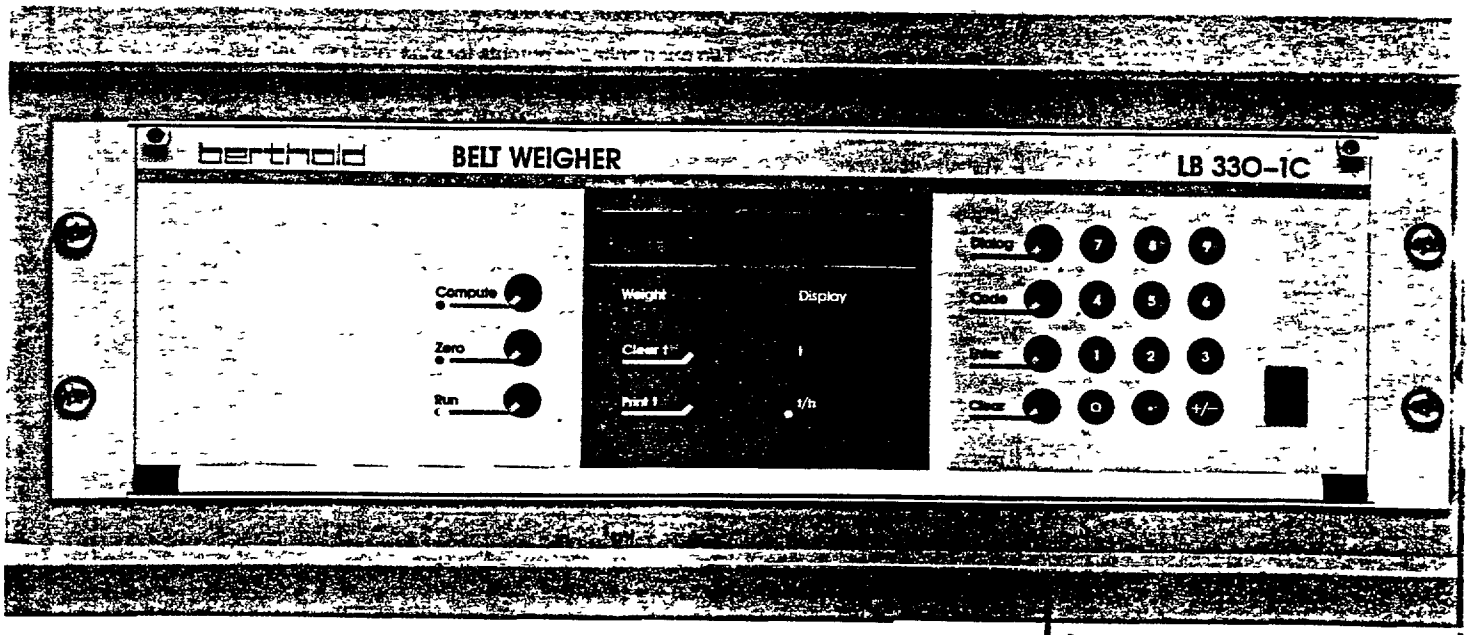
Width mm	A	B	H1	H2	L	Weight of Measuring frame approx. kg
500	1006	776	494	754	706	190
650	1156	926	584	844	856	220
800	1306	1076	674	934	1006	250
1000	1506	1276	794	1054	1206	290
1200	1706	1476	914	1174	1406	330
1400	1906	1676	1034	1294	1606	370
1600	2106	1876	1034	1294	1806	420

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



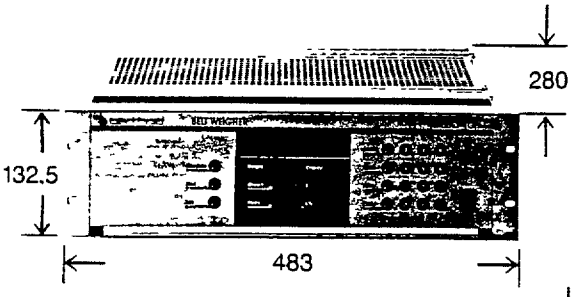


Evaluation unit installed in protection housing

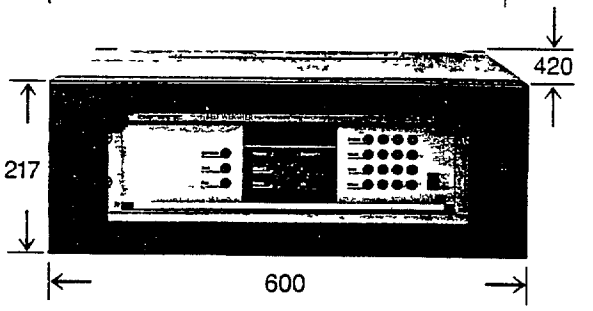
Dimensional Drawings

Dimensions in mm

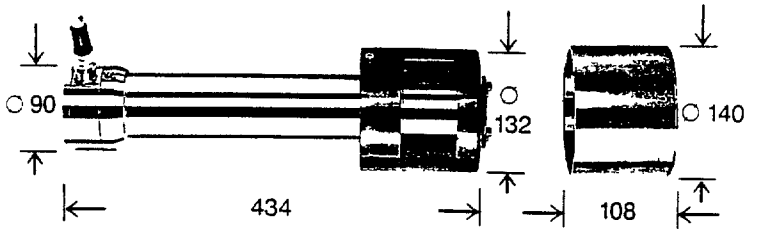
Evaluation unit
Weight approx 6 kg



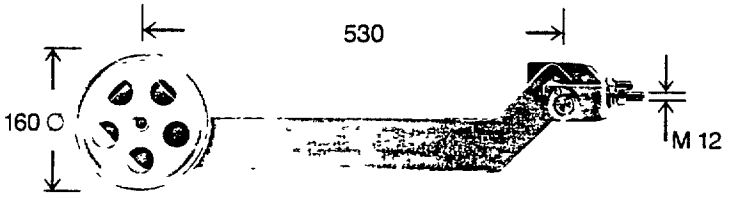
Evaluation unit in protection housing
Weight approx 18 kg



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 Ramsey Series 20B Belt Scale System

... a rugged, versatile performer.

The Ramsey Series 20B Belt Scale System is designed for general inplant conveyor-weighing applications in the most demanding industrial environments

The Series 20B offers a high degree of accuracy plus repeatable stability in helping you control feed rates to crushers, mills, screens and other processes It can monitor production output, control loadout of product, and monitor inventory while it generates information vital to the management and operation of your business.

Easy to install, indoors or outdoors, on fixed or portable conveyors, the Series 20B Belt Scale's rugged construction makes it a wise choice for particularly harsh applications including:

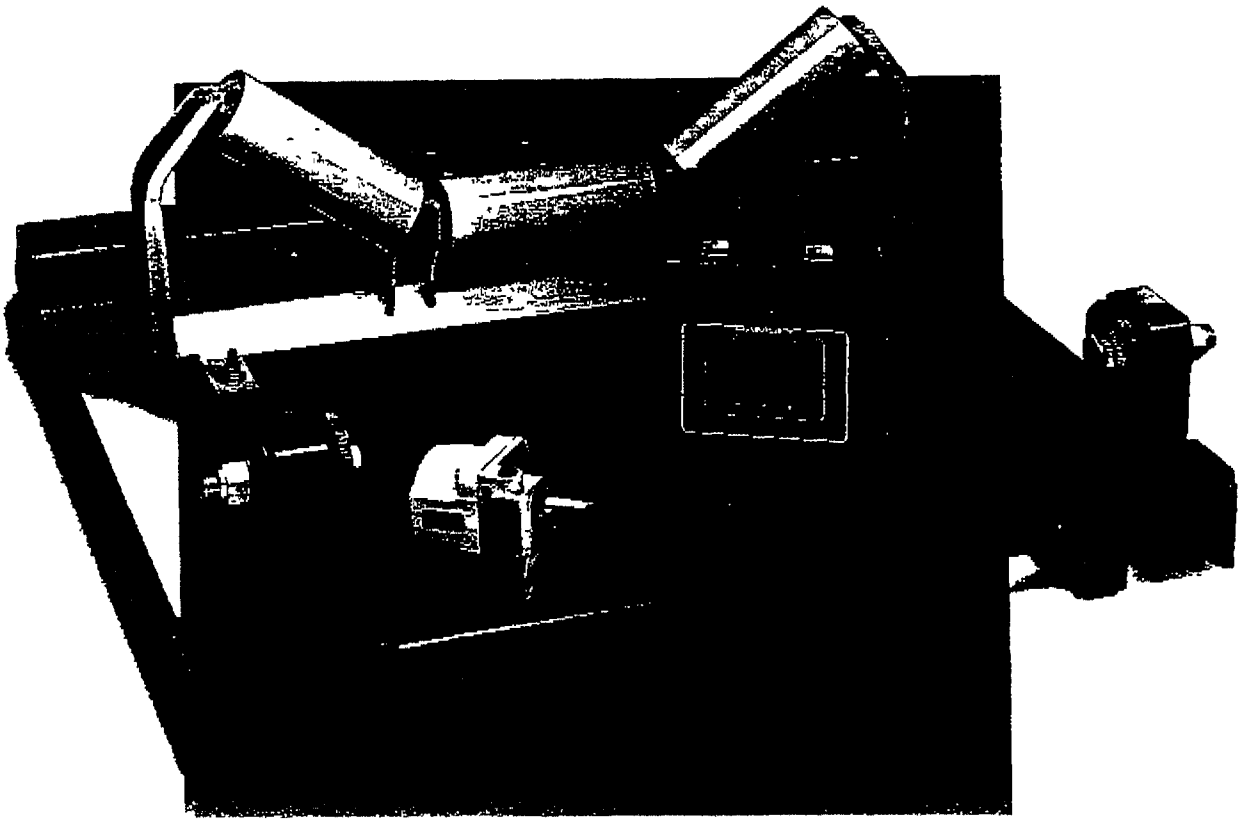
- crushing plants;
- chemical plants;
- asphalt plants,
- mines;
- cement mills.
- coal preparation plants;
- sand and gravel operations,
- coal-fired power plants;
- ore benefication processes,
- truck and rail loadout.

Continuing a tradition of innovative technology.

For over 40 years, Ramsey has earned a reputation for pioneering and developing belt conveyor scale technology. We have introduced most of the advances in electronic belt conveyors, including the first microprocessor-based scales

Now, the Series 20B Belt Scale System, featuring the Micro-Tech II Integrator with advanced digital hardware, gives you even greater capabilities.

The Micro-Tech II expands on the features offered by its predecessor which is in use in thousands of applications around the world New features include a large, easy-to-read display, user-friendly software with prompting to lead you through set-up and calibration, plus expanded computational and diagnostic capabilities



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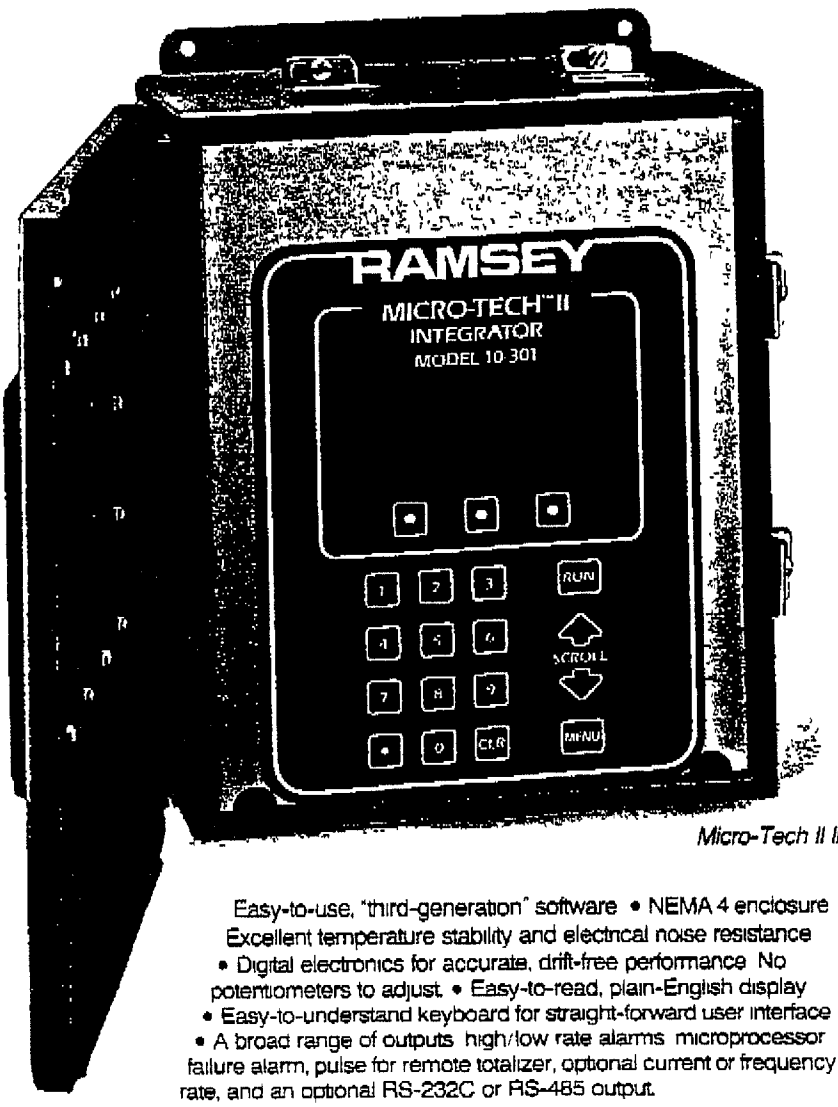
The Ramsey Series 20B. Built to handle even your toughest applications with unsurpassed accuracy and reliability.



Micro-Tech II Integrator

Easy-to-use, "third-generation" software • NEMA 4 enclosure Excellent temperature stability and electrical noise resistance • Digital electronics for accurate, drift-free performance No potentiometers to adjust. • Easy-to-read, plain-English display • Easy-to-understand keyboard for straight-forward user interface • A broad range of outputs high/low rate alarms microprocessor failure alarm, pulse for remote totalizer, optional current or frequency rate, and an optional RS-232C or RS-485 output.

The series 20B Belt Scale System combines the time proven reliability of Ramsey's scale carriage and speed sensor with the power and intelligence of the advanced electronics in the Micro-Tech II Integrator Each Series 20B element

- The Micro-Tech II Integrator,
- The Model 10-20 Carriage-Weighbridge,
- The Model 60-12 Digital Belt Speed Sensor

..plays a critical role in accurately weighing material moving on the belt

The easy-to-use, state-of-the-art Micro-Tech II Integrator.

With the advanced capabilities of the Micro-Tech II, you get enhanced accuracy and greater control over your operation It computes the rate at which material on the conveyor is passing It also totals material weight, energizes the weighbridge's load cell, powers the speed sensor, and provides all system information, calibration inputs and communications outputs.

The Micro-Tech II is designed for easy operation and calibration with a large, easy-to-read display, straight-forward, tactile-touch keyboard; and software that prompts the user through the proper set-up and operational procedures The third-generation" software is based on Ramsey's years of experience in belt scale development and application.

Easy-to-read display.

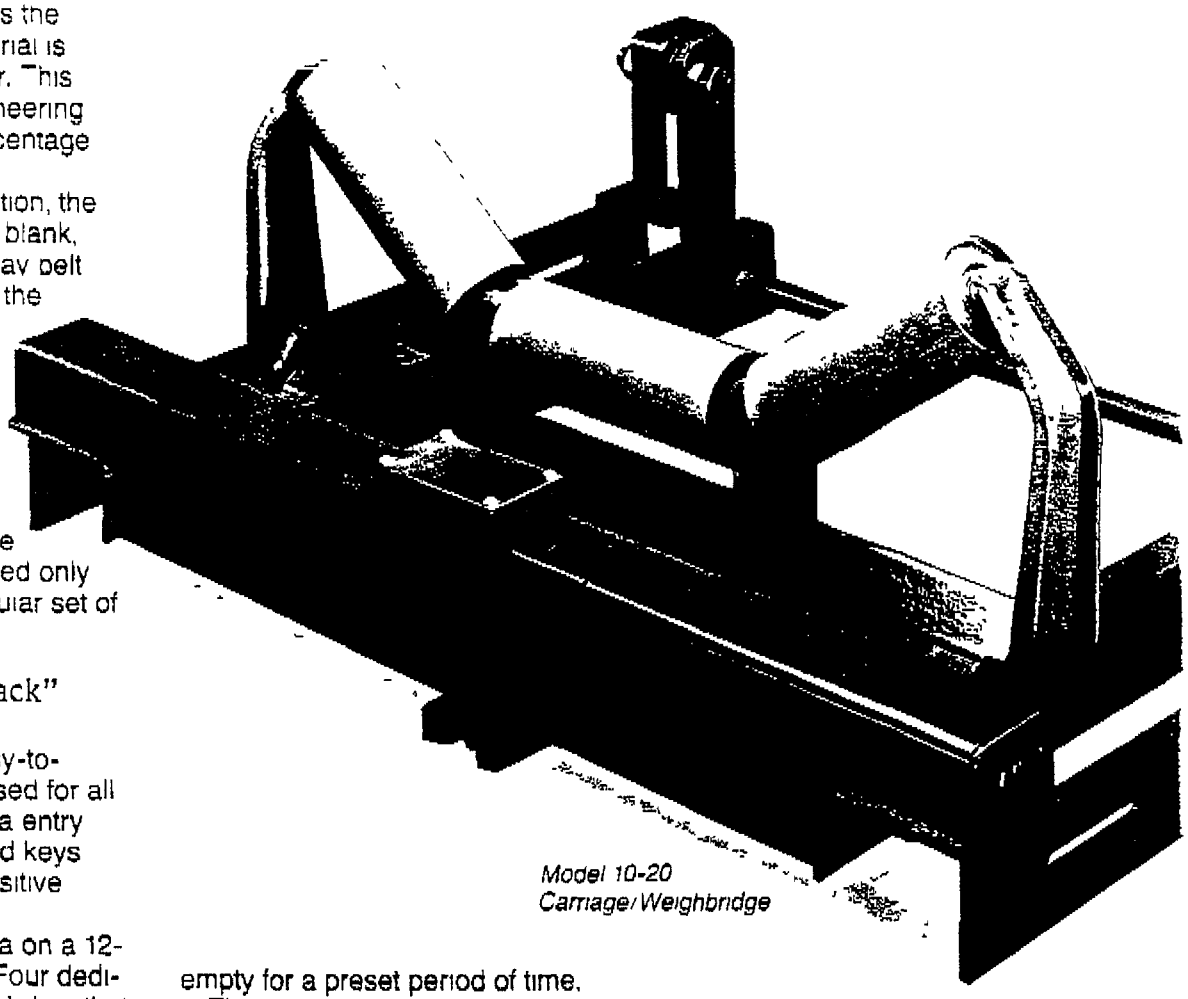
All data and user instructions are displayed on a bright, 4X20-character, alphanumeric, vacuum-fluorescent display. The engineering units are selectable to meet your particular application requirements. e g tons long tons, tonnes, pounds, kilograms.

In the normal running mode the top line displays total material weighed and is operator selectable to be either the master total or a resetable, shift total. Even if used in the reset-total mode, the master total is always being updated in the microprocessor's memory and can be called up on the display by the operator

The second line displays the current rate at which material is passing over the conveyor. This can be expressed in engineering units per hour or as a percentage of the calibrated range

At the operator's discretion, the third line can either be left blank, display belt speed or display belt loading The fourth line in the normal run mode is reserved for error messages.

In any calibrate or set-up mode, the first three lines are used to display prompt messages for the operator The fourth line identifies the function of the special "soft keys, activated only when required for a particular set of choices or options



Model 10-20 Carriage/Weighbridge

Simple, "positive feedback" keyboard.

The Micro-Tech II's easy-to-understand keyboard is used for all operator interface and data entry The large, clearly-identified keys have a tactile touch for positive operator feedback

The operator enters data on a 12-key, telephone-type pad. Four dedicated keys include a "RUN key that always returns you to the normal run mode, and three keys that allow you to access and scroll through the various set-up and calibrating menus

Three special soft keys provide set-up and calibration options

Quick and easy set-up.

On initial start-up, the Micro-Tech II leads the operator step-by-step through an intialization procedure The operator needs only to enter the applicable operating parameters of the specific installation No separate or external calculations are required

All future changes or selection of options are made via simple menus that are called up by the operator

A choice of easy calibration methods.

Micro-Tech II features operator-initiated, automatic zero and span functions A fully automatic, Auto Zero Tracking option is available that will initiate an auto-zero function whenever the conveyor belt runs empty for a preset period of time.

The auto span function allows you to use either Ramsey-pioneered, electronic calibration (standard on all units), or an applied test load, such as a chain or test weight A separate menu guides you through a weighed material load test.

Simplified troubleshooting.

A variety of special, built-in diagnostic functions assist in identifying operating faults. The microprocessor detects certain error conditions and generates an error message to alert the operator.

A test menu allows the operator to check the display and the microprocessor function, and to view a number of system-operating inputs and outputs Readily viewed, set-up menus allow verification of all set-up parameters.

If the operator cannot identify an operating problem, Ramsey technical service personnel can often interpret information from the unit over the phone to help get the system back in service quickly.

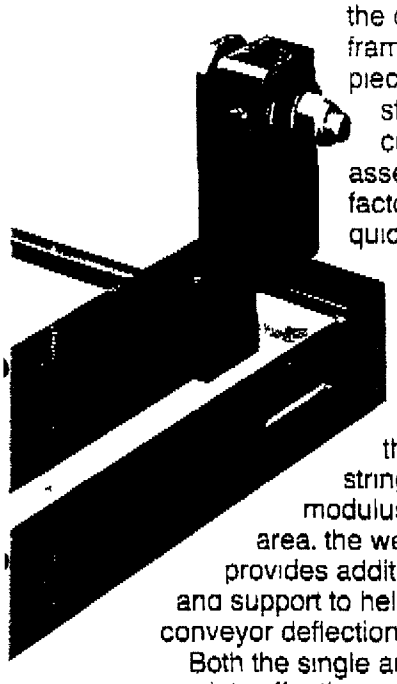
Accuracy.

On factory approved installations, Ramsey warrants that the Series 20B Belt Scale System will weigh and totalize to a value within ±½% of test value when calibrated against a known test weight, chain or Ramsey's standard electronic calibration.

The test rate must be between 25 and 100% of the scale system's calibrated capacity. Test duration is defined as at least 1000 counts on the master totalizer and at least ten (10) minutes running time Warranty is subject to the scale system being installed, operated and maintained in accordance with factory instructions

Permanently aligned weighbridge.

Rigid and rugged, the Model 10-20 Carriage/Weighbridge remains permanently aligned within the conveyor frame. The one-piece, drop-in style 10-20 is completely assembled at the factory and is quickly and easily installed and aligned in the conveyor. Designed and built to contribute to the conveyor stringer section modulus in the scale area, the weighbridge provides additional stiffening and support to help minimize conveyor deflection.



Both the single and dual idler models offer three point suspension and employ trunnion-type, frictionless pivots. These sealed units are impervious to vibration, moisture and product accumulation. This eliminates the problems associated with the application of knife edges and bearings in adverse environments.

Other features include:

- No moving or wearing parts;
- Precision, strain-gauge load cell applied in tension to guarantee load cell alignment and accuracy,
- A total deflection on weight idler(s) less than .004 inches,
- Slim profile to minimize material build-up and resultant zero shift,
- Optional counter-weighted carriages to meet light belt loading requirements

The world's most accurate and reliable belt speed sensor.

The Ramsey Model 60-12 Digital Belt Speed Sensor is the most reliable and accurate speed-sensing device ever developed for belt scale service. Any chance of belt slippage is eliminated and positive contact with the belt is always assured.

This is accomplished by direct-coupling the sensor to either the conveyor tail pulley, snubbing roll, or the large diameter lagged return roller. No wheels ride on the belt eliminating problems related to the build-up and slippage that cause speed measuring error.

The speed sensing element employs a brushless pulse generator which outputs pulse signals to the Micro-Tech II. Each pulse represents a unit of belt travel and the pulse frequency is proportional to belt speed.

Other features include

- Rugged, cast-aluminum housing suitable for outdoor installation,
- A.C. pulse generator—no brushes to adjust or replace.

We back up quality products with the best in customer service.

When you select a Ramsey 20B Belt Scale System, you get a high quality product backed by a service-oriented organization.

Knowledgeable sales representatives throughout the U.S. and around the world assist you with application requirements.

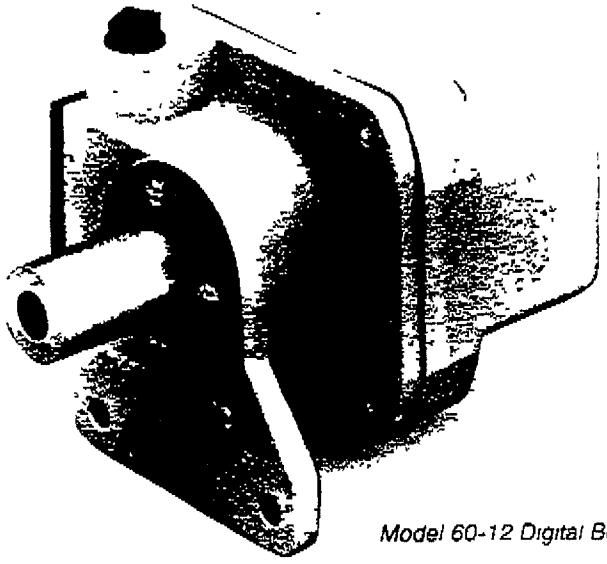
A large customer service staff at our Minneapolis headquarters, and at affiliated companies outside the U.S., assist you with technical service questions and spare parts requirements.

Experienced factory service technicians and authorized independent service representatives are available, on request, to provide you with on-site service support and assistance.

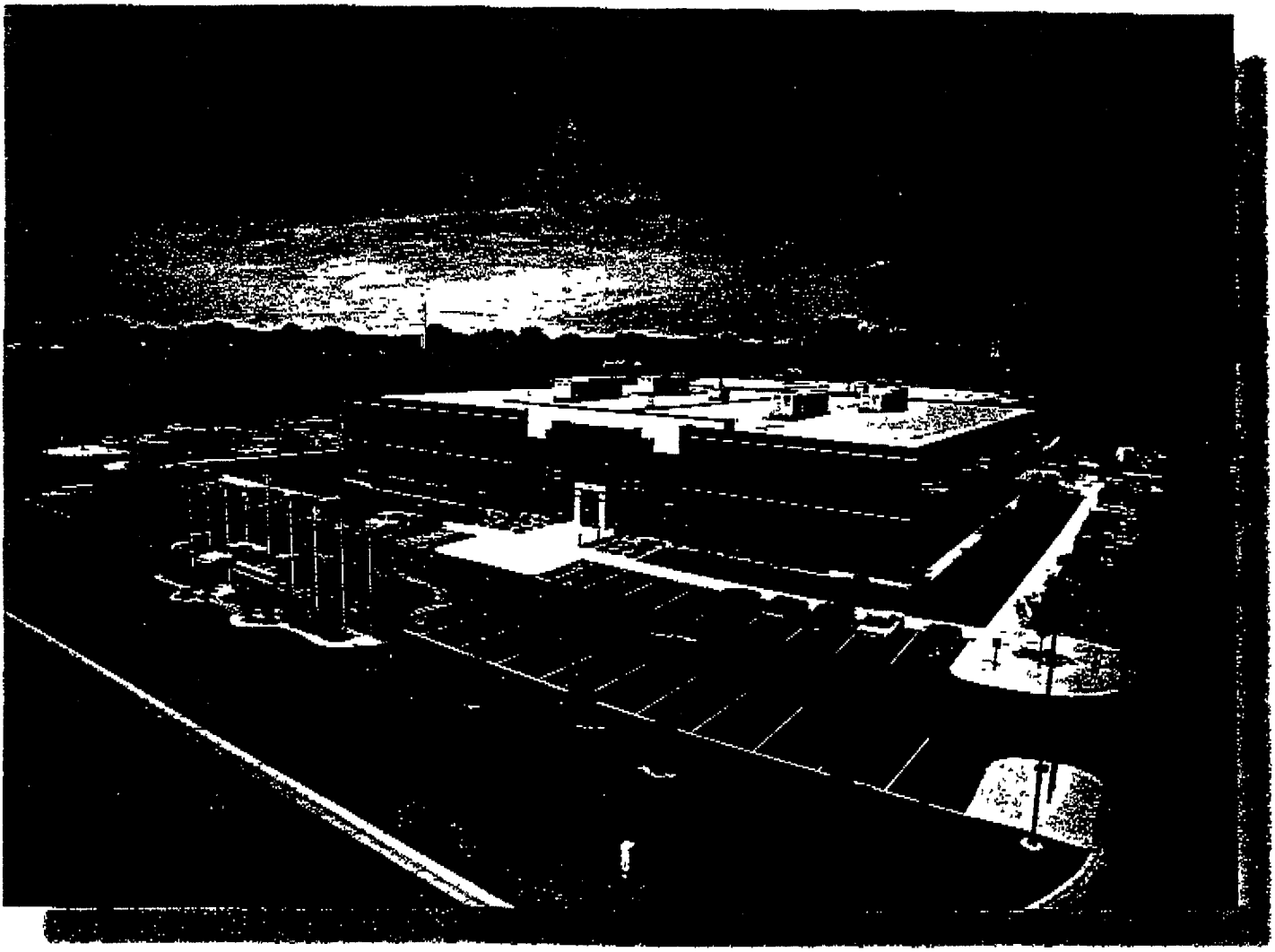
From the moment you make the decision to select Ramsey you know it's the right choice.

Technical data.

If you require additional detailed specifications, dimensions, shipping weights, etc., relative to the Series 20B Belt Scale System, please request the Series 20B Technical Data Sheet. Ramsey Catalog No. 13.301



Model 60-12 Digital Belt Speed Sensor



Ramsey Technology, Inc. has specialized in the field of process instrumentation and automatic control since 1953

Throughout Ramsey's product family you will find an intrinsic ruggedness in design and construction that assures reliable performance in the most demanding industrial environments In addition to the system described in this catalog, Ramsey undertakes custom automation control projects and is eager to work with you in the solution to your specific needs

Ramsey sales representatives are located throughout the United States and in dozens of countries worldwide. With that and manufacturing facilities on three continents, Ramsey can supply your needs wherever you are located.

For additional information on any of Ramsey's products, call or write Ramsey Technology, Inc , or any of our affiliate companies today!

RAMSEY TECHNOLOGY INC.

501 90th Avenue N W
Minneapolis, MN 55433
(612) 783-2500 FAX (612) 783-2525

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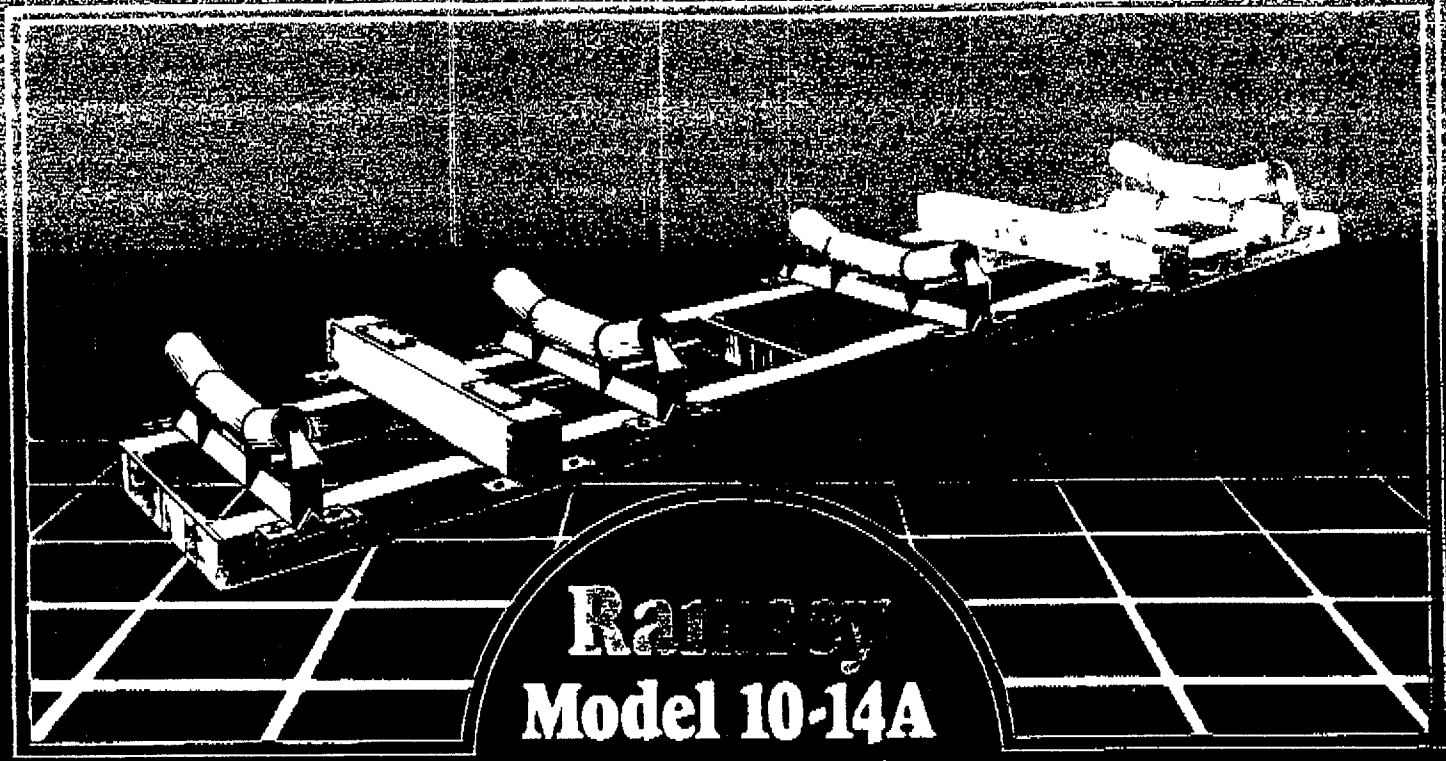
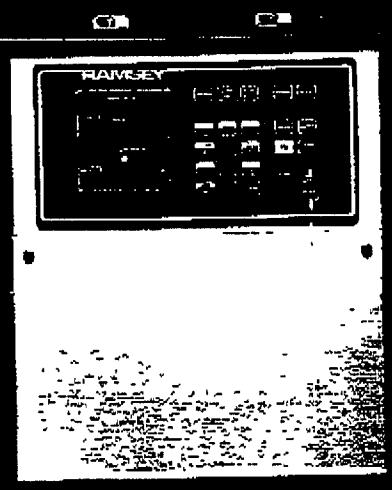


Ramsey
Model 10-14A
Precision Belt Scale System



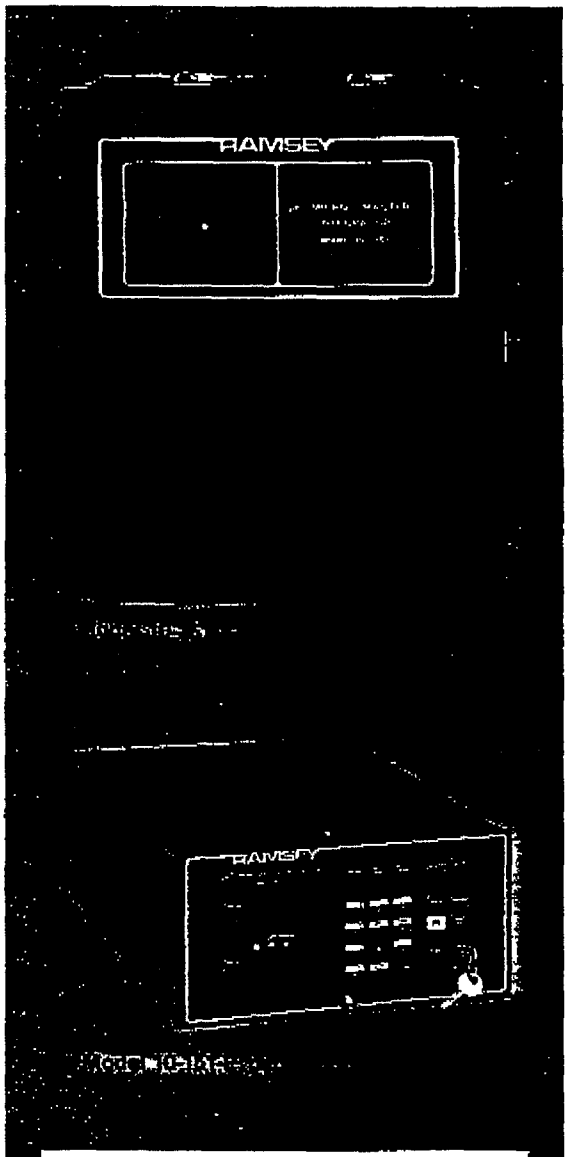
State of the Art Technology Provided by
RAMSEY'S µP® MICRO-MASTER™ Microprocessor-Based Integrator

Introduction:

Ramsey s Series 14 Precision Belt Scale is the most widely certified electronic belt conveyor scale on the market, with certification against Handbook 44 by many states and weighing bureaus within the United States, and certification against both OIML and EEC Class I standards outside the U.S

Ramsey s introduction of the Series 14A Belt Scale System is another step towards ultimate excellence A new world standard of precision performance for belt conveyor weighing Ramsey s μP® MICRO-MASTER™ Integrator has "second generation" microprocessor-based technology which provides the most advanced conveyor scale electronics available μP® (mū-pee) is Ramsey s symbol for microprocessor-based weighing technology

The Series 14A System continues to incorporate the Model 10-14 low deflection, full floating unitized carriage/weighbridge and Ramsey s 60-12 digital speed sensor, both widely proven on hundreds of precision conveyor weighing applications The new electronics package is what really makes the new Series 14A System a standout! The Model 10-150 load cell exciter/digitizer and Model 10-151 MICRO-MASTER integrator are the products of years of Ramsey experience incorporating second generation microprocessor technology and software. The result is unparalleled electronic stability and system weighing accuracy.



The Series 14A System is specifically designed for basis-of-payment, fee holder-type applications requiring certification by governmental and/or regulatory agencies, and generally for customers who want the best available conveyor weighing performance for their application

How the System Operates:

Ramsey Series 14A precision belt scales have four (4) major components The carriage/weighbridge, load cell digitizer, speed sensor, and integrator, often referred to as the totalizer

The carriage/weighbridge assembly houses four (4) precision load cells that serve as the primary weight sensors The load cells generate an electrical output signal proportional to belt loading, usually expressed in pounds per foot The full floating carriage mounts to the conveyor stringers and supports the weigh idlers The speed sensor is an electro-mecnanical device attached directly to the tail pulley or other large diameter idler pulley so positive contact with belt is assured. The speed sensor produces a variable frequency pulse output signal which is proportional to true belt speed The load cell digitizer energizes the load cells and converts the load cell output signal to an accurate, stable digital transmission to the MICRO-MASTER Integrator The integrator provides intelligence to the system, calculates and displays rate, total weight and other variables It also provides operating interface and diagnostics

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Model 10-14 Carriage/ Weighbridge

Ramsey's 10-14 carriage/ weighbridges are three (3) or four (4) idler suspension-type featuring full floating unitized assembly with no pivot points and no moving parts All carriage/weighbridges are constructed of structural steel tubing and are factory pre-assembled with checkrods to facilitate fast and easy field installation Only eight (8) bolts are required to mount the unit to conveyor stringers To reduce scale area deflection, additional conveyor stringer supports may be required. Four (4) hermetically-sealed precision load cell assemblies are applied in tension to support the weighbridge.

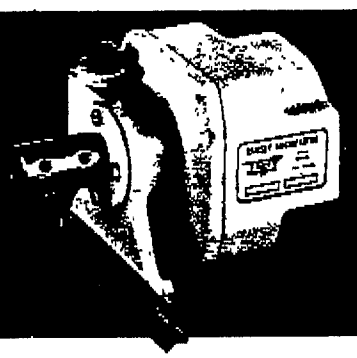
The load cells are sized to provide at least 100% overload protection and are structurally safe to 250% of rated belt scale capacity Each of the four load cells can withstand at least a 3,750 pound load

Static measuring accuracy of the carriage/weighbridge assembly is within 05% of scale capacity Because of excellent system linearity from 25 to 100% of rated capacity, test weights and/or roller-type calibration chains can be "sized to simulate loading at 40% to 75% of scale capacity instead of 75% of capacity which has been previous "rule of thumb" in the industry As a result, the cost of the calibrating equipment can often be significantly reduced.

WEIGHBRIDGE FEATURES

1 Rigid structural steel tubing construction with checkrods—maintains positive alignment
2 No moving or wearing parts—no adjusting, longer lifespan.
3 Factory pre-assembled—ease of field installation
4. Four (4) load cells applied in tension to carriage
5 Full floating weigh platform.

Model 60-12 Digital Speed Sensor:



The Ramsey Model 60-12 Digital Belt Speed Sensor is the most positive, reliable and accurate speed sensing device yet developed for belt scale service. The unit is designed and constructed for direct connection to a conveyor tail pulley, snubbing roll or large diameter lagged return roller where there is no chance of belt slippage, and positive contact with belt is assured. Problems associated with wheels attempting to contact the belt and resulting build-up and slippage are thus avoided

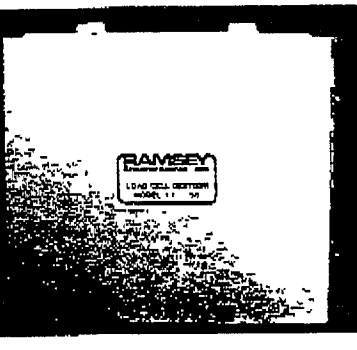
The speed sensing element employs a brushless pulse generator producing a stream of pulses, each pulse representing a unit of belt travel. Frequency of the pulse stream is proportional to true belt speed.

No brushes to replace or adjust The pulse output (belt speed) signal is fed to the MICRO-MASTER Integrator

DIGITAL BELT SPEED SENSOR FEATURES

1 Positive, direct connection to tail pulley shaft, snubbing roll or large diameter lagged return roll —no wheels riding on belt with resulting build-up and speed measuring error.
2. Rugged cast aluminum housing is suitable for outdoor installation.
3 AC pulse generator—no brushes to replace or adjust.

Model 10-150 Load Cell Exciter/Digitizer:



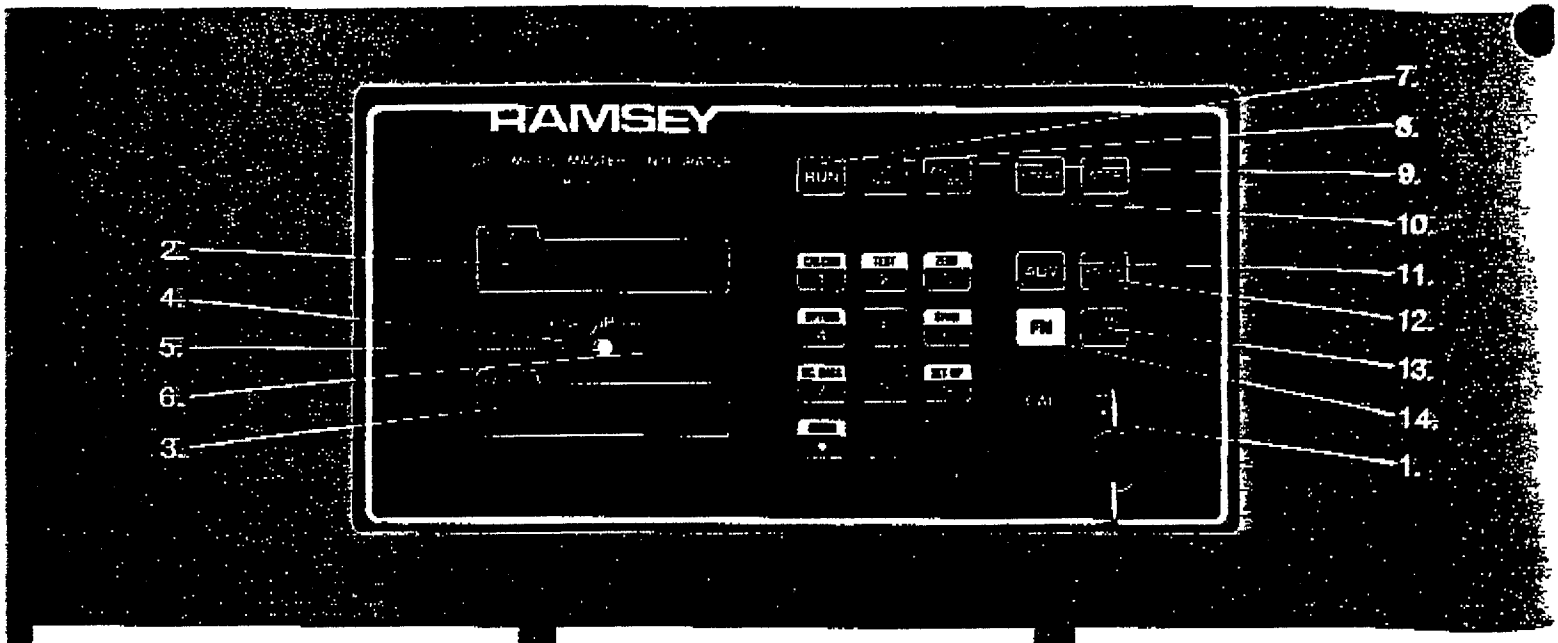
The Ramsey Model 10-150 Load Cell Exciter/Digitizer serves as an interface from the 10-14 carriage/ weighbridge to the Model 10-151 μP® MICRO-MASTER Integrator The unit powers the load cells and converts the analog force signals from the strain gauge load cells to an accurate, stable digital output for use in totalization in the MICRO-MASTER Integrator

The 10-150 is a digital microprocessor-based device providing A/D conversion and extraordinary temperature stability The enclosure is fabricated of 14-gauge steel and conforms to the NEMA standard for Type 4 (water-tight and dust-tight) In addition to protecting the electronic circuit boards from moisture and dirt, the enclosure also serves to shield the electronics from electrical noise

LOAD CELL DIGITIZER FEATURES

1. Accepts international power requirements 50/60 Hz, 100-260 Volts
2 Load cell digitizer is housed in a dust-tight, weather-tight enclosure that is suitable for outdoor installations.
3 No periodic adjustments or calibration
4 Digital accuracy
5. Extraordinary temperature stability

Model 10-151 EP MICRO-MASTER Integrator:



Ramsey's MICRO-MASTER Integrator has microprocessor-based technology which offers advanced software, the product of years of Ramsey innovation and experience. The bright easily-read alpha-numeric displays interface with the operator to assist in set-up, calibration and diagnostics. Multiple outputs are available for process monitoring and control including the capability for direct interface with a computer.

PANEL FEATURES

1 KEY SWITCH. When key switch is in the "RUN" position, the integrator is security safe. Key operating parameters of the integrator cannot be changed. When the key switch is in the "CAL" (calibrate) position, all operating parameters such as zero, span, test duration, etc., are accessible.

DIGITAL DISPLAYS

2 TOTALIZER. In normal "RUN" mode, the total material weight is read on the 12 digit vacuum fluorescent, alpha-numeric display, easily readable in high or low ambient light. When in "CALIBRATE" mode, the display can also indicate various messages such as scroll names. When the "RUN" button is depressed, the master total is again displayed.

3. RATE INDICATOR. In normal "RUN" mode, the rate of material passing over the belt scale is displayed in your choice of engineering units. The rate display is the same type and size as the totalizer. In "CALIBRATE" mode, the rate display also indicates various scroll options and scale constants which are selected via the keyboard. If an error occurs, the error location will be indicated on the rate display.

LED INDICATORS

4. (HIGH LOW RATE INDICATOR) When red LED illuminates a pre-settable low or high rate within the microprocessor has been exceeded. High or low rate remote alarm outputs are active when indicator is on.

5. µP (MICROPROCESSOR INDICATOR) While the green LED is illuminated, the microprocessor is operating in a normal mode.

6 ERROR. When red LED illuminates, an error within the weighing system has occurred. A remote alarm output will activate at this time.

OPERATING PUSHBUTTONS:

7 RUN. When depressed the "RUN" button causes the integrator to operate in normal mode.

8 AUTO ZERO. When depressed, the "AUTO ZERO" button initiates an automatic zero calibration.

9. AUTO SPAN. When depressed the "AUTO SPAN" button initiates an automatic span calibration.

10. START STOP. The "START" and "STOP" buttons are used to manually start or stop an auto zero, auto span, acquired test duration or test procedure.

11 ADVANCE. When depressed, "ADVANCE" button advances to the next scroll position, operation or option visible in either total or rate display.

12. ENTER. When depressed, the "ENTER" button allows insertion of newly computed values replacing old zero, span, etc.

13. LAMP TEST. When depressed displays will alternately flash all segments of alternate characters off and on. The HIGH/LOW and ERROR LED's will blink off and on about once a second.

14 FUNCTION. When depressed the "FUNCTION" button selects various special functions shown on upper half of digit pushbuttons and displays them in the total display.

NOTE. Certain pushbuttons are operable only with key in "CALIBRATE" position.

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FUNCTION AND KEYBOARD PUSHBUTTONS.

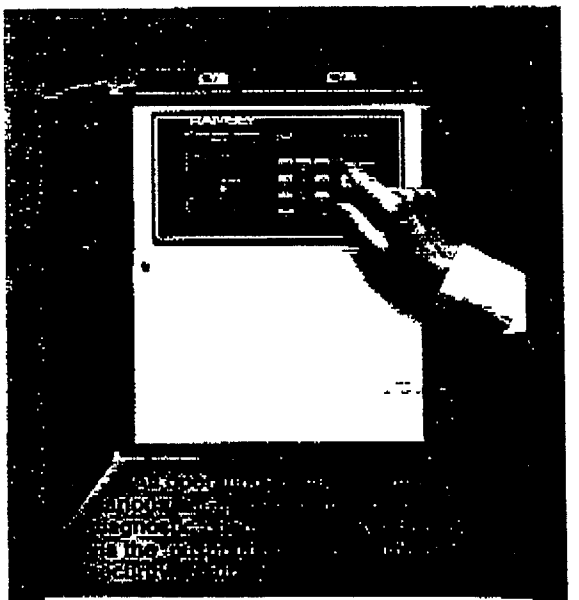
The 'Function' pushbutton relates to the 12-key keyboard. If pressed first, it addresses a keystroke on the keyboard to an upper case "function" as opposed to the lower case 'number'. It is through this keyboard with its various functions and numbers that all initial data peculiar to your scale installation is originally entered into the microprocessor's memory. Selection of operating choices such as English versus Metric, engineering units, scale capacity, etc., are entered via the keyboard. The keyboard is also used to call up and display various constants and data stored in memory, and interrogate the microprocessor for diagnostic and trouble-shooting purposes. The keyboard is non-functional when the key switch is in the normal "run" position. There is no concern over accidental data entry or system adjustments by unqualified operators. Only qualified personnel with a key to switch the unit to the "calibrate" position can access the keyboard and its many functions and data. All the functions and data stored in the MICRO-MASTER memory are too extensive to cover in this publication. Upon request, a Ramsey representative can provide more information or a demonstration of the power of MICRO-MASTER.

SET-UP:

To prepare MICRO-MASTER for operation, it is only necessary to enter several constants in the microprocessor memory via the pushbuttons. If full scale data is provided with order, these can be installed at the factory during check-out. Once installed, start-up can be as simple as running an auto zero, an auto span, and depressing the 'RUN' button.

CALIBRATION:

The automatic calibration feature allows you to use either Ramsey pioneered electronic calibration or an applied test load such as static weights or a chain. The choice is selectable via the pushbuttons. The microprocessor also provides a separate totalizer function to assist in running weighed material load tests. An additional selectable feature is Auto Zero Tracking where the auto zero function is automatically initiated when the belt runs empty for a period of time. (For more information on calibrating a conveyor scale, refer to Ramsey's Catalog Sheet Number 11.100.)



ACCURACY

On factory approved installations, Ramsey warrants that the Series 14A Precision Belt Scale System will weigh and totalize with an error of less than 0.25% (±⅛%) of test load at flow rates of between 25 and 100% of the scale systems' calibrated capacity when calibrated against an actual weighed material test. Further, Ramsey warrants that the scale system will repeat to within 0.1% of consecutively-run simulated calibration tests (e.g., Ramsey electronic calibration or test chain). Test duration is defined as at least three (3) circuits or revolutions of the conveyor, or at least 1,000 counts on the master totalizer and at least ten (10) minutes running time. Warranty subject to scale system being installed, operated and maintained in accordance with factory instructions.

DIAGNOSTICS

MICRO-MASTER features several diagnostic functions that allow the operator or serviceman to check the unit's stored data and operating functions. One unique feature is the unit's ability to "scroll" through its stored calibration constants and operating data. Simply pushing FUNCTION, SET-UP then ADVANCE repeatedly scrolls through various set-up functions on the totalizer display. Other diagnostic functions that allow checking of the load cells and microprocessor function are accessible via the pushbuttons.

MICRO-MASTER FEATURES

1. All digital data processing. MICRO-MASTER is a true digital device, not an analog device with a digital readout like others call "digital". Digital processing, integration and totalization of data provides optimum drift-free stability.
2. Advanced software. The product of years of Ramsey's innovation and experience.
3. Continuous self-checking of software and hardware. L.E.D. indicators illuminate when high/low rate alarm or when an error occurs.
4. Automatic calibration. Automatic zero, automatic span, selectable auto zero tracking and auto test duration are all built in.
5. Accepts international power requirements. 50/60 Hz 100-260 Volts.
6. Simple entry of all data and instructions via pushbuttons. All keys are of membrane tactile feedback type.
7. No internal adjustments. MICRO-MASTER contains no potentiometers or adjustable resistors to cause problems.
8. Multiple output capability. In addition to two pulse outputs and two current outputs and alarms, MICRO-MASTER also has 20 mA, serial digital or RS 232 outputs available (ASCII protocol.)
9. Vacuum fluorescent alpha-numeric displays provide easy-to-read digital display in high and low ambient light.
10. Extraordinary temperature stability.
11. Backed up by proven Ramsey know-how and service availability.

Mechanical Specifications

MODEL 10-14 WEIGHBRIDGE

Weigh Span three or four idler suspension 144" (3 66 meters) minimum weigh span

Clearance Requirements fits any standard conveyor No space required above belt line See plan view drawing for deck plate cut-out dimensions

Idlers idlers are normally furnished by customer Ramsey can supply on request

Weighbridge Design unitized assembly consisting of full-floating weigh platform and two support beams which attach to the conveyor stringers

Conveyor Sizes 18"-84" belt widths (400mm-2 000mm)

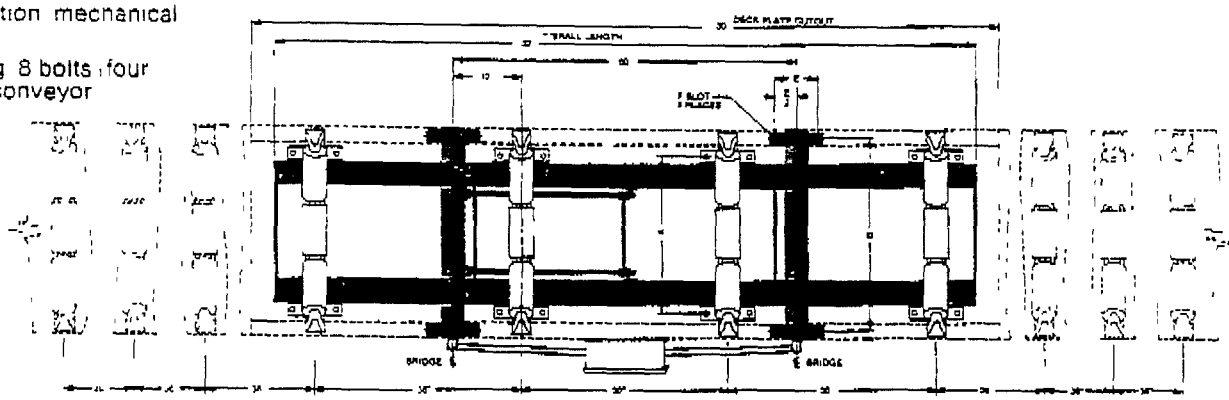
Weighbridge Construction mechanical steel tubing

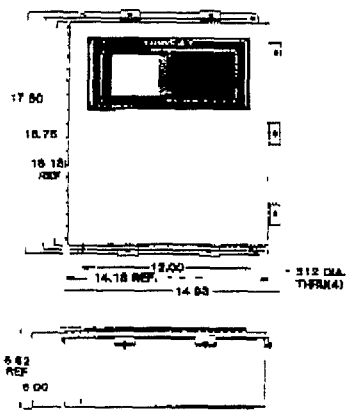
Weighbridge Mounting 8 bolts (four per support beam) to conveyor stringers

BELT WIDTH*	A	B	C	D	E	F	CRATED SHIPPING WEIGHT**		CRATED VOLUME**	
							10-14-3	10-14-4	10-14 3	10-14-4
84"	87	93	95½"	89 ¼	0	[illegible]x1"	965 Lbs	1 020 Lbs	96 Cu Ft	105 Cu Ft
72	75	81"	83 ½"	77¼"	10"	[illegible]x1"	905 Lbs	965 Lbs	84 Cu Ft	90 Cu Ft
60	63"	69"	71 ½"	65¼"	10"	[illegible]x1"	850 Lbs	905 Lbs	72 Cu Ft	78 Cu Ft
54"	57"	63"	65½"	59½"	10"	[illegible]x1"	820 Lbs.	880 Lbs	66 Cu Ft	72 Cu Ft
48	51"	57"	59½"	53 ¼"	10"	[illegible]x1"	790 Lbs	850 Lbs	60 Cu Ft	65 Cu Ft
42	45	51"	53½"	47 ¼	10"	[illegible]x1"	765 Lbs	820 Lbs	54 Cu Ft	58 Cu Ft
36	39	45"	47 ½"	41¼	7½"	[illegible]x1"	735 Lbs	795 Lbs	48 Cu Ft	52 Cu Ft
30"	33	39"	41½"	35¼"	7½"	[illegible]x1"	705 Lbs	765 Lbs	42 Cu Ft	46 Cu Ft
24"	27"	33"	35½"	29¼"	7½	[illegible]x1"	675 Lbs	735 Lbs	36 Cu Ft	39 Cu Ft
20	23"	29	31½"	25 ¼	7½"	[illegible]x1"	660 Lbs	715 Lbs	30 Cu Ft	33 Cu Ft
18	21"	27"	29 ½"	23¼	7½"	[illegible]x1"	650 Lbs	705 Lbs	30 Cu Ft	33 Cu Ft

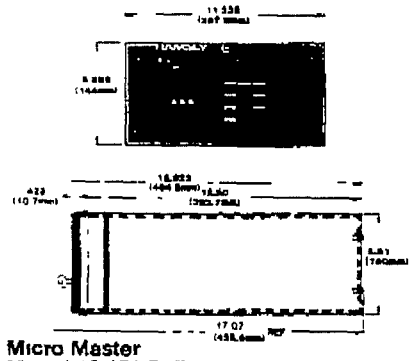
*NOTE Also available in D I N J . S and other metric standards
**NOTE Applies on single unit shipments only (idlers excluded)

For illustration purpose, only 4 idler dimension drawing is shown. 3 idler, 4 ft. spacing dimensional drawing available upon request.

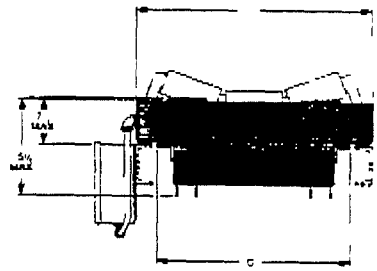




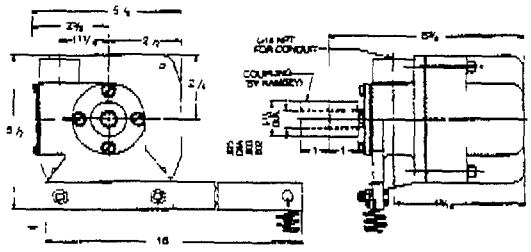
Micro Master
Model 10-151-4. Field, surface mount, NEMA-4
Weight: 39 5 lbs. Boxed shipping weight: Approximately 44 lbs



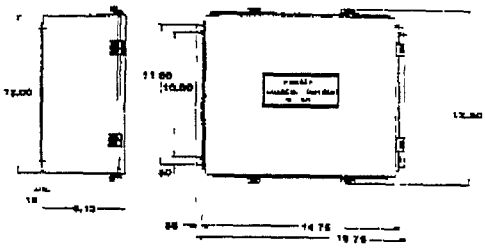
Micro Master
Model 10-151-P Panel mount
Weight: 22.75 lbs Boxed shipping weight. Approximately 25 lbs.



Cross Section



Model 60-12 Digital Speed Sensor
Weight 8 lbs
Boxed Shipping Weight 10 lbs.



Model 10-150 Load Cell Digitizer
Surface mounting, NEMA-4.
Weight 25 lbs.
Boxed shipping weight: 26 lbs.

NOTE Dimensions in inches

Electrical Specifications:

LOAD CELLS

Load Cell Type environmentally sealed super-precision strain gauge with special temperature compensation

Load Cell Mounting four (4) cells applied in tension

Non-Linearity Maximum 05% of rated output

Repeatability within 02% of rated output

Hysteresis: max 03% of rated output

Temperature Sensitivity ± 0006% per degree F on zero balance ± 0008% per degree F on rated output

Overload Protection (as applied in typical weighbridge) Minimum of 100% to maintain electrical integrity Minimum of 250% to maintain structural integrity (Each of the four load cells are capable of supporting at least 3 750 pounds)

LOAD CELL DIGITIZER, MODEL 10-150

DIGITIZER TYPE
Continuous electronic load cell to digital signal digitizing

CIRCUIT DESIGN
Modular, solid state, microprocessor-based electronics

CIRCUIT CONSTRUCTION
6502' microprocessor with 4K bytes ROM (program) memory and 128 bytes data memory Microprocessor operates at 300,000 instructions per second

POWER REQUIREMENTS
Selectable 110 130 150 220 240 or 260 VAC 50 or 60 Hz, 50 VA max

LOAD CELL EXCITATION
10 or 15 Vdc 260 mA maximum

OUTPUTS
Standard Digital Serial Data Output 20 mA current loop 600 baud compatible with Ramsey Model 10-151 Micro-Master Integrator

CALIBRATION
No periodic calibration required

OPERATING TEMPERATURE RANGE
−40°C to +50°C (−40°F to +122°F)

TEMPERATURE SENSITIVITY
For −10°C to +50°C
Zero 0 15 μV/°C maximum
Span 4 0 ppm/°C maximum
For −40°C to −10°C
Zero 0 15 μV/°C maximum
Span: 8 ppm/°C maximum

ACCURACY
Within 0 044% of load cell capacity over full temperature range of −40°C to +50°C Within 0 022% of load cell capacity −10°C to +50°C

LINEARITY
Better than 0 01% of net for inputs from 0 to 105% of full scale

CONVERSION RATE
10 conversions/second

ISOLATION
Complete optical isolation (250 Vac minimum) between inputs and outputs

ENCLOSURE
Surface mounting NEMA-4

μP MICRO-MASTER INTEGRATOR-MODEL 10-151

INTEGRATOR TYPE
Continuous electronic

CIRCUIT DESIGN
Modular 100 percent solid state microprocessor-based electronics.

CIRCUIT CONSTRUCTION
"6809 microprocessor with up to 24K bytes permanent (program memory), 1K byte data memory (calibration constants entered through front panel push buttons) Microprocessor operates at 250 000 instructions per second

POWER FAILURE PROTECTION
Replaceable long-life energy cell capable of protecting RAM for up to three years with power off

COUNT RATE
Up to 194 400 counts per hour (front panel selectable)

INPUTS
(1) Digital Serial Data (load) Input 20 mA current loop, from Load Cell Digitizer
(2) Auxiliary Digital Serial Input, 20 mA current loop, allows full remote control of front panel operations (RS232C optionally available.)
(3) Digital Voltage or Current Speed Input from Speed Sensor
(4) Operator Inputs
(a) 21 front panel operating pushbuttons, membrane (flush) type with tactile feedback
(b) One keyswitch, lead wire sealable for controlled calibration access

OUTPUTS
(1) Two blue-green vacuum-fluorescent displays, 12-character 16-segment alpha/numeric
(a) Total display Direct reading 8 digit display of accumulated total in English (pounds short or long tons) or metric (kilograms, or tonnes) units
(b) Rate display Direct reading 4-digit display of material flow rate in English or metric units
(2) Three L E D indicators
(a) Red ERROR ' (alarm) indicator
(b) Red HIGH/LOW (rate) indicator
(c) Green MICROPROCESSOR OK indicator
(3) Three isolated transistor switch outputs rated 24 Vdc, 100 mA for remote indication of ERROR HIGH RATE , and LOW RATE alarms
(4) Two Remote Total Counter Outputs
(a) Solid state optically isolated relay output with 240 Vac 2 5 Amp contact closure for remote AC mechanical counter Relay contact closure rate and duration front panel selectable
(b) Isolated Transistor switch output for high speed DC remote counter Switch rated 24 Vdc 1 6 mA
(5) Auxiliary Digital Serial Output isolated 20 mA current output for remote indication of displays (RS232C optionally available)
(6) Current Outputs (one included) selectable 0 mA to 20 mA or 4 mA to 20 mA for remote indication of 0 to 100% flow rate Second optional for remote indication of belt loading
(7) Second internal resettable total counter
(8) 24-hour clock 200-year calendar
(9) Internal test and diagnostics
(10) Pushbutton indication of all operating and calibration parameters
(11) R-Cal Output for remote control of Digitizer R-Cal relay

CALIBRATION
Test duration: Automatic calibration duration acquisition.
Zero: Automatic assisted and unassisted (Auto Zero Tracking) zero calibration Selectable Sealed Zero feature prevents unauthorized zeroing Adjustable Zero Limit controls zero adjustment range
Span: Automatic span calibration using weights, chain, R-Cal (electronic) material, or post (pre-weighed) calibration methods

ACCURACY
Within 0 009% of full scale.

LINEARITY
Integrator has *no* integrator linearity errors

OPERATING TEMPERATURE RANGE
−10°C to +50°C (+14°F to +122°F)

TEMPERATURE SENSITIVITY
Due to the digital nature of the integrator, there are *no* temperature induced zero or span errors

TEMPERATURE SENSITIVITY OF CURRENT OUTPUTS
Zero 0 25 μA/°C maximum
Span 35 ppm/°C typical
65 ppm/°C maximum

POWER REQUIREMENTS
Selectable 110, 130 150, 220, 240 or 260 Vac −15 + 10%, switch selectable, 48-62 Hz, 35 VA maximum

ENCLOSURES
Model 10-151-4 Field surface mount, NEMA-4
Model 10-151-P Panel mount, 288 x 144 DIN 43 700

Applications:

The Series 14A Precision Belt Scale System combines the advantages of a low deflection, full floating unitized weighbridge, with the computation capability of a microprocessor-based integrator. This provides you with a total system unequaled in ruggedness, stability and weighing accuracy.

The Series 14A Precision Belt Scale System provides the best possible weighing accuracy for loadout, inventory or fee holder-type applications. It is recommended for applications requiring certification by governmental and/or regulatory agencies.

Ramsey Technology, Inc. has specialized in the field of process, instrumentation and automatic control for over [illegible] years. Throughout Ramsey's product family you will find [illegible] rugg[illegible] construction that [illegible] reliable performance in the most demanding [illegible] environments.

Other [illegible] include: weighbe[illegible] weighing systems, [illegible] systems, con[illegible] spec[illegible] and bulk[illegible]ems.

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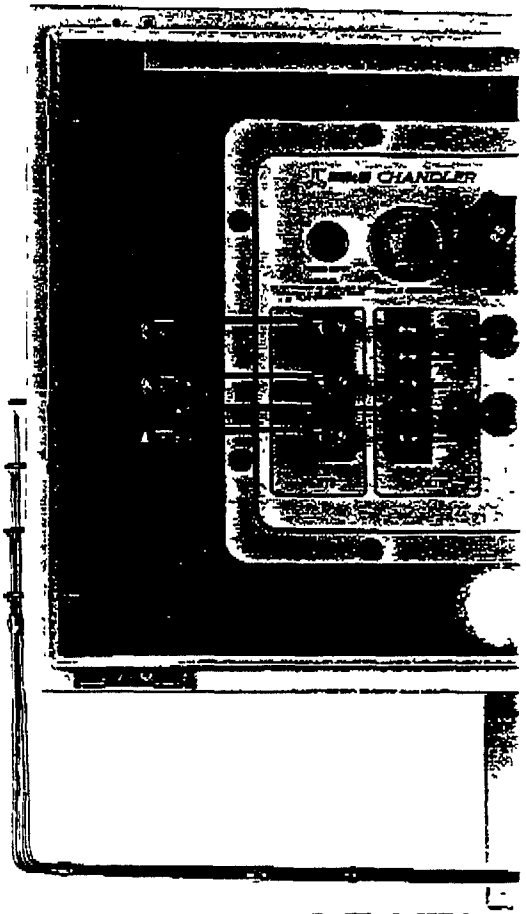
Catalog No. 10.401 (REV. 3/94)

Printed in U.S.A.

High Performance. Low Maintenance. Lower Costs.



For years, the natural gas industry has needed a more reliable, field-ready on-line BTU Analyzer. One that would be easier to install, easier to operate, and easier to maintain. With true, bidirectional communications for remote control and troubleshooting. And lower costs.

Today, EG&G Chandler — a Fortune 200 company and one of the most trusted names in oil and gas equipment for over 45 years — has met the need.

The Model 2920 On-Line BTU Analyzer.

The Model 2920 BTU Analyzer System is a stand-alone gas chromatograph designed to measure the heating value of up to six natural gas streams.

Built to withstand harsh environmental conditions, it delivers the repeatability and accuracy of a laboratory gas chromatograph

Easy, On-Site, One-Site Installation.

Unlike other on-line systems, the Model 2920 System is installed on-site in a single meter house. Electronics, the chromatograph and the stream selector are all located in one structure This makes routine maintenance easier — and dramatically reduces installation costs.

Factory Mutual System

It takes only hours — not days — to put the Model 2920 System into operation. delivery to on-line analysis.

The analyzer and related options are FM-approved for use in Class I, Division 2, Groups C & D environments, with operating temperatures from -25° to 45°C (-10° to 110°F).

Flexible, Modular Design.

The Model 2920 System was designed for easy installation and maintenance.

The system consists of two compact, self-contained modules housed in rugged NEMA-4 cases One module contains the gas chromatograph and the twin, on-board computers that run analysis operations and communications The other module contains the stream selection unit, valving for automated gas calibration, and alarm relays

The result? An on-line BTU Analyzer you can easily configure to match available space. The system's modular components also allow fast, easy field-repairs, for minimum downtime.

ISO 9001 CERTIFIED

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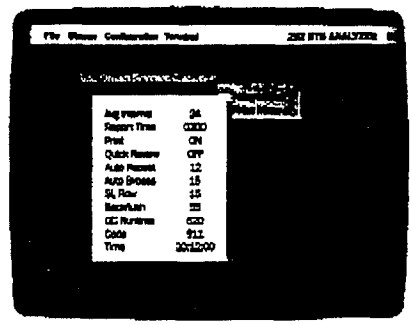
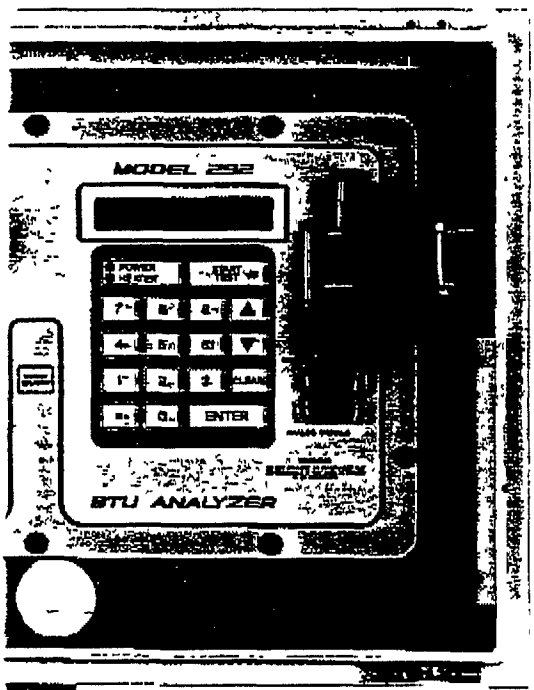
No Learning Curve.

Some systems are so complicated, it takes hours of training and service-support to put them to work.

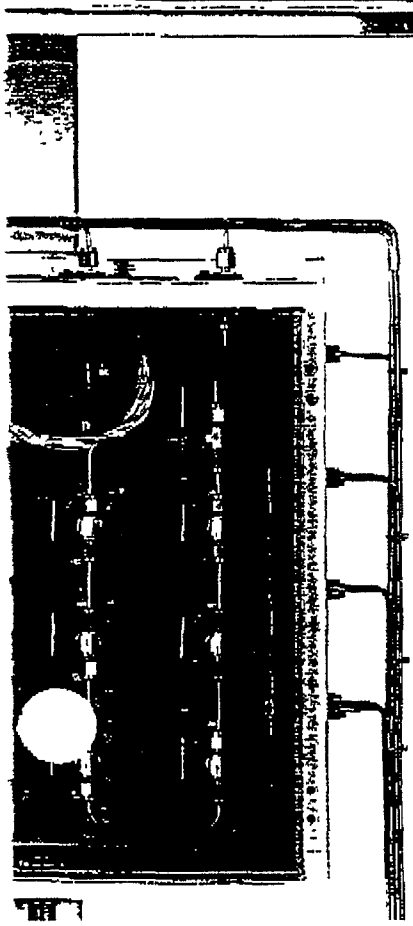
The Model 2920 System does away with the learning curve. The menu-driven operating system is so user-friendly, even an untrained layman can learn to run it — in minutes.





Easy To Install. Easy To Use. Easy To Maintain.

- Flexible, One-Site, One-Structure Installation For All Components Competitor's Components must be separated.
- FM-Approved For Class I, Division 2, Groups C& D Environments.
- Dual, On-Board Computers For Simultaneous Operation & Communications.
- Remote Communications, Diagnostics & Control.
- Up To Six Natural Gas Streams
- Accuracy Unsurpassed In The Industry.
- Repeatability Better Than ±0 5 BTU/ 1000 BTU.
- Automatic Calibration.
- Automatic Restart After Power Outages.
- Built-In Data Protection.
- Easy Maintenance Modular Design.
- Built-In Diagnostics.
- Parallel Port For Standard Printer.
- PC-Based Remote Control; Easy Interface With Industry Standard Communication Software.
- Compliance With Industry Standards: GPA. ASTM, ISO, AGA.

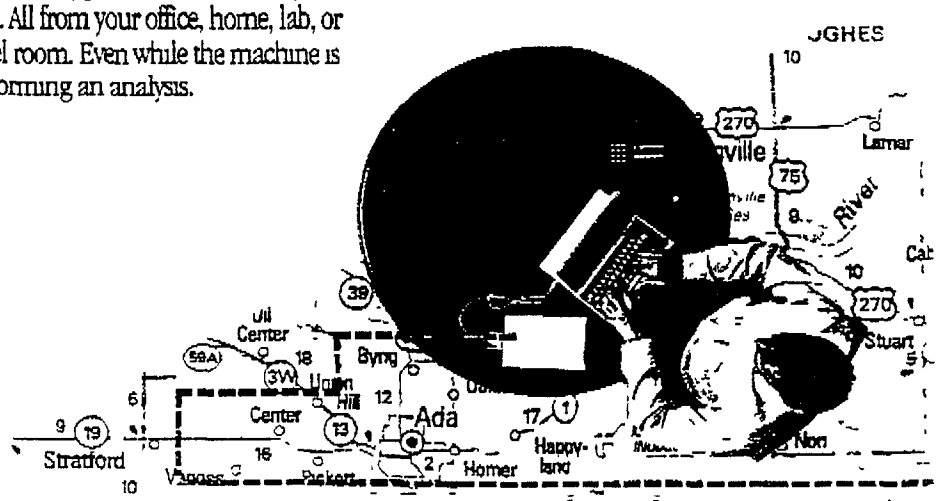


Total Off-Site Communications & Control.

Communicating with the Model 2920 System is as easy as dialing your phone. Using any computer and a standard modem, you have immediate access to all system functions and reports.

Monitor operations. Modify configuration or operating parameters. Run diagnostic tests. All from your office, home, lab, or hotel room. Even while the machine is performing an analysis.

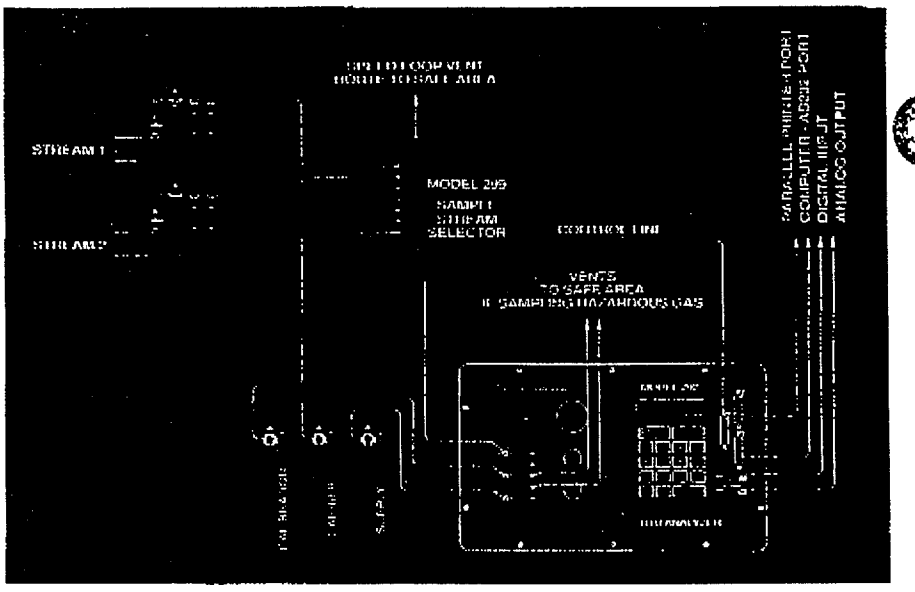
The benefits are obvious. No more long drives to sites to modify programs or verify that your system is working properly. With the Model 2920 System, anything you can do at the unit's keypad you can also do via modem.



Easy Operation.

With the Model 2920 System, a simple menu guides the user through every operation step-by-step — prompting the operator for information to configure parameters for gas analysis, calibration, data retrieval, and diagnostics.

- Sampling time can be set or adjusted quickly and easily
- SI (kJ/m³) units or English units (BTU/Scf) are simply selected from the menu.
- Samples are automatically purged between analyses.
- Calibration is quick — and automatic.
- Data are password-protected to prevent tampering.



Proven Performance.

The Model 2920 System uses field-proven technologies and industry-standard gas chromatographic techniques. And it's been performance-tested in a variety of real-world applications

With some systems, you have to wait until analyses are completed before you can communicate with the remote unit. With the Model 2920 System, you have uninterrupted access to data and controls, even during analysis. That's because the Model 2920 uses not one but two powerful, on-board computers. While one computer performs analyses, the other handles communications.

Advanced, built-in programming allows the unit to calculate heating value, relative density, and compressibility via the AGA 8 method. The system also analyzes composition with exceptional accuracy.

Oven temperature is precisely controlled to within ±0.01°C, eliminating errors caused by ambient temperature fluctuations. Analysis repeatability is better than ±0.5 BTU / 1000 BTU.

Our standard columns have an expected life span of 10 years. The proprietary manufacturing process ensures that the instrument will maintain superior test repeatability and accuracy over its entire service life.

A Thermal Conductivity Detector (TCD) gives you extremely high sensitivity to low concentrations of components.

For protection from harsh field conditions, all Model 2920 System components are encased in a rugged, weather-proof and moisture-resistant NEMA 4 package.

Value-Extra Features.

The Model 2920 System was designed and built to deliver more for your money. To meet that objective, we've included a long list of hardworking, easy-to-use extra features

These features include *Automatic Calibration* at user-defined intervals; *Automatic Shutdown and Restart for Power Failures*, with built-in Data Protection, and eight programmable *High/Low Signal alarms*.

Best of all, the Model 2920 System can eliminate the "hidden costs" of other on-line systems — for training, multi-structure installation, programming, support, and other items that don't show up in the quoted price.

Dollar for dollar, feature for feature, no other BTU Analyzer even comes close, in performance, ease of use, or value.

Don't Pay More For Less.

For a complete demonstration of Model 2920 System capabilities, simply give us a call.

EG&G INSTRUMENTS CHANDLER

P O Box 470710 • Tulsa, Oklahoma, U.S.A. 74147-0710
Telephone: (918) 250-7200 • FAX (918) 459-7199 • TELEX 205843

Specifications.

ENVIRONMENTAL REQUIREMENTS:

- Operating Temperature Range: -25° to 45°C (-10° to 110°F)
- Environmental Rating: Approved by Factory Mutual Research Co. for use in Class I, Division 2, Groups C & D locations.
- NEMA 4 enclosure

INTERFACE SPECIFICATIONS:

- Printer: Parallel/Centronics
- Computer: RS232C (DTE), 2400 Baud, 8 data bits, no parity, 1 stop bit

ANALOG OUTPUT SPECIFICATIONS:

- The analog output for a chart recorder is 0-10 Vdc, 1000 OHMS source impedance.

PRINTER SPECIFICATIONS:

- Printer: Epson 9-pin or equivalent with parallel (Centronics) interface

POWER REQUIREMENTS:

- Power: 110 or 220 Volts ±10%, 50/60 Hz, 250 VA max., 40 W operating

GAS REQUIREMENTS:

- Carrier Gas: Helium (Zero Grade, 99.995% pure)

  Pressure: 1035 kPa (150 psig)

  Connection: Stainless steel tubing provided with the analyzer. Flexible plastic tubing is NOT recommended.
- Supply Gas: Dry Instrument Air, Nitrogen or other inert gas (Instrument grade)

  Pressure: 520 kPa (75 psig)

  Connection: Hose provided with analyzer or other clean tubing rated for the pressure.
- Sample Gas: Analyzes dry pipeline quality natural gas that contains: nitrogen, methane, carbon dioxide, ethane, propane, i-butane, n-butane, i-pentane, neo-pentane, n-pentane, C_6 and heavier components

  Maximum inlet pressure: 21 MPa (3000 psig)

  Minimum inlet pressure: approximately 3.5 kPa (0.50 psig)

  Connection: Stainless steel tubing provided with the analyzer or other tubing rated for the pressure.

EG&G Instruments Chandler / Model 292 BTU Analyzer

Test time. Mar. 10 93 18:11 — Calibration #: 3
Test #: 165 — Stream #: 1 — Location No. 930308

	Standard / Dry Analysis				Saturated / Wet Analysis		
	Mole%	BTU*	R.Den.*	GPM**	Mole%	BTU*	R.Den*
Methane	95.027	962.02	0.5264	-	93.373	945.28	0.5172
Ethane	2.420	42.92	0.0251	0.6471	2.378	42.17	0.0247
Propane	0.667	16.83	0.0102	0.1839	0.656	16.53	0.0100
i-Butane	0.160	5.21	0.0032	0.0523	0.157	5.12	0.0032
n-Butane	0.134	4.37	0.0027	0.0421	0.131	4.29	0.0026
i-Pentane	0.051	2.03	0.0013	0.0185	0.050	1.99	0.0012
n-Pentane	0.023	0.93	0.0006	0.0084	0.023	0.91	0.0006
(C_6+)	0.079	3.99	0.0025	0.0339	0.077	3.92	0.0025
Moisture	0.000	0.00	0.0000	-	1.740	0.88	0.0106
Nitrogen	0.371	0.00	0.0036	-	0.365	0.00	0.0035
(CO_2)	1.070	0.00	0.0163	-	1.051	0.00	0.0160
Total	100.00	1038.3	0.5917	0.9861	100.00	1021.1	0.5922

** Uncorrected for compressibility at 60 OF & 14.730PSIA*
*** Liquid Volume reported at 60 OF*

		Standard / Dry Analysis	Saturated / Wet Analysis
Molar Mass	=	17.138	17.153
Relative Density	=	0.5928	0.5934
Compressibility Factor	=	0.9978	0.9977
Heating Value	=	22938. BTU/lb	22538. BTU/lb
Heating Value	=	1040.6 BTU/CF	1023.5 BTU/lb
Absolute Gas Density	=	45.3666 lbm/1000CF	45.4117 lbm/1000CF

Unnormalized Total: 100.038
Last Calibrated with Calgas of 1050.3 BTU/CF Mar. 10 93 16:31
C_6+ Last Update. Mar. 02 93 14:11
C_6+ BTU/CF 5065.8, C_6+ lbm/Gal 5.6425, and C_6+ Mol Wt. 92.00.

▲ *Typical BTU Analysis Report*

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P.O. Box 470710 • Tulsa, Oklahoma, U.S.A. 74147-0710
Telephone. (918) 250-7200 • FAX: (918) 459-7199 • TELEX 205843

ISO 9001 CERTIFIED

The Model 292 can also be configured for use at a stationary location. Ask for our brochure on the Model 2920 System for Stationary Applications.

Data Storage and Recall

The Model 292 has a storage capacity that holds data from as many as 64 analyses. The stored data are compiled into a report and filed by location number (sample site), which you enter on the keypad. When an operator enters a previously-used location number, the panel display indicates previous analyses stored under that number. This gives the operator instant access to a complete history of all data taken at that site.

The stored reports can be transferred to a printer or transferred to a computer at any time. Transferring the reports to a computer requires an accessory communication driver software package such as Procomm® and a modem in the computer.

Calibration

The Model 292 Portable BTU Analyzer is fully-calibrated when it leaves the factory. An operator can recalibrate the unit periodically to verify its superior repeatability. This is easy to accomplish using calibration gas, the keypad, and calibration software that is programmed into the unit. If no other calibration data are entered, the Model 292 will default to the original input provided at the factory. The date and heating value of the calibrated gas will be printed automatically on each analysis report. A calibration report can be re-printed at any time.

Equipment Supplied with Each Instrument

- Set of computer cables
- Two 10 ft by 1/8" OD flexible SS tubes, for carrier and sample gas.
- One 8 ft by 3/16" ID black nylon hose for supply gas.
- Operation Manual
- Factory Calibration Specs.

Specifications

Gas Inputs

Carrier Gas: 99.995% Helium, 1034 kPa (150 psig)

Supply Gas for Switching Valve: Nitrogen, Helium, or Instrument Air, 552 kPa (80 psig)

Connectors

Parallel Printer: Epson-compatible dot matrix printer

Computer RS232C: for serial communication (DTE) - typically through a modem

Analog Output: 0-10 VDC signal for plotting Chromatogram

System Interface: Digital I/O for use only with our Model 2920 System for Stationary Applications; RS232 serial communication (DTE)

Signal Input: Reserved for future system applications

Displayed Results

Compositional Analysis (mole %)

Heating Value;

kJ/m^3 (Btu/SCF) - Standard and Saturated

kJ/kg (Btu/lb mass) - Standard and Saturated

Compressibility Factor

Relative density

Absolute gas density, kg/m^3 (lb mass/1000 SCF)

Repeatability

Within ±1.0 Btu/1000 SCF

Voltage Requirements

120 VAC ±10% 50/60 Hz,
or
220 VAC ±10% 50/60 Hz

Can be operated with an Inverter from 12 VDC (see Inverter in Accessories)

External Tube Connections

Three Inlets: 1/8" NPT (female).

Five Vents: 1/16" tube.

(See Accessories for metric adapters)

Specifications (continued)

H_2S

The unit can operate with gas streams that contain H_2S without excessive degradation. The minimum detectable limit for H_2S is 2500 ppm.

Electrical Classification

Approved by FM (Factory Mutual) for Class 1, Division 2, Groups C & D specifications

Weights and Dimensions

Net Weight: 14 kg (30 lb)

Cabinet Dimensions:
46 x 28 x 48 cm
(18 x 11 x 19 in.)

Shipping Weight: 25 kg (55 lbs)

Shipping Dimensions:
58 x 58 x 56 cm
(23 x 23 x 22 in.)

Ordering Information

Model 292-20 BTU Analyzer, 120 VAC or 220 VAC (specify voltage when ordering). Complete with all the equipment listed. Order accessories from the following list.

Accessories

Inverter to provide operating power from a truck or auto battery:
Part #300-27404,
12VDC to 120VAC.
Part #300-28656,
12VDC to 220VAC.

Transmitter
Model 298 Four-Channel 4-20 mA Current Transmitter. Permits the transfer of any 4 of 43 parameters measured during a test (such as Heating Value, %N_2, %CO_2, %CH_4, Relative Density, etc.) to an external recording or storage device.

Portable Bottle Option
Model 292-400. Includes two regulators, gauges, bracket, carrying case, and two DOT-Approved aluminum bottles with a capacity of 195 liters (6.9 cubic feet)

APPENDIX B

Audit Records

KRIVOI ROG

SERIAL # 11003250
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE 350 T/H NO5 LEFT BLR LEFT SIDE

TIME: 16:15:04
DATE: 02/28/95

FUEL TP FUEL 15% NAT. GAS

COMBUSTION EFFICIENCY:	76.2	%
AMBIENT TEMPERATURE:	14	°C
STACK TEMPERATURE:	323	°C
OXYGEN: 3.4	05.2	%
CARBON MONOXIDE:	27	MGM
CARBON DIOXIDE:	13.0	%
COMBUSTIBLE GASES:	1.21	%
STACK DRAFT (INCHES H20): -	4.7	
EXCESS AIR:	32	%
OXIDES of NITROGEN:	869	MGM
SULFUR DIOXIDE:	2092	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

310°C AIR PREHEAT

KRIVOI ROG FW 196°F

SERIAL # 11003250

220 ATM 205 MW

SERIAL # 11003250
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE 350 T/H NO. 5 LEFT BLR RIGHT SIDE

TIME: 15:52:01
DATE: 02/28/95

FUEL TP FUEL 15% NAT. GAS

COMBUSTION EFFICIENCY:	83.2	%
AMBIENT TEMPERATURE:	13	°C
STACK TEMPERATURE:	319	°C
OXYGEN: 6.2	07.2	%
CARBON MONOXIDE:	21	MGM
CARBON DIOXIDE:	11.4	%
COMBUSTIBLE GASES:	0.86	%
STACK DRAFT (INCHES H20): -	5.0	
EXCESS AIR:	50	%
OXIDES of NITROGEN:	920	MGM
SULFUR DIOXIDE:	1706	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

KRIVOI ROG

SERIAL # 11003250
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE 360 T/H No. 5 RIGHT BLR LEFT SIDE

TIME: 16:00:48
DATE: 02/28/95

FUEL TP FUEL 5% NAT. GAS.

COMBUSTION EFFICIENCY:	79.7	%
AMBIENT TEMPERATURE:	14	°C
STACK TEMPERATURE:	303	°C
OXYGEN: 4.0	06.3	%
CARBON MONOXIDE:	24	MGM
CARBON DIOXIDE:	12.1	%
COMBUSTIBLE GASES:	1.30	%
STACK DRAFT (INCHES H20): -	4.6	
EXCESS AIR:	41	%
OXIDES of NITROGEN:	941	MGM
SULFUR DIOXIDE:	2246	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

BEST AVAILABLE COPY

KRIVOI ROG

SERIAL # 11003250
SERIAL # 11003250

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: BURNS & ROE 360 T/H No. 5 RIGHT BLR RIGHT SIDE

TIME: 16:08:42
DATE: 02/28/95

FUEL TP FUEL 5% NAT. GAS.

COMBUSTION EFFICIENCY:	77.9	%
AMBIENT TEMPERATURE:	14	°C
STACK TEMPERATURE:	304	°C
OXYGEN: 5.5	05.8	%
CARBON MONOXIDE:	24	MGM
CARBON DIOXIDE:	12.4	%
COMBUSTIBLE GASES:	1.47	%
STACK DRAFT (INCHES H20): -	4.1	
EXCESS AIR:	37	%
OXIDES of NITROGEN:	920	MGM
SULFUR DIOXIDE:	2352	MGM
CARBON MONOXIDE ALARM:	50	PPM

MODE:MGM OXY_REF=TRUE%

KRIVOI ROG POWER PLANT
Wednesday, 01 March 1995

The temperature check-out of knife switches and busbars boltings of 0 4 kW switchboards was carried out using the new heat spy given by USAID As a result of this check, the following hot spots were detected:

1	Knife Switch NRT-1B	Upper knife temperature is 63° - 95°C
2	Knife Switch R-42	A-phase busbar temperature is 113° and C-phase busbar temperature is 80°
3.	Knife Switch KNOU-2B	B-phase upper knife temperature is 80° and C-phase upper knife temperature is 65°C.
4	Knife Switch KNOU-3B	All phases knifes temperature is above 50°C.

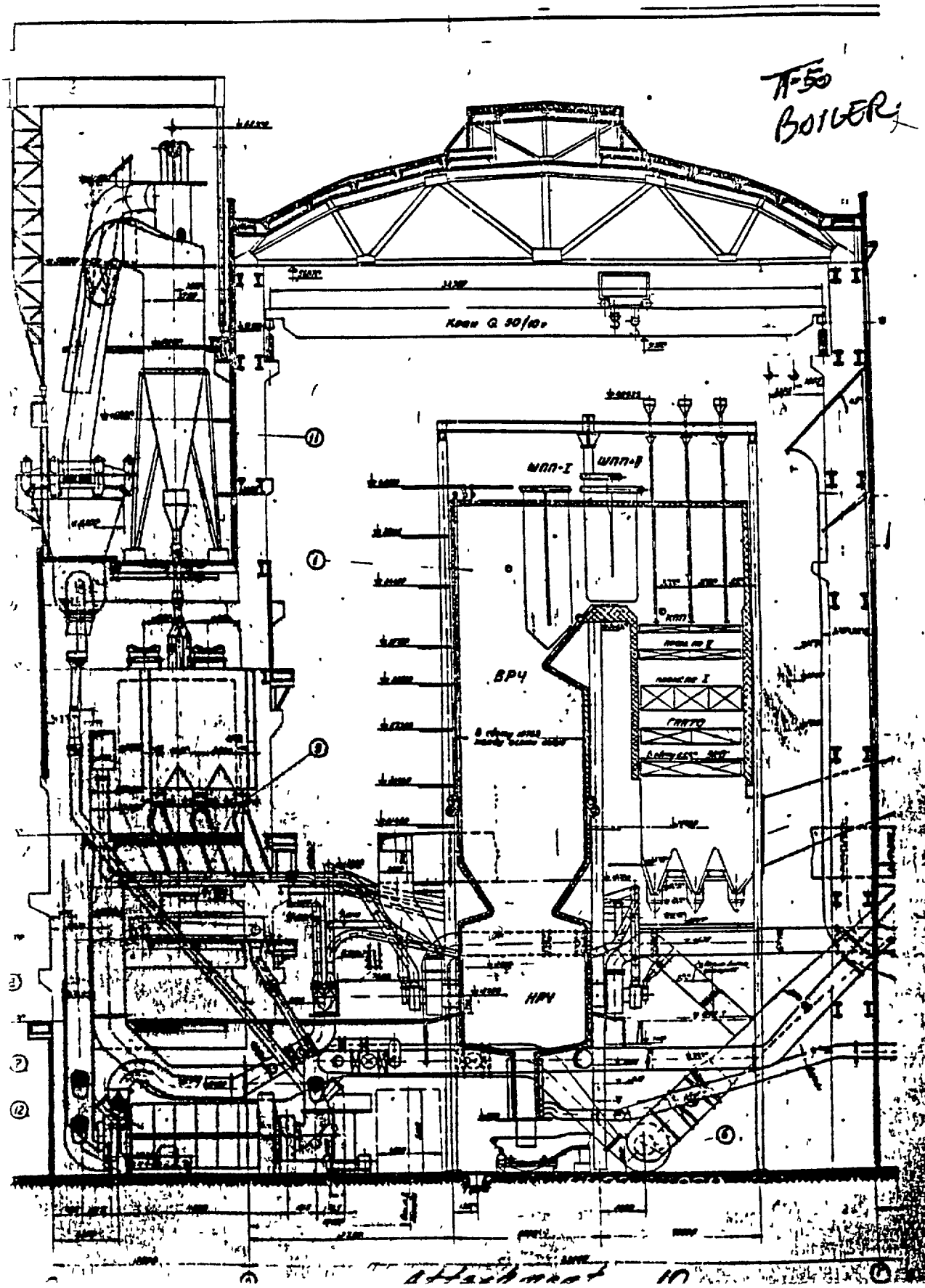
5 Hot spots were also detected at the following knife switches and busbars connections·

KNOU-5B, KNOU-5A, NPT-5A, P47a (Phases C, B), Circuit Breaker NOP-6, BM-3A (Phases C, B), NOP-2 (Phase A), MN-5 (Phase A), MN-4 (Phases A, B), OBK-1, P-65

Because of these findings, maintenance will be performed at earliest time to correct these problems before permanent damage happens.

APPENDIX C

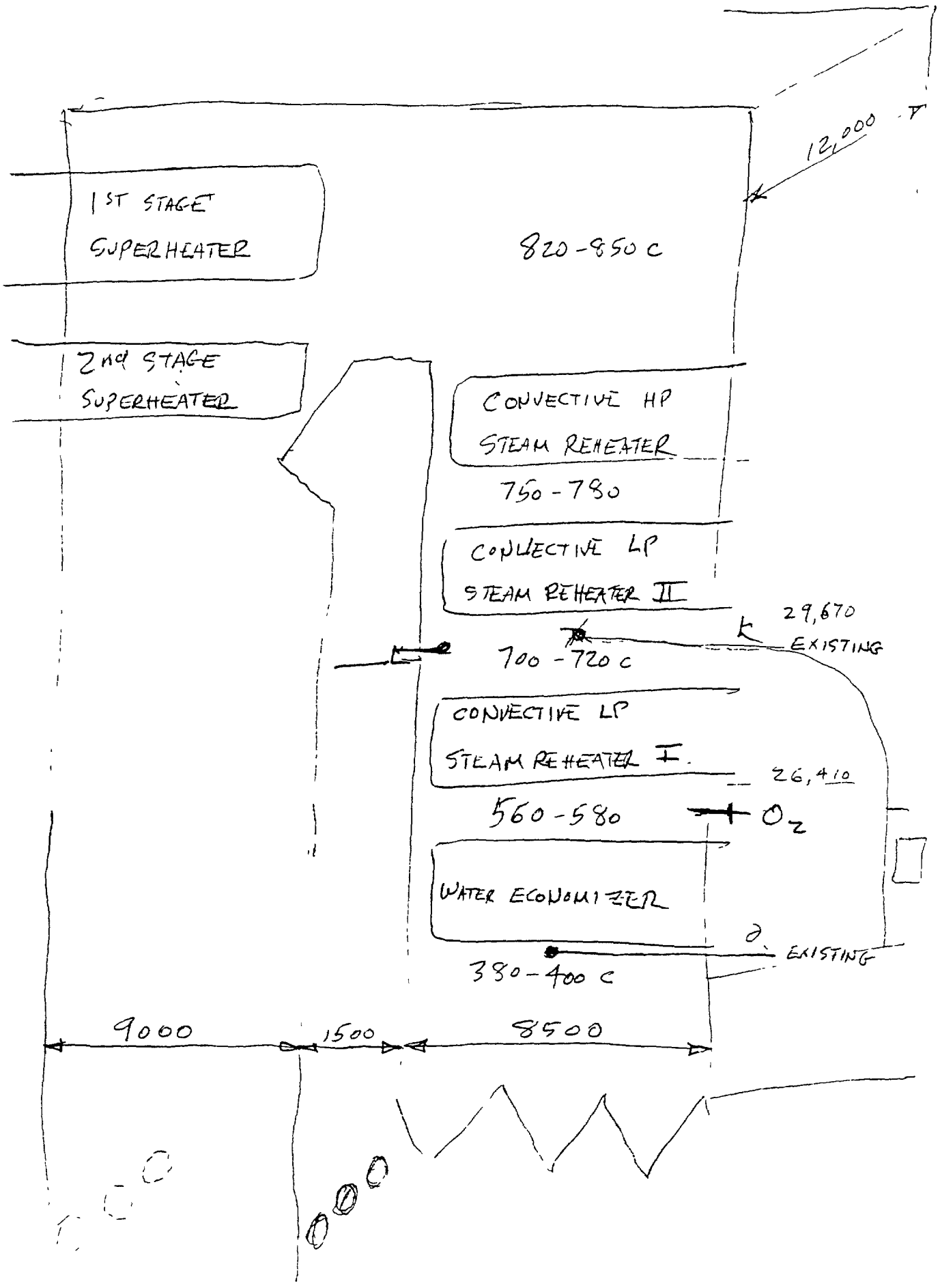
Power Plant Data

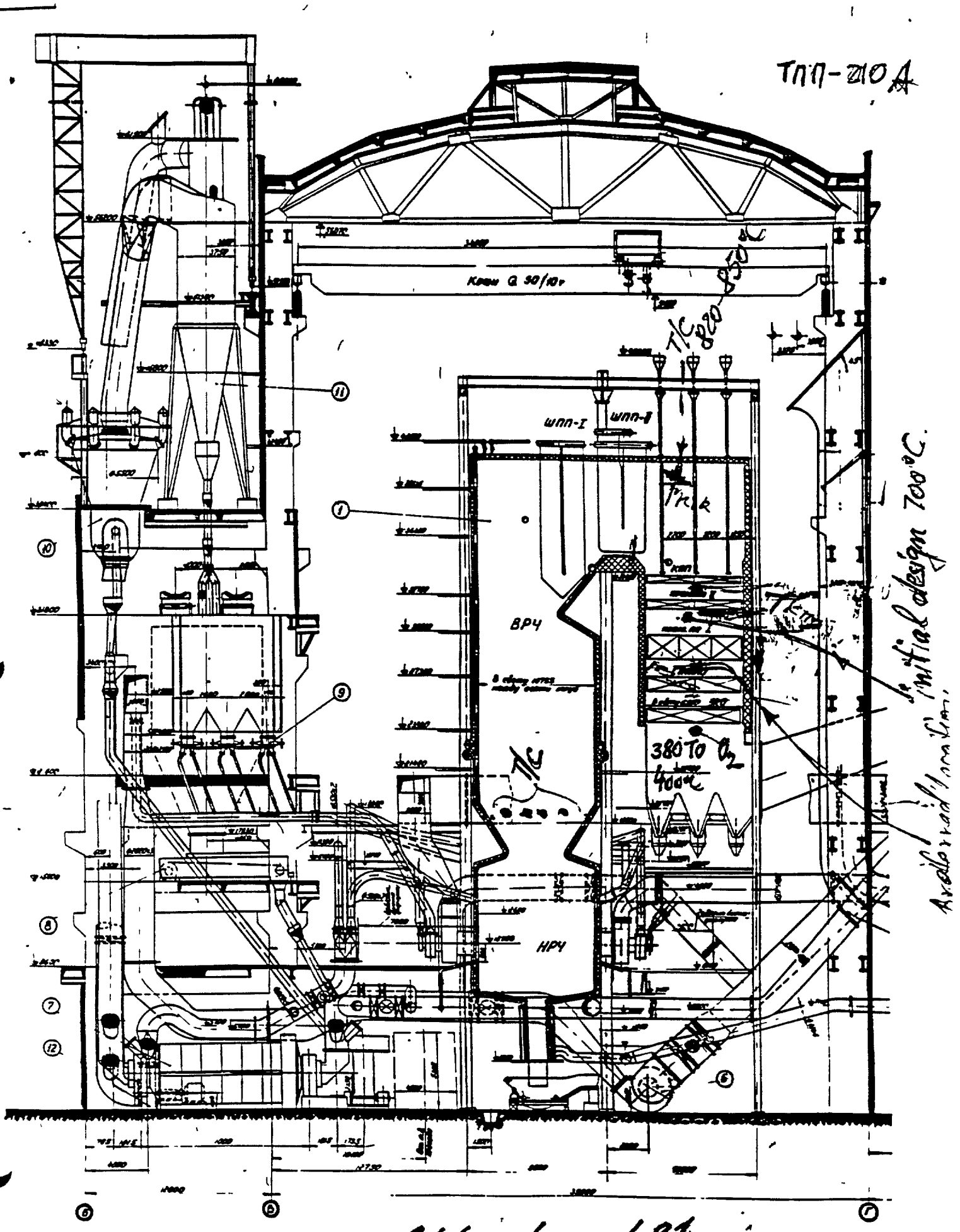

T-50
BOILER
Кран Q 50/10т
ШПП-I
ШПП-II
ВРЧ
НРЧ

KRIVOI ROG MON 27 FEB 95

FD AIR 300 - 350 C

P-50



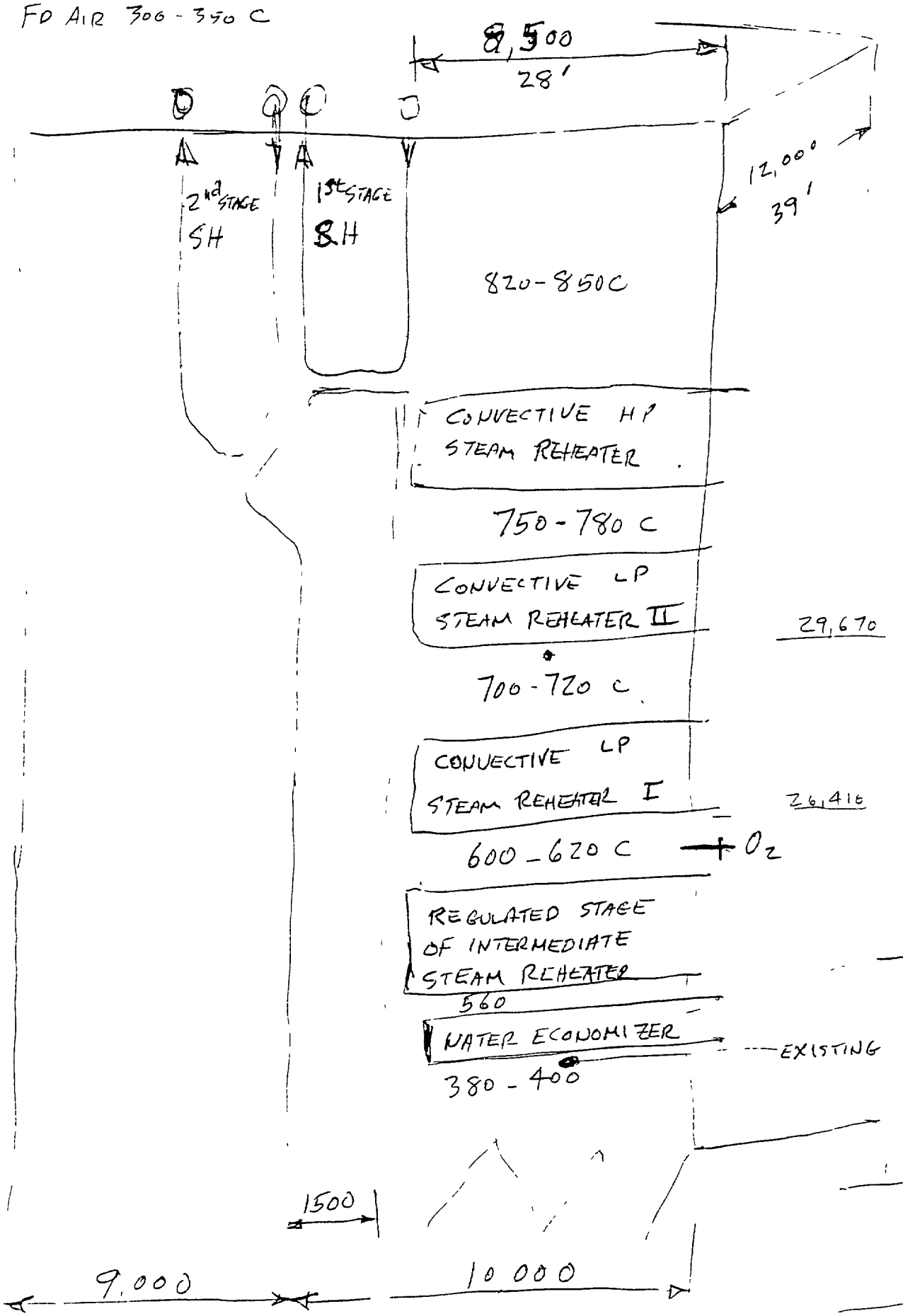


Attachment 21

KRIVOI ROG MON 27 FEB 95

TPP-210A

FD AIR 300 - 350 C



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01.03 95

1 Supply

2 Return

Block 1 to 4

3 Supply

4 Return

Block 5 to 10

KRIVOI ROG
MAZUT PIPING

	1	2	3	4	
ϕ mm	133	133	133	133	mm
Δ	4	4	4	4	mm
T	100 – 120°C	90 – 110°C	100 – 120°C	90 – 110°C	°C
P	18 – 22	15 – 20	35 – 40	32 – 37	Kg/cm^2
T/H	1 – 60	1 – 40	1 – 80	1 – 60	Ton/Hour

LIST OF ENERAC STANDARD FUELS

Position	Fuel	C(%)	H2(%)	N2(%)	O2(%)	S(%)	H2O(%)	ASH(%)	HHV BTU/LB	SUM	LHV Kcal/Kg
1	#2 Oil	0 867	0 124	0 001	0	0 008	0	0	19360	1	
2	#6 Oil	0 881	0 1	0 009	0 002	0 007	0	0	18300	0 999	
3	Nat Gas	0 714	0 236	0 05	0	0	0	0	21870	1	
4	Anthracite	0 8436	0 0158	0 0063	0 0191	0 0089	0 028	0 0783	13300	1	
5	Bituminus	0 665	0 0428	0 01	0 063	0 03	0 0788	0 11	11700	0 9996	
6	Lignite	0 451	0 03	0 009	0 148	0 012	0 293	0 057	7780	1	
7	Wood 50% H2O	0 247	0 03	0 003	0 218	0	0 5	0	4320	0 998	
8	Wood 0% H2O	0 495	0 06	0 005	0 435	0	0	0	8460	0 995	
9	#4 Oil	0 875	0 11	0 004	0	0 008	0	0	18800	0 997	
10	Kerosine	0 851	0 143	0 003	0	0 002	0	0	19900	0 999	
11	Propane	0 818	0 182	0	0	0	0	0	21677	1	
12	Butane	0 828	0 172	0	0	0	0	0	21132	1	
13	Coke Oven Gas	0 434	0 23	0 172	0 164	0	0	0	16230	1	
14	Blast Furnace	0 155	0 0025	0 554	0 286	0	0	0	1061	0 9975	
15	Sewer Gas	0 46	0 101	0	0 416	0	0 022	0	8032	0 999	
8	Mazut	0 8047	0 1017	0 0086	0.0067	0 0333	0 05	0 0013	18414	1 0063	9568
	Donetsk	0 522	0 01	0 005	0.015	0 015	0 085	0 348		0 97	4355
	TP Coal	0 506	0 04	0 015	0 018	0 019	0.056	0 346	9213	1	4820
15	Rus Gas	0 721	0 24	0 026	0 01	0	0	0	16598	0 996	7840
	Kuznetsk	0 614	0 021	0 015	0.047	0 003	0 097	0 203	9954	1	5300
7	Polsky	0 584	0 020	0 015	0 015	0 018	0 091	0 257	9345	1	4974

KRIVOI ROG

TP Coal - Krivoi Rog			%	
C	=	0.5061	50 6	Kcal/Kg x Kg/2.2046 Lb x 3 9685 BTU/Kcal = 1 8
H_2	=	0.040	4 0	
N_2	=	0 015	1 5	1.8 x Kcal/Kg = BTU/LB
O_2	=	0 018	1 8	
S	=	0.019	1 9	LHV = 4820 Kcal/Kg
W	=	0.056	5 6	
Ash	=	0 346	34 6	
		1.000	100 0	

W_a = 11 5C + 34 5 (H_2 - O/8) + 4 3 S

= 11.5 (0 506) + 34.5 (0 04 - 0.018/8) + 4 3 (0.019)

W_a = 7.203 LBS AIR/LB FUEL

W_{H2O} = 9H + W + 0.014 (1 + x) W_a, (1 + x = 1.00) excess air stochiometric

= 9 (0 04) + 0.056 + 0.014 (1.0) 7.203

W_{H2O} = 0 517 LBS WATER/LB FUEL FORMED FROM COMBUSTION

HHV = LHV + 1040 x W_{H2O}

= (1.8 x 4820 Kcal/Kg) BTU/LB + 1040 (0.517)

HHV = 9213 BTU/LB

TP Coal - Krivoi Rog		%
C	=	50 6
H_2	=	4 0
N_2	=	1 5
O_2	=	1.8
S	=	1 9
W	=	5 6
Ash	=	34 6
		100 0

Ft^3 Flue Gas/ Lb Fuel = 1 505C + 3 57 H_2 + 0.557 S + 0.135 N_2 - 0.448 0_2

= 1 505 (50.6) + 3.57 (4.0) + 0 557 (1 9) + 0.135 (1 5) - 0.448 (1 8)

= 90.89 Ft^3 Flue Gas/Lb Fuel

Ft^3 CO_2/Lb Fuel = 0 315C = 0 315 (50 6) = 15 939

CO_2% = 100 x Ft^3 CO_2/Ft^3 Flue Gas = 15.939/90.89

CO_2 = 17 54% Ultimate for Perfect Combustion

Mazut		Dry	Wet
C	=	84 7	80 47
H_2	=	10 7	10 17
N_2	=	0 9	0 86
O_2	=	0 7	0 67
S	=	3 5	3.33
W	=	0 0	5.0
Ash	=	0 14	0 13
		100 64	100 63

W_a = 11 5C + 34.5 (H - O/8) + 4 3 S

= 11.5 (0.8047) + 34.5 (0 1017 - 0.0067/8) + 4 3 (0 0333)

W_a = 12 88 LBS AIR/LB FUEL

W_{H2O} = 9H + W + 0 014 (1 + X) W_a, (1 + X = 1 0) Excess Air Stochiometric

= 9 (0 1017) + 0 05 + 0 014 (1 0) 12 88

W_{H2O} = 1.15 LBS WATER/1 LB FUEL FORMED FROM COMBUSTION

HHV = LHV + 1040 x W_{H2O}

= (1.8 x 9568 Kcal/Kg) BTU/LB + (1040 x 1 0)

= 18,414 BTU/LB

Mazut

C	=	80.47
H_2	=	10.17
N_2	=	0 86
O_2	=	0 67
S	=	3 33
W	=	5 0
Ash	=	0 13
		100 63

Ft^3 Flue Gas/
Lb Fuel = $1.505C + 3.57\ H_2 + 0\ 557\ S + 0.135\ N_2 - 0\ 448\ 0_2$

= 1.505 (80 47) + 3 57 (10.17) + 0.557 (3.33) + 0.135 (0.86) - 0 448 (0.67)

= 158.68 Ft^3 Flue Gas/Lb Fuel

Ft^3 CO_2/
Lb Fuel = 0.315C = 0 315 (80 47) = 25 348

CO_2% = 100 x Ft^3 CO_2/Ft^3 Flue Gas = 25.348/158 68

CO_2 = 15.97% Ultimate for Perfect Combustion

HEAVY RESIDUAL OILS

Representative Analyses

							Total (HHV)		Net (LHV)		LHV
	C	H	S	N+O	°API	SP GR.	BTU/lb	BTU/gal	BTU/lb	BTU/gal	Kcal/Kg
Mazut									15,736		8,742
Mazut	85 7	10 1	2 3	0 1 + 0 8					16,589		9,216
Mazut	84 71	10 71	3 5	1 57	8 0	1 015	18,150	153,570	17,170	145,260	9,539
Mazut									17,444		9,691
Residual	87.1	12.43	0.47	0.47	30.0	0 876	19,130	139,660	17,980	131,300	9,989
Residual	86.4	12.38	1.22	1 22	34 0	0 855	19,270	137,310	18,080	128,940	10,044
Venuez Residual	86 0	11 2	2.1	0 8	38.0	0 8348	19,390	134,960	18,180	126,570	10,100
Residual	85 7	13.93	0.37	0 37	40 0	0.825	19,450	133,760	18,230	125,390	10,128

HEAT OF COMBUSTION

Heating Values of Fuel Oils Corresponding to the API Gravity

	API Gravity at 60 deg F	Total Heating Value		Net Heating Value	
		Btu per Lb	Btu per Gal.	Btu per Lb	Btu per Gal
	0	17,670	158,610	16,660	149,470
	1	17,730	157,980	16,710	148,870
	2	17,800	157,380	16,780	148,330
	3	17,870	156,750	16,840	147,780
	4	17,930	156,110	16,910	147,250
	5	17,980	155,470	16,990	146,860
	6	18,030	154,860	17,050	146,340
	7	18,090	154,220	17,110	145,790
MAZUT →	8	18,150	153,570	17,170	145,260
	9	18,210	152 930	17,230	144,700
	10	18,260	152,280	17,270	144,000
	11	18,310	151,590	17,310	143,410
No. 6	12	18,360	151,000	17,350	142,720
	13	18,410	150,310	17,400	142,030
	14	18,450	149,720	17,440	141,440
	15	18,500	149,030	17,480	140,750
	16	18,550	148,440	17,520	140,160
	17	18,600	147,750	17,550	139,470
	18	18,650	147,160	17,590	138,790
No. 5	19	18,700	146,570	17,630	138,190
	20	18,740	145,880	17,660	137,510
	21	18,780	145,290	17,690	136,910
	22	18,820	144,600	17,730	136,230
	23	18,860	144,010	17,760	135,640
	24	18,900	143,420	17,800	135,040
	25	18,940	142,820	17,830	134,350
No 4	26	18,980	142,140	17,860	133,760
	27	19,020	141,540	17,890	133,170
	28	19,060	140,950	17,920	132,580
	29	19,090	140,360	17,950	131,890
	30	19,130	139,660	17,980	131,300
	31	19,160	139,080	18,000	130,710
	32	19 200	138,490	18,030	130 120
No. 2	33	19,230	137,900	18,050	129,530
	34	19,270	137,310	18,080	128,940
	35	19,300	136,720	18,110	128,350
	36	19,330	136,130	18,130	127,560
	37	19,360	135,540	18,150	127,160
	38	19,390	134,960	18,180	126,570
	39	19 420	134 350	18 200	125 980

GRAVITY

Relation of Gravity and Ultimate CO_2 in Flue Gas

Gravity, deg API	Ultimate CO_2, per cent
3	18 2
4	18 0
5	17 8
6	17 6
7	17 4
→ 8	17 1
9	16 9
10	16.7
11	16 5
12	16 4
13	16 3
14	16 1
15	15 9
16	15 8
17	15 6
18	15 5
19	15 3
20	15 2
21	15 1
22	14 9
23	14 8
24	14 7
25	14 6
26	14 5
27	14 4
28	14 3
29	14 1
30	14 0
31	13.9
32	13 8
33	13 7
34	13 6
35	13 5
36	13 4
37	13 3
38	13 3
39	13 2

Deg API	Specific Gravity	Per Cent Carbon*	Per Cent Hydrogen	Ratio of Carbon to Hydrogen
1 0	1 0679			
2 0	1 0599			
3 0	1 0520			
4 0	1 0443			
5 0	1 0366			
6 0	1 0291			
7 0	1 0217			
8 0	1 0143	84.71	10.71	7.91
9 0	1 0071			
10 0	1 0000		10 00	
14 0	9725	88 59	10 41	8 51
16 0	9593	88 39	10 61	8 33
18 0	9465	88 20	10 80	8 17
20 0	9340	88 01	10 99	8 01
24 0	9100	87 45	11 55	7 57
28 0	8871	87 11	11 89	7 33
30 0	8762	86 94	12 06	7 21
34 0	8550	86 38	12 62	6 84
38 0	8348	86 07	12 93	6 66

$O_2 + N_2 = 1.57$

ASH = 0.14±

MAX

S = 3.5%

80

Russian Natural Gas

H_2	=	1 1	C	=	0 721	Kcal/Kg x Kg/2.2046 Lb x 3 9685 BTU/Kcal = 1 8
CH_4	=	95 0	H	=	0.24	
C_2H_6	=	0 5	O	=	0 01	1.8 x Kcal/Kg = BTU/LB
C_3H_8	=	0 5	N_2	=	0 026	
N_2	=	1 5			0 997	LHV = 7840 to 8000 Kcal/Kg
O_2	=	0 5				
		99 1				

$$MW = 2\ H_2 + 16\ CH_4 + 30\ C_2H_6 + 44\ C_3H_8 + 28\ N_2 + 32\ O_2$$

$$= (2 \times 0\ 011) + (16 \times 0\ 95) + (30 \times 0.005) + (44 \times 0\ 005) + (28 \times 0\ 015) + (44 \times 0\ 005)$$

$$MW = 16\ 232$$

Conversion of Volumertric to Weight Analysis

$$C = (12\ CH_4 + 24\ C_2H_6 + 36\ C_3H_8) / MW$$

$$C = ((12 \times 0\ 95) + (24 \times 0.005) + (36 \times 0\ 005)) / 16\ 232 = 0\ 721$$

$$H = (2\ H_2 + 4\ CH_4 + 6\ C_2H_6 + 8\ C_3H_8) / MW$$

$$H = ((2 \times 0\ 011) + (4 \times 0.95) + (6 \times 0.005) + 8 \times 0.005)) / 16\ 232 = 0\ 24$$

$$O = 32\ O_2/MW = 32 \times 0.005 / 16.232 = 0\ 01$$

$$N_2 = 28\ N_2/MW = 28 \times 0\ 015 / 16.232 = 0\ 026$$

$$W_a = 11\ 5C + 34\ 5\ (H - O/8) + 4.3\ S$$

$$= (11.5 \times 0.721) + 34.5\ (0.24 - 0.01/8) + (4.3 \times 0)$$

$$W_a = 16.528 \text{ LBS AIR/LB FUEL}$$

$$W_{H2O} = 9H + W + 0.014\ (1 + X)\ W_a,\ (1 + X = 1) \text{ Excess Air, Stochiometric}$$

$$= (9 \times 0\ 24) + 0 + (0\ 014 \times 16\ 528)$$

$$W_{H2O} = 2\ 39 \text{ LBS WATER/1 LB FUEL FORMED FROM COMBUSTION}$$

$$HHV = LHV + 1040 \times W_{H2O}$$

$$= (1.8 \times 7840) + (1040 \times 2.39)$$

$$HHV = 16{,}598 \text{ BTU/LB LOW VALUE}$$
$$= 16{,}886 \text{ BTU/LB SPECIFICATION}$$

Russian Natural Gas

H_2	=	1 1
CH_4	=	95 0
C_2H_6	=	0 5
C_3H_8	=	0 5
N_2	=	1 5
O_2	=	0 5
		99 1

Ft^3 Dry Flue Gas/ Ft^3 Gas = (0 0189 H_2) + (0.0856 CH_4) + (0 1524 C_2H_6) + (0 2190 C_3H_8) + (0 01 N_2) + (0 0378 O_2)

= 8 335

Ft^3 CO_2/ Ft^3 Gas = (0 01 CH_4) + (0 02 C_2H_6) + (0.03 C_3H_8) + (0 01 O_2)

= 0.986

CO_2% = 100 x Ft^3 CO_2/Ft^3 Flue Gas = 0 986/8 335

CO_2 = 11.83% Ultimate for Perfect Combustion

Table 9-11. Analyses of Fuel Gases*

Gas	BTU/LB NET (LHV)	Constituents of gas, % by volume: CO	CO_2	H_2	N_2	O_2	CH_4	C_2H_6	Illuminants: C_2H_4	C_3H_6	Sp. gr. air = 1.000	Cu. ft. of air required for combustion of 1 cu. ft. gas	B.t.u./cu. ft. gross	B.t.u./cu. ft. net	Products of combustion, cu. ft./cu. ft. gas: CO_2	H_2O	N_2	Total (dry)	Ultimate CO_2, %	Net B.t.u./cu. ft. of the products of combustion	Flame temperature corrected for dissociation
Natural gas, Texarkana	20,421	....	0.80	....	3.20	...	96.00	.....	...	...	0.57	9.17	967	873	0.97	1.92	7.29	8.26	11.7	80.2	3580
Natural gas, Cleveland	21,025	....	.....	....	1.30	...	80.50	18.20	...	...	.65	10.70	1131	1025	1.17	2.16	8.50	9.67	12.1	81.1	3600
Natural gas, Oil City, Pa.	21,232	....	.....	....	1.10	...	67.60	31.30	...	...	.71	11.70	1232	1120	1.30	2.29	9.26	10.56	12.3	81.7	3620
Retort coal gas (horizontal)		8.6	1.5	52.5	3.5	0.3	31.4	.....	1.1	1.1	.42	5.00	575	510	0.50	1.21	3.99	4.49	11.2	83.5	3665
Coke-oven gas	14,540	6.3	1.8	53.0	3.4	.2	31.6	.....	2.7	1.0	.42	5.19	588	521	.51	1.25	4.13	4.64	11.0	82.7	3660
Coke-oven gas, Koppers ovens		6.8	2.2	47.3	6.0	.3	33.9	.....	2.6	0.9	.44	5.23	591	525	.54	1.23	4.19	4.73	11.4	82.3	3650
Carbureted water gas		33.4	3.9	34.6	7.9	.9	10.4	.....	6.7	2.2	.65	4.37	536	496	.74	0.75	3.54	4.28	17.2	88.5	3815
Blue water gas		42.8	3.0	49.9	3.3	.5	0.5	.....	...	...	.53	2.26	308	281	.46	.51	1.82	2.28	22.3	89.7	3800
Theoretical water gas		50.0	.....	50.0	.....	...	.....	.....	...	...	.52	2.39	325	298	.50	.50	1.89	2.39	20.9	90.3	3830
Anthracite producer gas		24.0	7.5	16.5	50.2	.6	1.2	.....	...	...	.85	1.05	134	124	.33	.19	1.36	1.69	19.5	65.6	3000
Bituminous producer gas		27.0	4.5	14.0	50.9	.6	3.0	.....	...	...	.86	1.24	150	140	.35	.19	1.49	1.84	19.0	69.2	3160
Blast-furnace gas	1,333	27.5	10.0	3.0	58.0	1.0	0.5	.....	...	...	1.00	0.78	102	100	.38	.04	1.21	1.59	23.9	61.0	2800
Oil gas (Protero 1920)		6.8	1.0	59.2	2.7	0.1	25.4	.....	3.8	1.0	0.35	4.91	575	510	.47	1.21	3.91	4.38	10.7	84.2	3725

* From "Combustion," 2d ed., Table 20, p. 34, American Gas Association, 1926. Reproduced by permission.

NET (LHV)	Kcal/kg	BTU/LB																			
RUSSIAN	7959	14,326											710	645							
NATURAL	8000	14,400											713	648							
GAS	8116	14,609		1.1		1.5	1.5	95	0.5		0.5		723	657					11.8		

KRIVOI ROG
COAL AND MAZUT CONSUMPTION FOR 1994

Months	Coal Consumption Ton of St. Fuel	Coal Price			Mazut Consumption Ton of Std. Fuel	Mazut Price	
		KRB/Ton	$/Ton	$		KRB/Ton	$/Ton
January	277,396	475,389	12 85	3,564,539	12,371	1,581,585	42.75
February	405,743	334,719	7 31	2,965,981	28,357	1,424,632	31.11
March	464,812	303,022	6.59	3,663,111	32,946	1,472,306	32.00
April	256,484	310,431	6 74	1,728,702	9,156	1,670,989	36 33
May	88,952	278,166	5.99	532,822	5,676	1,582,500	34 11
June	57,606	300,976	6.49	373,863	3,247	1,509,000	32 11
July	256,017	308,000	6 55	1,676,911	7,893	1,813,000	40 93
August	483,934	523,000	11 81	5,715,260	18,816	1,306,000	28 15
September	450,305	425,000	9 16	4,124,794	28,020	1,627,000	27.76
October	424,059	479,000	8 17	3,464,562	29,944	2,003,000	28 44
November	391,892	1,225,000	15.22	5,964,596	26,965	4,756,000	38 82
December	493,702	1,791,000	14 62	7,217,923	22,126	7,961,000	60 91
Annual	4,062,902	646,000	10.09	40,993,064	225,517	2,670,000	35 85

Total $8,088,935

KRIVOI ROG
NATURAL GAS CONSUMPTION FOR 1994

1994	Gas Consumption		Power Plant	* Gasprom			KRB/1000 m^3 Price	$/ 1000 Nm^3	$/ 10^6 BTU	$ Over Charge
	Tonnes	Normal m^3	Kcal/Kg	BTU/Ft^3	Kcal/Kg	DIF				
January	12,112	16,828,000	7,975	656	8,100	-143	426,929	11.54	0.50	3,437
February	6,056	8,407,000	7,975	656	8,100	-143	624,172	13 63	0.59	2,028
March	4,830	6,659,000	7,975	656	8,100	-143	492,640	10.75	0.46	1,261
April	27,036	37,477,000	7,975	656	8,100	-143	607,448	13.21	0.57	8,745
May	43,761	60,670,000	7,975	656	8,100	-143	607,448	13.09	0.57	14,155
June	65,029	90,214,000	7,975	656	8,100	-143	651,000	13.85	0.60	22,142
July	87,595	121,549,000	7,975	656	8,100	-143	689,000	15 55	0 67	33,306
August	79,809	110,712,000	7,975	656	8,100	-143	691,000	14 89	0.64	28,986
September	70,148	97,346,000	7,975	656	8,100	-143	902,000	13.92	0 60	23,885
October	51,548	71,516,000	7,975	656	8,100	-143	1,209,000	15 02	0 65	19,015
November	27,324	37,961,000	7,939	656	8,100	-161	3,303,000	26 96	1 16	20,251
December	19,538	27,078,000	7,904	656	8,100	-196	4,785,000	36 61	1 58	24,012
Annual	494,786	686,447,000	7,954	656	8,100	--	1,055,000	15.88	0 686	200,923

Total $10,901,642

* Average Specification Heating Value

1994 Total Heating Value Not Received
72 28 x 10^9 Kcal Lost
286 85 x 10^9 BTU's Lost

KRIVOI ROG
POWER AND HEAT RELEASE FOR 1994

Months	Power Release 1000 KW/H	Power for Auxiliary Equipment 1000 KW/H	Consumption of Power for Heat Generation 1000 KW/H	Release of Heat (Hot Water) 6 KAL
January	620,903	40,726	1,053	22,583
February	943,893	56,120	913	21,915
March	1,005,976	60,256	964	22,320
April	624,679	40,717	594	9,242
May	359,429	27,530	378	6,241
June	393,415	25,690	313	4,050
July	864,780	55,670	351	5,490
August	1,216,147	74,348	325	4,680
September	1,085,348	68,893	331	4,960
October	1,005,986	65,664	354	5,565
November	916,427	59,507	1,348	26,083
December	859,629	56,771	1,549	32,133
Annual	9,896,612	631,892	8,473	165,262

KRIVOI ROG POWER PLANT
CONSUMPTION OF SERVICE WATER AND
WASTES DISCHARGE FOR 1994

Month	Consumption of Service Water			Wastes Discharge 1000 m^3
	1000 m^3	Price		
		KRB/m^3	Total MLN KRB	
January	2119	235	498	3067 5
February	2000	420	840	2770.7
March	3200	274	564	3067 5
April	6000	274	2074	2968.6
May	7000	274	2419	404 7
June	9000	274	2430	391 7
July	9000	274	1447	404.7
August	8000	274	2160	404 7
September	7000	400	2648	391 7
October	4000	840	1600	2208.6
November	2400	1480	3222	2968 6
December	2000	2070	2629	3067.5
Annual	61719	365	22532	22116 6

UKRAINE 1994

AVERAGE MONTHLY EXCHANGE RATES $/KRV

January	37,000
February	45,800
March	46,000
April	46,000
May	46,400
June	47,000
July	44,300
August	46,400
September	58,600
October	80,500
November	122,500
December	130,700

98

Foreign exchange rate KRV UA to USD, DM, SUR for '93, '94, '95

date	Street Market buy	Street Market sell	UICE Auction Rate	NBU Official Rate
29/08/94	52500	53800	40400	20500
	33200	34000	25600	13240
	22 7	23 5	-	9 5
05/09/94	49000	50200	41600	22000
	31500	34000	25600	13700
	22	22 5	21	9 5
12/09/94	53200	54200	43500	24000
	33000	34000	26800	15470
	22 5	23 5	20 32	8 9
19/09/94	61500	62800	47200	29000
	39000	40000	25800	16820
	24 5	25 2	25 8	11 3
26/09/94	71000	72500	47200	28000
	45500	46500	25800	18100
	27 5	28 2	25 8	11 4
03/10/94	65000	66500	54000	30000
	42000	43000	35000	19370
	22 5	23 2	-	11 4
10/10/94	86000	90000	65000	35000
	55000	57000	-	22660
	27 5	29	-	12 4
24/10/94	93000	95000	75100	43000
	60500	62000	50400	28640
	28	29	28	14 3
31/10/94	78000	80500	78600	78600
	52000	53900	52600	52600
	27	33	28	28
07/11/94	100000	105000	79800	78600
	61500	64500	58100	52600
	30	31 5	-	28
14/11/94	130000	136000	85100	85100
	80200	84200	58100	58100
	38 1	40	26 5	26
21/11/94	135000	141500	85100	91200
	90000	91800	58100	60500
	38 2	42 5	26	26 5
29/11/94	125000	129000	104200	104200
	80000	86000	65000	65000
	38	40	30 2	30 2
05/12/94	129500	135000	110200	110200
	82000	86000	71000	71000
	38 5	40	34	34
12/12/94	129000	133000	110000	110000
	80000	83000	71000	71000
	36 8	38	33 5	33 5
19/12/94	130500	135000	109800	110000
	82000	85500	70900	71000
	36 5	40	34	33 5
26/12/94	131000	135000	107900	107900
	81000	85000	70100	68620
	36	38	27	31 2
30/12/94	133500	137000	104200	104200
	81000	84000	63000	66130
	35	38	26	29 4
06/01/95	147500	157500	104000	104000
	86000	94500	62500	66870
	36	38	28 8	29 3
23/01/95	143000	154000	110200	106400
	88000	91000	69200	69250
	33 5	36	27 8	27 6

Foreign exchange rate KRV UA to USD, DM, SUR for '93, '94, '95

date	Street Market buy	Street Market sell	UICE Auction Rate		NBU Official Rate	
20/01/93					650 79	
					398 16	
					-	
06/02/93		1103			937 57	
					576 15	
					-	
05/03/93		1701			1233 11	
					746 52	
					-	
14/04/93					3002 02	
					1886 07	
					-	
11/10/93					15720	
					-	
					-	
14/11/93					25000	
					-	
					-	
05/02/94	45800	46000				
	26500	27200				
	24	24 5				
09/05/94	46000	47000			12610	
	26400	27100			7660	
	24 2	25			6 8	
16/05/94	45500	46500			13100	
					-	
					8 5	
23/05/94	47600	48800				
	28000	-				
	23 8	24 5				
30/05/94	53000	55000	37950		14100	
	31000	-	24100		8550	
	25 6	27	22 2		7 4	

date	Street Market buy	Street Market sell	UICE Auction Rate		NBU Official Rate	
06/06/94	48000	49000	39970		15100	
	28400	29300	24200		9190	
	24	24 5	20 92		7 9	
13/06/94	47000	48000	39970		16500	
	28000	28800	24100		10040	
	24	24 5	20 92		8 6	
20/06/94	46000	47000	39970		17500	
	27500	28500	24100		10650	
	22 5	23 5	20 32		8 9	
04/07/94	43000	44500	39970		19500	
	27000	27500	24850		12220	
	21	23 5	20		9 8	
11/07/94	44000	45000	39970		19500	
	26500	27500	24850		12220	
	20 5	22	19 5		9 8	
18/07/94	45250	46400	39970		19500	
	28250	29000	25600		12720	
	21.4	22.25	19 5		9 6	
25/07/94	44750	45700	39970		19500	
	28000	29500	25000		14490	
	21	22	19 5		9 6	
01/08/94	44000	45000	39970		19500	
	27500	28300	25600		12400	
	20 1	20 7	19 5		9 5	
08/08/94	43500	44500	39970		19500	
	27500	28300	25600		12900	
	19 65	20 4	19 5		9 4	
15/08/94	44850	45900	39970		20500	
	28000	29000	25600		12940	
	20	20 5	19 5		9 7	
22/08/94	47000	48000	40500		20500	
	29400	30100	25300		13230	
	19 7	20 3	19 8		9 6	

KRIVOI ROG
01.03.95.

MEASURES TAKEN AT KRIVOI ROG POWER PLANT FOR IMPROVEMENT OF OPERATION EFFICIENCY AND EFFECTIVE FUEL UTILIZATION

1 Conversion of the generating units mode of operation to the neutral-oxygen water mode of operation

2. Rehabilitation of equipment and filters of the demineralizing unit

3 Replacement of turbine high-pressure and intermediate pressure cylinders at 5 generating units by more efficient ones

4. Introduction of the new УЗПН type burner units at the boilers of the ТПП-210А type.

5. Elaboration of the automatic system for control of water and chemical operation performance of all the generating units by the following parameters. sodium, pH, and electric conductivity.

6. Rehabilitation of unit control boards at 4 generating units with the purpose of upgrading of instrumentation.

7 Replacement of generator stators at 2 generating units; operation of rehabilitated generator rotors at 8 generating units

8 Replacement of the coupling autotransformer between the 154 kV switchyards and the 330 kV switchyards

9 Rehabilitation of precipitators of the generating unit No. 4 (currently at the execution stage)

10 Replacement of the ОСПТ-1150М type feed-pump turbines by those of the ОР-12ПМ type

11 Reconstruction of the ТПП-210А type boiler with the purpose of increasing its reliability by means of the feed water circulation scheme modernization (currently at the execution stage)

KRIVOI ROG PRIORITIES

1. On-line natural gas calorimeter

2 Laboratory calorimeter - Coal and mazut
Muffle furnace (220V) Proximate analysis ash fusion temp

3 Ash gage - dual gamma and microwave for ash content and moisture

4 Silica (SiO_2) analyzer - after No. III anion (7 point sample switching)

5 Dissolved oxygen in feedwater
ORP specific ion probes?

6 Vibration Fourier Waveform Vibration Analysis Portable Equipment

7 In-Situ oxygen zirconium oxide probes, heaters, calibrators and monitoring unit for one unit.

8. High resolution x-ray unit for Dnieperenergo system to use at all supercritical steam power plants.

01.03.95

KRIVOI ROG

LIST OF INSTRUMENTATION AND EQUIPMENT
FOR CHEMICAL LABORATORY

1 Oil products detector (analyzer) with the range of sensitivity from 0 to 5 mlg/kg.

2 Muffle furnace (1000°C) - 2 units

3. Desiccator (200°C) - 2 units

4 Laboratory scales (max weight 10 kg)

5 Laboratory scales (max weight 200 g) - 3 units

APPENDIX D

List of Contacts Made During Plant Audits

KRIVOI ROG
PEOPLE MET

1	Chebotar Valeriy	-	Director
2	Vladimir Luchnikov	-	Chief Engineer
3	Victor Cabanenko	-	Chief of Technical Department
4	Mariya Kotenko	-	Head of Archives
5.	Peter Solovey	-	Chief of Maintenance Department
6.	Georgiy Rats	-	Chief of Electric Department
7	Vasiliy Volokovikh	-	Maintenance Engineer
8	Vladimir Bryjakh	-	Electric Engineer
9	Egor Sysoev	-	Chief of Automatic Department
10.	Valeriy Torgunsky	-	Engineer
11.	Vadim Necrasov	-	Chief of Water Treatment
12.	Svetlana Nikolaenkova	-	Water Treatment Engineer

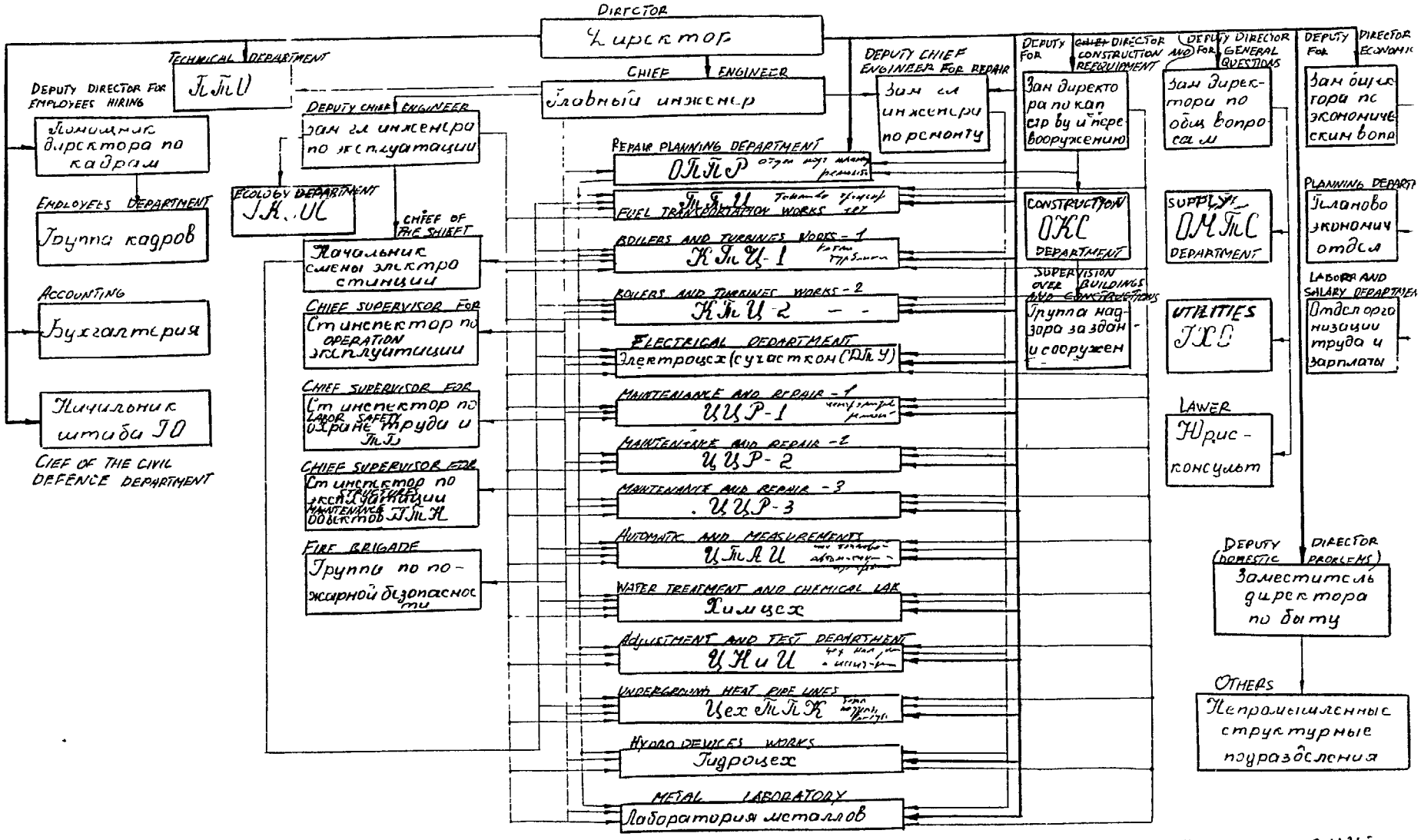
KRIVOI ROG

NUMBER OF EMPLOYEES AT THE POWER PLANT (01-02-95)

1.	Employees of Power Plant Total	4021
2.	Maintenance and Operational	3126
	Including Operation Staff	858
3	Others	895

ORGANIZATIONAL STRUCTURE OF KRIVOY ROG PP

Генеральный директор ПО „Энергоремонт"
Л. Г. Косульки



Директор Криворожской ГРП В.М. Чой

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APPENDIX E

Abbreviations and Unit Conversions

ABBREVIATIONS AND UNIT CONVERSIONS

AC	=	alternating current
amps	=	amperes
atm	=	atmosphere = 14.696 pounds per square inch
bar	=	100,000 pascals = 14.504 pounds per square inch
BTU	=	British thermal unit
cfm	=	cubic feet per minute
cm	=	centimeter = 0.3937 inches
cm^2	=	square centimeter = 0.155 square inches
CO	=	carbon monoxide
CO_2	=	carbon dioxide
DC	=	direct current
°C	=	degree CelsiusT[°C] = (5/9)*(T[°F] -32)
°F	=	degree Fahrenheit
°R	=	degrees RankineT[°R] = T[°F] + 460
ECO	=	Energy Conservation Opportunity
eff	=	efficiency
ex air	=	excess air
ft^2	=	square feet
ft^3	=	cubic feet
Gcal	=	gigacalorie = 1 billion calories = 3.968 million BTU
GJ	=	gigajoules = 1 billion joules
gph	=	U.S. gallons per hour
gpm	=	U.S. gallons per minute
GWh	=	gigawatt hours = 1 billion watt hours
H_2	=	hydrogen
H_2O	=	water
H_2SO_4	=	sulfuric acid
hectare	=	10,000 square meters = 2.471 acres
hectoliter	=	100 liters = 26.42 U.S. gallons
Hg	=	mercury
hr	=	hour
Hz	=	hertz = cycles per second
J	=	joules
kcal	=	kilocalories = 1 thousand calories = 3.968 BTU
kg	=	kilogram = 2.2046 pounds
Kgce	=	7,000 kcal = 27,776 BTU
kJ	=	Kilojoules = 1 thousand joules = 0.947813 BTU
km	=	kilometer = 0.621 miles
kN	=	kilonewton = 1 thousand newtons
kp	=	kopec = 1/100 ruble
kPa	=	kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	=	kilovolts = 1 thousand volts
kVA	=	kilovolt-amperes
kVAr	=	kilovars = 1 thousand volt-amperes (reactive)
kW	=	kilowatt = 1 thousand watts
kWh	=	kilowatt hour = 1 thousand watt hours

lbs	=	pounds
liter	=	0.2642 U.S. gallons = 0.03531 cubic feet
m	=	meter = 39.37 inches
m^2	=	square meter = 10.76 square feet
m^3	=	cubic meter = 35.31 cubic feet
mA	=	milliampere = 0.001 amperes
MCal	=	megacalorie = 1 million calories
metric ton	=	1 thousand kilograms = 1.1023 U.S. tons
mg	=	milligrams
min	=	minute
MJ	=	megajoules
mm	=	millimeter = 0.03937 inches
MPa	=	1 million pascals = 145.04 pounds per square inch
MVA	=	megavolt-amperes
MW	=	megawatt = 1 million watts
MWh	=	megawatt hours = 1 million watt hours
NG	=	natural gas
nm	=	nanometer
Nm^3	=	cubic meters at standard conditions of temperature and pressure (20°C and 1 atmosphere)
NO_x	=	nitrogen oxide
O_2	=	oxygen
P	=	pressure
PC	=	personal computer
ppm	=	parts per million
psi	=	pounds per square inch
psig	=	pounds per square inch (gauge)
R	=	ruble
s	=	second
SO_2	=	sulfur dioxide
sq ft	=	square feet
Tcal	=	tetracalorie = 1 trillion calories = 3.968 billion BTU
T	=	temperature
TPS	=	Thermal Power Station
V	=	volts
VA	=	volt amps
VARs	=	volt-amps reactive
yr	=	year

APPENDIX F

Letters of Receipt for Equipment
Energy Audit Items Lists

Министерство энергетики и электрификации УССР
ПРОИЗВОДСТВЕННОЕ ЭНЕРГЕТИЧЕСКОЕ ОБЪЕДИНЕНИЕ „ДНЕПРОЭНЕРГО"
ГОСУДАРСТВЕННОЕ ПРЕДПРИЯТИЕ КРИВОРОЖСКАЯ ГОСУДАРСТВЕННАЯ
РАЙОННАЯ ЭЛЕКТРОСТАНЦИЯ

322420 г. Зеленодольск Апостоловского
р-на Днепропетровской области

10.3.95 № 13/425

На № от

расчетный счет 221301 в
Центрально-городском отделении
АК ПИБ г. Кривой Рог (KRIVOI ROG)
МФО 305493 индекс 324099
г. Кривой Рог, пр. К. Маркса 5

Настоящим подтверждается, что представителем американской кампании "Бернз энд Роу" Джоном Холбергом переданы Криворожской ГРЭС следующие электронно-измерительные приборы:

I. Модель 2000 "ЕНЕРАК", Анализатор процесса сгорания, включая:
- зонд;
- программное обеспечение Виндоус.

2. Флюк. Модель 4I. Анализатор гармоник электричества, включая:
- клещи для тока 500 А;
- клещи для тока I000 А;
- программное обеспечение;
- портфель для прибора.

3. "Минолта" 300 НФ/300
Бесконтактный определитель температуры.

4. Переносной компьютер фирмы Тексас.
/программное обеспечение/.

5. Принтер "Окидата". Модель 380.

6. Сопутствующее оборудование:
- 2 комплекта кабелей для модема;
- устройство для подзарядки батарей;
- аккумуляторы типа "С";
- конвертор напряжения и вилки;
- модем;
- программа для установки русского языка;
- русифицированная клавиатура;
- программное обеспечение ВЭрд Перфект;

ст Высокопольн. 1994 р. Зак. № 1550—2000

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- программное обеспечение Виндоус;
- программное обеспечение Лотос;
- программмное обеспечение Проком Плас.

Приборы были закуплены, доставлены и переданы Криворожской ГРЭС в рамках программы Агенства по Международному Развитию США "Повышение эффективности работы украинских ТЭС".

Приборы переданы Криворожской ГРЭС в качестве безвозмездной помощи Украине со стороны правительства США в рамках двухсторонней договоренности и технико-экономическом содействии Украине со стороны США.

I.03.95г.

John E. Hallberg

Директор Криворожской ГРЭС
В.М.Чеботарь

Д.Холберг, ст.инженер
"Бернз энд Роу"

ENERGY AUDIT ITEMS

POWER PLANT ENERGY SAVINGS

Deaerator vents

Steam Traps

Boiler Blowdown

Mazut tanks vents & leaks

Leaks - Steam & feedwater & compressed air and Nat gas

Boiler leaks - fire box, flue gas ducts

ID fan wear, eff , leakage

FD Fans wear, eff., leakage

Air heater leakage, ESP leakage, efficiency if coal

Insulation-boiler, heaters, deaerator, piping, duct work

Generator losses - cooling system eff. (scale, crud)

Condenser/vac - leakage, cooling water fouling

ASME Short form (heat rate) & PT6 abbreviated

Boiler feed pumps - seals leakage

Valve Stem packing leaks

Turbine lube oil system - cooling system (scale, crud)

Boiler combustion - excess air, orsat, fuel flow, air flow, temp, press , burners, carbon losses

Electrical losses - transformers, large motors

District heating water losses (quantify)

ВОПРОСНИК ПО УЛУЧШЕНИЮ КПД СГОРАНИЯ НА УКРАИНСКИХ ЭЛЕКТРОСТАНЦИЯХ

Следующая работа будет проведена на каждой из электростанций, как минимум:

* Представление и обмен информацией с руководством станции

* Обсуждение и представление обьема работ

* Оценка технических и организационных возможностей

* Установление возможных направлений сотрудничества

* По возможности определение помощи на местах

* Определение и координирование рабочего графика

* Дискуссии с персоналом, отвечающим за работу станции

* Определение наличия существующих источников информации и данных

* Определение данных о работе станции на всем протяжении ее существования

* Визит на станцию для определения требований к выбранному измерительному оборудованию:

  Анализаторы сгорания
  Счетчики потока топлива (газ, нефть или уголь)
  Кислородные анализаторы

* Ознакомление с существующими чертежами по трубопроводам и измерительной технике для определения местонахождения пунктов мониторинга

* Определение физического местоположения для установки первичного элемента

* Определение местоположения для установки дистанционных модулей мониторинга

* Подбор персонала для обучения на местах навыкам проведению аудита

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

Reference

1 Plant Audit Visit Trip Report, October 1994
2 Preliminary Audit Report, December 1994
3 Plant Audit Visit Trip Report, Team #2, March 1995
4 Follow-up Audit Trip Report, July-August 1997

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.

Power Plant Selections

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

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

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

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

Kenney

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

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

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

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

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

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

Planning of Initial Audit Visits

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

Team #1:

Selisett N. Corban
Marc Giniger

Team #2:

John Hallberg
Cliff Crosman

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

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

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

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

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

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

Initial Audit of the Plants

Introduction

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

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

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

General

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

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

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

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

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

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

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

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

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

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

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

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

A. KURAKHOVSKA POWER PLANT (Sept. 25 thru Sept. 28)

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

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

The meetings were held with the following key personnel:

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

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

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

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

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

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

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

The meetings were held with following key personnel:

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

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

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

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

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

The meetings were held with the following key personnel:

- Oleg K. Gritsaniuck; Director

- Alexander G. Chupyra; Chief Engineer

- Valentin Kolomiets; Automation

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

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

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

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

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

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

The meetings were held with the following key personnel:

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

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

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

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

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

ATTACHMENT #2

PLANT VISIT SCHEDULE

REV 9/23/94

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

ATTACHMENT # 3

CHECK LIST
IMPROVING COMBUSTION EFFICIENCY
UKRAINIAN POWER PLANTS

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

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

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

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

ATTACHMENT 4

IMPROVING COMBUSTION EFFICIENCY
UKRANIAN POWER PLANTS

PUNCH LIST

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

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

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

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

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

F. Section/plan views of boiler.

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

H. Mode of unit operation - loading of units.

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

J. CO and O_2 monitoring.

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

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
YN	12 X 200	SUBCRITICAL	HIGH BITUMINOUS COAL	LVIVENERGO	1965-1969	ELECTRIC ONLY
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

PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

KRIVOI ROG POWER PLANT
(OCT. 5 THRU OCT. 8, 1994)

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

DECEMBER 1994

5906-02/Cover/12/9/94

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PRELIMINARY AUDIT REPORT
IMPROVING COMBUSTION EFFICIENCY

KRIVOI ROG POWER PLANT

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PRELIMINARY AUDIT REPORT

IMPROVING COMBUSTION EFFICIENCY

KRIVOI ROG POWER PLANT
(Oct. 5 Thru Oct. 8, 1994)

EXECUTIVE SUMMARY

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

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

Low-Cost, No-Cost Short Term Recommendations

1) Fuel Quality Improvement Plans

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

2) Boiler Startup and Shutdown Plans

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

3) Energy Saving Program

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

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Long-term Recommendations.

a) Portable combustion Analyzers

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

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

b) In Situ O_2 Analyzers

The combustion efficiency can be improved by replacing on boiler Unit 5 the existing extractive oxygen analyzers with four in-place zirconium oxide sensor analyzers as used in USA.

It is recommended: four devices per boiler unit 5.

c) 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:

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

It is recommended: three devices per boiler unit 5.

ii. Two mazut flow meters per each main pipeline (supply and return).

It is recommended: total of 4 devices per station.

iii. Two mazut flow meters (supply and return lines) per subboiler (total 4 per boiler).

It is recommended: four devices per boiler unit 5.

d) Portable infrared temperature monitor (heat spy).

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

It is recommended: one heat spy per station.

e) 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.

f) Laptop personal computer

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

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

Medium to Long-Term Recommendations

1) Implementation of energy saving program phase two.

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

3) Investigate lower cost SO_2/NO_x removal technologies.

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

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

5) New water treatment plant.

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

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

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

9) Provide proper analytical equipment to the chemical laboratory.

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

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

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

Observations and Assessments

- The station is well managed by experienced personnel. The engineering staff is competent.

- A reconstruction study of this station is being completed and consists of three options:

  - Reconstruction of all major equipment within existing structures.

  - Construction of similar power plant nearby.

  - Reconstruction of four units in existing structures and construction of six new units nearby

  Station would prefer the third option. At the present time due to financial condition of the Ukraine the equipment is replaced step by step.

- Starting 1987 considerable work of refurbishing and major component replacement on Unit 1 boiler and on Units 1 to 5 HP and IP turbine sections has been done. Some steam pipelines interconnecting the Unit 1 boiler and its turbine have been replaced.

- Plans are in place to continue the major component replacement on all boilers and turbines.

- The boilers have no burner management systems.

- The station has no NO_x pollution control system.

- The original mechanical governors are still in operation.

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

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

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

- The controls and instrumentations are outdated, the readings are unstable and

require ongoing maintenance to keep them operational. Spares are hard to be obtained.

- 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 32 different suppliers during any given week. The station has little input to the quality selected for the coal or control over the fuel acquisitions.

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

- The original boiler design performance when firing coal was revised in 1989 and subsequently the boiler maximum load output was reduced from 300 MW to 282 MW. Therefore the power plant MW output is derated to 2820 MW from 3000 MW, a total reduction of 180 MW (6%). The main steam temperature was also changed from 565°C to 545°C to increase boiler reliability.

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

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

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

- The efficiency calculations are performed on a per unit basis. Except for natural gas that is measured directly per boiler, all other fuel quantities (mazut and coal) are extrapolated from power station data. Actual fuel consumption of either mazut or coal per each unit is not known.

These efficiencies are compared to the efficiencies calculated based upon the boiler design performance recalculated in 1989.

- The station expressed concern about adequate spare parts available for the euqipment provided to improve combustion efficiency.

INTRODUCTION

ENERGO SYSTEM:	DNIPROENERGO
LOCATION:	100 KM SOUTH-WEST OF DNIPROPETROVSK
INSTALLED CAPACITY:	3000 MW 10 X 300 MW
COMMISSIONED:	1965-1973
FUEL.	COAL LOW-BITUMINOUS, ANTHRACITE SUPPLEMENTED BY MAZUT AND GAS

POWER PLANT DESCRIPTION

1. The Krivoi Rog Steam Power Station consists of ten supercritical 300 MW units firing coal. The station was commissioned between 1965 and 1973. The station was constructed in three stages. The first stage (units 1-4) consists of boilers from Podolsk and turbines from Kharkov, the second stage (units 5-8) consists of boilers from Taganrog and turbines from Kharkov, and the third stage (units 9-10) consists of boilers from Taganrog and turbines from Kharkov.

2. The coal the station fires is from the Donetsk region types T, TR and TK. The design coal characteristics consisted of a caloric value of 6,500 kcal/kg, 15% ash, and 5-6% water. The actual coal characteristics consist of a caloric value of 4,500 to 5,500 kcal/kg, up to 40% ash and a water content of 9%. The station also cofires natural gas and mazut with the coal in order for the units to reach rated performance. Typically the station fires 80% coal, 10% natural gas, and 10% mazut.

3. The experience gained in the operation of these units was incorporated into the design of future 300 MW units in the former U.S.S.R.

4. The Podolsk boilers are type P-50 of Russian manufacture from the Podolsk Machine Building Plant. The layout is of two identical boiler blocks coupled together to supply the required steam rate of 950 tons per hour. Each boiler is supercritical and capable of supplying steam at a rate of 475 tons per hour at a pressure of 255 bar gauge and live steam temperature of 545°C. Reheat steam is also produced at a temperature of 545°C. The boiler operates in a balanced draft mode. Coal is supplied to the boiler unit and held in raw coal bunkers prior to being fed to the ball mills. The motive air for transfer of the pulverized fuel is directed from the outlet of the air heaters and is used to dry the pulverized fuel in addition to transporting it to pulverized fuel storage bunkers. The contained air is returned back to the primary air system via centrifuge separators through which all the pulverized fuel is passed prior

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to storage in the pulverized fuel storage bunkers. The pulverized fuel storage bunkers supply pulverized fuel flow to the burners via individual bunker outlets feeding to rotary feeders which control the flow to the burners. The fuel flow is controlled manually from the Unit Control Room. The Taganrog boilers are type TPP-210A of Russian manufacture from the Taganrog Boiler Works. The characteristics of the Taganrog boilers are similar to those discussed previously for the Podolsk boilers.

5. The first unit has been in operation for approximately 30 years and has undergone considerable renovation. Starting in 1987 the cylinders of the high and medium pressure sections of the turbines in units 1 to 5 have been replaced. Some steam pipelines interconnecting the boiler and turbine have been replaced. Various heating surfaces have been replaced in the boilers. Some parts of the control system have been replaced. It is considered that these measures would prolong a unit's life another 25 years. There are plans to do the same kind of work on the other units. However, the financial condition of the Ukraine is an obstacle to completing these plans. The schedule has been shifted one year.

   Operational life of a unit is considered to be 200,000 hours of operation. The units of stages 2 and 3 have an operational life left of 5 to 7 years. Unit 6 has operated 180,000 hours with the rest of units less. Units are operated on the order of 6,000 to 8,000 hours per year.

6. A reconstruction study is being completed by a special agency and consists of three options:

   1. Reconstruction of equipment within existing structures.

   2. Construct similar power plant nearby.

   3. Reconstruction of four units in existing structures and construction of six new units nearby

   The objectives are to use actual coal, increase reliability of the boilers, remove SO_2, NO_x and gas emissions cleanup. The station would prefer the third option. The financial condition of the Ukraine is an obstacle to implementing the program. The station is now replacing the equipment step by step.

7. The emissions from 300 MW units are now on the agenda in the Ukraine. The station is interested in improving combustion efficiency to reduce emissions.

8. The total station operating and maintenance personnel is 2,500 plus 1,000 for social programs. In addition, there are 500 contracted maintenance personnel. There are workshops for repairing turbine and boiler components and a special workshop for automation.

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9. Installation of instruments for combustion efficiency should not create a problem due to item 8. above.

BOILER PLANT

10. Boiler Design Performance:

    a. The original type P-50 boiler design performance is shown on Attachment 1.

    b. The original type TPP-210A boiler design performance is shown on Attachment 2.

    c. The 1989 revised type P-50 boiler design performance is shown on Reference 1.

    d. The 1989 revised type TPP-210A boiler design performance is shown on Reference 2.

    e. The type P-50 and type TPP-210A boiler design performance will next be revised in February 1995.

    f. Discussion:

        i. The boiler performances are based upon coal and mazut cofiring with mazut being 5% of the total heat input.

        ii. The main steam temperature was changed from 565°C to 545°C to increase boiler reliability.

        iii. The maximum boiler load is now 282 MW due to the reduction in coal quality from the original boiler design performance coal. This will be addressed in the February 1995 boiler design performance revision.

11. Mode of Fuel Firing:

    a. Mazut Only:

        i. Mazut only during initiation of combustion (startup).

        ii. Mazut only for several hours if mill brakes, etc. (emergency). Maximum load on mazut is 180 MW (90 MW per subboiler).

    b. Natural Gas Only:

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i. A unit can operate at 300 MW on natural gas only.

c. Coal:

i. Always cofire mazut and sometimes natural gas.

ii. Try to keep mazut to 5-10% of boiler heat input. However, it could rise to 25% if poor quality coal is fired. Mazut is continuously cofired with coal when coal caloric value is equal or less than 5000 kcal/kg to have a maximum 280 MW unit output (maximum boiler load).

iii. Try to keep natural gas at 10-15% of boiler heat input.

iv. There is an explosion problem while cofiring natural gas and coal dust. Therefore, this is done only under very strict conditions and seldom.

12. As-Fired Fuel Analysis:

a. Coal:

i. Coal is supplied to station from 32 suppliers.

ii. The coal can go either of two ways: from railroad direct to coal storage or from railroad direct to station two conveyors (one plus one reserve).

iii. There is a special scale in the rail to weigh as-received coal to $\pm .5\%$ accuracy.

iv. Coal in storage is not blended. Usually as-delivered coal bypasses storage and goes directly from coal train to raw coal bunkers.

v. Mechanical coal samples are taken from the two conveyors and collected every 5 minutes and mixed for 24 hours and analysis done. Coal is then collected for 5 days, mixed and a more detailed analysis completed.

vi. Attachment 3 details minimum, maximum and average coal analyses

b. Natural gas:

i. Natural gas is practically not analyzed.

ii. Natural gas caloric value is essentially stable at 7,900 kcal/kg.

c. Mazut:

i. Mazut is sampled from one railroad tanker at delivery and from pipeline feeding boilers.

ii. Attachment 4 details typical mazut analyses.

13. Boiler As-Fired Fuel Performance:

a. A unit can produce 300 MW firing natural gas.

b. During coal firing a unit normally produces 250-260 MW. This occurs because amount of mazut fired is usually limited to 5% of the boiler heat input. The expense of mazut, heating services for mazut, and boiler manufacturer recommendation to limit mazut firing to 5% to maintain boiler's reliability are the factors to be considered.

14 Boiler Firing System Flow Diagram:

a. Units 1-4 (P-50 boilers) - as shown on Attachment 5. There are 12 burners per subboiler (24 burners total), and two raw coal bunkers, one mill, one separator, one cyclone, one coal dust bunker per subboiler.

b. Units 5-6 (TPP-210A boilers) - as shown on Attachment 6. There are 24 coal dust feeders and 12 burners total (6 burners per subboiler) with one common coal dust bunker per boiler. Each subboiler has its own mill, separator and cyclone. There is one raw coal bunker for subboiler A and two raw coal bunkers for subboiler B (units 5-8). There are two raw coal bunkers per subboiler for units 9 and 10.

c. Units 7-10 (TPP-210A boilers) - as shown on Attachment 7. There are 12 coal dust feeders and 12 burners total. The other equipment is as discussed in b. above.

d. All units have one additional oil burner per subboiler or 2 per boiler.

15. Section/Plan View of Boiler:

a. Attachments 8 and 9 are section views of the P-50 boilers.

b. Attachment 10 is a section view of the TPP-210A boilers.

FUEL SUPPLY

16. Flow Diagrams for Fuel Supply:

a. Mazut:

i. Attachment 11 is the mazut flow diagram for the P-50 boilers. A similar flow diagram exists for the TPP-210A boilers. The flow diagram shows the flow to the 12 burners plus one additional oil burner per subboiler (26 burners total).

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

iii. The power station would like to have 2 flow meters per each main pipeline (supply and return) for a total of 4.

iv. In addition, the power station would like to have 2 flow meters (supply and return) per subboiler (total of 4 per boiler) for a total of 40 or 44 including the flow meters from 16.a.iii. above.

b. Natural Gas:

Attachment 12 is a typical natural gas flow diagram per boiler. Natural gas flow meters already exist per subboiler and work well. The flow meters that exist per burner do not work.

c. Coal:

i. Attachment 13 shows the conveyor arrangement for the power station The conveyors on the top right deliver coal to the raw coal bunkers of units 1 to 4. Sampling takes place as discussed in 12.a.v. The location of the 2 scales that weigh the coal going to units 1 to 4 is also shown.

ii. A similar arrangement is shown on the top left for units 5 to 10. The four scales on the conveyors have a $\pm 1\%$ accuracy

iii. The power station would like to be able to meter the flow of the coal from each raw coal bunker to its subboiler between bunker and mill for a total of 36 meters (see item 14.).

PLANT OPERATION MODE

17. The power station typically operates with 5-6 units at base load, 2-3 units in reserve and 1 unit undergoing overhaul.

18. Attachments 14 and 15 detail the power station load with 6 to 7 units operating on October 3 and 4, 1994 and October 7, 1994 respectively for each hour of the day The maximum load per unit is 272 MW

19. Attachments 16 and 17 detail the same as 18. above except during July and February. In July 7 to 8 units are operating; and in February only 3 to 4 units are operating because of a lack of fuel.

20. The plant is a base load plant. The plant capacity may go down to 30% when operating, but a unit capacity cannot go less than 210 MW; operating range of a unit is 210 to 290 MW.

COMBUSTION CONTROL

21. Attachments 18 to 20 detail the combustion control scheme. Coal is usually fed to the boilers at maximum coal feeder speed, with cofiring of mazut used to bring the boiler to the required load. The forced draft fan air damper positions are adjusted manually based upon a chart which indicates the unit load as a function of the amount of coal and oil fired. In addition, the air damper adjustment is made based upon O_2 analyzer indications. The schemes on Attachments 18 and 19 are used to control the main steam temperature. The control of fuel and combustion air ratio is essentially a manual operation based upon maintaining the required unit load with constant boiler outlet main steam pressure and temperature and with O_2 indications less than 4%.

22. CO and O_2 Analyzers:

    a. None of the units have CO monitoring.

    b. As shown on Attachment 21, two O_2 analyzers are located per subboiler after the economizer where the temperature is 380 to 400°C or four per boiler.

    c. The power station would like to locate the two O_2 analyzers per subboiler (4 per boiler) after the reheater of the first stage where the exhaust gas temperature is 550 to 600°C for a total of 40 O_2 analyzers per plant.

    d. The thermocouples shown are used for monitoring only. The four metal temperature thermocouples located above the fuel chamber are unreliable.

CALCULATION OF BOILER EFFICIENCY

23. The methodology for the boiler efficiency calculation is shown on References 3 and 4 for February and August 1994 respectively. The calculations are done on a per unit basis. As discussed previously, in items 12 and 16, 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 5 day basis. These efficiencies are compared to the efficiencies calculated based upon the boiler design performance as discussed in item 10.

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

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

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

1. Two mazut flow meters per each main pipeline (supply and return) - 4 devices total per station.

2. Two mazut flow meters (supply and return) per subboiler (total 4 per boiler) - 40 devices total per station.

3. Devices to meter the flow of coal from each raw coal bunker to its subboiler located between bunker and mill (4 devices for units 1 to 4 and 9 to 10, 3 devices for units 5 to 8) - 36 meters total per station.

4. Two in-situ O_2 analyzers per subboiler or a total of 4 per boiler - 40 devices total per station.

5. Continuous opacity monitor for each stack - 5 monitors total per station.

6. Portable combustion analyzer - one per station.

7 Adequate spare parts supplied for equipment provided to improve combustion efficiency.

I. Котлоагрегат

3.I. Характеристика оборудования:

Котел прямоточный, пылегазовый, двухкорпусной, симметричный с выносными воздухоподогревателями, П-образной компановки с жидким шлакоудалением на сверх критические параметры. Тип котла ПП-950-255-II, модели П-50, изготовлен Подольским машиностроительным заводом им. Орджоникидзе (ЗиО) в 1967г. заводской № 7 - смонтирован и введен в эксплуатацию на Криворожской ГРЭС-2 в 1968г., станционный № 4.

Attachment I

3.2. Таблица основных проектных данных.

№ п/п	Наименование показателей	Размерность	Величина	Примечание
I	2	3	4	5
I.	Завод-изготовитель		ЭиО	
2.	Тип и марка котла		ПП-950-255БМ П-50	
3.	Число корпусов		2	
4.	Производительность:	т/час		
	- по острому пару	"	950	(2х475)
	- по вторичному пару	"	760	(2х380)
5.	Теплопроизводительность брутто-нетто	Гкал/ч	660/6I0	
	то же	мвт.	768/709	
6.	Температура пара за котлом	оС		
	- острого пара		535	снижена до 545о согласно эксплуатационного циркуляра Т-4/7I от 3.03.7Iг.
	- вторичного пара		570	
7.	Давление пара на выходе из котла:	кгс/см2		
	- острого	"	255	
	- вторичного	"	36,0	
8.	Давление питательной воды на входе в котел	"	30I	
9.	Давление вторичного пара на входе в котел	"	38,5	
I0.	Температура вторичного пара на входе в котел	оС	309	
II.	Температура питательной воды	"	264	
I2.	Температура уходящих газов	"	I43	
I3.	Температура горячего воздуха	"	350	
I4.	Расчетный КПД котла брутто	%	92,63	
I5.	Объем топочной камеры	м3	2240	
I6.	Объем предтопка	"	709	
I7.	Тепловое напряжение топки	ккал/м3час	147.10^3	

ATTACHMENT 1

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I	2	3	4	5
I.	Тепловое напряжение предтопка	ккал / м3час	466.10^3	
I9.	Количество горелок	штук	2х I2	
20.	Тип горелок	По ОСТ 24.036.05.73	ДГ2W-35	ЗиО вихревые 2-х улиточные
2I.	Производительность горелок по твердому топливу марки "Т"	т/час	5,0	производительность по природному газу 3540 нм3 час.
	- то же	мвт.	35,0	
	- то же	Гкал/час	30,0	
22.	Топливо расчетное:			
	-теплотворная способность $Q_н^р$	ккал/кг	6550	
	- зольность - $A^р$	%	I5,2	
	- влажность - $W^р$	%	5,0	
23.	Расчетный расход топлива	т/час	I00,3	
24.	Регулирование перегрева	-	2 впрыска	
25.	Регулирование пром.перегрева	-	ШПГО	
26.	Гидравлическое сопротивление паро-водяного тракта	кгс/см2	45,7	
27.	Гидравлическое сопротивление тракта промперегрева	-	3,5	
28.	Аэродинамическое сопротивление газового тракта	кгс/м2	I99	(мм водн.ст.)
29.	Аэродинамическое сопротивление воздушного тракта.	"	232	"

Attachment 1

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Ш. КОТЛОАГРЕГАТ *Attachment 2*

3.I. Характеристика оборудования

котел прямоточный, пылегазовый, двухкорпусной, симметричный П-образной компановки с жидким шлакоудалением на сверхкритические параметры с выносными регенеративными воздухоподогревателями.

Тип котла ПП-950-255-2Ж, модели ТПП-2I0-А, изготовлен Таганрогским заводом "Красный котельщик" в эксплуатацию на Крив.ГРЭС *введён* 22.I2.I973г., ст. № I0.

3.2. Таблица основных проектных данных.

№№ пп	Наименование показателей	Размерность	Величина	Приме
I	2	3	4	5
I.	Производительность котла *по*			
	- острому пару	т/ч	950	
	- по вторичному пару	"	800	
2.	Теплопроизводительность котла			
	- брутто	Гкал/ч	630	
3.	Температура за котлом пара			Снижен
	- острого	°С	565	

	- вторичного	°C	570	до 545°C согласно экспл.цир-кулярa Т-4/7I от 3.03.7Iг.
4.	Давление ~~[illegible]~~ пара на выходе из котла - острого	кгс/см2	255	
	- вторичного	-"-	37	
5.	Давление вторичного пара на входе в котел	-"-	39,5	
6.	Температура вторичного пара на входе в котел	°C	307	
77	Температура питательной воды на входе в котел	-"-	260	
8.	Давление ~~[illegible]~~ питательной воды на входе в котел	кгс/см2	300	
9.	Температура уходящих газов	°C	I66	
I0.	Температура горячего воздуха	-"-	375	
II.	Расчетный КПД котла брутто	%%	9I,I	
I2.	Объем топочной камеры	м3	23I0	
I3.	Объем предтопка	-"-	7I0	
I4.	Тепловое напряжение - топки	ккал/м3час	$I45xI0^3$	
	- предтопка	-"-	$450/I0^3$	
I5Ф.	Количество горелок	шт	2x6	
I6.	Тип горелок	по ост 24.836 05-73	АГУЛ - 75	ТКЗ вихревые, улитко-лопаточные
I7.	Производительность горелки (по твердому топливу марки "Т")	т-ч	I0	
	- то же	мВт	75	
	- тоже	Гкал/ч	65	
	- п о природному газу	нм3/ч	7580	
I8.	Топливо расчетное	марка	"Т"	Донецкое месторожд
	- калорийность	ккал/кг	5900	
	- зольность Ар	%%	2I,6	
	- влажность Wp	%%	6,0	
I9.	Расчетный расход топлива	т/ч	II5,2	
20.	Регулирование перегрева - по острому пару			
	- по вторичному пару		3 впр. регулир. ступень	

ATTACHMENT 9

Attach ent 3

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Дата	Место отбора проб	Влага аналитическая	Влага рабочая	Зола аналитическая	Зола сухая	Зола рабочая	Сера аналитическая	Летучие горючие аналитические	Летучие горючие горючие	Теплотворная способность аналит бомбы	Теплотворная способность сухая бомбы	Теплотворная способность горючая бомбы	Теплотворная способность горючая низшая	Теплотворная способность рабочая низшая	Анализ произвел	Р на лаб
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
6.07 –	Сборн. суточ	0,5	5,3	35,2		33,5								4927		
7.07 –	— " —	0,5	5,0	30,9		29,5								5259		
8.07 –	— " —	0,7	5,5	40,6		38,6								4481		
9.07 –	— " —	1,1	5,0	37,6		36,1								4726		
10.07 –	— " —	0,6	4,9	45,9		43,9								4105		
6.07 – 10.07	Сборн. 5ти суточ проба	0,7	5,1	37,7	38,0	36,1	2,0	7,6	12,3	5090		8263	7955	4651	Медв	Ов
11.07	сборная суто	0,6	5,0	41,4		39,6								4348		
12.07	— " —	0,7	5,5	42,6		40,5								4263		
13.07	— " —	0,7	5,0	44,1		40,6								4345		
14.07	— " —	0,4	4,8	41,6		39,8								4378		
15.07	— " —	0,6	4,8	40,2		38,5								4412		
11.07 – 15.07	сборн. 5 ти суточ. проба	0,9	5,0	41,1	41,5	39,6	1,0	7,7	13,3	4734		8162	7840	4445		Ов
16.07	Сборная суто	0,9	4,0	35,5		34,4								4876		
17.07	— " —	0,6	4,5	38,4		36,9								4635		
18.07	— " —	0,6	6,1	37,8		35,7								4550		
19.07	— " —	0,8	4,8	39,5		37,9								4486		
20.07	— " —	0,7	7,5	36,7		34,2								4549		
16.07 – 20.07	Сборн 5-ти суточн проба	0,8	5,4	37,6	37,9	35,8	1,3	7,7	12,5	5028		8162	7880	4595		
21.07	Сборн. суточ.	0,5	5,2	39,2		37,3								4500		
22.07	— " —	0,5	6,0	35,5		33,5								4871		
23.07	— " —	0,6	4,8	34,4		32,9								4880		
24.07	— " —	0,4	4,9	30,4		29,0								5179		
25.07	— " —	0,5	4,5	31,2		29,9								5142		
21.07 – 25.07	сборная 5-ти суточ. проба	0,5	5,0	34,0	34,2	32,6	2,20	7,8	11,9	5428		8287	7976	4960		

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ATTACHMENT 3

Дата	Место отбора проб	Влага аналитическая	Влага рабочая	Зола аналитическая	Зола сухая	Зола рабочая	Сера аналитическая	Летучие горючие летучие аналитические	Летучие горючие горючие	Теплотворная способность аналит бомбы	Теплотворная способность сухая бомбы	Теплотворная способность горючая бомбы	Теплотворная способность горючая низшая	Теплотворная способность рабочая низшая	Атмосф производ	Рас нач бат
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
16.08 -	Сборн. суточ.	0,5	4,8	37,1		35,5								4781		
17.08 -	— " —	0,6	4,4	32,8		31,5								5733		
18.08 -	— " —	0,6	5,8	35,8		33,9								4819		
19.08 -	— " —	0,7	6,0	38,9		36,8								4568		
20.08 -	— " —	0,7	4,0	26,6		25,7								5634		
16.08-20.08	Сборн. 5ч	0,8	4,9	33,8	34,1	32,4	2,16	7,7	11,8	5427		8298	7989	4981	Мезо	
	суточ проба													Avg		
21.08 -	Сборн. суточ	0,6	4,6	33,7		32,3								5051		
22.08 -	— " —	0,8	6,8	31,8		29,9								5016		
23.08 -	— " —	0,6	6,0	18,5		17,5								6076		
24.08 -	— " —	0,7	4,0	28,6		27,6								5440		
25.08 -	— " —	0,6	4,7	37,6		36,0								4709		
21.08-25.08	Сборная 5ч	0,6	5,2	30,3	30,5	28,4	1,98	7,7	11,1	5813		8413	8119	5319	Мезо	
	суточ проба													Avg		
26.08 -	Сборн. суточ	0,7	5,0	30,9		29,6								5280		
27.08 -	— " —	0,4	5,6	28,2		26,7								5463		
28.08 -	— " —	0,6	5,5	36,6		34,8								4814		
29.08 -	— " —	0,5	5,1	28,5		27,2								5466		
30.08 -	— " —	0,5	6,5	42,5		39,9								4313		
26.08-30.08	Сборн. 5ч	0,8	5,5	33,7	34,0	31,6	2,23	8,0	13,7	5449		8319	7995	4953	Мезо	
	суточ. проба															
1.09 -	Сборн. суточ.	0,5	6,1	33,0		31,1								4984		
2.09 -	— " —	0,6	5,4	28,6		27,2								5356		
3.09	— " —	0,5	5,2	35,0		33,3								4886		
4.09	— " —	0,6	5,5	30,2		28,7								5228		
5.09	— " —	0,6	4,4	40,3		38,8								4515		
1.09-5.09	Сборн 5ч															
	суточн проба	0,7	5,3	33,1	33,3	31,6	2,28	8,4	12,7	5495		8301	8064	4919		

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ATTACHMENT 3

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Attachment 4

Дата 1	Причина и место отбора 2	Удельный вес 3	Наличие влаги 4	температура вспышки 5	Вязкость 6	Заключение 7	№ протокола 8	Анализ пробы 9	Роспись нач цеха нач лаборатории 10
		место отбора				влага % мазута	мазут	г/см³ кг/см²	при 20°
с 1.07 - 10.07		Бак №3				4,2%	65°	0,916	0,943
с 11.07 - 20.07		Бак №3				4,2	59°	0,927	0,957 г/см³
с 21.07 - 31.07 93		Бак №3				3,2	64°	0,932	0,959 г/см³
1.08 - 10.08.		Бак №3				4,8 %	65°	0,928	0,956
11.08 - 20.08		Бак №3				1,2%	56	0,938	0,966
21.08 - 31.08		Бак №3				2,2	60°	0,934	0,959
1.09 - 10.09 93г		Бак №3				3,0	59°	0,952	0,976 г/см³
11.09 - 20.09 93г		Бак №3				5,0	63°	0,942	0,969
21.09 - 30.09 93г		Бак №3				3,0%	65°	0,940	0,968
1.10 - 10.10 93г		Бак №3				4,2%	55°	0,932	0,954 г/см³
11.10 - 20.10. 93г		Бак №3				3,8%	59°	0,931	0,955 г/см³
21.10 - 31.10. 93г		Бак №3				2,0% 48	(2,13)	0,943	0,961 г/см³
1.11 - 10.11 93г		Бак №3				1,4%	55°	0,912	0,934 г/см³
11.11 - 20.11 93г		Бак №3				1,4%	55°	0,927	0,949 г/см³
21.11 - 30.11 93г		Бак №3				0,5%	57°	0,930	0,953 г/см³
1.12 - 10.12 93г		Бак №3				1,7%	63°	0,922	0,949 г/см³
11.12 - 20.12 93г		Бак №3				1,5%	67°	0,920	0,949 г/см³
21.12 - 31.12		Бак №3				2,2%	53°	0,928	0,949 г/см³

Дата 1	Причина и место отбора 2	Удельный вес 3	Наличие влаги 4	температура вспышки 5	Вязкость 6	Заключение 7	№ проб 8	9	
Сера %	Сс								
2,54	9707	19							
		20							
2,22	9765	21							
2,47	9563	22							
2,93	9614	23							
2,57	9628	№24							
2,23	9413	25.							
2,40	9611	26							
2,46	9615	27							
1,97	9647	28							
1,95	9748	29							
2,13	9646	30							
1,83	9834	31							
2,2	9860	32							
2,38	9726	33							
2,3	9712	34							
2,3	9674	35							
2,12	9707	36							

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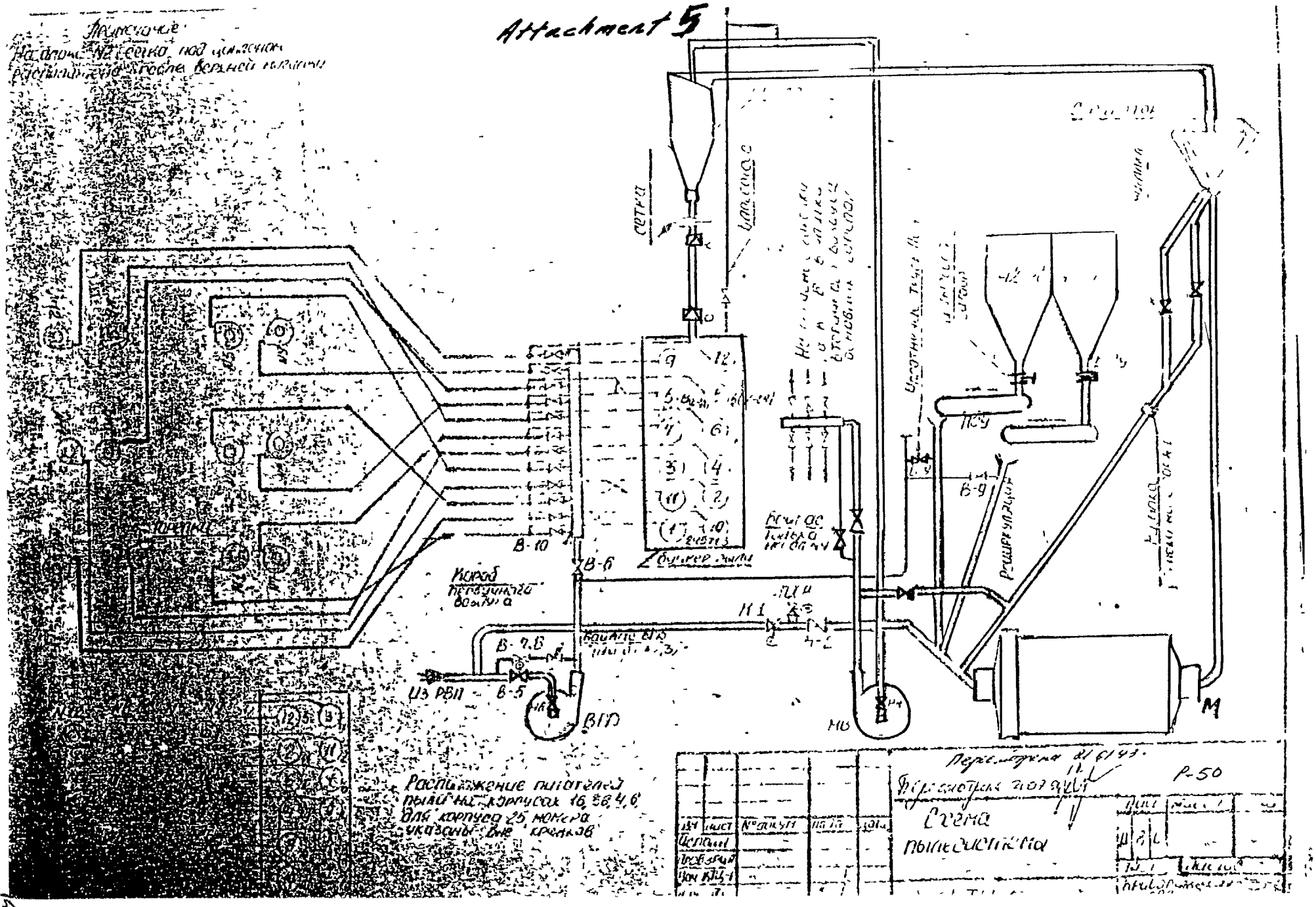
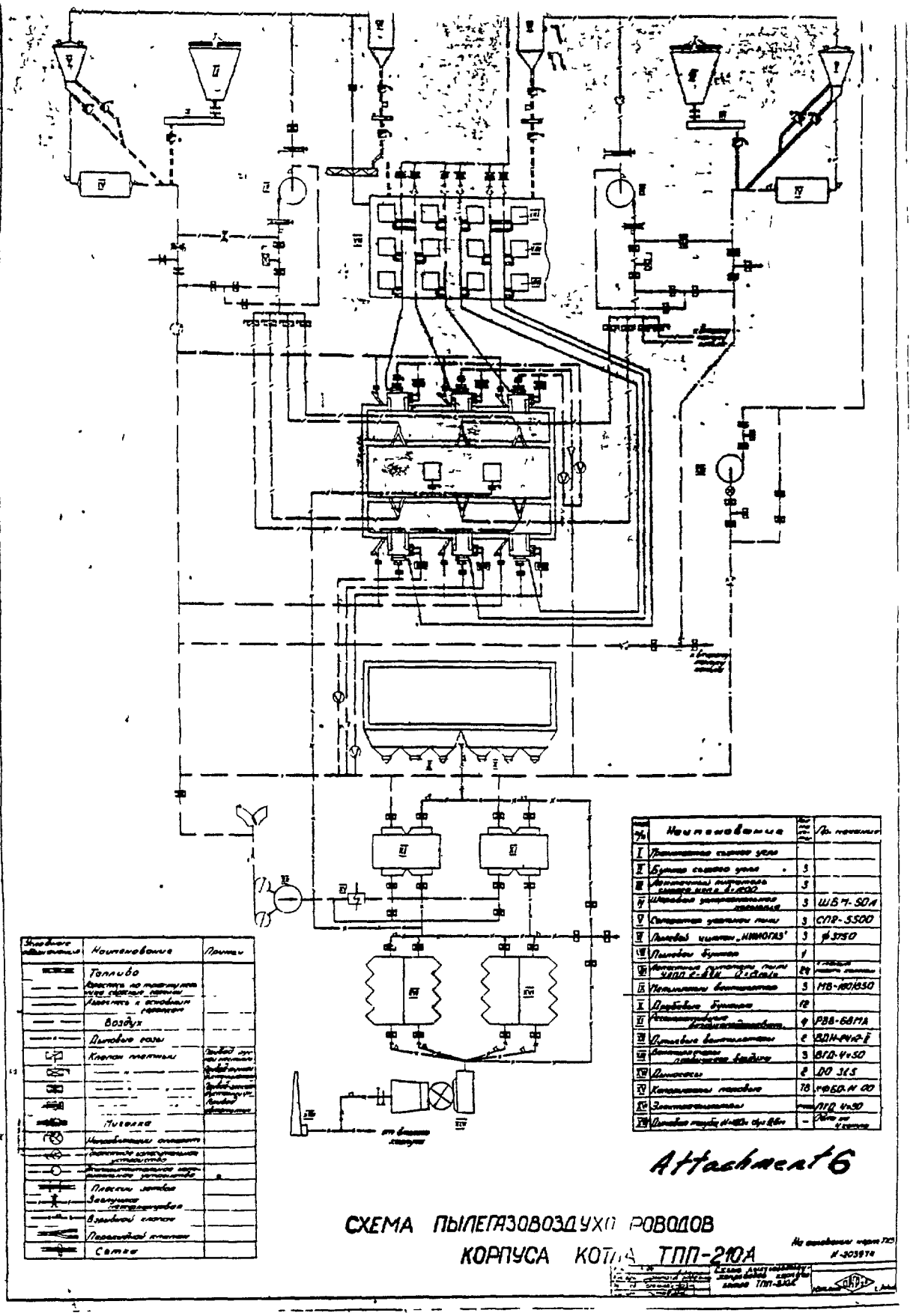
Attachment 5





Условные обозначения	Наименование	Примечание
	Топливо	
	Пластины по пластинам	
	Пластины к основным горелкам	
	Воздух	
	Дымовые газы	
	Клапан пластины	
	— " —	
	— " —	
	— " —	
	Пыльная	
	Пылевые отложения	
	Пылевые взрывные устройства	
	Пылевые предохранительные устройства	
	Пластины заслонки	
	Заслонка предохранительная	
	Взрывной клапан	
	Предохранительный клапан	
	Сетка	

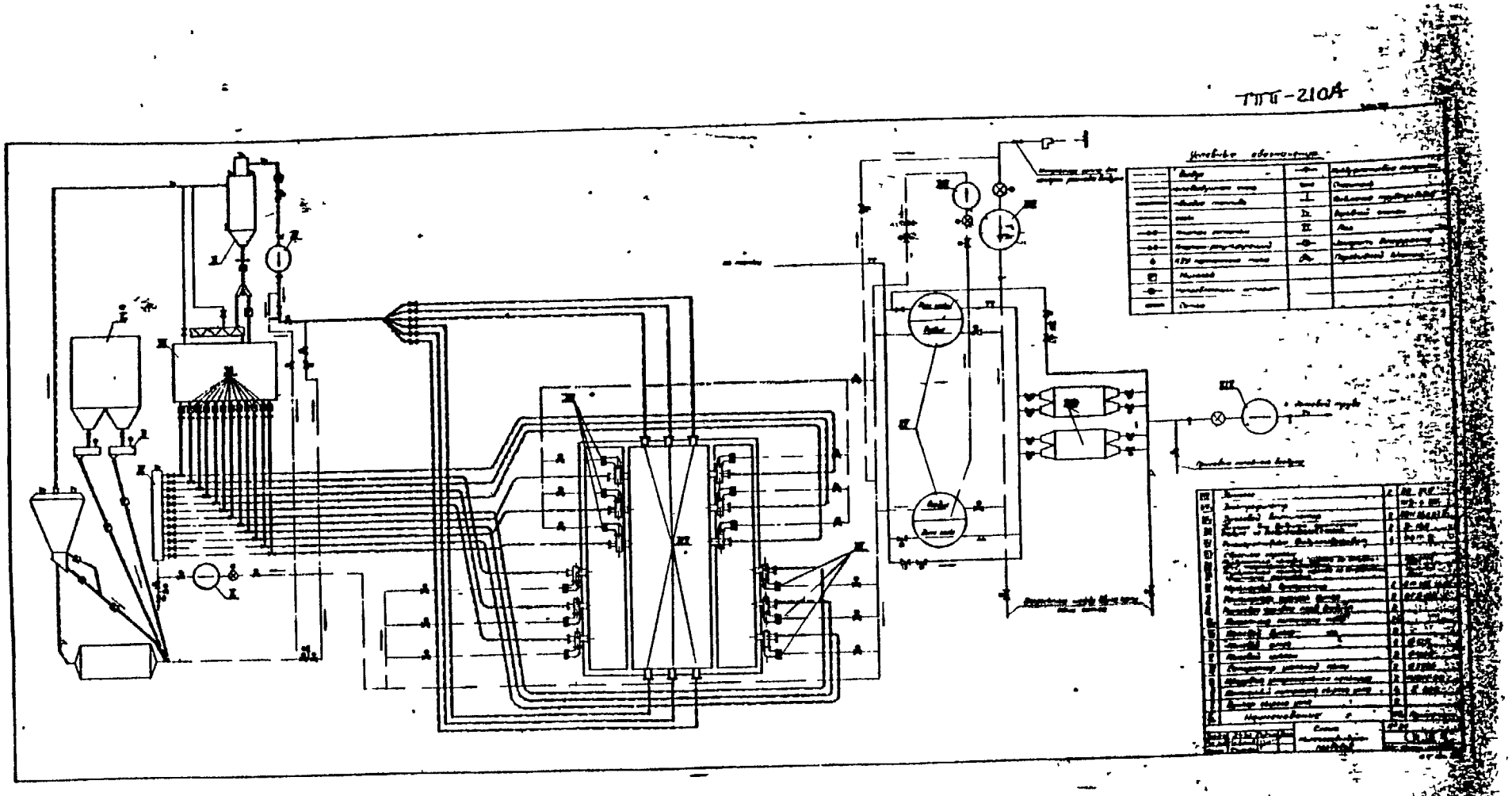
Позиция	Наименование	Кол.	Марка, № чертежа
I	Пылесистема сырого угля		
II	Бункер сырого угля	3	
III	Автоматический питатель сырого угля А1-630	3	
IV	Шаровая углеразмольная мельница	3	ШБМ-50А
V	Сепаратор угольной пыли	3	СПР-5500
VI	Пылевой циклон „НИИОГАЗ"	3	⌀3750
VII	Пылевой бункер	1	
VIII	Вертикальные бункеры пыли МПП 2-8УИ 0,5 стали	24	Типовой проект 704-1-...
IX	Центробежные вентиляторы	3	ЦВ-180/850
X	Дробевые бункеры	12	
XI	Регулируемые дозирующие	4	РДВ-68МА
XII	Дутьевые вентиляторы	2	ВДН-14×2-II
XIII	Вентиляторы первичного воздуха	3	ВГД-4×50
XIV	Дымососы	2	ДО 31,5
XV	Конвейеры пневмо	78	ГФ60.Н 00
XVI	Электрофильтры	[illegible]	ПГД 4×90
XVII	Дымовая труба H=180м ⌀8м	–	Проект ОРГЭС 4 серия

Attachment 6

СХЕМА ПЫЛЕГАЗОВОЗДУХОПРОВОДОВ КОРПУСА КОТЛА ТПП-210А

На основании черт. ТКЗ № 303974

Схема пылегазовоздуховодов корпуса котла ТПП-210А



Attachment 7

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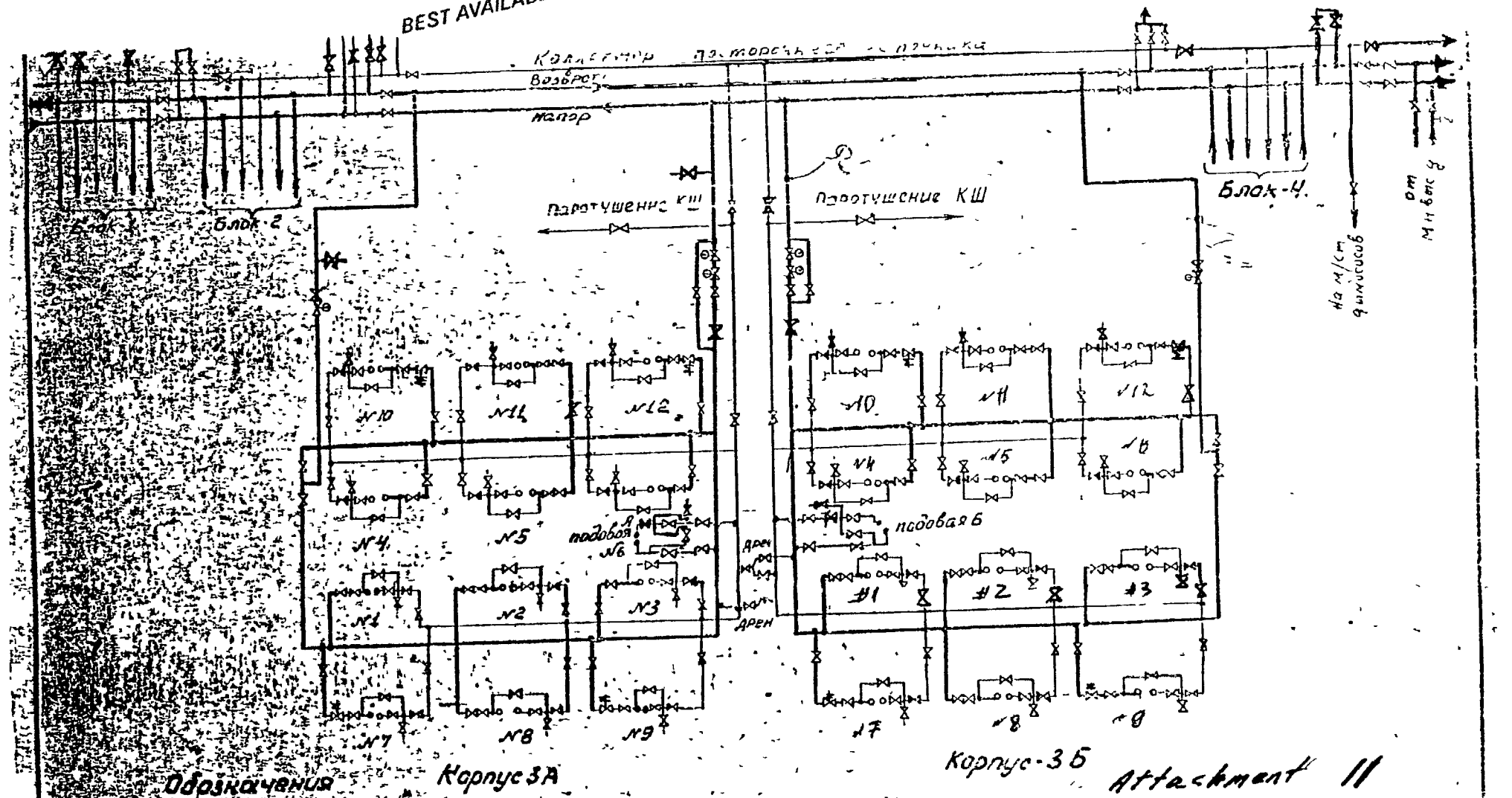

Attachment II

Обозначения

— мазут
— пар
— вентиль задвижка с электроприводом
— вентиль с электромагнитным приводом
— обратный клапан
— паровой вентиляторная форсунка

Изм	Лист	N докум	Подп	Дата
Чертил		Шубин		
Проверил		Комаров		
Нач ЦТ		Сорока		
Нач ПТ		Кадышевский		
Гл инж				
Гл инж				

Паронагнетательная схема Блока №3

КТЦ-1

Лист	Листов
1	3

Криворожская ГРЭС Днепроэнерго

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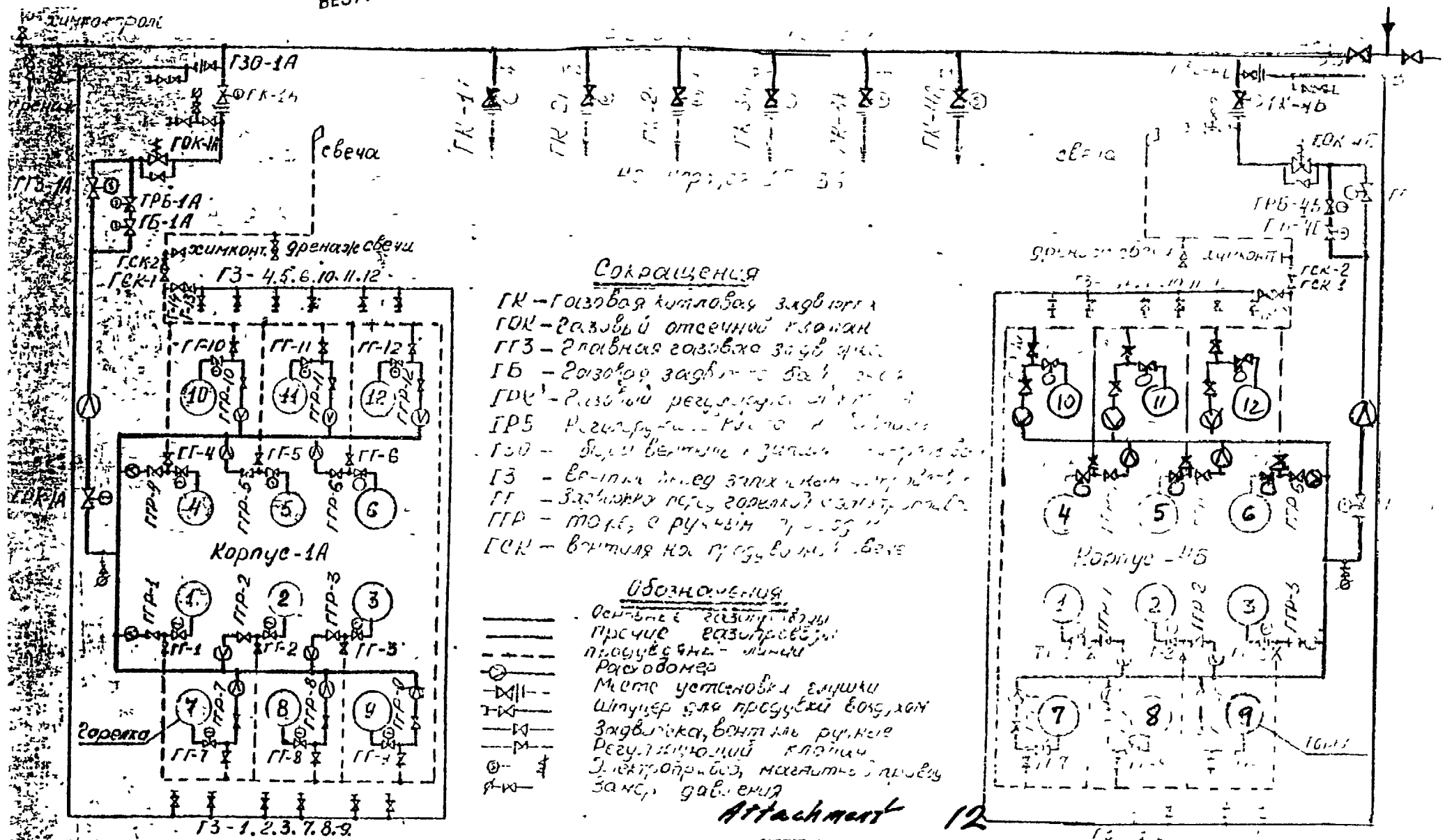

Сокращения

ГК – Газовая котловая задвижка
ГОК – Газовый отсечной клапан
ГГЗ – Главная газовая задвижка
ГБ – Газовая задвижка безопасности
ГРК – Газовый регулирующий клапан
ГРБ – Регулирующий клапан безопасности
ГЗ0 – Задвижка ветвиться в запальник
ГЗ – Задвижка перед запальником
ГГ – Задвижка перед горелкой
ГГР – Тоже с ручным приводом
ГСК – Вентиль на продувочной свече

Обозначения

- Основные газопроводы
- Прочие газопроводы
- Продувочные линии
- Расходомер
- Место установки заглушки
- Штуцер для продувки воздухом
- Задвижка, вентиль ручные
- Регулирующий клапан
- Электроприводы, магнитный привод
- Замер давления

Attachment 12

Примечание.

На корпусах „А" разводка аналогична К-1А,
На корпусах „Б" аналогична К-4Б

Изм.	Кол.	Уч.	Лист	№ док.	Подп.
Чертил					
Проверил					
Нач. КТЦ					
Нач. ПТО					

Рассмотрена 01.45.

Схема газопроводов КТЦ-1

Лит.	Масса	Масштаб

Лист	Листов
1	3

Криворожсталь

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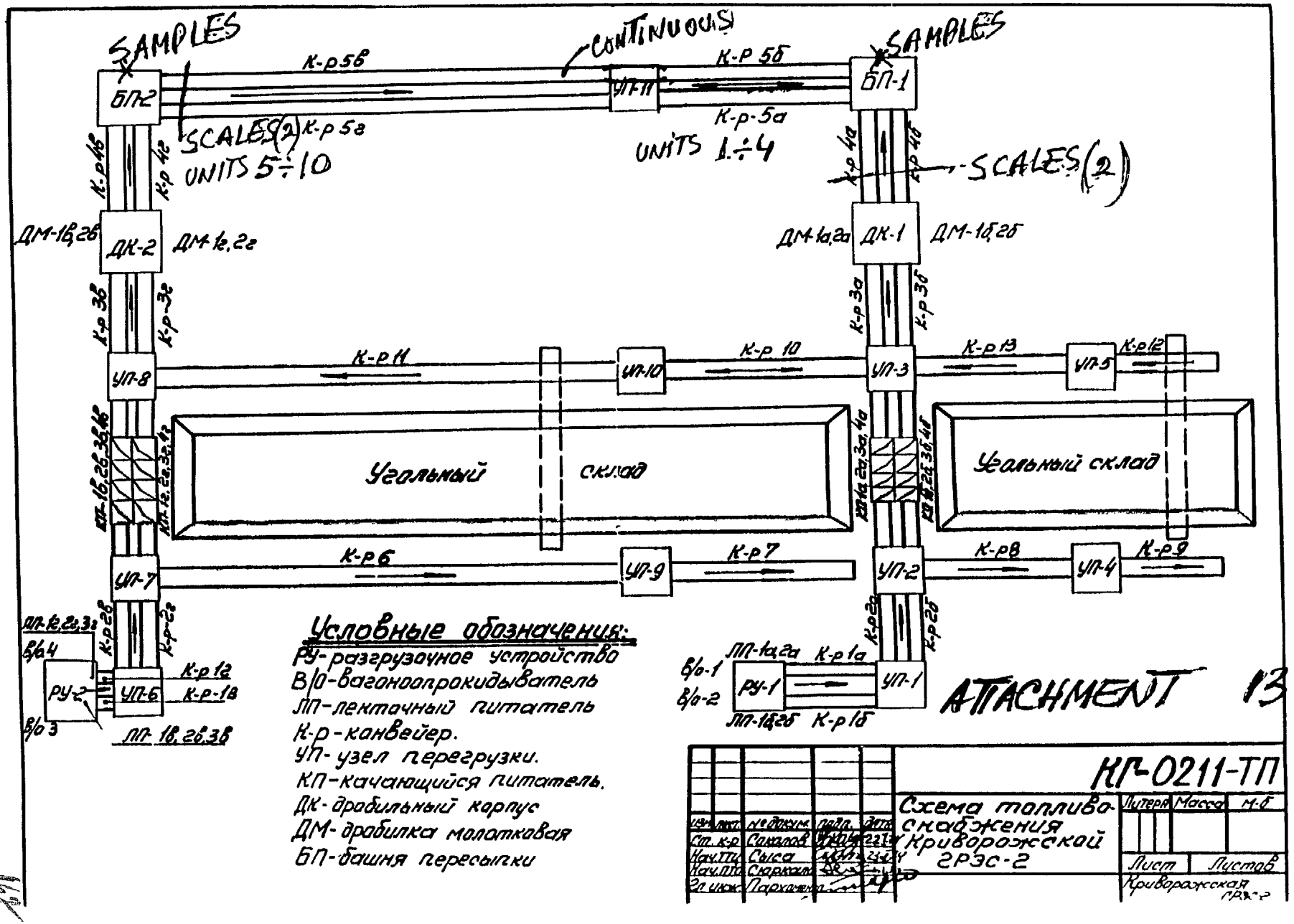

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Диспетчерский график нагрузок по электро
октябрь october

Записи в течение смены

Смена с 0^{00} до 8^{00}	3.10.94г. 1÷5=1350, 6=1380; 7—17=1650; 18÷22=1770; 23÷24=1570; Σ 38270000 кВт 12[01] Откл. бл. 8 от сети.
Смена с 8^{00} до 16^{00}	4.10.94 1÷6=1350; 7=1500; 8÷14=1600; 15÷16=1500 17÷20=1600; 21÷24=1500 Σ 36200000 кВт
Смена с 16^{00} до 24^{00}	

-1 6 units

ATTACHMENT 14

BEST AVAILABLE COPY

Диспетчерский график нагрузки по станции
октябрь осторжек

ЗАПИСИ В ТЕЧЕНИЕ СМЕНЫ

Смена с 0 00 до 8 00 units	1. 10.94 1-6 = 1460 7-8 = 1570 9 = 1590 10-17 = 1610 18-21 = 1630 22 = 1540 23 = 1460 24 = 1380 Б. 37 270 000 квт
Смена с 8 00 до 16 00	
Смена с 16 00 до 24 00	

ATTACHMENT 15

BEST AVAILABLE COPY

Диспетчерский график нагрузок по станции
июль ЛИВУ

ЗАПИСИ В ТЕЧЕНИЕ СМЕНЫ

Смена с 0 00 до 8 00 -8 units:	30.07.94. 1 = 1730 2-5 = 1700 6 = 1750 7 = 1940 8 = 1940 9-13 = 1970 14-19 = 1950 20 = 1900 21 = 2000 22 = 2080 23 = 2000 24 = 1800 Σ 45490
Смена с 8 00 до 16.00	
Смена с 16 00 до 24 00	

ATTACHMENT 16

BEST AVAILABLE COPY

Диспетчерский график нагрузок по станции. February
февраль

	ЗАПИСИ В ТЕЧЕНИЕ СМЕНЫ
1.02.94 Смена с 0 00 до 8 00	1÷3=780; 4÷5=790; 6=940; 7÷8=1010; 9÷11=1050; 12÷13=950; 14=1010; 15=990; 16÷17=950; 18÷21=1050; 22=980; 23=920; 24=900 Σ 22830 2 подмечен к-та.
02.02.93 Смена с 8.00 до 16 00	1-6=880 7-8=930 9=1020 10-11=940 12-15=920 16=930 17=960 18-20=1070 21=940 22=920 23-24=900 Σ 22480
Смена с 16 00 до 24 00	

4 units, balance not operating lack of fuel

ATTACHMENT 17

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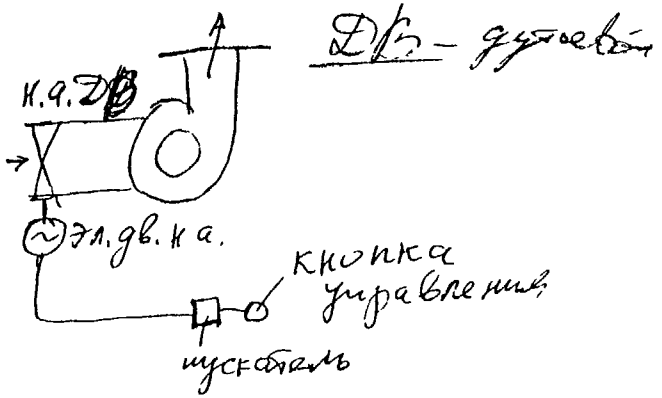

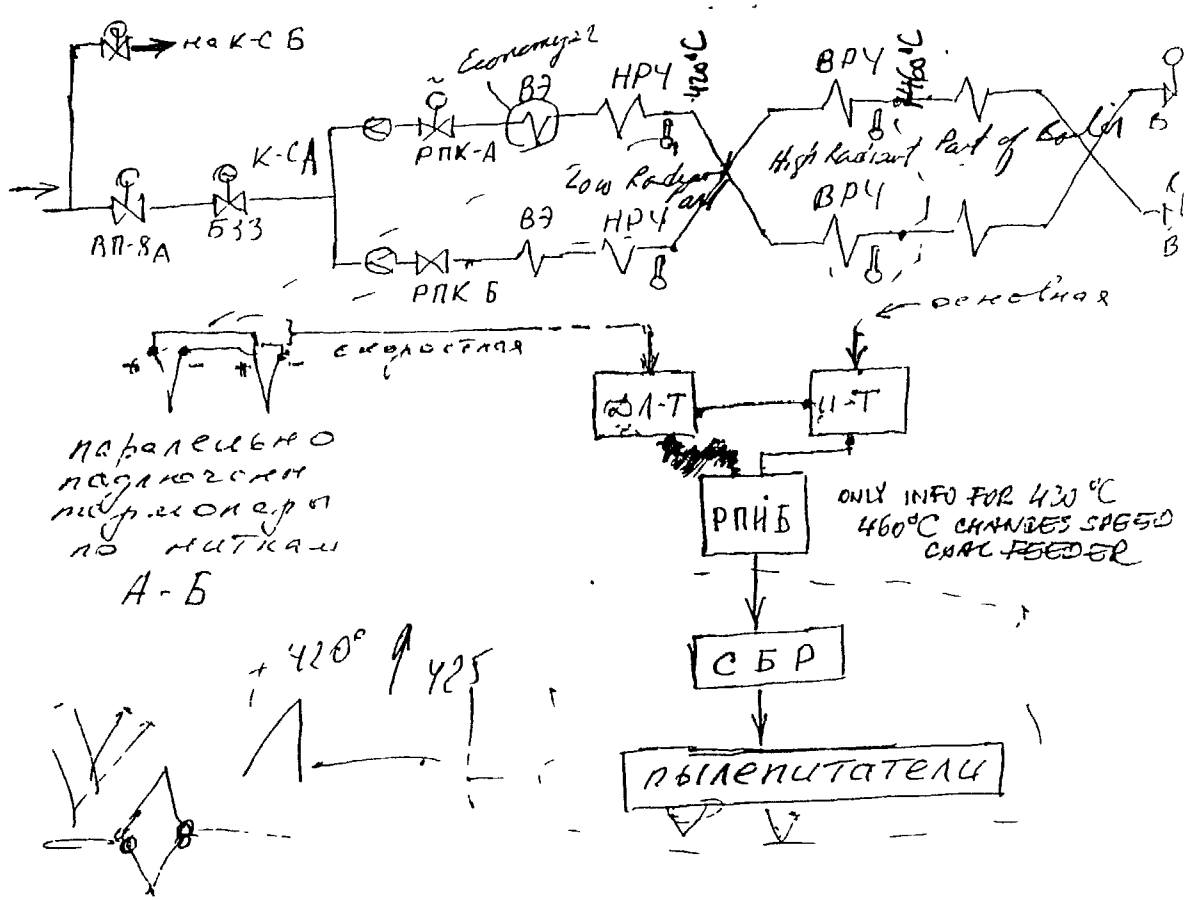

Регулятор тепловой нагрузки

ATTACHMENT # 18

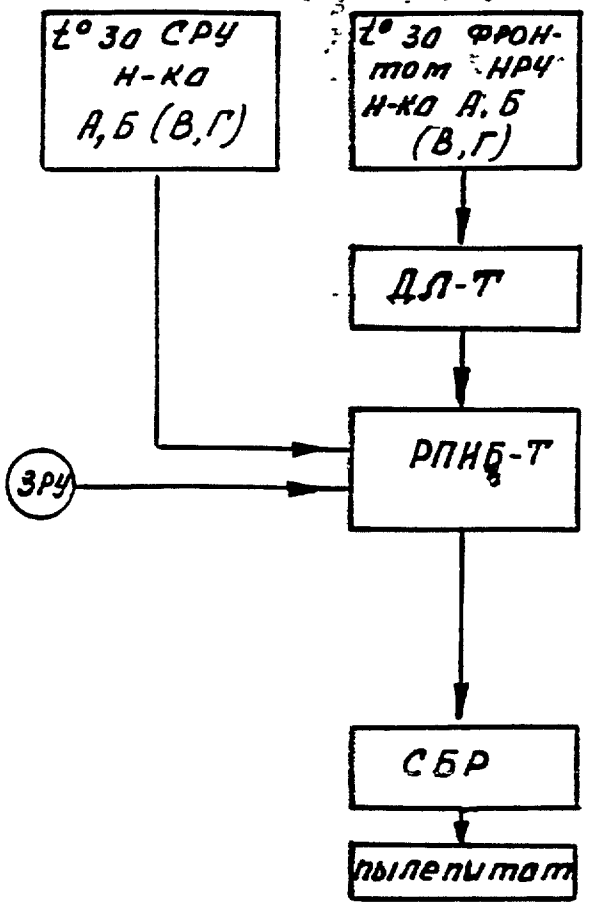

Рис.7 Регулятор тепловой нагрузки, 02-03 КА
БЛ. 1÷4

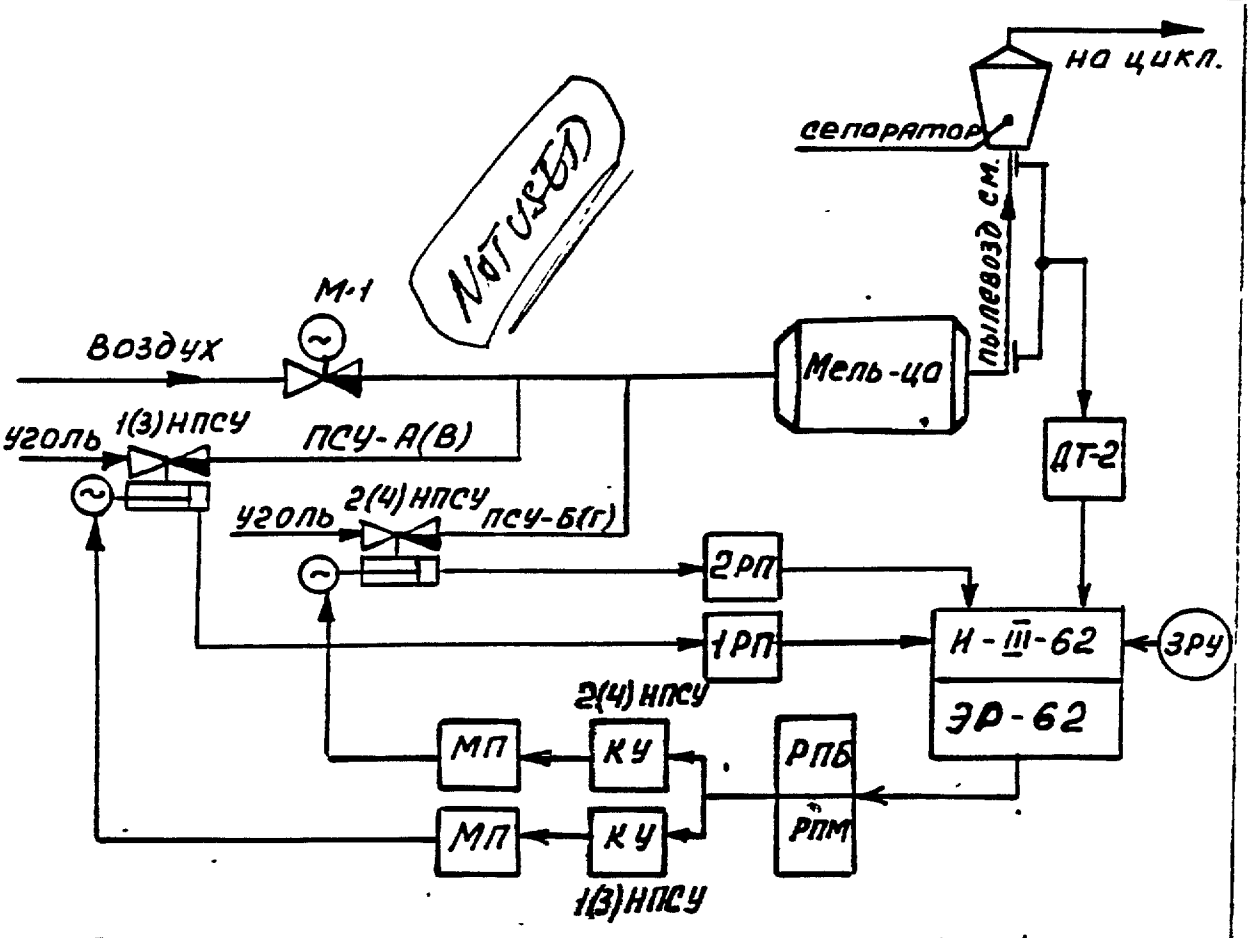

Рис 8 Рег-р загрузки мельницы 1÷4 НПСУ

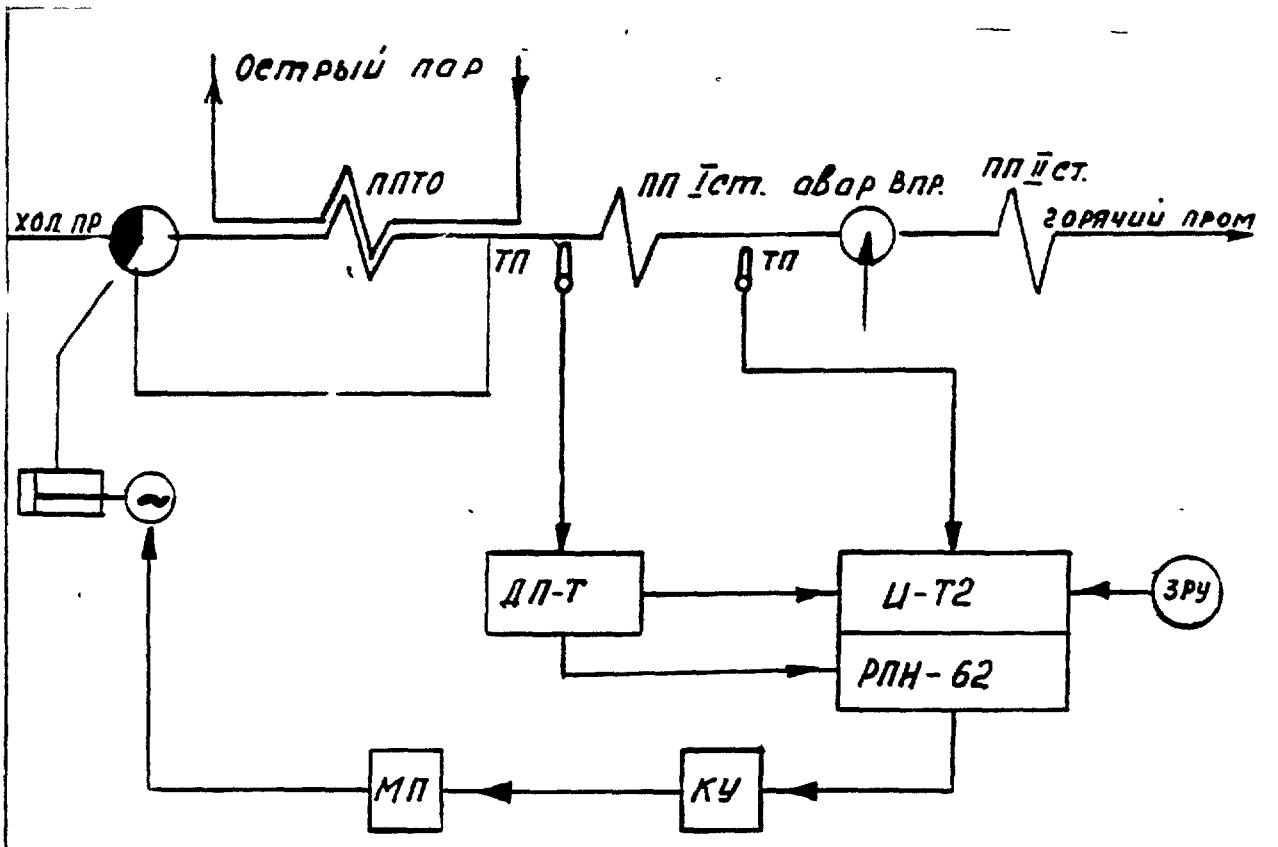

Рис. 3 Регулятор температуры вторичного пара, 03 ÷ 06 кл, бл. 1÷4

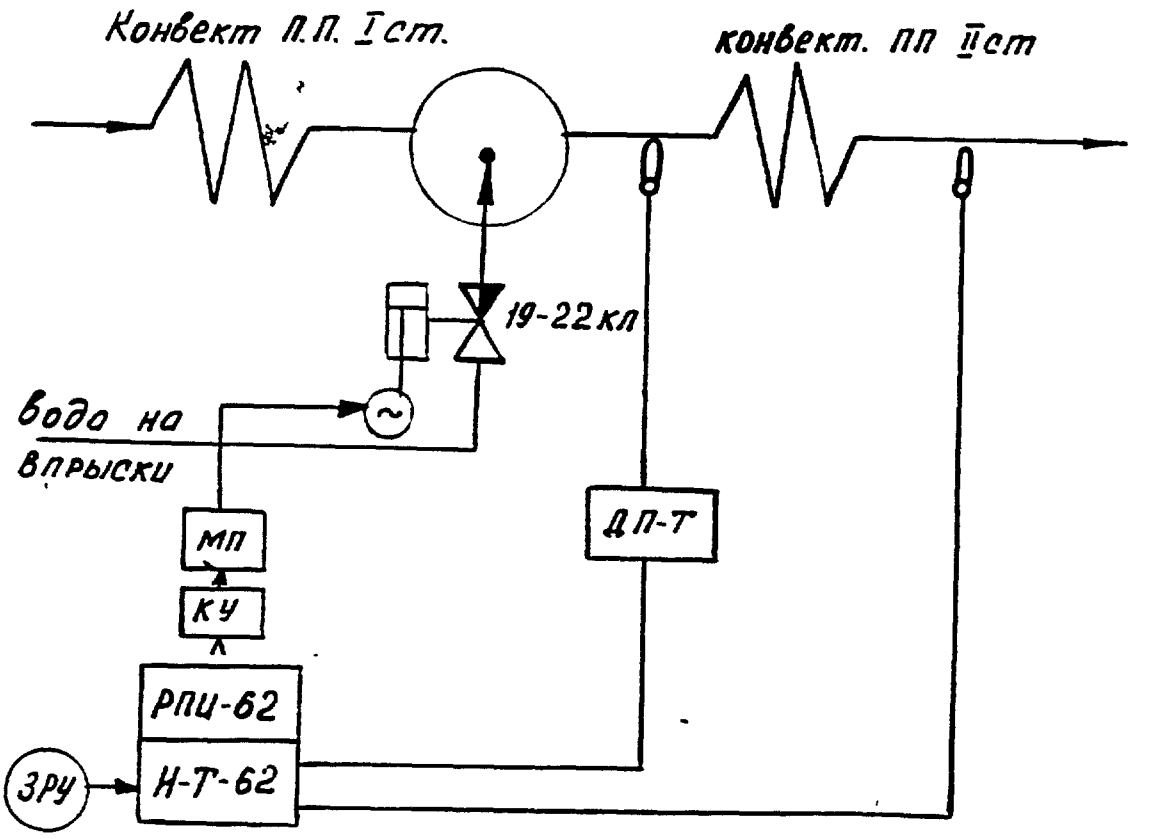

Рис 4 Р-р предельной температуры вторичного пара (аварийный впрыск, 19 ÷ 22 кл, бл. 1÷4

Аттестат 20

TRIP REPORT

PLANT AUDIT VISITS

ODESSA, SIMFEROLPOL, KRIVOI ROG AND BURSHTYN

TEAM NO 2

UKRAINE

Prepared by: P. Gupta 4/7/95
for John E. Hallberg, P.E./Date

Prem Gupta 4/7/95
Prem Gupta/Date

April, 1995

Burns and Roe Enterprises, Inc.
Oradell, New Jersey 07649

5906-01/02A/TRIP/4/7/95

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TRIP REPORT

1.1 Introduction

USAID/ENI retained Burns and 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 and roe performed the plant audit visits during a Feb 6--Mar 11 trip to the Ukraine in accordance with the Delivery Order objectives. The following report describes the activities of Team #2 (John E. Hallberg, P.E. and Prem Gupta), which visited Odessa CHP plant, Simferopol CHP plant, Krivoi Rog TPP and Burshtyn TPP. A report describing the activities of Team #1 (Selisett Corban, P.E. and George Keller, P E.) which visited Kourakhovska, Uglegorsk and Zmiev TES was issued separately

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

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

Feb 8 through Feb 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 Daichok 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 Ukraine.

1.3.2 Thurs. Feb 16, 1995 - Travel to Odessaenergo - Odessa CHP Plant

Feb 17 through Feb. 21, 1995 - In Odessa CHP Plant

On Feb. 7, we went to the plant with messrs Andrew Parinov (USAID), Andryi Kononov and Vitali Plotnikov (IDEA) and met with George Vukozich, the plant director. We worked in the directors office setting up the equipment, demonstrating its use and discussing the program for combustion efficiency.

On Feb. 18 we spent some time letting the two selected engineers practice setting up the Enerac Combustion Analyzer and going through the functions. We then went to the boiler house to run some tests. We set up at the crossover to the convection pass near the extraction point for the

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existing oxygen analyzers on power steam boiler 5 - left side. The boilers were burning natural gas. We took two samples on the left side, then took one sample on the right side and got off the boiler when the reading showed carbon monoxide went over range with excess air reading moving between 0 and 2 percent. We were informed that the FD fan on the right side was not operating because of breakdown. The plant immediately reduced load on this boiler.

We ran three tests on the left side of boiler No. 7. The combustion efficiency was fair but could be improved by reducing excess air.

We continued our discussions with the engineers requesting information and data required for our audit report and planning our work for Monday.

On Feb. 20, we met with the Chief of the laboratory, Antonina Ogorodnikova to gather data and information on natural gas and mazut. We obtained test data for 1994 giving monthly average, maximum and minimum heat contents in KJoules/Nm^3 and Kcal/Nm^3 with total gas consumption by month in million Nm^3 and corresponding pricing. It appears that Odessaenergo is being sold short by an average 115 Kcal/Nm^3 by Gasprom. This is why they place such a high priority in obtaining an online recording calorimeter to prove the delivery of gas.

We went to the offsite hot water peaker boilers (3) and steam boilers (2) to look at locations to put in-situ oxygen probes and locate flow meters for mazut and get measurements. the assigned engineers were also made familiar with the operation of "Heat Spy" and Fluke harmonic analyzer.

Past noon we took the combustion analyzer to get more test data on boilers No. 5 and 7, except this time at the I.D. fans. One test was made on each side of boiler No. 7. The oxygen and excess air readings were very high, partly due to air leakage from the air heaters. We discussed the readings with the Chief Engineer of the power plant Oleg Yarotskiy and boiler expert from Odessaenergo Nicolai Marenkov. They agreed to make a slight adjustment to reduce excess air to tune the boiler and we took additional readings. The results were significant, proving to the engineers the value of this instrument for saving fuel.

We returned to the Director's office to gather the remaining information from the plant. We were given copies of boiler control diagrams, dimensions for cable runs for oxygen analyzers, etc. We also were given a letter of receipt for the equipment given to them. The engineers will provide additional test runs for our use.

1.3.3 Tuesday, Feb. 21, 1995 - Travel to Krymenergo - Simferopol CHP Plant

Feb. 21 through Feb. 24 - In Simferopol CHP Plant

On Feb. 21 evening we arrived at the power plant. The plant Director Alexander Chuprinko and Deputy Director Oleg greeted us. He gave a brief description of the power plant. Andryi Kononov and Vitali Plotnikov met us and made introductions.

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On Feb. 22, we brought the equipment to the Deputy Director's office. Three representative engineers from Crimenergo as well as many engineers from the power plant staff were present. Andryi Kononov gave an introduction on the purpose of the combustion efficiency program by USAID. We then gave a brief description of our scope of work and handed out copies of the checklist "Improving Combustion Efficiency" in Russian language. We also provided a list of information required for preparing our audit report.

We set up all of the instruments and demonstrated the functions and operation of the Enerac Combustion Analyzer. By noon we brought the analyzer to the boiler house and took tests at right and left side of No. 1 steam boiler near the extraction points for existing oxygen analyzer The two extraction pipes connect to a common shunt pipe to the I.D. fan suction. A single extractive type paramagnetic oxygen analyzer pulls a sample below the intersection of the two pipes. The Enerac indicated the same concentration as the existing analyzer, which was calibrated in January 1995, is installed on the newest boiler and the operators feel confident in its accuracy. A second set of tests were taken at the I.D. fan inlet.

The operators were requested to slightly close the FD fan inlet vane damper to reduce the amount of excess air. This test showed 0.1% increase in boiler efficiency, a 0.8% reduction in oxygen, a 0.4% increase in carbon dioxide and a 8% reduction in excess air.

We made a tour of the turbine building and the gas turbines and returned to the Deputy Director's office to discuss the information we required, and to learn more about the power plant. We were given a description of the plant water systems. They gave us copies of boiler control diagrams.

On Feb. 23, we went to the hot water boilers to take combustion tests. No. 1 boiler was shut down and No. 2 boiler was operating full load on natural gas. These boilers burn only mazut during winter when natural gas is curtailed to supply domestic use. We could not find a good sampling point before the convection backpass, so we took flue gas samples from a sample point ahead of the I.D. fans. The sample pipe was too small to insert the Enerac probe to get stack temperature. A hose was used to connect the probe to the sample pipe. Therefore, the efficiency numbers are not valid. Four tests, two before and two after reducing excess air showed some impressive results. Carbon monoxide can be reduced by further tuning of burner registers and fan dampers to improve turbulence in the furnace.

We opened the rear wall access door on No. 1 boiler at the upper backpass to determine a good location for a single oxygen probe, heater and calibration unit. Two tubes will have to be bumped to make an opening for the oxygen probe. The plant engineers didn't have any problem with doing this. Gas temperature is about 800C.
We obtained sizes, temperatures and flow rates for mazut flow meters. There are four hot water supply, four hot water return lines to district heating and two industrial steam supply lines with no condensate returns. They do not have any problems measuring these flow rates.

We met with Ludmilla Lavilla, the Chief of the water treatment and chemical laboratory to

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discuss analytical instrumentation priorities and specifications for the power plant. Makeup water for the power plant comes from the Simferopol reservoir. The water is lime softened in clarifiers, from which the water flows to two treatment plants consisting of anthracite filters. activated carbon filters and two stages of sodium form cation exchange softeners.

Softened water is supplied to the cooling towers, boilers, and district heating system. They have had serious problems of organic fouling of cation resins due to oil breakthrough from the activated carbon filters. The hydrocarbon carryover goes with the feedwater to the boilers and results in carbonaceous deposits in the superheater tubes, resulting in reduced heat transfer, increased fuel consumption when steam temperature drops, hot spots on tubes and possible tube ruptures. Their most urgent need is to obtain two oil in water analyzers to detect hydrocarbon breakthrough from the two activated carbon trains for cleaning and reactivating the carbon

Another very high priority instrument need by the power plant is an online natural gas calorimeter to certify the delivery of gas from Gasprom, Russia. We were given data for 1994 of laboratory tests showing the heat content of gas actually delivered being lower on average than the gas heat content the power plant was paying for. Although this analyzer does not contribute directly to reducing energy consumption, it will prove the loss of thousands of dollars each year of energy paid for but not received.

Later we received copies of gas and mazut data for consumption and pricing, and a letter of receipt for the equipment. The engineers said they would use the Enerac combustion analyzer to do tuning of the boilers over the next week and send us the results.

We met with the Chief Engineer of Krimenergo, Alexander P. Opatko . We discussed a broad range of subjects regarding the plans and projects for energy development in the Crimea. He placed major emphasis on the recent Ukraine Presidential Decree for development of alternative energy technologies, which Crimea, like California, has a rich potential. As a result of the extensive drilling program over the past ten years exploring for gas and oil, geothermal resources have been discovered which could provide up to 40% of Crimea heating needs. He is very much interested in our experience in geothermal technology and would like to develop greater U.S. cooperation in engineering, development and equipment. He also would like to learn more about other mature U.S. alternate technologies such as refuse burning, wind power, energy storage and solar.

On Feb. 24, the plant engineers were using the combustion analyzer on their own taking tests and tuning the boilers. We spent the day in discussions with the Deputy Director reviewing the information we received, getting clarifications and translations of some terms.

1.3.4 Saturday, Feb. 25, 1995 - Travel to Dniproenergo-Krivoi Rog Power Plant

We met the Director, Deputy Director, Plant Chief Engineer and the Chief Engineer of Krimeaenergo before departing for Dniproenergo-Krivoi Rog Power Plant. The Chief Engineer of Krimeaenergo again emphasized the hope for future cooperation on alternative energy

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technology and requested information, brochures and qualifications.

Feb. 26 Through March 1 - In Krivoi Rog Power Plant

On Feb. 27, we brought the equipment to the power plant and set it up in the archives library. We then went to meet the Director Valeriy Chebotar and the Chief Engineer Vladimer Ludekof and gave a brief introduction and description of the instruments we brought for them and presentation of our scope of work. The Director gave a description of the power plant. The Director and Chief Engineer then came with us to the library to look at the instruments. They then called for specialists to come meet with us.

We first met with Vadim Necrasov, Chief of water treatment and chemical laboratory and Svetlana Kikolionkova, Engineer - chemical laboratory. We discussed boiler water chemistry and fuel analyses and requested data on coal, mazut and natural gas.The most critical need is for online monitoring of oxygen in feedwater and silica (SiO_2) after the demineralizer for makeup to the condensers. Each unit has a condensate polisher. They also expressed a critical need for an online natural gas calorimeter measuring Kcal/Kg and Sp.G. and a laboratory calorimeter for measuring coal and mazut heating value in Kcal/Kg.

We were then introduced to the boiler engineers and electrical engineers who would be responsible for the instruments we brought.

We demonstrated the functions and operation of the Enerac and let the two assigned engineers practice using the instrument. We were given monthly data for 1994 consumption and prices of coal, gas and mazut.

HHV of TP coal, mazut and Russian natural gas was calculated and programmed into the Enerac with the Texas Instrument computer. We then went to No. 5 block right boiler (TPP-210A) to take some tests. We tried to get a sample at the convection backpass (about elev. 26000) where the existing oxygen analyzer extraction point is located. This location is between the backpass and furnace above the three back burners. The engineer tried to insert the probe into a sample port, but it hit something and would not go through.

We went back to No. 5 unit and took four good tests, one each through the center thermocouple insertion point ahead of each regenerative air heater.

During dinner meeting, Dr. Osborne (USAID) asked why the CIS has not used Enerac type analyzer before, to the Director and Chief Engineer. They explained that the former Soviet Union did not have the advanced manufacturing capabilities to make this kind of computerized analyzer. We explained that it is only in the past few years that the state-of-the-art electrochemical specific gas sensors have been developed in the U.S. and Europe and that the Enerac is presently the most advanced U.S. made analyzer which is computer programmable. Up to this time the Orsat flue gas analyzer has been the most accurate method for testing flue gas composition by volume for CO, O_2, CO_2, and N_2 by difference. The disadvantage in it's

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use is that it takes a lot of time to set up and use, and the operator has to be experienced and constantly practice in order to get accurate readings.

On March 1, we met with the Chief Engineer, his assistant and the two boiler engineers to discuss the combustion efficiency test results and other items. Mr. Ken Carlson, BRC Project Director from Washington, D.C. was present at this meeting. The Chief Engineer seemed to be impressed at the readings shown on the Enerac printout from the previous afternoon's tests. Considering the quality of coal being burned and less than full load at 225 MW, the test results were good, indicating that the boilers were performing well. He noticed the higher flue gas temperature from the left furnace burning 15% natural gas (323,319C) vs. the right furnace burning 5% natural gas (303,304C). He recognized that improvement in performance can be made because of unburned combustible and carbon monoxide levels, where carbon dioxide levels could increase closer to the ultimate level for perfect combustion. They made several copies of the Enerac printouts for the engineers to have.

We were told that Unit 5 was reconstructed about five years ago. Unit 6 is presently disassembled and undergoing reconstruction after five years of operation. There is a lot of fireside deposits on furnace wall tubes and convection backpass tubes which results in loss of boiler efficiency. There is a lot of concern about ash slagging on the superheaters and reheaters from the different coals they receive, and they would like to get a laboratory instrument for determining ash fusion temperature to determine slagging characteristics and thus have better control over the fuel mix and boiler operation.

Because of a shortage of mazut, they presently use natural gas for flame stabilizing. They presently get coal from Donetsk, Lugansk and Kuznetsk fields. The coal is received at two car dumpers, sent to the fuel yard and mixed with dozers. From the reclaim the coal goes to the mills and it cannot be determined what kind of coal or characteristics goes to the boilers. Up to five times a day the fuel characteristics going to the boilers could change. There is usually about a four hour lead time because of holdup time in hoppers.

They could see the advantages of having nuclear dual gamma ash gage on the coal conveyors going to the boilers. This instrument could give real time readouts of percentage ash and moisture, which would allow the operators to choose the mode of operation of boilers to adjust for changes in moisture, ash content and volatiles. However, they are concerned about the cost, would much prefer to have laboratory instruments to determine proximate analyses (fixed carbon, volatiles, ash, moisture), heating value and ash fusion temperature. If they can register these instruments with the National Standardization Committee, they will be able to test coal deliveries and issue claims to suppliers for deficiencies in quality.

They urgently need an online gas calorimeter because they are being shorted on heat content by Gasprom. Their laboratory calorimeter is not commercial (certified), the tests are not continuous so they cannot make a claim for credits. We were given test results for monthly averages for 1994 as well as gas consumption.

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We discussed the possibility of installing in-situ zirconium oxide oxygen probes on at least one unit, two furnaces, two per furnace, four required. If so, they would prefer installing at same location as existing extraction points to be able to compare with Russian made extractive type oxygen analyzer. Maintenance, calibration and accuracy for existing analyzers is very good and operators have high confidence in the readings. They would rather see the money spent on other higher priority instruments they need. We discussed the possibility of using infrared (IR) type carbon dioxide analyzers in addition to the existing oxygen analyzers.

We obtained line sizes and design information for specifying sonic flow meters for two supply and two return mazut lines serving the boilers. We talked about the possibility of using the pulverized coal feeders to measure revolutions with counter switches and summing to measure fuel feed to boilers. The engineers think there would be 20-25% error due to wear and spacing of feeder plates. This idea needs to be further explored.

The electrical engineer found the heat spy so useful in the first day of use that the chief engineer would like to obtain a second one. The electrical engineer found some hot spots on generator buses and some hot contacts on switchgear and they were going to immediately take action to do maintenance. Also. he will put the power analyzer to use to look for transmission and switchyard problems and he will run tests on fan and pump motors to check the motor efficiencies and the pump and fans performance.

The chief engineer asked if we knew of analytical instrumentation for performing waveform analysis to determine vibration harmonics in balancing turbine generators. They do not have the technology to balance rotors adequately after overhaul and repairs, and have sustained large economic losses to maintenance and operation from damage to bearings and blading. We said we would get them information on portable Fourier waveform harmonic analyzers and orbit vector plotters with associated computer interface equipment, transducers, fittings, cables, etc

They also want to learn about U.S. technology for identifying hidden cracks in weld joints in complex shapes and sections in supercritical steam service. They have dye penetrant, mag particle, ultrasonic and X-ray NDT, but their X-ray equipment does not have the needed energy level film resolution.

For the Enerac combustion analyzer, they said it would be difficult to obtain the necessary specification calibration gases of good quality and would prefer to have the calibration gas kit provided. This is an action item, to determine if these gases can be obtained in Kiev to specification and furnished to the power plants. It is necessary to calibrate the analyzer about every three to four months.

If in-situ oxygen analyzers are provided, it is necessary to furnish S.S. tubing since it is very difficult to obtain. They also need the necessary lengths of twisted wire, and interconnecting cables.

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1.3.5 Thursday, March 2 - travel to Lvivenergo - Burshtyn Power Plant

March 3 through March 7 - In Burshtyn Power Plant

On March 3, we met with the Chief Engineer of the Power Plant. The chief engineer then called in a group of engineers and specialists. We presented our plan and explained the scope of work. We then had all the equipment brought into the chief engineer's office and we set it up and showed it to the specialists.

At noon we met Dr. Osborne and Andrew Parinov (USAID), Darian Diachok, and Andrei Kononov (IDEA) for a few minutes to give a status on successes of the three previous plant visits.

We trained the two assigned boiler engineers for operation of the Enerac. We asked for analyses of the coals being burnt in the plant.

On March 4, we met with Orest Daniluk, Deputy Director. He said one of their biggest problems is losing their technical specialists. Many of the engineers have gone on to work in foreign countries or gone into positions in ministries or government. The present Director in the Ministry of Energy Vilen Semenuk was formerly Chief Engineer at Burshtyn and the present Chief Engineer of Lvivenergo Stephan Melnir was also Chief Engineer at Burshtyn.

On March 6, we were given the analysis for Polsky coal. We calculated the higher heating value (HHV) and programmed the Enerac. We then went to Unit (block) No. 4 to run tests. These units have the dual block Taganrog TP-100 (two boilers per turbine) T-type boilers. We took four flue gas samples at the same locations where the existing Russian extractive type analyzers are connected. Therefore, the "stack" temperature readings are not correct, resulting in invalid efficiency calculation results. However, the flue gas constituent values are directly measured, except CO_2 which is calculated based on fuel analysis and the measured oxygen content. This 200 MW rated unit was burning about 95% Polsky coal with about 5% gas at a maximum derated output of 165 MW. The Enerac readings for oxygen corresponded very close to the oxygen readings from the existing Russian analyzers.

The operators felt quite confident in the O_2 analyzer readings, however, the instruments have to be routinely maintained and calibrated. We then took flue gas samples at the two I.D. fans to compare reading to see how much leakage there was from the air heaters. This unit had the Ljungstrom regenerative air heaters replaced with tubular air heaters during reconstruction However, all the readings, including oxygen and excess air, indicated significant air inleakage, probably most from ductwork and precipitator leaks.

We then went to Block 5 boilers and took flue gas samples at the same extraction points as the existing oxygen analyzers. These boilers were burning 60% natural gas and 40% mazut, at 95 MW load and reduced steam pressure and temperature. The oxygen levels were high due to somewhat high excess air. The high oxygen readings correlated with the control room

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readings from the existing extractive oxygen analyzers.

We met with Nikolai Kobyev, Deputy Chief Engineers for reconstruction and Development, to discuss the priorities for instrumentation needs as identified during previous trip. The same issue about natural gas heat content at other power plants was raised and we were given data for 1994 showing the Gasprom values and Burshtyn laboratory values. The data indicates that they are not receiving the fuel energy that they are paying for. Although an on-line gas calorimeter does not contribute directly to improving "combustion" efficiency, it may be a tool for recording actual gas energy consumption and reduction of payments for imported gas.

We talked about the problem of the existing extractive oxygen analyzers requiring so much maintenance and calibration. Because of a previous discovery that the shunt line from backpass to I.D. fan was filled with acidic sludge, and fouled the analyzers, we suggested to Nickolai that maybe two couplings could be welded on the shunt line bend near the backpass to inject steam to flush the sludge in the pipe by high velocity into the backpass to clear the holes in the pipe, and to the I.D. fan duct connection. They should disconnect the sample hose to analyzer before flushing the line. Nicolai thinks this is a good idea and said they will try this on one boiler. He thinks that instead of buying new in-situ oxygen analyzers, the money can be better spent on more important and useful instruments. They have received four of new improved but similar design analyzers manufactured in Kiev, which will be installed on Unit 3 which is presently under reconstruction.

On March 7, we again met with Nickolai to continue our discussions on priorities of necessary instruments. We talked about a possible way to measure pulverized coal feed from the bunkers to the burners by counting revolutions of the rotory feeders and totalizing electronically since these are volumetric feeders. Since the rotary plates wear over time, the question is of how much the accuracy would deteriorate over time. Nicolai thought this might be a good idea to look into further, and would be a lot less expensive than putting weight transducers on the two belt feeders from the raw coal bunkers to the pulverizers.

Nickolai was the person who during our last trip asked about an ash gauge. We showed him the literature form the three manufacturers of the dual gamma nuclear gauges and the budget pricing. He described their existing sampling and analysis system and procedures.

In 1994 they paid 2.2 billion KRB ($24,000) in fines for emissions based on the delivery analyses of sulfur in coal and mazut and then calculating SO_2 and SO_3 concentrations in mass flow of flue gas based on boiler loads. The calculated results are only educated estimates at best based on the accuracy of sulfur contents variations over time and estimates of the tons of coal burned. They have a Zeigler CEM installed for No. 3 stack (Units 1, 4, 9, 10, 11, 12) which was purchased by the Ministry in U.S.A. and installed by MLV, an Austrian company, and the power plant paid for it. They cannot use it now because they need about $4000 to $6000 to purchase calibration gases and pay for renewal of the service contract. They also have a one year old German manufacture IMR combustion analyzer similar to the Enerac, except conforming to European standards using the Seigert equation. They need a new oxygen sensor,

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which typically for all electro-chemical oxygen cells last about one year. They also need the special calibration gases and service on the analyzer.

They also placed a high priority on getting better level gauges on four main mazut storage tanks to measure deliveries and consumption of mazut. The present level instruments are pressure transducers near tank bottom, indicating level based on height and density of liquid. The gauges are not very accurate due to variations of density of mazut and water content and plugging of the tank nozzles with crud.

New ultrasonic level instruments would provide accurate level readings, and are not that expensive.

They found the heat spy to be so useful that they would like to obtain a second instrument to be used by their electrical maintenance engineers to locate hot spots in switchgear contacts, transformers, motors and generators. They also asked about vacuum leak detector instrumentation and techniques for identifying and locating condenser vacuum leaks.

1.3.6 On March 8, we left Bursktyn for Kiev On March 9, debriefing was held with Dr. Osborne, Darian Diachok, Andrew Parinov and Andryi Kononov, and Tom Kerney of the World Bank, to participate in completion of filming of a TV documentary on the USAID and World Bank roles in the Ukraine energy program.

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TRIP REPORT

Delivery Order No 6 - Energy Efficiency and Reliability, Ukraine
Subtask 2 3 - Implementation Phase (Follow-up Visit)
July 21 to August 9, 1997

INTRODUCTION

USAID has provided funds for Burns and Roe Enterprises, Inc to procure and supply energy efficiency instruments and perform plant audit visits at seven Ukrainian Thermal Power Plants The objective of these visits has been to improve combustion and boiler efficiencies, improve monitoring and energy management

During February - March of 1995, each plant was provided with an Enerac combustion analyzer, a laptop computer and printer, an infrared thermometer and a Fluke power analyzer

Burns and Roe engineers conducted follow-up visits and training during July 22 - August 16 in Ukraine in accordance with the Delivery Order objectives The following report describes the activities of John E Hallberg, P E and Alexander Filippov who visited Krivoi Rog TPP, Simferopol CHP Plant, Odessa CHP Plant and Burshtyn TPP A report describing the activities of George Keller, P E who visited Zmiev, Uglegorsk and Kourakhovska Power Plants is issued separately

WORK PLAN

For each power plant

1. Review the steps taken by the plant for implementation of recommendations and assist in completion
2. Provide additional training and assistance on installation and use of the equipment
3. Refine and finalize the audit report and the recommendations for short and long term actions based on follow-up discussions with power plant personnel and minor additional audit work, if necessary
4. Measure actual energy savings based on audit recommendations and equipment installation, if measurements are not possible, estimate and provide the rationale of the method that is used for estimation

TRIP REPORT AND RESULTS

Mon & Tue, July 21-22, 1997 - Travel to Kiev, Ukraine
Wed, July 23, 1997 - Travel to Krivoi Rog (Zelenodolsk)
Thr & Fri, July 24-25, 1997 - In Krivoi/Rog TPP

PERSONS MET DURING MEETINGS

Vladimir F Soroka - Chief Engineer (new)
Peter Solovey - Chief of Maintenance Department
Rjabokon Nikolay - Deputy Chief of Automation

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Vladimir Pachura - SeniorMaster, Head of Automation Department
Anatolij Propopenko - Electrical Specialist
Vasily Bokiy - Infrared Thermometer
Andrey Kolobayev - Fluke power analyzer, Ultrasonic flow meter

INSTRUMENTS SUPPLIED TO KRIVOI ROG TPP

Zirtek oxygen analyzers, 4 probes for 2 boilers, 2-two channel analyzers
Panametrics two channel ultrasonic flow meter
Instromet natural gas chromatograph, display unit and accessories
Oxygen cell and consumables for Enerac

DISCUSSION

Of all the personal contacts made in February, 1995, we met only one person, Peter Solovey - Chief of Maintenance Department The former Chief Engineer, Vladimir Luchnikov was promoted two years ago to First Deputy Minister of Energy in Kiev The new Chief Engineer - Vladimer Soroka was promoted from the Boiler Department He was very busy and did not seem to be familiar with the work we were doing

There is a Canadian company at the plant working on "Group Project Implementation", a $260 million World Bank loan for rehabilitation of Units 6, 7 & 8 It was said that they are preparing tenders This firm has installed a satellite system for telephone, fax and E-mail

They find the Enerac combustion analyzer to be very good compared to other instruments However, they do not see any advantages to use it effectively in this plant on the supercritical boilers, as there are no appropriate measuring ports They claim that the instrument is expensive to maintain, requiring calibration every three months, with a calibration gas kit which they do not have Also, the oxygen sensor must be replaced every year They recently received a new sensor, but haven't installed it yet because they cannot calibrate it (supplemental calibration gas kits have been reordered for each plant)

The infrared thermometer is used a lot in the Electrical Department for checking contacts Mechanical technicians use it on generator and turbine where they cannot measure direct It is used for routine maintenance measuring hot spots on bus connections, at distribution substation, on motors, bearings, transformer bushings, insulators, etc They now use the infrared thermometer in place of manual hand test for rotor and stator "hot spots" They also use it on heat exchangers to find scale and sludge build-up in heat exchangers

Sometimes the technical people will not believe the instruments, but will trust their experience or hand or senses An example is for coal mill bearings where many have been destroyed, but the infrared thermometer can find hot spots quickly and save a lot of money It would be very useful for operations to have this instrument, everybody who needs it, instead of one man It would be best for each control room to have one

Last Monday, 21 July, they started using the Panametrics ultrasonic flow meter to measure

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cooling water flow to condensers Next they plan to measure boiler feedwater and district heating water flow rates. They recognize many opportunities for using this instrument to save energy The most important use is for balancing the district heating demand load

A practical example we observed was to measure the flow rates of 25 cu m/sec through a filter with new media installed The chemists said flow rate would decrease due to increased pressure drop, but there was no way to check it In a matter of a few minutes, the specialist confirmed the flow rate with the ultrasonic flow meter

Another example is where they plan to check mazut flow to quantify measurement differences and losses. This morning they could not account for 80 tonnes of mazut burned in three boilers, how much per boiler and why. Was it easier to burn the mazut than poor coal in one of the boilers, or was the coal unusually bad that night?

They requested technical literature on doppler ultrasonic flow meters for use in open channel flow measurements in cooling water flumes

They installed oxygen analyzer probes on the base loaded Unit 1 dual boilers, two probes per boiler with signals to two dual channel analyzers installed in the control room behind the main panel Jerry Harger from Zirtek commissioned the instruments in June and trained the personnel.

During startup, one electronic board failed and Zirtek replaced it Out of 8 probes (4 spare), four were damaged, the ceramic broken One analog output for the plotter failed after Jerry Harger left The analog outputs are connected to their strip recorders They plan to move the analyzers (display) to the front panel as operators become confident in readings The oxygen readings were averaging about 4%, temperature about 700°C Air heater temperature as about 500°C +

Reference air for the probes is temporarily supplied from compressed air cylinders, good for one week. The only compressed air available is plant air which is wet and dirty with oil They plan to install a coalescer and filters

Positive advantage of the zirconium oxide probes is that they are "ten times less maintenance" and very stable Two maintenance technicians work full time on the Soviet made paramagnetic oxygen analyzers to repair and adjust them Every morning they have to blow down, clean and adjust them on all the boilers, and whenever operators call them to check on erratic readings

The Instromet Encal Gas Chromatograph was received in May and they had not yet installed it We looked at the instrument in the shop and answered questions about connections They have been studying the Russian language manuals

We went to the natural gas metering substation to look at where they planned to install the

chromatograph They believe the control house is too small and want to build a new 3m x 3m brick building, but have no money They are concerned about regulations, safety and maintenance. They will take the sample line off of main before orifice run They are planning to install display control unit in laboratory After much discussion, they think they can clean up the control house and install GC in there by August 8

The employees haven't been paid until today, 25 August, 30% of their December 1996 salary The plant could not even find enough money to buy milk for the kindergarten children They need money to buy freon for the turbine building overhead crane cab air conditioner, where temperature reaches 120°F

It is hard to get people motivated, even though they are highly skilled and experienced The plant still generates power when they can get enough fuel, and do not get paid for the power It is a catch-22 situation where they know they need modern instruments to measure and analyze fuels to save large sums of money and energy, but no money to even buy spare parts and supplies

We did not get information on results from using the Fluke power analyzer as the specialist was said to be on vacation

Sat, July 26, 1997 - Travel to Simferopol
Sun, July 27, 1997 - Rest and writing notes
Mon and Tues, July 28-29, 1997 - In Simferopol CHP Plant

PERSONS MET DURING MEETINGS:
Anatoliy K. Voronovskiy - Chairman of the Board, Director, Krimenergo
Alexander Chuprinko - Director of Simferopol Power Plant
Vladimir Cherkosov - Chief Engineer
Vasily V Kurinnoy - Worked at all seven power plants
Valery Babichev - Chief of Technical Department (computer expert)
Alexander Dubinets - Chief of Electrical Works
Valery Duzhenko - Chief of Electrical Laboratory
Sergey Kojevnikov - Chief of Boiler and Turbine Works
Alexander Litvinov - Chief of Automatic and Measuring Equipment Department

INSTRUMENTS SUPPLIED TO SIMPEROPOL CHP PLANT
Zirtek oxygen analyzers (2) probes for one boiler, one two-channel analyzer
Panametrics two channel ultrasonic transit time flow meter
Panametrics one channel ultrasonic transit time flow meter
Instromet natural gas chromatograph, display control unit and accessories
Oxygen cell and consumables for Enerac

DISCUSSION
Valery Babiehev - Chief of Technical Department is trying to develop a computerized

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information system for the plant and would like to combine the data from all instruments into one program He has written a program in C-language for downloading data from the Panametrics He asked where is the program from Panametrics for downloading data to a computer They use the flow meter every day for measuring hot water flow and mazut flow to boilers

They do not have a program diskette for the Enerac S N 11003252 They used to buy reference gases to calibrate instruments in plant, but now calibrate the Enerac and use it to check other instruments But they cannot use it to plot and analyze data on the printer as described in the manual, and wonder if there is special software to make it work We were given a document showing calculation of efficiency and energy savings of about $34,000 during 1995 using the Enerac We were also given a document from the Central Crimean Regional Department of Environmental Protection regarding a dispute in comparison of inspector using coloremetric burettes to test flu gas vs Enerac readings always being lower and a requirement to do parallel tests with the Donorgres Laboratory "TESTO-33" instrument

The Electrical Department has been using the Fluke power analyzer extensively to measure current, voltage and phase angles with very good results They measure voltage on busses, current on current transformers.

The accuracy of the Fluke is higher than measuring equipment in the plant for measuring voltage and current They trust the instrument very much and use it to check other measuring instruments. When testing phases on a group of transformers at the gas turbines, they found an unbalance They could perform maintenance on the scheme, but the cost would be higher than the energy losses

They used the Fluke to try to find the weak points in boiler feedwater pump motors and identified that stator winding need to be replaced They also discovered that copper rotor bars end connections were weakening, resulting in losses The problem is that these are old 3 KV motors no longer made, as 6 KV is standard

They also found a small 200W unbalance of about 20% at administration building where one phase was overloaded and they corrected it The important lesson is that the Fluke is useful for identifying energy losses

The infrared thermometer Minolta Cyclops is used to check for heat losses from boilers, drum insulation, steam lines, etc They found bad insulation on a stream drum and replaced it They tried to check the accuracy of instrument against a thermocouple and found 40°C difference They do not trust the accuracy, but said they do not have a manual in Russian or table of emissivities We mentioned that the Mikrom manual was translated and should be similar

They used the instrument to find a steam leak under insulation in the main building They

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were starting a boiler, 370°C, 40 kg/cm^2 and saw there was a problem, valve was steaming, not normal They measured insulation temperature difference near the valve and found a 10 cm crack on weld of 325 x 24 mm pipe

We went to the power plant control room to look at the Instromet Encal gas chromatograph (GC) display mounted in the main panel Above it is mounted a data logger which can input real time heat content from the GC to record total from metered gas flow At present, they input a fixed value of KCal/cu m

We then went to the gas metering substation to see the GC installation They ran new shielded cable about 3000 ft from GC to control room display control unit. They took a sample line from downstream of orifice meter run to control house where GC is mounted on the wall They added a filter in the sample line with silica gel dissicant for removing moisture and crude from gas sample All tubing and wiring is installed, waiting for calibration gases to clear customs in Kiev, so the startup engineer can travel to commission the GC Their biggest concern is the need for a spare electronics display board. Attached is a diagram of the system

We went to look at the installation of oxygen analyzers on one of the two large hot water heating boilers The electronic two-channel analyzer display unit was mounted in the boiler control panel They mounted the probes below the observation ports on backpass of the boilers They made up an extra pair of flange-nozzles and installed them in the second boiler so the probes could be switched to that boiler when operating

They mounted the reference air control panel between the two boilers with cable and copper air tubing run to both They found a very small air blower-compressor salvaged from an old hydrogen analyzer, which they mounted inside the cabinet

We were provided with a table of consumption, heating values and prices for natural gas and mazut for 1996-1997, attached In-plant cost to produce electricity is 5 3 Kp/KWh (2 91¢/KWh), and Kremenergo sells at 7 11 Kp/KWh (3 91¢/KWh)

Wed, July 30, 1997 - Travel to Odessa
Thr & Fri, July 31-Aug 1, 1997 - In Odessa CHP Plant

PERSONS MET DURING MEETINGS
George Vukovich- Director
Oleg Yarotski - Chief Engineer - Power Plant
Sergey Donchenko - Chief of Instrumentation
Valerie Gurburov - Equipment Engineer
Antonina Ogorodnikova - Chief Chemist

INSTRUMENTS SUPPLIED TO ODESSA CHP PLANT
Zirtek oxygen analyzers, 2 probes for one boiler, 1 two-channel analyzer

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Instromet natural gas chromatograph, display control unit, accessories

Silica Analyzer	--	In Customs
Conductivity Meter	--	In Customs
pH meter	--	In Customs
Oil in water analyzer	--	In Customs

DISCUSSION

The power plant is in the process of being transferred to Municipal ownership and control, not privatized. The only instruments to pass Customs clearance were the gas chromatograph (GC) and boiler oxygen analyzers The other instruments are on plant territory one month in custody under Customs control. They do not know when released

The Enerac, infrared thermometer and Fluke power analyzer are in the custody and being used by the firm "Energo Naladka (Energy Adjustment) Enterprise"

The Enerac was used intensely until February 1996 when the oxygen cell failed They now have a new cell, but no calibration gas kit or instructions They provided a detailed write-up on its use and energy savings (attached).

The Minolta Cyclops infrared thermometer was used to measure boiler and piping insulation, temperatures of bearings, motors, buss connections to 6 KV, 6-110KV contacts, etc They provided a detailed write-up on its use (attached)

We could not get any information about use of the Fluke power analyzer or results. They provided a letter that did not give any real descriptions of its usefulness

We looked at installation of the oxygen probes and reference air cabinet at about 24 m elevation They used an old soft drink dispenser cabinet, modified the compressor for air, added an accumulator tank and filter and mounted the control air cabinet inside it They also found some additional copper tubing from salvage The analyzer display unit is mounted in the main boiler control panel, with a cutout for mounting a strip chart recorder

It was decided to mount the Instromet Encal gas chromatograph in the chemical lab since there is a sample line already installed The GC cabinet is mounted on the wall, display control unit sitting on a desk, and electrical outlets installed No tubing was installed, but can be quickly completed There was a lot of discussion whether the GC should be installed at the gas metering substation

They have a data logging system similar to Simferopol scheme, except they used a Pentium computer for logging

We were provided a list of data for gas and mazut consumption, heat contents and prices

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In Plant Cost to Produce	Import Power	Annual Ave. Cost	Avg. Sell
Winter - 3 Kp/KWh (1 65¢)	6 5 Kp/KWh (3 57¢)	6 5 Kp/KWh (3 57¢)	8
Summer - 20 Kp/KWh (10 9¢)	6 5 Kp/KWh (3 57¢)	6 5 Kp/KWh (3 57¢)	8

ODESSA - 31 July 1997

In the result of the computation modes and elimination of the insulation defects carried with application of instruments Enerac + Cyclops, these were achieved economy of fuel in terms of the condition of fuel (7000 KCal/Kg)

Consumption of Conventional Fuel		Savings
1995	878 tons	0 4%
1996	724 tons	0 4%
1997	222 tons	0 2%

For the period of operation of the gas analyzer Enerac 2000 between March 1995 and December 1996, a brigade team of adjusters and engineers of the Central Research and Technical Department of Odessa Energy Adjustment, there were fulfilled the works that are similar for 9 out of 14 installed boilers

Odessa Heat Power Plant - Mode and ecological and heat and technical tests of the steam boilers KU-1

1 TP-170, Station #5, 6, 7, and 8 adjustments of the furnace mode, ecological and heat and technical tests with optimization of the harmful substances in the coming out smoke output gases

2 TP-47, Station 10 adjustment of the furnace mode, ecological and heat and chemical adjustment with optimization of exhaust of the harmful substances into the atmosphere in the coming out smoke gases.

At the boiler of KU-2

1 GM-50, Station 1, 2, 3 adjustment of the furnace mode, ecological, heat and technical adjustment with optimization of the exhausted harmful substances,

At the boilers of the water heating boiler house of Odessa Heat Power Plant

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1. PTVM-100, Station 2 - adjustment of the furnace mode, ecological, heat and technical adjustment with optimization of the exhausted harmful substances

At the enterprises of Odessa Heat Supply Network

1 There were carried out ecological, heat and technical tests of the water heating boilers at the following boiler houses

Severnaya-1 - Northern	Boilers PTVM-50, No 1 and 2 Boilers PTVM-100, No 3 and 4
Yuzhnaya-1 - Southern	Boilers PTVM-50, No. 1, 2, 3 and 4
Chuboska -	Boilers KBGM-50, No 3 and 5

Besides on the steam boilers of Odessa Steam Power Plant they regularly carried out work aimed at correcting the mode guidelines after a long term non-operation of the equipment, in case of operating the boilers, on a combined fuel (gas + mazut), determination of the operation characteristics of the boilers on the ground of the results of the gas analysis (leakages along the gas path of boiler) There were also carried out express tests of the boilers before their repair and after repairing to evaluate the fulfilled repair works

CONCLUSIONS

During the period of operation of the instrument Enerac 2000, the specialists from the group for adjustment of the heat and technical equipment of Enterprise Adjustment one can come to the following conclusions

- Operation of the instrument for determination and adjustment of the optimal combustion mode for a set load gives reduction of the working time by 50-60%

- The efficiency of carrying out of adjustment and regulation (controlling) of the furnace process as the boiler is rising on account of reduction of the time for making samples, and it increases the capacity of the boiler by 0 8 - 1 2% due to the precision of the instrument readings

- Work with the instrument Enerac 2000 is of large effect in the work of the operations people of the boilers concerning corrections of the furnace mode when working in the non-stationary modes of the boiler work, as well as it gives a large reduction of time when fulfilling the mode and adjustment and also ecological and heat and technical tests of a boiler with the aim of making the mode guidelines as well as the ecological and heat and technical characteristics of the boiler

Remarks (or comments) (concerning the organization and service maintenance)

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- A low life time resource of the oxygen sensor life (1 year)
  Service maintenance is not available
  (they were talking about having a representative in Moscow, but from the standpoint of Ukraine, that is another country abroad, another currency and problem of logistics Should have representative in Kiev or another large city)
- The instrument has not been registered or certified with the State Standards of Ukraine

REVIEW ON FUNCTIONING OF METER CYCLOPS 300AF/300

The instrument is used for precise measurement of the temperatures of surfaces without direct contact with the medium in the range from -50 to 1000°C The adjustment people of the enterprise "Odessa Energo Naladka" used the instrument for the following purposes

1 Measuring temperatures of the outside surfaces of the cover boiler aggregates at Odessa Heat Power Center to determine the heat losses into the surroundings

2 Measuring temperatures of surfaces, insulation of the steam and hot water pipelines for restoring and repairing the heat insulation of the pipelines.

3 To check the temperatures of heating the cases of the bearings of the rotating mechanisms and the temperature of heating the motors

4 To check the temperatures of connections of the buss lines in the distributive devices with the voltage of 0 4-6 KV

5 To check the temperature of connections of the buss lines of open distributing devices with the voltages of 6-110 KV, at transforming substations

Usage of the instrument cyclops 300AI/900 resulted in identification of the places of damaging the outside cover of the boilers and insulation of the pipelines Elimination of damaging of the cover and restoration of the pipeline insulation made in due time resulted in reduction of the heat losses into the environment from 0 05-0 15%

Checking of temperatures of the bearings in rotating mechanisms (fans, smoke suckers (I D Fans), pumps, etc) allowed to replace them in due time preventing getting of the equipment out of order

The systematic checking of the temperature of the connections of buss in the distributing devices and at the substations permitted to prevent the emergency situations at the Odessa Heat Power Center

CONCLUSIONS

The instrument is reliable and suitable in operation, it has small overall size Providing availability of a printer, its possible to register the readings

availability of a printer, its possible to register the readings

REMARKS

1 The instrument has not been certified with the State Standards of Ukraine

2 Service maintenance is not available

Sat, August 2, 1997 - Travel to Burshtyn
Sun, August 3, 1997 - Rest and Writing
Mon and Tue, August 4-5, 1997 - In Burshtyn Power Plant

PERSONS MET DURING MEETINGS

Vasyl' Bendasiuk - Director (New)
Igor I Bozenenkow - Deputy Director - Foreign Affairs (Former Director)
Orest Daniluk - Deputy Director - Technical
Nikolay Kobzev - Deputy Chief Engineer for Reconstruction and Development
Gorgory Stepas - Deputy Chief Engineer - Operations
Ivan Berkosha - Chief of Technical Department
Tanasiy Semotyuk - Head of Adjustments Workshop
Mykola Korvotsky - Head of Chemical Workshop - GC
Peter Chopik - Senior Forman Automation Workshop - O_2 Analyzers
Dept of Automatic Control Systems
Michail Zelanovsky - Deputy Chief of Adjustment Dept - Enerac, Infrasec
Yaroslav Pyrihh - Computer Specialist
Nina Kryzhanovskaya - Senior Foreman - Electrical Department

INSTRUMENTS SUPPLIED TO Burshtyn

Zirtek oxygen analyzers, 2 probes for one T-boiler, 1 two-channel analyzer
Panametrics two channel ultrasonic transit time flow meter
Instromet natural gas chromatograph, display control unit and accessories
Oxygen cell and consumables for Enerac

DISCUSSION

There have been significant management changes and financial problems at this power plant which seem to have had a negative effect on employee morale and successful results with USAID energy efficiency and monitoring instrumentation

The new Director, Vasyl' Bendasivk, came from Dobrotvotor APP 900 MW power plant There was a fluidized bed boiler project at that plant which is no longer operating The former Director is now Deputy Director of Foreign Affairs There seems to be a lot of political in-fighting and lack of support for highly skilled and experienced technical specialists wanting to see progressive improvements made

They are in the process of another organizational change in Lvivenergo where 300 new

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paid December salary

It is difficult for employees to be motivated when last week they received only 20% of their February salary The power that the plant generates for domestic and export consumption is paid for in bartered goods, not cash

About the Enerac combustion analyzer, they asked why the manual has detailed instructions for plotting and emissions analysis, but the instrument says "no function" The built-in printer is supposed to print curves, but it does not work They can only get plots on computer screen by using Enercomp for Windows They had discussions with Uglegorsk power plant about the Enerac Also, the refresh diskette is a 5 25 in floppy, whereas the TI laptop has a 3 5 in. drive Enerac S N 11003249 They used it for a while to measure CO_2 and NO_X in flue gas

They also have a German IMR combustion analyzer (1994) similar to Enerac, which also needs an oxygen sensor, calibration gases and service, but no money to purchase.

They report that the Zeigler UNICON CEM system installed on stack No 3 several years ago is still non-functional because they need calibration gases The probe in stack is damaged because of lack of use and no maintenance They said $455,000 was wasted They said the amount of fines for emissions has decreased because the number of units operating has decreased Fees (fines?) paid for emissions in 1996

Emissions	Hrvina	
Soot	212,588	
Sulfur Anhydride	459,107	
NO_X	76,352	
CO	4,538	
V_2O_5	404	
	752,989	$413,732

They also have a flue gas analyzer ANALIT-PRIBOR which was manufactured in Kiev It is reported to be a microprocessor type photo sensitive spectrum analyzer measuring CO_2, CO, SO_2, NO_X, NO, NO_2, and having a long life The instrument is not portable, but compact in size and easily moved It was installed on Unit 9 for awhile near I D fan, but removed because it was getting damaged in the dirty atmosphere

The infrared thermometer was used up until six months ago to find problems, but batteries died and they cannot find 2 Hrvina ($1 10) to buy four new ones The electrician used it to check a large "fuse" on a transmission tower which was overheating from a short circuit and could have been a serious safety incident They used it to check insulation and covers on boiler burners They also used it to find and repair insulation on steam lines from boilers They did not seem to be aware of other uses for checking temperatures of motors, bearings, contacts, etc The electricians apparently refused to use it

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They recently received the Panametrics two-channel ultrasonic flow meter and training on how to use it The technical specialist has studied the manual and plans to use it for measuring mazut

The Fluke power analyzer is being used for measurements only in secondary circuits up to 100V, 0 2, 0 3, 0 5 amp A more suitable application would be in primary circuits It has been useful for preparing current phase diagrams and use in HV switchyard circuits for checking measurements from current and voltage transformers

They know that harmonics from large motors are a serious problem and the Fluke would be a valuable instrument for analyzing, but it is not the responsibility of their department

The Instromet gas chromatograph has not yet been installed because of financial problems, and trying to decide where it should be located They said there is no space in the natural gas metering substation control house, and have decided to remodel a secure room near Unit 2 They have a contract with another organization to install about 50m of sample line from the main gas distribution line to boiler room They will raise walls to ceiling to enclose room and provide insulation They were asked where they will vent sample and calibration gases to atmosphere and where KCal output signal would be integrated with meter station flow, pressure and temperature logging on computer They do not yet know The instrument and accessories are still packed in boxes and it is questionable if equipment will be installed and commissioned by the end of August

The two Zirtek oxygen probes are installed on Unit 3 boiler angled downward above a burner on each side This is not a good location because of the possibility of flame impingement and high temperature and slag damage Zirtek engineer recommended location higher up in radiant section in fire box Recommended temperature range for zirconium oxide cell long term performance is 600 to about 1200°C

The reason probes were installed on Unit 3 is the fuel split is about 90% coal, 5% gas and 5% mazut and burner design results in unstable flame and inefficient combustion During the commissioning test, oxygen was measured at 11-12% and 870-900°C. The boiler is presently shut down for repairs

Some of the experts wanted to install probes the same way at all 16 burners Our impression is that they do not want to relocate the probes higher in the furnace

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but recognition of the creativity and innovation of many talented specialists which can go a long way to help solve problems and improve energy efficiency in many small ways in the Burshtyn power plant

Wed. August 6,1997 - Travel to Kiev
Thur & Fri. August 7-8, 1997 - Kiev meetings, trip report
Sat. August 9, 1997 - Travel to USA

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State Committee of the Autonomous Crimean Republic for the Environment and Natural Resources Protection
The Central Crimean Regional Department for Nature Protection

March 12-25 1997

"Krymenergo" GAEK
Ministry for Power Engineering of Ukraine
74, Kievskaya Str.
Account 221902 in "Pzominvest Bank" kRB
MFO 324430, OKPO 00131400

Statement of Checking How the Legislation on Water Protected Facilities is Observed

I, the State Inspector at the Central Crimean Regional Natural Protection Office, Ms I P Shcherbakova, in the presence of the representatives from "Krymenergo" GAEK - Engineer of the Industrial & Technical Department, Ms O Yu Valia-Yeva, Senior Engineer from Simferopol HPP, Ms V N Cherkassova, have carried out checking how the legislation on the water protected facilities is observed at the Heat Power Plant named after V.I. Lenin, the latter being an independent structural unit within "Krymenergo" GAEK (the provisions on the structural unit of December 1, 1995) The checking has been performed on the ground of the Law of Ukraine "on the natural environment protection" The checking resulted in finding out the following

In 1996, at Simferopol HPP, there was produced

- Power energy - 294,713 MW - h
- Heat energy - 350,976 Gcal
- Reactive energy - 72,724 8 MVar

Between January and February in 1997, there was produced

- Power energy - 57,557 MW - h
- Heat energy - 132,276 Gcal

The consumption of fuel in 1996 was

- Natural gas - 123,336 thousand m^3
- mazut - 9,891 ton

at the average sulfur content of 1 7%

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In January 1997, there was consumed

- of the natural gas - 18,812 thousand m^3 at the lowest fuel combustion heat Q = 7,800 KCal/m^3

- of mazut - 0 ton

At the moment of the inspection, there are in operation.

- two power boilers - BKZ-160-100FB
- one water heating boiler KVGM-100
- a steam turbine T-34155-90
- a generator at No 3 in the synchronous compensater mode

The gas and turbine plants do not function due to the absence of the fuel

The enterprise was given the developed and approved standards of MAE levels valid until January 1, 1998 Until the same date, there is valid the permission to release the harmful substances into the atmosphere in the amount of 3,893 086 ton/yr (887 286 g/s)

According to the report - 2TP-air in 1996, the exhausts amounted to 761 610 t/yr, including there

- the mazut ash - 4 930 ton/yr,
- sulfur anhydride - 354 930 ton/yr,
- nitrogen dioxide - 401 760 ton/yr

The others include - the mazut ash (4 920 ton/yr)

The standards concerning the maximum admitted exhausts by each boiler when working on mazut set the exhausts of the mazut ash in recalculation on the vanadium pentaoxide The quantity of the given substance is determined by calculation, but in Chapter 2 of the Report 2TP-air is not specified for the given substance

According to an agreement with DONORGRES, there is fulfilled each quarter inventory of the exhausts sources given by each boiler with submitting a statement on the efficiency and the exhausts into the atmosphere due to the data from the reports and the instrumental measurements in 1996 the CO_2 content in the flue gases is absent

At the HPP there are monthly calculated exhausts of the harmful substances with taking into account the values of the sulfur content of the fuel determined by the laboratory of the enterprise, and the same is done concerning its lowest combustion heat

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However, there are no records kept in the register books of the exhausts into the atmosphere, nor is kept the register for the exhausts measurements (the forms of the registers were recommended due to "Instructions for organizing control of the exhausts at a HPP" - RD 34 02 306-88) Enerac-2000 was not used by the laboratory of the HPP during 1996 due to the resource of the oxygen analyzer to be over

On March 18, 1997, the laboratory of the State Committee for the Natural Resources and Environment, p20 - function together with the laboratory of the HPP performed parallel taking samples from the operated boiler systems The laboratory of the State Committee used the national production instrument - "Inspector - 1 - Express-Method", the Laboratory of the HPP used "Enerac-2000.

The comparison of the results shows discrepancy between the values concerning the exhausts For example, when the steam boilers BKZ-160-FB on No 1 are being operated, the analytical control instrument registers absence of CO in the fuel gas exhausts (Enerac-2000), the express-method "Inspector" determines their presence on the level of 62 5 mg/m, that is within the process requirements and corresponds to the approved maximum admitted exhausts levels

Analysis for the Boiler BKZ-160-100FB at No 3 was not performed by the laboratory of the State Natural Protection Committee due to the mismatching the sample-taking holes

In the exhausts of the water heating boiler KVGM-100 at No 1, measurements with both the instruments show presence of CO, the values determined by the laboratory of the State Committee is higher in this case too than those determined by the HPP

The values for the nitrogen oxide exhausts are practically the same, except for the exhausts from BKZ-160-100FB at No 1, the reading from Enerac-2000 is 102 5 mg/m^3, the reading from "Inspector" is 150 mg/m^3 The results of the checking measurements are attached

As the method of "Inspector 1" is a test-method, it is suggested to carry out two parallel measurements by Enerac-2000 and using the instruments "TESTO-33" from the laboratory of DONORGRES The results shall be in written form submitted to the inspection

Concerning formation and arrangement of the wastes, there has been found as follows

According to the data from the HPP, the territory is made up of three areas with the total area of 26 88 hectares

- 1 - 23 18 he - the industrial area
- 2 - 3 09 he - the ash-dumping area
- 3 - 0 6 he - an area in the collective orchards zone

In the limits on arrangement of the wastes issued by the State Committee for the Natural

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Protection valid for 1997, there were not set the wastes resulting from draining the sewage waters at the ash-dumping area.

The construction and installation works office "Krymenergostroi" has not submitted the act on setting the borders of the area in the nature

State Inspector / Signature / I P Shcherbakeva

Persons present at the time of the inspection

Engineer of "Krymenergo" GAEK O Yu Valiayeva
Chief Engineer of Simferopol HPP V N. Cherkesov

On the ground of the above said, there is suggested.

1 To make an additional checking of the exhausts of the harmful substances into the atmosphere

2 To keep records in the register for exhausts and in the register for measurements of the exhausts into the atmosphere - The grounds for that - "Instructions for organization of the control over the exhausts at the HPP" - RD 36 02 306-88

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ODESSA CHP PLANT
Fuel Consumption

Month	X1000 m^3 Gas			Mazut	
	Consumption	Measured Calories	Contract Calories	Consumption	Calories
1-95	26350	7922	7979	3858	9630
2-95	23373	7907	7865	842	9630
3-95	23224	7894	7953	105	9630
4-95	17588	7872	7959	--	--
5-95	8179	7865	7918	--	--
6-95	1722	7850	7860	1045	9630
7-95	--	--	--	3217	9630
8-95	--	--	--	3173	9750
9-95	284	7850	7922	3810	9750
10-95	10143	7850	7922	407	9750
11-95	16623	7845	7922	2901	9750
12-95	20029	7834	7870	8277	9613
Total	147515	7879	7850	27635	9670

ODESSA CHP PLANT
Fuel Consumption

Month	X1000 m^3 Gas			Mazut	
	Consumption	Measured Calories	Contract Calories	Consumption	Calories
1-96	23557	7870	7946	6947	9530
2-96	20496	7890	7952	4477	9530
3-96	22081	7861	7927	3234	9639
4-96	15165	7820	7870	--	--
5-96	8828	7831	7850	--	--
6-96	6868	7862	7910	1007	9680
7-96	5583	7865	7890	1853	9652
8-96	6955	7865	7910	1117	9530
9-96	3605	8037	7998	50	9530
10-96	2027	8046	7965	1170	9530
11-96	10672	8028	7957	--	--
12-96	21492	8012	7945	51	9530
Total	147329	7902	7967	19906	9567

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ODESSA CHP PLANT
Fuel Consumption

Month	X1000 m^3 Gas			Mazut	
	Consumption	Measured Calories	Contract Calories	Consumption	Calories
1-97	27380	7996	7924	--	--
2-97	25122	7905	7922	--	--
3-97	20271	7960	7917	--	--
4-97	14130	7927	7945	--	--
5-97	8901	7923	7960	--	--
6-97	7915	7902	7984	--	--
7-97	7705	7907	7995	--	--

Gas \$83/1000 m^3 Mazut \$95 to \$118 per tonne

COAL CONSUMPTION

	1995 P		1996 P	
	B (T)	Q p	*B (T)	Q p
I	379710	7097	367645	4285
II	298164	4393	256612	4210
III	320951	4509	264699	4354
IV	279651	4210	216863	4333
V	309413	3910	254222	4583
VI	319353	4022	255993	4747
VII	288009	3982	260548	4715
VIII	362394	4092	231768	4743
IX	391070	3672	231428	4717
X	419617	3608	229952	4496
XI	344118	3779	247744	4413
XII	311231	4437	268332	4106
Pic	4023711	4037	3085806	4464

NATURAL GAS

	1996 P		1997 P	
	B (T)	Q p	*B (T)	Q p
I	22069	8030	41599	8043
II	15726	8023	14889	8078
III	7813	8040	13023	8125
IV	1178	8030	20083	8115
V	--	--	34271	8100
VI	--	--	36519	8097
VII	--	--	23345	8123
VIII	14068	8098		
IX	25593	8110		
X	17410	8135		
XI	14222	8123		
XII	33175	8130		
PIC	151254	8092		

7/29/97

Simferopol Power Plant

Mazut and Natural Gas Consumption·

1996: Total
Gas 123,336,000 Nm^3
Mazut 9891 tons

Heat Content (Average) Gas 7969 $Kcal/Nm^3$
$83/1000 M^3 Mazut 8767 $Kcal/Nm^3$

Elec = 5.3 Kopecks/KWH Cost, 7 11 Kopecks/KWH Krimenergo Sells

Month 1996	X1000 Nm^3 Gas			Mazut	
	Consumption	Measured Calories	Contract Calories	Consumption	Price/ton
Jan	13456		7924	279 tons	USD 194
Feb	13203		7879	634 (8660 Kcal)	197
Mar	10472	7858/8076	8796	3063	197
Apr	7258			912	197
May	6806			---	
June	7161	8435	8410	---	
July	9891	8651	8778	246	200
Aug	13478	8736	8875	---	
Sept	8447	8667	8930	1193 (9208 Kcal)	180
Oct	4580	8444	8835	2717	170
Nov	11263	7862	8135	142 (8602 Kcal)	180
Dec	17321	7841	7986	327 (8800 Kcal)	180

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Simferopol Power Plant

Mazut and Natural Gas Consumption

Month 1997	X1000 Nm^3 Gas			Mazut	
	Consumption	Measured Calories	Contract Calories	Consumption	Price/ton
Jan	18812	7886	8097	---	185
Feb	17551	7841	7967	301	185
Mar	18526	8092		138	190
Apr	14817	7879		598	190
May	12531	8343		25	190
Jun	12674	8246		---	190