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# BURNS AND ROE ENTERPRISES, INC.

## Audit Report
## DONETSK METALLURGICAL PLANT
## DONETSK, UKRAINE

*FINAL*

**August 1997**

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| **Prepared by:** | **Burns and Roe Enterprises, Inc.** |
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Delivery Order No 6
Energy Efficiency and Reliability - Ukraine
Task 3 - Industrial Energy Efficiency

Donetsk Metallurgical Plant

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# 1.0 EXECUTIVE SUMMARY

## 1.1 Introduction

As part of Delivery Order #6 of the NIS Energy Efficiency and Market Reform Project, the United States Agency for International Development (USAID) sponsored a total of five industrial energy audits at large energy consuming industries in Ukraine One of the audits was completed by Burns and Roe Enterprises, Inc , of Oradell, New Jersey, the other four audits were conducted by Resource Management Associates of Madison (RMA), and Foster Wheeler USA Corporation This report details the findings of the Burns and Roe energy audit performed at the Donetsk Metallurgical Plant located in Donetsk, Ukraine

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

The audit team of John Hallberg and Yefim Donkin spent six days at the Donetsk Metallurgical Plant in Donetsk, Ukraine. They performed the following energy audit as representatives of Burns and Roe Enterprises, Inc (BREI) of Oradell, New Jersey. The scope of the audit was limited due to the size of the plant (9,000 employees) and the five day schedule. A list of equipment used for the audit can be found in Appendix A.

The Donetsk plant is 100% government owned and is one of the oldest integrated steel mills in Ukraine, producing sheet steel, structural shapes and pipe The plant produces specialized alloy steel shapes and blanks not made elsewhere in Ukraine

Products are supplied for use in automotive, ship building, coal, agriculture and transport machinery manufacture It was reported that up to fifty percent of production is exported for hard currency. It was also reported that for the past five years the government has not provided adequate support and money for maintenance, spare parts and supplies because of a belief that the steel production was not required in Ukraine Consequently, the mill, and in particular the power plant, which is the heart of the steel mill, are in very poor repair resulting in constant equipment failures and frequent shutdowns Much of the equipment is more than 30-40 years old, and the plant has a major 15 year rehabilitation strategy in progress for obtaining modern western steel making technology. Although production has declined in recent years, the management is optimistic that the demand for high quality alloy steels will increase

## 1.2 Principal Findings

Several Energy Conservation Opportunities (ECOs) for both the power plant and the mill 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 and electricity consumption and for controlling boiler efficiency which would result in simple payback periods as short as six months

The larger cost long term measures include major combustion control system upgrades, including interlocks and flame safeguard systems, replacing some large pumps, compressors and motors and water treatment equipment Costs would be from $500,000 to 3 5 million dollars and would result in payback periods of about two to four years.

Considering the age of the power plant and poor efficiency of energy utilization, it is recommended that the longer range plans should seriously consider complete replacement or major repowering and rehabilitation of the power plant with modern efficient energy technology, based on a more detailed integrated engineering study of the steel mill modernization and utility requirements.

The plant organization structure has positions of Chief and Assistant Chief Engineers for energy Because of the recent shortage of hard currency for natural gas, the management is motivated to improve energy utilization for generation of steam, electric power and compressed air

The following Table 1 summarizes several conservation opportunities which will pay for themselves within short periods of time. Energy costs for electricity and natural gas have been increasing monthly, and these efficiency measures will become more economical as the domestic energy costs approach world energy costs It is apparent that many other opportunities exist within the steel mill for energy savings which could not be analyzed for this audit.

**An investment of $216,000 in energy conservation improvements (ECO-01 through ECO-08) will result in annual savings of $1,363,000 corresponding to a fuel equivalent of 32.7 million standard cubic meters of natural gas, and 2.5 million kilowatt hours of electricity.**

## Table 1 - Summary of Energy Conservation Opportunities (ECOs)

| ECO# | Description | Annual Fuel Savings in $m^3$/yr of natural gas (electricity) | Annual Energy Savings | Annual $ Cost Savings | | Project Cost (US$) | Simple Payback | |
|---|---|---|---|---|---|---|---|---|
| | | | | World Energy Prices | Local Energy Prices | | World Energy Prices | Local Energy Prices |
| 1 | Energy Conservation Management Program | 14,000,000* | $3\ 2 \times 10^{11}$ BTU | $570,000 | $502,000 | $30,000 | 19 days | 22 days |
| 2 | Power Demand Meters | ($2\ 1 \times 10^6$ kWh) | $2\ 1 \times 10^6$ kWh | $64,398 | $21,463 | $9,000 | 7 weeks | 5 months |
| 3 | Valve Packing and Tools | 4,127,000 | $9\ 4 \times 10^{10}$ BTU | $18,948 | $16,602 | $14,000 | 9 months | 10 months |
| 4 | Instrument Calibrators | 3,161,000 | $7\ 2 \times 10^{10}$ BTU | $151,426 | $132,678 | $14,000 | 5 weeks | 6 weeks |
| 5 | Portable Flow Meter | (380,000 kWh) | $3\ 8 \times 10^5$ kWh | $11,498 | $3,833 | $9,000 | 10 months | 28 months |
| 6 | In Situ Oxygen Analyzers | 1,273,000 | $2\ 9 \times 10^{10}$ BTU | $60,900 | $53,360 | $75,000 | 15 months | 17 months |
| 7 | Natural Gas Bypass Control Valves | 2,283,000 | $5\ 2 \times 10^{10}$ BTU | $109,200 | $95,680 | $30,000 | 15 weeks | 17 weeks |
| 8 | On-line Gas Calorimeter | 7,903,000 | $1\ 8 \times 10^{11}$ BTU | $378,000 | $331,200 | $35,000 | 5 weeks | 6 weeks |
| 9 | Analytical Instruments | 427,504<br>32,307,986** | $1\ 01 \times 10^{11}$ BTU | $152,778 | $131,995 | $100,000 | 8 months | 9 months |
| 10 | Sodium Softener for Cooling Water Makeup | $92,000 | $92,000 | not applicable | $92,000 | $330,000 | not applicable | 3 6 years |
| 11 | Combustion Control System | 1,282,512<br>96,923,959* | $3\ 03 \times 10^{11}$ BTU | $458,336 | $395,984 | $550,000 | 1 2 years | 1 4 years |
| 12 | Blast Furnace Gas Scrubber Pumps | ($2\ 2 \times 10^6$ kWh) | $2\ 2 \times 10^6$ kWh | $65,760 | $21,920 | $250,000 | 3 8 years | 11 4 years |

**Savings are shown equated to natural gas, but would actually be a combination of all fuels (natural gas, furnace gas, coke gas, mazut, coke, and coal)*
***Blast furnace gas $m^3$*

## 2.0 PURPOSE OF AUDIT

The purpose of this audit is to identify Energy Conservation Opportunities (ECOs) for short term low cost measures and for longer term higher cost measures to improve plant energy efficiency and reduce dependence on imported oil and gas.

The Donetsk Metallurgical Plant was selected as a critical energy intensive facility important to the Ukraine economy, having many opportunities to reduce energy consumption by improving efficiency of energy utilization. This plant was selected based on discussions with officials from Ministry of Energy, Donbassenergo, Energy Efficiency Center in Kiev and technical institutes

## 3.0 FACILITY BACKGROUND

### 3.1 Description of Facility

Donetsk metallurgical plant was founded in 1872 and now it is one of the oldest ferrous metallurgy enterprises in Ukraine.

In 1960, for the first time in the world, the production facilities for continuous steel casting was started up in the plant and these facilities are still in operation.

In 1968, a unit for cast-iron desulfurization was started up which made it possible to produce world-standard-quality cast iron

In 1974, a new design of charging unit was introduced in the blast furnace workshop.

In the 1970's, the fundamental plant updating was initiated. In 1974, a new cogging mill started working In 1978, the largest in Ukraine high-powered electric steel furnace workshop came into operation

In 1981, for the first time in metallurgy, equipment for coal dust injection into blast furnace went into operation sharply reducing coke consumption

In 1982, an evacuation unit was installed in the electric steel furnace workshop and the technology of vacuum steel treatment was implemented

In 1985, the largest workshop in Ukraine for exothermic slag-forming mixtures used during steel casting came into operation

At the present time the plant consists of blast furnace workshop (2 blast furnaces with working capacity 1033 $m^3$), open-hearth furnace workshop (6 open-hearth furnaces with capacity 150 tons), electric arc steel furnace workshop (2 electric arc furnaces with capacity 100 tons each), cogging mill workshop (continuous billet mill 950/900), section rolling workshop (light-section-250 and medium-section-350 and 400 merchant mills) and sheet rolling mill (2300 mill)

Apart from the main production workshops, there are the power plant supply workshop, maintenance workshops, scrap metal reprocessing workshop, railway and transportation sites, synthetic slag-forming mixtures production workshop, plant storehouses for raw and other materials storage

## 3.2 Product Background

The merchant mills produce simple and shaped sections· round, square, hexahedral with dimensions 12-65 mm., strip and spring steel (5-25 mm. thick and 22-160 mm wide), shaped sections for automobile construction, ship-building, coal mining, agriculture, road machine construction And the plant is the only supplier of many of above mentioned items

In the 1990's, a general overhaul was started in the plant for the following reasons

1. Poor ecological situation in the region
2. Low efficiency of fuel and energy consumption by existing metallurgical technologies and equipment
3. Necessity to increase the profitability of production within market economy conditions

## 3.3 Viability of Facility

Simultaneously with construction of new workshops for production of finished products, the design for steel smelting workshops rehabilitation is being carried out. The consortium of German companies "Korf Lurgi" and "Mannesmann Demag" has already prepared a preliminary design for open-hearth furnaces workshop rehabilitation. German company "Fuks" executes project engineering for electric steel furnaces workshop rehabilitation Suggested works will make it possible to reduce the consumption of power 2 times and natural gas almost 10 times In fact, there will not be any detrimental wastes At the same time, the possibilities for high-quality grades of alloy steel will be extended.

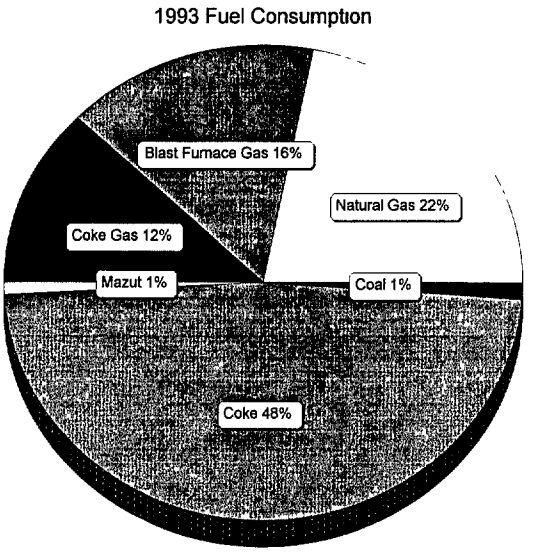
Due to the rehabilitation in the near future, the plant will become a fully renovated, effective, competitive and ecologically safe enterprise specialized in production of high-quality rolled products from alloyed steel grades and other products necessary for Ukrainian economy.

## 3.4 Facility Energy Use

### 3.4.1 Consumption

Energy sources used at the Donetsk Metallurgical plant include coal, electricity, natural gas, coke gas, blast furnace gas, and mazut as a backup boiler fuel It takes 6.0 to 6 5 GCal (24 to 26 MBTU) of total energy to produce a metric tonne of steel. The principle energy source is coal, which is used to produce coke. Coal and coke account for 69% of energy use in the steel industry, and electricity accounts for 7%.

Total plant electrical load is about 75 megawatts, composed of 49 megawatts of purchased power and 16 megawatts of generated power The plant electrical generation facility has 49 megawatts of capacity Production of electricity is limited due to lack of fuel and boiler reliability Central space heating is provided from the on-site cogeneration power plant




Donetsk Metallurgical consumed the following amounts of utilities in 1993·

| Utility | Amounts | |
|---|---|---|
| Natural Gas | 621,280,000 $Nm^3$ | 14 15x$10^6$ MBTU |
| Blast Furnace Gas | 3,446,367,000 $Nm^3$ | 9 74x$10^6$ MBTU |
| Coke Gas | 402,772,000 $Nm^3$ | 7 41x$10^6$ MBTU |
| Mazut | 49,640 metric tonnes | 0 85x$10^6$ MBTU |
| Coke | 1,186,176 metric tonnes | 30 42x$10^6$ MBTU |
| Coal | 90,690 metric tonnes | 0 79x$10^6$ MBTU |
| | Total | 63 36x$10^6$ MBTU |
| Power consumption without auxiliaries of power plant | 567.7 million kWh | |
| Thermal Energy (steam, hot water) | -not available- GCal | |
| Oxygen | 34 3 million cubic meters | |
| Compressed air | 315 4 million cubic meters | |
| Service water | 10 5 million cubic meters (estimate) | |
| Wastewater discharge | 4 47 million cubic meters | |

Natural gas is used in conjunction with coke gas and blast furnace top gas to produce steam for power generation and process steam. The five boilers have a total capacity of 565 metric tons of steam per hour.

Natural gas (combined w/oxygen) is also used in the blast furnace. The blast furnace top gas is then recovered to be used for boiler fuel A blast furnace typically uses 480 kg of coke per ton of iron produced Coke has a heating value of 6900 kcal per kg (27,600 BTU/kg) of coke

### 3.4.2 Energy-using Systems

Heating, Compressed Air and Electricity Production

Space heating, production heating, compressed air and electricity generation are provided by the boilers

Domestic Hot Water

Domestic hot water is made with steam. Energy consumption for this use is insignificant in comparison to process loads on the plant site

Production

All significant electricity consumption in the plant goes toward production. The plant's monthly electrical peak demand is about 100 megawatts of power. Major electrical energy users include arc furnaces, large pumps for cooling water circulation, large motors for mechanical rolling of metal, and support equipment such as conveyor systems to move products through the process phases

Natural gas, coke gas, and blast furnace gas are used in boilers to generate steam for electricity production Natural gas is also used in production furnaces

### 3.4.3 Energy Costs

Electricity is currently purchased from Donessenergo. Fuel costs have rapidly increased in the past three years. Energy prices, in general, are currently increasing on a monthly basis and are expected to continue to increase until world prices for energy are reached (See Appendix D for world and regional energy prices ) A 10 to 15% percent increase in rates per month is typical Using an exchange rate of 120,000 coupons per dollar, purchased electricity costs were $0.0171/kWh (2050/kWh) This includes a demand and consumption charge. The cost of electricity produced by on-site electrical generation averages one-third the price of purchased power, or $0.006 per kWh (720 coupons/kWh).

### 3.4.4 Energy Management Plan (Appendix H)

The plant engineers worked together with UkrNIImet Research Institute and Lengipromez Institute designers to develop a long term strategy through 2010 The rehabilitation plan has been developed in a way that the new efficient replacement production facilities revenues and

energy savings will be sources of financing for additional plant overhaul and rehabilitation Capital investments in overall plant rehabilitation are being driven by environmental requirements, high fuel and energy costs forcing use of new efficient metallurgical technologies and equipment, and increasing profits

## 4.0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS

### 4.1 Boiler/Power Plant

The boiler/power plant supplies power, steam and compressed air to the steel production facilities. Some steam is used to produce electricity, and the remaining steam and hot water are used for plant heating and for process heat. Thirty percent of the plant's electrical energy is produced on site, the remainder is purchased from the local utility. The boiler plant has five boilers The oldest was installed in 1957, the newest in 1980 See Table 2 for boiler design capacities.

**Table 2**
Boiler Plant Boilers

| Quantity | Steam Capacity | Pressure |
|---|---|---|
| 3 | 75 T/hr | 39 atm |
| 1 | 120 T/hr | 80/39 atm |
| 1 | 180 T/hr | 80 atm |

Makeup water is obtained from the plant water system and treated. Since a large amount of makeup water is used, the amount of condensate returned to the boiler plant is small. The steam is used, or the condensate disposed of, after the production process. The exact amount of condensate lost could not be determined.

### 4.2 Energy Conservation Management Program (ECO-01)

Environmental requirements and high fuel and energy costs are compelling plant management to consider capital investments in overall plant rehabilitation as described in section 3 4 4, Energy Management Plan, and in the long term strategic plan described in Appendix H. New and more efficient production facilities could be a major foundation for improved energy savings, however, there are many opportunities for savings and conservation which can be implemented by the plant staff, which do not involve large capital expenditures, through an energy conservation management program Success of such a program is dependent on availability of appropriate **energy audit equipment, employee training in energy conservation concepts**, and an effective **energy management department** (or committee) with the support of senior management.

With appropriate energy audit equipment, members of the plant staff can identify and quantify energy savings opportunities with short term paybacks for substantial cost savings. For instance· The addition of instruments to monitor oxygen in the flue gas to permit verification that the

proper fuel-to-air ratio is maintained will provide improvements in combustion efficiency Maintenance and repair of air leaks into the draft system as well as heat, water and steam leaks, will also reduce losses and improve efficiency

Boiler combustion efficiency can be improved by providing the operators with portable combustion analyzers (with laptop computers for data storage and fuel characterization). This would allow them to periodically measure the combustion efficiency every 4 to 8 hours and to adjust the controls accordingly The cost of the equipment could be paid back in less than six months

Portable energy audit equipment which would be beneficial for the Donetsk Metallurgical Plant

- boiler combustion analyzer
- non-contact ultrasonic flow meter
- non-contact temperature measuring device
- 3-phase electrical meter with logging and down loading capability
- hot wire anemometer
- laptop computer
- energy management reference books

An energy management department reporting to senior management should have the responsibility and authority to develop, implement and monitor energy conservation, training, reliability and rehabilitation programs The stated goals for these programs, as a minimum, should be emphasized as follows

- Conserve energy
- Reduce environmental pollution
- Improve operational efficiency
- Improve equipment reliability
- Introduce new technologies
- Establish energy management procedures
- Train plant staff in energy conservation concepts

The energy manager must promote energy conservation awareness to all end users of energy The end users must be the ones responsible for finding the most efficient way to utilize energy in their work area The responsibility of the energy management department is to work with plant personnel to

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

ADVERTISE successful energy conservation projects and lessons learned; and
REPLICATE successful conservation projects to all parts of the plant

If only a modest 0.5% improvement in overall plant efficiencies could be achieved, the resultant savings in fuel cost alone would be about $570,000 per year (neglecting savings from purchased electrical power), the energy savings would be about 3 2x$10^{11}$ BTU (See ECO-01)

### 4.3 Power Demand Meters (ECO-02)

There are ten meters for measuring imported power to the mill. At least three meters are broken and out of service at a given time The plant is unable to obtain spare parts because the meters were originally made in Vilnius, Lithuania many years ago and are now obsolete. The mill has to rely on the utility outside metering for billing The existing meters are 1 0% accuracy, whereas new meters are 0 5% accuracy. This metering is important for measuring and auditing reductions in imported power as a result of other energy efficiency improvements throughout the plant.

### 4.4 Valve Packing Tools and Valve Packing (ECO-03)

Large quantities of high pressure steam (and demineralized water) are lost in the power plant and steel mill due to valve stem packing leaks There is a need for a kit of valve packing tools including metric wrenches, pick hammer, chisels, picks, gland puller, penetrants, graphite, emery cloth, 220V pencil grinder and stones, etc. Also, a selection of square metric packing sizes 6-30 mm, Garlock 1312 or equivalent (about 65 lbs) to pack about 120 valves should be provided

### 4.5 Instrument Calibrators (ECO-04)

The engineers requested portable pressure calibration standards for field calibration of transmitters Most of the transmitters have one to two percent accuracy, but could give pressure and flow measurements in error by as much as plus or minus five percent if out of calibration. Many examples can be given where energy is wasted because of inaccurate monitoring and control of pressure and flow of steam, hot water, mazut and fuel gas being consumed in the plant However, using natural gas fuel flow measurement as one example, a one half percent improvement in total flow measurement accuracy for combustion excess flow would result in a significant reduction of wasted fuel.

### 4.6 Portable Flow Meter (ECO-05)

There is a critical need for a portable sonic flow meter to measure cooling water flows in the plant and balance systems to ensure that large pumps are operating at their best efficiency point (BEP) There are many large pumps throughout the steel mill which could be optimized for large energy savings. However, only one example has been evaluated as an example of energy savings for large pumps. The example is for the power plant circulating water pumps for a 10% improvement in efficiency Payback for one system is less than one year at world energy price, which would be about the same payback for a permanently installed flow meter.

## 4.7 In Situ Oxygen Analyzers (ECO-06)

The boilers air to fuel ratio is controlled manually It is impossible for the operators to continuously adjust boilers for optimum combustion, especially when blast furnace gas feed varies and steam loads vary

Installation of two zirconium oxide oxygen probes in each of five boilers' flue gas path will give operator oxygen readings to accurately adjust fuel-air ratios This will increase boiler efficiency by an estimated three percent Payback would be about one year.

## 4.8 Natural Gas Bypass Control Valves (ECO-07)

The existing natural gas control valves are operated manually to follow steam load based on steam pressure. The valves are sized for full load, and operator response plus lag time results in significant waste of natural gas due to slow closing of the large valves. The engineers estimate that natural gas consumption could be reduced by 1 5% if a smaller parallel bypass control valve is installed at each boiler

## 4.9 On-line Gas Calorimeter (ECO-08)

Reported heating value specification for Russian natural gas is 8116 kcal/kg However, the technical specialists complain that the delivered heating value as delivered runs low by as much as 200 kcal/kg when the plant is paying for gas on a volumetric basis. They want to be able to measure and record natural gas deliveries continuously on-line on the basis of heat content in kcal/kg, with specific gravity, Wobbe index, temperature, and pressure. The plant presently measures heat content in the water and gas laboratory on a weekly basis by collecting samples in a gas bomb and running the test in a bomb calorimeter This sampling method is dangerous, time consuming, subject to error and only gives an intermittent sampling of gas delivery rather than an accurate total of energy received and consumed.

# 5.0 SYSTEMS AUDITED - LONG TERM RECOMMENDATIONS

## 5.1 Analytical Instruments for Water and Gas Laboratory (ECO-09)

The power plant engineers provided a list of instruments needed to improve performance and reliability of operation of the power plant and the air separation plants. New flow transmitters would replace old, obsolete and inaccurate transmitters to better monitor improvements in efficiency and performance of the boilers Also, instruments are needed for monitoring quality of makeup and feedwater to boilers and purity of oxygen used in steel making If only a one percent savings in fuel can be achieved by improved monitoring of steam and fuel gas flows, the payback for these instruments would be less than one year

## 5.2 Sodium Softener for Cooling Water Makeup (ECO-10)

The plant presently pays 5000 coupons ($0 04) per cubic meter of makeup water for cooling and process. This water from the river is not treated and is fed directly to the cooling tower Sulfuric acid and a combination zinc-phosphate dispersant/corrosion inhibitor are fed to the

tower. The water quality is so poor that only about 1 33 cycles is achieved in the tower There is significant scale in condensers and heat exchangers which results in large losses of energy and waste of water which the plant must purchase In addition, shutdowns required for removal of scale and corrosion products (from acid) results in losses of production The cooling towers have old inefficient slat type asbestos fill which should be replaced Drift is at least 0 5%, which is a very large loss of water Also, spray nozzles keep getting plugged up with crud and corrosion products (rust) which results in loss of thermal efficiency.

A sample of 76mm pipe for air to water heat exchanger had 25-28mm of cementitious calcium carbonate/silica scale It is estimated that about $90,000 per year could be saved in water costs by softening the makeup water, increasing cooling tower cycles from 1 33 to 2 5, and about $180,000 per year savings of 750 kW (3%) at $0 03/kWh due to reduction of condenser scale

## 5.3 Combustion Control System (ECO-11)

We were given a copy of a letter from the Ukraine government inspection agency officially notifying the Donetsk Metallurgical Plant that the boilers must be upgraded because of lack of technical protection requirements required by current regulations Basically it is a requirement for upgrading the boilers with combustion control systems, including interlocks and flame safety.

We were given copies of boiler fuel supply logic diagrams and had many discussions of modifications for improvement of boiler operations. The conclusion kept coming back to the need for a combustion control and flame safeguard system for the boilers.

In addition to the benefits of improving the safety of boiler operations, as much as a one percent improvement in boiler thermal efficiency may be achievable, which could result in as much as a one percent savings in fuel consumption. Automatic control of fan dampers for combustion air and control valves for steam and fuel to meet load demand will provide more rapid response than manual control, which will result in stable and efficient combustion Monitoring oxygen in the flue gas to minimize excess air will help to reduce the waste of fuel

## 5.4 Blast Furnace Gas Scrubber Pumps (ECO-12)

There are five 650 kW scrubber water pumps for blast furnace gas scrubbers which are subject to severe wear from abrasives The pumps are cast iron and when new are 83% efficient but rapidly deteriorate to about 65% efficiency, which is a large loss of electrical energy for pumping. There is a need to replace this equipment with alloy construction Approximately $65,000 per year in power costs could be saved at $0.03 per kWh

## 6.0 IMPACT OF SAVINGS

The short term energy savings investments that have been recommended will typically provide financial payback within the same budget year Due to present economic conditions, reserve cash flows are not available to make internal plant investments with greater than a month payback. Despite this cash flow problem, internal resources such as manpower and available materials can be utilized to improve energy efficiency in some areas

All of the energy conservation projects have multiple applications within the steel mill as well as in other industrial facilities. The concepts proposed for energy conservation were originated as projects that are commonly implemented in the U.S.

## 7. RESULTS OF FOLLOW-UP VISIT

### 7.1. Visit Objectives

During August 11-12, 1997, Burns and Roe resident engineer, Alexander Filippov, made an equipment follow-up visit to the Donetsk Metallurgical plant The visit was made with the following objectives

- Assist the plant with the use of the measuring instruments
- Discuss equipment installation
- Assess energy conservation achievements in response to the 1995 energy audit
- Assess energy conservation impact of the delivered equipment

The original program design allowed time for the plant to implement recommended energy efficiency measures and begin monitoring the results prior to the equipment follow-up visit The follow-up visit occurred two months after the plant had received the first lot of energy efficient equipment All equipment has been cleared from customs, and given to the plant personnel The plant energy manager and his deputies were reluctant to provide any information about the plant even about energy conservation other than related directly to the delivered equipment, without the director's permission A formal request to the director for necessary information was submitted by A Filippov During the meeting with the plant director, he was very cooperative, understanding, and ordered plant personnel to provide Burns and Roe with necessary information for the final audit report The plant personnel who utilize the equipment are very professional and use the instruments extensively

### 7.2. Main Energy Conservation Opportunities (ECOs) Identified in 1995

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

| 14ECO | DESCRIPTION | ESTIMATED SAVINGS (USD/YR ) |
|---|---|---|
| ECO #1. | Energy Conservation Management Program | $502,000 |
| ECO #2 | New Power Demand Meters Installation | $21,463 |
| ECO #4 | Instrument Calibrators Installation | $132,678 |
| ECO #8 | On-line Gas Calorimeter Installation | $331,200 |

All the above recommendation were accepted, and equipment delivered Under ECO #1 the following instruments were provided

- ENERAC 2000 combustion analyzer
- Mid-range infrared thermometer MICRON
- Hot wire anemometer KURZ
- Power analyzer RUSTRAK RANGER
- Desktop computer with the software
- Energy Reference books

### 7.3. List of Contacts

During the follow-up visit at Open Joint Stock Company "Donetsk Metallurgical Works" on August 11-12, 1997, A Filippov met with following plant representatives

- Chairman of the Board of Directors, Alexander Ryzhenkov
- Chief Energy Manager, Vladimir Kharchenko,
- Deputy Chief Energy Manager, Alexander Danilov
- Chief of Industrial Thermal Laboratory, Alexander Yevtushkin,
- Chief of Electrical Measurements Laboratory, Arkadiy Zorikov
- Chief of Central Electrical Laboratory, Alexander Tatarov
- Ecology Specialist, Alexander Smolianitsky
- Chief of Gas Department, Valentin Verbitsky
- Chief of Instruments and Automation Department, Nikolay Sanzhakov
- Chief of Equipment Department, Tatiana Vazhinskaya

### 7.4. Status of the Plant During August, 1997 Visit

During the period 1995-1997 the plant has changed the form of ownership and become an open joint stock company Shares were sold to employees at a low price of 25 kopecks (approx 13 cents) a share, and outside the plant at stock market price The plant has one main investor - Joint Venture "Metalrussia", which invested the equivalent of USD 50 million in the plant Accordingly several work shops of the plant have become half-independent, with their own financial operations The plant produces cast iron, different types of steel and steel products The plant is trying to keep its place in the Ukrainian steel market, but as many others, faces the problem of cash shortage Most operations are in the form of barter According to plant information, in 1997 only one train car of steel was sold for cash in Ukraine The electrical bills are also covered through barter operations The plant gets cash mostly from export operations There is a lot of foreign activity at the plant related to feasibility studies for possible investments Three western firms are bidding for electrical furnace refurbishment A company from Hong Kong is investigating the possibility of USD50 million investment in electric steel melting department

The level of production reduced since 1995 Of two blast furnaces, one is in operation, all five open-hearth furnaces are operating, and both electric arc steel furnaces are operating Three section rolling workshops work only at 1 shift (3 shifts before), sheet rolling mill works at 1-2 shifts (3 shifts before)

## 7.5. Accomplishments During Visit

### 7.5.1. Energy Conservation Data

Donetsk metallurgical plant management is concerned about energy conservation, and the current energy manager pays keen attention to this topic. However, paradoxically, the departments or single workers do not profit directly from energy conservation measures implementation The financial system is such that the departments do not have their own funds and can calculate energy savings only on paper. They cannot use money saved by energy conservation measures implementation However most of the staff is highly professional and do their best in this respect. The following information reflecting some energy conservation and energy consumption issues was collected from the Chief Energy Manager

| *ENERGY CONSERVATION MEASURES FOR 1997* | |
|---|---|
| ECM | Savings (converted to USD) |
| Diversion of furnace fuels to gas and mazut | 81,000 |
| Heat insulation of external wall surface of heating furnace of the mill 400 | 8,594 |
| Heat insulation of external wall surface of heating furnace of the mill 250 | 594 |
| Shut down heating burners in places where there is no permanent personnel presence | 919 |
| Shut down heating burners after work shift | 3,567 |

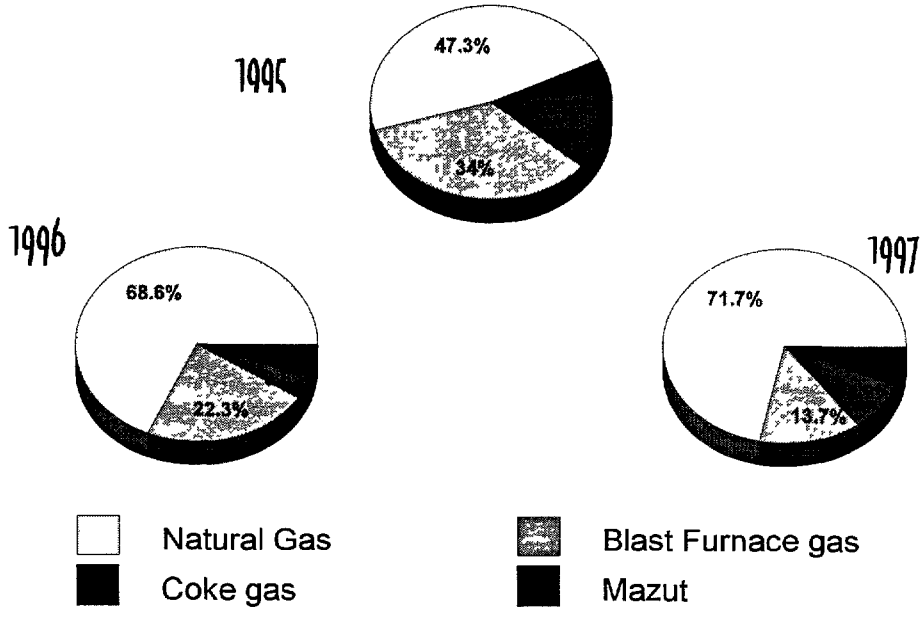
During the first quarter of 1997 the plant saved

Fuel - 16623 tons of standard fuel (USD 868,000)
Heat - 31158 GCal (USD 257,729)
Electricity - 18262.27 kWh

Below is the data of ***fuel consumption*** from 1995 through 1997

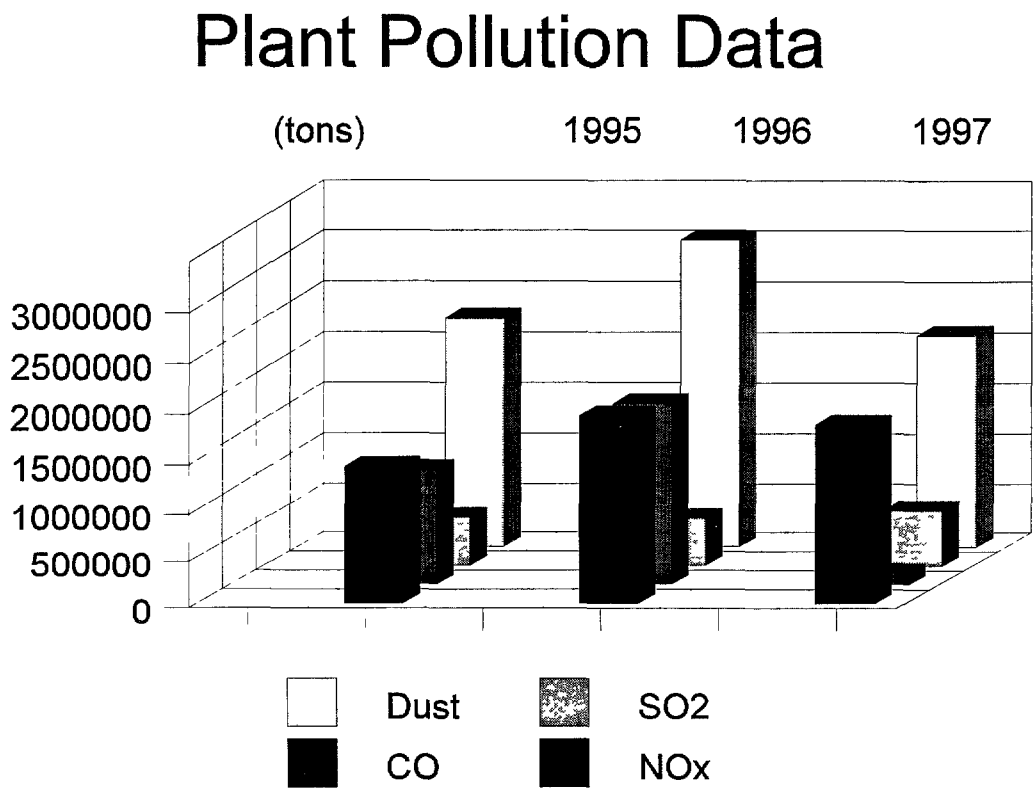
| Year | Natural Gas at USD 82 per 1000 cub.m | | Blast Furnace Gas at USD 0 049 per 1000 cub m | | Coke Gas at USD 30 8 per 1000 cub m | | Mazut at USD135-157 per 1 ton | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | real 1000 cub m | normal fuel tons of | real 1000 cub m | tons of normal fuel | real 1000 cub m | tons of normal fuel | real tons | tons of normal fuel | normal fuel, tons |
| 1995 | 242571<br>47 3% | 275252 | 1385313<br>34 % | 198100 | 135569<br>13 3% | 77410 | 23142<br>5 4% | 31704 | 582466<br>100% |
| 1996 | 331466<br>68 6% | 373680 | 921110<br>22 3% | 121515 | 34510<br>3 6% | 19704 | 21554 | 29528<br>5 5% | 544427<br>100% |
| 1997<br>6 months | 170529<br>71 7% | 192057 | 317749<br>13 7% | 36831 | 38570<br>8 2% | 22023 | 13223<br>6 4% | 16971 | 267882<br>100% |

*Fuel consumption at the plant*



Electricity consumption by different products is as follows

| *Product* | *Units* | *Electricity consumption (kWh)* | | |
|---|---|---|---|---|
| | | *1995* | *1996* | *1997* |
| Cast iron | *tons* | 23 3 | 49 1 | 14 3 |
| Steel | *tons* | 33 1 | 44 6 | 14.3 |
| Electric steel | *tons* | 676 | 689 | 27 0 |
| Finished steel | *tons* | 96 | 90 5 | 79 7 |
| Compressed air | *1000 cub m* | 121 | 124 | 125 |
| Oxygen | *1000 cub m* | 958 | 941 | 931 |
| Water | *1000 cub m* | 493 | 497 | 461 |



### 7.5.2. Follow-up monitoring

The results of the follow-up monitoring of delivered equipment installation are as follows

**ECO No. 1 ENERGY MANAGEMENT PROGRAM**

***ENERAC 2000 combustion analyzer*** is being utilized very extensively All major work shops of the plant which have combustion processes request for the tuning Currently this instrument was used on:

- *Boilers at the power plant* The regime charts are being developed, high level of access air was identified. The boiler BKZ-75 (middle pressure) were tuned according to the recommendations It burns three types of gas coke, natural, and blast furnace gas Tuning allowed to increase efficiency by 2-3%
  Prices for gases
  - coke gas - USD 27/1000 cub m
  - natural gas - USD 82/1000 cub m
  - blast furnace gas - USD 6 5/1000 cub m

  Calculations were made showing the potential savings of 1786 GCal per month due to optimization of regeneration turbines regime and 679 tons of standard fuel per month due to optimization of mid-pressure boilers of the power plant This results in savings of **USD 427,000** per year for heat and **USD 578,000** per year for fuel Such optimization now becomes much easier due to utilization of the combustion analyzer

- *Steel furnaces*. The combustion analyzer was used for checking pollution from furnaces The results showed that during burning of coke gases, the amount of pollutants was in the allowed range

- *Lime annealing furnace* The ENERAC 2000 was used for tuning the furnace. It took about 7 hours to make complete tuning. After that, consumption of fuel (coke and natural gas) was decreased by 15% Recommendations for the operation were given

- *Open hearth furnace* Environmental measurements and tuning were requested

The plant engineer had trouble with moisture sensors during measurements on furnaces During discussion A. Filippov explained some specifics of measuring sulfur content with ENERAC to avoid this problem

- *Environmental monitoring* The environmental laboratory is going to perform environmental tests all over the plant The plant pays penalties for extra pollution, but

also has "allowed" amounts. Without special instruments the plant was not able to prove the actual data before the environmental commission, now they are optimistic and expecting the ENERAC to help in this

***Infrared thermometer MICRON.*** The plant representatives say that they need high range temperature thermometer, while a mid-range one was delivered When Burns and Roe specified the instrument, another energy manager was at the plant He requested a mid-range instrument and did not consider the need for measuring flame temperature in boilers Now the personnel use this thermometer to check hot spots at the switch yard, and insulation on steamlines A Filippov explained more possible applications of this instrument based on the experience of other Ukrainian industrial and power plants The instrument is very easy-to-use, and did not require training

***KURZ Anemometer*** is used for

- measuring gas flow in pipe lines which do not have flowmeters With this purpose special openings are being made

- tuning the ventilation system in work shops.

- measuring consumption of compressed air by different consumers One of the examples shows that actual consumption was 200 cubic meters per hour instead of estimated 50 cubic meters per hour. This opens potential for regulation and control over compressed air consumption

- measuring flue gases from electric steel melting furnace

***RUSTRAK RANGER power analyzer.*** The engineer who uses this instrument is very well qualified and will make as much use of this instrument as possible The meter was on hand only for one month and the personnel had not learned all possibilities of this complicated device Among possible applications they claim following:

- reactive power analysis
- synchronous motors tuning in order to compensate reactive load
- tuning and checking electric arc furnaces

The chief of electric laboratory asked several questions about specific features of Rustrak Ranger, which require manufacturer consultation Assistance will be provided in obtaining the needed information

***Energy reference books*** (one on electric motors and another on energy management) stay in the chief energy manager's office They are in English which does not allow to use them very

broadly, although several specialists claimed that several times they used these books for reference

***Desktop computer*** has become an important part of energy management at the plant One of its applications is for making pollution maps around the region Also it is used for downloading data from the energy instruments, performing complex calculations and making representative reports.

## ECO NO. 2 INSTALLATION OF NEW POWER DEMAND METERS

The initial idea after the audit in 1995 was to replace ten power demand meters at the plant for measuring imported power The meters were provided and they had 0 5% accuracy compared to 1% accuracy of old ones But during 1996-1997 the changes in Ukrainian power system let the customers to introduce a multi-tariff system of payments for electricity The Donetsk metallurgical plant currently is using two-tariff system of electric bills payment. The next step is to switch to multi-tariff system which requires special multi-tariff power meters

Current prices for electricity are as follows

*Two-tariff prices*
- declared availability price of 1 kW - USD 3 2
- consumed electricity price for 1 kWh - USD 0 029

*One-tariff price*
for secondary customers
- consumed electricity price for 1 kWh - USD 0 036

*Electric heating*
- consumed electricity price for 1 kWh - USD 0.1

*Reactive power*
- consumed electricity price for 1 kVARh - USD 0 00342

The supplied meters do not have multi-tariff function although they can be upgraded The plant has a contract with Dnepropetrovsk company "Oblik" for installation of a full computerized metering system. Since the energy management do not consider installation of supplied meters reasonable they agreed with "Oblik" to give to them these meters as a partial payment for the complete metering system, which cost Ukrainian Hryvnia 240,000 (USD 130,000) The estimated payback period for this system is 6 months

## ECO No. 4 INSTALLATION OF INSTRUMENT CALIBRATORS

The pressure calibrators were delivered to the plant and are used by Chief of Instrument and Automation department Nikolay Sanzhakov The pressure calibrators will provide for increasing the accuracy of metering devices by 1-1.5%, which will result in significant fuel savings During

a short time when the instrument was in use the first internal tests of manometer and flowmeters was performed, and calibration of different instruments all over the plant The specialists plan to use it for tuning turbine control system

**ECO No. 8 ON-LINE GAS CALORIMETER INSTALLATION**

The chief of gas department is responsible for the installation and utilization of the on-line gas calorimeter supplied for the plant The calorimeter (Instromet) was received in May 1997, but calibration gases came late, and customs clearance took around one month The calorimeter was installed at the plant gas distribution station A technical representative from the manufacturer is to come in August, 1997 to start-up the calorimeter The management realizes that this instrument will provide the possibility to track on-line the heat content of natural gas that the plant buys from commercial companies.

## 7.6. Lessons Learned

Some items listed below can be considered during preparation of future programs

Purchase of computers should be done with Russian Language software, not only world-wide known software like Microsoft Office and Lotus Smart Suite but specialized software for specific instruments can be used very efficiently for energy conservation purposes The management of the plant understands the use of integrated computer control systems, and having such programs on at least one personal computer is a first step towards such systems At the moment Donetsk metallurgical plant utilizes an integrated financial and inventory computer system

Purchased instruments should be tested for operability before shipping to customer by someone other than the manufacturer.

Issues of local certification of equipment should be addressed to ensure that the equipment can be used effectively

A schedule of a project should allow considerable time for customs clearance and permissions from ministries or institutions. Experience shows it took an average 2-4 weeks (in some cases even longer) to clear the equipment through customs and more time to obtain permissions from corresponding ministries or institutions to utilize it

# APPENDIX A

Energy Conservation Opportunities (ECOs)

# Energy Conservation Opportunities (ECOs)

| | |
|---|---|
| ECO-1 | Energy Conservation Management Program |
| ECO-2 | Power Demand Meters |
| ECO-3 | Valve Packing Tools and Valve Packing Material |
| ECO-4 | Instrument Calibrators |
| ECO-5 | Portable Flow Meter |
| ECO-6 | In Situ Oxygen Analyzers |
| ECO-7 | Natural Gas Bypass Control Valves |
| ECO-8 | On-line Gas Calorimeter |
| ECO-9 | Analytical Instruments for Water and Gas Laboratory |
| ECO-10 | Sodium Softener for Cooling Water Makeup |
| ECO-11 | Combustion Control System |
| ECO-12 | Blast Furnace Gas Scrubber Pumps |

**ECO-01**

## ENERGY CONSERVATION MANAGEMENT PROGRAM

Based on the 1993 plant fuel consumption data, and using approximate 1994 world energy prices, the overall fuel costs for the plant are as follows

| | $/MBTU (1994 world prices) | MBTU | Annual fuel cost |
|---|---|---|---|
| Natural gas | $2 10 | $14.15x10^6$ | $29,715,000 |
| Blast furnace gas | $1 26 | $9.74x10^6$ | $12,272,400 |
| Coke gas | $1 03 | $7 41x10^6$ | $7,632,300 |
| Mazut | $1 37 | $0.85x10^6$ | $1,164,500 |
| Coke | $2 00 | $30.42x10^6$ | $60,840,000 |
| Coal | $3 00 | $0 79x10^6$ | $2,370,000 |
| Total | | $63.36x10^6$ | $113,994,200 |

If only a modest 0 5% improvement in overall plant efficiencies could be achieved, the resultant savings in fuel cost alone would be about $570,000 per year (neglecting all savings from purchased (offsite) electrical power); the energy savings would be about $3.2x10^{11}$ BTU

0 005(%) x $113,994,200 = $570,000
0.005(%) x $63.36x10^6$ MBTU = $3.2x10^{11}$ BTU

Equating the total fuel savings (in BTU) to natural gas, the equivalent annual fuel savings would be 14,000,000 $m^3$

$3.2x10^{11}$ BTU − 22,775 BTU per $m^3$ (natural gas) = 1 $4x10^7$ = 14,000,000 $m^3$

The equipment cost to implement such a program is small in comparison to the savings, a suitable set of energy audit equipment can be purchased for about $30,000.

Payback at world energy prices.
$30,000/$570,000 per year = 0.053 year = 19 days

Payback at local energy prices (using domestic prices for all fuels at 88% of world prices, as with natural gas)
annual fuel cost savings = $570,000 x 0 88 = $502,000
$30,000/$502,000 per year = 0 060 year = 22 days



25

**(ECO-01 continued)**

The following is an illustration of potential savings based on boiler combustion efficiency tests·

**Boiler Combustion Efficiency - Portable Combustion Analyzer and Computer**

**Description of Existing Equipment and Operating Conditions**
Tests of combustion efficiency were made with a portable Bacharach unit Boilers 1, 2, and 3 were being fired with a mixture of natural gas and blast furnace gas The actual instrument readings were based on 100% natural or 100% low energy gas as fuel and therefore not correct for the mixture of gases used However, the results indicate potential savings can be obtained by increasing the combustion efficiency This can be accomplished by the operators using manual controls.

**Description of Proposed Modifications**
An estimated one percent increase in efficiency will save large amounts of fuel The estimated fuel used by each boiler follows

| Quantity of Boilers | Steam Capacity | Gas in Cubic Meter Per Hour Blast Furnace | Natural | |
|---|---|---|---|---|
| 3 | 225 T/hr | 25,000 ea | 3,000 ea | |
| 1 | 120 T/hr | 42,000 | 2,000 | |
| 1 | 180 T/hr | 49,000 | 5,000 | |
| | | 166,000 | 16,000 | (9.64%) |

Assumed heat content·

Natural gas, 1000 BTU/ft$^3$ 8000 kcal/kg
Blast furnace gas, 80 BTU/ft$^3$ 700 - 800 kcal/kg

Average annual load on boiler plant·

3 x 75 T/hr = 225
1 x 120 T/hr = 120
1 x 180 T/hr = 180
525 T/hr

Output average load (at assumed 80% capacity factor) =
525 T/hr x 0 80 x 8760 hr/year = 3,679,200 T/year

Input at 80% efficiency = $\frac{3{,}679{,}200\text{T}}{\text{yr}} \times \frac{2200\text{ lb}}{\text{ton}} \times \frac{1000\text{ BTU/lb}}{0\ 80\text{ eff}} = 1.01\text{x}10^{13}$ BTU/yr

Cost savings
The saving in fuel due to a one percent increase in efficiency results in savings of 1 01x10$^{11}$ BTU/year The saving of natural gas is equal to 9 64 percent of the total savings

**(ECO-01 continued)**

At domestic prices of $1.84 per 1,000,000 BTU of natural gas, the dollars saved equal:
101,000,000,000 BTU x 0 0964 x $1.84/1,000,000 BTU = $17,915/yr

At world prices of $2 10 per 1,000,000 BTU of natural gas, the dollars saved equal·
101,000,000,000 BTU x 0 0964 x $2.10/1,000,000 BTU = $20,446/yr

Simple Payback
One Enerac 2000 combustion analyzer with accessories has a total cost of $6,000. An allowance of $4000 is designated for the laptop computer (optional, but may be desirable for storing significant amounts of performance data) for a total cost of $10,000

Payback at Local Prices· $10,000/$17,915 = 0.56 years ≅ 7 months
Payback at World Prices· $10,000/$20,446 = 0.49 years ≅ 6 months

**Equipment Specification**

Enerac Model 2000
220 Volt, 50 Hertz, RS-232 port
Siegert Fuel Equations
$NO_x$, $SO_2$
12 inch and 48 inch probes
20 foot sampling hose
2 cases of thermal paper

Domestic Price of Natural Gas

$$\frac{\$65}{1000\ Nm^3} \times \frac{Nm^3}{35\ 31\ ft^3} \times \frac{ft^3}{1000\ BTU} \times \frac{1{,}000{,}000}{1} = \$1\ 84/10^6\ BTU$$

World Price of Natural Gas

$$\frac{\$74}{1000\ Nm^3} \times \frac{Nm^3}{35\ 31\ ft^3} \times \frac{ft^3}{1000\ BTU} \times \frac{1{,}000{,}000}{1} = \$2.10/10^6\ BTU$$

Projected World bank Data for Natural Gas

$3.5 - $8/$10^6$ BTU by 2010
$110 - $250/Thousand Cubic Meters (TCM)

**ECO-02**

**POWER DEMAND METERS**

Some of the meters for measuring imported power are broken and the plant is unable to obtain spare parts The existing meters are 1 0% accurate and new modern American made meters are 0 5% accurate which will result in the following potential energy savings due to variations in monitoring and billing by utility. Ten meters at $900 each are required, = $9000

567,747,000 kWh Consumed
138,488,000 kWh Produced
429,259,000 kWh Imported
x 0 005(%) Accuracy
2,146,295 kWh Variation

x $0 01/kWh **Local Price**
$21,463 Annual Variation

x $0 03/kWh **World Price**
$64,389 Annual Variation

Simple Payback

$9,000/$21,463 per yr =
0 42 yr ≅ 5 months

$9,000/$64,389 per yr =
0 14 yr ≅ 7 weeks

**ECO-03**

**VALVE PACKING TOOLS AND VALVE PACKING MATERIAL**

Large quantities of high pressure steam (and demineralized water) are lost in the power plant and steel mill due to valve stem packing leaks.

There is a need for a kit of valve packing tools including metric wrenches, pick hammer, chisels, picks, gland puller, penetrants, graphite, emery cloth, 220V pencil grinder and stones, etc, cost = $4,000

Also, a selection of square metric packing sizes 6-30 mm, Garlock 1312 or equivalent (about 65 lbs) to pack about 120 valves should be provided, cost = $10,000 (Option since the total cost of this material is dependent on the number of valves to be serviced, the cost could be increased or decreased in accordance with availability of funds )

Total cost = $14,000

Assume 1/16" packing leaks, 600 psi steam, 65,000 lb/month

65,000 lb/mo x 12 mo/yr x 1000 BTU/lb x 120 valves = $9\ 36 \times 10^{10}$ BTU/year saved

Natural Gas - 9 64% of fuel, blast furnace gas and treated water no cost

Simple Payback

At local prices

$1\ 84/10^6$ BTU x 0.0964(%)/gas x $9.36 \times 10^{10}$BTU/year = $16,602/year

$14,000/$16,602 = 0.84 yr ≅ 10 months

At world prices:

$2\ 10/10^6$ BTU x 0.0964(%)/gas x $9.36 \times 10^{10}$BTU/year = $18,948/year

$14,000/$18,948 = 0.74 yr ≅ 9 months

**ECO-04**

**INSTRUMENT CALIBRATORS**

The engineers requested portable calibration pressure calibration standard for field calibration of transmitters Most of the older transmitters have one to two percent accuracy Using natural gas flow measurement as an example, a 0 5% improvement in flow measurement for combustion control would result in a significant reduction of wasted fuel Cost of two instrument calibrators is about $14,000

Delivered Natural Gas

621,280,000 $Nm^3$/yr x 0 005(%) = 3 11x$10^6$ $Nm^3$/yr savings

3 11x$10^6$ x 8116 kcal/kg x 0 7207 kg/$m^3$ x 3.9685 BTU/kcal = 7 2x$10^{10}$ BTU/yr

Simple Payback - Local Price

7 2x$10^{10}$ BTU/yr x $1.84/$10^6$ BTU = $132,678/yr
$14,000/$132,678 = 0 11 yr ≅ 6 weeks

Simple Payback - World Price

7 2x$10^{10}$ BTU/yr x $2 10/$10^6$ BTU = $151,426/yr
$14,000/$151,426 = 0.09 yr ≅ 5 weeks

**ECO-05**

**PORTABLE FLOW METER**

There is a critical need for a portable sonic flow meter (price = approximately $9,000) to measure cooling water flows in the plant and balance systems to ensure that large pumps are operating at their best efficiency point (BEP) There are many large pumps throughout the steel mill which could be optimized for large energy savings However, only one example will be evaluated as an example of energy savings for large pumps The following example is for the power plant circulating water pumps for a 10% improvement in efficiency, from 65% to 75%·

$$HP = \frac{22{,}040 \text{ gpm} \times 60 \text{ ft}/2.31}{1715 \times 0.65} = 513.5 \text{ HP}$$

$$\times 0.75 = 445 \text{ HP}$$

68 5 HP savings

Energy Savings

68 5 HP x 746 W/HP x 7,500 hr/yr = 383,260 kWh/yr

Simple Payback - Local Prices

383,260 kWh/yr x $0 01/kWh = $3,833/yr
$9,000/$3,833 = 2.35 yr ≅ 28 months

Simple Payback - World Prices

383,260 kWh/yr x $0.03/kWh = $11,498/yr
$9,000/$11,498 = 0 78 yr ≅ 10 months

Instrument

"Controlotron" System 990P or equal ultrasonic flow meters, clamp-on, with transducers for pipe size groups 1-5 (12.7 mm - 9144 mm), 220 VAC plus battery power

**ECO-06**

## IN SITU OXYGEN ANALYZERS

The boilers' air to fuel ratio is controlled manually. It is impossible for the operators to continuously adjust boilers for optimum combustion, especially when blast furnace gas feed varies and steam loads vary

Installation of two zirconium oxide oxygen probes in each of five boilers flue gas path will give operator oxygen readings to accurately adjust fuel-air ratios This will increase boiler fuel savings by an estimated three percent.

Energy Savings (See ECO-01)

The savings in fuel due to a three percent increase in efficiency results in $3.01 \times 10^{11}$ BTU/year

The savings of natural gas is equal to 9.64 percent of the total savings or $2\ 90 \times 10^{10}$ BTU/year

Cost Savings - Local Price

$2\ 90 \times 10^{10}$ BTU/yr x \$1.84/$10^6$ BTU = \$53,360/yr
\$75,000/\$53,360 = 1 4 yr ≅ 17 months

Cost Savings - World Price

$2.90 \times 10^{10}$ BTU/yr x \$2 10/$10^6$ BTU = \$60,900/yr
\$75,000/\$60,900 = 1 2 yr ≅ 15 months

Equipment Specification

The cost per boiler is approximately \$15,000 x 5 boilers equal to \$75,000 If a cost is given for blast furnace gas, the payback would be further reduced

Specification of specific boiler probes and analyzers will require further on-site engineering

**ECO-07**

## NATURAL GAS BYPASS CONTROL VALVES

The existing natural gas control valves are operated manually to follow steam load based on steam pressure The valves are sized for full load, and operator response plus lag time results in significant waste of natural gas due to slow closing of the large valves. The engineers estimate that natural gas consumption could be reduced by 1 5% if a smaller parallel bypass control valve is installed at each boiler.

Five boilers use approximately 150,000,000 $m^3$/yr

150,000,000 $m^3$/yr x 0.015(%) = 2,250,000 $m^3$/yr savings

2,250,000 $m^3$/yr x 8116 kcal/kg x 0.7207 kg/$m^3$ x 3.9685 BTU/kcal = $5.2 \times 10^{10}$ BTU/yr

Simple Payback - Domestic Price

$5.2 \times 10^{10}$ BTU/yr x \$1.84/$10^6$ BTU = \$95,680/yr
\$30,000/\$95,680 = 0 31 yr ≅ 17 weeks

Simple Payback - World Price

5 $2 \times 10^{10}$ BTU/yr x \$2 10/$10^6$ BTU = \$109,200/yr
\$30,000/\$109,200 = 0 27 yr ≅ 15 weeks

Control Valves

Assumed 4" butterfly, wafer type, electric operator, 1500 $Nm^3$/hr, 3000 mm $H_20$
Five valves at \$6,000 = \$30,000

**ECO-08**

## ON-LINE GAS CALORIMETER

Reported heating value specification for Russian natural gas is 8116 kcal/kg. However, the technical specialists complain that the delivered heating value as delivered runs low by as much as 200 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.

Delivered Natural Gas

621,280,000 $Nm^3$/yr x 0.7207 kg/$m^3$ = 447,760,000 kg/yr

Assume 1/2 of supply is low by 200 kcal/kg.

0 5 x 447,760,000 kg/yr x 200 kcal/kg = $4.4776 \times 10^{10}$ kcal/yr

4 $48 \times 10^{10}$ kcal/yr x 3 9685 BTU/kcal = $1.8 \times 10^{11}$ BTU/Yr

Simple Payback - Local Price

1 $8 \times 10^{11}$ BTU/yr x \$1 84/$10^6$ BTU = \$331,200/yr
\$35,000/\$331,200 = 0 11 yr ≅ 6 weeks

Simple Payback - World Price

1 $8 \times 10^{11}$ BTU/yr x \$2 10/$10^6$ BTU = \$378,000/yr
\$35,000/\$378,000 = 0 09 yr ≅ 5 weeks

**ECO-09**

## ANALYTICAL INSTRUMENTS FOR WATER AND GAS LABORATORY

Total Annual Boiler Heat Input (From ECO-01) = 1 01 x $10^{13}$ BTU/yr

Assumed One Percent Savings = 1 01 x $10^{11}$ BTU/year

Cost Savings - Natural Gas

At domestic price of $1.84 per $10^6$ BTU, the dollars saved =
1 01 x $10^{11}$ BTU x 0 0964 (%NG) x $1 84/$10^6$ BTU=
$17,915

At world price of $2.10 per $10^6$ BTU, the dollars saved =
1.01 x $10^{11}$ BTU x 0 0964 (%NG) x $2.10/$10^6$ BTU=
$20,446

Cost Savings - Blast Furnace Gas

At domestic price of $1.25 per $10^6$ BTU, the dollars saved =
1.01 x $10^{11}$ BTU x 0.0964 (%NG) x $1 25/$10^6$ BTU=
$114,080

At world price of $1.45 per $10^6$ BTU, the dollars saved =
1 01 x $10^{11}$ BTU x 0 0964 (%NG) x $1.45/$10^6$ BTU=
$132,332

Total Fuel Savings

At domestic prices, $17,915 + $114,080 = $131,995
At world prices, $20,446 + $132,332 = $152,778

Simple Payback

Payback at local prices, $100,000/$131,995 = 0 75 years (9 months)
Payback at world prices, $100,000/$152,778 = 0 65 years (8 months)

**(ECO-09 continued)**

**Power plant request instrumentation list**

| | | | Quantity |
|---|---|---|---|
| 1. | Steam Pressure Transmitter | | |
| | P = 6 0 MPa | | 1 |
| | P = 16 MPa | | 1 |
| 2. | Steam Flow Transmitter | | |
| | 0 - 100 ton/hour | $\Delta h$ = 160 KPa | 3 |
| | 0 - 250 ton/hour | $\Delta h$ = 100 KPa | 1 |
| | 0 - 250 ton/hour | $\Delta h$ = 250 KPa | 1 |
| 3 | Blast Furnace Gas Flow Transmitter | | |
| | 0 - 63000 $m^3$/hour | $\Delta h$ = 1.6 KPa | 3 |
| | 0 - 160000 $m^3$/hour | $\Delta h$ = 1.6 KPa | 1 |
| | 0 - 125000 $m^3$/hour | $\Delta h$ = 1.6 KPa | 1 |
| 4. | Natural Gas Flow Transmitter | | |
| | 0 - 6300 $m^3$/hour | $\Delta h$ = 16 KPa | 3 |
| | 0 - 8000 $m^3$/hour | $\Delta h$ = 6.3 KPa | 1 |
| | 0 - 10000 $m^3$/hour | $\Delta h$ = 1 6 KPa | 1 |
| 5 | Water Analyzer | | 5 |
| 6 | Oxygen Meter for the Feedwater | | 5 |
| 7. | Portable Flow Meter for Water | | 2 |
| 8. | Gas Chromatograph (Analyzer) for Oxygen Purity | | 2 |

**ECO-10**

**SODIUM SOFTENER FOR COOLING WATER MAKEUP**

Flow rates, in gallons per minute, gpm:

| | | |
|---|---|---|
| Circulating water, | $Q_c$ = BTUH/500 $\Delta T$ | |
| Evaporation rate, | $Q_e$ = 0.0075 $Q_c$ x R/10 | (0 0075 = annual average, 0 009 = summer peak) |
| Drift, | $Q_d$ = 0.0001 $Q_c$ | |
| Leaks and losses, | $Q_l$ | |
| Blowdown, | $Q_b$ = $[Q_e/(N-1)] - (Q_d + Q_l)$ | |
| Makeup, | $Q_m$ = $Q_e + Q_b + Q_d + Q_l$ | |

(makeup water only, does not consider blowdown discharge cost @ 400 coupons/$m^3$, and @ 107,000 coupons/dollar)

| | | |
|---|---|---|
| | BTUH = | 79,344,000 |
| Range, | R = | 7 2F |
| | $Q_e$ = | 198.4 gpm |
| | $Q_d$ = | 110.2 gpm |
| | $Q_l$ = | 22 gpm |
| Number of cycles | N = | 2 5 |
| | $Q_b$ = | $[198.4/(2.5-1)] - (110.2 + 22) = 0$ |
| | $Q_m$ = | $198.4 + 0 + 110.2 + 22 = 330$ gpm |

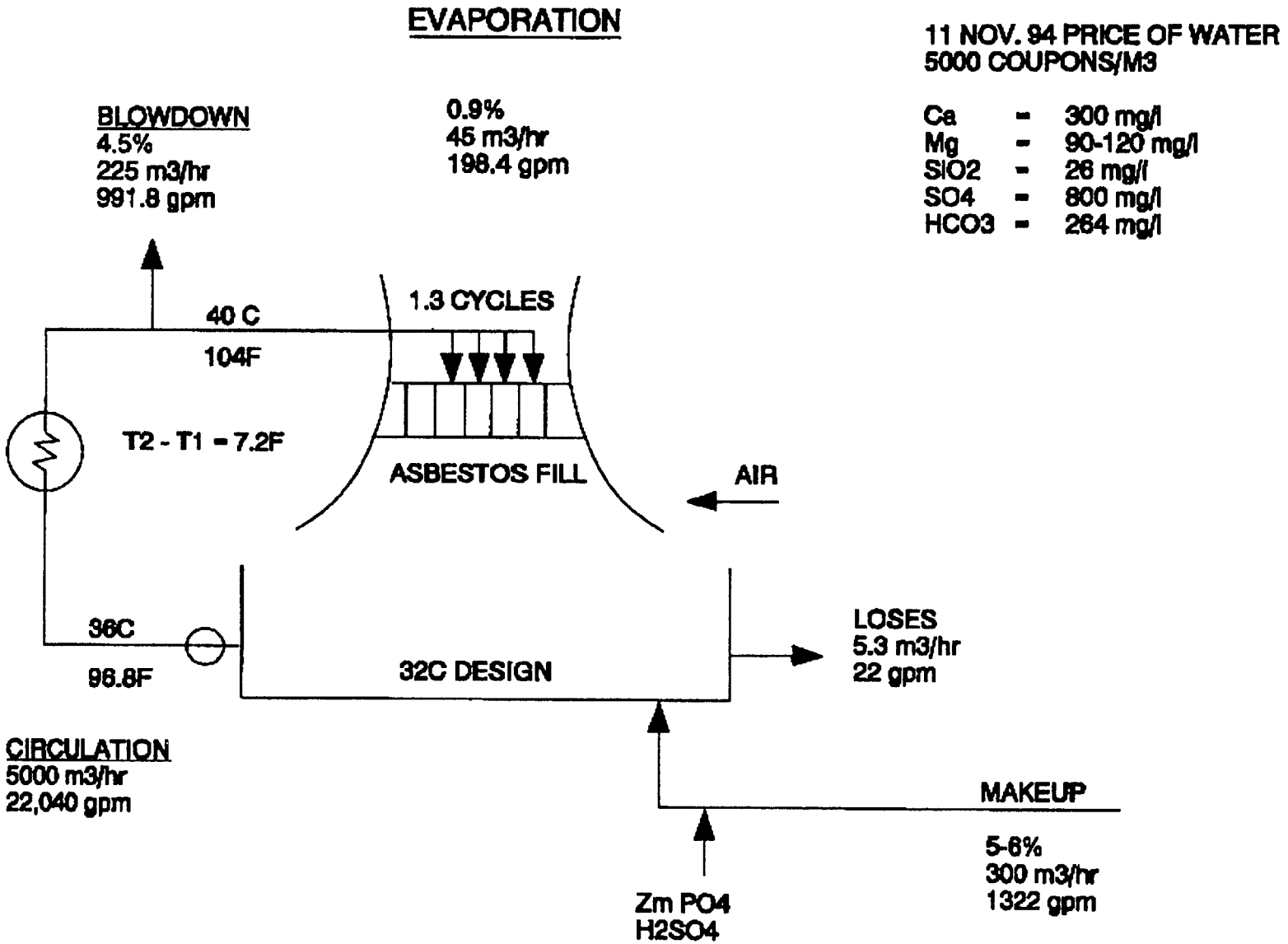
330gpm − 4 4045 gallon·hr/$m^3$·minute = 75 $m^3$/hr

Existing makeup = 300 $m^3$/hr

300 $m^3$/hr - 75 $m^3$/hr = 225 $m^3$/hr

8760 hr/yr x 225 $m^3$/hr x 5000 coupons/$m^3$ x \$/107,000 coupons = \$92,000/yr savings

Simple Payback: \$330,000/\$92,000 = 3.6 yr




SODIUM SOFTENERS FOR MAKEUP

**ECO-11**

**COMBUSTION CONTROL SYSTEM**

The boilers' combustion air to fuel ratio is controlled manually It is impossible for the operators to continuously adjust boilers for most efficient combustion when blast furnace gas feed varies and steam loads vary The combustion analyzer readings indicated very high $O_2$ (too much excess air) A combustion control system in combination with in situ oxygen analyzers will significantly improve overall boiler efficiency as well as safety Assuming a three percent improvement in efficiency, there would be approximately three percent overall savings in fuel.

Total Annual Boiler Heat Input (From ECO-01) = 1 01 x $10^{13}$ BTU/yr

Assumed Three Percent Savings = 3 03 x $10^{11}$ BTU/year

Cost Savings - Natural Gas

At domestic price of $1.84 per $10^6$ BTU, the dollars saved =
3 03 x $10^{11}$ BTU x 0.0964 (%NG) x $1.84/$10^6$ BTU=
$53,745/yr

At world price of $2 10 per $10^6$ BTU, the dollars saved =
3.03 x $10^{11}$ BTU x 0 0964 (%NG) x $2.10/$10^6$ BTU=
$61,339/yr

Cost Savings - Blast Furnace Gas

At domestic price of $1.25 per $10^6$ BTU, the dollars saved =
3.03 x $10^{11}$ BTU x 0.0964 (%NG) x $1.25/$10^6$ BTU=
$342,239/yr

At world price of $1 45 per $10^6$ BTU, the dollars saved =
3 03 x $10^{11}$ BTU x 0.0964 (%NG) x $1 45/$10^6$ BTU=
$396,997/yr

Total Fuel Savings

At domestic prices, $53,745 + $342,239 = $395,984/yr
At world prices, $61,339 + $396,997 = $458,336/yr

Simple Payback

Payback at local prices, $550,000/$395,984 = 1 4 years
Payback at world prices, $550,000/$458,336 = 1 2 years

**ECO-12**

**BLAST FURNACE GAS SCRUBBER PUMPS**

There are five 650 kw scrubber water pumps for blast furnace gas scrubbers which are subject to severe wear from abrasives Each of the two scrubbers is served by two 100% pumps, one operating, one in standby The fifth pump serves as a maintenance spare. The pumps are cast iron and when new are 83% efficient but rapidly deteriorate to about 65% efficiency, which is a large loss of electrical energy for pumping Replacement of this equipment (at an estimated cost of $250,000) can save over $65,000 per year in power costs at $0.03 per kWh.

Flow, Q = 1200 - 1600 $m^3$/hr ($m^3$/hr = 4 4045 gpm)

= 5285 - 7047 gpm Pump: 650 kW = 871 HP

Pressure, P = 13 kg/$cm^2$

= 13 kg/$cm^2$ x 14.22 psi/ kg/$cm^2$ = 185 psi

BHP (lower flow) = 5285 x 185 psi / 1715 x 0 83 = 686 HP x 746 = 513 kW

BHP (higher flow) = 7047 x 138 psi / 1715 x 0.65 = 871 HP x 746 = 650 kW

using lower flow

871 HP = 650 kW @ 65% (operating)
686 HP = 513 kW @ 83% (design)
difference = 185 HP = 137 kW per pump

For two scrubbers, there are two operating pumps·

Annual energy savings

2 pumps x 137 kW x 8000 hr/yr = 2 192x$10^6$ kWh = 2.2x$10^6$ kWh

Simple Payback

Local prices: 2 192x$10^6$ kWh x $0.01/kWh = $21,920 per year
$250,000/$21,920 = 11.4 years

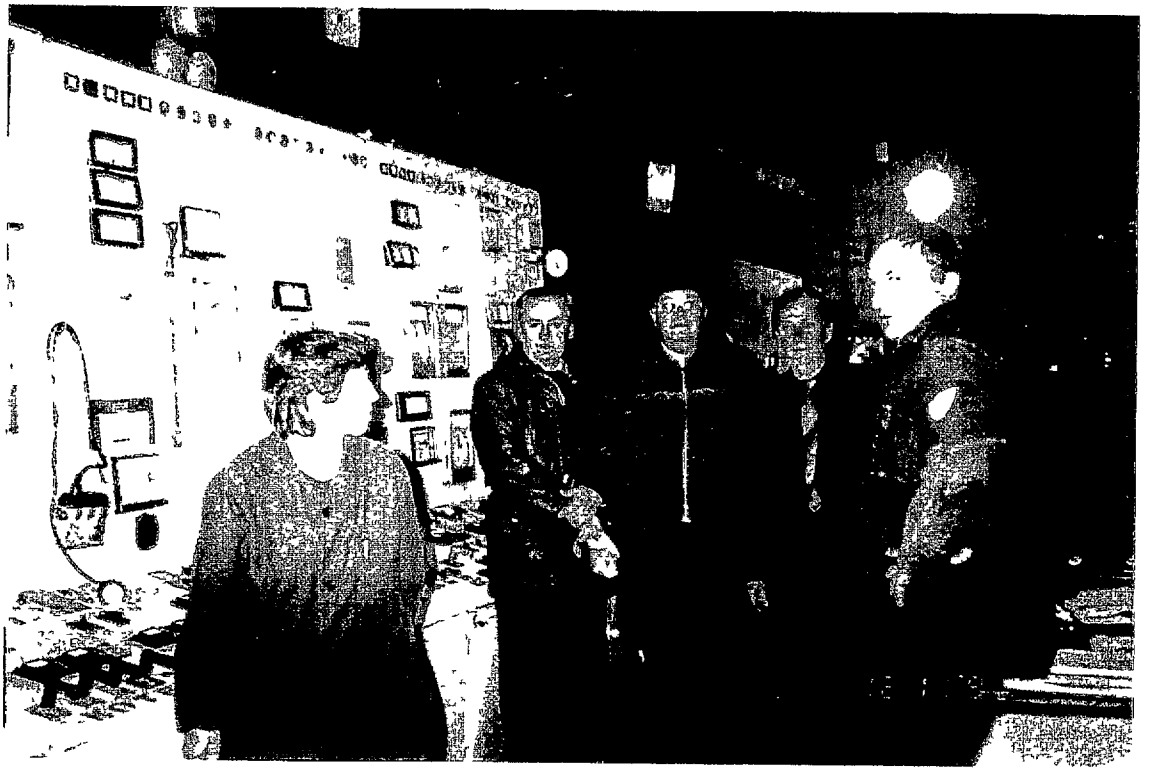
World prices. 2.192x$10^6$ kWh x $0.03/kWh = $65,760 per year
$250,000/$65,760 = 3.8 years

# APPENDIX B

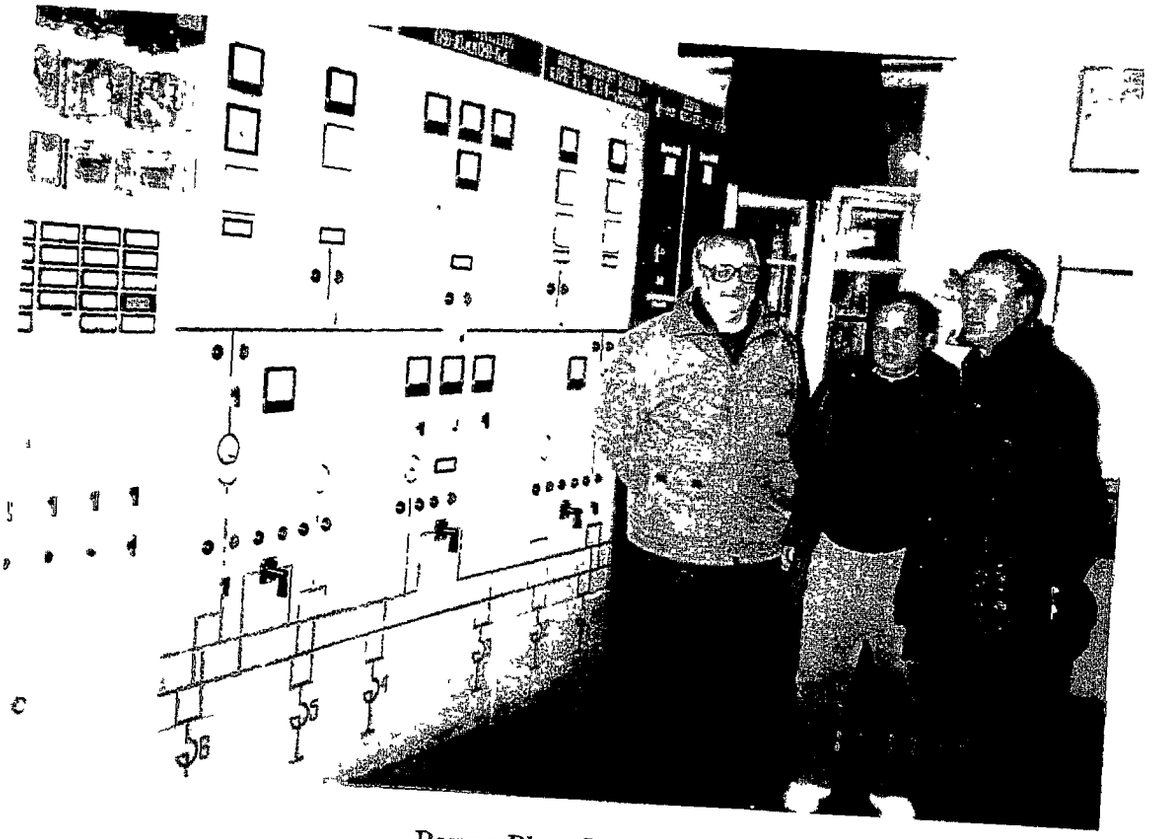
Photographs of Facility and Equipment
Audit Records, Technical Data

Vasili Ukrainski
Deputy Chief Engineer

Yefin Donkin
Burns and Roe Auditor

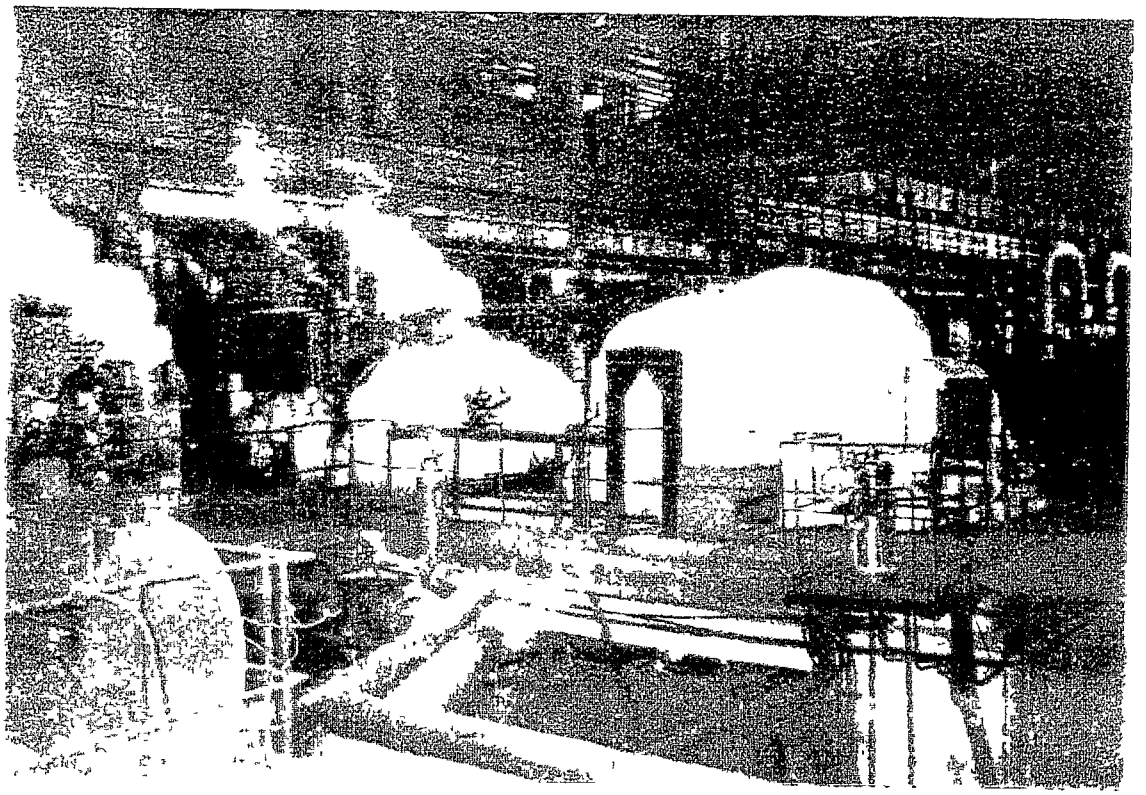


Boiler Control Board

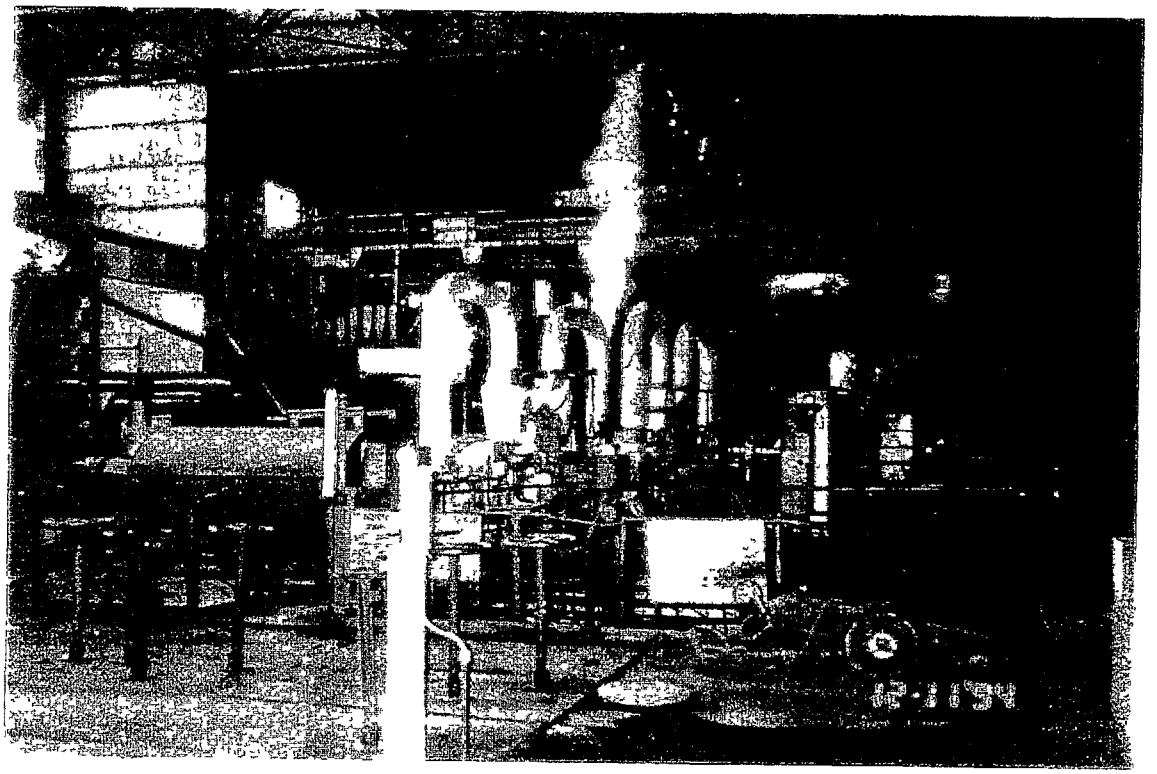


Power Plant Panel
Electrical Distribution

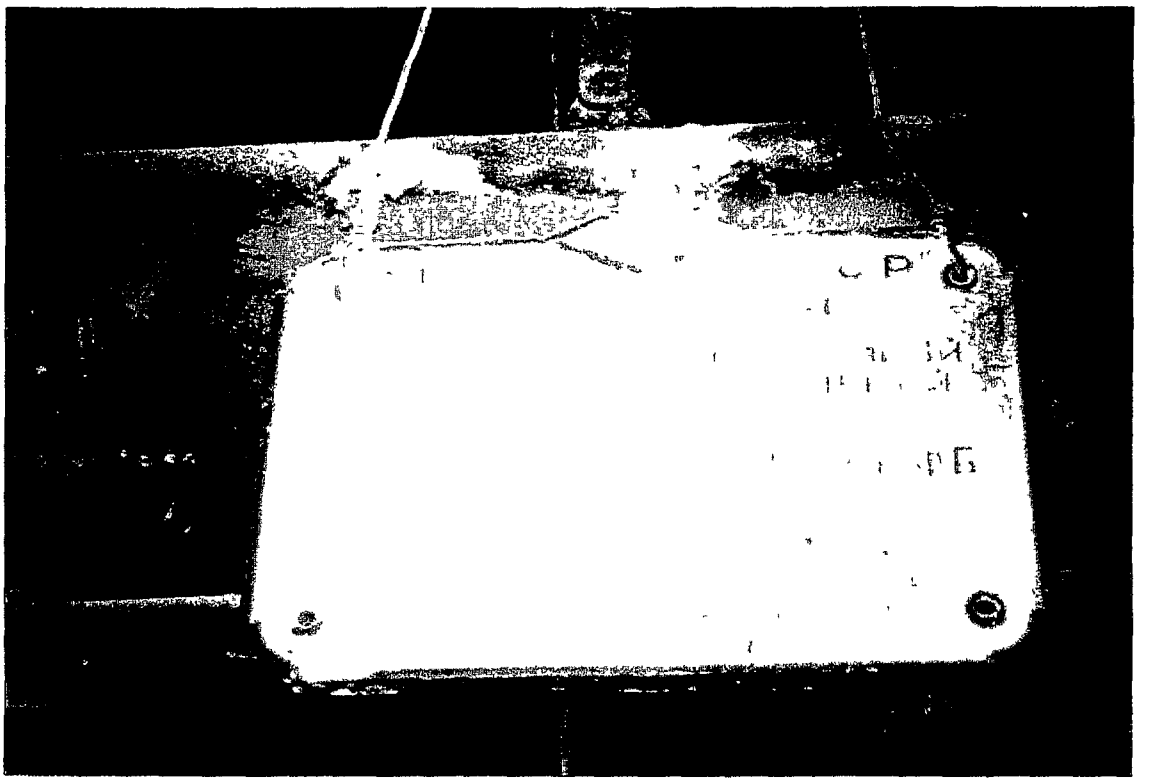
Power Demand Meters
for Import Power



Steam Turbine Drive
Centrifugal Air Compressors

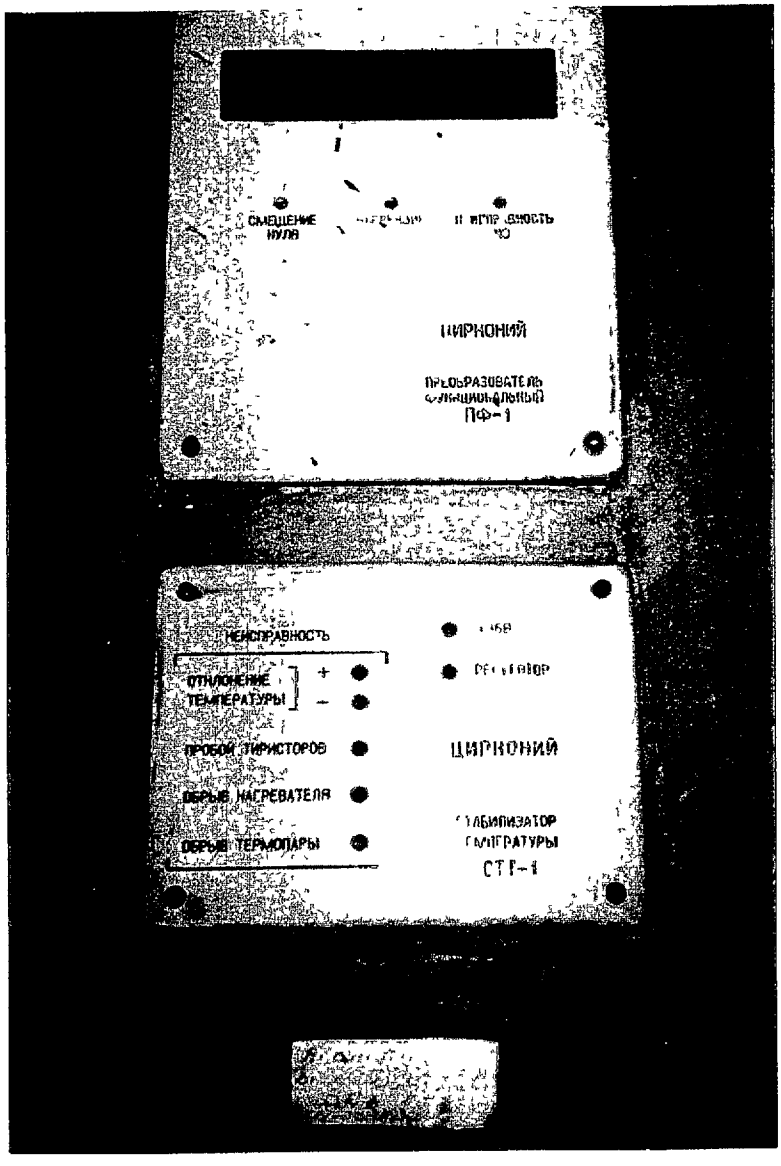


Power Plant Steam Turbine Generators



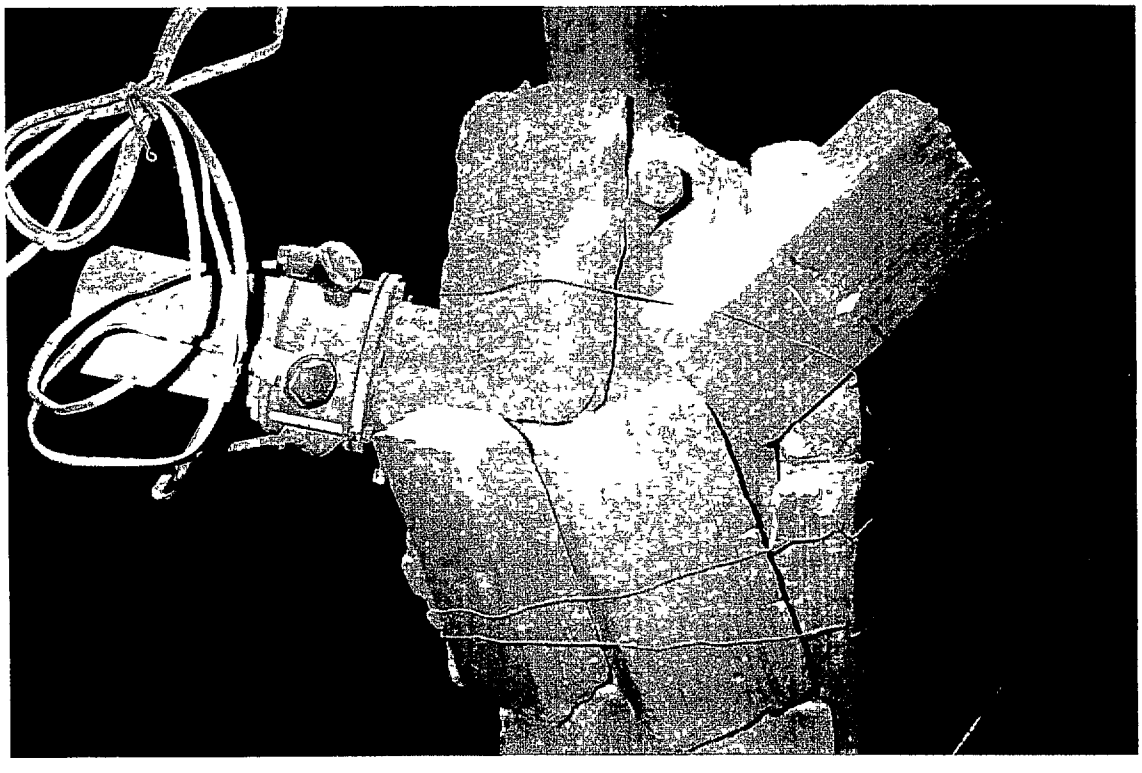
Boiler Nameplate

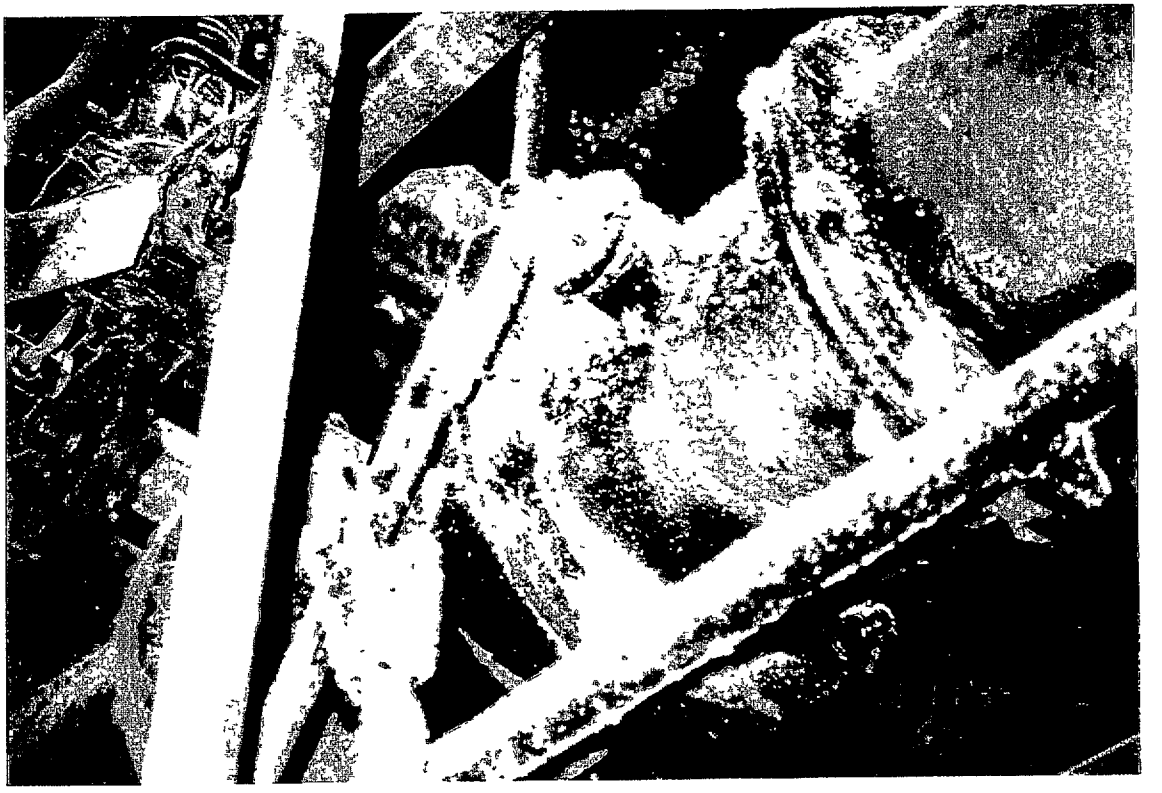
John Hallberg - Flue Gas Sampling
Burns and Roe Auditor

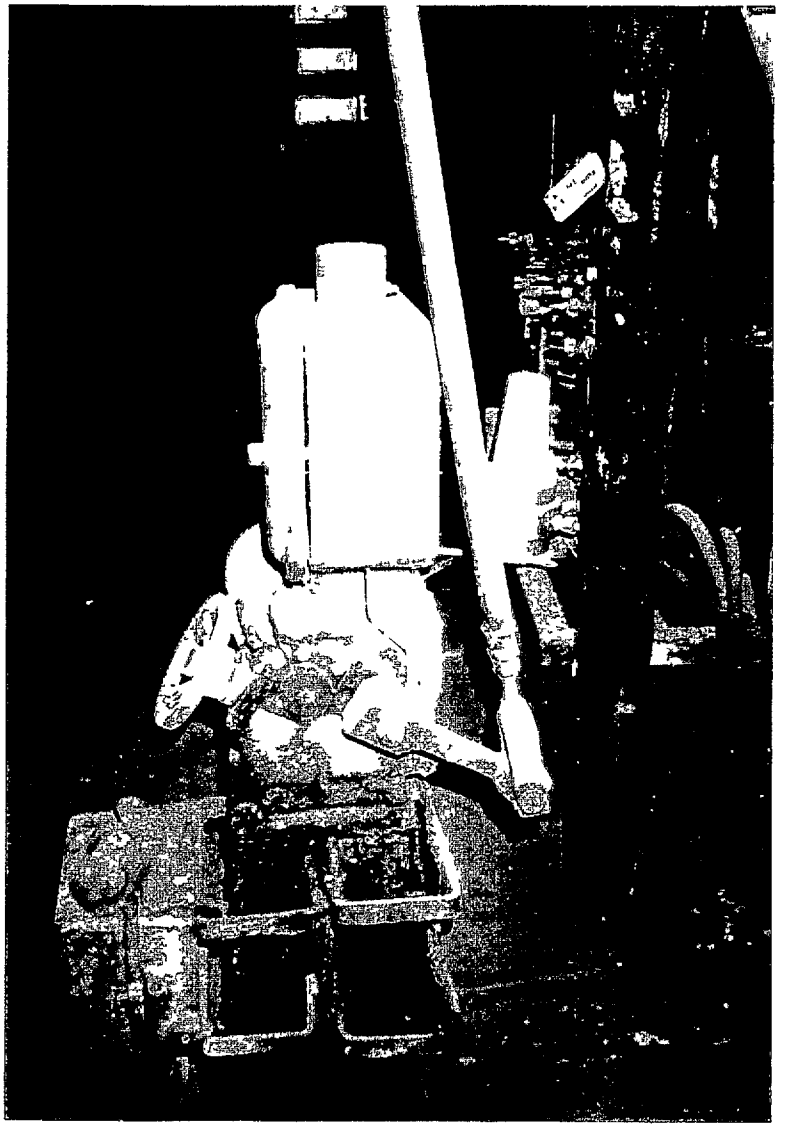



Flue Gas
Oxygen Analyzer

Zirconium Oxide
Sensor Probe

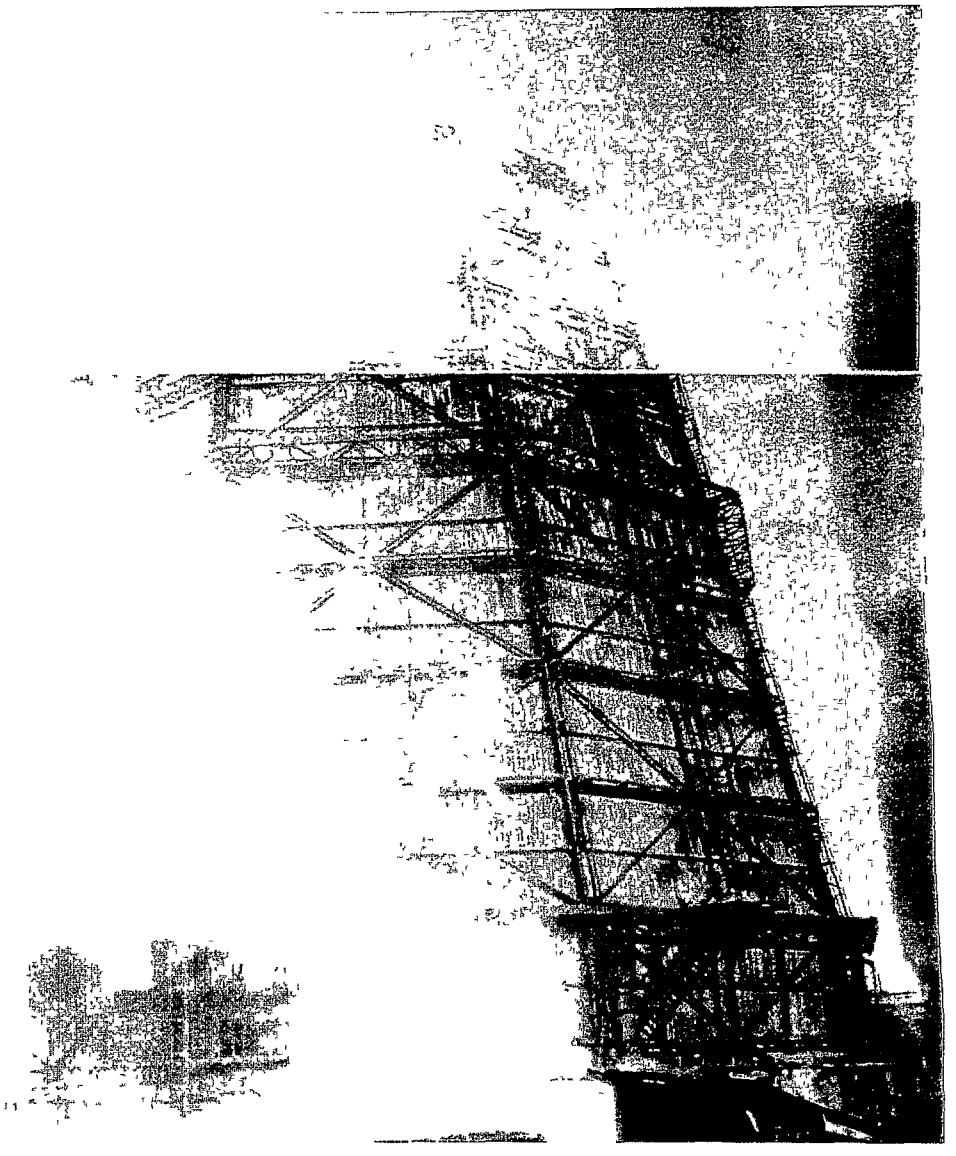




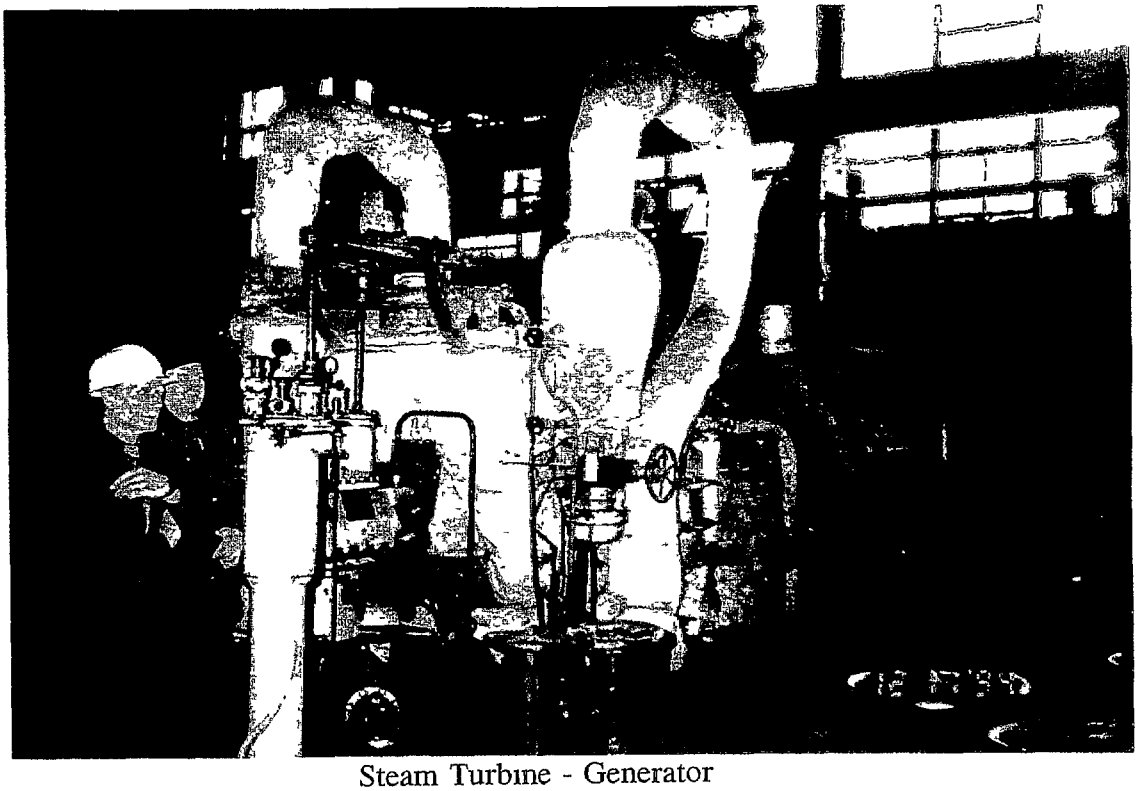


Natural Gas
Butterfly Control
Valve For Boiler

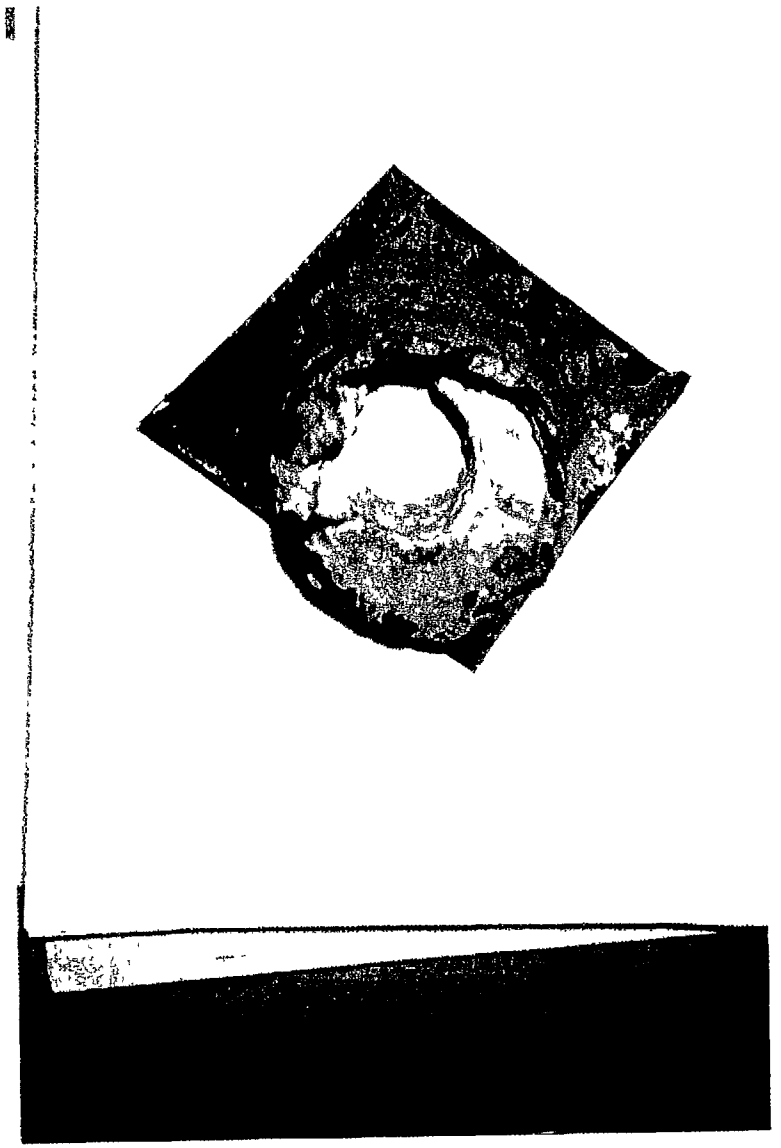
Natural Gas
Control Valve
Drive Motor



Natural Draft Cooling Tower - Drift



Steam Turbine - Generator



Heat Exchanger Pipe
Cooling Water Scale

Valve Packing Steam Leaks
Broken Windows

**Shipped to:**

Mr Andriy Parinov
Energy and Natural Resources Program Advisor
U. S Agency for International Development
USAID Mission
19th Floor
8/10 Esplanadna Street
252023 Kiev, Ukraine

Energy Efficiency Auditing Instrumentation
Set # 2

| ITEM | DESCRIPTION | QTY | SERIAL # |
|---|---|---|---|
| 1 | Platinum RTD thermometer w/ probes | 1 | 93120822 |
| 2 | Wahl Heat Spy infrared thermometer | 1 | 3-2313 |
| 3 | Rechargeable battery pack for Heat Spy | 1 | n/a |
| 4 | TIF 2000A clamp-on digital wattmeter | 1 | n/a |
| 5 | Fluke 85 digital multimeter | 1 | 58720202 |
| 6 | Fluke 80i-410 current probe for multimeter | 1 | n/a |
| 7 | TIF 2300 power factor meter | 1 | 10422 |
| 8 | Sperry SLM-110 digital light meter | 1 | L-244871 |
| 9 | Kurz 444 hot wire anemometer | 1 | PCE 6418-I |
| 10 | 24" probe for Kurz anemometer | 1 | n/a |
| 11 | Battery recharger | 1 | n/a |
| 12 | Rechargeable 9 volt batteries | 12 | n/a |
| 13 | Voltage converter | 1 | n/a |
| 14 | Nova Strobe DB stroboscopic tachometer | 1 | 2113392 |
| 15 | Foreign plug adaptor | 1 | n/a |
| 16 | Dranetz / PowerStar manuals | 1 | |
| 17 | Dranetz 808A power analyzer w/cables, paper | 1 | 8080NA017 (084) |
| | - current probes | 3 | 2013NA024 (084) |
| | | | 2013NA036 (084) |
| | | | 2013NA034 (084) |
| 18 | Canon INNOVA laptop computer | 1 | M030157 |
| 19 | HP DeskJet portable printer | 1 | JP41R1K064 |
| 20 | Bacharach 300NSX combustion analyzer | 1 | YC0513 |
| 21 | Bacharach 48" probe for comb anal. | 1 | n/a |

Shipped by: USAI/MOSCOW

Received by:

Name:

Title.

Signature:

Date:

USAID MOSCOW

Name: ANDREI PARINOV

Title: PROJECT DEVELOPMENT SPECIALIST

Signature:

Date: 11/3/94

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DONETSK METALLURGICAL PLANT – COMBUSTION EFFICIENCY TESTS – SUNDAY NOV. 13, 1994

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STEAM FLOW T/H | 60 | | | | 50 | | | | 55 | | | |
| BLAST FURNACE GAS Nm³/H | 35,000 | | | | 0 | | | | 30,000 | | | |
| NATURAL GAS Nm³/H | 1,800 | | | | 4800 | | | | 3,000 | | | |
| | BOILER No. 3 | | | | BOILER No. 2 | | | | BOILER No. 1 | | | |
| BACKPASS | LEFT | SIDE | RIGHT | SIDE | LEFT | SIDE | RIGHT | SIDE | LEFT | SIDE | RIGHT | SIDE |
| TIME | 10:58 | 10:57 | 10:54 | 10:53 | 10:49 | 10:48 | 10:44 | 10:43 | 10:40 | 10:37 | 10:29 | 10:26 |
| FUEL | LEG | KOKS | KOKS | LEG | LEG | KOKS | KOKS | LEG | LEG | KOKS | KOKS | LEG |
| PRIMARY °C | | | | | | | | | | | | |
| * STACK °C | 470 | 470 | 490 | 490 | | 560 | 620 | | 530 | 530 | 520 | 520 |
| % OXYGEN | 14.9 | 13.9 | 14.8 | 14.9 | 13.5 | 13.2 | 10.7 | 10.8 | 16.6 | 17.8 | 9.6 | 9.6 |
| * % EXCESS AIR | 129 | 111 | 125 | 111 | 95 | 112 | 61 | 57 | 222 | 302 | -8 | -86 |
| % CO2 | 3.8 | 6.9 | 6.5 | 3.5 | 4.7 | 7.6 | 10.1 | 6.4 | 2.7 | 3.1 | 11.2 | 7.1 |
| % CO | 8 | 8 | 9 | 10 | 8 | 6 | 7 | 7 | 6 | 7 | 22 | 69 |
| PPM NOx | 22 | 25 | 22 | 22 | 62 | 61 | 52 | 82 | 31 | 20 | 26 | 23 |
| PPM SO2 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| * % EFFICIENCY | 79.4 | 82.0 | 79.7 | 79.4 | | 83.1 | 86.8 | | 72.2 | 62.6 | 88.1 | 88.1 |
| * % STACK LOSS | 20.6 | 17.9 | 20.3 | 20.6 | | 16.9 | 13.2 | | 27.7 | 37.4 | 11.9 | 11.9 |
| % NITROGEN | 73.3 | 71.2 | 70.2 | 71.3 | 73.8 | 73.2 | 72.2 | 75.8 | 74.7 | 72.1 | 57.2 | 15.3 |

* CALCULATED WITH SIEGERT EQUATION USING 15 NOV TEMPS, 180°C ΔT

DONETSK METALLURGICAL PLANT – COMBUSTION EFFICIENCY TESTS – TUESDAY NOV. 15, 1991

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STEAM FLOW T/H | 60 | | | | 60 | | 60 | | | |
| BLAST FURNACE GAS Nm³/H | 35,000 | | | | 0 | | 35,000 | | | |
| NATURAL GAS Nm³/H | 1,500 | | | | 5,300 | | 2,000 | | | |
| | BOILER NO. 3 | | | | BOILER NO. 2 | | BOILER NO. 1 | | | |
| BACKPASS | LEFT SIDE | | RIGHT SIDE | | LEFT SIDE | RIGHT SIDE | LEFT SIDE | | RIGHT SIDE | |
| TIME | 12:38 | 12:37 | 12:33 | 12:32 | 12:29 | 12:24 | | | 12:16 | 12:15 |
| FUEL | COAL GAS | LOW ENERGY GAS | LOW ENERGY GAS | COAL GAS | NATURAL GAS | NATURAL GAS | | | LOW ENERGY GAS | COAL GAS |
| PRIMARY °C | 290 | 290 | 310 | 310 | 380 | 440 | 350 | 350 | 340 | 340 |
| STACK °C | | | | | | | | | | |
| % OXYGEN | 14.2 | 13.3 | 14.4 | 14.4 | 11.3 | 7.8 | | | 9.1 | 12.8 |
| * % EXCESS AIR | 119 | 91 | 116 | 134 | 63 | 30 | | | 23 | 75 |
| % $CO_2$ | 6.6 | 4.8 | 4.1 | 6.4 | 5.4 | 7.3 | | | 7.5 | 8.0 |
| % CO | 8 | 8 | 8 | 7 | 7 | 6 | | | 11 | 10 |
| PPM NOx | 32 | 34 | 32 | 31 | 73 | 91 | | | 50 | 49 |
| PPM $SO_2$ | 4 | 4 | 4 | 2 | 0 | 1 | | | 0 | 1 |
| * % EFFICIENCY | | 83.3 | 80.8 | | 85.6 | 89.4 | | | 88.5 | |
| * % STACK LOSS | | 16.7 | 19.2 | | 14.4 | 10.6 | | | 11.5 | |
| CONTROL ROOM STACK °C | 470 | | 490 | | 560 | 620 | 530 | | 520 | |
| % NITROGEN | | | 73.5 | 72.2 | 76.3 | 78.9 | | | 72.4 | 69.7 |

BEST AVAILABLE COPY

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## ENERGY LOSSES

| | |
|---|---|
| $Q_1$ = Useful | 50 - 90% |
| $Q_2$ = Moisture in Fuel | |
| $Q_3$ = H Moisture in Fuel | 3 - 5% |
| $Q_4$ = Moisture in Air | |
| $Q_5$ = Dry-Gas Sensible Heat | 6 - 30% |
| $Q_6$ = Incomplete Combustion (CO) | 0 - 5% |
| $Q_7$ = Carbon in Refuse | 0 - 2% |
| $Q_8$ = Surface Heat and Misc. | 2 - 9% |

**Flue Gas Analysis**

$$N_2 = 100 - (O_2 + CO + CO_2)$$

$$\% \text{ Excess Air} = \frac{O_2 - 0.5\ CO}{0.264\ N_2 - (O_2 - 0.5\ CO)} \times 100$$

= 30 - 40% Stokers

= 20 - 30% Pulverized Coal

= 12 - 15% Oil

= 8 - 10% Gas

## Table 26. Effect of Excess Air on $CO_2$ in Combustion Products

The figures in standard type are the percentages of carbon dioxide in the dry flue gas resulting from the use of various amounts of air. The figures in *italics* are rates of air supply (per unit of fuel) corresponding to the listed percentages of excess air.

| FUEL | %$CO_2$ or cu ft air per unit fuel | % Excess Air | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 40 | 60 | 80 | 100 | 150 | 200 |
| | | % of Theoretical Air | | | | | | | | |
| | | 100 | 110 | 120 | 140 | 160 | 180 | 200 | 250 | 300 |
| Natural Gas (Cleveland) | %$CO_2$ | 12.0 | 10.7 | 9.8 | 8.3 | 7.2 | 6.3 | 5.7 | 4.5 | 3 7 |
| | cu ft air / cu ft gas | *10 0* | *11.0* | *12.0* | *14.0* | *16.0* | *18 0* | *20 0* | *25 0* | *30 0* |
| Blast Furnace Gas | %$CO_2$ | 25.5 | 24 4 | 23 4 | 21.7 | 20.1 | 18.8 | 17.7 | 15 3 | 13 5 |
| | cu ft air / cu ft gas | *0.68* | *0.75* | *0.81* | *0.95* | *1.09* | *1.22* | *1 36* | *1 70* | *2 04* |
| Producer Gas (Bituminous) | %$CO_2$ | 18 6 | 17 4 | 16.4 | 14 6 | 13 2 | 12.0 | 11.1 | 9 2 | 7.9 |
| | cu ft air / cu ft gas | *1.24* | *1.36* | *1.49* | *1.74* | *1.98* | 2.23 | *2.48* | *3 10* | *3 72* |
| Coke Oven Gas (By-Product) | %$CO_2$ | 10.8 | 9.8 | 8.9 | 7.5 | 6.5 | 5.7 | 5.1 | 4 1 | 3.4 |
| | cu ft air / cu ft gas | 5.45 | *6.00* | *6.54* | *7.63* | *8.72* | *9.81* | *10 9* | *13 6* | *16 4* |
| Carbureted Blue Gas (Heavy Oil) | %$CO_2$ | 15.7 | 14.3 | 13 0 | 11.1 | 9.7 | 8.6 | 7 7 | 6 2 | 5 1 |
| | cu ft air / cu ft gas | 5.21 | 5.73 | 6.25 | *7.29* | *8.34* | *9 38* | *10 4* | *13 0* | *15 6* |
| Propane (Refinery) | %$CO_2$ | 14.0 | 12.6 | 11.5 | 9.8 | 8.5 | 7.5 | 6.7 | 5.3 | 4 4 |
| | cu ft air / cu ft gas | 23 2 | 25 5 | *27.9* | 32.5 | 37.2 | *41.8* | *46 4* | *58 0* | *69 6* |
| Butane (Refinery) | %$CO_2$ | 14.3 | 12.9 | 11.7 | 10 0 | 8.6 | 7.6 | 6.8 | 5.4 | 4.5 |
| | cu ft air / cu ft gas | *30.0* | *33.0* | *36 0* | *42.0* | *48.0* | *54 0* | *60 0* | *75 0* | *90.0* |
| Distillate Oil (Mid-Continent) | %$CO_2$ | 15.2 | 13.8 | 12.6 | 10.7 | 9.3 | 8.2 | 7 4 | 5 9 | 4 9 |
| | cu ft air / gal oil | *1348* | *1483* | *1618* | *1887* | *2157* | *2426* | *2696* | *3370* | *4044* |
| Residual Oil (Mid-Continent) | %$CO_2$ | 15.6 | 14.1 | 12.9 | 11.0 | 9.6 | 8.5 | 7.6 | 6.1 | 5.0 |
| | cu ft air / gal oil | *1480* | *1628* | *1776* | *2072* | *2368* | *2664* | *2960* | *3700* | *4440* |
| Bituminous Coal | %$CO_2$ | 18 4 | 16.7 | 15.3 | 13 0 | 11.4 | 10.1 | 9 1 | 7 2 | 6.0 |
| | cu ft air / lb coal | *141.3* | *155.4* | *169 6* | *197 8* | *226* | *254* | *283* | *353* | *424* |
| Anthracite Coal | %$CO_2$ | 19.8 | 18.0 | 16.5 | 14.1 | 12.4 | 11.0 | 10 0 | 7 9 | 6 6 |
| | cu ft air / lb coal | *129 7* | *142.7* | *155 6* | *181.6* | *208* | *234* | *259* | *324* | *389* |
| Coke | %$CO_2$ | 20.4 | 18.5 | 17.0 | 14 5 | 12.7 | 11 3 | 10 2 | 8.1 | 6.8 |
| | cu ft air / lb coke | *131.9* | *145 1* | *158 3* | *183 7* | *211* | *237* | *264* | *330* | *396* |

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## Table 9-11. Analyses of Fuel Gases*

| NET (LHV) Kcal/Kg | 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: $C_2H_4$ | $C_6H_6$ | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11,345 | 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 |
| 11,681 | 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 |
| 11,684 | Natural gas, Oil City, Pa. | 21,032 | .... | ..... | .... | 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 | 16,540 | 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 | | |

## 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 |

## 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 | 776 158,610 | 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 |
| | 12 | 18,360 | 151,000 | 17,350 | 142,720 |
| No. 6 | 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 |
| | 26 | 18,980 | 142,140 | 17,860 | 133,760 |
| No. 4 | 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 |

## 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 | | | $O_2 + N_2 = 1.57$ |
| 2 0 | 1.0599 | | | ASH = 0.14± |
| 3 0 | 1.0520 | | | |
| 4 0 | 1.0443 | | | |
| 5 0 | 1.0366 | | | MAX |
| 6 0 | 1 0291 | | | S = 3.5% |
| 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 |

1. Difference in percentage of carbon and hydrogen content will cause variations, since the more hydrogen in an oil, the more heat it will produce.
2. The type and percentage of various hydrocarbons in an oil will cause differences, as the paraffinic, naphthenic, olefinic, and aromatic hydrocarbons possess different heating values.
3. Sediment and water present in the oil may be minimal, but can also be considerable. Regardless of the amount, sediment and water, especially water, will help to decrease the heat value of a fuel oil.
4. The percentage of ash is usually small, but as it is non-combustible, there will be some loss of heat.
5. Sulphur content will vary from 0.25 per cent to 3 per cent and 4 per cent. When a pound of sulphur is burned, only 4,000 Btu are liberated, as compared to 14,600 Btu for a pound of carbon, and 62,000 Btu per pound for hydrogen. Therefore, if there is a large amount of sulphur, there will be a decrease in per cent of carbon and hydrogen present, with a resultant lowering of the heat value.
6. The amount of oxygen in fuel oil is usually quite small. When it is present, it will unite with the hydrogen of the fuel to form water vapor, even before the secondary air, or oxygen supplied for combustion, can reach the hydrogen. This results in a decrease in available hydrogen, thus decreasing the heating value.

The factors listed above can be ignored for most practical purposes, but they illustrate why the heating values of fuel oils will vary. Of the six factors mentioned, only factor 3 should cause any degree of trouble. Sometimes, with residual oils such as No. 5 and 6, the sediment and water content may be fairly high. It is possible to have 10 per cent to 15 per cent of sediment and water present, which would decrease the heating value considerably and, of course, cause interference in the operation of the combustion equipment.

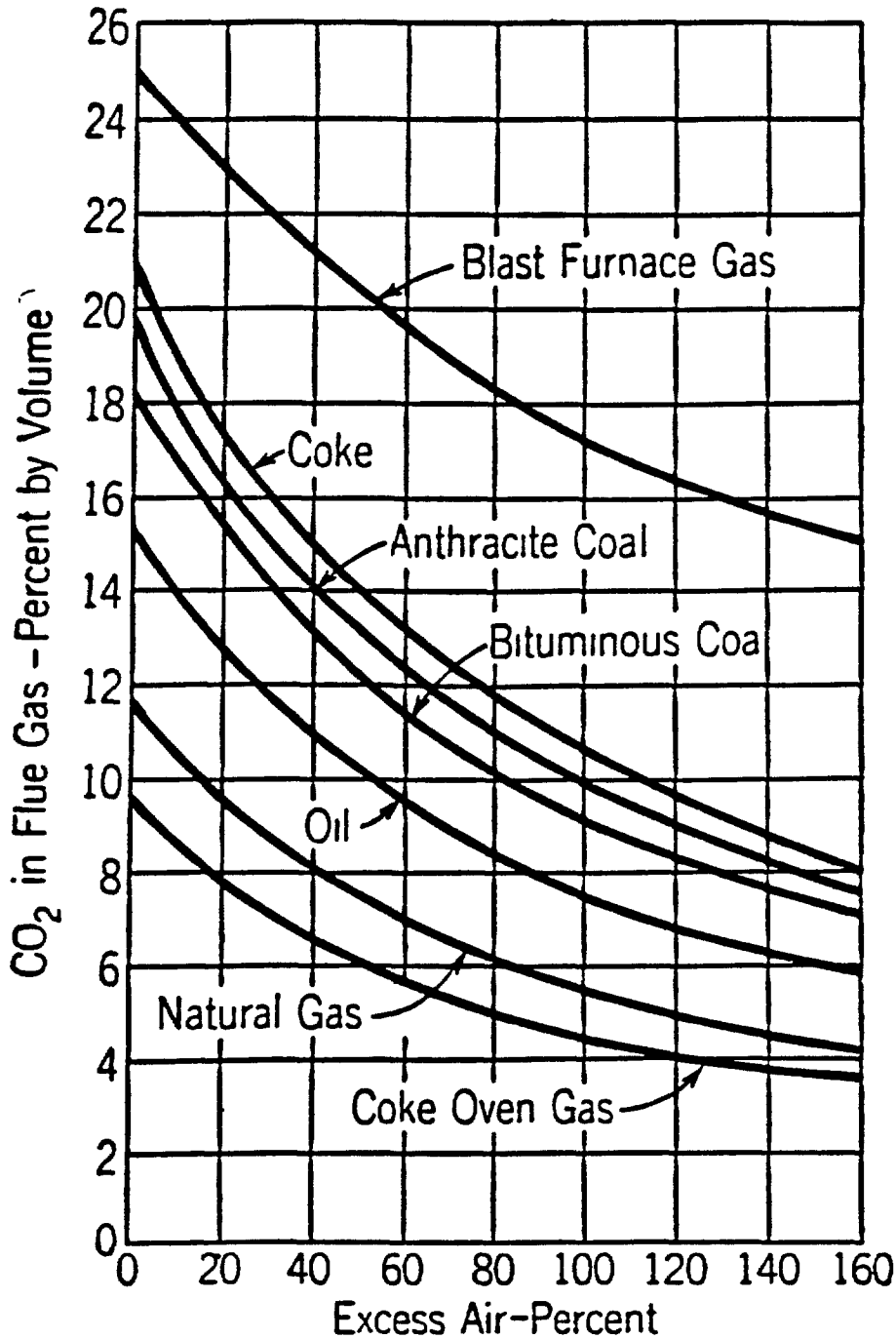



FIG. 2-3. Carbon dioxide ($CO_2$) variation with fuels and excess air.

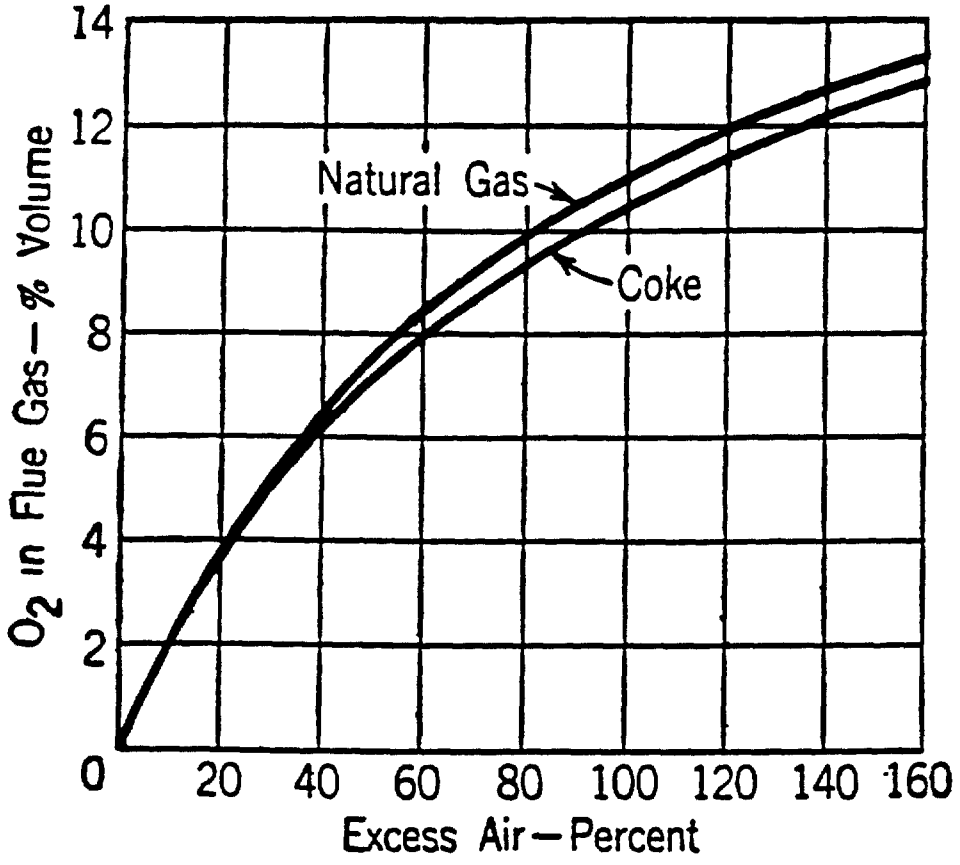



FIG. 2-4. Oxygen ($O_2$) variation with fuels and excess air.

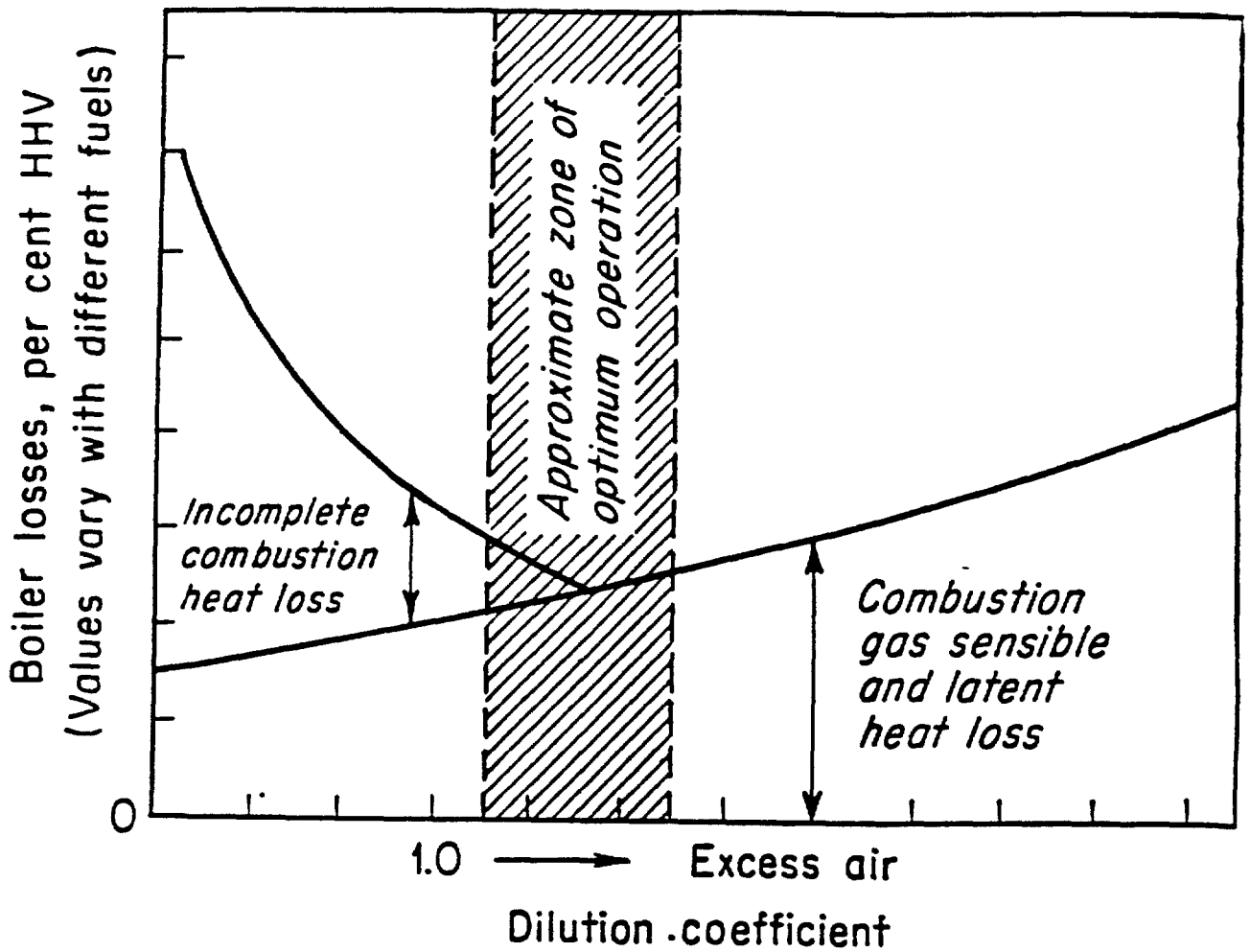



FIG. 2-5. Air flow related to optimum combustion efficiency.

**TABLE C3.6** Loss Due to Steam Leaks*

| Size of orifice (in) | Steam wasted per month (lb) | Water wasted (gal) |
|---|---|---|
| 250-lb gauge | | |
| ½ | 1,780,000 | 213,600 |
| ⅜ | 1,001,000 | 120,100 |
| ¼ | 445,000 | 53,400 |
| ⅛ | 111,000 | 13,300 |
| 1/16 | 27,800 | 3,300 |
| 1/32 | 7,000 | 800 |
| 300-lb gauge | | |
| ½ | 2,125,000 | 255,000 |
| ⅜ | 1,195,000 | 143,400 |
| ¼ | 531,000 | 63,700 |
| ⅛ | 132,800 | 15,900 |
| 1/16 | 33,200 | 4,000 |
| 1/32 | 8,300 | 1,000 |
| 400-lb gauge | | |
| ½ | 2,804,000 | 336,500 |
| ⅜ | 1,577,000 | 189,200 |
| ¼ | 701,000 | 84,100 |
| ⅛ | 175,200 | 21,000 |
| 1/16 | 43,800 | 5,300 |
| 1/32 | 11,000 | 1,300 |
| 600-lb gauge | | |
| ½ | 4,157,000 | 498,800 |
| ⅜ | 2,338,000 | 280,600 |
| ¼ | 1,039,000 | 124,700 |
| ⅛ | 259,000 | 31,200 |
| 1/16 | 65,000 | 7,800 |
| 1/32 | 16,300 | 2,000 |

*Values in the table are based on the use of Grashof's formula.

*Table 1: Energy losses of steam and compressed air leakages*

| Leak size | Steam Leakage flow [1] | | Air leakage flow [2] | | |
|---|---|---|---|---|---|
| mm | kg/h | US$/yr | litre/s | KW | US$/yr |
| 1 | 2.7 | 250 | 1 | 0.5 | 320 |
| 3 | 25 | 2,500 | 10 | 4.8 | 3060 |
| 5 | 75 | 7,500 | 27 | 13 | 8,300 |
| 10 | 300 | 30,000 | 105 | 50 | 31,500 |

1) 10 bar; 8,500 h/yr; 2,700 MJ/t steam; $\eta$ boiler = 0.9; gas price $ 0.125/ $m^3$
2) 8,500 h/yr; 0.13 KWh/$m^3$

# APPENDIX C

Plant Raw Material and Production History

Plant Energy Consumption History

Boilers No. 3, 4 and 5 Performance Test Data

## DONETSK METALLURGICAL PLANT

ANNUAL PRODUCTION

| TONNES | 1992 | 1993 |
|---|---|---|
| Cast Iron Production | 1191868 | 1003294 |
| Ore | 76253 | 9486 |
| Sinter | 1335711 | 1262183 |
| Apatite | 615838 | 489199 |
| Total | 2027802 | 1760868 |
| Open Hearth Steel | 877224 | 796736 |
| Cast Iron | 531176 | 490952 |
| Scrap | 419414 | 382459 |
| Lime | 9113 | 8915 |
| Magnetite | 12867 | 10755 |
| Electric Arc Furnace | 419046 | 332338 |
| Cast Iron | 63022 | 83113 |
| Scrap | 433497 | 311698 |
| Lime | 28952 | 21928 |
| Magnetite | 5332 | 6404 |

| DONETSK METALLURGICAL PLANT | Nat. Gas $Nm^3 \times 10^3$ | Blast Furnace Gas, $Nm^3 \times 10^3$ | Coke Gas, $Nm^3 \times 10^3$ | Mazut, Tons | Coke, Tons | Coal, Tons |
|---|---|---|---|---|---|---|
| | 1993 ANNUAL FUEL CONSUMPTION | | | | | |
| Blast Furnaces | 49645 | --- | --- | --- | 591420 | 42100 |
| Air Heaters | --- | 729100 | --- | --- | --- | --- |
| Open Hearth Process | 70215 | --- | 89015 | 19130 | --- | --- |
| | | | | | | |
| Rolling Mill | 65970 | 14160 | 76240 | --- | --- | --- |
| | | | | | | |
| Power Plant | 106740 | 980000 | 35065 | 5690 | --- | --- |
| | | | | | | |
| Electric Arc | 6470 | --- | --- | --- | --- | --- |
| Auxiliaries | 322240 | 1723107 | 202452 | 24820 | 594756 | 48590 |
| | JANUARY - JUNE 1994 | | | | | |
| Blast Furnaces | --- | --- | --- | --- | 143470 | 1470 |
| Air Heaters | --- | 132744 | --- | --- | --- | --- |
| Open Hearth | 15200 | --- | 33280 | 4865 | --- | --- |
| | | | | | | --- |
| Rolling Mill | 15800 | 490 | 24550 | --- | --- | --- |
| | | | | | | |
| Power Plant | 47430 | 254800 | 23770 | 1410 | --- | --- |
| | | | | | | |
| Arc Furnaces | 1500 | --- | --- | --- | --- | --- |
| | | | | | | |
| Auxiliaries | 85390 | 388020 | 83047 | 6275 | 146681 | 2155 |

## Результаты исследований работы котлоагрегата N 5 ТЭЦ-ПВС ДМЗ

Тип котла: ТТМ-159/С0 (Е-220/100-ГМ)

продолжение

| Дата испытаний | Время измерений час.мин | Температура дыма, град С | | | | | | | | Тем-ра горячего воздуха град С | | Тем-ра питательной воды, град С | Разрежение в топке, кгс/М2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | в пов.камере | | после ВЭ | | до РВП | | после РВП | | | | | |
| | | слева | справа | слева | справа | слева | справа | слева | справа | слева | справа | | |
| 2.09.92 | 12час 45 | 470 | 510 | 275 | 273 | 250 | 125 | 255 | 130 | 215 | 215 | - | |
| | 13час 25 | 470 | 505 | 275 | 272 | 250 | 125 | 255 | 130 | 220 | 220 | - | |
| 17.09.92 | 12час 45 | 470 | 490 | 265 | 260 | 250 | 125 | 250 | 125 | 205 | 210 | - | |
| | 13час 15 | 470 | 485 | 260 | 260 | 250 | 125 | 250 | 125 | 200 | 210 | - | |
| 18.09.92 | 9час 15 | 475 | 495 | 275 | 275 | 270 | 120 | 250 | 125 | 215 | 220 | 155 | |
| | 9час 45 | 470 | 490 | 275 | 278 | 265 | 125 | 260 | 125 | 205 | 215 | 152 | |
| | 10час 15 | 470 | 490 | 280 | 275 | 265 | 125 | 260 | 130 | 210 | 220 | 154 | |
| | 10час 45 | 470 | 485 | 280 | 277 | 265 | 125 | 260 | 125 | 210 | 220 | 154 | |
| 3.10.92 | 10час 00 | 470 | 500 | 270 | 272 | 260 | 265 | 230 | 145 | 210 | 215 | 150 | |
| | 10час 30 | 480 | 510 | 272 | 272 | 265 | 255 | 240 | 145 | 205 | 215 | 150 | |
| | 11час 07 | 470 | 505 | 272 | 274 | 260 | 260 | 230 | 135 | 205 | 215 | 154 | |

## Результаты исследований работы котлоагрегата N 5 ТЭЦ-ПВС ДМЗ

Тип котла: ТТМ-159/СО(Е-220/100-ГМ)

| Дата испытаний | Время измерений час.мин | Расход топлива | | | | | | Паропроизводительность, т/час | Давление в барабане, КГС/СМ$^2$ | Тем-ра перегретого пара, град С | Расход воды, т/ч | Состав дымовых газов | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | природный газ | | коксовый газ | | доменный газ | | | | | | CO2 | O2 | CO | NOx |
| | | тыс.м$^3$ в час | тепл. доля | тыс.м$^3$ в час | тепл. доля | тыс.м$^3$ в час | тепл. доля | | | | | %об | %об | %об | мг/м$^3$ |
| 2.09.92 | 12час 45 | - | - | 0,20 | 0,0132 | 73,0 | 0,9867 | 115 | 83,0 | 460 | - | 14,5 | 13,8 | 0,0013 | 104 |
| | 13час 25 | - | - | 0,20 | 0,0138 | 70,0 | 0,9862 | 115 | 83,0 | 465 | - | 14,3 | 14,7 | 0,0010 | 102 |
| 17.09.92 | 12час 45 | 0,1 | 0,0117 | 1,55 | 0,0942 | 72,0 | 0,8941 | 93 | 83,0 | 465 | 76 | 10,2 | 12,8 | 0,0008 | 102 |
| | 13час 15 | 0,1 | 0,0126 | 1,80 | 0,1179 | 65,0 | 0,8695 | 89 | 83,0 | 465 | 90 | 6,4 | 16,2 | - | 83 |
| 18.09.92 | 9час 15 | 0,1 | 0,0156 | - | - | 60,0 | 0,9845 | 87 | 83,0 | 460 | 80 | 9,2 | 13,4 | - | 104 |
| | 9час 45 | 0,1 | 0,0163 | - | - | 57,0 | 0,9837 | 87 | 83,0 | 460 | 85 | 6,8 | 15,6 | - | 102 |
| | 10час 15 | 0,1 | 0,0155 | - | - | 60,0 | 0,9845 | 88 | 83,0 | 455 | 77 | 9,4 | 13,4 | | 102 |
| | 10час 45 | 0,1 | 0,0155 | - | - | 60,0 | 0,9845 | 87 | 82,5 | 460 | 85 | 6,8 | 15,4 | - | 85 |
| 3.09.92 | 10час 00 | - | - | 0,20 | 0,0155 | 62,0 | 0,9844 | 100 | 82,2 | 465 | - | - | 16,0 | 0,0020 | 188 |
| | 10час 30 | - | - | 0,20 | 0,0155 | 62,0 | 0,9844 | 100 | 82,2 | 465 | - | - | 17,0 | - | 156 |
| | 11час 07 | - | - | 0,20 | 0,0153 | 63,0 | 0,9847 | 100 | 82,2 | 465 | - | | 17,0 | | 107 |

# Результаты исследований работы котлоагрегата N 4 ТЭЦ-ПВС ДМЗ

Тип котла: БКЗ-160-100Д

продолжение

| Дата испытаний | Время измерений час.мин | Давление воздуха на горение | | Температура дыма, град С | | | | | | Тем-ра горячего воздуха град С | | Тем-ра питательной воды, град С | Разрежение в топке, кгс/М$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | у дымососа | | за ВЭ | | за ВП | | | | | |
| | | слева | справа | слева | справа | слева | справа | слева | справа | слева | справа | | |
| 15.12.92 | 9час 30 | 110 | 105 | 135 | 135 | 340 | 340 | - | - | 260 | - | 160 | 4 |
| | 10час 00 | 105 | 105 | - | - | 350 | 350 | - | - | 260 | - | 150 | 4-5 |
| | 10час 00 | 110 | 110 | 140 | 140 | 360 | 360 | - | - | 240 | - | 150 | 4-5 |
| | 11час 00 | 110 | 110 | 160 | 160 | 380 | 380 | - | - | 270 | - | 150 | 3-4 |
| | 11час 30 | 110 | 110 | 160 | 160 | 340 | 340 | - | - | 270 | - | - | - |
| 16.12.92 | 9час 00 | 110 | 110 | 130 | 130 | 360 | 360 | - | - | 260 | - | 150 | 4,5 |
| | 9час 30 | 120 | 120 | 140 | 140 | 360 | 360 | - | - | 260 | - | 150 | 6 |
| | 10час 00 | 110 | 110 | 150 | 150 | 340 | 340 | - | - | 250 | - | 160 | 6 |
| | 10час 30 | 120 | 120 | 140 | 140 | 360 | 360 | - | - | 250 | - | 150 | 5 |
| | 11час 00 | 110 | 110 | 140 | 140 | 360 | 360 | - | - | 250 | - | 150 | - |

# Результаты исследований работы котлоагрегата N 4 ТЭЦ-ПВС ДМЗ

Тип котла: ЕКЗ-160-100Д

| Дата испытаний | Время измерений час.мин | Расход топлива | | | | | | Паропроизводительность, т/час | Давление в барабане, МПА | Тем-ра перегретого пара, град С | Расход воды, т/ч | Состав дымовых газов | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | природный газ | | коксовый газ | | доменный газ | | | | | | CO2 | O2 | CO | NOx |
| | | тыс.м3 в час | тепл. доля | тыс.м3 в час | тепл. доля | тыс.м3 в час | тепл. доля | | | | | %об | %об | %об | мг/м3 |
| 15.12.92 | 9час 30 | 3,2 | 0,287 | 0,0 | 0,0 | 75,0 | 0,713 | 115,0 | 86,0 | 520 | 100 | 10,0 | - | - | 231,2 |
| | 10час 00 | 3,2 | 0,287 | 0,0 | 0,0 | 75,0 | 0,713 | 115,0 | 86,0 | 520 | 98 | 12,2 | - | - | 306,3 |
| | 10час 30 | 3,5 | 0,313 | 0,0 | 0,0 | 72,5 | 0,687 | 120,0 | 80,0 | 525 | 98 | 10,6 | - | - | 245,1 |
| | 11час 00 | 3,4 | 0,314 | 0,0 | 0,0 | 70,0 | 0,686 | 115,0 | 80,0 | 520 | 98 | 12,0 | - | - | 231,2 |
| | 11час 30 | 3,4 | 0,307 | 0,0 | 0,0 | 72,5 | 0,693 | 120,0 | 80,0 | 520 | 85 | 9,4 | - | - | 183,8 |
| 16.12.92 | 9час 00 | 3,8 | 0,384 | 0,0 | 0,0 | 57,5 | 0,616 | 85,0 | 84,0 | 540 | - | 9,4 | 13,3 | - | 231,2 |
| | 9час 30 | 3,0 | 0,384 | 0,0 | 0,0 | 50,0 | 0,639 | 80,0 | 80,0 | 525 | 70 | 7,4 | 16,0 | - | 250,0 |
| | 10час 00 | 2,4 | 0,291 | 0,0 | 0,0 | 55,0 | 0,709 | 85,0 | 80,0 | 525 | - | 8,6 | 14,0 | - | 156,2 |
| | 10час 30 | 2,2 | 0,293 | 0,0 | 0,0 | 50,0 | 0,707 | 80,0 | 80,0 | 520 | - | 7,0 | 15,4 | - | 154,2 |
| | 11час 00 | 2,2 | 0,293 | 0,0 | 0,0 | 50,0 | 0,707 | 80,0 | 80,0 | 520 | 55 | 8,2 | - | - | 159,8 |

## Результаты исследований работы котлоагрегата N 3 ТЭЦ-ПВС ДМЗ

Тип котла: БКЗ-75-39ФБ

продолжение

| Дата испытаний | Время измерений час.мин | Температура дыма, град С | | | | | | | | | | Тем-ра горячего воздуха град С | | Тем-ра питательной воды, град С | Разрежение в топке, кгс/М$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ух.газов | | за IIст.ВЭ | | за IIст.ВП | | за Iст.ВЭ | | за Iст.ВП | | | | | |
| | | слева | справа | слева | справа | слева | справа | слева | справа | слева | справа | слева | справа | | |
| 2.09.92 | 11час 50 | 585 | 595 | 415 | 435 | 370 | 380 | 225 | 220 | 160 | 165 | 345 | 365 | 104 | |
| | 12час 35 | 565 | 575 | 410 | 425 | 365 | 375 | 225 | 205 | 160 | 165 | 340 | 365 | 104 | |
| 3.09.92 | 9час 15 | 540 | 550 | 390 | 410 | 345 | 355 | 215 | 200 | 145 | 150 | 325 | 340 | 104 | |
| | 9час 45 | 535 | 545 | 385 | 405 | 340 | 350 | 215 | 200 | 145 | 150 | 320 | 335 | 104 | |
| | 10час 50 | 540 | 565 | 395 | 420 | 350 | 365 | 220 | 205 | 155 | 160 | 330 | 350 | 104 | |
| 17.09.92 | 10час 45 | 525 | 550 | 370 | 395 | 320 | 325 | 200 | 155 | 120 | 140 | 310 | 295 | 104 | |
| | 11час 15 | 535 | 555 | 385 | 415 | 345 | 360 | 215 | 200 | 150 | 155 | 320 | 335 | 104 | |
| | 11час 45 | 525 | 550 | 380 | 415 | 345 | 370 | 220 | 210 | 160 | 165 | 325 | 345 | 104 | 4,0 |
| | 12час 15 | 530 | 555 | 385 | 415 | 350 | 370 | 220 | 205 | 160 | 165 | 330 | 350 | 104 | 3,9 |
| 28.10.92 | 11час 30 | 565 | 560 | 410 | 420 | 360 | 370 | 225 | 210 | 165 | 165 | 340 | 355 | 104 | 2,3 |
| | 12час 00 | 570 | 565 | 400 | 425 | 365 | 370 | 225 | 210 | 160 | 165 | 340 | 355 | 104 | 2,6 |
| | 12час 40 | 570 | 565 | 410 | 415 | 365 | 370 | 215 | 205 | 160 | 165 | 345 | 355 | 104 | 2,2 |
| 29.10.92 | 9час 30 | 545 | 535 | 380 | 380 | 310 | 315 | 195 | 175 | 130 | 130 | 290 | 315 | 104 | 4,1 |
| | 10час 20 | 545 | 535 | 380 | 385 | 310 | 315 | 195 | 175 | 130 | 130 | 290 | 315 | 104 | 4,2 |
| | 11час 00 | 545 | 535 | 380 | 385 | 310 | 315 | 195 | 175 | 130 | 130 | 285 | 315 | 104 | 4,4 |
| 4.11.92 | 11час 30 | 485 | 505 | 350 | 375 | 310 | 330 | 190 | 175 | 140 | 140 | 295 | 310 | 104 | 4,6 |
| | 12час 00 | 475 | 490 | 345 | 370 | 305 | 325 | 190 | 175 | 140 | 140 | 295 | 310 | 104 | 3,8 |

# Результаты исследований работы котлоагрегата N 3 ТЭЦ-ПВС ДМЗ

Тип котла: БКЗ-75-39ФБ

| Дата испытаний | Время измерений час.мин | Расход топлива | | | | | | Паропроизводительность, т/час | Давление в барабане, КГС/СМ$^2$ | Тем-ра перегретого пара, град С | Расход воды, т/ч | Состав дымовых газов | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | природный газ | | коксовый газ | | доменный газ | | | | | | CO2 | O2 | CO | NOx |
| | | тыс.м$^3$ в час | тепл. доля | тыс.м$^3$ в час | тепл. доля | тыс.м$^3$ в час | тепл. доля | | | | | %об | %об | %об | мг/нм$^3$ |
| 2.09.92 | 11час 50 | - | - | 2,70 | 0,220 | 47,0 | 0,780 | 73,0 | 36,0 | 450 | - | - | 6,0 | - | 194 |
| | 12час 35 | - | - | 2,35 | 0,198 | 46,5 | 0,802 | 72,0 | 36,0 | 440 | - | - | 8,0 | 0,020 | 153 |
| 3.09.92 | 9час 15 | - | - | 1,80 | 0,178 | 40,5 | 0,822 | 66,0 | 35,5 | 435 | - | - | 10,1 | 0,002 | 143 |
| | 9час 45 | - | - | 1,35 | 0,181 | 40,0 | 0,819 | 64,0 | 36,0 | 430 | - | - | 11,0 | 0,002 | 136 |
| | 10час 50 | 0,8 | 0,870 | - | - | 50,0 | 0,130 | 66,0 | 36,0 | 440 | - | - | 10,2 | - | 123 |
| 17.09.92 | 10час 45 | 3,6 | 0,245 | - | - | 11,0 | 0,755 | 58,0 | 36,0 | 440 | - | 12,4 | 7,0 | 0,002 | 188 |
| | 11час 15 | 2,0 | 0,332 | - | - | 38,0 | 0,668 | 62,0 | 36,0 | 440 | - | 16,2 | 6,6 | - | 107 |
| | 11час 45 | 1,0 | 0,182 | - | - | 42,5 | 0,818 | 60,5 | 36,0 | 440 | - | 16,0 | 8,0 | 0,0015 | 96 |
| | 12час 15 | 0,56 | 0,110 | - | - | 43,0 | 0,890 | 59,5 | 36,0 | 440 | - | 16,8 | 8,8 | - | 61 |
| 28.10.92 | 11час 30 | 1,4 | 0,231 | 0,30 | 0,028 | 42,4 | 0,743 | 69,0 | 35,5 | 440 | - | 18,0 | 6,0 | - | 133 |
| | 12час 00 | 1,4 | 0,241 | 0,30 | 0,027 | 40,0 | 0,732 | 70,0 | 35,5 | 445 | - | 17,2 | 6,6 | - | 151 |
| | 12час 40 | 1,2 | 0,218 | 0,30 | 0,028 | 39,0 | 0,754 | 69,0 | 36,0 | 445 | - | 17,2 | 6,6 | - | 113 |
| 29.10.92 | 9час 30 | 5,0 | 0,980 | 0,20 | 0,020 | 0,0 | 0,0 | 65,0 | 35,5 | 445 | - | 7,0 | 8,6 | - | 463 |
| | 10час 20 | 5,0 | 0,990 | 0,10 | 0,010 | 0,0 | 0,0 | 63,0 | 35,5 | 450 | - | 7,0 | 9,0 | - | 438 |
| | 11час 00 | 5,0 | 0,990 | 0,10 | 0,010 | 0,0 | 0,0 | 63,0 | 35,5 | 455 | - | 7,0 | 9,6 | - | 313 |
| 4.11.92 | 11час 30 | - | - | - | - | 37,5 | 1,000 | 44,0 | 35,0 | 420 | - | 15,6 | 7,6 | - | 25 |
| | 12час 00 | - | - | - | - | 37,0 | 1,000 | 41,0 | 34,5 | 420 | - | 14,6 | 7,4 | - | 25 |

# APPENDIX D

Regional Energy, Fuel and Utility Prices

## DONETSK METALLURGICAL PLANT

| COST DATA | 1994 | | |
|---|---|---|---|
| | OCTOBER | NOVEMBER | DECEMBER |
| Natural Gas | $65/1000 $Nm^3$ | | |
| Coke Gas | Kp 500,000/1000 $Nm^3$ | | |
| Coke | Kp 5,400,000/TON | | |
| Mazut | Kp 6,500,000/TON | | |
| Water | Kp 5,000/$m^3$ | | |
| Discharge | Kp 400/$m^3$ (500 $m^3$/Hr) | | |
| Electricity | Kp 511/KWH | Kp 1300/KWH | 2050/KWH |

Electric Power 1993

Consumed 567,747,000 KWH

Produced 138,488,000 KWH

Kp = Ukraine Coupons

PROPOSED
by Deputy Minister of Energy and Electrification
O M Sheberstov

APPROVED
by Deputy Ministry of Economics
V M Kalnik

# TARIFFS

on Electricity Generated by Energy Enterprises under the Ministry of Energy of Ukraine

Valid from August 25, 1994

| Energy Enterprises | Two -part tariffs | | One-part tariffs, karb/kW h | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand charge per 1 kW karb per month | Charge for 1 kW h of consumed electricity Karb | Industry or treated similarly consumers of the current up to 750 kVA Group 2 | Food-processing industry Group 4 | Electrified rail road transportation Group 5 | Electrified local transportation Group 6 | Non-industrial consumers Group 7 | State establishments |
| 1 VinitskEnergo | 240,000 | 1500 | 2000 | 1300 | 1800 | 1800 | 1800 | 1200 |
| 2 DneprEnergo | 125,000 | 1000 | 1300 | 1200 | 1800 | 1800 | 1800 | 1100 |
| 3 DonbassEnergo | 125,000 | 900 | 1300 | 1200 | 1800 | 1800 | 1800 | 1100 |
| 4 KievEnergo | 150,000 | 1400 | 1800 | 1400 | 1800 | 1800 | 1800 | 1300 |
| 5 CrimeaEnergo | 240,000 | 1900 | 2200 | 1400 | 1800 | 1800 | 1800 | 1300 |
| 6 LvivEnergo | 240,000 | 1400 | 1800 | 1400 | 1800 | 1800 | 1800 | 1300 |
| 7 OdessaEnergo | 240,000 | 1400 | 1900 | 1300 | 1800 | 1800 | 1800 | 1200 |
| 8 KharkivEnergo | 125,000* | 1200* | 1500* | 1300* | 1800* | 1800* | 1800* | 1200 |

*The ecological supercharge of 5 % have to be added to these tariffs

Notes 1 The existing rules on settling of energy purchases are valid
2 The tariffs for electricity consumed by the district heating system, and domestic hot water system are
750 karb/kW h -- during the time of low night consumption
3490 karb/kW h -- during any other hours
3 The limits for monthly electricity consumption by consumers are canceled

Director of the department of prices
on the production of enterprises of energy, chemical,
metallurgical, and construction materials industry

O I Gridasov

25

PROPOSED by
Deputy Minister of Energy
and Electrification
O M Sheberstov

APPROVED by
Deputy Ministry of
Economics
V M Kalnik

TARIFFS
on Thermal Energy Generated by
Energy Enterprise of Ministry of Energy of Ukraine

Valid from August 25, 1994
Karbovants per Gcal

| Energy Enterprises | Industrial or considering Equal to Industry Sectors (not shown into the other Groups) Group 1 | Residential Enterprises, small industrial and commercial enterprises Group 2 | Greenhouses, hotbeds, Agriculture Group 3 |
|---|---|---|---|
| 1 VinitskEnergo | 639,800 | 95,000 | 397,500 |
| 2 DneprEnergo | 1,433,200 | 95,000 | 556,500 |
| 3 DonbassEnergo | 678,000 | 95,000 | 397,500 |
| 4 KievEnergo | 1,123,900 | 95,000 | 556,500 |
| 5 CrimeaEnergo | 1,552,500 | 95,000 | 556,500 |
| 6 LvivEnergo | 510,200 | 95,000 | 420,000 |
| 7 OdessaEnergo | 1,643,400 | 95,000 | 556,500 |
| 8 KharkivEnergo | 1,274,100 | 95,000 | 397,500 |

Notes 1 The existing rules on settling of energy purchases are valid
2 Value added taxes are not included in these tariffs
3 The tariffs introduced from March 1, 1994 are canceled with the introduction of new ones

Director of the department
of prices on the production of enterprises
of energy, chemical, metallurgical, and
construction materials industry

O I Gridasov

WORLD BANK DATA FOR NATURAL GAS

$3.5 - $8 / 106 BTU by 2010
$110 - $250/ Thousand Cubic Meters (TCM)

JAN 4, 1995

**CRUDE OIL (NYME)**
**1,000 bbl.; dollars per bbl.**

| | OPEN | HIGH | LOW | SETTLE | CHANGE | |
|---|---|---|---|---|---|---|
| Feb | 17.70 | 17.82 | 17.41 | 17.44 | — .32 | 86,446 |
| Mar | 17.68 | 17.79 | 17.40 | 17.41 | — .30 | 56,027 |
| Apr | 17.72 | 17.77 | 17.44 | 17.45 | — .28 | 22,884 |
| May | 17.76 | 17.76 | 17.48 | 17.49 | — .26 | 13,421 |

Prev. vol. 48,471; Prev. day's open int.354,416 unch

**HEATING OIL (NYME)**
**42,000 gallons; cents per gal.**

| | | | | | | |
|---|---|---|---|---|---|---|
| Feb | 51.30 | 51.60 | 49.90 | 49.94 | — 1.29 | 48,040 |
| Mar | 51.00 | 51.26 | 49.65 | 49.69 | — 1.21 | 25,138 |
| Apr | 50.25 | 50.40 | 49.05 | 49.14 | — 1.11 | 15,418 |
| May | 49.60 | 49.70 | 49.10 | 48.64 | — 1.06 | 8,203 |

Prev. vol. 47,196; Prev. day's open int.132,743 — 6,293

**UNLEADED GASOLINE (NYME)**
**42,000 gallons; cents per gal.**

| | | | | | | |
|---|---|---|---|---|---|---|
| Feb | 53.60 | 53.90 | 52.65 | 52.75 | — 1.03 | 19,676 |
| Mar | 53.30 | 53.50 | 52.55 | 52.69 | — .83 | 10,195 |
| Apr | 56.25 | 56.25 | 55.25 | 55.38 | — .98 | 10,786 |
| May | 55.75 | 55.75 | 54.90 | 54.83 | — .95 | 5,742 |

Prev. vol. 23,643; Prev. day's open int.53,203 — 3,694

**NATURAL GAS (NYME)**
**10,000 mm british thermal units**

| | | | | | | |
|---|---|---|---|---|---|---|
| Feb | 1.760 | 1.795 | 1.680 | 1.683 | — .042 | 27,928 |
| Mar | 1.770 | 1.790 | 1.675 | 1.681 | — .052 | 17,632 |
| Apr | 1.720 | 1.739 | 1.655 | 1.644 | — .049 | 9,778 |
| May | 1.710 | 1.730 | 1.650 | 1.644 | — .044 | 9,483 |

Prev. vol. 11,425; Prev. day's open int.133,834 + 1,668

June 2 1994

ENERGY PRICE UPDATE

End-use energy prices for OECD Europe

Source OECD, third quater 1993, IEA Statisitics Energy Prices and Taxes

| | units | | year of price estimate |
|---|---|---|---|
| Gasoline | $US/liter | 0 988 | 1992 |
| | $US/toe | 1220 5 | 1992 |
| Diesel Fuel | $US/liter | 0 623 | 1992 |
| | $US/toe | 712 | 1992 |
| Light Fuel Oil for industry | $US/1000 liter | 312 46 | 1992 |
| | $US/toe | 363 2 | 1992 |
| Light Fuel Oil for households | $US/1000 liter | 401 27 | 1992 |
| | $US/toe | 468 3 | 1992 |
| Heavy Fuel Oil for industry | $US/1000 liter | 151 08 | 1992 |
| | $US/toe | 156 5 | 1992 |
| Electricity for industry | $US/kWh | 0 076 | 1991 |
| | $US/toe | 887 | 1991 |
| Electricity for households | $US/kWh | 0 138 | 1991 |
| | $US/toe | 1607 7 | 1991 |

| | units | | year of price estimate |
|---|---|---|---|
| Heavy Fuel Oil for utilities | $US/1000 liter | 137 43 | 1991 |
| | $US/toe | 143 2 | 1991 |
| Natural gas for industry | $US/10^7 kcal | 170 54 | 1991 |
| | $US/toe | 189 5 | 1991 |
| Natural gas for utilities | $US/10^7 kcal | 145 48 | 1991 |
| | $US/toe | 161 6 | 1991 |
| Natural gas for households | $US/10^7 kcal | 490 7 | 1992 |
| | $US/toe | 545 2 | 1992 |
| Steam Coal for industry | $US/tonne | 103 41 | 1991 |
| | $US/toe | 154 3 | 1991 |
| Steam Coal for utilities | $US/tonne | 80 2 | 1991 |
| | $US/toe | 137 3 | 1991 |

TOE = Tons Oil ~~Equipment~~ Equivalent

MAZUT

$$\frac{\$137\ 43}{1000\ l} \times \frac{3\ 785\ l}{gal} \times \frac{gal}{8\ 34\ lb \times 1\ 015\ specific\ gravity} \times \frac{2204\ lb}{tonne} = \frac{\$135\ 43}{metric\ tonne}$$

NATURAL GAS

$$\frac{\$14\ 548}{10^6\ kcal} \times \frac{252\ 161\ cal}{BTU} \times \frac{kcal}{1000} = \frac{\$3\ 668}{10^6\ BTU}$$

OECD - EUROPE

| Sector | Fuel | US$/toe | US$/mmBtu | US$ per | | notes |
|---|---|---|---|---|---|---|
| Transport | | | | | | |
| | Gasoline | 1,107 | 28 | 0 86 | litre | 1 |
| | Diesel | 661 | 17 | 0 58 | litre | 1 |
| Industrial | | | | | | |
| | Light Fuel Oil | 290 | 7 | 383 | tonne | 2 |
| | Heavy Fuel Oil | 151 | 4 | 158 | tonne | 1 |
| | Electricity | 742 | 19 | 0 064 | Kwh | 3 |
| | Natural Gas | 151 | 4 | 141 | k m^3 | 4 |
| | Steam Coal | 128 | 3 | 90 | tonne | 3 |
| | Coking Coal | 92 | 2 | 58 | tonne | 3 |
| | Thermal | 298 | 8 | 30 | Gcal | 5 |
| Household | | | | | | |
| | Electricity | 1,282 | 32 | 0 110 | Kwh | 3 |
| | Thermal | 436 | 11 | 44 | Gcal | 5 |

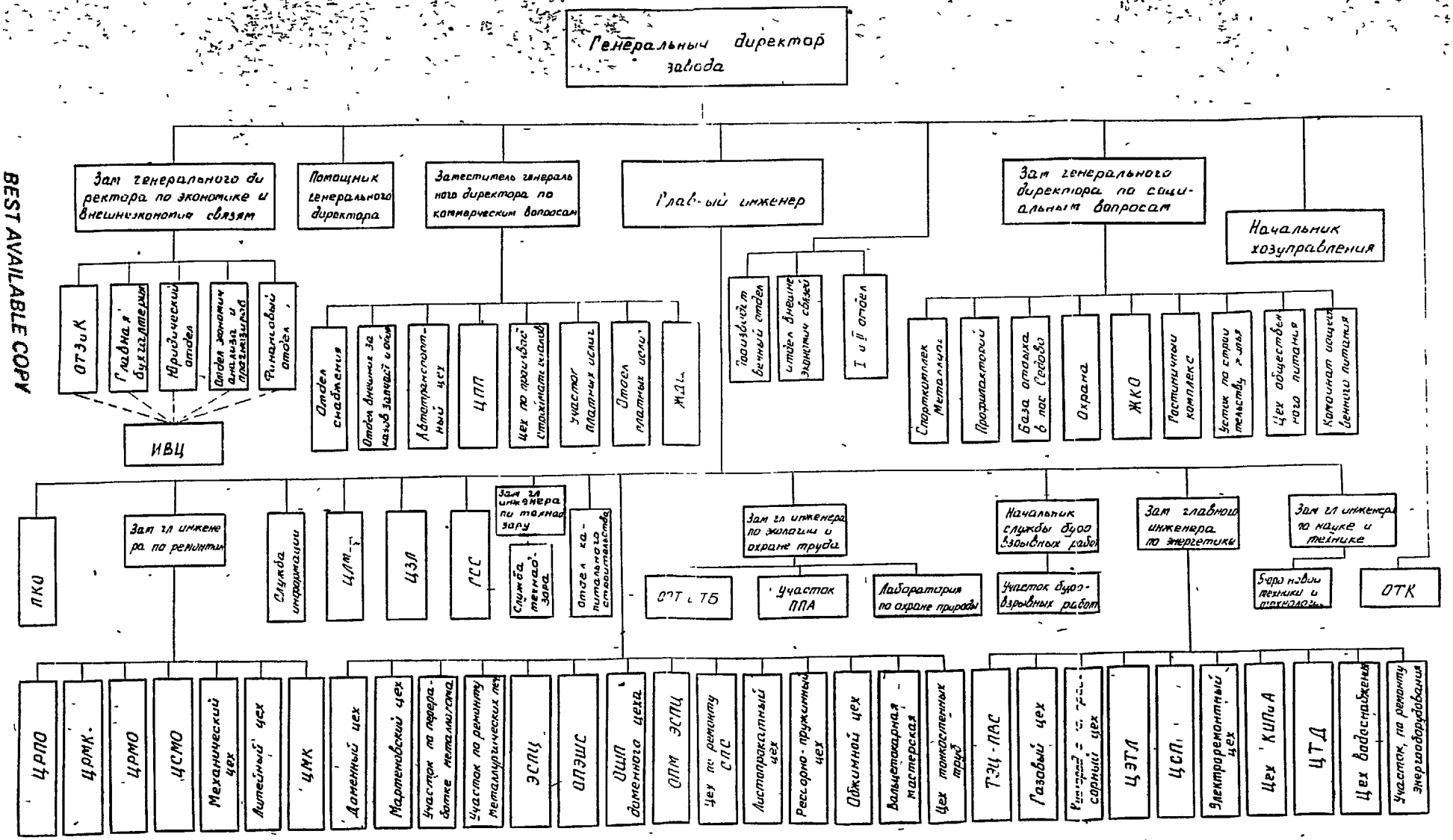
Source IEA, 1991, IEA Statistics, Energy Prices and Taxes,
Second Quarter 1991, OCDE/OCED Paris, pp 283-298

| notes | comments |
|---|---|
| 1 | Q2 1991 OECD Europe price |
| 2 | Q3 1991 Danish price, similar to OECD Europe Price |
| 3 | 1989 OECD Europe price |
| 4 | 1988 OECD Europe price |
| 5 | per discussion at RMA meeting |
| 6 | Q2 1991 price |
| 7 | 1990 price |

# APPENDIX E

Organization Chart

# СХЕМА УПРАВЛЕНИЯ ДОНЕЦКИМ МЕТАЛЛУРГИЧЕСКИМ ЗАВОДОМ




BEST AVAILABLE COPY

# APPENDIX F

List of Contacts Made in Facility

## CONTACTS MADE DURING AUDIT

November 7-17, 1994

### Donetsk Metallurgical Plant

Vladimir Tereshenko - Director

Boris Krikunov - Deputy Director

Gergi Morozov - Chief of Dept. International Affair

Michael Ovsanikov - Deputy Chief Engineer, Energy

Sergi Nikitin - Chief of Power Plant

Oleg Shebanov - Principal Thermal Engineer

Anatoly Gurev - Deputy Chief, Power Plant

Boris Pavlov - Chief of Electrical Laboratory

Gennady Abramovich - Chief Engineer, Water Supply

Vladimir Chebotarev - Chief Engineer, Power Plant

Vasili Ukrainski - Chief Electrical Engineer, Power Plant

Vladimir Donchenko - Chief of Electrical Department, Power Plant

Anatoly Levitsky - Chief of the Plant

Anna Strelnikova - Chief of Water and Gas Laboratory

Vladislav Tsukanov - Chief Technical Department

Донецкий областной
исполнительный комитет

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Александр Петрович
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каб.311сл.

тел служ: (0622) 90-72-69; 90-08-61 тел. дом:59-64-63

УО7-48Д

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(0622) 95-8409 дом

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ФИЛИППОВ

НАЧАЛЬНИК ОТДЕЛА КООРДИНАЦИИ
МЕЖОТРОСЛЕВЫХ СВЯЗЕЙ И КОНВЕРСИИ

340105 ДОНЕЦК,
Б. ПУШКИНА, 34

ТЕЛ. СЛ. (7-0622) 90-72-65
90-37-73

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завод

*ТЕРЕЩЕНКО*
*Владимир Петрович*
*главный инженер завода*

УКРАИНА,
340062, г Донецк,
ул Ив Ткаченко 122

Тел служ 61-23-02,
61-21-28
Телекс 128, 129
факс 66-40-51,
115701 СОЛО

---

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Киевский институт
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**ДИАТЯН**
**Эдуард Грайрович**
**Заместитель директора**

Украина, 252135, Киев, пр. Победы 4.
Раб. тел. (044) 274-00-04, дом. тел. 517-49-29.
Факс (044) 274-60-61

# APPENDIX G

Abbreviations and Units Conversions
Pipe Size Metric Conversion Table

| | |
|---|---|
| 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 |
| $Kg_f$ | = kilogram |
| Kgcc | = 7,000 kcal = 27,776 BTU |
| kJ | = kilojoules = 1 thousand joules = 0.947813 BTU |
| km | = kilometer = 0.621 miles |
| kN | = kilonewton = 1 thousand newtons |
| kp | = kopeck = 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 | = million |
| 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 | = teracalorie = 1 trillion calories = 3.968 billion BTU |
| T | = temperature |
| TPS | = Thermal Power Station |
| V | = volts |
| VA | = volt-amps |
| VArs | = volt-amps (reactive) |
| VSD | = variable speed drive |
| yr | = year |

# PIPE SIZE METRIC CONVERSION TABLE

| Diameter | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nominal Size | | Outside Diameter | | Nominal Size | | Outside Diameter | |
| Millimetres | Inches | Millimetres | Inches | Millimetres | Inches | Millimetres | Inches |
| 6 | ⅛ | 10.3 | 0.405 | 350 | 14 | 355.6 | 14.000 |
| 8 | ¼ | 13.7 | 0.540 | 400 | 16 | 406.4 | 16.000 |
| 10 | ⅜ | 17.1 | 0.675 | 450 | 18 | 457.2 | 18.000 |
| 15 | ½ | 21.3 | 0.840 | 500 | 20 | 508.0 | 20.000 |
| 20 | ¾ | 26.7 | 1.050 | 550 | 22 | 558.8 | 22.000 |
| 25 | 1 | 33.4 | 1.315 | 600 | 24 | 609.6 | 24.000 |
| 32 | 1¼ | 42.2 | 1.660 | 650 | 26 | 660.4 | 26.000 |
| 40 | 1½ | 48.3 | 1.900 | 700 | 28 | 711.2 | 28.000 |
| 50 | 2 | 60.3 | 2.375 | 750 | 30 | 762.0 | 30.000 |
| 65 | 2½ | 73.0 | 2.875 | 800 | 32 | 812.8 | 32.000 |
| 80 | 3 | 88.9 | 3.500 | 850 | 34 | 863.6 | 34.000 |
| 90 | 3½ | 101.6 | 4.000 | 900 | 36 | 914.4 | 36.000 |
| 100 | 4 | 114.3 | 4.500 | 950 | 38 | 965.2 | 38.000 |
| 125 | 5 | 141.3 | 5.563 | 1000 | 40 | 1016.0 | 40.000 |
| 150 | 6 | 168.3 | 6.625 | 1050 | 42 | 1066.8 | 42.000 |
| 200 | 8 | 219.1 | 8.625 | 1100 | 44 | 1117.6 | 44.000 |
| 250 | 10 | 273.0 | 10.750 | | | | |
| 300 | 12 | 323.8 | 12.750 | | | | |

| Wall Thickness | | | | | | | |
|---|---|---|---|---|---|---|---|
| Millimetres | Inches | Millimetres | Inches | Millimetres | Inches | Millimetres | Inches |
| 1.73 | .068 | 5.16 | .203 | 8.74 | .344 | 21.95 | .864 |
| 2.24 | .088 | 5.49 | .216 | 9.27 | .365 | 22.23 | .875 |
| 2.31 | .091 | 5.54 | .218 | 9.53 | .375 | 23.01 | .906 |
| 2.41 | .095 | 5.56 | .219 | 10.31 | .406 | 23.83 | .938 |
| 2.77 | .109 | 5.74 | 226 | 10.97 | .432 | 24.61 | .969 |
| 2.79 | .110 | 6.02 | .237 | 11.07 | .436 | 25.40 | 1.000 |
| 2.87 | .113 | 6.35 | .250 | 11.13 | .438 | 26.19 | 1.031 |
| 2.90 | .114 | 6.55 | .258 | 11.91 | .469 | 27.79 | 1.094 |
| 3.02 | .119 | 7.01 | .276 | 12.70 | .500 | 28.58 | 1.125 |
| 3.07 | .121 | 7.04 | .277 | 14.02 | .552 | 29.36 | 1.156 |
| 3.20 | .126 | 7.09 | .279 | 14.27 | .562 | 30.96 | 1.219 |
| 3.38 | .133 | 7.11 | .280 | 15.09 | .594 | 32.54 | 1.281 |
| 3.56 | .140 | 7.14 | .281 | 15.88 | .625 | 33.32 | 1.312 |
| 3.68 | .145 | 7.62 | .300 | 16.66 | .656 | 35.71 | 1.406 |
| 3.91 | .154 | 7.80 | .307 | 17.12 | .674 | 38.10 | 1.500 |
| 3.96 | .156 | 7.92 | .312 | 17.48 | .688 | 44.45 | 1.750 |
| 4.55 | .179 | 8.08 | .318 | 18.26 | .719 | 50.80 | 2.000 |
| 4.78 | .188 | 8.18 | .322 | 19.05 | .750 | | |
| 4.85 | .191 | 8.38 | .330 | 20.62 | .812 | | |
| 5.08 | .200 | 8.56 | .337 | 21.44 | .844 | | |

# APPENDIX H

Translations from Russian

1. Donetsk Metallurgical Plant (Description)
2. Concept of the Donetsk Metallurgical Plant Development
3. Donetsk Boiler Monitoring Inspectorate - The Order
4. Open Hearth Furnaces Air Compressors
5. Donetsk Metallurgical Plant Description
   (according to questionnaire of the Regional Executive Committee)
6. Boilers Characteristics

## 1. Donetsk Metallurgical Plant

Donetsk metallurgical plant was founded in 1872 and now it is one of the oldest ferrous metallurgy enterprises in Ukraine. At that remote year, the first blast furnace was started up In 1917, there already were functioning 7 blast furnaces, 10 open-hearth furnaces and 20 puddling furnaces, 2 acid Bessemer converters, blooming mill 900/170, Lauth three-high mill, jobbing mills 250, 350 and 400. For many years of its operation, the plant experienced several modernizations and upgradings. And now, despite its considerable age, the plant rapidly develops and specializes in production of high-grade steel. For the time of its existence the plant was leading in introduction of advanced metallurgical technologies and after familiarization spread them throughout the branch enterprises. The following are several examples of it.

In 1951, for the first time in the country, the system of evaporative cooling was implemented in the open-hearth furnaces workshop Now this system is successfully used not only in metallurgy but also in other branches of industry where an effective cooling of equipment is needed. For elaboration and introduction of this new cooling system, the group of the plant metallurgists were awarded with State reward.

In 1960, for the first time in the country, the technology of natural gas use for cast iron smelting was introduced in the plant. For this achievement some employees of the plant were given the Lenin award.

Also in 1960, for the first time in the world, the production facilities of continuous steel casting was started up in the plant and these facilities are still in operation

In 1968, a unit for cast-iron desulfurization was started up which made it possible to produce world-standard-quality cast iron

In 1974, a new design of charging unit was introduced in the blast furnace workshop that made it possible to increase reliability 4-5 fold. That design of charging unit was introduced to other related enterprises.

In 70's, the fundamental plant updating was initiated. In 1974, a new cogging mill started working. In 1978, the largest in Ukraine high-powered electric steel furnace workshop came into operation. It resulted in a sharp increase of very efficient bearing steel production. Production of special purpose steel also increased.

In 1981, for the first time in the metallurgy, an equipment for coal dust injection into blast furnace came into operation that resulted in sharp reduction of coke consumption For the introduction of that technology, a group of the plant employees was awarded with State reward.

In 1982, an evacuation unit was installed in the electric steel furnace workshop and the technology of vacuum steel treatment was implemented. Use of this technology improved the quality of critical grades of steel

In 1985, the largest in Ukraine workshop for exothermic slag-forming mixtures used during steel casting came into operation.

At the present time the plant consists of blast furnace workshop (2 blast furnaces with working capacity 1033 $m^3$), open-hearth furnace workshop (6 open-hearth furnaces with capacity 150 tons), electric arc steel furnace workshop (2 electric arc furnaces with capacity 100 tons each), cogging mill workshop (continuous billet mill 950/900), section rolling workshop (light-section-250 and medium-section-350 and 400 merchant mills) and sheet rolling mill (2300 mill)

Apart from the main production workshops, there are power supply workshop, maintenance workshops, scrap metal reprocessing workshop, railway and transportation sites, synthetic slag-forming mixtures production workshop, plant storehouses for raw and other materials storage

The plant is specialized in production of merchant shapes and sheet metal, billets of construction and alloy grades of steel that distinguish this plant from any other metallurgical plants in Ukraine (except "Dneprospetzstal") producing conventional grades of rolling steel. The analysis, carried out by the UkrNIlmet" research institute and related to rolled steel consumption in Ukraine and CIS countries and the prognosis for this consumption in future showed a stable demand for high-quality rolled steel DMZ assortment, taking into account the growth in demand of machine-constructing enterprises.

According to specialization, the merchant mills 250, 350 and 400 produce simple and shaped sections: round, square, hexahedral with dimensions 12-65 mm , strip and spring steel (5-25 mm. thick and 22-160 mm wide), shaped sections for automobile construction, ship-building, coal mining, agriculture, road machine construction And the plant is the only supplier of many of abovementioned items.

Sheet rolling mill produces sheets 5-20 mm thick, 1250-1800 mm wide and 7 m long Cogging mill 950/900 produces merchant shapes 135 mm, skelps and round billets 120-220 mm

In 90's, a general overhaul was started in the plant which was caused by a series of reasons·

1. Poor ecological situation in the region.
2. Low efficiency of fuel and energy consumption by existing metallurgical technologies and equipment
3. Necessity to increase the profitability of production within market economy conditions

During the elaboration of overhaul, plant design experts together with "Lengipromez" Institute designers worked out the scheme of rehabilitation in a way that new efficient production facilities would be the sources for the whole plant overhaul financing and at the same time could meet the consumptive market requirements As the first step of the rehabilitation, a modern production of coil springs for passenger cars was chosen They were going to be produced from the plant rolled products. The need for these springs is both in Ukraine and abroad. An intention was also to produce thin-walled pipes, pipes for gas and water and on their basis

different grades of metal products To make the products competitive on the world market, some foreign companies known as leaders in the production organization were recruited for this work.

In August 1994, a workshop for thin-walled, water and gas pipes was started up The workshop was constructed with the participation of Canadian, American and Italian companies In the near future the production of coil springs for passenger cars will come into operation Production facilities are constructed under the design of German company "Hoiser".

Simultaneously with construction of new workshops for production of finished products, the design for steel smelting workshops rehabilitation is being carried out. The consortium of German companies "Korf Lurgi" and "Mannesmann Demag" has already prepared a preliminary project for open-hearth furnaces workshop rehabilitation. German company "Fuks" executes a project engineering for electric steel furnaces workshop rehabilitation. Suggested works will make it possible to reduce the consumption of power 2 times and natural gas almost 10 times In fact, there will not be any detrimental wastes. At the same time, the possibilities for high-quality grades of alloy steel will be extended

Even now, thanks to introduction of new devices and technology, one can notice a considerable extension of the products range in the rolling production. As for suggested measures for rolling mill workshops rehabilitation they will help to a great extent to meet Ukrainian and other consumers demands for high-quality rolled products with low quantity of by-products

So, due to the rehabilitation in the near future, the plant will become a fully renovated, effective, competitive and ecologically safe enterprise specialized in production of high-quality rolled products from alloyed steel grades and other products necessary for Ukrainian economy

**PLANT OUTPUT**
(Thousand Tons)

| Product Name | 1992 | 1993 |
|---|---|---|
| Conversion cast iron | 1191.9 | 1003.3 |
| Steel | 1297.3 | 1129.9 |
| Merchant rolled products | 1046.3 | 922 9 |

There are 9400 employees at the plant (01-10-94)
24 hours working day, without days off

## 2. Concept of the Donetsk Metallurgical Plant Development

Ferrous metallurgy is one of the major, basic branches of the Ukrainian national economy

Share of metallurgy in industry·

| | |
|---|---|
| Commercial Production | - 13.4% |
| Capital assets | - 13.0% |
| Number of employees | - 6 5% |
| Power Consumption | - 15 6% |
| Fuel Consumption | - 14 2% |

From 1988 to 1993, the production of main kinds of metal products declined by more than 30% And in 1994, the decline in productivity still goes on.

Due to the following reasons the general situation in the ferrous metallurgy sector may be defined as critical.

1. Continuous ageing of capital assets.
2. Low efficiency of fuel and energy use
3. Poor ecological situation in large industrial centers

All these factors are also typical for our plant That is why the basic technical re-equipment was initiated in 1990. It was caused by the following factors

1. Capital assets approaching end of useful life
2. Unfavorable ecological situation
3. Energy sources crisis
4 Need to increase production profitability under market economy conditions

### Present Situation

At the present time, the Donetsk plant consists of blast furnace workshop (2 blast furnaces with working capacity 1033 $m^3$), open-hearth furnace workshop (6 open-hearth furnaces with capacity 150 tons and slabbing mill UNPS), electric steel furnace workshop (2 electric steel furnaces with capacity 100 tons each), cogging mill workshop (continuous billet mill 950/900), section rolling workshop (light-section-250, medium-section-350 and 400 mills) and sheet rolling mill (2300 mill)

Production and estimated capacities are given in Table 1.

TABLE 1

| Workshop | Estimated Capacity (th. ton) | Production Capacity (th. ton) |
|---|---|---|
| Blast furnace workshop | 1138.0 | 1273.0 |
| furnace 1 | 569.0 | 639.0 |
| furnace 2 | 569 0 | 639.0 |
| Open-hearth furnace workshop | 945 0 | 945.0 |
| UNPS | 310 0 | 310 0 |
| Electric steel furnace workshop | 460.0 | 460.0 |
| Cogging mill workshop | 1425 0 | 1396.0 |
| (commercial) | 530.0 | 579.0 |
| Sheet rolling workshop | 520.0 | 600.0 |
| Section rolling workshop | 365 0 | 480.5 |
| 400 mill | 120.0 | 163.5 |
| 350 mill | 120 0 | 157.0 |
| 250 mill | 125.0 | 160.0 |

The plant is specialized in production of merchant shapes and sheet metal, billets of ordinary, construction and alloy steel grades

According to specialization the merchant mills 250, 350 and 400 produce simple and shaped sections: round, square, hexahedral with dimensions 12-65 mm, strip and spring steel (5-25 mm thick and 22-160 mm wide), shaped sections for automobile construction, ship-building, coal mining, agriculture, road machine construction And the plant is the only supplier of many of abovementioned items

Sheet rolling mill used for production of sheets 5-20 mm thick, 1250-1800 mm wide Cogging mill 950/900 used for production of square billets 120-180 mm and round billets 120-220 mm.

The peculiarity of the plant is the orientation towards high-quality production including rolled products of bearing, coil spring, chrome and other alloyed and special steel grades in relatively simple assortment circle, square, sheet, strip, sections for special purposes From the UkrNIImet (research institute) point of view, such general orientation of the steel smelting and rolling Donetsk metallurgical plant (DMP) should continue and develop to 2010 because the demand for the plant rolled products has been steadily growing for the last 10-15 years This tendency is expected to go on till 2010 and further.

TABLE 2
Table of capital assets life (for 01-02-94)

| Name of Equipment | Capital Assets Life, (%) |
|---|---|
| Blast furnaces | |
| Furnace 1 | 100 |
| Furnace 2 | 100 |
| Open-hearth furnaces 1-6 | 100 |
| UNPS | 100 |
| Electric steel furnaces | |
| No 1 | 100 |
| No. 2 | 100 |
| Mill 950/900 | 75 |
| Mill 2300 | 100 |
| Mill 400 | 96 5 |
| Mill 350 | 87.8 |
| Mill 250 | 100 |

With the purpose to determine an optimal conception of the plant development, a contest for the best project was announced in 1990 In this contest several engineering institutions took part, such as: Giprostal, Ukrgipromez, Lengipromez At the meeting of Scientific and Technical Council, a preference was given to the Lengipromez project and its conception of the plant development was taken as the basis The main idea of this conception was to increase the competitiveness of the plant and to reduce the negative impact on the environment. The scheme of rehabilitation provided that new efficient production facilities be the sources for the whole plant overhaul financing and at the same time could meet the consumptive market demands As the first step of the rehabilitation a modern production of coil springs for passenger cars as well as production of thin-walled pipes, pipes for gas and water and on their basis different kinds of metal products were chosen After putting these workshops into operation the rehabilitation of steel-smelting workshops will be carried out and then the rehabilitation of rolling production (see Table 3)

**Expected perspective of the plant main workshops development.**

Blast furnace workshop

Measures for technical re-equipment is mainly aimed at the ecology improvement, reduction of coke consumption, upkeep of working equipment in good operating condition and production of special cast iron for machine construction.

Blast furnace workshop consists of two blast furnaces producing conversion cast iron in amounts of 1200 thousand tons The need for the blast furnace workshop operation is caused by the following reasons

- to provide the EOF furnace in the open-hearth furnace workshop with molten cast iron in amounts of 480 th tons.

- to provide electric steel furnace workshop with molten and pig cast iron

- to provide machine construction industry of Ukraine with conversion cast iron of high quality due to clean raw materials use.

- to produce blast furnace gas (taking into account the shortage of natural gas) that is the basis of heat production in the plant. This gas is also used in Donetsk coke-chemical plant

- an equipment for coal dust injection into blast furnace helps to achieve the lowest consumption of coke among metallurgical plants in Ukraine

- updated furnaces design and high level of technologies, including:

  1 High temperature, oxygen forced blasting,
  2. High pressure of blast furnace gas,
  3. Two cast iron tapping holes at each furnace,
  4. Evaporative cooling of furnace shafts by means of steel thick-walled pipes spread with thermally stable concrete.

Open-hearth furnace workshop

During rehabilitation, six (6) now working furnaces will be stopped and instead of them, one EOF furnace, made by German companies "Korf Lurgi" and "Mannesmann Demag" will be installed Decisive factors for the choice of corresponding metallurgical technology are the following

- low energy capacity of the process due to complete utilization of the exhaust gas heat,

- the available electric power in the region is not enough for high capacity furnaces construction in the workshop,

- the scrap reserve in Ukraine and in the plant is rather scarce,

- the scrap consumption in the plant is high because of the electric smelting furnace operation,

- consumption of the large quantity of molten and hard cast iron is preferable because of low content of harmful alloys and high energy capacity of cast iron,

- the expected total production volume of about 700,000 tons of cast billets per year will not allow the use of metallurgy production on the basis of blast furnaces - oxygen convertor because of high capital and production costs,

- ecological safety of the process

Table 3 Index of hard currency requirements for technical re-equipment of the Donetsk metallurgical plant in 1992 - 2000 (mn /DM)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Springs production workshop | 0 13<br>0.2 | 27.3<br>44 0 | 16.8<br>26.6 | — | — | — | — | — | 44.23<br>70.8 |
| Pipes and metal products production workshop | — | 14.8<br>23.7 | 6 4<br>10 2 | — | — | — | — | — | 21.2<br>33.9 |
| Open-hearth furnace workshop overhaul with installation of EOF furnace | 0 25<br>0.4 | 0.31<br>0.5 | 3 4<br>5.4 | 21.6<br>34 6 | 5.0<br>8.0<br>+<br>51.3<br>82.0 | 73.1<br>117.0<br>+<br>10.6<br>17 0 | — | — | 165.56<br>264 9 |
| Electric steel smelting workshop rehabilitation with installation of two-shaft furnace of the "Fuks" company | — | — | 1 9<br>3.0<br>+<br>15 6<br>25 0 | 30.3<br>48.5 | 5 3<br>8 5 | — | — | — | 53 1<br>85.0 |
| Installation of spiral stand for the mill 950/900 | — | — | — | 10<br>17 | — | — | — | — | 10.0<br>17 0 |
| Mill 300 | — | — | — | — | — | — | 75.0<br>120 0 | 75 0<br>120.0 | 150 0<br>240.0 |
| Total | 0 38<br>0.60 | 42 41<br>68.20 | 44 1<br>70.20 | 61.9<br>90 1 | 61.6<br>98.5 | 83 7<br>134 0 | 75 0<br>120 0 | 75 0<br>120.0 | 444 09<br>716.6 |

Table 4 Comparative characteristics of open-hearth furnaces and EOF furnace operation.

| | Units of Measurement | Open-Hearth Furnace (2-8) 1993 | EOF Furnace (Designed) |
|---|---|---|---|
| Annual steel production | ton | 798750 | 740388 |
| Specific consumption· metal charge, total including: | kg/ton | 1167 0 | 1174.2 |
| molten cast iron | kg/ton | 570 | 683.6 |
| scrap | kg/ton | 500 | 419.4 |
| Fuel and energy: | | | |
| mazut | kg/ton | 26 5 | ---- |
| natural gas | $m^3$/ton | 58.6 | 5.6 |
| oxygen | $m^3$/ton | 43 | 65.3 |
| electric power | kW/hour/ton | 26 5 | 23.4 |
| Refractories | kg/ton | 23.5 | 0.8 |
| Refractory Mass | kg/ton | ---- | 4 0 |

Simultaneously with the EOF furnace start-up, a ladle-furnace and casting unit (MNLZ) is to be put into operation. The special construction of this casting unit was provided for slabs and merchant bars production

Electric steel furnace workshop

During rehabilitation, two existing electric arc furnaces will be replaced by tandem furnace with two shaft-type heating systems for scrap and one 63 MW transformer

Table 5. Comparative characteristics of now used electric arc furnaces and a furnace of "Fuks" company

| | Existing situation | After rehabilitation |
|---|---|---|
| Annual production (designed) thousand ton | 460 | 990 |
| Transformer capacity, MW | 2 x 50 | 63 |
| Power consumption, kW/hour/ton | 600 | 325 |
| Electrode consumption, kg/hour | 5.65 | 2.5 |

Produced steel will be processed at the ladle-furnace and cast for billets at casting unit (MNLZ). Billets will be cast of bearing steel - 400 th tons 500 th tons of steel will be casted in merchant billets for "350 mill" and 50 th tons will be casted when MNLZ is under repair

Produced steel assortment

- bearing
- spring (silicon steel)
- carbon steel
- manganese steel
- alloyed steel

Cogging mill works

From the "UkrNIImet" point of view, general technical level (taking into account technologies, equipment and quality of products) is 1.2, that is the technical level of rolled products production corresponds to high level in this branch of industry achieved at the best cogging mills of the same capacity The state of equipment is evaluated as "satisfactory" That is why the following directions of cogging workshop technical reequipment were chosen

1 Widening the range of round rolled products by lessening diameters of billets This measure is necessary for filling the round billets production gap within the limits from 70 to 130 mm The most fast growth in demands for these diameters is expected in the near future in machine construction industry of Ukraine It will need round rolled products of construction and alloyed steel grades.

This widening of assortment will be achieved by means of the third stand installation at the mill 950/900

The variant of three-roll reduction stand-200 ("Mannesmann Demag") installation seems to be the most technologically effective This equipment makes possible using round billets of about 200 mm in diameter to produce in one operation finished rolled products with diameters 65mm, 120mm and with installation of a four-roll stand after the three-roll stand - to produce square billets with side dimensions from 55 to 110 mm.

In comparison with a duo-reversing mill - 750 this variant has a number of considerable advantages, the main of which are

- no need for installation of long and wide front auxiliary table,

- no need for installation of link-chain support-manipulators before and after the stand,

- no need for pulpit

2 Possibility to improve the finishing, checking and package of the rolled products with installation of correspondent equipment

Sheet rolling mill workshop

The technical level of the sheet rolling mill-2300 (the UkrNIImet analysis) is lower than that of mill-950/900 The rate of modem requirements correspondence = 0.93. The equipment of this stand is outdated and there are no efficient means for sheet rolled products thermal treatment

Demands for sheets (6-20 mm) produced by the mill-2300 is diminishing due to conversion of military ship building plants to other production Other Ukrainian and CIS metallurgical plants producing this type of steel sheets provoke a strong competition for sales markets

There could be (elaborating now) the following directions for rehabilitation of sheet rolling mill workshop:

1. Production of steel sheets certified according to European or American standards

2. Widening of the mill-2300 assortment with sheets 2-5mm thick

3 To use more types of thermal treatment of rolled products.

4. To produce strips 100-500mm wide for cold-rolled steel strips production

5 To produce curved shapes and using them other metal products

Spring production workshop (merchant shapes rolling facilities)

Merchant mills - 250, 350 and 400 are worn out and have outdated main and auxiliary equipment They are characterized by manual work at many technological operations and insufficient quality of finished rolled products. Because of this, the first stage is aimed at modernization of the mill-250, which will produce initial materials for spring production facilities to be started up in 1994. Then, construction of multisection mill 350-300 on the new site The workshop will be specialized in production of finished items for machine construction - springs and coil springs Construction of workshop for their production is executed by the "Hoiser" company The capacity of this workshop (two shifts) will be 2 5 million springs.

Maintenance workshop

Maintenance workshop is brought to correspondence to requirements of the main production workshops of the plant

Exception is a foundery workshop that should organize commercial steel casting to be sold for contracted prices and the workshop of synthetic and slag-forming mixtures All the available equipment of this workshop should be used for construction materials production to be sold for contracted prices

Energy supply workshop

During technical re-equipment of energy supply workshop, special attention will be paid to thermal power plant and oxygen supply facilities. The capacity of these facilities should be brought to correspondence with the requirements of the main production workshops of the plant.

Transport (railway)

Almost all railway freight turnover both external and internal is executed by the railway transport. There is a developed network of tracks in the plant as well as the plan for its further development.

The length of railways for one million tons of steel production (specific length) is more than 2.0 - 2.5 times than at similar plants

The plant has the highest rate of freight turnover with reference to produced steel.

| | | Capacity, tons freight/ton of steel production |
|---|---|---|
| Communar plant | - | 12.7 |
| Makeevka plant | - | 12.7 |
| Petrovskogo plant | - | 11.6 |
| Enakievo plant | - | 9.2 |
| Donetsk plant | - | 15 3 |

One locomotive operating efficiency is the lowest compared to similar plants:

| | | Capacity, thousand tons/year |
|---|---|---|
| Communar plant | - | 733 |
| Makeevka plant | - | 632 |
| Petrovskogo plant | - | 650 |
| Enakievo plant | - | 535 |
| Donetsk plant | - | 523 |

This data is for 1991, but certainly during elaboration of detailed design it is necessary to pay attention to reorganization and operation of railway and other transport

Ecology

During a process of workshops rehabilitation there will be a tendency of considerable improvement of ecology (Table 6)

Due to the fact that the open-hearth furnace workshop produces 50% of the plant waste gases and there is no required sanitary belt around it, in 1992, two of the most ecologically dangerous open-hearth furnaces (No 1 and 4) were taken out of operation.

In 1994-95, two more open-hearth furnaces will be stopped (No 2 and 3) and in their places a new EOF furnace will be constructed After commissioning of the EOF furnace, the rest of open-hearth furnaces will be stopped and as the result of this, pollution from waste gases will be reduced by about 3 times (Table 3)

**TABLE 7**

| Waste Gases | 1993 | After Rehabilitation |
|---|---|---|
| Dust | 1244 | 122 |
| CO | 568 | 407 |
| $SO_2$ | 428 | 204 |
| $NO_2$ | 1031 | 517 |
| Total | 3272 | 1250 |

The start-up of new production facilities in 1994 such as thin-walled pipes, furniture workshops and spring workshop will not increase the quantity of wastes because all of the equipment is to be mounted in the former production buildings of the most polluted workshops of skelps production.

As a whole for the plant, due to rehabilitation, the volume of waste gases thrown out to the atmosphere will be reduced 2 times As for the most harmful pollutants such as $NO_x$ - 4 3 times, $SO_x$ - 2.3 times Waste gases thrown out to atmosphere by the open-hearth furnace workshop will be reduced 2.6 times, which will let us improve the ecological situation in Leninskly and Voroshilovskly districts of the town.

TABLE 6

THE DYNAMICS
OF CHANGES OF AIR POLLUTION THAT RESULT FROM REHABILITATION OF THE PLANT

| Total Discharge t/year | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 10,643 174 | 10,643 174 | 9,001 174 | 9,001 174 | 9,001 186 | 7,359 184 | 7,359 184 | 7,359 184 | 5,325 186 | 5,325 186 |
| including | | | | | | | | | | |
| Particulate | 3,224 540 | 3,224 540 | 2,709 540 | 2,709 540 | 2,709 540 | 2,194 540 | 2,194 540 | 2,194 540 | 1,286 540 | 1,286 540 |
| $O_2$ | 1,089 077 | 1,089 077 | 883 977 | 883 977 | 883 977 | 677 077 | 677 077 | 677 077 | 469 077 | 469 077 |
| CO | 3,130 723 | 3,130 723 | 2,919 723 | 2,919 723 | 2,919 723 | 2,708 723 | 2,708 723 | 2,708 723 | 2,693 723 | 2,693 723 |
| $NO_2$ | 3,020 818 | 3,020 818 | 2,310 818 | 2,310 818 | 2,310 818 | 1,600 818 | 1,600 818 | 1,600 818 | 697 818 | 697 818 |
| $H_2S$ | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 | 178 000 |
| HF | 0 016 | 0 016 | 0 016 | 0.016 | 0 016 | 0 016 | 0 016 | 0.016 | 0 016 | 0 016 |
| steams of HCI | --- | --- | --- | --- | 0 006 | 0 006 | 0 006 | 0 006 | 0 006 | 0 006 |
| steams of $H_2SO_4$ | --- | --- | --- | --- | 0 002 | 0 002 | 0 002 | 0 002 | 0 002 | 0 002 |
| steams of NaOH | --- | --- | --- | --- | 0 004 | 0.004 | 0 004 | 0 004 | 0 004 | 0 004 |

## 3. DONETSK BOILER MONITORING INSPECTORATE

Donetsk City May 18, 1994

### THE ORDER

To the head of the central heating and power plant (CHPP) - PVS DMZ
S I Nikitin

Basing on the Regulation on GGTN of the Ukraine, I, a distnct inspector of Donetsk regional boilers monitonng inspectorate A. A. Sophischenko, together with an engineer of the energy department of DMZ L V. Derevjanko and at the presence of the head of the boiler shop A V Ivanenko and the head of the machine shop A F Kruglikov, in the period between 16/05/94 and 18/05/94 carried out an inspection of the state and safety conditions of
boilers 18895, 19414, 20082, 33049, 45675,
containers 32670, 33114, 50658, 50879, 50880, 50881, 50882, 52557, M-172,
pipelines 19135, 20320, 33048, 19134, 20319, 27686, 33046, 33162, 8298, 12556, 33047, 33408, 47667, 47666, 47689, 47673, 47690, 47691, 47668, 47716, 47715, 47797, 47798, 47799, 47642, 47770, 47771;
cranes 18688, 15205, 32047, 21838, 31942, 42844, 42073

Purpose of the inspection
"The state of bearing ropes of cranes as well as devices preventing their falling down from pulleys "

| | | |
|---|---|---|
| 1 | Available protection systems are not included in the scheme of boilers stopping § 17 41, PTE, article 6 7 1 of "The Rules " | According to a decision of ETK of the plant , it is necessary that a specialised organization be engaged in fufilment of a project that determines what kind of protection systems should be installed at the plant, taking into consideration the technological scheme of the plant Term 3rd and 4th quarters of 1994 |
| 2 | The boilers (except for No 18895) are not equipped with technological protection systems that should stop a boiler in case the flame in the furnace goes out Clause 2.4 4 of "The Instructions on Providing Explosion Safety of Boiler Rooms" No 08-4/23-1194 of 16/10/89 | The same |
| 3 | The boilers are not equipped with technological protection systems that should stop a boiler if the pressure of all burned gases and mazut decreases simultaneously Clause 2.4 4 of "The Instructions " | The same |



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| | | |
|---|---|---|
| 4 | At the boilers (except 18895 and 19414), there is no technical block-system that prohibits starting up of the firing burners without a 10 minute ventilation of the furnace Clause 2 4 4 of "The Instructions " | The same |
| 5 | At the boilers No 3, 4, 5, the automatic regulation of the relationship "fuel-air" does not work § 3 to 6 of "The Guiding Directions on the Automatic Regulation Equipment " | The automatic regulation system shall be put into operation in the 3rd quarter of 1994 |
| 6 | There is no schedule of replacing of physically worn out medium pressure boilers No 1, 2, 3 that have been in operation for more than 30 years Letter UDO 02/31 of 05/02/87 | A specialised organization shall be engaged in carrying out of a project of rehabilitation of the central heating and power plant - PVS, taking into consideration finishing of operation of worn out boilers |
| 7 | An overhaul of boiler No 4 has not been carried out according to decisions of the ETK of the plant No 58 of 15/02/93 and No 186 of 03/06/93. The decisions of the ETK have not been confirmed by a conclusion of a specialized organization | Operation of the boiler is not allowed until either an overhaul has been carried out or a specialised organization has confirmed that the boiler can operate under reduced parameters |
| 8. | There is no conclusion of a specialised organisation about a possibility of further operation of boiler No. 3 reg No 20082 that has already been in operation for the normative number of years | A technical diagnosis of the boiler shall be developed with a specialised organisation engaged<br>Term 3rd quarter of 1994 |
| 9 | On boiler No 5 a flaw detection of cracks in places of welding of in-drum units has not been carried out (a letter of GGTN of the USSR No 15-1/264 of 27/04/90), an inspection of the metal, according to clause 2 of "The Instructions on Control of the Metal of Boilers," has not been carried out I-34-70-013-84 | A flaw detection shall be carried out before an overhaul of the boiler is complete |
| 10 | Due to unsatisfactory performance of medium pressure deaerators, the content of oxygen in the feed water is constantly exceeded up to 0 1 mg/l that results in premature failures of economizer and steam-overheating pipes of boilers No 1, 2, 3 Article 8 2.1 | The deaerators shall be repaired |



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**On Containers**

| | | |
|---|---|---|
| 11 | The term for operation of evaporators No 50879, 50880, 50881, 50882 and boiler No 32670 has expired (more than 20 years) Article 6 3 6. of amendment No 1 of "The Rules " | It is required that a specialized organization diagnose the containers in order to make a conclusion concerning a possibility of their further operation Term 3rd quarter of 1994 |
| 12 | A rehabilitation of deaerators BVD reg No 33114 and 50658 (according to a recommendation of emergency commission No T-4/69 and Q-02-82(T)) has not been carried out | The required repair works shall be performed during the repair period of 1994 |
| 13 | Personnel that operates containers and pipelines has not been trained in the OTO of the plant Article 7 2 2 | The personnel shall be trained in the 3rd quarter of 1994 |

**On Pipelines**

| | | |
|---|---|---|
| 14 | According to the attached plan, indicators of movements are not available at steam lines No. 47770 and 47799. Article 2 5 2 | Indicators shall be installed during the repair period of 1994 |
| 15 | The register of measurements of heat movements is not kept at steam lines No 47770 Clause 4 6 of "The Methodological Directions on Control of Heat Movements at Steam Pipelines of CHPP " RD No 34 39 301-87 | Measurements shall be made and the register shall be filled after installation of indicators |
| 16 | A register of measurements of heat movements is not available at steam line No. 47797 Clause 4 3 RD No 34 39 301-87 | A register shall be started in 10 days |
| 17 | Measurements in the registers at steam lines No 47798 and 47799 do not coincide with the design parameters Clause 4 4 of "The Directions " | This shall be corrected in 10 days |
| 18 | There is no numbering at the indicators corresponding to the Clause 3 8 RD | The same |
| 19. | Required inscriptions, coloured signs, rating plates are absent at the pipelines Articles 7 1 and 5 3 3 | The same |
| 20 | A diagnosing of bendings of steam line No 33047 that goes from ROU 100/33 No 9 has not been carried out according to letter No 166-D/92 of 15/04/92 | The bendings shall be diagnosed in the 3rd quarter of 1994 |

| | | |
|---|---|---|
| 21 | The metal of feed pipeline 19135 has not been fully controlled "The Instructions on Inspections of Feed Pipelines of Steam Boilers " | The required works shall be performed during the repair period of 1994 |
| 22 | Pipeline 19135 was not shown to the boiler monitoring inspector for performing of a technical validation after a welding repair Article 5 2 3 v). | Operation of pipeline 19135 is prohibited |
| 23 | The 2nd BSD steam line reg No 20319 (the main steam collector) has not been replaced because of high graphitization of the metal (conclusion of PTP) | The line shall be replaced during the repair period of 1994 |
| 24 | The administration of the enterprise has not performed technical validations of the pipelines since 1990 | Validations shall be performed at least once a year |

**On Cranes**

| | | |
|---|---|---|
| 25 | Registration of load-lifting mechanisms is not in good order Numbers of load-lifting mechanisms are not indicated in the register, some certificates are absent Article 97. | This shall be corrected in 1 month |
| 26. | Crane repair and inspection registers have not been kept since 1993 Article 289 | The registers shall be constantly filled |
| 27 | There is no schedule of crane repairs for 1994 Article 289 | A schedule of repairs shall be drawn up in 10 days |
| 28 | Crane operators do not have a list of moved loads with indications of their weight and pictures of right methods of their slinging | The lists and pictures shall be made and handed to crane operators in 10 days |
| 29 | Safety devices are damaged at crane 42844 Article 297 | Operation of crane 42844 is prohibited |

**Results of Inspection**

| | | |
|---|---|---|
| 1 | Bearing ropes of all cranes are in satisfactory condition | |
| 2 | At autocrane No 42844, there are no devices preventing falling down of lift ropes from pulleys Article 124 | Required devices shall be installed in 2 weeks |



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Individuals, responsible for elimination of the listed above failures

- head of the CHPS-PVS S I Nikitin,
- heads of the machine and boiler shops

A report on completing of the present order shall be sent to Donetsk Boiler Monitoring Inspectorate on the following address Donetsk, Cheljuskintsev st , 123 o 18 06 94

The order was given by (signature) A A Sophischenko

A copy of the order was presented to

Head of CHPP-PVS DMZ (signature) S I Nikitin



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## DONETSK METALLURGICAL PLANT

Changing of the mode of operation of open-hearth furnaces (use blast furnace air from electric blower)

Previous situation

Compressors of AEG company (1935-1938) have been providing blast furnaces 3, 4 and open hearth furnaces (8 furnaces) with air 3 units are under operation

Operational characteristics of turbine P = 15/25 kgf/cm$^2$ (2/15, 2/25 only one is under operation), T = 300/400°C, N = 5 MW

Operational characteristics of compressor: P = 1.5 kgf/cm$^2$; Q = 1800 m$^3$/min; n = 2200-2800

Present status

No 3 and 4 open-hearth furnaces are supplied by one compressor unit. Air consumption is 600 m$^3$/min included great (up to 25%) leakages through leakiness in feeding pipelines connecting station and open-hearth mill (the distance is approx equal to 300-350 m). Air pressure P = 0.5 kgf/cm$^2$.

Proposal

Shut down the station because of its wear and obsolescence, install at open hearth furnace workshop one or two electric-driven blowers with the following characteristics:

P = 0 5 kgf/cm$^2$; Q = 600 m$^3$/min
Steam saving - 20 tons/hour (2 tons of standard fuel/hour)

Exporting up the [illegible] of [illegible] [illegible] [illegible]
[illegible] - [illegible] furnace for [illegible]
[illegible] the [illegible] export - capital [illegible]

Kiev, USAID
Attn A Kononov

Fax (044) 220-4692

According to your enquiry please find attached the information concerning the questions of energy efficiency
If you need additional information, please call by phone 61-2324

Deputy Chief Engineer V Krikunov

Donetsk Metallurgical Plant Description
( according to the questionnaire of the Regional Executive Committee )

1 Being one of the oldest in Ukraine Donetsk Metallurgical Plant is an integrated one At the present the plant includes the following productions blast furnace process including two blast furnaces with effective capacity 1033 $m^3$, open-heart process including six furnaces with capacity 150 t each, electro-arc casting process including two 100 t furnaces, pressing process as a part of a continuous blank mill 950/900, rolling for the sorts process as a part of small and medium sorting mills 350 & 400, sheet rolling as a part of mill 2300, thin-walled pipe process and metal products made of them

Project capacities are in the table

| | Capacity | | | Capacity | |
|---|---|---|---|---|---|
| Blast furnace process | 1138,0 | | Sheet rolling process | 520,0 | |
| blast furnace 1 | 569,0 | 1 | Rolling for the sorts process | 365,0 | |
| blast furnace 2 | 569,0 | 1 | Mill 400 | 120,0 | |
| Open-hearth process | 787,5 | 6 | Mill 350 | 120,0 | |
| UNRS ( open-hearth) | 310,0 | 1 | Mill 250 | 125,0 | |
| ESPC ELECTROSTATIC ARC FURNACE | 460,0 | 2 | Pipe & Metal Producing Process | | |
| Pressing process (inpt) commodity | 1425,0<br>530,0 | | thin-walled pipes<br>metal works (thousand of sets ) | 22,0<br>120,0 | |

CONTINUOUS POUR STEEL

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Besides the main producing processes, there are energy supplying processes, repair processes, scrap processing, railway and autotransport processes, synthetic slag making mixtures, warehouses

The plant is specialized in production of sheet and grade rolling, blanks made of constructional and alloyed steels, that distinguishes it from other metallurgical Ukrainian plants ( excluding Dneprospecstal producing rolling from regular steels The analysis of present changes in consumption of rolling in Ukraine and CIS states held by Ukrainian Research Institute of Metallurgy with a forecast for future showed constant demand for qualitative rolling of DMZ grade, taking into consideration demand growth of machine building complex enterprises

According to the specialization grade mills 250, 350 and 400 produce regular and shaped profiled, square, hexahedron with a size on a cycle 12-65mm, strip and spring steels with the thickness of 5-25mm, wideness 22-160mm, shaped profiles for branches automobile building, ship building, coal, agricultural, transport machinery In this regard the plant is the monopolist in Ukraine

The sheet mill produces sheets 5-20 mm in thickness, 1250-1800 mm in width and 7 m in length

The 950/900 blooming mill produces graded blanks of 135 mm, skelp and round blanks of 120-220 mm

2 Management structure of the industry

??? Minstry of Industry of Ukraine - Division of Ferrous Metallurgy - Donetsk Metallurgical Plant

3 Products manufactured by the plant in comparison with those manufactured by Ukrainian metallurgical plants

| | |
|---|---|
| 1 Round steel<br>12-65<br>140-220 | Krivorozhstal<br>Makeevka<br>named Dzerzhinsky<br>Dneprospetstal |
| 2 Square steel<br>16-60<br>130-200 | Krivorozhstal<br>Makeevka<br>Dneprospetstal<br>Azovstal |
| 3 ??? steel<br>0-20 x 20-100 | Makeevka<br>Konstantinovka<br>Enakievo |
| 4 Hexahedral rolled steel | Krivorozhstal |
| ??????????? Besides this, in contradiction to the usual carbonic grades manufactured at the other plants, at Donetsk metallurgical plant the specified grades are produced of structural alloy steel | |
| 5 Spring T-like and channeled steel | not produces in the Ukraine |

| | |
|---|---|
| 6 Profiles for ??? with continuous thickening | not produces in the Ukraine |
| 7 Profiles for blades of digging machines | not produces in the Ukraine |
| 8 Plate steel 6-20 x 1250-1800 | Alchevsk metallurgical plant |
| 9 Conversion pig iron | All metallurgical plants with blast-furnace manufacture |

4 Data on output, $10^3$ t

| Product | 1992 | 1993 |
|---|---|---|
| Conversion pig iron | 1191 9 | 1003 3 |
| Steel | 1297 3 | 1129 9 |
| Rolled steel for sale | 1046 3 | 922 9 |

5 Exports

| Product | 1992 | 1993 |
|---|---|---|
| Conversion pig iron, $10^3$ t | 455 5 | 347 2 |
| Percentage of total production of iron for sale | 75 0 | 75 5 |
| Rolled steel for sale, $10^3$ t | 240 0 | 366 0 |
| Percentage of total production of rolled steel | 23 0 | 39 6 |

8 Monthly consumption of energy (August 1994)

- electric energy, $10^3$ kWh - 40,300
- natural gas, $10^3$ $m^3$ - 15,000
- blast-furnace gas, $10^3$ $m^3$ - 100,200
- coke gas, $10^3$ $m^3$ - 13,000
- masout, t - 1,300

9 Preventive repairs and overhauls are carried out in accordance with the defined schedule

10 Energy expences as the percentage of total yearly output amounted 10 43% in 1992, 18 26 in 1993 The planned value for 1994 is 38 1%

11 9400 people are working at the plant

12 Operational mode - 24 hours a day, without days off

13 In the staff schedule of the plant is a position of a chief energy engineer

14 The plant does not receive hot water from the regional heating system

Head of BNTT V I Tsukanov

## DONETSK METALLURGICAL PLANT

Boiler's characteristics

1, 2, 3 Medium pressure boilers, P = 35 kgf/cm$^2$, with natural circulation and II-shaped configuration, steam temperature 435°C, output - 75 tons/hour.

Two flat-flame burners. Gas consumption: blast-furnace gas - 40 thousand m$^3$/hour, natural gas - 4000 m$^3$/hour, coke oven gas - 2000 for each burner.

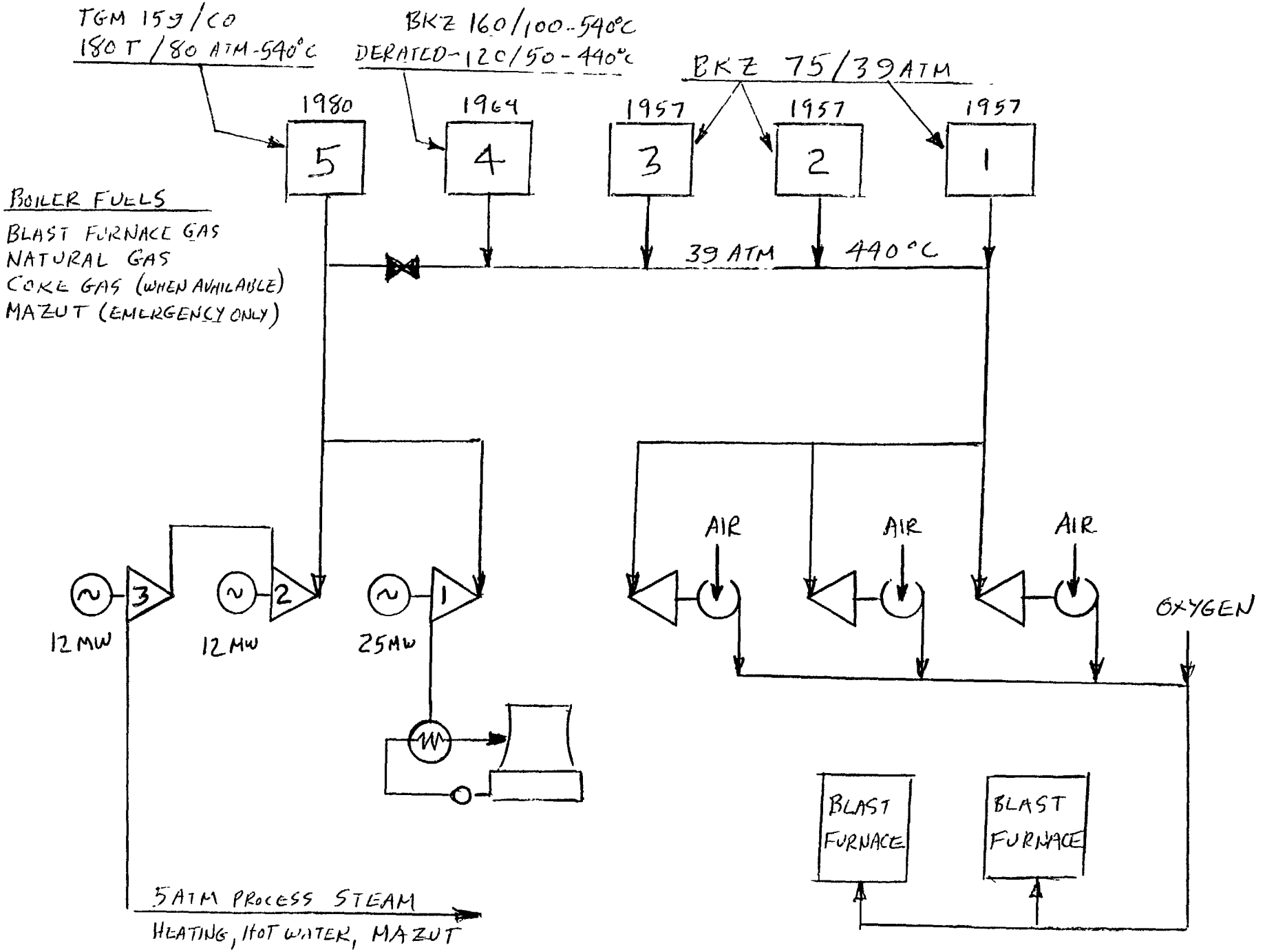
4, 5 High pressure boilers. P = 100 kgf/cm$^2$, T = 520°C, II = 160-200 tons/hour

Burners.
4 = Two flat-flame burners. Gas consumption: blast-furnace gas - 60 thousand m$^3$/hour (P = 400), natural gas - 7000 m$^3$/hour (P = 3400 mm water column).
5-8 (two layers) centrifugal burners with gas separate burning. Gas consumption. blast-furnace gas - 25 thousand m$^3$/hour (total. 25x4=100); natural gas - 4 tons/hour (total: 4x4=16 tons/hour)
Gas pressure blast-furnace gas - 400 mm water column, coke oven gas - 400 mm water column, natural gas - 3500 mm water column.

# APPENDIX I

Drawings and Diagrams

1. Schematic - Power Plant
2. Schematic - Cycle of Blast Furnace Scrubber Water
3. Flow Diagram - Power Plant
4. Flow Diagram - Boilers, Turbines/Generators and Air Compressors

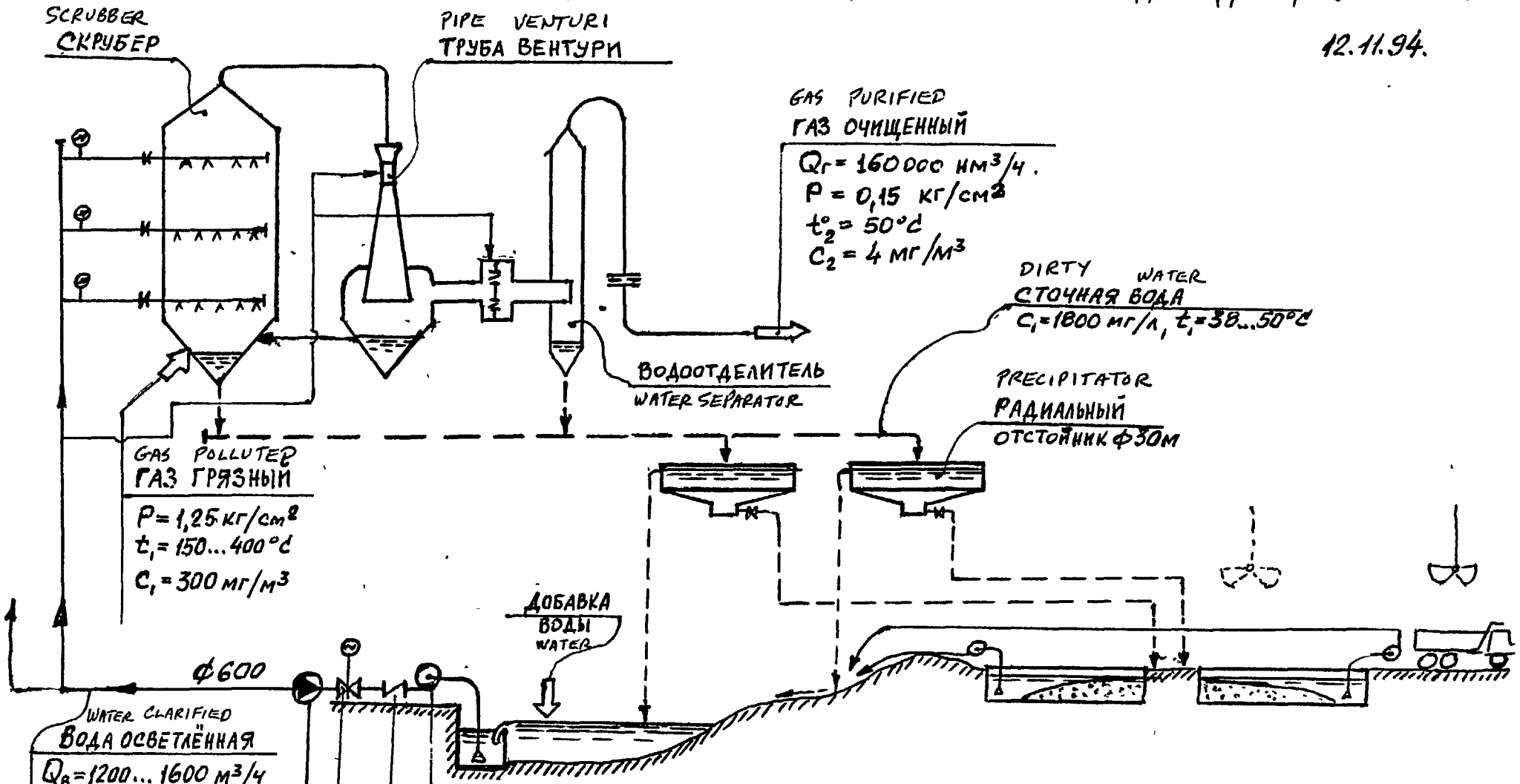



SCHMATIC - POWER PLANT

SCHEMATIC CYCLE OF WATER SUPPLY CLEANING GAS BLAST FURNACE OF PLANT IN DONETSK, UKRAINE

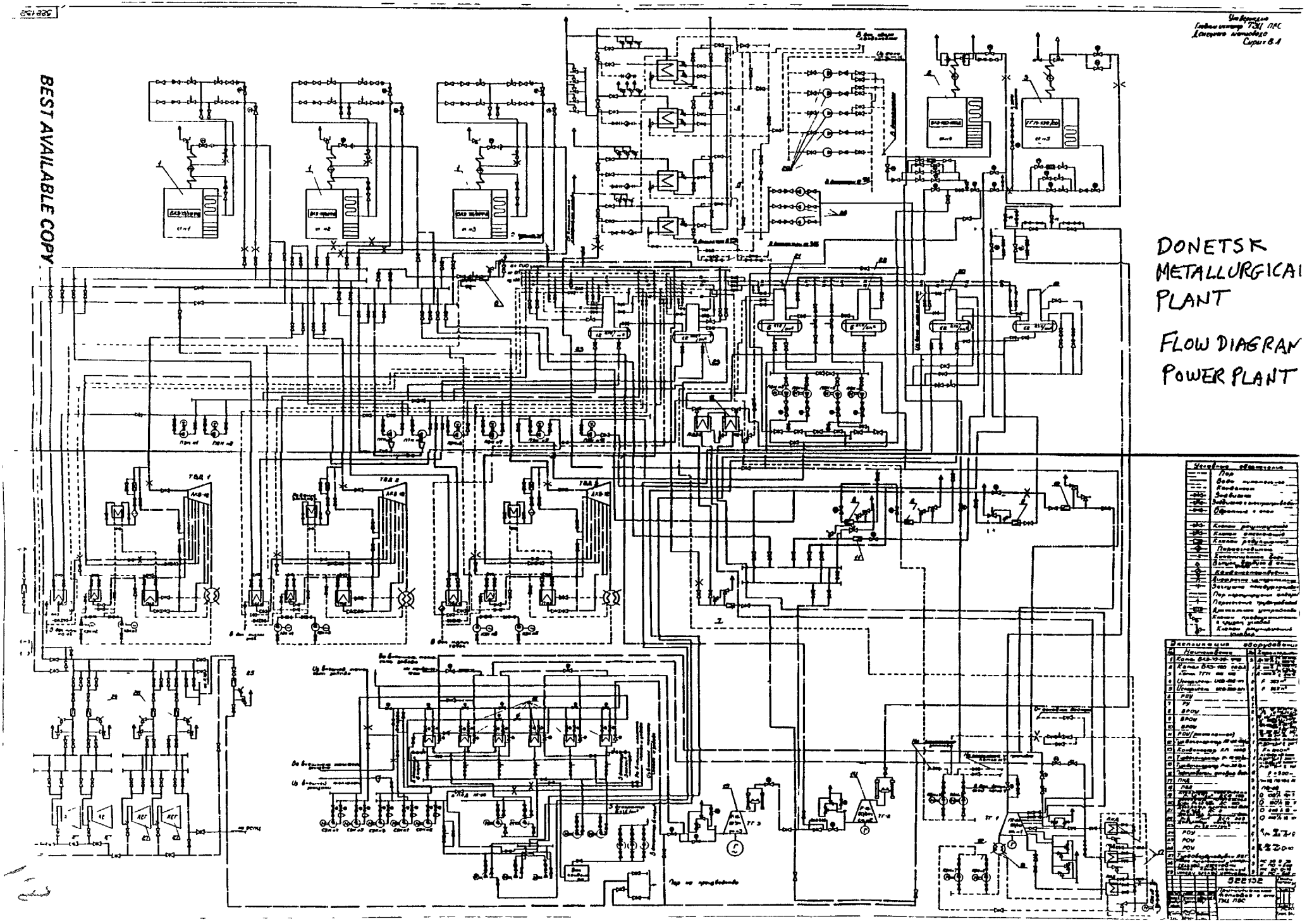
# СХЕМА ОБОРОТНОГО ВОДОСНАБЖЕНИЯ ОЧИСТКИ ГАЗА ДОМЕННЫХ ПЕЧЕЙ ЗАВОДА В ДОНЕЦКЕ. УКРАИНА.

12.11.94.




DEMAND OF THE PLANT

**Потребность завода:** ① – Насос центробежный (PUMPS CENTRIFUGAL) абразивоустойчивый (ABRASION RESISTANT) (5 единиц (UNITS)) $Q = 1200$ м³/ч, $H = 13,0$ кг/см², $n = 1480$ об/мин (RPM), эл. двиг. (MOTOR) $N = 650$ кВт (KW), асинхронный, короткозамкнутый (SQUIRLE CAGE INDUCTIO), $U = 6000$ В, $n = 1480$ об/мин. ② – Клапан обратный поворотный стальной Ду400, Ру16 кг/см² – 5 единиц ③ – Задвижка стальная с эл. приводом Ду400, Ру16 – 13 единиц. ④ – Измеритель расхода воды для трубы Ф400...600 – 10 единиц

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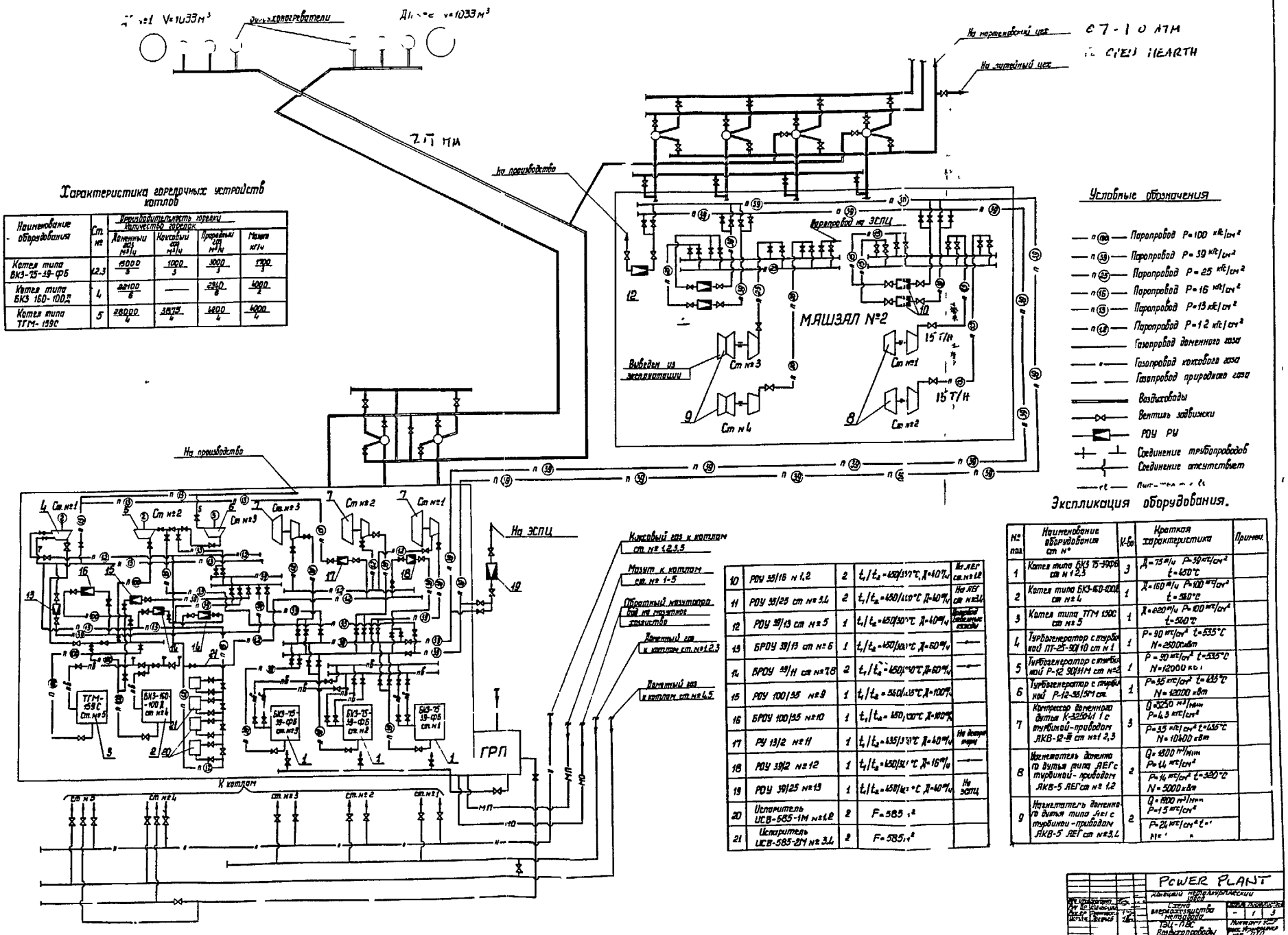


## Характеристика горелочных устройств котлов

| Наименование оборудования | Ст. № | Производительность горелки / Количество горелок: Доменный газ м³/ч | Коксовый газ м³/ч | Природный газ м³/ч | Мазут кг/ч |
|---|---|---|---|---|---|
| Котел типа БКЗ-75-39-ФБ | 1,2,3 | 15000 / 3 | 10000 / 3 | 9000 / 3 | 1900 / 3 |
| Котел типа БКЗ 160-100Д | 4 | 22100 / 6 | — | 2240 / 6 | 4000 / 2 |
| Котел типа ТГМ-159С | 5 | 28000 / 4 | 38175 / 4 | 4800 / 4 | 4000 / 4 |

## Условные обозначения

- Паропровод P=100 кгс/см²
- Паропровод P=39 кгс/см²
- Паропровод P=25 кгс/см²
- Паропровод P=16 кгс/см²
- Паропровод P=13 кгс/см²
- Паропровод P=12 кгс/см²
- Газопровод доменного газа
- Газопровод коксового газа
- Газопровод природного газа
- Воздуховоды
- Вентиль задвижки
- РОУ РУ
- Соединение трубопроводов
- Соединение отсутствует

## Экспликация оборудования.

| № поз. | Наименование оборудования ст. № | К-во | Краткая характеристика | Примеч. |
|---|---|---|---|---|
| 1 | Котел типа БКЗ 75-39ФБ ст № 1,2,3 | 3 | Д=75 т/ч P=39 кгс/см² t=450°C | |
| 2 | Котел типа БКЗ-160-100Д ст № 4 | 1 | Д=160 т/ч P=100 кгс/см² t=510°C | |
| 3 | Котел типа ТГМ 159С ст № 5 | 1 | Д=220 т/ч P=100 кгс/см² t=510°C | |
| 4 | Турбогенератор с турбиной ПТ-25-90/10 ст № 1 | 1 | P=90 кгс/см² t=535°C N=25000 кВт | |
| 5 | Турбогенератор с турбиной Р-12 90/31М ст № 2 | 1 | P=90 кгс/см² t=535°C N=12000 кВт | |
| 6 | Турбогенератор с турбиной Р-12-35/5М ст. | 1 | P=35 кгс/см² t=435°C N=12000 кВт | |
| 7 | Компрессор доменного дутья К-3250-41 с турбиной-приводом АКВ-12-II ст № 1,2,3 | 3 | Q=3250 м³/мин P=4,3 кгс/см² | |
| | | | P=35 кгс/см² t=435°C N=10000 кВт | |
| 8 | Нагнетатель доменного дутья типа АЕГ с турбиной-приводом АКВ-5 АЕГ ст № 1,2 | 2 | Q=1800 м³/мин P=4 кгс/см² | |
| | | | P=14 кгс/см² t=320°C N=5000 кВт | |
| 9 | Нагнетатель доменного дутья типа АЕГ с турбиной-приводом АКВ-5 АЕГ ст № 3,4 | 2 | Q=1900 м³/мин P=1,5 кгс/см² | |
| | | | P=24 кгс/см² t=[illegible] N=[illegible] | |
| 10 | РОУ 39/16 № 1,2 | 2 | $t_1/t_2$=450/197°C, Д=40 т/ч | На АЕГ ст. № 1,2 |
| 11 | РОУ 39/25 ст № 3,4 | 2 | $t_1/t_2$=450/110°C Д=40 т/ч | На АЕГ ст № 3,4 |
| 12 | РОУ 39/13 ст № 5 | 1 | $t_1/t_2$=450/90°C Д=40 т/ч | Резервный паропровод |
| 13 | БРОУ 39/13 ст № 6 | 1 | $t_1/t_2$=450/90°C Д=60 т/ч | — |
| 14 | БРОУ 39/11 ст № 7,8 | 2 | $t_1/t_2$=450/90°C Д=60 т/ч | — |
| 15 | РОУ 100/35 № 9 | 1 | $t_1/t_2$=540/[illegible]°C Д=100 т/ч | |
| 16 | БРОУ 100/35 № 10 | 1 | $t_1/t_2$=450/[illegible]°C Д=100 т/ч | |
| 17 | РУ 13/2 № 11 | 1 | $t_1/t_2$=435/[illegible]°C Д=40 т/ч | Не демонтировать |
| 18 | РОУ 39/2 № 12 | 1 | $t_1/t_2$=450/[illegible]°C Д=16 т/ч | — |
| 19 | РОУ 39/25 № 13 | 1 | $t_1/t_2$=450/[illegible]°C Д=40 т/ч | На ЭСПЦ |
| 20 | Испаритель ИСВ-585-1М № 1,2 | 2 | F=585 м² | |
| 21 | Испаритель ИСВ-585-2М № 3,4 | 2 | F=585 м² | |

POWER PLANT

Схема энергоснабжения металлургического завода. ТГМ-159С. Паропроводы. Воздуховоды

BEST AVAILABLE COPY

# APPENDIX J

References

1. Delivery Order No. 6 - Ukraine Energy Efficiency and Reliability
2. Energy Audit Guidelines
3. Information Request List
4. Checklist - Improving Combustion Efficiency - English and Russian
5. Energy Audit Items

## 4.3 Task 3: Industrial Energy Efficiency

### A. Introduction

The Donbass region is the industrial center of Ukraine, and it is characterized by heavy industry and coal mining. This region, in addition to its energy intensity, is known for its air pollution. The heavy industry of this region contribute a tremendous amount of pollutants into the air. The health of the industrial Donbass region is critical to the Ukraine. Efforts to improve the energy efficiency of the industrial sector in the Donbass region will have wide spread impact, notably reducing Ukraine's dependence on imported oil and gas.

The downward economic spiral has resulted in the Ukraine being unable to pay for its shipments of foreign fuel. This has resulted in reductions and/or curtailment of fuel shipments. This past winter fuel shipments were spread throughout the Ukraine in order to reduce the impact of inadequate fuel supplies. The result was shortages throughout the country. District heating systems operated at much lower temperatures than normal.

The objectives of this work are as follows:

1. Demonstrate energy saving in some of the Donbass region energy intensive industries.

2. Introduce modern energy management principles in these industries (organizations).

## B. Technical Approach

In order to accomplish these objectives, the following technical approach will be utilized:

1. The initial activity of developing energy resource flow analysis for the Donbass region will be completed. This effort will capitalize on previously established energy contacts within Ukraine and also in the Donbass region, and those individuals who will be instrumental in assisting on this activity.

2. Discussions with Ministries and regional officials will be conducted to assess potential energy conservation opportunities. The focus of this activity will be on low cost opportunities for conserving or reclaiming energy sources.

3. Criteria for plant selection will be discussed with these officials, including representatives of the Ministry of Industry and the Ministry of Energy, so that a tentative list of plants can be compiled. The Donbass region is concentrated with steel plants (foundries and production of steel), cement plants, and chemical plants. The Director for the new Energy Efficiency Center in Kiev, the Chief Engineer of Donbassenergo and others, will be consulted to select a few installations of a list of the one hundred most energy intensive plants in the Donbass region. This list will assist in identifying the appropriate facilities to audit. Many of these plants have been audited by a Ukrainian organization, the Academy for Energy Saving Problems. This data will also be available to use as a tool in selecting these plants.

4. Each of the plants identified will be contacted, and a site visit arranged to work out details of the audit. An audit schedule will be discussed with the plant management, and a work plan will be developed. Energy audit reports, including energy calculations and specifications for the equipment selected will be developed.

5. Equipment vendors will be contacted, and the equipment will be procured. Once the equipment is available, it will be shipped to each of the five audited plants. The equipment is to be installed by the recipient plants at no cost to the program or USAID.

6. Site inspection visits will be scheduled to ensure that the equipment has been properly installed. Monitoring of energy consumption and energy savings will be discussed with the plant management. Plant personnel will be asked to complete monitoring data sheets, which will be forwarded to our engineers for analysis.

7. A seminar will be conducted describing the program and illustrating the installed equipment. U.S. manufacturers and vendors will be invited to participate in the seminar to demonstrate energy efficiency equipment. Representatives of all major industries in the Donbass region and elsewhere within Ukraine will be invited.

## C. Work Plan

### Subtask 1: Regional Energy Resource Flow Analysis

A team of specialists will visit Donetsk to work with the regional and local officials to develop an energy resource flow for the Donbass region. This team will identify the energy resources and energy demands of the region. The team will also meet with officials responsible for procuring and controlling energy use. Local specialists in Ukraine will be drawn upon so that the resulting analysis can be used in a Ukrainian Institution as an ongoing and dynamic database for continuing use and update. A draft energy resource flow report and energy map will be developed.

### Subtask 2: Identification of Low Cost/No Cost Measure

A team of engineers, and analysts will travel to the Donbass region to work with Ministry of Energy and Ministry of Industry officials to identify potential low cost/no cost energy opportunities. An investment plan for the region will be developed and will be completed in the U.S.

### Subtask 3: Selection of Industrial Plants

The team identified in Subtask 2 above, will work in Donetsk with local officials to define the most energy intensive industries. The team will discuss the selection of five plants to be audited with local and regional authorities to determine a list of target plants. The selection will be based on many factors, including energy intensity, total energy consumption, viability of plant, type of fuel used, and number of similar plants. The selection process will be aimed at selecting only one plant from each industrial sector.

### Subtask 4: Gaining Access to Selected Plants

The team from Subtask 2 and Subtask 3 above, will travel to the targeted sites to discuss this project with the plant management. The team will verify that the targeted plant(s) will be a good site for this project, and then the team members will work with the plant management to coordinate a work schedule and develop a work plan.

### Subtask 5: Energy Audits

Five separate teams of engineers will travel to the Donbass region to audit the selected plants. A set of guidelines and audit standard format will be provided for the teams. Each team will be equipped with standard energy auditing equipment to conduct the audit. Each team will review the energy flows within the plant being audited; measure energy flows of selected equipment/processes; suggest improvements to plant management; and mutually

determine recommendations for energy improvements with the plant management. Energy calculations and specifications of recommended equipment will be prepared in the U.S.

**Subtask 6: Procurement and Installation**

Procurement:

A list of equipment, designed to conserve energy, will be prepared along with technical specifications and potential suppliers. Burns & Roe will procure the pre-approved list of equipment under the Core Contract provisions.

Installation:

Once the equipment has been ordered and shipped, the recipient facilities are to install the equipment. An installation oversight will be provided, as required, to ensure compatibility and proper installation practices are applied.

**Subtask 7: Monitoring and Evaluation** (SEND TO RMA)

Proper monitoring documentation will be provided for the plant operators to fill out and copies will be issued to Burns and Roe for review and information. Data received from each plant will be reviewed to determine if the data is reasonable. Any questions regarding the data will be reviewed with the plant operators/management. The data will be analyzed to illustrate the energy consumption resulting form the installed equipment. This consumption will be compared to measurements taken during the energy audit. An evaluation report will be prepared for each facility.

**Subtask 8: Workshop/Seminar**

A seminar will be conducted in Donetsk to present the energy efficiency activities in the five facilities. Each team leader will make a presentation on the work performed in their facility. Representatives of the Donbass region, including Ministry officials and audited plant management, will also make presentations. U.S. manufacturers and vendors of energy efficiency equipment will also be asked to participate. The team leaders will use part of this time to make another inspection of the installed equipment and to review its performance.

## 5.0 Schedule

The overall duration of this Delivery Order is estimated to be 12 months from authorization to proceed. Milestone schedules for each of the three tasks are provided on the following pages.

## 6.0 Deliverables

The following documents will be prepared:

Activity Implementation Plan - will cover all tasks

**Task 1:** Specifications for general hardware and instrumentation

Draft and final project report documenting:
- evidence of improved plant performance
- evidence of reduced environmental impact
- likelihood of replication to other thermal power plants
- evidence of progress in achieving expected results

**Task 2:** Specifications for energy audit equipment

Energy Audit reports for each plant

Specifications for low cost equipment

Workshop/Seminar

Draft and final project report documenting:
- evidence of improved combustion efficiency
- energy savings

**Task 3:** Specifications for energy audit equipment

Energy Audit reports for each plant

Specifications for low cost equipment

Workshop/Seminar

Draft and final project report documenting:
- evidence that modern energy management principles are in use
- energy savings



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Subtask 5: ENERGY AUDITS

Energy audits will take one week per plant

A report will be prepared outlining findings and recommendation for each plant

The report should include:

-energy calculations (results in metric and english units)

-specific actions for improved energy efficiency
    *management actions
    *low cost/no cost actions
    *recommended equipment to be procured
        + short term measures affordable by project
        + long term measures ,higher cost, large savings

-specifications for all recommended equipment

-illustrative costs for all recommended equipment

-estimated shipping costs

-simple payback analysis of each recommendation

-project interactions which may reduce savings

-submit completed audit report to Sam Gerges B&R, 4 weeks after the teams last audit is finished

-photos for report, slides for later workshop / seminar

-executive summary to be translated into Russian (Ukranian ?)

Subtask 6: PROCUREMENT AND INSTALLATION

<u>Procurement:</u>
Provide technical assistance to Glenn Fick B&R for clarifications and sorting out of:
    manufacturers options
    possible substitutes
    testing of equipment if necessary
    making necessary adjustments
    translation of manuals into Russian as required
Selection of equipment with plant accessible servicing and spares

<u>Installation:</u>
In most cases, it is expected that plant technicians will install equipment themselves with supervision by the consultant or the equipment supplier or the local representative of the supplier. If commissioning or installation assistance is required, these

costs must be included with equipment costs. One site visit after installation is to be included.

Subtask 7: MONITORING AND EVALUATION

Coordinate the monitoring of plant projects implemented. Provide data sheets as required for daily data collection.

Prepare a report including the data collected and evaluate the effectiveness of the energy efficiency gains. Include an analysis of any divergence form expected performance. This is to be used in the seminar/workshop in May of 1995.

Subtask 8: WORKSHOP / SEMINAR

Each audit team leader from B&R, Foster Wheeler, and RMA will participate in the workshop / seminar to present findings, and results from energy savings equipment implementation.

DONETSK

## INFORMATION REQUEST

Ownership of plant - 100% Government

Management Organization Chart

Raw materials, tons 1992, 1993 (ORE, SINTER, SCRAP, etc.)

Total building area, $m^2$ - Plant - 5,000,000 $m^2$

Recent building additions, $m^2$

End users of products

Export sales, % of production

Market demand for products

Maximum annual plant capacity

Present annual plant capacity

Estimated production increases or decreases

Impact of increasing energy prices on production

What are criteria for investing money for improvements

Fuel costs

Electricity costs - Power use in plant by process/product

Power input from utility

German technology blast furnace

Get copy of answers in Russian to firswt questionnaire

Brochures, description of plant

Major process equipment list with design parameters (HP, KW, fuel consumption, cooling water, etc )

Improvement and rehabilitation plans for next few years.

Water analysis and list of analytical and monitoring instruments

Boiler gas control logic schematic

List of fuels input to boilers

List of valve packing and sheet gasket sizes.

# 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

# 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

## 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)

TRIP REPORT
DELIVERY ORDER NO. 6

TASK 3: Industrial Energy Efficiency
Donetsk Metallurgical Plant
November 7-17, 1994

The Burns and Roe audit team of John E. Hallberg and Yefin Donkin arrived in Kiev, Ukraine on Sunday, 6 November and met in IDEA offices with Andriy Kononov and Tebodin to complete arrangements for travel, housing and audit equipment. Audit equipment was picked up from USAID Mission and travel to Donetsk on Tuesday took about ten hours.

On Wednesday, 9 November the audit team was unable to enter the plant due to a serious emergency in the power plant which shut down the steel mill. Later we were informed that on November 5 someone tried to cut a 6 kv cable with an axe, which started a fire in adjacent control cable trays. On 7 November several cables that run on the opposite wall of the cable channel mysteriously caught fire almost at the same time. This shut down the power plant which supplies steam, power and compressed air for operation of the mill. The Ukraine Security Agency and local police were investigating and plant security was very strict. There is a serious problem in Donetsk with theft of copper. Therefore, Wednesday was spent checking out the test equipment, making sure all batteries were charged, calibrations checked, printers operating, etc. and reviewing the manuals.

Thursday, 10 November we met with the plant Director Mr. Vladimir Tereshenko and were introduced to members of the management staff. We described the purpose and scope of the energy audit and requested the assistance and suggestions of the plant specialists. The Director gave an overview of the plant processes and operations and where their concerns are regarding energy matters. He made the point to emphasize that the power plant is the heart of the steel mill and first priority should focus on improving the efficiency and reliability of its operation.

Friday, 11 November we met with the Deputy Chief Engineer of Energy, Michael Ovsaynikov in his office in the power plant area with other specialists. We were given diagrams of the power plant boilers, turbine generators and steam turbine driven air compressors for blast furnaces. We spent the day gathering information on the interrelationship of the power plant with the steel mill for supplying power, steam, and compressed air to the plant. Briefly, there are five boilers, three turbine generators and three turbine drive air compressors. The boilers burn primarily blast furnace gas with 5-15% natural gas, and coke gas from off-site when it is available. Mazut can be burned only as emergency fuel. The plant is interconnected through the switchyard with two 110 kv transmission lines for import of utility power.

Several energy conservation opportunities were identified during our discussions, which stimulated interest and enthusiasm in the specialists to come up with other energy saving ideas in the next few days.



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On Saturday, 12 November, we met again at the power plant to recap and set the agenda for activities over the next three days. We then toured the power plant. Initial impressions were that the plant is in dire need of general clean-up and repair of broken windows, lighting, insulation and steam leaks. Out of ten zirconium probe type oxygen analyzers on boiler flue gas, only two are working with questionable accuracy. They were manufactured in Kharkov, Ukraine, experimental, and they cannot get replacement elements (probes). The oxygen analyzers are necessary for controlling excess air to boilers for efficient operation.

The existing demand metering for imported power is old and unreliable and needs to be replaced. This equipment was made in Vilnius, Lithuania. The metering is important for measuring reductions in imported power as a result of other efficiency improvements throughout the plant. They need copper wire to rewind a power transformer supplying electric arc furnaces to improve efficiency and reduce losses.

The existing natural gas control valves are operated manually to follow steam load based on steam pressure. The valves are sized for full load, and operator response plus lag time results in significant waste of natural gas due to slow closing of the large valves. The engineers estimate that natural gas consumption could be reduced by 1.5% if a smaller parallel bypass control valve is installed at each boiler.

The plant presently pays 5000 coupons ($0.04) per cu. meter of makeup water for cooling and process. This water from the river is not treated and is fed directly to the cooling tower. Sulfuric acid and a combination zinc-phosphate dispersant/corrosion inhibitor are fed to the tower. The water quality is so poor that only about 1.33 cycles is achieved in the tower. There is significant scale in condensers and heat exchangers which results in large losses of energy and waste of water which the plant must purchase. In addition, shutdowns required for removal of scale and corrosion products (from acid) results in losses of production. The cooling towers have old inefficient slat type asbestos fill which should be replaced. Drift is at least 0.5%, which is a very large loss of water. Also, spray nozzles keep getting plugged up with crud and corrosion products (rust) which results in loss of thermal efficiency.

A sample of 76mm pipe for air to water heat exchanger had 25-28mm of cementitious calcium carbonate/silica scale. It is estimated that about $90,000 per year could be saved in water costs by softening the makeup water, increasing cooling tower cycles from 1.33 to 2.5, and about $180,000 per year savings of 750 kw (3%) at $0.03/Kwh due to reduction of condenser scale.

The heating value of the natural gas is about 8000 Kcal/kg +/- 200 Kcal/kg. The laboratory takes samples to be tested in the laboratory bomb calorimeter, which is a difficult process and subject to errors. There is a need for an online calorimeter to continuously measure the heating value and specific gravity of the natural gas.

There are five 650 kw scrubber water pumps for blast furnace gas scrubbers which are subject to severe wear from abrasives. The pumps are cast iron and when new are 83% efficient but rapidly deteriorate to about 65% efficiency, which is a large loss of electrical energy for pumping. There is a need to replace this equipment. Approximately $65,000 per year in power costs could be saved at $0.03 per kwh.

On Sunday,13 November 1994 we brought the combustion analyzer, heat spy, and power analyzer to power plant to do testing. The existing zirconium probe analyzers are inserted in 90mm pipe bypass from backpass to Induced Draft (I.D.) fan suction, about 15 meters below the backpass at operating floor on each side of the boilers. There is a 25mm sample point with a pipe cap at each analyzer. The 90mm bypass lines are mostly uninsulated bare pipe which results in cooling of flue gas from 300-450 C to less than 100 C, condensing water and forming a sludge from the soot in the flue gas. This crud fouls the analyzer probes, causing corrosion and failure. It could be that the bypass lines are partially or completely plugged, with little or no flue gas passing the probes. Therefore, flue gas sampling was done at the backpass through an observation port, in an access door, on each side of the boiler. A lot of pieces of asbestos insulation and dust was everywhere around boiler platforms. Future auditor visits to old plants should bring nose breathing filters to protect from inhaling asbestos dust from broken insulation. Two efficiency runs were made on each side of divided backpass of each boiler for two fuel types - coal gas and low energy gas because of the mix of blast furnace gas and natural gas being burned. Estimated heating values of the fuels are as follows:

| | BTU/cu.ft. | Kcal/kg | Usage split |
|---|---|---|---|
| Natural gas | 1000 | 8000+/- | 5-15% |
| Coke gas | 590 | 4000+/- | Reference |
| Low energy gas | 473 | 3907 | Reference |
| Mixture | 141-212 | 1157 to 1739 | AS BURNED |
| Blast furnace gas | 80 | 700-880 | 95-85% |

The test runs for "low energy gas" are the nearest fuel setting in analyzer. The oxygen ($O_2$) and carbon monoxide (CO) readings indicate that excess air to boilers is much greater than what is required, which result in loss of combustion efficiency and waste of fuel.

The 120 Tons/Hr (T/H) boiler No. 4 (1964) was shut down due to Forced Draft (FD) fan problems. The 180 T/H boiler No. 5 (1980) had a tube leak in the generator section and no one was permitted to go near or on the boiler. This boiler cannot be shut down until boiler No. 4 is back on line because of need for power, steam and compressed air to the mill and blast furnaces.

The electrical engineer did not show up, therefore measurements could not be made on any large motors. However, we were promised data on Monday which has already been obtained. In the afternoon we met with the Deputy Chief Engineer of the power plant for further discussions. We were given a copy of the electrical one line diagram for the plant.

We were given a bleak picture of the current situation in the power plant. For the past five years the Ukraine government has not provided support or money for maintenance, spare parts and

supplies for the Donetsk Metallurgical Plant because of a belief that Ukraine did not need the steel production. The plant has deteriorated to such a point that it will require large investments of capital and manpower to bring it up to current standards of western technology. Because of the unending equipment failures, lack of spare parts and supplies, fuel shortages and low wages, employee morale is extremely low and there is massive theft of just about anything that can be removed and carried away. Today we arrived and were informed that communications in the plant was knocked out because someone had stolen a section of telephone copper cable. It is next to impossible to get anything fixed. Light bulbs, fixtures and wire are missing everywhere. They would like to obtain a few high intensity flood lights to install high up in the power plant area for security and safety, which hopefully, would make it more difficult to steal.

On Monday, 14 November 1994, we returned to the power plant for additional meetings and discussion with specialists. Many of the management people were still tied up in meetings concerning the thefts of cable. Two men who tried to cut the 6 KV cable were found in a hospital with severe electrical burns to their hands and chest.

Since about 50% of metal products are reportedly exported for hard currency, and since the plant is 100% government owned, all fuel is supplied by the government. Therefore, the impact of increasing fuel prices on production is apparently not a concern of the plant management. As the price of fuels increase, the price of export steel products are increased accordingly. However, we were told that there is a problem with "dumping" of steel products below world prices.

The plant has a detailed breakdown of energy usage for each process/product on a monthly basis. We saw the book containing this data, however, were only given a summary for 1993 and six months of 1994. They considered this detailed breakdown confidential and were concerned that it could be misinterpreted or misused.

We were given a copy of a letter from the Ukraine government inspection agency officially notifying the Donetsk Metallurgical Plant that the boilers must be upgraded because of lack of technical protection requirements required by current regulations. Basically it is a requirement for upgrading the boilers with combustion control systems, including interlocks and flame safety.

The management cannot and will not shut down the power plant, because to do so would be to shut down the mill, put 9000 people out of work and lose hard currency revenues.

In response to our repeated request over the past four days to discuss energy issues regarding steel mill processes, the engineers avoided this and kept focusing on the importance of the power plant. We were supposed to make a tour of the steel mill, but it was again put off to tomorrow.

We were given copies of boiler fuel supply logic diagrams and much discussion of fixes which could be done to improve boiler operations. The conclusion kept coming back to the need for a combustion control and flame safeguard system for the boilers.

In addition, there is a need for a portable flow meter, calibration equipment for checking transmitters, a valve repair tool kit, packing and sheet gasket materials for eliminating the numerous high pressure steam leaks everywhere. We were also given a list of instruments they need.

The engineers again questioned how to get spare parts for the equipment supplied by USAID, accuracy of equipment, how to test and how to get certification, guarantees and service. These are questions which the purchasing agent and USAID need to address during the procurement phase. Also, future auditors need some guidance on how to respond to these questions during their plant visits. These people are concerned that after a year or so, equipment will break down or need replacement parts or consumables, and it will be no better than the old Russian equipment it is replacing, trading one problem for another.

Tuesday, 15 November, 1994, we returned to the Deputy Chief Engineer's office to obtain more technical information. We were given cost for electricity, fuel and water, analysis of makeup and cooling tower water, description and parameters for some analytical instruments. Also, typical efficiency of large motors is 82-83%. There are two 10,000 KW and one 3,600 KW motors which drive the air compressors in the two oxygen plants. Also, we were given a written description of two 60 years old German air compressors for the open hearth process.

About noon we made another set of combustion efficiency runs with the Bacharach combustion analyzer because No. 2 boiler was burning only natural gas. Boiler No. 4 was shut down and No. 5 too dangerous to go near because of the boiler tube leak.

In the afternoon we went to the main administration offices to try to obtain the additional production data and cost, rehabilitation plans, organization chart, etc. on our information request list. After a run-around and much resistance, Yefin Donkin was fortunate to find the right person, and we were given all the above plus a copy of their 15 year strategy plan "Concept of the Donetsk Metallurgical Plant Development" for rehabilitation and production growth (Appendix H) which has been translated.

Our observation about the senior management attitudes toward us, and American interest in their problems and desire to provide support, is an attitude of skepticism bordering on outright hostility from some individuals.

The last person we met, who openly provided us with so much valuable information at the last minute was Mr. Vladislav Tsukanov, summed up the attitude we sensed from most of the people we met. "What are you doing here? Why do you need all this information?"

We were informed that they are paying hard currency to a German company for design development of new technology. Japanese were interested, Italians and Germans were interested. "Why did not any American companies show interest? Many foreign companies are showing a lot of activity not only in Donetsk, but other steel mills."

"Is American technology behind European, do they not have anything to offer?" Bids from 2 German, 1 Italian and 1 Russian company have been received for new continuous steel making process.

The following Summary Meeting Agenda was discussed on the last day of the plant to go over the preliminary recommendations for energy conservation equipment and subsequent schedule.

**LAST DAY**
**SUMMARY MEETING AGENDA**
**Tuesday, November 15, 1994**

1. Present recommendations list based on our observations and discussions with specialists, obtain agreement.

2. Specifications for recommended items (plant).

3. Procurement (BRC and USAID).

4. Installation trip after delivery (BRC).

5. Seminar - May, 1995 (Possibly in Kiev). USAID, Consultants, Western Vendors, Plant Specialists.

6. Plant Specialists Audit Program (Plant).

7. Follow-up trip to obtain efficiency data.

8. Receive requested information from plant.

9. Final report to USAID, Plant, Ministry, etc.

10. Closure/Departure

## DONETSK METALLURGICAL PLANT

### PRELIMINARY RECOMMENDATIONS FOR ENERGY CONSERVATION EQUIPMENT

1. Portable combustion analyzer with spare cells ($O_2$, CO, $CO_2$-NDIR, $NO_x$, $SO_2$).

2. Laptop computer with spare battery and software and Russian fonts, portable printer, spare cartridge, and 220V chargers.

3. Demand meters for import power.

4. Valve repair tool kit.

5. Valve packing 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 30 mm

6. Instrument calibration equipment.

7. Portable flow meter for water lines.

8. Oxygen sensors for boilers (10 required).

9. Boiler natural gas bypass control valves (1500 $Nm^3/H$, 3000 mm $H_2O$), 5 required.

10. On-line gas calorimeter. ($Kcal/Nm^3$, Sp. Gr., Wobbe index)

11. Analytical instruments for water and gas laboratory.

12. Copper wire for transformer rewind.

13.* Sodium softener for cooling water make-up.

14.* Combustion control/flame safeguard - 5 boilers.

15.* Corrosion resistant pumps and valves for blast furnace gas scrubbers.

*Note: These items are long term improvements requiring larger expenditures for large savings.

# APPENDIX K

Vendor Information

## DELIVERY ORDER NO. 6 - TASK 3: INDUSTRIAL ENERGY EFFICIENCY

### TYPICAL RECOMMENDATIONS FOR ENERGY CONSERVATION EQUIPMENT

1. Portable combustion analyzer with spare cells ($O_2$, CO, $CO_2$-NDIR, $NO_x$) w/ 11" and 24" probes.

2. Laptop computer with spare battery and software, Russian fonts, portable printer, spare cartridge, and 220V chargers and carrying case.

3. Oxygen sensors for boilers.

4. Portable sonic flowmeter for water (pump) flow testing and cooling system balancing

5. Sonic transit time flowmeters for mazut and water

6. Valve repair tool kit (metric).

7. Valve gland packing material

8. Instrument calibration equipment· Portable field pressure standard
   Dead weight tester

9 On-line gas calorimeter (Kcal/Kg, Sp Gr.)

10 Demand meters for imported power

11. Analytical instruments for water, gas, oil and fuels.

12. Ash, moisture and weight analyzer for coal (dual gamma Cesium and Americium)

13 Field instruments for monitoring (auditing) and controlling flow, temperature, level, quality and consumption of water, condensate, feedwater and fuel.

## PORTABLE COMBUSTION ANALYZER

($O_2$, CO, $CO_2$ - NDIR, $NO_x$, $SO_2$)

| | |
|---|---|
| Bacharach<br>625 Alpha Drive<br>Pittsburgh, PA 15238 | 412-963-2109 Tel<br>412-963-2640 Fax<br>Bill Sponn, P E.<br>Engineering Manager |
| Cosa Instrument Corporation<br>55 Oak Street<br>Norwood, NJ 07648 | 201-767-6600 Tel<br>201-767-6804 Fax<br>Sheila Zilocchi |
| Enerac<br>Energy Efficiency Systems, Inc.<br>1300 Shames Drive<br>Westbury, NY 11590 | 516-997-2100 Tel.<br>516-997-2129 Fax<br>Ray Gorman |
| Nova Analytical Systems, Inc<br>1925 Pine Avenue<br>Niagra Falls, NY 14301 | 716-285-0418 Tel<br>716-282-2937 Fax<br>Jim McPherson |
| IMR Environmental Equipment, Inc<br>5401 Central Ave<br>St Petersburg, FL 33710 | 813-328-2818 Tel<br>813-328-2826 Fax<br>Paul Sadwick |
| West Mark Sales, Inc (Rep)<br>2330 Westwood Blvd., Suite 100<br>Los Angeles, CA 90064 | 310-474-8211<br>310-470-1277<br>Lars G Wikblad |

## INSITU FLUE GAS OXYGEN MONITORS
(Zirconium Oxide)

| | |
|---|---|
| Ametek<br>Thermox Instrument Div.<br>150 Freeport Road<br>Pittsburgh, PA 15238 | |
| RC Hoffman Co., Inc. (Rep.)<br>2272 E. Walnut Street<br>P.O. Box 5766<br>Pasadena, CA 91117-0766 | 818-568-9211 Tel<br>818-568-9228 Fax<br>Chet Reynolds<br>714-643-0831 Tel. |
| Rosemount Analytical, Inc.<br>1201 North Main Street<br>P.O Box 901<br>Orrville, OH 44667-0901 | 216-682-9010 Tel<br>216-684-4458 Fax<br>Julie Wertz |
| Cosa Instrument Corporation<br>55 Oak Street<br>Norwood, NJ 07648 | 201-767-6600 Tel.<br>201-767-6804 Fax<br>Sheila Zilocchi |
| Mensco, Inc. (Rep )<br>250 S. Paseo Sonrisa<br>P O Box 694<br>Walnut, CA 91789 | 909-598-1061 |
| Panametrics, Inc.<br>221 Crescent Street<br>Waltham, MA 02154 | 617-899-2719 Tel.<br>617-899-8582 Fax |
| Westmark Sales, Inc (Rep )<br>2330 Westwood Blvd.<br>Suite 100<br>Los Angeles, CA 90060 | 310-474-8211 Tel.<br>310-470-1277 Fax<br>Lars Wikblad |
| Zircoa<br>31711 Solon Road<br>Solon, OH 44139 | 216-349-7220 Tel.<br>216-248-8864 Fax<br>Heidi Carson |
| Industrial Automation Group<br>Walnut, CA | 909-399-5234<br>Ron Henson |

## FUEL GAS MONITORS

(On-line Calorimeters - Kcal/Nm$^3$, Sp Gr., Wobbe Index)

| | |
|---|---|
| Cosa Instrument Corporation<br>55 Oak Street<br>Norwood, NJ 07648 | 201-767-6600 Tel.<br>201-767-6804 Fax<br>Sheila Zilocchi |
| Mensco, Inc. (Rep.)<br>250 S. Paseo Sonrisa<br>P.O. Box 694<br>Walnut, CA 91789 | 909-598-1061 |

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| | |
|---|---|
| Fluid Data Inc.<br>1201 N. Velasco<br>Angleton, TX 77515-3099 | 409-849-2344 Tel.<br>409-849-2166 Fax<br>Sharon Palmer |
| H.P. Liske Co. (Rep.)<br>P.O Box 80186<br>San Marino, CA 91118 | 818-441-4190 Tel.<br>818-441-2723 Fax<br>Herb Liske |

---

| | |
|---|---|
| Process Analyzers, Inc.<br>231 Lower Morrisville Rd.<br>Fallsington, PA 19054 | 215-736-2596 Tel.<br>215-736-8194 Fax<br>Harold V Carter |

## COAL ANALYZERS
ASH, MOISTURE AND WEIGHT

NEUTRON ACTIVIATION (Californium 252) Ultimate & Mineral

| | |
|---|---|
| Gamma-Metrics<br>5788 Pacific Center Blvd.<br>San Diego, CA 92121 | 619-450-9811 Tel<br>619-452-9250 Fax<br>Richard A. Kahn<br>Richard Woodward |

---

DUEL GAMMA ASH GAUGES
RADIOACTIVE ATTENUATION - (Cesium & Americium)
Microwave - Moisture

| | | |
|---|---|---|
| 1. | Berthold Systems, Inc.<br>Hopewell Business & Industrial Park<br>101 Corporation Drive<br>Aliquippa, PA 15001-4863<br>(Made in Germany) | 412-378-1900 Tel<br>412-378-1926 Fax<br>David Strelic, VP Sales |
| 2. | Process Technology, Inc.<br>2769 East Fourth Avenue<br>Colombus, OH 43219 | 614-252-9583 Tel<br>614-253-9652 Fax<br>Mel Laurlia - Sales<br>Robert Brown - V.P. |
| 3 | Energy Technololgies, Inc.<br>127 Perimeter Park Drive<br>Knoxville, TN 37922<br>"Coal Scan" (Ref. SAIC Development) | 615-690-1838<br>615-690-2119<br>David Swindle |

## NON-INVASIVE FLOW METERS
SONIC TRANSIT TIME AND DOPPLER

| | |
|---|---|
| Parametrics, Inc (Transit Time)<br>221 Crescent Street<br>Waltham, MA 02254 | 617-899-2719 Tel.<br>617-894-8582 Fax |
| West Mark Sales, Inc. (Representative)<br>2330 Westwood Blvd., Ste. 100<br>Los Angeles, CA 90064 | 310-474-8211 Tel.<br>310-470-1277 Fax.<br>Lars Wikblad |
| Polysonics Inc. (Doppler)<br>10335 Landsbury, Ste. 300<br>Houston, TX 77099 | 713-530-0885 Tel.<br>713-498-7721 |
| Patten Corporation (Representative)<br>10851 Bloomfield<br>Los Alamitos, CA 90720 | 714-821-6640 Tel.<br>213-594-0318 Fax.<br>Dave Davis, Doug Welsh |
| Badger Meter, Inc (Transit Time)<br>Industrial Division<br>6116 E. 15th Street<br>Tulsa, OK 74112 | 918-836-8411 Tel.<br>918-832-9962 Fax.<br>Craig Stewart |
| Ponton Industries, Inc.<br>Sante Fe Springs, CA | 310-945-1621<br>Ross Doty |
| Dynasonics, Inc.<br>3535 S W. Corporate Parkway<br>Palm City, FL 34990 | 407-286-9933 Tel.<br>407-287-0011 Fax<br>Brandon Keough |
| Controlotron Corp.<br>155 Plant Ave.<br>Hauppauge, NY 11788 | 516-231-3600 Tel.<br>516-231-3334 Fax<br>Laura Hines |
| Fountain Valley CA | 714-827-8489<br>Al Miatello, Regional<br>Sales Manager |
| RPS Industries<br>Santa Fe Springs, CA | 310-921-7200 Tel. |
| TN Technologies, Inc<br>P.O. Box 800<br>Round Rock, TX 78680 | 512-388-9100 Tel.<br>512-388-9200 Fax<br>Rick Golden, Regional<br>Sales Manager |
| RM Controls<br>Santa Fe Springs, CA | 310-946-0767 Tel.<br>310-946-2776 Fax<br>Chuck Ratcliff |

## FUEL LABORATORY INSTRUMENTS

(Calorimeters, Gravimetric, Elemental, Ir)

| | |
|---|---|
| Leco Corporation<br>3000 Lakeview Avenue<br>St. Joseph, MI 49085-2396 | 616-983-5531 Tel.<br>616-983-3850 Fax<br>Jerry L. Bergenhagen |
| Parr Instrument Company<br>211 Fifty Third Street<br>Moline, IL 61265 | 309-762-7716 Tel.<br>309-762-9453 Fax<br>Thomas G. Tingle, Jr. |
| Preiser Scientific<br>94 Oliver Street<br>P O. Box 1330<br>St. Albans. WV 25177-1330 | 304-727-2902 Tel.<br>304-727-2932 Fax<br>Chris Cline |

# ENERAC™ 2000

## A new generation in combustion management

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# ENERAC 2000

The Enerac 2000 represents a new generation in integrated combustion management. Its unique modular design provides the flexibility to select the optimum combustion analyzer to meet every need For the first time, the capabilities of a comprehensive combustion analyzer can be expanded with add-on communication, environmental (NOX–SO2), and data modules.

All the modules can be purchased with the unit or quickly field installed when needed Each is priced well within the budgetary authority of most combustion managers Enerac 2000, an integrated combustion management tool that will

- Improve Plant Performance
- Increase Safety
- Save Fuel

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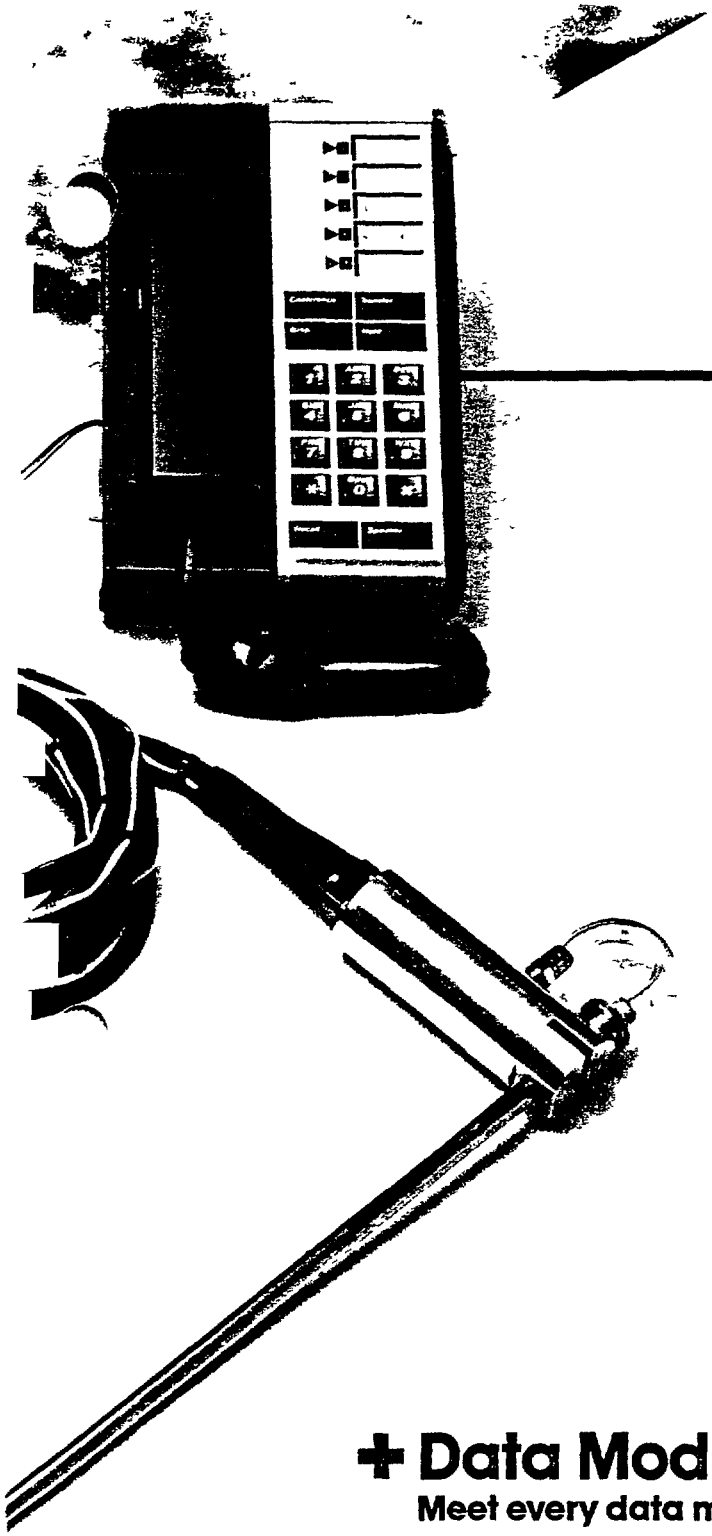


**Interface Computers Direct or Via Telephone Modem**

# + Communication Module:

## Meets the needs of a computerized world.

### Computer Interface:

A unique feature of the Enerac 2000 is the ability to communicate with computers directly through an RS-232 port or remotely via an internal modem The 2000 can be monitored and operated from across the room or across the country.

Remote operation gives the combustion manager instant access to data, integrated program management and improved productivity When added to the 2000's comprehensive testing capabilities, the combustion manager has access to a level of information never before available.

### Factory Testing:

Another key advantage of the Enerac 2000 is remote *factory testing** With a simple phone call, the Enerac 2000 can be *factory tested* to insure it is working properly The results of the *test* will be printed by the unit In essence, the factory has come to the shop floor

For the first time, a user can have the same reliability in a portable analyzer that one expects from expensive permanently installed equipment The combustion manager can now be sure that routine testing programs will be carried out .accurately

# + Data Modules

## Meet every data management need

### Printer:

An easy to read 4 inch printer, allows all current and stored test data to be retrieved and documented instantly A permanent record is always available

Serial #12345
ENERAC MODEL 2000
Combustion Test Record

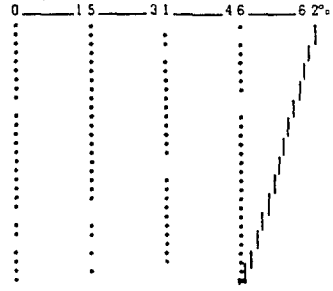
FOR YOUR COMPANY
TIME 12 41 35
DATE 08/05/87
FUEL #6 OIL 18660 BTU/LB

| | |
|---|---|
| AMBIENT TEMPERATURE | 80°F |
| STACK TEMPERATURE | 590°F |
| OXYGEN | 10 0% |
| CARBON MONOXIDE | 20 PPM |
| CARBON DIOXIDE | 8 6% |
| COMBUSTIBLE GASES | 0 02% |
| COMBUSTION EFFICIENCY | 76 5% |
| STACK DRAFT (INCHES $H_2O$) | -01 2 |
| EXCESS AIR | 86% |
| OXIDES of NITROGEN | 40 PPM |
| SULFUR DIOXIDE | 150 PPM |
| CARBON MONOXIDE ALARM | 50 PPM |

TEST PERFORMED BY

Serial #12345
ENERAC MODEL 2000
Combustion Test Record

DATE 10/08/87 OXYGEN TIME 12 16 13
SCALE 3 TIME 1 SEC
0 ——— 1 5 ——— 3 1 ——— 4 6 ——— 6 2%



# + NOX and SO2 Environmental Modules:

**Meet the needs of a sensitive environment.**

Environmental concerns are fast becoming an important factor in combustion management. New regulations are being added daily Inexpensive and easy to install NOX and SO2 Modules can provide the combustion manager with reliable testing capability Base line information of a plant's performance can be developed so there are no surprises When the need arises, help is only a module away

The Enerac 2000 is designed to be as advanced in the year 2000 as it is today Let us show you how it will make a difference. Contact us now for more information, and to arrange a demonstration. Call today at:

**1-800-695-3637**

**Plotter:**

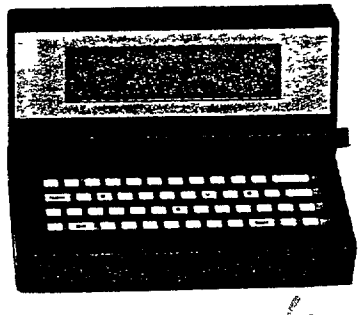
With the press of a single button the combustion manager can capture a record of any parameter vs time (three scales & 59 time intervals) An unbelievably convenient tool for problem solving, making adjustments, or recording performance

**Data Storage:**

This option allows the combustion manager to store the results of up to 99 complete tests, one a week for an entire year, or every service call for a month. A two digit boiler identification number is also provided All stored data can be printed or sent to a computer—even over the telephone. Now test results can be easily saved and communicated.

**Micro-Computer:**

An optional pocket computer which fits into the unit's cover brings additional capabilities to the field Data can be stored, logged, analyzed and integrated Custom software is available



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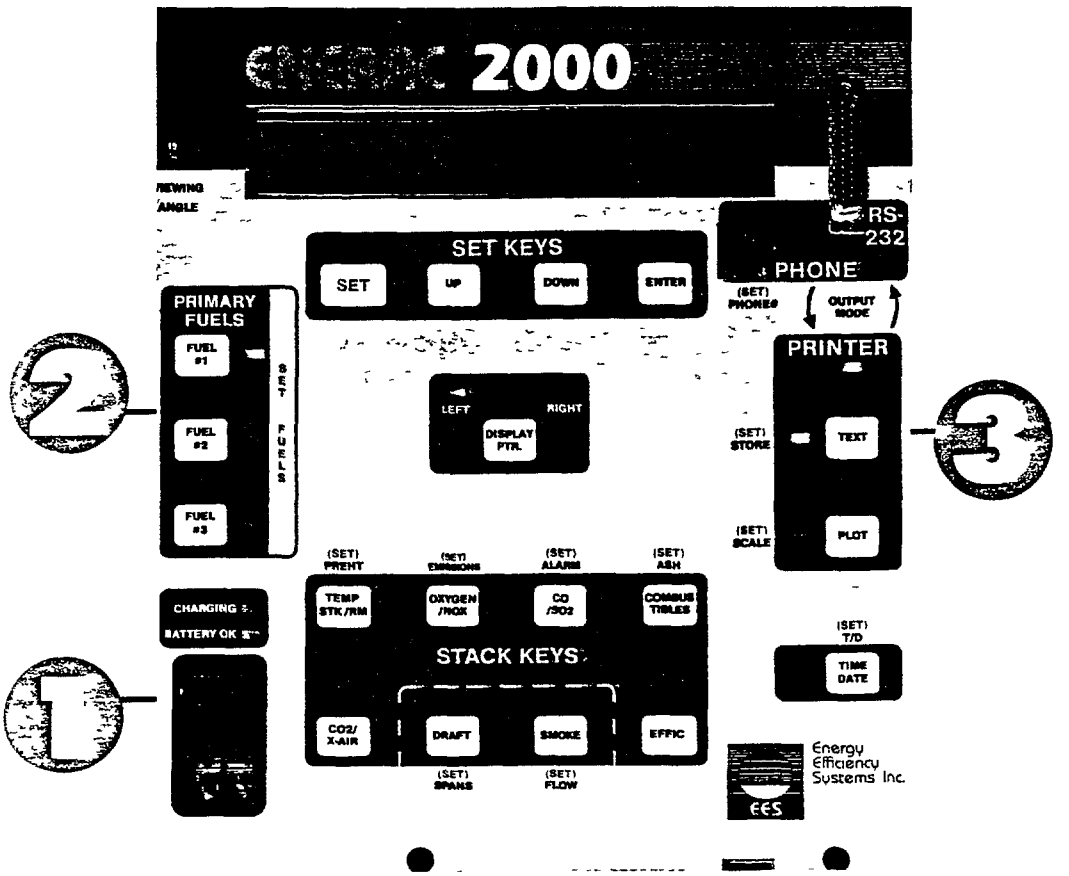
# Comprehensive Combustion Analyzer

Oxygen, carbon monoxide, combustibles, three factor efficiency calculation, RS-232 port, backlit display, calculated excess air, calculated $CO_2$, stack and ambient temperatures, pre-heat compensation, adjustable CO alarm, 15 fuels, time & date, combustibles in ash, inconel probe, up to 2000°F (1093°C) readings, high capacity water trap, draft test, smoke test, auto-calibration, anti-theft software, etc

## ✚ PLUS




### Easy to Use

Simple three button operation

1. On
2. Fuel
3. Text

### Reliable

- Self diagnostics
- Help messages
- Auto-calibration
- Auto-notice of routine maintenance
- Auto-span gas & draft calibration

### Expandable

- Add-on modules
- Programmable fuels
- Computer ready

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## MEASURED PARAMETERS

| | Range | Resolution | Accuracy |
|---|---|---|---|
| [illegible] | 0–150° F | 1° F or C | 3° F |
| [illegible] | 0–2000° F (–1000° C) | 2° F (1° C) | 5° F |
| [illegible] | 0–25% | 0.1% | 0.2% |
| [illegible] | 0–2000 PPM | 1 PPM | 5% of reading |
| [illegible] | 0–2000 PPM | 1 PPM | 5% of reading |
| [illegible] | 0–2000 PPM | 1 PPM | 5% of reading |
| [illegible] | 0–2 50% | 0 01% | 10% of reading in CH4 gas |
| [illegible] | +10 0 to –40 0" water | 0.1" water | 5% of reading |
| [illegible] | Smoke spot method, 0–9 smoke numbers in unit increments Automatic timing | | |
| [illegible] | Time in hours, minutes, seconds. Date in month, day, year format | | |

## COMPUTED PARAMETERS

| | Range | Resolution | Accuracy |
|---|---|---|---|
| [illegible] | 1–100% | 0 1% | (4 loss) 1% (above condensation) 2% (below condensation) |
| [illegible] | 0–40% | 0 1% | 5% of reading |
| [illegible] | 0–1000% | 1% | 10% of reading |
| [illegible] | 0–2000 MG/M3 0–10#/MBTU | 1% 0 001% | 5% of reading |

## MODEL 2000 SPECIFICATIONS

**PHYSICAL:**

1 Case 18" x 13" x 6" Aluminum case with lock Weight 15 lbs
2 Probe 13"L x 3/8"OD Inconel probe with aluminum handle and 10' hose std (Other sizes optional)

**ELECTRICAL:**

1 Battery 6V rechargeable cell 4 hour continuous operation on batteries Quick 4 hour recharge
2 AC 120V 60 Hz std (220V 50 Hz optional) 1A

**DISPLAY:**

0 5" High by 24 Character single line LCD with backlight illumination and adjustable viewing angle

**PRINTER.**

4" wide, 40 char per line thermal printer with form feed and line feed buttons and end of paper override Operates in any of three modes

1 Text Mode 25 line printout of current values of all measured parameters (time req 20 sec )
2 Plot Mode Any one parameter vs time plotted, 3 ordinate scales full, half, quarter Time scale Selectable, 1 sec/dot-1 min/dot in 1 sec/dot intervals
3 External Print Mode Prints messages sent via RS-232 port

**STORAGE:**

Internal 99 individually selectable buffers hold one complete set of measurements each, including boiler identification number, in non volatile memory Buffer contents can be sent to printer, RS-232 port or modem

**MICRO-COMPUTER:**

Accessory micro-computer can store up to 300 measurements in non volatile memory

**COMMUNICATIONS:**

1 RS-232 Port 1200 baud, 1 start bit, 8 bits, 1 stop bit, no parity
2 Modem Internal 1200 baud auto-answer modem connects to any modular phone line for remote communication

(A 50 word command set sends instructions to the unit for remote control and trouble-shooting)

**MISCELLANEOUS:**

1 Fuels 15 fuels, 3 in foreground, 12 in background standard Custom fuels available on request
2 CO Alarm Selectable 0-2000 PPM in 10 PPM steps
3 Combustibles in ash Presettable 0-100% in 5% steps
4 Messages One hundred diagnostic and help messages
5 Calibration Autozero on start up Soft ware span calibration CO, NOX, SO2 combustibles and draft

*Factory Testing–Available Spring 198

Energy Efficiency Systems, Inc.
1300 Shames Drive
Westbury, New York 115
(516) 997-2100 • Toll Free 1-800-695-363
FAX 516-997-2129

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# Burns and Roe Company

800 Kinderkamack Road
Oradell, NJ 07649
Phone: (201)265-2000

Reply Fax: (201)986-4294

Date: 12/2/94

W O. No. 5906-03

| To | From: |
|---|---|
| JOHN E. HALLBERG<br>(714) 828-7007 | YEFIM DONKIN |

Subject: .
KWATT/KVARHOUR METERS

Number of Pages (including this page): 2

Please find attached the fax from Byran Laboratories They offered us ABB KWH KVAR meters

The technical data of these meters are follows

Bi-directional, three phase, four wire, 120 V AC ( Plant potential transformers are rated 6 KV 120V) 5A ( Plant current transformers rated 5A on secondary ) 50 HZ meters

The meters have an accuracy - 0 5 (0 5%) and KYZ output The KYZ output will allow to interface with plant digital control system ( a system like SKADA)

We can assume that at least 30% of the existing plant meters don't work because of the shortage of spare parts, and all other meters have an accuracy - 1 (1%)

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Pyram Laboratories Est 1910
1111 East Second Street, Plainfield, New Jersey 07062 • 908-561-1020 • Fax: 908 561 1604 • 800-766-1212

# FACSIMILE IDENTIFICATION SHEET

TO YEFIN DONKIN DATE 12-6-94

COMPANY FAX # 201-986-4294

FROM BRIAN PAGE 1 OF 6

SUBJECT PFQ KWH METER/KVARH METER

MESSAGE-COMMENTS

ATTACHED ARE SPECIFICATION SHEETS
FOR OUR Model AIR-KWH-KVAR/HOUR METER
3Θ4W 120VAC + 5AAC INPUT
TELL US THE PT RATIO + CTRATIO THAT
YOU WILL USE SO THAT WE CAN CALIBRATE
THE UNITS CORRECTLY
PRICES BASED ON TEN (10) UNITS $859.50 each
WITH KYZ OUTPUTS - YOU DESIGNATE NEEDS
WHEN ORDERING PULSES PER REV KWH or
KVAR/PULSE. NOTE BI-DIRECTIONAL SPECS

Delivery 6 weeks ARO

OCALA, FLORIDA 32674 4101 S.W. 34th Avenue, Suite 905-333 • 904-365-2590 • Fax 904-365-9879

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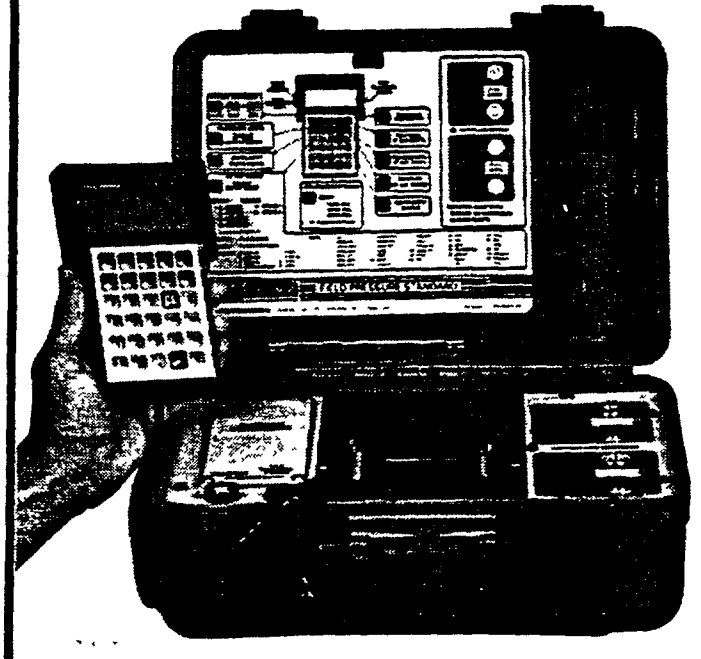
DEADWEIGHT

$3000 - 8000

PORTABLE

$5000 - 7500

# Do you perform high accuracy pressure calibrations in the field?



*Now you have a choice.*

*You can buy 2 portable dead weight testers or a **MENSOR Field Pressure Standard.** You can move up to advanced technology or just stick with the old.*

*You do have a choice, so choose wisely – choose **MENSOR!***

- ☑ Dual Range
- ☑ Accuracy to 0.01% FS
- ☑ Ranges to 6,000 psi
- ☑ Absolute & gauge
- ☑ Battery powered
- ☑ Hand held terminal
- ☑ Weather resistant case
- ☑ Serial computer interface

**1-800-984-4200** x 13 DORY

**MENSOR CORPORATION**
**SAN MARCOS, TEXAS**

mensor

**512-396-4200**
**FAX 512-396-1820**

Circle 5 on I&CS Reader Service Card



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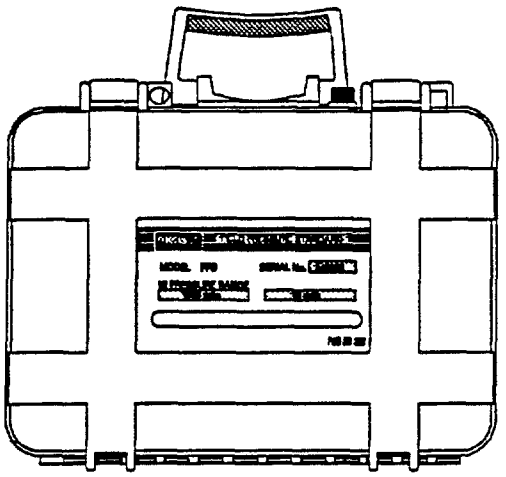
mensor

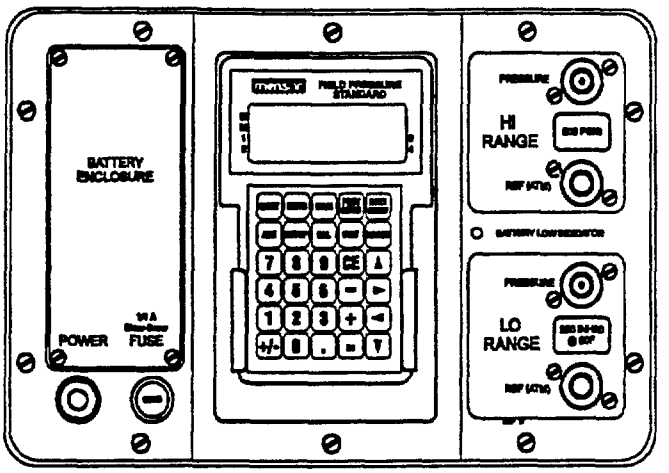
PRECISION INSTRUMENTS & SYSTEMS

**ADVANCE PRODUCT RELEASE**

JUNE 1, 1994

# *SERIES 5000*
# *FIELD PRESSURE STANDARD*






## FEATURES

* Dual Range
* Ranges fro 10 inH20 to 6,000 psi
* Absolute, Gauge or Sealed Gauge
* Battery Powered
* 0.025% FS Accuracy (optional 0.01% FS)
* Weather Resistant Case
* Hand-held Terminal
* Serial Computer Interface

The Mensor **Series 5000 Field Pressure Standard** (FPS) high accuracy pressure measurement from the lab to the field. The FPS was specifically designed for field or plant use in applications requiring two different pressure ranges for calibrating transducers, transmitters and other pressure devices without removal from the field or plant location. The rugged, weather resistant case, internal battery, and hand-held display terminal make the FPS ideal for portable calibration applications. The LCD display, incorporating adjustable back lighting, can be viewed in all levels of ambient light. A user friendly menu makes learning to use the FPS a simple process for the operator.

For more information call **1-800-984-4200**

MENSOR CORPORATION • 2230 IH-35 SOUTH • SAN MARCOS, TX 78666 • 512-396-4200 • FAX 512-396-1820

mensor

PRECISION INSTRUMENTS & SYSTEMS

# SERIES 5000 FIELD PRESSURE STANDARD

Domestic Price List
PL5000A
Effective June 1, 1994

| Configuration | Ranges | Base Price |
|---|---|---|
| | | 0.025% FS |
| Gauge / Gauge | 15 psi to 1000 psi | $ 4,975.00 |
| Gauge / Absolute | 15 psi to 1000 psi | $ 4,975.00 |
| Absolute / Absolute | 15 psi to 1000 psi | $ 4,975.00 |

To order special ranges and / or the optional 0.01% FS accuracy, include the price adder from the chart below for each transducer. Specify the range and accuracy of both transducers.

**Example:**

Base Price.....$4,975.00
with 5 psig transducer at 0.010% FS.....575.00
with 3000 psia transducer at 0.025% FS.....400.00
Total $5,950.00

| Transducer | Range | Price Adder | |
|---|---|---|---|
| | | 0.025% FS | 0.010% FS |
| Gauge | 0.36 to < 1 psi | $650.00 | Note 1 |
| Gauge | 1 psi to < 15 psi | $350.00 | $575.00 |
| Gauge | 15 psi to 1000 psi | N/A | $325.00 |
| Gauge | >1000 psi to 1200 psi | $100.00 | $200.00 |
| Absolute | 15 psi to 1000 psi | N/A | $325.00 |
| Abs. or Sealed Gauge | 1500, 2000 or 2500 psi | $250.00 | Note 1 |
| Abs. or Sealed Gauge | 3000 psi | $400.00 | Note 1 |
| Abs. or Sealed Gauge | 5000 psi | $550.00 | Note 1 |

Notes:

1. Consult factory for more information.
2. Specify absolute, gauge or sealed gauge on each transducer.

MENSOR CORPORATION • 2230 IH-35 SOUTH • SAN MARCOS, TX 78666 • 512-396-4200 • FAX 512-396-1820

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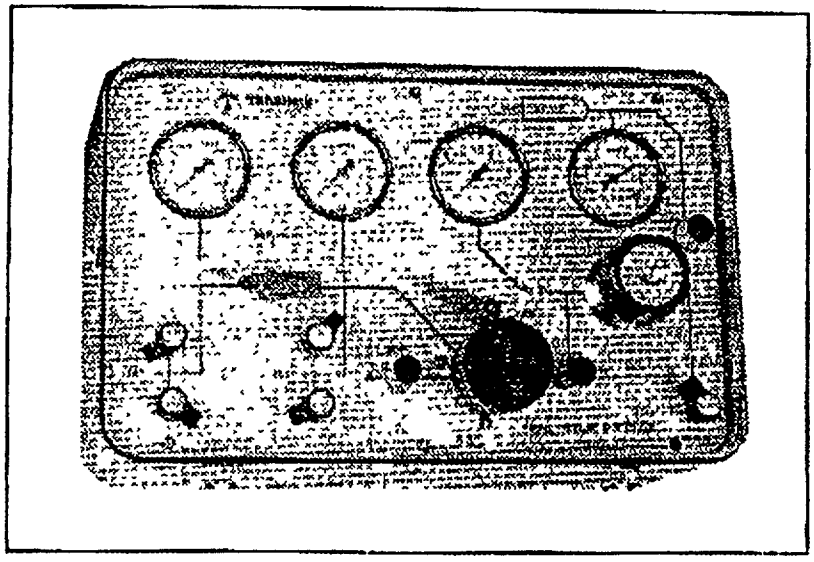
COSA

# Differential Pressure Generator Model 9100



RECEIVED
DEC 22 19
ISOLINE
PACIFIC CO. CAL

- Static pressure to 3000 psi
- Differential pressure to 300 psi

The model 9100 is a pneumatic pressure generator capable of producing differential pressure at static pressures to 3000 psi. The 9100 is used to calibrate differential pressure sensors at their actual working static pressure thus eliminating zero drift. The unit consists of a gas storage bottle, a pressure regulator and control values for generating static line pressures. When the static line pressure is stable differential pressure can be generated by means of a high pressure volume controller.

Monitor gauges display storage bottle pressure, regulated pressure and high and low line pressures.

The model 9100 was designed to be used in conjunction with the 2090 DP differential pressure indicator

The 9100 can be used with the enclosed storage bottle or an external source for large volume applications.

# Specifications: Model 9100

| | |
|---|---|
| **Operating Pressure:** | Line pressure 0 - 3000 psi |
| | Differential pressure: 0 - 300 psi |
| **Monitor Gauges:** | 4 pcs |
| | Range: 0 - 3500 psi available |
| **Gas Bottle:** | 2 liter refillable |
| | Working pressure to 3000 psi |
| | Rated to 4000 psi |
| **High Pressure Regulator:** | Working pressure 0 - 3000 psi |
| **Needle valves:** | Model T1700 with adjustable soft seat |
| **Supply Hose:** | 1/4" NPT 3 5 feet |
| **Test Hose.** | 2 pieces 1/4" 3.5 feet |
| **Housing.** | Aluminum carrying case with removable lid |
| **Dimensions:** | 16" x 11 5" x 10" |
| **Weight.** | 35 Lbs |

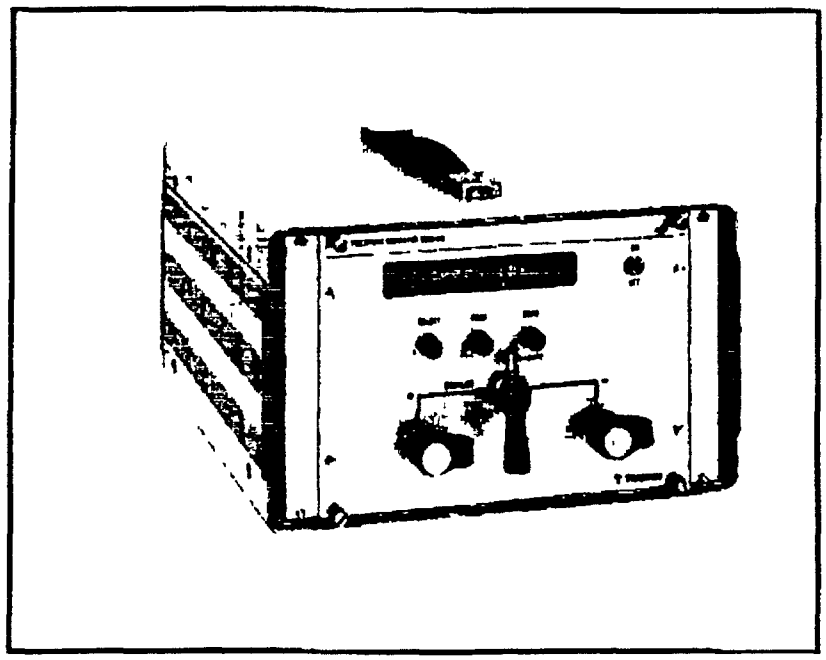
COSA

COSA INSTRUMENT CORPORATION
55 Oak Street Norwood NJ 07648 (201) 767 6600

Represented by:

COSA

# Differential Pressure Indicator Model 2090 DP



**•0.05% Full Scale Accuracy**

**•Static Pressure Ranges to 3500 psi**

**•Wet/Wet Differential Measurement in $inH_2O$, inHg or psi Increments**

The model 2090 DP Differential Pressure indicator is a highly accurate measuring instrument for sensing small pressure differences in elevated line pressures with gaseous media or liquids

The microprocessor based 2090 DP is accurate to +/- 0 05% full scale which includes linearity, hysteresis, repeatability and temperature effects.

The piezoresistive differential pressure transducer is protected from overpressure by a special pressure limiting assembly Various output signals can be installed such as 0-5 volts, 4-20mA or RS232 Automatic re-zeroing, peak hold, unit selection, direct reading and continuous averaging are easily selected through the front mounted push buttons.

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# Specifications: 2090 DP

**Accuracy.** +/- 0 05% full scale within a temperature range of 40°F to 150°F including linearity, hysteresis, repeatability and temperature effect

**Static Pressure Ranges**
- 0 to 1500 psi
- 0 to 2500 psi
- 0 to 3500 psi

**Differential Pressure Ranges**
- 0 to 100 $inH_2O$
- 0 to 250 $inH_2O$
- 0 to 400 $inH_2O$ 0-40 OPTIONAL
- 0 to 850 $inH_2O$

**Five engineering units per instrument**
- $inH_2O$
- mmHg
- psi
- $mmH_2O$
- bar

**Resolution** .....0 05% F S Minimum

**croprocessor**
Resolution of calculation 18 bits
Internal memory 2 kb RAM + 4kb PROM
Clock Frequency 4mHz

**Display** Alpha-numeric
- 16 Characters
- Fluorescent

**Test Connections** 1/4' female NPT

**Power Supply**
- 110V +/- 10% 50/60 Hz
- Rechargeable NiCd Battery (optional)

**Outputs** (optional)
- 0 - 5 Vdc
- 4 - 20 mA
- RS232
- IEEE 488

**Dimensions** (including case)
- (W x H x D)
  10 5" x 6 5" x 12 5"

**Weight** 19lbs

COSA

COSA INSTRUMENT CORPORATION

Represented by

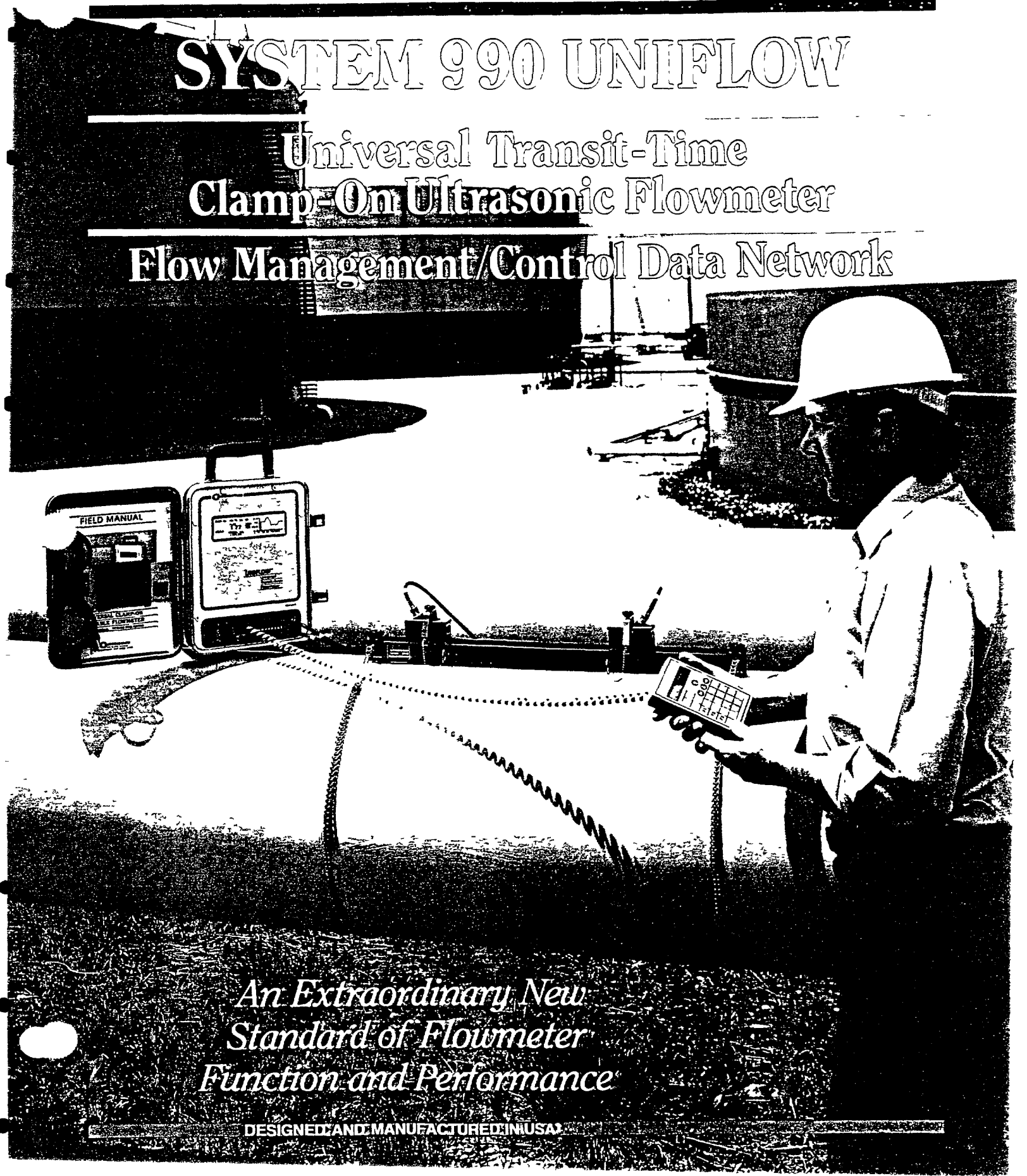
**TRANSDUCER SYSTEMS COMPANY**
916 LAKE STREET
HUNTINGTON BEACH, CA 92648
(714) 869 7690

CONTROLOTRON

# SYSTEM 990 UNIFLOW

## Universal Transit-Time Clamp-On Ultrasonic Flowmeter

## Flow Management/Control Data Network




*An Extraordinary New Standard of Flowmeter Function and Performance*

DESIGNED AND MANUFACTURED IN USA

# Controlotron's SYSTEM 990 UNIFLOW

## Performance - Function - Applicability - Economy

## Superior to Conventional Intrusive Flowmeters!

## WHAT IS SYSTEM 990 UNIFLOW?

**Uniflow* fulfills the potential of Clamp-On Transit-Time Flowmeter technology.** It outperforms conventional flowmeters, whether Magmeter or Orifice Plate, Venturi or Turbine, Vortex or any other type of Ultrasonic flowmeter Its reliability, economy and low installation cost will make it your preferred choice And its wide applicability lets you use Uniflow in place of the many different flowmeters you now need for different applications

**Uniflow is Universal.** It operates on just about any size and type of pipe, and most liquids It provides any flowmeter function that you need Uniflow offers Portable and Dedicated NEMA 4 models, in Single and Dual Channel versions It provides three functions in one affordable instrument

**Flowmeter...Stripchart Recorder...Datalogger**

**Uniflow is easy to use.** No need for complicated instruction manuals Uniflow's user-friendly Hand-Held Terminal talks to you in English (some models available in German, Spanish or French) and lets you tell Uniflow just what you want it to do Little or no training is needed It even tells you how to mount the transducers, and its Installation Menu never needs words spelled out Just choose from its list of options to obtain a host of functions not available in most conventional flowmeters

### WIDE APPLICABILITY

Uniflow combines Controlotron's MultiPulse™ System, and patented, award winning TransX™ Transmission and Wide Beam transducer technologies The result is a clamp-on flowmeter of unprecedented ability to handle many different application conditions! Uniflow operates accurately with higher levels of liquid aeration, cavitation and liquid non-homogeneity than any previous Ultrasonic flowmeter

Uniflow users can standardize on field programmable Uniflow in place of the many different flowmeters often used for different applications Users may stock basic NEMA 4X or 7 Uniflow models Then, plug-in only the standard Analog or Digital Data Function Modules needed for each application Uniflow is easily installed at new sites, or moved from obsolete sites to new and different applications Portable Uniflow can be used to demonstrate the superior performance expected of Dedicated Uniflow models over any previously used conventional flowmeter

### IS UNIFLOW ECONOMICAL?

Uniflow cost compares favorably with all types of conventional flowmeters of lesser function and performance Dual Channel and Four Channel models offer even greater savings Portable Uniflow makes even "one shot" flow measurement affordable

* Uniflow is a trademark of Controlotron

## WHAT DOES UNIFLOW DO?

**FLOW MEASUREMENT** It measures the flowrate of most liquids in most pipes between 1/2 and 216 inches OD (1/4 to 360 inches available) You choose your preferred digital flow rate display units

**FLOW DISPLAY OPTIONS** Uniflow offers a choice of LCD Graphics Display, for Digital, Stripchart and Datalogger data display, or large Digital format LCD Display of Flowrate, Total and Alarm Status Lower cost "Blind" models are also offered

**FLOW TOTALIZER** Choose Positive, Negative, Net or Batch/Sample Flow Total, with up to 7 digits of display precision, and in any volume units that you choose at the site A pulse output drives remote totalizers

**DATALOGGER** Never a need to write down data Uniflow's unique DataSaver will record any data you tell it to instantly, or at any time interval that you choose Later you can review this date/time stamped data on the optional Graphics Screen, or output to Uniflow's optional 996P Printer or a Personal Computer via its RS-232 full modem compatible port

**STRIPCHART** Uniflow's optional Graphics Display makes a Stripchart record of analog flow data Choose either flow rate or liquid sonic property data, chart speed and data scaling Uniflow adds report time stamps, and lets you review past flow trends at your convenience

**STATUS ALARMS** Uniflow keeps watch on all flow and application conditions, such as Empty Pipe Hi/Lo Flow Alarm, Reverse Flow, Fault and Liquid Aeration Selected alarms operate relay outputs

**DATA OUTPUTS** Uniflow has programmable spanned and absolute flowrate data outputs such as 4 to 20 mA, 0 to 10 volts, pulse rate and alarm relays In addition, it reports either real-time or memorized digital flowrate total and alarm status data to your computer from its industry standard RS-232 Port at selectable rates up to 9600 Baud

**DIAGNOSTICS** Uniflow has a Diagnostic Menu which lets you see and control Uniflow operating conditions Or if you like, run Uniflow diagnostic tests with the transducers either on your pipe, or on Uniflow's unique 996PS Pipe Simulator The Diagnostic Menu also shows application conditions

**LIQUID ANALYSIS** Uniflow measures liquid sonic propagation velocity, closely related to liquid physical properties Users can identify the liquid for interface detection, and in many cases compute the liquid density for mass flow measurement Uniflow can also detect liquid aeration This ability allows Uniflow to publish an aeration number, Vaer which represents the degree of aeration present in the application



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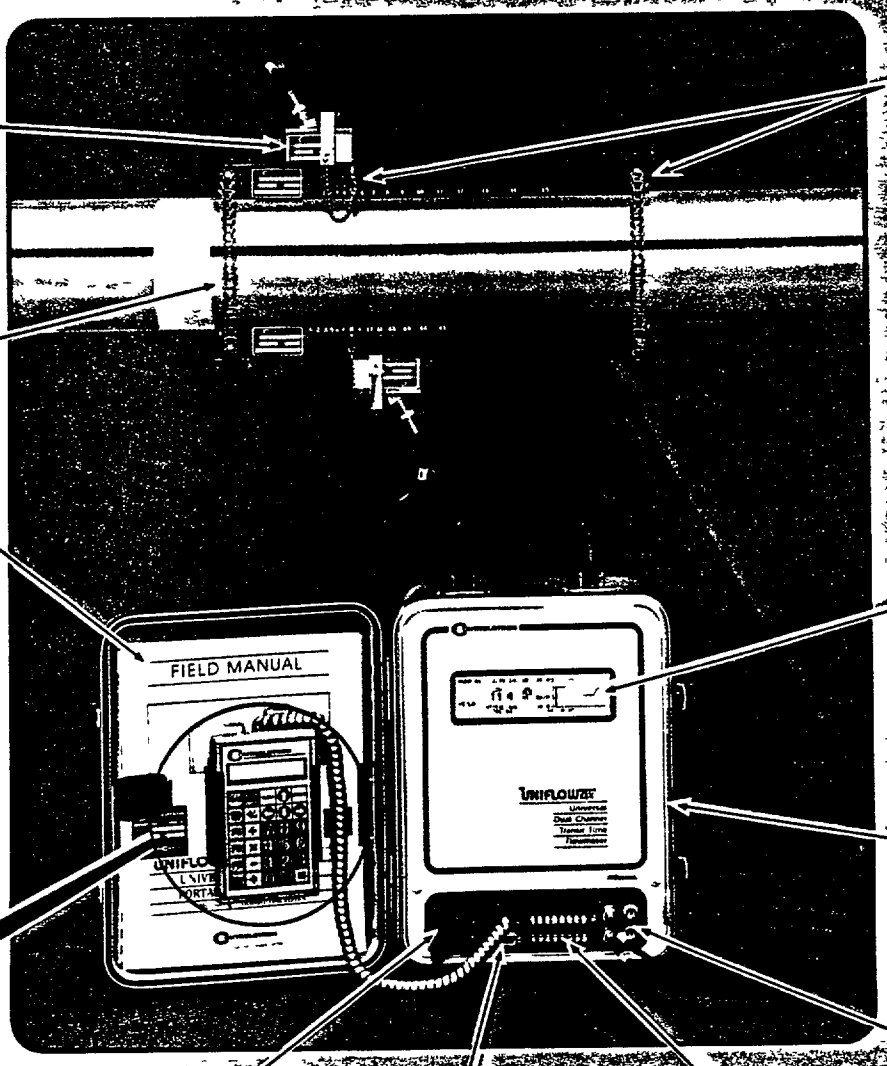
# PORTABLE UNIFLOW Easy t
# Use for Periodic Flow Survey, I
# In-Line Flowmeter Calibration

**994P Single or 994DP Dual Channel Portable permits simultaneous dual pipe flow measurement for simple flow tracing, flow balance or leak detection.**

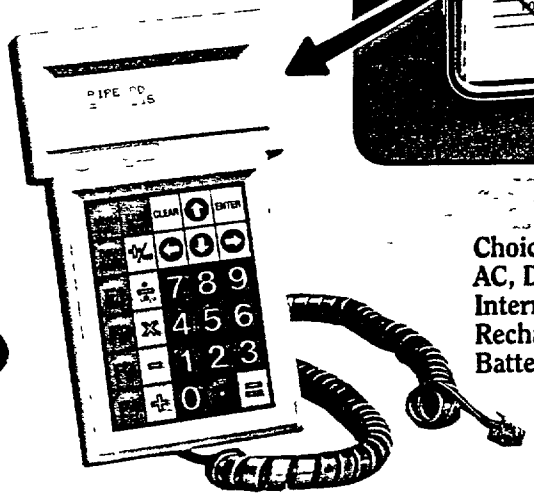



Patented Universal 991 Ultra-Stable Metallic Clamp-On Transducers (shown in Direct Mode).

"Universal" Size Stainless Steel Mounting Chain

Uniflow cover holds Field Manual for ready availability.

995T Hand-Held CDU Terminal removable from cover for convenient hand- held operation.




Hybrid Direct/ Reflect Mode 992MT PinStop Mounting Track assures fast, accurate and versatile Transducer installation. No tools needed for Track or Transducer installation.

Select the flow data format of your cho on Graphics Displa

Sealed cable case available for use in inclement weather

Dual Channel Mod shown in single channel operation

Choice of AC, DC or Internal Rechargeable Battery Power.

RS-232 Connector for Data I/O or Printer connection.

Function Output Connector for Analog and Relay Outputs.



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# ) Carry - Simple to Use - Widely Applicable
# w System Maintenance,
# and Flow Balancing.

## GRAPHICS DISPLAY SCREENS

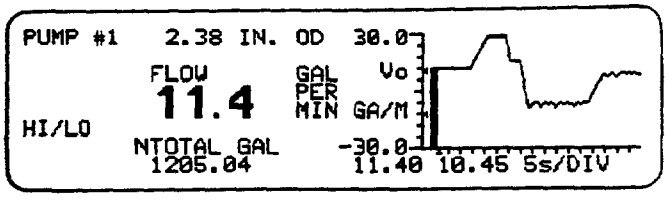
**1. Digital Display with Stripchart**
On one screen see your Flow Rate and Total in digital units of your choice, plus an Analog Stripchart with user selected data, span and timebase. Flow and operating condition alarms are brought to your attention by on-screen indicators. Site name and pipe OD shown on screen.

**2. Stripchart**
Valuable for trend analysis, the full screen Stripchart lets you see events that occurred while you are away from the site. Select either flow rate data, or process condition related liquid sonic propagation velocity or signal strength.

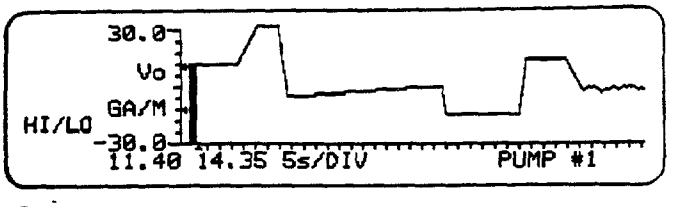
**3. Dual Channel Datalogger**
Use the 995 CDU to tell Uniflow what data you want it to collect, and how often to collect it. Then either view the data on the Graphics Screen, or print it out on Uniflow's 996P transportable AC/Battery 80 column Printer.

**4. Dual Channel Digital and Analog Barchart**
This display lets operators keep track of flow in two pipes simultaneously, complete with Flow Total and Status for each pipe.

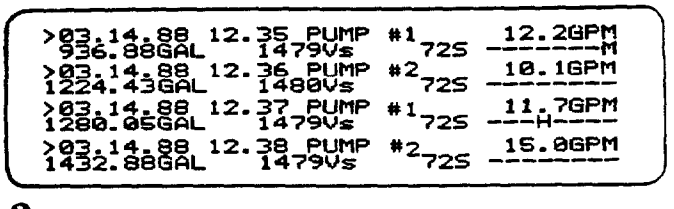
**5. Dual Channel Stripchart**
Ideal for answering the question, "Where is the flow going?", this user settable display also makes a wide variety of trend and process diagnostic questions easy to answer.



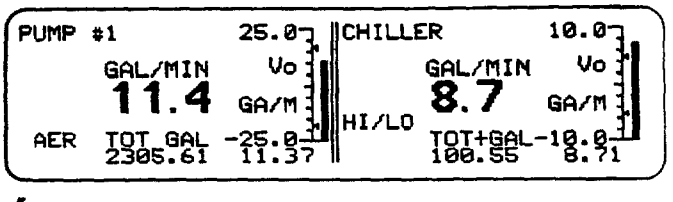

1. Digital Display with Stripchart



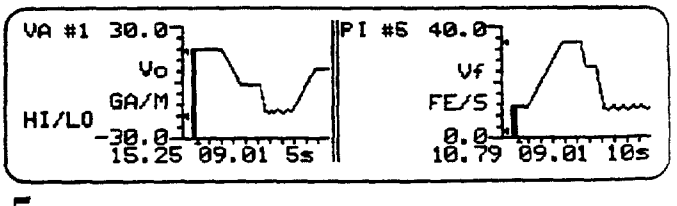

2. Stripchart




3. Dual Channel Datalogger




4. Dual Channel Digital and Analog Barchart




5. Dual Channel Stripchart

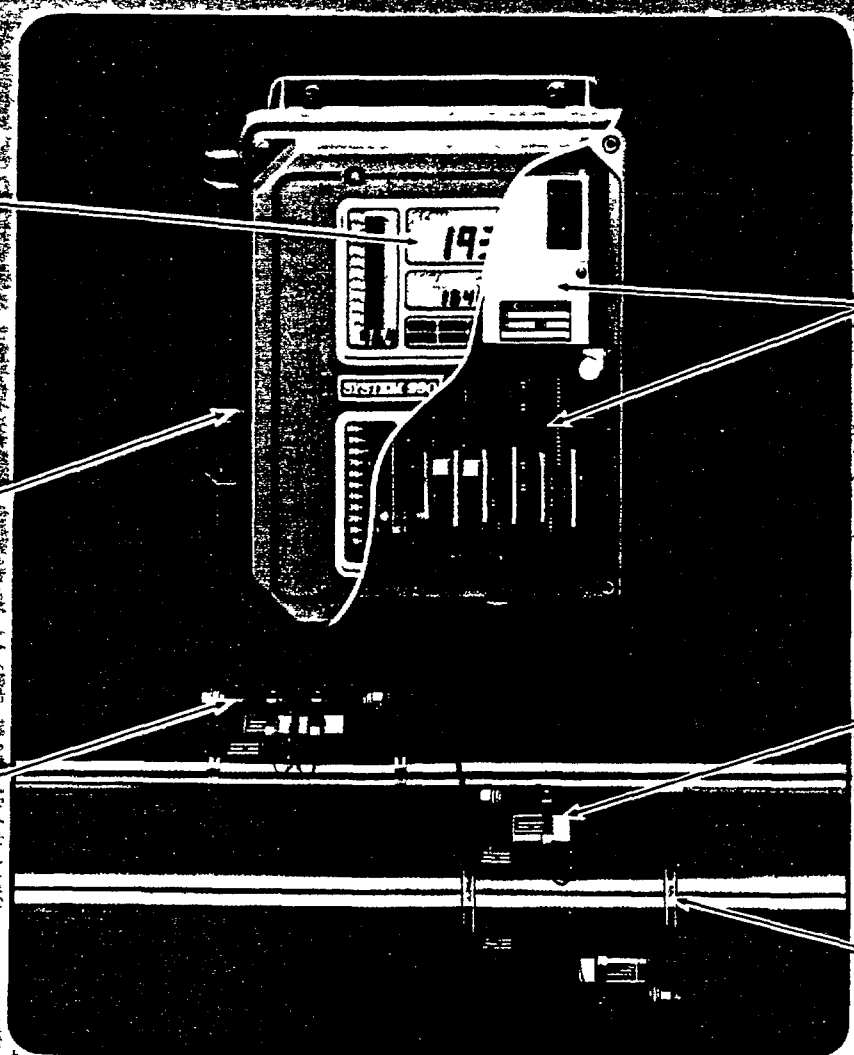
## 992TC TRANSDUCER CARRY CASE KIT

Makes System 990 truly portable by keeping cables, transducers, mounting tracks, 996PSP Pipe Simulator and all transducer accessories in one convenient shoulder strap case.

# DEDICATED UNIFLOW

## Better Performance, Reliability and Economy than Magmeters, Vortex, Venturis, Turbines and Orifice Plates in Most Applications.

**System 990N Uniflow Dedicated NEMA 4X Field Programmable Flow Computer**



Large Digit LCD Flow, Total, Analog Barchart and Status Display for each Channel. Dual Channel Graphics Display Optionally Available.

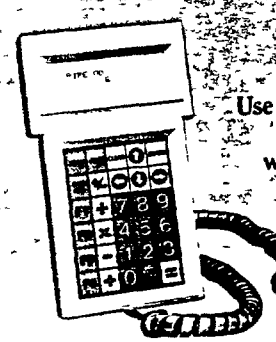
All printed circuit modules, including power supply, plug-in for simple function upgrade or maintenance.

NEMA 4X Case, suitable for essentially all field environments. Intrinsically safe models available.

Weatherproof, submersible, NEMA 4 Transducers are intrinsically safe (shown in Direct Mode).

Transducers mount in either Direct or Reflect Mode with PinStop location accuracy. Tracks mount in just minutes (shown in Reflect Mode).

Stainless Steel Track Mounting Straps.



Use the 995T Hand-Held CDU to tell Uniflow the pipe size you want to work on, and what you want it to measure, display, record or control. It takes only minutes to setup a site and install transducers, and only seconds to recall a previously saved site. Used only for Site Setup and Installation, only one 995T Hand-Held CDU is needed to service many individual 990N NEMA 4 Systems.

The 996P Portable Thermal Printer features quiet, high-contrast printing. An RS-232C serial connector is provided for interconnection to a Flow Display Computer. A rechargeable battery allows printing up to 1,500 character lines, before recharging. This printer is provided in a convenient soft carry case.

BEST AVAILABLE COPY



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# Wide Applicability Lets You Standarc

# Eliminates Need for Different Flowr

## MODELS AVAILABLE

Controlotron's System 990 offers any construction you need for your application whether Portable, NEMA 4X Intrinsically Safe, or NEMA 7 Explosion Proof Choose the power source you need 100/120 or 220/240 VAC, or 9 to 36 VDC, or internal, rechargeable Battery Choose from highly economical "Blind" units, or have your choice of LCD Graphics or Integral Digital Display In short, whatever your preference it's probably available as a Uniflow standard!

### PORTABLE UNIFLOW MODELS

#### Single Channel Portable UNIFLOW

The Single Channel Portable 990P Uniflow is ideal for applications that only need periodic flow measurement, to save the cost of a permanent flowmeter installation Use it to test your pumps and valves as part of your plant s preventative maintenance program Check the calibration of your conventional flowmeters Or use it to see how well a Dedicated NEMA 4X or 7 Uniflow will operate as a replacement for a conventional intrusive flowmeter

Of special convenience for users of Portable Uniflows are the models with integral Rechargeable Battery These are of especial value for use in areas remote from power or hazardous

#### Dual Channel Portable UNIFLOW DP

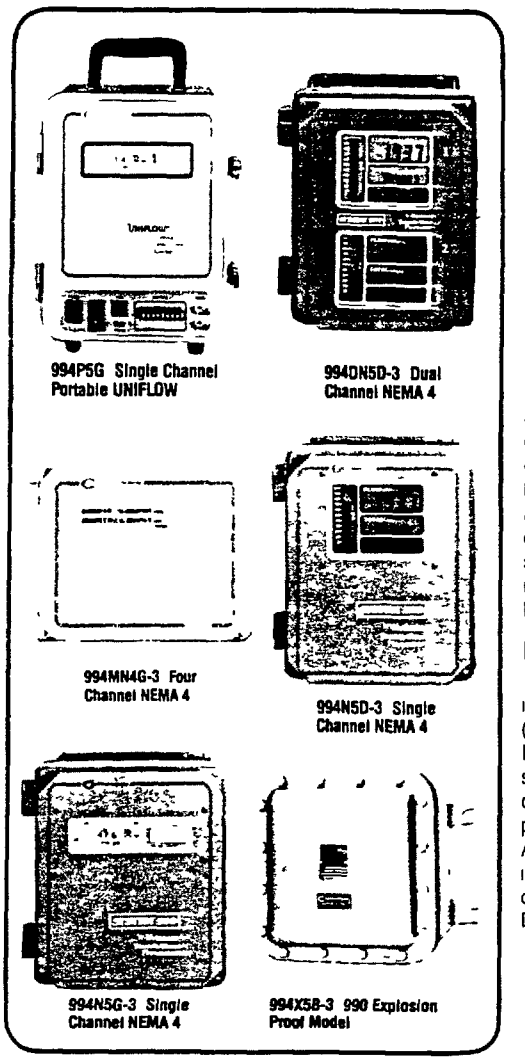
Dual Channel Portable 990DP Uniflow (shown on page 3) has all the functions of the Single Channel Portable but with the added benefits of simple flow balancing, flow tracing and leak detection 990DP operates both channels simultaneously so that interactive manifold effects can be observed

### DEDICATED UNIFLOW MODELS

#### Single Channel Dedicated NEMA 4X

Available with either Graphics or Digital Display, or as a Blind flow transmitter the Single Channel 990N NEMA 4X model is the workhorse of the Uniflow family 990N contains all the flow functions of the Portable models including optional Datalogger, Stripchart and industry standard RS-232 I/O Data Port

Dedicated models are field programmable Users can stock standard Uniflow models and easily program them for different applications as they arise Then simply plug-in any needed standard Uniflow Function Modules such as Analog Data, Alarm Relay or RS-232 I/O Port, to a compatible 994 Flow Computer


994P5G Single Channel Portable UNIFLOW

994DN5D-3 Dual Channel NEMA 4

994MN4G-3 Four Channel NEMA 4

994N5D-3 Single Channel NEMA 4

994N5G-3 Single Channel NEMA 4

994X5B-3 990 Explosion Proof Model

#### Dual/Four Channel Dedicated NEMA 4X

The Dual Channel Dedicated 990DN NEMA 4X and Four Channel 990MN NEMA 4X Uniflows have all the features of the single channel model but support multiple independent pipe sizes simultaneously, using time share multiplexing

When supplied "Blind", these models provide the ultimate in economy, and will generally result in lower per channel cost than most conventional flowmeters When supplied with either the Dual Channel Graphics Display or Dual LCD Digital Displays, each channel is functionally equivalent to separate Single Channel 990N models

#### Dual Beam System Models

When faced with the need for highest possible accuracy, for custody transfer or pipeline leak detection applications, consider the advantages of Controlotrons 990DBN Dual Beam System Here, crossed orthogonal sonic beams eliminate any crossflow error produced by upstream elbows or disturbances, and assure exceptional data stability 990DBN is the preferred alternative to intrusive 4 Path Chordal flowmeters, offering better performance at much lower cost

#### Dedicated NEMA 7 Explosion Proof Models

Uniflow is available in NEMA 7 construction in both single channel (990X) and dual channel (990DX) models for those applications for which Factory Mutual certified Intrinsically Safe construction is not sufficient Industry standard digital and analog data outputs are provided plus an optional remote digital data display Also available in the Single Channel model is an integral Digital Display Dual Channel models are capable of supporting remote NEMA 7 Digital LCD Displays for each channel

For help in selecting your Preferred Mode request Bulletin 990SLECT and 990 Applicatio Information Form

## UNIFLOW ACCESSORIES

#### 996P TRANSPORTABLE PRINTER

The 996P Transportable 80 column battery operated Printer lets you make a hard copy of memorized Uniflow datalogger information, output from Uniflow's RS-232 Port, anytime you need it, even in the field

#### 996PSP PIPE SIMULATOR

996PSP permits simple Uniflow equipment test Simply place Uniflow's transducers on its 996PSP Then view Uniflow s Diagnostic Display to confirm that both Flow Computer and Transducers are operating properly

#### 996D REMOTE DIGITAL DISPLAY

Available in either panel mount or NEMA 4 construction the 996D provides users with remote data display from either a Blind or display equipped NEMA 4X or 7 Flow Computer



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# ze on Controlotron's UNIFLOW...

# eters on Different Applications.

## UNIFLOW FEATURES

### *FAST SIMPLE INSTALLATION*

Uniflow s universal applicability is invoked by 'telling' it the few things it needs to know to measure flow accurately at any site Just tell it the pipe size, the kind of data you wish to measure and your preferred data units, offered on a convenient "no spelling required" Menu List How long does this take? Less than 5 minutes!

Then install Uniflow clamp-on transducers They are Pin Stop located for quick and repeatable installation Just put the pin at the computed Spacing Indices on the mounting track and place the transducer against the pin No need to measure spacing or read obscure ruler scales to obtain the most precise installation possible and without any special training How long? Usually under 5 minutes

Portable and some Dedicated Uniflow models can Save as many as 16 different Site Setups for instant Recall when revisiting a periodically surveyed site This avoids need for highly trained personnel to conduct routine data collection

Portable Transducers are conveniently carried in their own Carry Case, together with their Mounting Tracks, Cables, Pipe Conditioner, Coupling Compound and Pipe Simulator, used to check entire 990 System operation There is also a Portable Flow Computer Soft Case available to protect your portable computer during transit

### *SIMPLE OPERATION SETUP*

Uniflow has no conventional adjustments ' Its Menu asks you how you want it to operate Simply tell Uniflow to set its Empty Pipe Alarm Then tell it to set Zero Flow (even if flow can t be shut down) Tell it how fast you want it to respond to flow changes, and such like Uniflow will behave just as you tell it to

### *DUAL CHANNEL UNIFLOW DP*

The Portable Dual Channel Uniflow DP supports a variety of applications that would otherwise require two separate flowmeters For example, use it for Flow Balancing or Leak Tracing, or Pump and Valve diagnostics

### *HIGH TEMPERATURE OPERATION*

Uniflow transducers use patented Controlotron Metall construction to permit operation at far higher temperatures tha any other Ultrasonic flowmeter up to 450°F They also provide fa better data calibration stability than that obtainable with ordinar plastic transducers

### *HIGH RELIABILITY*

Uniflow s all digital design uses low power component substantially reducing internal temperature rise which is the ma cause of early failure There are no adjustments to "drift in th primary flow detection circuits, as all system calibration is controlle digitally All circuits are protected against ESD, the main cause "unexplained' circuit failure And Uniflow has a substantial reductic of component count, greatly reducing the potential for electron failure

### *SIMPLE MAINTAINABILITY*

Uniflow uses all Plug-In Module construction Even its pow supply plugs in In the unlikely event of a component failur operation is restored in minutes by simple replacement from small supply of guaranteed interchangeable spare modules Ar Uniflow's built-in Diagnostic Display helps to identify the probab source of any problem quickly, whether due to equipment application conditions

Like all other Controlotron Ultrasonic flowmeters, Uniflow ca be tested in the field, so that there is never a need to return it to th factory for operation check

### *INSTRINSIC SAFETY*

Uniflow is designed to meet international intrinsic safe standards for hazardous areas NEMA 4X (IP65) and NEMA (Flameproof) systems are available with U S (FM) approval fc use in Class I and II, Division 1 and 2, Groups C, D, E, F, G area European Standard (CENELEC) transducer certification fc EEx m II T5 use with all 990 systems is available, Canadian (CS/ certification and European Standard EEx ia II T5 certifications a pending Contact your representative to discuss your needs

## APPLICATIONS

Uniflow's wide applicability, excellent performance, moderate cost and non-intrusive design makes it suitable for use in essentially every application now serviced by conventional flowmeters such as Orifice Plates, Magmeters, Turbines, Vortex, Venturi and Coriolis devices. Typical applications include·

| | | |
|---|---|---|
| Petroleum Production & Pipelines | Molten Sulphur | Paint Application Control |
| Chemical | Aircraft Fuels | Solvents |
| Water and Waste Water | Hydraulic Fluids | Product Custody Transfer |
| Nuclear Power Coolant Flow | Chilled and Hot Water | Radioactive Wastes |
| Condensate | Deaerated Coal Slurries | Liquified Gasses (Ethylene, Propane, LPG) |
| Milk and Related Food Products | Paper and Pulp Slurries | Heating Oil |
| Beer and Wine | Deaerated Drilling Mud | |



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# [illegible]

## How UNIFLOW WORKS

Uniflow is a Clamp-On Flowmeter which detects liquid flow rate by its effect on the Transit-Time of Ultrasonic Pulses, alternatively injected through the pipe wall in the upstream and downstream directions by Controlotron's patented ultrastable metallic transducers. Each transmission is not a single pulse, as in prior types of ultrasonic flowmeters, but rather as many as 100 pulses resulting in the extraordinary sensitivity and calibration stability of Uniflow's MultiPulse™ System.

Uniflow also benefits from its patented TransX™ Transmission System. This is a method by which Uniflow measures the sonic properties of the application's pipe, and automatically optimizes its ultrasonic beam transmission. This gives Uniflow its Universality, the ability to operate on most pipes and most liquids, and its extraordinary immunity to such conditions as liquid aeration and non-homogeneity.

## How DOES UNIFLOW PERFORM?

### EXTRAORDINARY PERFORMANCE

Uniflow's Digital MultiPulse™ System uses no analog circuits, not even phase locked loops. This produces the greatest precision, sensitivity and stability ever achieved in an ultrasonic flowmeter. Flow response is extremely linear over its full ±40 fps range (including zero flow), and is virtually drift free.

Uniflow's SMARTSLEW™ real time data analysis results in extremely low data scatter, even at high slew rate settings. When set for its fastest flow response rate, Uniflow is ideal for flow control or detection of flow transients which would be missed by slower flowmeters. Slower response can be selected, if desired, to avoid reporting flow pulsations which are not of interest.

Uniflow intrinsic calibration accuracy is usually within 1% to 2% in most applications and within 1/4% to 1% if flow calibrated. Intrinsic repeatability will generally be within 1/2% for most pipe sizes.

## SYSTEM 990 UNIFLOW SPECIFICATIONS

**APPLICABILITY**

**LIQUIDS:** Any sonically conductive homogeneous liquid of low to moderate aeration (up to 30% maximum)

**LIQUID (PIPE) TEMPERATURE:** −40°F to +250°F (−40°C to +120° C) Standard
−80°F to +450°F (−60°C to +230° C) Optional

**PIPE SIZES.** 0.25" to 8" OD (6.35mm to 203.2mm) Specify Group 2 Flow Computer
0.5" to 24" OD (12.7mm to 609.6mm) Specify Group 3 Flow Computer
0.5" to 48" OD (12.7mm to 1219.2mm) Specify Group 4 Flow Computer
0.5" to 216" OD (12.7mm to 5486.4mm) Specify Group 5 Flow Computer
0.5" to 360" OD (12.7mm to 9144mm) Specify Group 6 Flow Computer

**PIPE MATERIAL.** Any sonically conductive pipe material. Metal, Glass, Plastic, etc.

**PIPE WALL THICKNESS:** 0.01" to 3.00" (0.25mm to 76.2mm)

**LINER MATERIAL.** Any sonically conductive material, Glass, Plastic, Cement, etc., intimately bonded to the pipe interior

**LINER THICKNESS** Up to 1" (25.4mm), dependent on material

**FLOW VELOCITY RANGE:** ±40 fps (±12.2m/sec), minimum

**991 CLAMP-ON TRANSDUCERS**

**PIPE SIZE RATINGS**

- Group 0 0.25" to 2" (6.35mm to 50.8mm) pipe OD
- Group 1 0.5" to 4" (12.7mm to 101.6mm) pipe OD
- Group 2 1.25" to 8" (31.75mm to 203.2mm) pipe OD
- Group 3 6" to 24" (152.4mm to 609.6mm) pipe OD
- Group 4 20" to 48" (508.0mm to 1219.2mm) pipe OD
- Group 5 36" to 360" (914.4mm to 9144.0mm) pipe OD

**RATING:** Intrinsically safe. Radiation Resistant and Submersible available

**CONSTRUCTION:** Aluminum, stainless steel and special alloy or plastic

**CONNECTORS:** Condulet for NEMA 4, BNC for Portable

**992 MOUNTING TRACKS**

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

**994 FLOW COMPUTER**

- **POWER** 100/120 or 220/240 VAC, 1ϕ, 40 VA
  9 to 36 VDC, 20W, portable systems available with internal battery
- **TEMPERATURE:** −5°F to +115°F (−20°C to +45°C)
  (except for Graphics Models)
- **SIZE.** 10.5" W, 9" D, 13" H (266.7mm W, 228.6mm D, 330.2mm H)
- **WEIGHT:** 12.8 pounds (5.8 kilograms), (without Battery)
- **RATING.** Intrinsically safe. NEMA 4X with cover closed
- **MODULES.** Plug-In, Interchangeable W/O special tools
- **RANGES** Group 2 Transducer Sizes 0, 1 and 2
  Group 3 Transducer Sizes 1, 2 and 3
  Group 4 Transducer Sizes 1, 2, 3 and 4
  Groups 5 & 6 Transducer Sizes 1, 2, 3, 4 and 5

**994 PERFORMANCE (Standard Conditions)***

- **SENSITIVITY** 0.001 fps (0.3mm/sec) at any flow rate including zero
- **LINEARITY:** 0.003 fps (0.9mm/sec) under standard conditions
- **DATA UPDATE RATE.** 10 Hz
- **SLEW RATE:** 0.1 to 40 ft/sec/sec (0.03 to 12.2m/sec/sec), (settable)
- **FLOW PROFILE COMPENSATION:** Reynold's Number 0 to $10^7$
- **ZERO DRIFT STABILITY** 0.02 fps (6mm/sec) for transducer sizes 0 to 2
  0.01 fps (3mm/sec) for transducer sizes 3 to 5

**995 HAND HELD CONTROL/DISPLAY TERMINAL**

- 4 row, 80 character LCD
- 30 Keys, Numeric or Function identified

*** Submit Application Form for estimate of performance under specific application conditions. For statement of accuracy, site survey is required.**

# HOW TO SPECIFY AND ORDER SYSTEM 990 UNIFLOW

Selecting the most appropriate model and optional functions and features, offered in System 990, 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 993 AFAC Module**
- **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. Determine which 990 System best fills your needs, Portable or NEMA 4 Use the Application Information Form to assure application guarantee.
2. Specify the Components of your selected system, choosing the component options which contain your desired features, and their corresponding part numbers
3. Specify the desired optional plug-in Function Modules and/or Remote Accessories by part number below
4. 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**<br>P = Portable<br>N = NEMA 4 | **B = TYPE**<br>M = Metal Body<br>P = Plastic Body<br>V = Sonic Velocity | **C = TEMPERATURE**<br>S = 250°F (120°C) max.<br>H = 375°F (190°C) max<br>VH = 450°F (230°C) max. | **D = SIZE***<br>0S = 0.25" to 0 5" (6 35mm to 12 7mm) pipe OD<br>0,0A = 0.25" to 2" (6 35mm to 50 8mm) pipe OD<br>1 = 0 5" to 4" (12 7mm to 101 6mm) pipe OD<br>2,2A = 1 25" to 8" (31 75mm to 203.2mm) pipe OD<br>3,3A = 6" to 24" (152 4mm to 609 6mm) pipe OD<br>4,4A = 20" to 48" (508 0mm to 1219 2mm) pipe OD<br>5,5A = 36" to 360" (914 4mm to 9144mm) pipe OD<br>* See 991XA for guidelines in selecting "A" Series Transducers | |
| **992MTABCD-E MOUNTING TRACK** | **A = MODEL**<br>P = Portable<br>N = NEMA 4 | **B = TYPE**<br>D = Direct Beam<br>R = Reflect Beam<br>H = Hybrid Track | **C = STYLE**<br>M = Metal XDCR<br>P = Plastic XDCR | **D = MATERIAL**<br>A = Aluminum<br>S = Steel<br>SH = For VH XDCRS | **E = PIPE OD RANGE (min )** (See 990SLECT Manual)<br>0S = 0 25" to 0 5" (6 35mm to 12.7mm) pipe OD<br>0 = 0 25" to 2" (6 35mm to 50 8mm) pipe OD<br>1 = 0 5" to 4" (12.7mm to 101 6mm) pipe OD<br>2 = 1 25" to 8" (31 75mm to 203 2mm) pipe OD<br>3 = 6" to 24" (152.4mm to 609 6mm) pipe OD<br>4 = 20" to 48" (508 0mm to 1219 2mm) pipe OD<br>5 = 36" to 84" (914 4mm to 2133 6mm) pipe OD<br>5X = 6' to 10' (1 83m to 3 05m) pipe OD<br>5Y = 10' to 18' (3 05m to 5 49m) pipe OD<br>5Z = 18' to 30' (5 49m to 9 14m) pipe OD |

| | | | | | |
|---|---|---|---|---|---|
| **992CAB-C TRANSDUCER CABLE** | **A = MODEL**<br>P = Portable<br>N = NEMA 4<br>NP = NEMA Computer to Portable XDCR<br>PN = Portable Computer to NEMA XDCR | **B = ENVIRONMENT**<br>S = Standard Temp<br>D = Plenum Rated<br>W = Submersible Kit | **C = LENGTH**<br>C = Length in ft | **992MTM-A MAGNETIC TRACK MOUNT KIT** | **A = PIPE OD RANGE**<br>4 = 20" to 48" (508 0mm to 1219 2mm) pipe OD<br>5 = 36" to 360" (914 4mm to 9144 0mm) pipe OD |

| | | | | |
|---|---|---|---|---|
| **992TC-A TRANSDUCER CARRY CASE KIT** | **A = SIZE**<br>0S = Size 0S XDCR, 0 = Size 0 XDCR, 1 = Size 1 XDCR, 2 = Size 2 XDCR,<br>3 = Size 3 XDCR 4 = Size 4 XDCR, 5 = Size 5 XDCR (For Portable XDCRS Only) | **993A APPLICATION FUNCTION AND CONTROL MODULE** | **A = MODEL**<br>C = Control Only Module<br>M = Datalog Memory & Control Module | **994TC PORTABLE FLOW COMPUTER SOFT CASE** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **994ABCD-EF FLOW COMPUTER** | **A = MODEL**<br>P = Portable<br>N = NEMA 4X<br>X = NEMA 7<br>DP = Dual Portable<br>DN = Dual NEMA 4X<br>DX = Dual NEMA 7<br>MN = Four Channel<br>DBN = Dual Beam NEMA 4X<br>DBP = Dual Beam<br>FTN = Flow Tube NEMA 4X<br>FTP = Flow Tube Portable<br>PB = Portable Blind | **B = PIPE OD**<br>2 = 0 25" to 8" (6 35mm to 203 2mm)<br>3 = 0 5" to 24" (12 7mm to 609 6mm)<br>4 = 0 5" to 48" (12 7mm to 1219 2mm)<br>5 = 0 5" to 216" (12 7mm to 5486 4mm)<br>6 = 0 5" to 360" (12 7mm to 9144 4mm) | **C = DISPLAY**<br>B = Blind<br>G = Graphics<br>GL = Lit Graphics<br>D = Digital | **D = POWER SOURCE**<br>S = 100/120 VAC<br>M = 220/240 VAC<br>B = 9 to 36 VDC<br>SB = 115 VAC + Battery<br>MB = 230 VAC + Battery | **E = PROGRAM LOADING**<br>1 = Basic Data<br>2 = Add RS-232 & Datalog<br>3 = Add Graphics + Stripchart | **F = SPECIAL**<br>C(n) = Case Option<br>N(n) = CC Nuclear Grade<br>S(n) = Intrinsically Safe |

| | | | |
|---|---|---|---|
| **994-7A ANALOG COMPUTER MODULE** | **A = MODEL**<br>BLANK = Programmable Isolated 4 to 20 mA, 0 to 10 VDC and Pulse Rate Outputs one per channel (Single & Dual Channel Systems only)<br>V = Programmable, 0 to 10 VDC Output, one per system (Four Channel Systems only) | **994-8A OUTPUT CURRENT MODULE** | **A = MODEL**<br>M = Dual Programmable 4 to 20 mA Outputs, two per system (Four Channel Systems only) |

| | | | | | |
|---|---|---|---|---|---|
| **994-10ABC ALARM RELAY MODULE** | **A = MODEL**<br>P = Portable<br>N = NEMA 4 | **B = TYPE**<br>A = Normally Open<br>B = Normally Closed | **C = RATING**<br>D = Dry Reed (10 VA max.)<br>M = Mercury Wetted (50 VA max )<br>(Not available in Portable Units or in "NC" Type) | **995TA HAND-HELD CDU TERMINAL** | **A = MODEL**<br>BLANK = Standard 995 Hand-Held Terminal<br>1 = 995 Hand-Held Terminal w/External CDU Option & Case |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **995VA UNINTERRUPTIBLE POWER SOURCE** | **A = POWER SOURCE**<br>S = 110/120 VAC<br>M = 220/240 VAC | **996P PRINTER** | **996P-5 PRINTER PAPER, 5 PACK REFILLS** | **996PSP-A PIPE SIMULATOR** | **A = XDCR SIZE**<br>A = 0, 1, 2, 3 or 4 | **996DABC REMOTE DISPLAY** | **A = TYPE**<br>D = Digital | **B = MODEL**<br>N = NEMA 4X<br>P = Panel Mount | **C = POWER SOURCE**<br>S = 100/120 VAC<br>M = 220/240 VAC |

**For help in selecting your Preferred Model, request Bulletin 990SLECT and 990 Application Information Form.**

## SYSTEM 990 UNIQUE FEATURES

The flowmeter furnished shall be the Controlotron System 990 Uniflow Transit-Time Clamp-On 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
- ☑ 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
- ☑ 2 Year Limited Warranty
- ☑ 16 Site Setup Memory Option for most Models
- ☑ Full Diagnostic Data Access
- ☑ Plug-In Function Options
  - ☑ Analog Data Module, 0 to 10 VDC and 4 to 20 mA
  - ☑ External Data A/D Convertor
  - ☑ Alarm Relay Module, 4 Relays per Channel
  - ☑ Digital and Graphics Display Computer/Driver
  - ☑ RS-232 Serial Data I/O, Selectable Baud Rates
- ☑ Intrinsically Safe Construction
- ☑ Made in USA

## 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 other new and unique instruments of outstanding value and performance characteristics, such as

**Portable System 990E:**
Thermal Energy Flowmeter

**Dedicated System 990E:**
Thermal Energy Flowmeter

**System 990FT:**
In-Line Transit-Time Ultrasonic Flowmeter

**System 990FTD:**
In-Line Transit-Time Mass Flowmeter
(Low Flow & Custody Transfer)

**System 990DB:**
Dual Beam Flowmeter

**System 990DV:**
Mass Flow Flowmeter

**System 990LD:**
Leak Detection System

**Portable System 190 Spectra:**
Portable Fourier Flowmeter

**Dedicated System 190 Spectra:**
NEMA 4X Fourier Flowmeter

**System 1010:**
Miniature Aerospace Flowmeter

**System 660:**
Clamp-On Pressure Indicator or Switch

**990 Flow Management/Control Data Network Systems**
**990DN:** Flow Data Network
**990EDN:** Thermal Energy Data Network
**990LD:** Pipeline Leak Detector Network
**990DVN:** Pipeline Custody Transfer Network
**990 Portalab:** Transportable Maintenance Flow Lab

## RENTAL/PURCHASE PLAN

Users who wish to familiarize themselves with Uniflow prior to purchase may avail themselves of Rental plans (where available) Advance purchase, of the 990PFM-2 or 990NFM-2 Field Manual will provide detailed information beyond this brochure

## 2 YEAR WARRANTY

This product is warranted for two years from the date of purchase Please contact Controlotron's Customer Service Department for more detailed information regarding this limited product warranty

## MISAPPLICATION POLICY

For detailed information regarding our product misapplication policy, please contact Controlotron's Customer Service Department

## 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.

Your Local Representative

AL MIATELLO
WESTERN REGIONAL SALES MANAGER
4213 VIA VERDE
CYPRESS, CA 90630
714-827-8489 TEL + FAX

CONTROLOTRON

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PRINTED IN USA

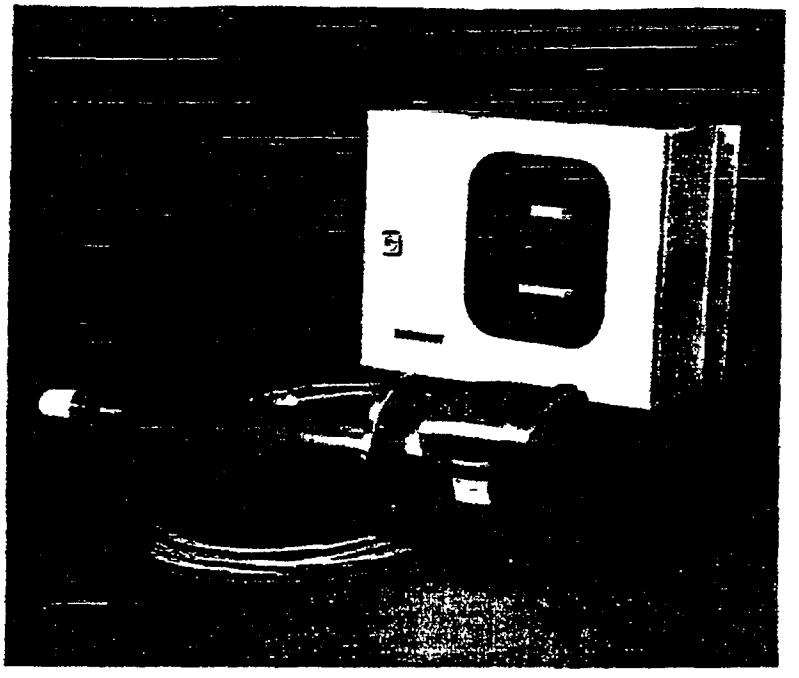
990SB-8
1/93-15M

# WORLD CLASS 3000

# OXYGEN ANALYZER PACKAGE

## FEATURES

- *Totally Field Repairable*
- *Rugged 316 SS Construction*
- *Cell Protection*
- *Easy Calibration*
  *No Potentiometers to Adjust*
- *Computer Compatible*
- *Quick Change Diffusion Element*
- *Field-Proven Cell Design*
- *Flame Arrestor (Optional)*
- *Operates Without Instrument Air as Reference*
- *FM Approved Package (Optional)*



## WORLD CLASS TECHNOLOGY FROM THE WORLD LEADER

The Rosemount in situ, zirconium oxide oxygen analyzer has long been established as the industry standard The Rosemount World Class 3000 Oxygen Analyzer combines all state-of-the-art features into one package.

The World Class 3000 is totally field repairable, as internal components are conveniently accessible for servicing in-house. The heater/thermocouple assembly can also be replaced without removing the probe from the process In addition, zirconium oxide sensor cells incorporate a patented self-protection feature that automatically protects the sensor electrodes from harmful corrosive gases often found in many combustion processes

The new digital analyzer electronics have been designed and manufactured incorporating the very latest in microprocessor technology. The controller is available in a standard NEMA 4 (IP55) wall mounting enclosure. The enclosure is complete with a six-character alphanumeric liquid crystal display (LCD) providing continuous information on flue gas oxygen concentrations Alternatively, by selecting another mode on the membrane key pad, stack temperature or % efficiency can be displayed The analyzer calibration can easily be performed by key selection without the need for special equipment or knowledge

Each basic analyzer package includes Oxygen Sensing Probe, shield, 20-foot cable, electronics, adapter plate and accessories, reference air set and calibration gas rotometer

The controller is shipped from the factory pre-set for 4-20 mA output representing 0 to 10% oxygen Various other output signals and oxygen ranges are field selectable

Typical applications include conventional power boilers, steel mill blast furnace gas boilers, refinery process heaters, kilns (lime, phosphate and cement), recovery boilers, pulp and paper industry bark boilers, oxygen enrichment systems, windboxes, incinerators, air pre-heater leakage and marine boilers

Supersedes Product Data 106-300,
Pages 1-6, dated June, 1992



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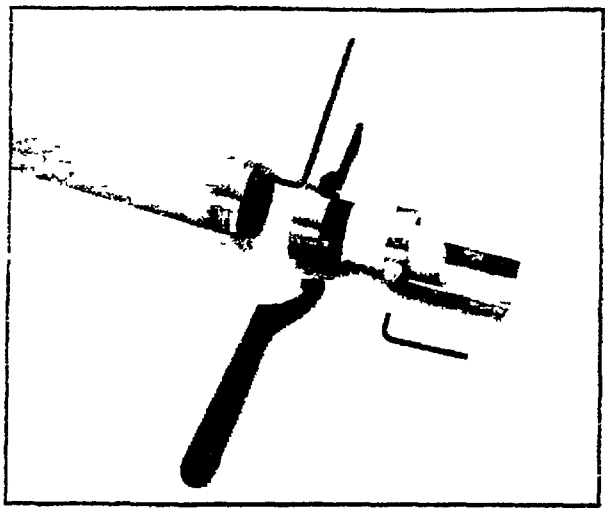

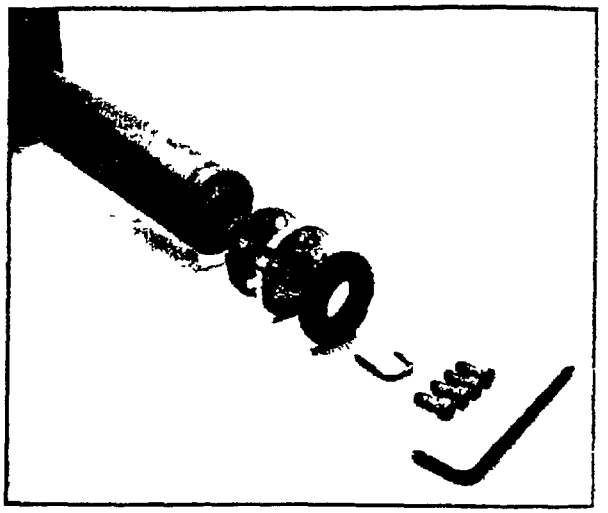

## WORLD CLASS 3000 OXYGEN SENSOR

| 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 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 (704°C):® See page 3. | 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

- Meets requirements in EPA Federal Register Volume 40, Number 194.
- Output voltage and sensitivity increase as the oxygen concentration decreases.
- Permits changes in fuels or ambient air humidity without changing the excess oxygen setpoint.
- Use with any fuel including coal or residual fuel burners. Diffusion element keeps cell clean while gas flow keeps diffusion element clean.
- Shield and cell housing specially chosen for resistance to sulfur dioxide and other corrosives.
- Output suitable for use with receivers such as indicators, recorders, controllers, data loggers or computers.
- Output field selectable.



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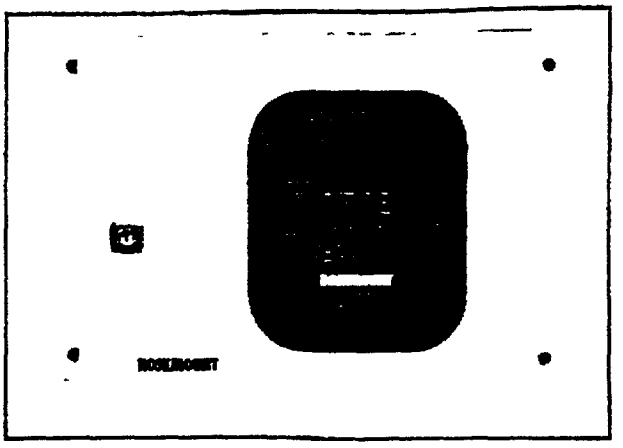
## DIGITAL ELECTRONIC FEATURES

- Unique active cell protection action that is automatically activated when the analyzer detects reducing atmospheres.
- Semi-automatic analyzer calibration (operator initiated) - test gases required.
- Easy operator interface provided by a 6 character alphanumeric Liquid Crystal Display (LCD) and membrane keyboard.
- Displays: Oxygen $O_2$
  Stack Temperature
  % efficiency
- Simplified setting up procedure and access to all analyzer parameters via keyboard/display.
- Alarm indication of fault conditions including High/Low $O_2$ alarms when $O_2$ is above or below setpoints.
- No adjustable components in functional part of circuit.
- Automatic heater shutdown if thermocouple leads are reversed, short circuit, or open circuit.
- Linearized or logarithmic output signal with several keyboard selectable range options.
- Isolated voltage or current output switch selectable.
- Easily replaces existing analog electronics.
- Fully automatic calibration (optional)




- High/Low oxygen alarms - voltage free contacts.
- RS 422 serial link for panel mounted printer, baud rate selectable up to 4800, format width 20 characters; alternatively RS 422 serial link with computer interface suitable for an IBM Personal Computer or World Class 3000 averager.

## SPECIFICATIONS ① ②

### OXYGEN SENSING EQUIPMENT

**Probe lengths, nominal:** 18 inches, 3 feet, 6 feet depending upon duct dimensions
**Material of construction:** 316 LSS (all wetted parts)
**Ambient temperature range of Digital Electronics enclosure:** 32-120°F (0-50°C)
**Temperature limits in process measurement area:** ③ 50-1300°F (10-704°C)
**$O_2$ analog output:** 0.1% $O_2$ or statistically ±3% of reading, whichever is greater using Rosemount test gases
**$O_2$ Range:** Field selectable
**Cell speed of response:** 1 millisecond
**System speed of response (amplifier output):** less than 3 seconds
**Resolution sensitivity — transmitted signal:** 0.01% $O_2$
**Temp. Controller housing:** NEMA 4 (IP55)
**Probe reference air flow (optional):** 2 SCFH clean, dry, instrument quality air (20.95% $O_2$)
**Calibration gas mixtures:** Rosemount Test Gas Kit Part No. 6296A27G01 contains 0.4% $O_2N_2$ Nominal and 8% $O_2N_2$ Nominal
**Calibration gas flow:** 5 SCFH
**Power Supply:** 100/115/220V ±10% Vac at 50/60 Hz
**Power requirement:** 150 VA
**Approximate shipping weights:**
**18 inch package:** 55 pounds
**3 foot package:** 60 pounds
**6 foot package:** 65 pounds

① All static performance characteristics are with operating variables constant.
② Specifications subject to change without notification. Our policy is one of continuous product improvements, and we reserve the right to change specifications.
③ Temperatures over 1000°F may affect the ease of field cell replaceability.



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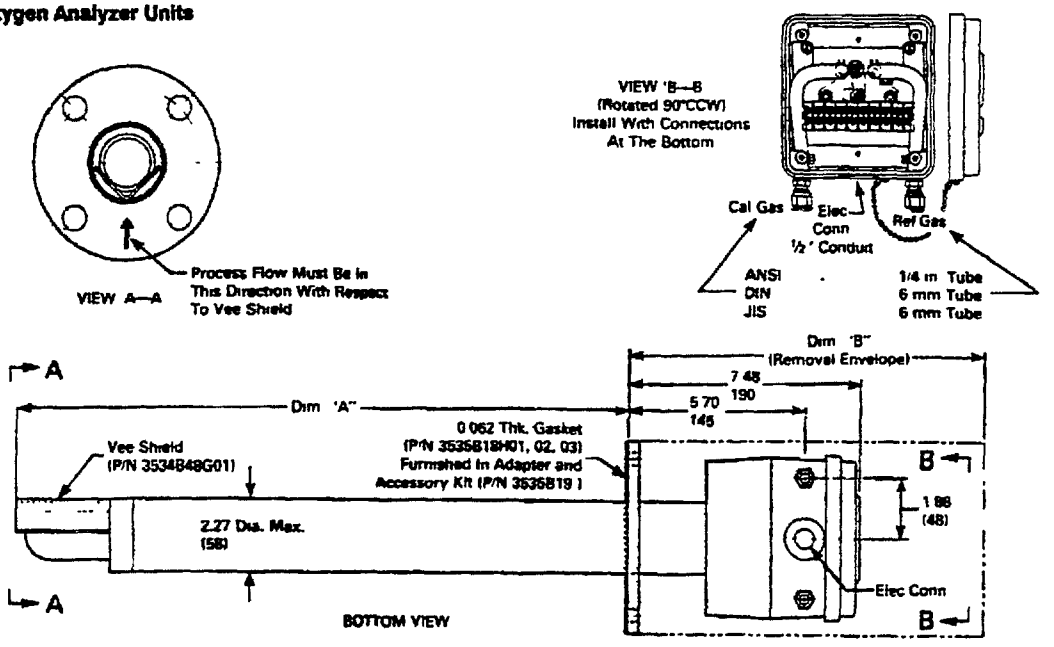
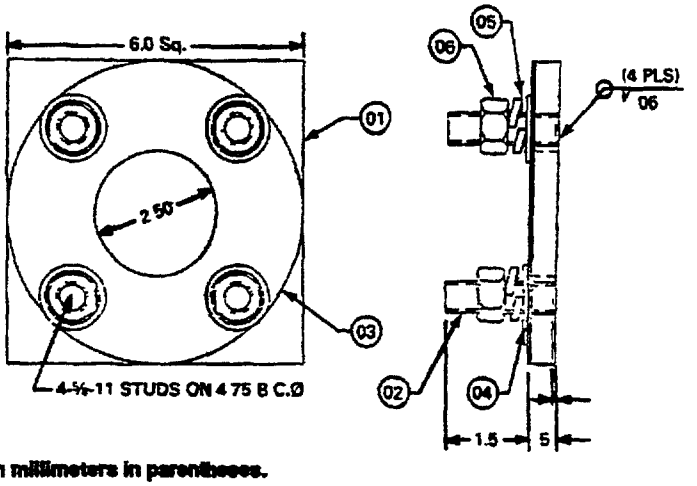
# DIMENSIONAL DRAWINGS

**Outline for Oxygen Analyzer Units**



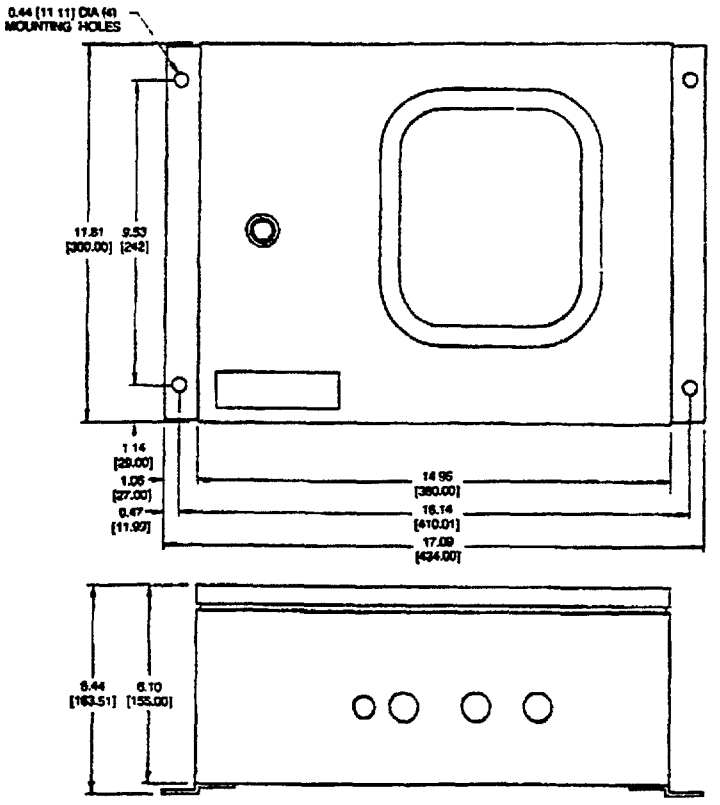

**Adapter Plate Outline**



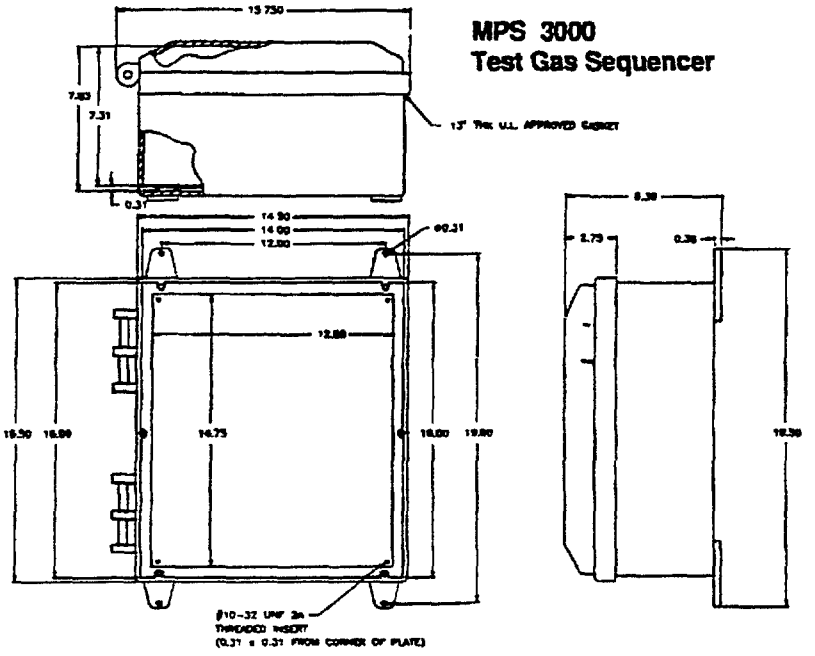

**Note: All dimensions are in inches with millimeters in parentheses.**

| Installation Dimension Schedule | | | | | | |
|---|---|---|---|---|---|---|
| **Table I. Mounting Flange** | | | | **Table II. Insertion/Removal** | | |
| **Dimensions Dia. in. (mm)** | **ANSI [P/N 4512C17H01]** | **DIN [P/N 4512C19H01]** | **JIS [P/N 4512C18H01]** | **Dimensions in. (mm)** | **Dim. "A" Insertion Depth** | **Dim. "B" Removal Envelope** |
| Flange | 6.00 (153) | 7.28 (185) | 6.102 (155) | 9700D86G01, 04, 07 18 in. Probes | 19.80 (503) | 27.31 (694) |
| Hole Size | 0.750 (20) | 0.708 (18) | 0.590 (15) | 9700D86G02, 05, 08 3 Ft. Probes | 37 80 (960) | 45.31 (1151) |
| 4 Holes Eq. Sp on B C. | 4.75 (121) | 5.708 (145) | 5 118 (130) | 9700D86G03, 06, 09 6 Ft. Probes | 73.80 (1875) | 81.31 (2065) |

## Electronics Housing Dimensional Drawing




**Note: All dimensions are in inches with millimeters in parentheses. Dimensional drawings are subject to change without notification.**



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# ORDERING INFORMATION

| 3000D | World Class 3000 Oxygen Analyzer with Universal Digital Electronics Package |
|---|---|

Sensing Probe - Tool Kit - Instruction Book

| Code | Sensing Probe Type |
|---|---|
| 1 | Quick Change Diffusion Element Probe (ANSI) |
| 2 | Flame Arrestor Probe (ANSI) |

| Code | Probe Assembly |
|---|---|
| 1 | 18" Probe |
| 2 | 18" Probe with 3 Ft. By Pass |
| 3 | 18" Probe with 6 Ft. By Pass |
| 4 | 18" Probe with 9 Ft. By Pass |
| 5 | 3' Probe |
| 6 | 3' Probe with Abrasive Shield |
| 7 | 6' Probe |
| 8 | 6' Probe with Abrasive Shield |

| Code | Electronics (Nema 4, IP55) |
|---|---|
| 01 | 115 Volt (US) |
| 02 | 115 Volt with heater (US) |

| Code | Printer Software & Keypad Display |
|---|---|
| 1 | Standard Printer Software |
| 2 | IBM P/C Software |
| 3 | Multiprobe 3000 Software |

| Code | Printer Software & Keypad Display |
|---|---|
| 5 | US Keypad & Display |

| Code | Reference & Test Gas Hardware |
|---|---|
| 11 | Cal. Gas Rotometer & Ref Gas Set |
| 22 | MPS 3000 (115 Vac) for single probe operation |

| Code | Probe Cable (Weatherproof) |
|---|---|
| 11 | 20 feet (6 m) |
| 12 | 40 feet (12 m) |
| 13 | 60 feet (18 m) |
| 14 | 80 feet (24 m) |
| 15 | 100 feet (30 m) |
| 16 | 150 feet (45 m) |

| Code | Mounting (To Stack or Existing Mounting Plate) |
|---|---|
| 1 | Mounting to Stack (New Installation) |
| 2 | Mounting to Model 218 Mounting Plate (with Model 218 Shield Removed) |
| 3 | Mounting to Model 218 Shield or other Mounting Plate |

| Code | Mounting (To Stack or Existing Mounting Plate) |
|---|---|
| 1 | Mounting an ANSI Probe (Ordering Probe Only) |
| 2 | Mounting an ANSI Bypass or Abrasive Shield |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3000D | 1 | 1 | 01 | 1 | 5 | 11 | 11 | 1 | 2 | EXAMPLE | | |

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ROSEMOUNT® Measurement Control Analytical Valves

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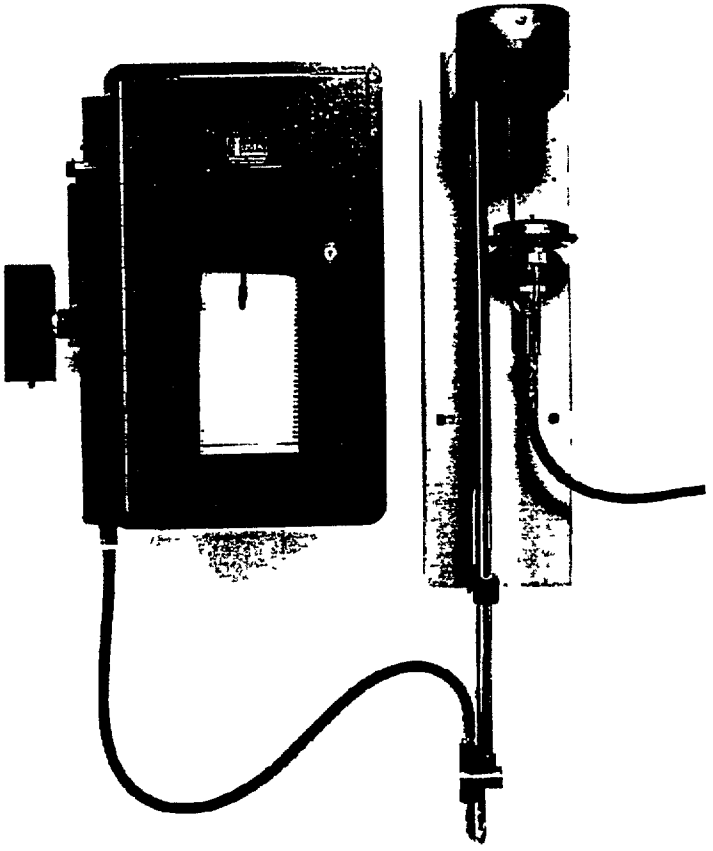
# fuel gas monitors

## AND TELEMETER AMPLIFIER



SIGMA INSTRUMENTS

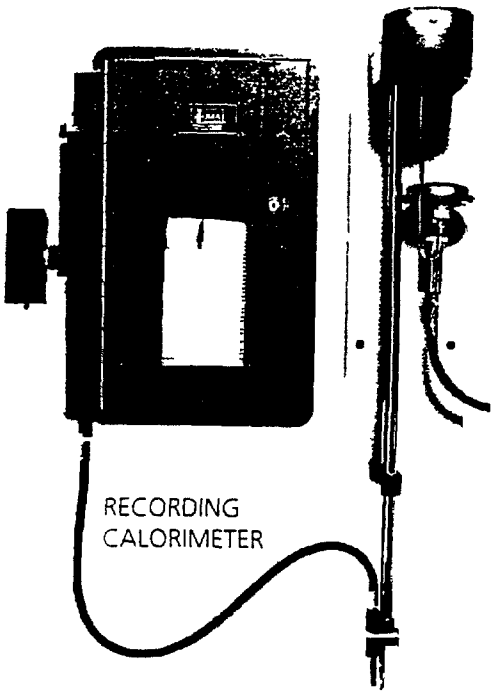
Designers, Manufacturers & Suppliers Of
Gas Measurement & Control Equipment

ecorc

1 18

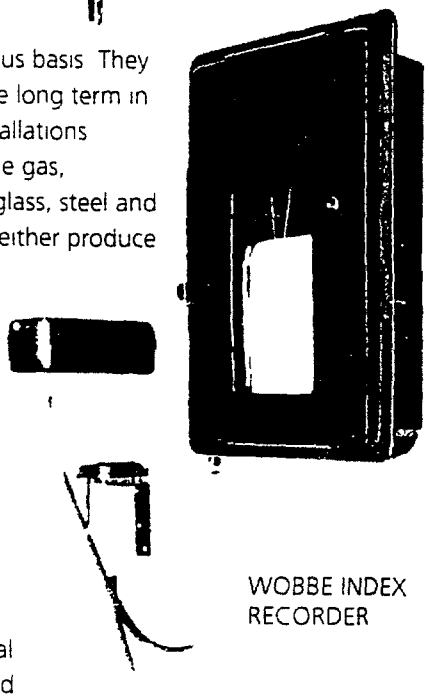
# fuel gas

The **SIGMA** Gas Calorimeter and Wobbe Index Recorder are two of today's most sensitive, readily available watchdogs for gas energy and Wobbe index values Requiring only 9 square feet of wall or panel space each, these instruments continuously record the heating value (Btu/scf) or Wobbe value of any combustible gas or gas mixture They are accurate to ±1% under suitable operating conditions The gas calorimeter automatically compensates for variations in specific gravity, ambient temperature and barometric pressure Telemetering outputs can be built into the units when required The instruments are designed and built to provide maximum reliability on a continuous basis They have been proven in the long term in many thousands of installations worldwide, including the gas, petro-chemical, water, glass, steel and other industries, which either produce gas or are large gas consumers



RECORDING CALORIMETER

These instruments are almost maintenance-free, do not require specially skilled supervision, and in-house personnel with no special training can handle servicing The combination of low initial cost and low running and maintenance involvement helps explain their wide acceptance



WOBBE INDEX RECORDER

## RECORDING CALORIMETER

The **SIGMA** gas calorimeter is recognised for its reliability and versatility Any combustible gas or gas mixture can be monitored The analyser comprises two main units a two-stage regulator for sample flow, and an expansion tube sensing device with a recorder The simplicity of its construction provides for continuous operation without supervision, minimal maintenance, extreme ease of field parts replacement when necessary, and many years of service The unit is shipped ready for installation, and setup can easily be carried out by in-house personnel Connection of the sample stream and the electrical supply line are all that is normally necessary Full operating and maintenance instructions are contained in the service manual supplied with the equipment

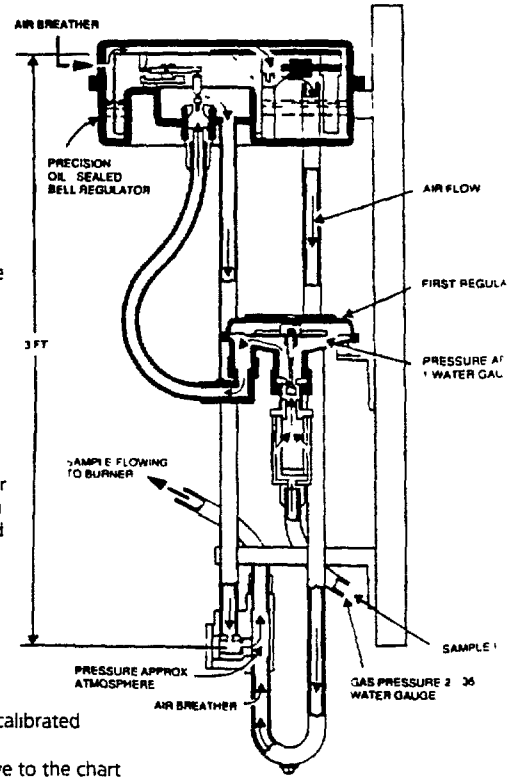
## HOW IT WORKS

The calorimeter consists of two sections

1 A gas flow regulator
2 A sensing mechanism with recorder or LCD display

As shown in the diagram below, the sample flow regulator controls the flow of gas to the burner of the sensing mechanism so that the actual flow corresponds to a constant flow at 60°F and 30"Hg The gas sample is admitted to the first regulator at 5-36"wg, and reduced to 1"wg A pre-regulator is used for higher sample input pressures The second stage regulator is an oil-sealed bell-type giving precise regulation so that the sample emerges from the control orifice at slightly above atmospheric pressure for conveyance to the sensing mechanism

The sample, automatically compensated for density and temperature changes, is burned at the base of a differential expansion tube unit This differential is magnified by a mechanical linkage which creates pen movement or updates the LCD display Air for combustion is compensated for barometric and temperature changes




The calorific value may be continuously recorded on a calibrated chart

As an alternative to the chart recorder, an LCD display may be fitted, giving direct digital readings of the index or an indicating scale to give analogue readings

# monitors

## WOBBE INDEX RECORDER

The **SIGMA** Wobbe Index Recorder functions in the same manner as the Calorimeter but does not compensate for sample density changes It measures a value which is a function of both heating value and specific gravity This value is known as the Wobbe Index value When basic gas supplies have to be supplemented by gas drawn from an alternative source, changes can take place in heating value and specific gravity Maintenance of a constant heating value cannot, in these circumstances, always be an assurance of constant heat input, since it does not guarantee a constant rate of heat supply Heat released by a gas burner is determined by

1 The size of orifice controlling discharge
2 The differential pressure across the orifice
3 The calorific value of the gas
4 The specific gravity of the gas

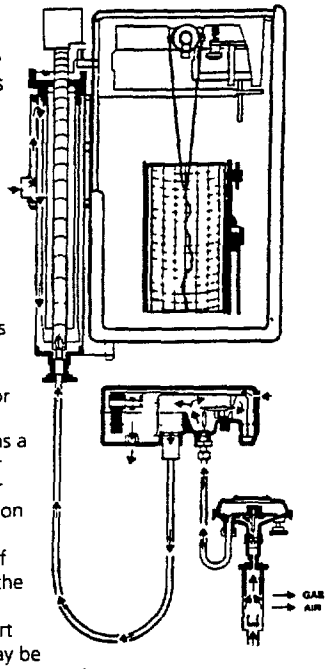
If 1 and 2 are fixed values, the thermal output will be proportional to the heating value and inversely proportional to the square root of the specific gravity, or

$$\text{thermal output} = k \left[ \frac{\text{calorific value}}{\sqrt{\text{specific gravity}}} \right]$$

where k is a constant
The value within the brackets is known as the Wobbe Index

## HOW IT WORKS

Continuous determination of Wobbe Index has been effectively used for years in the steel, glass, oil and petrochemical industries and numerous others
The Wobbe recorder is functionally similar to the calorimeter except that the flow regulator section does not compensate for gas density changes This is because these changes must be reflected for the Wobbe measurement in addition to the heating value changes
A gas sample enters the regulator at 5-36"wg The first regulator stage reduces the sample to 1"wg The second stage is a precision oil-sealed bell-type regulator which, in combination with the control orifice, maintains a constant flow to the burner
The expansion and recorder function is identical to that on the Calorimeter except that barometric compensation of ambient air is not used for the Wobbe measurement
As an alternative to the chart recorder, an LCD display may be fitted, giving direct digital readings of the index or an indicating scale to give analogue readings




## TECHNICAL DATA

### MEASUREMENT RANGES

**Recording Calorimeter**
80-3000 BTUs and equivalent units (special equipment available for zero based gases) For the measuring capability of individual instruments refer to recorder chart sheets

**Wobbe Index Recorder**
From below 100 to 2000 BTU Wobbe and equivalent units

### TYPES OF GAS
Town/city, natural, coke oven, coke oven/blast furnace, blast furnace, reformed refinery fuel, butane/air, propane/air, sewage/sludge, biogas, landfill etc

### RESPONSE
Dead time 40 seconds (typically)
Response (66% of change) 7 minutes (typically)

The above are typical of the capability of the instrument but will vary depending on the gas under test The figures are obtained by timing from the moment that a change of gas composition reaches the filter

### CHARTS
Chart width 100mm (4")
Speed 12 7mm (½") or 25 4mm (1")/hr

### VISIBLE RECORD
200mm (8") through cabinet door

### DIMENSIONS

**Recorder units - Calorimeter and Wobbe Index Recorder**
Size 635mm (25") high x 432mm (17") wide x 223mm (9") deep
Weight 32kg (70 lbs) Wall or panel mounting - dimensions are maximums over the flange and chimney

**Regulator unit - Calorimeter**
Size 1168mm (46") high x 229mm (9") wide x 280mm (11") deep
Three screw mounting
Weight 10kg (22 lbs)

**Regulator unit - Wobbe Index**
Size 635mm (25") high x 223mm (9") wide x 279mm (11") deep
Three screw mounting Weight 7kg (16lbs)

Both regulators are fitted with primary governor, complete with supply failure cut off device requiring manual reactivation

Full instructions on mounting, panel cut-out dimensions and positioning of Recorder relative to Regulator are supplied with the instrument

### SERVICES

**Gas**
Regulator is fitted with a flexible pipe terminating in ¼" gas male threaded connector

**Electrical**
220v 50Hz, 110v 50/60Hz single phase supply To drive electric chart table and Telemeter Amplifier Model 90

Note Mechanical drive for chart table available on request

### ORDERING INFORMATION

**RECORDING CALORIMETER MODEL 101**
Comprises Gas Flow Regulator, Barometric Compensator, Recorder & supply of charts

**Accessories**
- Telemeter Amplifier Model 90
- Data Logging Unit

### WHEN ORDERING PLEASE STATE

A) Type of gas
B) Specific gravity
C) Calorific value
D) Range of variation from nominal (type of chart required)
E) Supply pressure

# telemeter amplifier model 90

## TECHNICAL SPECIFICATION

**FUNCTION**

Remote landline transmission of recorder information over large distances Also provides output signals for pneumatic controllers or transmitters used in automatic gas control applications For use with **SIGMA** Recording Calorimeter and **SIGMA** Wobbe Index Recorder.
Can provide continuous reproduction of Recorder trace to remote station, which may house different types of instrumentation also connected to the master recorder.

**MOUNTING**

Fits inside Recorder case.

**POWER SUPPLY**

110V/220V, 50/60Hz

**OPERATION**

Operates in conjunction with small transducer mounted on Recorder pen spindle Transducer follows pen movement. Amplifier unit processes transducer signals.

**ACCURACY**

Does not affect Recorder accuracy
Linearity better than 1%.
Stability better than 1% of full scale within temperature limits.

**OUTPUTS**

Voltage or current outputs from amplifier selectable from a number of ranges.

**Current mode**

- 0 - 10 mA DC into 2kΩ total load.
- 4 - 20 mA DC into 1kΩ total load.
- 10 - 50 mA DC into 400Ω total load.

**Voltage mode**

- 0 - 100mV DC.
- 0 - 5V DC.
- 0 - 10V DC.

**Status**

Voltage and current outputs earth free allows +ve or -ve lines to be taken to earth.

Internal switch provides mains input selection of either 110 or 220V AC. Continuous output signal plus 4 adjustable switches to provide switched outputs at preset warning and limit positions. Adjustable limits provide early warning and shut down facilities to ensure plant and instrument safety

**OPERATING TEMPERATURE**

0 - 45° C.

**MONITOR**

4 independent stations adjustable to any point over the scale range.

Red LED indicator for 'low' and 'high' warning.

Each station fitted with setting control

Single pole changeover relay for each station

Contact rating 240V AC, 3A

Override fitted for initial start up

**ORDER INFORMATION**

Telemeter Amplifier Model 90
Part No. FG0003.

Comprises transducer mounted on a pen spindle with bracket assembly and amplifier units. Complete with connecting wiring and LED indicator lamps

SIGMA INSTRUMENTS

COSA INSTRUMENT CORPORATION
55 OAK STREET/NORWOOD, NEW JERSEY 07648
TELEPHONE (201) 767-6600/FAX (201) 767-6804

*The information contained in this brochure is subject to change without notice*

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COSA INSTRUMENT CORPORATION

# SIGMA MARK II
# CALORIMETER SPECIFICATION

| | |
|---|---|
| MEASUREMENT RANGE | 0-4000 Btu/Scf or Wobbe Index Value (Metric Units Available) |
| RANGE: | With span value up to 50% of initial range value (depending on application)<br>Example: 800-1200 Btu/Scf = 50.0%<br>800-1600 Btu/Scf = 100% |
| ACCURACY: | ±1.0% of Upper Range Value - Wobbe Index Recorder<br>±0 5% of Measured Value - Calorimeter |
| REPEATABILITY: | ±0.1% of Upper Range Value |
| LINEARITY: | ±0.2% of Upper Range Value |
| *RESPONSE TIME: | Initial response, 60 seconds |
| OUTPUT SIGNAL: | Built-in continuous 4" strip chart recorder |
| AMBIENT LIMITS. | 40°F - 100°F<br>-20°F - 120°F (*Conditioned enclosure) |
| GAS SAMPLE RATE | 0.4 - 4.0 Scf/Hr., depending on Btu value |
| MOUNTING | Wall, panel or optional indoor or outdoor free standing enclosures |
| *AREA CLASSIFICATION | General Purpose |
| POWER: | 115 Volts ±10%/60Hz |
| PRINCIPLE OF OPERATION· | Gas sample is burned continuously and barometrically compensated dilution air is added. Total combustion temperature rise is processed and linearized on strip chart recorder, or optional 4-20 mA output signal, if specified. |
| OPTIONAL ACCESSORIES. | 4-20 mA with dual HI/LOW Alarms or 3-15 PSIG output. Sample conditioning equipment for $H_2S$ removal. Various remote readout devices; sample conditions; *fully piped and wired enclosures, other voltages. |

* * * HAZARDOUS AREA OR CONTROL APPLICATION REQUIRING FAST RESPONSE? ASK US FOR UNION FAST RESPONSE CALORIMETER DETAILS.

**HEAD OFFICE.** 55 Oak Street Norwood, NJ 07648 Tel (201) 767-6600 Fax (201) 767-6804
HOUSTON OFFICE 9410 Winkler Dr Houston TX 77017 Tel (713) 947-9591 Fax (713) 947-7549

# recorder charts.

The records charts listed are the standard charts designed for use with INSTECH Recording Calorimeters and Wobbe Index Recorders

The measuring ranges have been selected to accommodate the widest possible range of values and magnifications and to take into account the various measuring units used in the measurement of calorific value e.g. BTUs Calories Megajoules etc

Where there is no standard chart to suit your specific requirement specially designed charts can be supplied Further details are available on request

| Centre line value | Chart range | Part number 1/2/in/hour | Part number 1in/hour | Chart ref. |
|---|---|---|---|---|
| 0 | ±20% | 510059 (1/4 in/hr) | 510060 | 50/E |
| 3.75 | 2.5 - 5.0 | 510240 | | 100/41 |
| 5.7 | 3.8 - 7.6 | 510440 | | 100/38 |
| 5.7 | 3.8 - 7.6 | 510436 | | MJ/100/31 |
| 6.5 | 0 - 13 | 510040 | | 14/100 |
| 10. | 8 - 12 | 510425 | | 50/108 |
| 16.65 | 11.1 - 22.2 | | 510433 | 100/40 |
| 17.5 | 14 - 21 | 510428 | 510-2- | 50/101 |
| 18 | 9 - 27 | 510322 | | 200/12 |
| 20 | 16 - 24 | 510428 | 510-2- | 50/107 |
| 20.83 | 16.66 - 25 | 510430 | | 50/110 |
| 22.5 | 20 - 25 | 510058 | | 25/101 |
| 23.5 | 18.8 - 28.2 | 510149 | | 50/102 |
| 25 | 20 - 30 | 510147 | 510-21 | 50/100 |
| 27 | 18 - 36 | 510232 | | 100/36 |
| 32. | 16 - 48 | 510324 | | 200/13 |
| 32.5 | 26 - 39 | 510145 | | 50/104 |
| 33.75 | 27 - 40.5 | 510143 | | 50/106 |
| 40. | 22 - 58 | 510274 | 510279 | 160/14 |
| 42.5 | 34 - 51 | 510146 | | 50/105 |
| 45 | 18 - 72 | 510323 | | 300/3 |
| 50 | 40 - 60 | 510046 | | 50/109 |
| 50. | 25 - 75 | 510310 | | 200/4 |
| 50 | 0 - 100 | 510034 | | 14/2 |
| 57 | 38 - 76 | 510427 | — | 100/100 |
| 57.5 | 23 - 92 | 510326 | | 300/4 |
| 57.5 | 30 - 85 | 510420 | 510144 | 50/103 |
| 70. | 40 - 100 | 510295 | | 160/65 |
| 75 | 50 - 100 | 510193 | 510194 | 100/17 |
| 75 | 0 - 150 | 510039 | | 14/5 |
| 87.5 | 70 - 105 | 510118 | 510119 | 50/26 |
| 90. | 60 - 120 | 510426 | 510233 | 100/37 |
| 91 | 70 - 112 | 510154 | | 60/3 |
| 100 | 80 - 120 | 510061 | 510062 | 50/1 |
| 105 | 70 - 140 | 510225 | 510226 | 100/32 |
| 108. | 60 - 156 | 510292 | | 160/27 |
| 112.5 | 90 - 135 | 510114 | 510115 | 50/24 |
| 112.5 | 75 - 150 | 510219 | 510220 | 100/29 |
| 120. | 80 - 160 | 510187 | 510188 | 100/14 |
| 125 | 0 - 250 | 510032 | | 14/1 |
| 137.5 | 110 - 165 | 510071 | | 50/5 |
| 142.5 | 80 - 205 | 510251 | 510252 | 160/5 |
| 150 | 120 - 180 | 510120 | 510121 | 50/27 |
| 150 | 100 - 200 | 510223 | | 100/31 |
| 150. | 100 - 200 | 510440 | | |
| 160. | 80 - 240 | 510314 | | 200/8 |
| 175 | 140 - 210 | 510122 | | 50/28 |
| 180. | 100 - 260 | 510272 | 510273 | 160/13 |
| 187.5 | 150 - 225 | | 510084 | 50/11 |
| 200 | 100 - 300 | | 510317 | 200/9 |
| 212.5 | 170 - 255 | 510098 | 510099 | 50/17 |
| 225 | 150 - 300 | 510179 | 510180 | 100/10 |
| 250. | 200 - 300 | 510137 | | 50/34 |
| 290 | 160 - 420 | 510280 | 510432 | 160/16 |
| 300 | 200 - 400 | 510181 | 510182 | 100/11 |
| 300. | 100 - 500 | 510330 | 510331 | 400/16 |
| 312.5 | 250 - 375 | 510082 | 510083 | 50/10 |
| 350 | 0 - 700 | 510038 | | 14/4 |
| 360. | 120 - 600 | 510434 | | 400/4 |
| 375 | 250 - 500 | 510171 | 510172 | 100/6 |
| 400 | 320 - 480 | 510073 | 510074 | 50/6 |
| 400 | 200 - 600 | 510306 | 510307 | 200/2 |
| 450 | 360 - 540 | 510092 | 510093 | 50/15 |
| 450. | 250 - 650 | 510275 | 510276 | 160/15 |
| 450. | 300 - 600 | 510213 | 510214 | 100/26 |
| 475 | 380 - 570 | 510088 | 510089 | 50/13 |
| 495 | 440 - 550 | 510046 | 510047 | 25/2 |
| 500 | 400 - 600 | 510104 | 510105 | 50/20 |
| 525 | 350 - 700 | 510209 | 510210 | 100/25 |
| 540 | 300 - 780 | 510270 | 510271 | 160/12 |
| 550. | 490 - 610 | 510050 | | 25/4 |
| 550. | 423 - 677 | 510155 | | 60/4 |
| 562.5 | 450 - 675 | 510116 | 510117 | 50/25 |
| 600. | 400 - 800 | 510231 | | 100/35 |
| 600. | 400 - 800 | 510167 | 510168 | 100/4 |
| 625 | 500 - 750 | 510100 | 510101 | 50/18 |
| 630. | 350 - 910 | 510245 | 510246 | 160/2 |
| 650. | 500 - 800 | 510150 | 510151 | 60/1 |
| 675 | 450 - 900 | 510201 | 510202 | 100/21 |
| 675 | 600 - 750 | 510052 | 510053 | 25/5 |
| 720. | 400 - 1040 | 510262 | 510263 | 160/9 |
| 750. | 600 - 900 | 510140 | 510141 | 50/70 |
| 750. | 500 - 1000 | 510163 | 510164 | 100/2 |
| 750. | 400 - 1100 | 510300 | | 175/1 |
| 825 | 550 - 1100 | 510169 | 510170 | 100/5 |
| 832.5 | 740 - 925 | | 510057 | 25/7 |
| 875 | 700 - 1050 | 510063 | 510064 | 50/1M |
| 900. | 500 - 1300 | 510260 | 510261 | 160/8 |
| 900. | 600 - 1200 | 510160 | 510161 | 100/1M |
| 900 | 450 - 1350 | 510305 | | 200/1 |
| 937.5 | 500 - 1375 | 510302 | | 175/2 |
| 975 | 650 - 1300 | 510227 | | 100/33 |
| 1000. | 0 - 2000 | 510036 | 510037 | 14/3 |
| 1000. | 750 - 1250 | | 510159 | 66/1 |
| 1000. | 500 - 1500 | 510312 | | 200/6 |
| 1000. | 800 - 1200 | 510065 | 510066 | 50/2M |
| 1035 | 920 - 1150 | 510044 | 510045 | 25/1 |
| 1050 | 700 - 1400 | 510229 | 510230 | 100/34 |
| 1060 | 600 - 1560 | 510268 | 510269 | 160/11 |
| 1100 | 800 - 1400 | 510439 | 510429 | 75/1 |
| 1125 | 900 - 1350 | 510108 | 510109 | 50/21 |
| 1200. | 800 - 1600 | 510189 | 510190 | 100/15 |
| 1250. | 1000 - 1500 | 510086 | 510087 | 50/12 |
| 1260. | 700 - 1820 | 510253 | 510254 | 160/5M |
| 1300. | 1000 - 1600 | 510152 | 510153 | 60/2 |
| 1350. | 900 - 1800 | 510183 | 510184 | 100/12 |
| 1375 | 1100 - 1650 | 510090 | 510091 | 50/14 |
| 1500. | 1000 - 2000 | 510197 | 510198 | 100/19 |
| 1500. | 1200 - 1800 | 510096 | 510097 | 50/16 |
| 1500. | 500 - 2500 | 510328 | | 400/3 |
| 1530 | 850 - 2210 | 510290 | | 160/26 |
| 1600. | 800 - 2400 | | 510309 | 200/3 |
| 1750. | 1400 - 2100 | 510110 | 510111 | 50/22 |
| 1800. | 1200 - 2400 | 510195 | 510196 | 100/18 |
| 1800 | 1000 - 2600 | 510241 | 510242 | 160/1 |
| 1880 | 1500 - 2260 | 510069 | | 50/4 |
| 2000 | 1000 - 3000 | 510318 | | 200/10 |
| 2000 | 1600 - 2400 | 510133 | 510135 | 50/46 |
| 2100 | 1400 - 2800 | 510191 | | 100/16 |
| 2125 | 850 - 3400 | | 510320 | 300/1 |
| 2250 | 1500 - 3000 | 510175 | 510176 | 100/8 |
| 2500 | 2000 - 3000 | 510136 | | 50/33 |
| 2600 | 2000 - 3200 | | 510157 | 60/6 |
| 2750 | 2200 - 3300 | 510080 | 510081 | 51/10M |
| 2900 | 1600 - 4200 | 510249 | | 160/4 |
| 3000. | 2000 - 4000 | 510235 | 510236 | 100/50 |
| 3000. | 1000 - 5000 | 510325 | 510-28 | 400/1 |
| 3250 | 1800 - 4680 | 510284 | 510285 | 160/23 |
| 3375 | 2700 - 4050 | | 510103 | 50/111 |
| 3750 | 2500 - 5000 | 510199 | 510200 | 100/20 |
| 4000 | 2000 - 6000 | | 510211 | 200/5 |
| 4000 | 3200 - 4800 | 510094 | 510095 | 50/15M |
| 4000 | 2200 - 5800 | 510277 | 510278 | 160/15M |
| 4050 | 3600 - 4500 | 510-8 | | 25/3 |
| 4500. | 3000 - 6000 | 510215 | 510216 | 100/27 |
| 4500 | 3600 - 5400 | 510106 | 510107 | 50/20M |
| 4550. | 3500 - 5600 | | 510156 | 60/5 |
| 4650. | 3100 - 6200 | 510211 | | 100/25M |
| 4750. | 3800 - 5700 | 510125 | | 50/30 |
| 5000. | 4000 - 6000 | 510112 | 510113 | 50/23 |
| 5040 | 2800 - 7300 | 510288 | 510289 | 160/25M |
| 5250. | 3500 - 7000 | 510217 | | 100/28 |
| 5340 | 3000 - 7800 | 510231 | | 1000/35 |
| 5400 | 3000 - 7800 | 510282 | | 160/18 |
| 5550 | 3700 - 7400 | 510437 | | 100/42 |
| 5625 | 4500 - 6750 | 510075 | 510076 | 50/7 |
| 6000 | 3000 - 9000 | | 510219 | 200/11 |
| 6000 | 4000 - 8000 | 510173 | 510174 | 100/7 |
| 6000 | 2000 - 10000 | | 510227 | 400/2 |
| 6250. | 5000 - 7500 | 510067 | | 50/3M |
| 6300 | 3500 - 9100 | 510286 | 510287 | 160/24 |
| 6750. | 4500 - 9000 | 570431 | 510234 | 100/39 |
| 7200 | 4000 - 10400 | 510283 | | 160/19 |
| 7500 | 3000 - 12000 | 510321 | | 300/2 |
| 7500 | 6000 - 9000 | 510130 | 510131 | 50/40M |
| 7500 | 5000 - 10000 | 510165 | | 100/3 |
| 8100 | 4500 - 11700 | 510266 | 510267 | 160/10 |
| 8450 | 7500 - 9400 | | 510055 | 25/6 |
| 8750. | 7000 - 10500 | 510078 | 510079 | 50/9 |
| 9000 | 6000 - 12000 | 510177 | 510178 | 100/9 |
| 10000. | 8000 - 12000 | 510132 | 510134 | 50/45M |
| 10500. | 7000 - 14000 | 510205 | | 100/23 |
| 10800. | 6000 - 15600 | 510247 | | 160/3 |
| 11250. | 9000 - 13500 | 510127 | | 50/31 |
| 12000 | 8000 - 16000 | 510185 | 510186 | 100/13 |
| 12500 | 10000 - 15000 | 510124 | | 50/29 |
| 12600 | 7000 - 18200 | 510255 | | 160/6 |
| 13500. | 9000 - 18000 | 510221 | | 100/30 |
| 13700 | 11000 - 16400 | 510102 | | 50/19 |
| 14400. | 8000 - 20800 | 510258 | | 160/7 |
| 15000. | 10000 - 20000 | 510237 | 510238 | 100/50M |
| 18000 | 12000 - 24000 | 510207 | 510208 | 100/24 |
| 18750 | 15000 - 22500 | | 510129 | 50/32 |
| 21600. | 12000 - 31200 | 510281 | | 160/17 |
| 22500 | 15000 - 30000 | 510203 | 510204 | 100/22 |
| 27500. | 22000 - 33000 | 510142 | 510123 | 50/71 |
| 30000 | 20000 - 40000 | 510206 | | 100/43 |



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COSA

# SIGMA GAS CALORIMETERS

## *SIGMA GAS HEATING VALUE MONITOR:*
## *For measuring Heating Values in a wide range of Fuel Gases*

*All SIGMA analyzers feature a recorder and a gas flow regulator. The wall mounted analyzer includes local reac out of measured value on a continuous 4" strip chart. Dilution air entering the sensor tube system is barometricall compensated for flow rate to provide ± 0.5% measurement accuracy. The gas flow regulator is suitable fc sample pressures up to 36" W C. and a low pressure cut-off valve protects against inlet pressures below 2" W.C Supplied with 12 roll charts, accessory kit and users manual.*

*For further details - Please refer to the model selection guide below and ordering information on page two*

### *MODEL SELECTION GUIDE*

*Calorimeter ..... Calibrated to read higher values in BTU/scf at S.T.P.*

*Wobbe Index ..... Calibrated to read Wobbe Index Values = Heating Value / $\sqrt{\text{specific gravity}}$*

| | |
|---|---|
| *Applications:* | *Appliance and Boiler Manufacturers, Chemical Processing, Co-Generation, District Heating Companies, Gas and Power Utilities, Glass Manufacture, Industrial Process, Land Fills, Peak Shaving Plants, Power Houses, Refineries, Sewage Treatment, Steel and Primary Metals, Synthetic Fuels.* **(All Gas monitoring applications requiring continuous recording).** |

| *Model Number:* | *Model CLV or WLV* | *MODEL CHV or WHV* |
|---|---|---|
| *Sample Gases:* | *Blast Furnace Gas* | *Natural Gas* |
| | *Producer Gas* | *Refinery Tail Gas* |
| | *Coal Gasification* | *Coke Oven Gas* |
| | *Chemical Processing* | *Liquefied Petroleum Gas* |
| | *Synthetic Fuels* | *Sewage and Land Fill Gas* |
| | *Off Gases* | *Coal Gasification* |
| *Features:* | • *Special Electric low BTU Burner* | • *Fully Mechanical Operation* |
| | • *Ignition Support Gas not required* | • *Continuous Instrument Air not requirec* |
| | • *Fully mechanical operation* | • *Local Read-out provided* |
| | • *Continuous Instrument Air not required* | • *Chart Speed 1/2"/Hr (1" optional)* |
| | • *Local Read-out provided* | • *Optional 4-20 mA output with dual high/low alarms* |
| | • *Chart Speed 1/2"/Hr (Monthly) (1" Two Weekly optional)* | • *Optional free-standing enclosure* |
| | • *Optional 4-20 mA output with dual high low alarms* | • *Other ranges can be measured with simple parts exchange* |
| | • *Optional free-standing enclosure* | • *Highest Accuracy* |
| | • *Low cost simple installation* | • *Low cost simple installation* |

*(Applications and features apply to both Calorimeter and Wobbe Index Analyzers)*

*Equipment Guarantee:* *Equipment rated for continuous service without attention. Guaranteed for one year against defective materials and workmanship when correctly installed for approved applications and operated in accordance with instructions contained in manual*

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# SIGMA GAS HEATING VALUE MONITOR

(ORDERING INFORMATION - ALSO REFER TO BULLETINS SIG 100 AND SELECTION GUIDE ON PAGE ONE)

CLV Calorimeter; for Heating Value Measurement between 50 -200 BTU/scf. .....
WLV Wobbe Index; for Heat Release Measurement between 50 - 200. .....
CHV Calorimeter; for Heating Value Measurement above 200 BTU/scf .....
WHV Wobbe Index; for Heat Release Measurement above 200.....

RANGE OF MEASUREMENT
50/ Insert chart number from chart selection guide # ST 3 (example 50/2M)

RANGE OF MEASUREMENT (to special order)
25/ 100/ 160/ 200/ 400/ chart number from selection guide

SPECIFIC GRAVITY OF SAMPLE GAS
A Above 1.0 (Air = 1.0) example L. P. Gas
B Below 1.0 (Air = 1.0) example Natural Gas

CHART SPEED
1/2 1/2"/Hr, Standard (electric drive) monthly chart duration
1 1"/Hr, Optional (electric drive) two-weekly chart duration

OUTPUT SIGNAL
N None
A Amplifier TAM 90 - 4-20 mA output, with 4 adjustable alarms .....

ENCLOSURE - FREE STANDING
1 None
2 Indoor use - piped and wired - rated NEMA 12 .....
3 Outdoor use - heated, piped and wired, NEMA 3 .....

RANGE OF MEASUREMENT
XX TO XXX - see chart selection guide for availability

CHV 50/2mB 1/2 A 2 800-1200 = Sample Order Code

**Other Optional Equipment and Accessories:**

Pair of Purifiers, for $H_2S$ removal - (iron or zinc oxide Customer supplied) .....
Filter Unit for removal of dust with spare element - specify with purifier .....
Pressure Regulator (Little Joe) - for inlet pressure from 1.0 to 150 psig .....
Corrosion Resistant Valve Seatings - Specify for Steel Mill use .....
Chart Drive - Spring Wound, mechanical operation .....
Lower 'U' Tube conversion set - for specific gravities above 1.0 .....
Additional Range Orifice - for other measuring ranges - to be specified .....
Additional Roll Charts - specify chart number and range .....
Remote Recorder, 4" strip chart - (4-20 mA output option also required) .....
Remote Digital Indicator - (4-20 mA output option also required) .....
Power Supply for other voltages -specify volts and Hz .....
Users Manual additional copies .....
Installation Prints or Reproducible Drawings .....

***All prices, orders and contracts are subject to confirmation and acceptance by COSA INSTRUMENT CORPORATION at its home office, Norwood, NJ and are subject to change in accordance with supplier price variations up to the time of written order. Prices do not include on-site services. Unless otherwise stated, items listed are supplied as separate components for assembly or connection by user on-site. All prices are F.O.B. shipping point - Norwood N.J. Terms - Net 30 Days, subject to approval.***