ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

Prepared for:

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The contents of this report include recommendations based on data provided by the client organization, measurements made on site, calculations, and engineering judgement. The conclusions reached were based on a limited engagement of only about ten days duration in Kostroma, and not an exhaustive engineering analysis. RCG/Hagler, Bailly, Inc. certifies that this report conforms to the level of best commercial practice for industrial energy audits of similar level of effort, as conducted in the United States. This report has been prepared under the guidance of a registered Professional Engineer, licensed to practice in the United States.

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Energy Audit
District Heating System

Kostroma, Russia

Prepared for:

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Prepared by:

RCG/Hagler, Bailly, Inc.
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The RCG/Hagler, Bailly team gratefully acknowledges the assistance and cooperation shown by USAID, Russian Commission for Humanitarian and Technical Assistance, Ministry of Fuel and Power, Kostromaenergo, Rabochiiy Metallist, Kostroma Ornamental Plant Farm, Kostroma Canalization, Barovay School, and Gorzhilupravenya. We also gratefully acknowledge the personalized assistance and cooperation of the following individuals:

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EXECUTIVE SUMMARY

A team of engineers from RCG/Hagler, Bailly, Inc., Joseph Technology, Duke Power, and Vnipienergoprom carried out site activities in the city of Kostroma, Russia from April 20-25, 1992. Their objective was to work together with officials from the City of Kostroma, Kostroma Region Heating Company (KostromaOblTeplEnergo, KOTE), Kostroma Electric Company (KostromaEnergo), the City Municipal Housing Commission (Gorzhiluprovenya) and other organizations to examine the state of the district heating system and to identify opportunities for improvements in energy efficiency of the system.

During the project, various facilities were reviewed, including

- generation: two thermal cogeneration facilities (TETS) of KostromaEnergo (42 and 170 MW electric), one large thermal power station (GRES) of KostromaEnergo (3,600 MW electric) which also supplies heat to a town of 25,000 people, small boilerhouses of KostromaOblTeplEnergo (1-4 Gcal) serving municipal areas, and industrial boiler room of Rabochiy Metallist (manufacturer of bucket excavators).

- distribution: pipelines and substations of KostromaOblTeplEnergo

- heat utilization: residential buildings, a school, an industrial plant, and greenhouses.

A seminar was held to introduce engineers and managers to energy management concepts and energy audit instruments. Tests of combustion efficiency, electric motor efficiency, boiler water treatment, and distribution system heat loss were carried out using RCG/Hagler, Bailly's energy audit instruments.

The primary energy forms used in Kostroma are natural gas and electricity. Some heavy fuel oil (mazout, 2% sulfur) and peat (turf) is used in the power stations. Annual statistics related to energy consumption are as follows:

Kostromaenergo (3 thermal power stations)

Combined heat and power station No. 1 (TETS-1):	
TETS-1 electric peak demand	40 MW
TETS-1 electric energy generation	0.2 TWh
TETS-1 heat rate (fuel assigned to power)	1,200 kcal/kWh
TETS-1 thermal energy delivered	1,500,000 Gcal
Combined heat and power station No. 2 (TETS-2):	
TETS-2 electric peak demand	170 MW
TETS-2 electric energy generation	1.2 TWh
TETS-2 heat rate (fuel assigned to power)	1,400 kcal/kWh
TETS-2 thermal energy delivered	2,000,000 Gcal
Gas & oil-fired steam power station (GRES):	
GRES electric peak demand	3,600 MW
GRES electric energy generation	19 Twh
GRES heat rate	2,200 kcal/kWh
GRES thermal energy delivered	300,000 Gcal
Kostromaoblteplenergo (170 boilerhouses)	
Heat purchased	1,000,000 Gcal
Heat generated	800,000 Gcal

The services provided by the energy enterprises of Kostroma are very valuable to the economy of the region. Energy prices in Russia at the time of the RCG/Hagler, Bailly team's visit were increasing rapidly, but were still far below European prices, reflecting a transition from the historical energy price subsidies provided in the Soviet Union. European market energy prices in 1992 are estimated as follows:

natural gas	$12 per Gcal
mazout	$70 per ton
electric power	$60 per MW per year
electric energy	$0.05 per kWh
district heat	$20 per Gcal at source
district heat	$30 per Gcal at end-use

Based on European market energy prices, the total economic cost of fuel energy consumed by the heat and power companies of Kostroma is estimated as $500 million per year. The economic value of the heat and power delivered by these companies is approximately $1.3 billion, as shown below.

Fuel energy used by Kostromaenergo -

Natural gas:

4.4 billion m^3 per year (36 Pcal/year),
at an economic value of $432 million per year

Heavy fuel oil:

1.1 million tons per year (12 Pcal/year),
at an economic value of $77 million per year

Fuel energy used by Kostromaoblteplenergo -

Natural gas:

120 million m^3 per year (1 Pcal/year),
at an economic value of $12 million per year

Energy supplied by Kostromaenergo to its customers-

net generated electric power:

3,600 MW peak demand,
at an economic value of $216 million per year

net generated electric energy:

20 TWh per year,
at an economic value of $1 billion per year.

heat supplied to Kostroma:

3 million Gcal per year
at an economic value of $60 million per year.

Energy supplied by Kostromaoblteplenergo to its customers-

heat supplied to Kostroma:

1.8 million Gcal per year
at an economic value of $54 million per year.

The RCG/Hagler, Bailly team estimates the short-term, low-cost potential for energy efficiency improvement in the district heating system in Kostroma as about 10%, as follows:

Short-term, low-cost energy savings potential

Heat generation	0-1%
Heat distribution	1-3%
Industrial heat use	5-10%
Institutional heat use	5-10%
Residential heat use	5-10%

Changes to improve operation and maintenance of existing systems will be required to realize these improvements. Technical personnel in Kostroma are experts in their fields, dedicated to efficiency and hard-working. They will need additional tools and instrumentation to achieve these goals.

Assuming conversion to a market economy for district heating commodity, the RCG/Hagler, Bailly team estimates the medium-term (next five years) potential for energy efficiency improvement in the district heating system of Kostroma as about 30% (including the short-term, low-cost projects), as follows:

Medium-term energy savings potential

Heat generation	0-1%
Heat distribution	2-10%
Industrial heat use	10-20%
Institutional heat use	10-20%
Residential heat use	15-30%

SUMMARY OF ENERGY EFFICIENCY RECOMMENDATIONS

In general, the RCG/Hagler, Bailly team found that the Russian standard of management of district heating systems operations and maintenance was significantly below Western standards. Many of these problems may result from the many years of Socialist system, which did not provide proper incentives for efficiency. Furthermore, the lack of an ownership mentality has prevented the traditional Russian frugality and work ethic from being reflected in the workplace - the dirty jobs are not getting done. Although optimization of operations management and improvement of maintenance may

not require significant expenditure to accomplish, it nevertheless may be very difficult because it will be very difficult to change the energy-related behavior of people overnight, after these many years.

To succeed in the market economy, however, the people of Kostroma must overcome these barriers. The installation of costly capital equipment to improve energy efficiency is not the solution - the economy of Kostroma must instead invest what little capital is available to improve the quality and quantity of production of goods for export to hard currency markets.

Instead, the RCG/Hagler, Bailly team recommends that a well-organized, but low-cost, program be established in the City of Kostroma and Kostroma region to implement energy efficiency measures in the short-term. The first-step and second-step priority low-cost, market-oriented measures identified by the RCG/Hagler, Bailly team below (and described in more detail in this report) can save 30% of district heating energy, with economic benefits to Kostroma region of more than $15 million per year, with an average economic payback period of about one year.

The recommendations are listed below. More details are provided in Chapter 4.

First Step Priority - short-term, low-cost projects

A. Optimize Operations Management

Action A.1: Improve control of supply temperature - modulate on hourly basis instead on every six-eight hours. Estimated savings: 0.2% of heating energy, which would give an economic benefit to the Kostroma region of $100,000 per year.

Action A.2: Improve control of supply temperature - optimize the GRAFIK based on trial and error procedure. Estimated savings: 5% of heating energy, which would give an economic benefit to the Kostroma region of $2.5 million per year.

Action A.3: Improve combustion efficiency in small boilerhouses, maintain optimum efficiency in heat/power stations. Estimated savings: 0.5% of fuel in small boilerhouses and 0.1% of fuel in power stations, which would give an economic benefit to the Kostroma region of $560,000 per year.

Action A.4: Improve control of water quality in steam boilers. This could improve boiler efficiency in industrial boilers by 0.25%.

Action A.5: Organize energy management information system for City to track trends in efficiency.

Action A.6: Organize small library of US manufacturers contacts for supply of equipment and possible joint ventures in manufacturing of high efficiency equipment.

B. Improve the Standard of Maintenance

Action B.1: Improve heat transfer effectiveness in the system - test, balance and clean heat exchangers to increase return water temperatures. Investigate temperature drop and state of flow in piping systems in buildings, and repair as indicated. Estimated savings: 10% of heating energy, which would give an economic benefit to the Kostroma region of $5 million per year.

Action B.2: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping (examples - residential building, greenhouse, and school). Estimated savings: 5% of heating energy, which would give an economic benefit to the Kostroma region of $2.5 million per year.

Action B.3: Use IR scanner on thermal systems, such as boilers and distribution piping, to detect excessive heat loss - repair insulation as indicated. Estimated savings: 1% of heating energy, which would give an economic benefit to the Kostroma region of $500,000 per year.

Second Step Priority - convert heat supply to a market economy

C. Medium Term - install metering and controls and revise tariff designs

Action C.1: Install Gcal metering at key points in network, and develop a loss-tracking system. Estimated savings: 2% of heating energy, which would give an economic benefit to KostromaOblTeplEnergo and KostromaEnergo of $1 million per year.

Action C.2: Install Gcal metering at inlet to all buildings, and convert to a tariff based on Gcal at the building level. Estimated savings: 2% of heating energy, which would give an economic benefit to Kostroma region of $1 million per year.

Action C.3: Provide heat allocation meters in individual flats - evaporative type on all radiators and flow meters on hot water taps, and convert to a tariff based on Gcal at the individual customer level. Estimated savings: 5% of heating energy, which would give an economic benefit to Kostroma region of $2.5 million per year.

Action C.4: Improve controls - install thermostatic radiator valves to control temperature in heated spaces. Estimated savings: 5% of heating energy, which would give an economic benefit to Kostroma region of $2.5 million per year.

Action C.5: Upgrade ability to provide services - organize energy audit service firms and provide them with instruments. Estimated savings: 1% of heating energy, which would give an economic benefit to Kostroma region of $500,000 per year.

Action C.6: Upgrade awareness of energy efficiency - organize education and training programs. Estimated savings: 1% of heating energy, which would give an economic benefit to Kostroma region of $500,000 per year.

Action C.7: Convert factories in Kostroma to produce equipment needed to improve energy efficiency.

Third Step Priority - capital investments for modernization

D. Long-Term - Improve Efficiency of Systems

D.1 Install distributed heating systems of high efficiency where applicable.

D.2 Reduce heat loads by upgrading insulation.

D.3 Improve distribution systems by using pre-insulated piping with leak-detection systems on new installations and improving drainage of existing installations.

SUMMARY OF ENERGY EFFICIENCY EQUIPMENT PROCUREMENT RECOMMENDATIONS FOR 1992 U.S.A.I.D. PROJECT

Changes to improve operation and maintenance of existing systems will be required to realize these improvements. The hard-working technical personnel in Kostroma will need additional tools and instrumentation to achieve these goals. The RCG/Hagler, Bailly team recommends that Kostroma receive a package of equipment from USAID to assist their energy management program. The proposed procurement list and budget, subject to approval by USAID, is summarized in Exhibit 2. The minimum budget already agreed by USAID will be $50,000 for equipment. Two alternates are proposed, for consideration if USAID is able to provide additional funding.

EXHIBIT 1
SUMMARY OF PROCUREMENT RECOMMENDATIONS

	Variant "A"	Variant "B"	Variant "C"
Small library of information on US manufacturing companies	1,000	1,000	1,000
PC-386 computer/printer for city energy management	3,000	3,000	3,000
Equipment for Kostromaoblteplenergo - heat supply & distribution			
Leak detection system	5,000	5,000	5,000
2 Thermocouple kits	2,000	2,000	2,000
2 Ultrasonic stethoscopes	3,000	3,000	3,000
2 Combustion analyzers	8,000	8,000	8,000
3 Dissolved solids water testers	1,000	1,000	1,000
6 Small combustion kits	2,000	2,000	2,000
2 Infrared pyrometers	3,000	3,000	3,000
Equipment for Gorzhiluprovenya - residential building maintenance			
Ultrasonic stethoscope	1,500	1,500	1,500
Thermocouple kit	1,000	1,000	1,000
Equipment for Rabochiy Metallist - industrial plant maintenance			
Library US contacts	200	200	200
Ultrasonic leak detector	4,000	4,000	4,000
Thermocouple kit	1,000	1,000	1,000
Small combustion kit	300	300	300
Equipment for residential buildings			
Weatherstripping	5,000	5,000	15,000
2 Gcal meters		8,000	8,000
Wall insulation			30,000
Substation temp. controller			3,000
Equipment for school			
Gcal meter	5,000	5,000	5,000
20 Thermostatic valves	1,000	1,000	1,000
Substation temp. controller			3,000
Equipment for greenhouse			
Plastic for sealing leaks	2,000	2,000	2,000
Equipment for Kostromaenergo & city to detect heat loss			
Thermal imaging vision		40,000	40,000
Equipment for Kostromaenergo			
Vibration analyzer			5,000
2 portable O2 analyzers			2,000
TOTAL BUDGET	49,000	97,000	150,000

CHAPTER 1: AUDIT REPORT

1.0 BACKGROUND

1.1 Origin of Project

This project was funded in February 1992 by the United States Agency for International Development as part of humanitarian and technical assistance from the people of the United States to the people of Russia. The project is designed to introduce short-term energy management techniques and low-cost American technologies in Kostroma's district heating system and to demonstrate the results to other cities in Russia. The project also includes an educational program to train local professionals in energy management, and to involve universities and professional associations to perpetuate and advance this training.

The prime contractor for the implementation of the project is RCG/Hagler, Bailly, Inc., of Arlington, Virginia, under A.I.D. Contract No. CCS-0002-C-00-2006-00, signed February 25, 1992.

1.2 Project Objective

The objective of the project is to serve as a catalyst to begin the development of market-oriented systems designed to improve district heating system energy efficiency in Russia, especially in the short-term.

1.3 Project Strategy

The project has the following strategy:

- to demonstrate energy management techniques and low-cost American technologies in typical urban district heating systems and to disseminate the results of these examples to Russia,
- to begin to create a market for energy efficiency services in Russia and to assist firms, especially in the private sector, that can serve this market,
- to train Russian professionals in energy management, and to involve universities and professional associations that can continue such training over the long-term

- to stimulate trade and joint venture opportunities for American energy efficiency equipment suppliers in Russia.

District heating systems (clients) in Kostroma and Ekaterinburg will receive assistance to implement an energy management program. Each program will study examples of individual elements of the client system, including combustion, heat generation, heat transmission, and heat utilization. Each program will include advice in energy management from American and Russian experts, an energy audit report, and a package of low-cost equipment valued at a minimum $50,000. This part of the program will be donated by the USAID, at no cost to the client.

Each client will agree to participate in the program, and to pay a share of the cost. The client will make management and operational changes which are identified during the audit to improve efficiency immediately (such as adjusting air/fuel ratio on boilers or using most efficient equipment in priority). The client will agree to put the USAID equipment package to work, and will pay all necessary local costs, including Russian customs duty (if any), delivery in Russia, the cost for installation, operating cost, and future maintenance of the equipment.

At the end of the project, a seminar/conference will be held in Russia to inform managers of other district heating systems of the results of the program.

1.4 Project Tasks and Schedule

The following are the main activities of the project:

1. Plant selection and project organization (March 92)
2. In-plant audits and diagnostic studies (April 92)
3. Complete energy audit reports (May 92)
4. Develop equipment specifications (April - May 92)
5. Procure equipment and deliver to plants for installation (May - September 92)
6. Return to plants for further assistance (after most equipment is delivered, September 92)
7. Conference in Russia to present preliminary results of program (October 92)
8. Final report to USAID based on findings (October 92)

1.5 Participating Entities

1.5.1 Client agencies

Several Russian agencies are clients, in the sense that they serve as coordinating agencies or receive some assistance under the project.

Commission for International Humanitarian and Technical Assistance (CIHTA) of the Government of Russian Federation, Ministry of Social Protection - CIHTA serves as a primary federal government coordinating counterpart organization for our assistance.
Alexander Alexandrovich ZHITNIKOV, Chairman
Victor Alexandrovich GULYASHKO, Deputy Chairman

Ministry of Fuel and Power (MFP), Russian Federation - MFP serves as primary federal government technical counterpart organization.
Victor Victorovich NETCHAEV, Head of Main Scientific and Technical Department

Kostroma Regional (Oblast) Administration (SRA) -
Victor Velentinovich BACHIRIKOV, Deputy Head

City of Kostroma, Municipal Services Association -
Igor Vitalyevich SOLONIKOV, Head

KostromaOblTeploEnergo (KOTE) -
Dmitriy Alexandrovich ERSHOV, Director
Nikolaj Ivanovich PUSHKIN, Chief Engineer
Vladimir Yuriovich OHAPKIN, Manager, Baravaya 4

KostromaEnergo -
Yuri Pavlovich NAZAROV, General Director
Alexander Maseyovich KRASILSICH, Chief of Heating Supply
Valery Veniatinovich EVHARITSKY, Chief Engineer GRES

Gorzhiluprovlenya (Building Maintenance Commission) -
Alexander Vitalyvich SMIRNOV, Chief Engineer

City of Kostroma, Ornamental Plant Farm -
Mikhail Vasilyevich EGOROV, Director

It was determined by Kostroma Oblast and the City of Kostroma that the project should include facilities from a variety of organizations, including heat sources, heat distribution,

and end-users. The project is coordinated by the Kostroma City Government - Municipal Services Association, so as to serve as a model for future cooperation and expansion into other parts of the city and region.

As a gift from USAID, at no cost, City of Kostroma will receive:
advice in energy management from US and Russian consultants,
an energy audit report,
a package of equipment valued about $30-50,000.

In return, Kostroma agrees to serve as a model for other plants in Russia, and agrees:

1. to allow the consultants to work in the facilities, to make measurements and to collect data on energy and heat load.

2. to provide engineers and technicians to work together with the audit team for inspections, data collection, and measurement.

3. to make "no-cost and low-cost" management, operations, and maintenance changes designed to improve efficiency, as identified by the consultants and agreed by plant management as being practical, so that energy savings results can be achieved during the audit and during the program. All changes will be made by plant personnel, not by the consultants.

4. to protect RCG/Hagler, Bailly's instruments from theft while in the plant during the work.

5. to put the equipment package to the best possible use, including paying any costs required for clearing Russian customs duty, installation, operation, and maintenance of the equipment.

6. to participate in conferences/meetings in Moscow and/or Ekaterinburg, to inform USAID and other district heating plants in Russia of the results of the program.

1.5.2 The RCG/Hagler, Bailly Team

The Russia Energy Efficiency and Market Reform Project (heating system efficiency component) is organized as a major program with two levels of organization: a contractual organization among a consortium of corporate entities and a technical organization of the various professionals who will contribute to the project.

Prime contractor for the project is RCG/Hagler, Bailly, Inc. Subcontractors for the Kostroma project are:

- Joseph Technology Corporation
- Duke Power Company

RCG/Hagler, Bailly, Inc.

RCG/Hagler, Bailly, Inc. was founded in 1980 and is a subsidiary of RCG International, Inc., the consulting and technical services arm of New York-based Reliance Group Holdings. The firm provides management, economic, regulatory, and technical counsel throughout the world in the fields of energy, natural resources, and environmental management. RCG/Hagler, Bailly is headquartered in Arlington, Virginia, and operates from several offices in the United States and overseas.

RCG/Hagler, Bailly has worked with various multilateral lending agencies, including the U.S. Agency for International Development, the World Bank and the International Finance Corporation, the International Energy Agency, and the Inter-American Development Bank. The firm's staff members have worked closely with and coordinated the activities of key players in numerous public- and private-sector cooperative ventures. These include projects in Eastern Europe, including the A.I.D. emergency Energy Program for Central and Eastern Europe (which has a scope of work very similar to that for the proposed program in Russia), Western Europe, Asia, the Middle East, and Latin America. The firm has also participated in several joint World Bank-USAID projects, with a focus on programs to promote energy efficiency.

David A. Keith, P.E. - Project Director

David Keith, a Principal at RCG/Hagler, Bailly, Inc., is a specialist in energy efficiency who has more than 15 years experience managing multi-million dollar projects. He performs technical audits for energy efficiency and productivity, gives training courses in energy efficiency, advises on energy pricing policy, and prepares feasibility studies and bankable documents for projects funded the World Bank and other development banks. Keith's work has focused on energy conservation, energy policy, and energy pricing programs in the U.S. since the mid 1970's and internationally since 1980. Keith also serves as Project Director for the A.I.D. Emergency Energy Program for Eastern Europe (for Hungary, Yugoslavia, Estonia and Latvia) and the A.I.D. Regional Energy Efficiency Program for Eastern Europe (energy efficiency, energy pricing and energy restructuring for all countries in the region). Keith obtained a M.Sc. in Mechanical Engineering, B.M.E., and B.Sc. in Applied Psychology, all from Georgia Institute of Technology.

Joseph Technology Corporation

Joseph Technology Corporation, Inc. (JTC) is an independent consulting engineering firm based in Woodcliff Lake, New Jersey. The firm is primarily engaged in feasibility studies, engineering, design, construction supervision and related support services. District heating/cooling (DHC) and cogeneration represent the major practice area of the company. Joseph Technology has assembled a team of engineering and financial specialists with diverse experience and capabilities including DHC and cogeneration system development, planning, financing, design, and construction supervision. JTC is headed by two brothers, Ishai Oliker and El Oliker, who are district heating design engineers, originally from the Soviet Union, where they established their careers before emigrating to the United States in 1975. Joseph Technology continues to maintain close ties with organizations within the Soviet Union and Eastern Europe. JTC has also worked with the Electric Power Research Institute on several cooperative ventures in the USSR.

El Oliker - Deputy Project Director

El Oliker is the director for development and design of district heating/cooling and cogeneration systems for Joseph Technology Corporation. Oliker has managed numerous district heating projects in the United States and abroad. He has written 18 technical papers and holds several patents pertaining to district heating, cogeneration, thermal storage and environmental control. Oliker has over 20 years of work experience, including the practical application of district heating systems in the USSR. He was previously employed by a design and construction company in the USSR and has recently completed a project on emission control devices in USSR power plants for EPRI. Oliker obtained a degree of Candidate in Power Engineering from Leningrad Engineering Institute and M.Sc. in Thermal Engineering from Kuibyshev Institute of Technology.

Duke Power Company

As the seventh-largest investor-owned electric utility in the United States, Duke Power Company serves 4.5 million people in a 50,000 sq. km. service area in North Carolina and South Carolina. Headquartered in Charlotte, NC, the Company supplies electricity to more than 1.6 million residential, commercial and industrial customers.

Duke Power's three nuclear generating stations, eight coal-fired stations and 26 hydroelectric stations produced 73.8 billion kilowatt-hours of electricity in 1990. Electric revenues totaled $3.7 billion. About 70 percent of sales were in North Carolina and 30 percent were in South Carolina. Retail customers are served from 94 customer service offices throughout Duke Power's service area. In addition, the Company makes wholesale, bulk power and contractual sales.

Mark Landseidel - Heat and Power Generation Expert
Mark Landseidel has 10 years experience in engineering for thermal electric power plant operations and maintenance, and for thermal power plant improvement projects. Landseidel is currently assigned to Duke Power Company's Cliffside Steam Station, a 5 unit 800 MW coal-fired electric power station. He recently completed a major project, the planning and coordination of a life extension project for Cliffside units 1-4. This rehabilitation and modernization project will enable these units to continue operations for the next 20 years. Landseidel is currently Engineering Supervisor, leading all maintenance activities for Cliffside units 1-5. He obtained a B.S. in Engineering Science from Colorado State University.

VNIPIEnergoprom, Russian Partner Firm

RCG/Hagler, Bailly selected two Russian companies as partner firms, to serve as members of the RCG/Hagler, Bailly team for the implementation of the energy management program. Each firm is working in a different city. VNIPIEnergoprom serves as partner for the project in Kostroma.

VNIPIEnergoprom is the all-union design institute for district heating engineering. The institute has more than 8,000 engineers, and offices in 22 cities of the USSR. For the Kostroma project, VNIPIEnergoprom assigned engineers Stanislav Pavlovich TROFIMOV (Chief Specialist) and Dr. Vladimir Lvovich YAKIMOV.

VNIPIEnergoprom has several responsibilities, including:

1. provide two expert engineers to join the energy audit team for 5-10 days in the client city. The engineers will make measurements, collect data, make engineering calculations, and identify potential efficiency improvements.

2. translate English/Russian for RCG/Hagler, Bailly engineers.

3. provide transportation for the audit teams and RCG/Hagler, Bailly's audit tools and make hotel reservations in client city.

4. provide communications between RCG/Hagler, Bailly in the U.S. and the client after the audits.

5. receive the draft energy audit report from RCG/Hagler, Bailly and present the results in a meeting at the plant.

6. develop engineering specifications for the equipment package and obtain the plant's approval for the specifications.

7. coordinate receiving of US equipment in Russia, delivery to the plants, and supervision of the installation of the equipment in the plants.

8. for equipment to be purchased in Russia with USAID funds, obtain bids and serve as RCG/Hagler, Bailly's agent to purchase the equipment.

9. organize and participate in a seminar on energy management to be held at the end of the program.

1.6 Country and Economic Settings

Russia is a newly independent country which was formerly the largest Republic of the Soviet Union. Russia had a leading role in the Soviet Union, with the capital in Moscow and the most prestigious educational and design institutions and many of the largest factories also located in Russia.

Russia is well-endowed with energy resources, including coal, oil and gas. Electricity generation is heavily dependent upon nuclear reactors.

The economy of Russia, at the time of the energy audit, was in serious depression. Production in most industrial enterprises has fallen drastically, to perhaps one-half of traditional Soviet levels. Shortages exist for most imported goods, even those from other former Soviet Republics.

The mood of the Russian people at the time of the energy audit was one of devastation. The developments of the past decades have left the country ill-prepared for the realities of the market economy. Many leaders of the technical community feel a sense of loss and wounded pride. Others find hope in the future, and seek to make the changes required.

1.7 Geography

The City of Kostroma is the principal city of Kostroma Oblast (region). Kostroma was founded in 1152, and is located at the confluence of the Kostroma River and the Volga River, approximately 320 kilometers NorthEast of Moscow. The city was originally a trading center, and was based on the local textile industry. The city population is about 300,000 people. The city is divided into four main districts: Leninsky, Sverdlovskiy, Dimitrovskiy, and Volgorechensk.

Kostroma has 70 large or medium industrial factories with a total of 55,000 workers. The main industries are: electric power generation, machinery, textiles, food processing, and

wood products. Kostroma's textile industry produces about one-quarter of all textiles produced in Russia. Agriculture is diversified, primary activities being grain harvesting and dairy farming. For centuries Kostroma has been considered one of the flax-growing centers in Russia.

The electric power industry is a major part of the local economy. Kostromskaya GRES which has the capacity of 3,600 MW is one of the largest thermal electric generating stations in all of Russia.

Tourism has good potential as a growth industry in Kostroma. Besides the beauty of the Volga, the city has a historic monastery, from which the first czar of the Romanov dynasty came. The monastery is well-preserved, and includes a new museum which traces the history of the Romanov dynasty, and presents the czars in a favorable light. The city also has a very attractive old central region and several interesting old churches. The city has a modern hotel which has a very good restaurant, and a new motel.

The climate of Kostroma is characterized by the following climatological profile:

- The average temperature for the coldest five days (temperature used for heating design) is -31°C.
- The average temperature for the coldest month is -15.6°C.
- The average temperature for the heating season is -4.5°C.
- The length of the heating season is 222 days.
- The annual heating load for 1990 was 3,031 degree-days (degrees in °C), based on 12°C as a reference point[1]. The annual heating load for 1991 was 2,912 degree-days.

1.8 Energy Supply/Demand Situation

Heat in Kostroma is supplied from central district heating networks. About half of the heat is generated in thermal electric cogeneration systems (TETS), and is supplemented by heat from boilerhouses.

[1] The degree-day method is commonly used in the U.S. to estimate annual heating load. To calculate degree-days, a record is kept of the difference between the average daily temperature and the reference point. For example, if the reference point is 12°C and the average daily temperature is -5°C, then that day would have a heating load of 17 degree-days. If the average daily temperature is 12° or higher, then the heating load is 0 degree-days. Similar methods are not used in Russia, so the RCG/Hagler, Bailly team constructed an approximation of degree-days, based on average monthly temperature and a reference point of 12°C.

The main fuel now used for heat generation in Kostroma city limits is gas, with heavy fuel oil (mazout) as supplementary or stand-by fuel.

Hot water in Kostroma is generated from heat from the district heating network. There are two systems of supply:

> open system - in which case the hot water flowing through the distribution network is drawn through the taps
>
> closed system - in which case the hot water in the network serves as the heat source to a shell-and-tube heat exchanger. On the other side of the heat exchanger (secondary), city water is heated, and this secondary water is drawn through the taps.

In Kostroma, the closed system is used predominantly.

Annual heat consumption in city of Kostroma is:

- TETS-1 heat delivered in 1991 1,500,000 Gcal/year
- TETS-2 heat delivered in 1991 2,000,000 Gcal/year
- GRES heat delivered in 1991 300,000 Gcal/year
- 170 boiler houses in 1991 800,000 Gcal/year

Primary fuel used in city of Kostroma is gas with a lower heating value of 8100 kcal/m^3. The annual fuel consumption in the City of Kostroma is approximately:

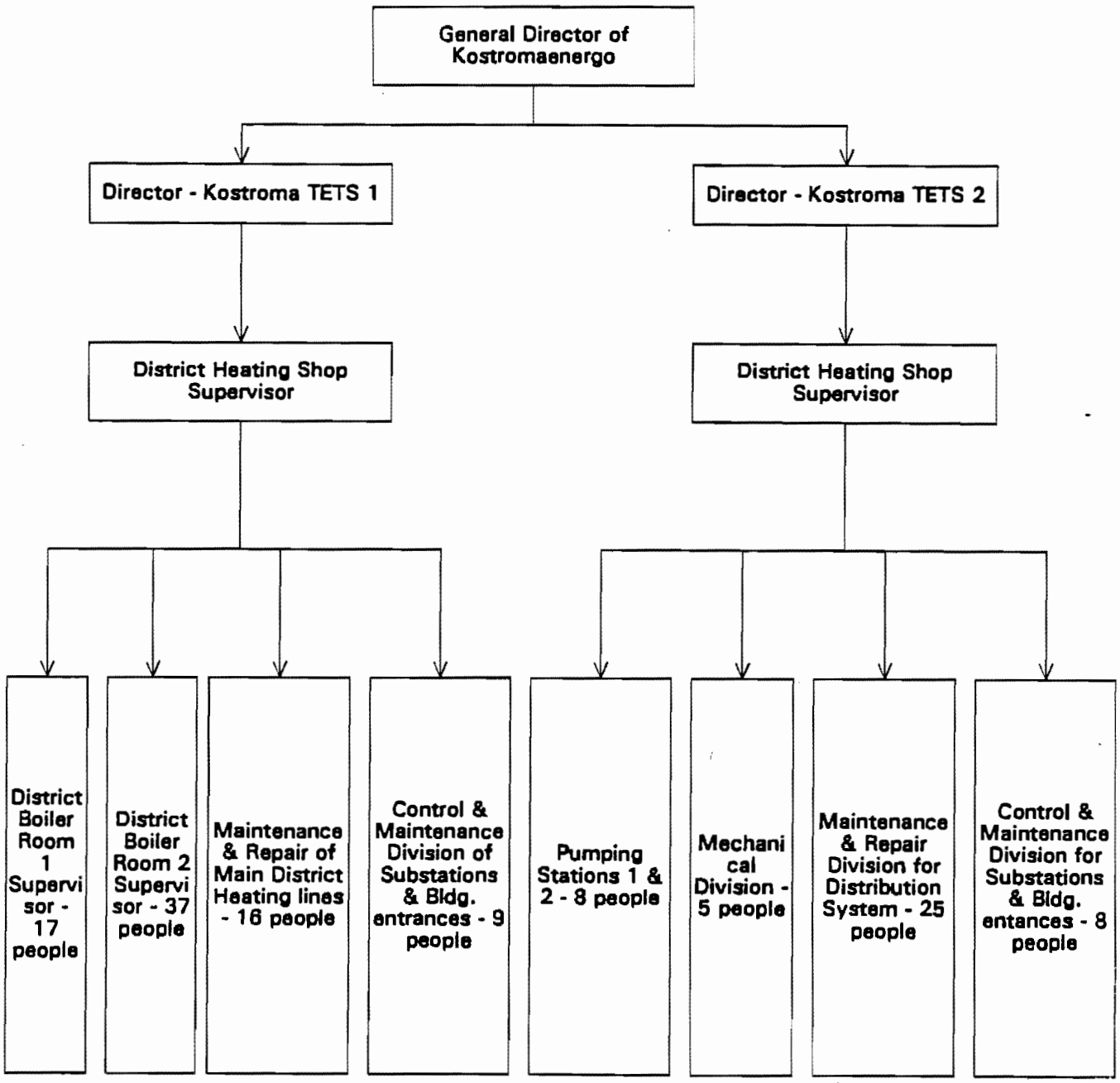
- gas 55 million m^3/year
- coal 40,000 ton/year
- heavy oil 12,000 ton/year

Two organizations provide heat in Kostroma - KostromaEnergo and KostromaOblTeplEnergo.

KostromaEnergo is the electric utility, which sells heat as a byproduct. Table 1 provides an organization chart of KostromaEnergo, focusing on the district heating division.

KostromaOblTeplEnergo (KOTE) is the district heating company for the whole Kostroma Oblast (region). KOTE buys heat from the primary distribution network of KostromaEnergo, distributes the heat in the KOTE secondary distribution systems, and resells the heat to users. In other areas, on the fringe of the city and beyond, separate stand-alone systems have been built. In these areas, KOTE operates small boilerhouses and dedicated distribution systems.

KOSTROMAENERGO DISTRICT HEATING CO. ORGANIZATIONAL CHART



A listing of the other major heat generation systems in the City of Kostroma is provided in Table 2.[2] According to this survey, the reported peak heat output from KostromaEnergo TETS (1 and 2) is 915 Gcal/hr. The reported peak heat output from other sources (including KOTE) is 1,060 Gcal/hr, the largest of which are the boiler rooms of various factories in Kostroma. Based on these data, it appears that about half of peak heat demand in Kostroma can be supplied by TETS (combined heat and power), with the remainder supplied from other sources.

Table 3 provides a listing of KostromaEnergo data of the design performance indexes for heat supply, and other data concerning system capacity.

Table 4 provides a listing of KostromaEnergo data concerning the major heat customers (and their peak loads) supplied from the two major heat sources, TETS-1 and TETS-2.

Table 5 provides a listing of KostromaEnergo data of the actual heat consumption of the major heat customers, in 1990 and 1991, for both hot water and steam.

KostromaEnergo exports electricity to the neighboring regions. The Kostromaenergo interconnected power system is integrated into the interconnected Power System of the Center of Russia. There are also 46 hydroelectric power plants with total capacity of 1800 kW supplying electricity in the Kostroma region.

1.9 Energy Price Regime

Energy prices in Russia at the time of our visit were changing rapidly. In Kostroma the price of heat and electricity production increased 10-15 times from January, 1992.

The tariffs , production costs and fuel consumption for TETS-1 and TETS-2 -two main cogeneration plants in the city of Kostroma are presented in Table 6.

The heat production cost in city of Kostroma on average is 225 R/Gcal, and in Kostroma region is 400 R/Gcal.

1.10 Audit Type/Methodology/Scope

The audit focused on a specific case study, or "system slice", of facilities. This system slice included Kostromaenergo GRES, TETS-1 and TETS-2 (combined heat and power station), KOTE boilerhouses, distribution lines, and end-users (industrial, school,

[2] Data provided based on a survey conducted by VNIPIEnergoprom in 1989.

TABLE 2
HEAT SOURCES IN CITY OF KOSTROMA
Reported for 1989 and Projected for 2000

Heat Source Name	Installed Capacity			
	Electric (MW)		Heat Load (Gcal/hour)	
	1989 Report Data	2000 Estimate	1989 Report Data	2000 Estimate
TETS-1	42	36	425	540
TETS-2	170	170	490	1440
Boiler Room-Factory Motor Detail			234	234
Boiler Room-Factory "Rabochiy Metallist"			84	98
Boiler Room-Factory "Strommachine"			51	141
Boiler Room-Experimental Factory of Cement Material			30	75
Boiler Room-Auto Repair Factory			35	77
Boiler Room-Ship-mechanical Factory			34	49
Boiler Room			43	43
Dmitrievskiy District PK N2			112	143
Boiler Room - Pastuchova 37			34	34
Factory Boiler Room				360
108 Small Industrial and Civil Boiler Rooms			403	152

Source: VNIPIEnergoprom survey, 1989

TABLE 3

HEAT SUPPLY INDEXES IN CITY OF KOSTROMA (TETS-1 AND TETS-2)

#	Description	Unit	TETS-1	TETS-2
1	Heat capacity	MW/Gcal/g	523/450	826/710
2	Own needs	MW/Gcal/g	46/40	81/70
3	Heat supply	MW/Gcal/g	476/410	745/640
4	Available heat load			
	Total	MW/Gcal/g	451/388	821/706
	Steam	MW/Gcal/g	139/120	88/ 76
	Hot Water	MW/Gcal/g	311/268	732/630
5	Temperature schedule	°C	170/70 with reduction by 150°	170/70 with reduction by 140°
6	Main distribution system length			
	Total	Km	30.3	48.6
	Steam	Km	26.6	39.3
	Hot Water	Km	3.7	9.3
7	Maximum diameter	mm	800	600
8	Mimimun diameter	mm	300	200
9	Annual heat sale (1991)	thousand G/J	5489	8199
10	Specific fuel consumption	kg/G/J	40.9	40.8
11	Distribution system losses	thousand G/J/%	293/4.76	504/6.15

TABLE 4
LIST OF CUSTOMERS, HEAT SOURCES AND PEAK LOADS
IN CITY OF KOSTROMA

#	Customer Name	Peak Load Gcal/hr	
		Steam	Water
	TETS 1		
	Total 127 customers including:	120.2	267.6
1	Kostromaobltechenergo		129.0
2	ZKO Lenin Factory		10.2
3	ZKO Lworikina Factory		6.6
4	ZKO of Industrial Flax Union		
	Industrial Companies		
1	Lenin Flax Mill	33.5	30.8
2	Plywood Factory	30	
3	Industrial Flax Union	17.8	26
4	Zworickin Flax Mill	14	11.9
5	Krasin Polymer Machinery Factory	8.8	0.6
6	Shoe Union "X-October"	5.2	
7	Yarn Factory "Work Flag"	4	5.8
	TETS 2		
	Total 140 customers including:	75.5	648.2
1	Kostromeobtechenergo		221.0
	Industrial Customers		
1	LKO and DSK "Kostromastroy"	21	91
2	Automation Line Production Factory		15
3	Kostromaselshilstroy KPD	6.25	1.5
4	Kostromameliorazia ZBI & PPCO	7.3	11.9

TABLE 4 (cont'd.)
LIST OF CUSTOMERS, HEAT SOURCES AND PEAK LOADS
IN THE CITY OF KOSTROMA

#	Customer Name	Peak Load Gcal/hr	
		Steam	Water
5	Union "Techsteelmach"	6	12
6	All Union "Factory Kostrimomallesprom"	4.9	5.5
7	Gormol Komlinat "Work Banner"	5	5.8
8	Factory of Solar Treatment Equipment	2.16	9.8
9	Green House Factory "Isakovskiy"	12	92.6
10	Factory of outside memory devices		18
11	Wood treatment machinery		
12	Green House of Artificial Decorative Plants	2	92.6
13	PATP		7.8
14	Heat Exchangers Factory		6.3
	Driirsievskay District Boiler Room		
	Total 65 customers including:		50.6
1	Kostroalltexenergo		
2	ZEY-8		5.71
3	ZCO of Factory "Motorgetal"		13,696
	Industrial Factories		
	Polygraphcombinat		12,332

TABLE 5
HEAT SUPPLY TO CUSTOMERS IN CITY OF KOSTROMA

		Hot Water (Gcal)		Steam (Gcal)		Total (Gcal)	
#	Customer Name	1990	1991	1990	1991	1990	1991
A	Main Heat Supply	1469902	1568963	404298	387988	1874200	1956951
B	Distribution System	46480	59279.1	69451	61073.9	115931	120353
C	Distribution Losses %	3.2	3.8	17.2	15.7	6.18	6.15
D	Heat Supply to Customers	1423422	1509683.9	334847	326914.1	1758269	1836598
1	Factory "Tekstilmash"	12055	11654.3	28346	28244.6	40401	39898.9
2	Milk Product Factory	6465	3552.3	24572	17102.9	31037	20655.2
3	ZBE KPD Factory	15485	15437.9	37603	44423.3	53088	59861.2
4	Kostromaglavsnab	4765	4860.2			4765	4860.2
5	Greenhouse Factory	207652	229270.2	4882	2807.3	212534	232077.5
6	Factory "Luch"	8026	8468.4	1146	1003.4	9172	9471.8
7	VTK	3936.5	(9 month)			3936.5	(9 month)
8	Conservatory	18293	16590			18293	16590
9	Lesprom ZBE Factory	6227	6477.8	26674	24704.7	32901	31182.5
10	CKBTM	4903	(9 month)			4903	(9 month)
11	Universal Base	4191	(9 month)			4191	(9 month)
12	PATP No. 1	9858	9540.8			9858	9540.8
13	ZBK Factory	5480	5054.3	98142	98025.8	103822	103060.1
14	Mechanical Factory	29353	33336.4	6582	6915.4	35936	40251.8
15	Electromechanical Factory	43020	50375.1	10625	10226.6	53645	60601.7
16	Automation Line Factory	42241.5	37598.3			42241.5	37598.3
17	DOC Factory	26977	27236			28977	27236
18	B/ch 21602	4730	(9 month)			4730	(9 month)
19	Heat Exchanger Factory	23181	29655.3			23181	29655.3
20	CCK	9812	8983.9	45934	32919.9	55746	41903.8

		Hot Water (Gcal)		Steam (Gcal)		Total (Gcal)	
#	Customer Name	1990	1991	1990	1991	1990	1991
21	Agroprom ZBE Factory	1822	2206.3	10609	8843.7	12431	11050.0
22	KMPO "Color" (KOO)	12847	6244.3	1626	9948.2	23473	16192.5
23	Communication Autobase	2739	2098.7			2739	2098.7
24	Autobit	1516	(9 months)			1516	(9 months)
25	Butter-Cheese Base	650	1339.1	1355	230.6(2m)	2005	1569.7
26	KUMC	2087	1930.7			2087	1930.7
27	ABZ Gorkomchoza			21679	20529.7	21679	20529.7
28	B/ch 29497	21909	(9 months)			21909	(9 months)
29	XVII Partyforum Factory	2676	3263.5			2676	3263.5
30	ATP Kostromskoe	820	(9 months)			820	(9 months)
31	PHV	282 (9months)	824			282 (9 months)	824
32	PTK Kamaz	1115 (6 months)	2024.7			1115 (6 months)	2024.7
33	Oblremstroimebelbit Union			4032 (7 months)	7675.2	4032 (7 months)	7675.2
34	Cooperative "Estern"				13312.8		13312.8
35	KOTA	600741.6	659027.1			600741.6	659027
36	Supply Control		3984				3984
37	Other	287566.4	328650.3	2040		289606.4	328650.3

TABLE 6

TARIFFS, PRODUCTION COSTS AND FUEL CONSUMPTION
FOR KOSTROMA TETS 1 AND TETS 2.

Description	Unit	TETS 1	TETS 2
1. First quarter (1992) production cost	R/Gcal	52.9	53.8
Fuel	R/Gcal	37.4	42.8
2. Fuel cost in the first quarter of 1992	R/Gcal		
Gas	R/TCE	220.21	220.21
Heavy Oil	R/TCE	284	284
Peat	R/TCE	230	230
3. Fuel cost in the second quarter of 1992			
Gas	R/TCE	1111	
Heavy Oil	R/TCE	1611	1611
Peat	R/TCE	250	
Fuel consumption in 1991			
Gas	TCE	186095	276143
Heavy Oil	TCE	38460	311347
Peat	TCE	52638	
Heat tariffs in first quarter of 1992			
Domestic hot water for the industry	R/Gcal	124	124
Domestic hot water for residential customers	R/Gcal	109	109
Hot water for residential heating	R/Gcal	55.6	55.6
Hot water for KostromaOblTeploEnergo	R/Gcal	38.5	38.5
Steam	R/Gcal	136.7	136.7

* TCE - Ton Coal Equivalent, 1 TCE = 7 Gcal

greenhouse, and residential). In addition to these facility-specific activities, the RCG/Hagler, Bailly team held meetings with City officials and collected key data relative to the characteristics of the other parts of the Kostroma district heating system. This information is useful to expand the results of the audit.

The RCG/Hagler, Bailly Team worked in Kostroma from April 20-25, 1992. The list of business cards for the persons contacted during the visits is given as Appendix 1. During this brief period, our Team carried out the following activities:

1. Management meeting to discuss the current operational situation and plans for future reforms with the City and Regional administrators, director of the heat and power company, chief engineers, and other key decision-makers.

2. System familiarization tours to inspect facilities and make first general observations.

3. Project implementation meeting to discuss and select locations and areas of focus for the USAID Energy Efficiency Project and determine needs for personnel, equipment, and access to facilities.

4. Seminar on energy audits and portable efficiency instrumentation. This seminar was attended by about 20 engineers from various companies and associations in the Kostroma region.

5. Equipment efficiency and thermal loss measurements on-site during detailed inspections at several example locations, using fixed instruments and RCG/Hagler, Bailly's portable instruments. Combustion efficiency was measured for operating boilers at selected heat generation stations.

6. Combustion tune-up was attempted for operating boilers found to be operating with high excess combustion air or insufficient air, in order to achieve measurable energy savings as part of the audit. Adjustments were made to three boilers of the KostromaOblTeplEnergo (KOTE) system, achieving on-the-spot energy savings of 1.5%.

7. Computer database and graphical analysis was developed using TETS-2 historical operating statistics (from daily and monthly reports) to determine efficiency trends and relationships between heating load and fuel consumption.

8. Efficiency improvement project ideas were developed by the RCG/Hagler, Bailly Team and discussed by the Team over the course of the week.

9. A preliminary list of energy efficiency project ideas was prepared by the RCG/Hagler, Bailly Team and discussed with the city management and KOTE.

10. A draft procurement list was prepared by the RCG/Hagler, Bailly Team and discussed with city management and KOTE. Based on agreement from city management, specifications for the equipment will be developed later.

11. A final briefing was held with city management and KOTE to present the RCG/Hagler, Bailly Team's findings, in the form of a draft energy audit report.

The following activities are planned for Kostroma, after the audit visit:

1. RCG/Hagler, Bailly completes audit reports, partner firms return to plants to assist plant managers on operational changes and partner firms complete equipment specifications.

2. RCG/Hagler, Bailly identifies US equipment suppliers and requests USAID approval. RCG/Hagler, Bailly contacts vendors to expedite project and obtain manufacturers commitments to quality and possible cost-sharing.

3. RCG/Hagler, Bailly obtains USAID approval (working with partner firms to make changes if required by USAID) and purchases equipment.

4. As soon as received, RCG/Hagler, Bailly sends equipment to Kostroma Municipal Services Association via air freight.

5. Partner firm (VNIPIEnergoprom) assists in use of equipment, and gives any training required.

6. City installs and use equipment and measure results. Partner firms maintain contact with client plants to monitor results.

7. RCG/Hagler, Bailly engineer and partner firms return to plants to evaluate results and provide further assistance

8. Conferences in Moscow to present results of program to engineers and managers of other district heating systems. Representative of International District Heating and Cooling Association will attend and US manufacturers of district heating equipment will exhibit their products.

Chapter 2: DESCRIPTION OF HEATING FACILITIES IN KOSTROMA SYSTEM

Based on the recommendation of the city officials, Kostromaenergo, and KostromaOblTeplEnergo, several facilities were selected as sites for the energy efficiency program.

The entire team inspected TETS-2, GRES, and the greenhouse. The RCG/Hagler, Bailly audit team divided into three groups to inspect (1) TETS-1; (2) boilerhouses of KOTE at Borovay 4; and (3) school, residential buildings, and the distribution system.

A seminar was presented by the RCG/Hagler, Bailly team to some 20 energy engineering professionals from the Kostroma region. The topics covered were energy management, instrumentation used in energy audits, and short-term energy conservation measures.

2.1 Heat Generation Systems

2.1.1 KostromaEnergo - heat and power facilities

The brochure of KostromaEnergo is presented as Appendix 2.

2.1.1.1 Combined heat & power station TETS-1

The 42 MWe Kostromscay TETS-1 plant was built in 1930 and has been upgraded through the years. TETS-1 has six boilers, all identical each rated 75 ton/hr at 37 bar 440°C. The boilers are capable of burning peat (local from Kostroma region), oil or gas. TETS-1 has four turbine generators, tied to all six boilers by common header. Three turbines are non-condensing at 12 MW electrical and extracting steam at 5 bar. One (1) turbine is condensing at 6 MW electrical extracting at 3 bar. Total station capacity is 42 MW electrical, 200 Gcal/hr for heating and 150 Gcal/hr heat for industrial process. Based on KostromaEnergo's allocation system, station heat rate is 1,190 kcal/kWh[3]. On an annual basis fuel burned is typically 70% gas, 15% oil, and 15% peat. Technical characteristics of Kostromscay TETS-1 are indicated in Table 7.

On April 22, 1992, four boilers and three turbines were in service and electrical output was 26 MW. Two boilers were burning peat and two were burning gas. The peat fire looked

[3] In the USSR system, 170 g/kWh, where heat rate is indicated in coal equivalent, based on 7000 kcal/kg. All heating values are lower heating value (net calorific value).

On April 22, 1992, four boilers and three turbines were in service and electrical output was 26 MW. Two boilers were burning peat and two were burning gas. The peat fire looked

Table 7

TECHNICAL CHARACTERISTICS OF THE EQUIPMENT

Kostromscay TETS-1

Equipment	Parameters					Equipment Put in Operation in 1986-1990				
	Amount	Type	Electrical Power (MW)	Boiler Capacity		Amount	Type	Electrical Power (MW)	Boiler Capacity	
				Water Gcal/hr	Steam T/hr				Water Gcal/hr	Steam T/hr
Peaking Boilers	2	PTBM-50		100						
	1	PTBM-100		100						
Turbine	3	P-12-35/5	36							
	1	P-6-35/5	6							
Steam Generators	2	TP-35			70	2	TP-35			70
	5	BKZ-75-39			375	1	BKZ-75-39			75

fairly good, supported with gas and oil. The excess combustion oxygen in stack gas varied considerably between boilers (4-8%), with the value of eight percent on one of those burning peat. Separate boiler and turbine control rooms and operators communicate by intercom system. Most of the control system instrumentation appeared to be working but system is old and could use an upgrade. Fuel and load controls were set in manual mode, air and water in automatic mode. Electrical output of the station is determined by the required heat output. Peat mills operate similar to our hammer type coal crushers.

One of the 12 MW turbines was down for scheduled maintenance. Turbines are inspected on a 6-year interval. Typical turbine outage is done by Russian contractors and planned for three weeks using twenty men with total cost including materials of 100,000 rubles (or $1,000). Tools used for maintenance are far below U.S. standards.

TETS-1 has 550 total employees. Four hundred work within the plant (330 craft and 70 engineering, supervision and administration). Operations works an eight hour shift (20 per shift). The other 150 support the TETS community with daycare, housing, etc.

The overall condition of the plant is fair. Considering the age of the facility this is not surprising. Plant engineer stressed their biggest problem with the plant is locating underground leaks on the heat supply and return piping.

2.1.1.2 Combined heat & power station TETS-2

The 170 MWe Kostromscay TETS-2 was built in 1974, and has technical characteristics as indicated in Table 8. TETS-2 has four steam boilers all identical non-reheat natural circulation each rated 210 ton/hr at 140 bar and 560°C. TETS-2 was originally designed for peat (which is locally available in Kostroma region), but was changed during the construction phase to an oil-fired plant, and the fuel delivery system for peat was never installed[4]. In 1989, the plant was connected to gas supply, and it is now fired by oil and gas.

Three of four boilers must be in operation to achieve full load 170 MW. Two boilers are connected to each of two turbine generators, one rated 63 MW and dual extraction (industrial steam at 8-13 bar plus steam for district heating at 0.5 bar), the other 110 MW, with single steam extraction at 0.5 bar 121°C for district heating.

The station uses three heat exchangers (boilers) for hot water production from the 0.5 bar extracted steam. Of these, two are used as main (heating to 105°C) and one is peak

[4] Some Russian experts are now recommending conversion to Kuznesk coal, but this would require a large capital investment and would have environmental implications for the city.

Table 8

TECHNICAL CHARACTERISTICS OF THE EQUIPMENT

Kostromscay TETS-2

Equipment	Parameter					Equipment Put in Operation in 1986-1990				
	Amount	Type	Electric Power (MW)	Boiler Capacity		Amount	Type Manuf.	Electric Power (MW)	Boiler Capacity	
				Water Gcal/hr	Steam T/hr				Water Gcal/h	Steam T/hr
Peaking Boilers	2	PTBM-100		200		3	KVGM-100 Dorogob. Boiler Factory		300	
Turbine	1	PT-60-130/13	60							
	1	T-110/120-130-3	110							
Steam Generators	2	BKZ-210-140			840					

(heating to 150°C). TETS-2 also has two fired hot water boilers, one in series with the heat exchangers (peaker) and one in parallel.

The outlet temperature of the heat supplied from TETS-2 is determined by the "GRAFIK", which was established years ago. This grafik indicates a supply temperature of up to 85-130°C, against a return of 58-62°C. The temperature of hot water supplied from the TETS depends on the outside air temperature, and is modulated once every six hours.

The peak heating load supplied from TETS-2 was 10,000 Gcal/day in January. The load at the time of the audit (April 21, 1992) was about 5,500 Gcal/day. the load in summer is about 2,500 Gcal/day.

The mass flow rate of hot water heating TETS-2 averages about 7,000 m^3/hour. Make-up is about 100 m^3/hr in summer and 180 m^3/hr in winter. The plant operates 9 district heating pumps rated to 12 bar (120 meters of water), against a typical pressure difference (supply/return) of 7.5 bar. Of these pumps, six have capacity 1,200 m^3/hr and three have capacity 2,500 m^3/hr.

The basic regime of operation of TETS-2 is determined by electrical dispatch. The station operates in a stable regime in winter, and as a peak-following generator in summer. In winter, electrical output can be reduced by only about 15 MW (from 170 MW down to 155 MW) if TETS-2 is required to produce maximum heat. The plant has two natural draft cooling towers, and in summer is limited to 160 MW output due to high condenser pressure. In summer, the plant has greater flexibility, and can turn down to 10 MW.

The units are cycled very little. Each boiler and turbine is inspected/overhauled on a 4-year interval. They do one boiler every year and one turbine every two years. The standard duration for boiler outages is 36 days, but recent overhauls have been taking 55 days due to the installation of some modernization equipment (two-stage combustion systems for NOx reduction). Turbine outages require 40-45 days.

TETS-2 has experienced some boiler tube failures since 1985 due to poor water chemistry. This is attributed to organic compounds in water, mainly algae feeding off waste discharged from upstream plants.

TETS-2 has 575 total staff. Of these, 458 work within the plant (350 craft and 108 engineering, supervision, administrative). The midnight shift operates with a staff of 20. The 117 others support the TETS community.

Hot water for district heating is supplied from TETS-2 through mains which begin at 820 mm diameter and end at 426 mm diameter. The length of mains supplied from TETS-2 is 25 km. the mains are positioned mostly underground in concrete-lined channels.

The plant operators and management would prefer to burn gas, but they have a rate limit, which has both daily and monthly limits, so they burn mazout as required. Mazout is supplied from the Yaroslavl refinery at 2-2.5% sulfur. Fuel prices at the time of the audit:

Gas:	800 Rubles/thousand m^3
	= 98.8 Rubles/Gcal
Mazout:	2,100 Rubles/tonne
	= 221.1 Rubles/Gcal

Performance data

Average annual station heat rate is 1,670 kcal/kWh LHV (239 g/kWh), using KostromaEnergo's fuel allocation system. Their system first allocates fuel consumption to heat supplied (based on a ratio of 1.2 Gcal/Gcal, or an equivalent boiler efficiency of 83.3%), with the remainder of fuel allocated to power.

The coldest day of the 1991/92 heating season was January 15, 1992. On that day, the following conditions were recorded:

Average ambient temperature:	-28°C
Electricity generation:	3,852 MW
Average electrical load:	160.5 MW
Heat rate (fuel charged to power):	1,414 kcal/kWh
District heat supplied:	11,622 Gcal
Average heat supply rate:	484 Gcal/hr
Fuel consumption:	
Heavy fuel oil (mazout):	1,386 tonnes
Natural gas:	656,000 m^3

For the coldest day, the heat supplied by TETS-2 was below the GRAFIK by 100 Gcal/hr (almost 20%). TETS-2 staff indicated that the main reason for this deficit is the recent construction of some greenhouses (three, with an area of 3 ha each). Because of this, KostromaEnergo is developing expansion plans for TETS-2. These plans include several options. Two of the variants include conversion to coal, and the third option includes gas-fired hot water boilers.

Summary performance data for TETS-2 for 1990 and 1991 was provided by KostromaEnergo, and is presented in detail in Appendix 3, and summarized below.

1. Heating load - Kostroma weather data
   1990 - 3,031 heating degree-days[5]
   1991 - 2,912 heating degree-days

2. TETS-2 electricity generation
   1990 - 1.17 million MWh (gross);
   1.06 million (net)
   1991 - 1.19 million MWh (gross)
   1.08 million (net)

3. TETS-2 total heat sales to city
   1990 - 1.87 million Gcal
   1991 - 1.96 million Gcal

4. TETS-2 fuel consumption
   1990 - 208,000 tonnes oil (52% of Gcal)
   226 million m^3 gas (48% of Gcal)
   1991 - 198,000 tonnes oil (46% of Gcal)
   272 million m^3 gas (54% of Gcal)

5. TETS-2 average annual heat rate (specific energy consumption)

	Fuel charged to power[6]
1990 -	data not available
1991 -	1,670 kcal/kWh

6. TETS-2 average annual station use of electricity (pct of gross generation)

	Total	For Electric generation
1990	9.4%	data not available
1991	9.2%	4.3%
1991	31.5 kWh/Gcal (electricity for district heating pumping, etc.)	

[5] In degrees C, based on 12°C.

[6] According to the allocation system used at TETS-2

7. Annual average efficiency performance ratio (Gcal of heat supplied[7] divided by heating load in degree-days)

1990 - 446 Gcal/°-day
1991 - 480 Gcal/°-day

8. Monthly minimum average efficiency performance ratio (best month of the year)

1990 - 281 Gcal/°-day
1991 - 351 Gcal/°-day

9. Estimated inefficiency (losses) in system

Because of deficiencies in the design of the system, the district heating system in Kostroma does not lend itself to accurate control. This lack of controllability is evidenced in the degree of inefficiency in the system, that is how much heat supply exceeds demand, and is therefore lost. In addition, heat losses in distribution lines are more or less fixed losses.

Extreme variability in the performance ratios can be observed in the graphical data, and is indicated in the difference between the figures listed in parts 7. and 8. above. Based on this poor relationship between the annual average efficiency performance ratio and the ratio for the best month of the year, RCG/Hagler, Bailly estimates the losses in the supply of heat by TETS-2 to the city, as follows:

1990 - 37%
1991 - 27%

Based on graphical analysis of heating demand (degree-days) and heating supply, (corrected for domestic hot water load and fixed distribution losses), RCG/Hagler, Bailly estimates the inefficiency in the supply of heat by TETS-2 to the city, as follows:

1990 - 16%
1991 - 24%

Observations during audit

During the audit visit on April 21, 1992, Unit 1 was running at 48 MW and Unit 2 was generating 88 MW. Heat supply to two outlets in parallel was 4,300 m^3/hr plus 1,000

[7] Corrected to account for fixed losses and heat used for domestic hot water supply

m^3/hr. Make-up was at the rate of 160 m^3/hr[8]. The hot water supply temperature was 85°C and the return was 53°C. The supply of heat was thus 169.6 Gcal/hr (about 35% of peak day heat output).

Three boilers were in service. Stack gas oxygen meters and opacity meters are installed. They have laboratory instruments to measure CO and NOx.

Boiler #1
Firing 5.6 ton/hr oil (mazout 2-2.5% sulfur)
plus 10,000 m^3/hr gas
Stack temperature: 175°C
Stack gas excess O_2 concentration: 0.3%

Boiler #2
Firing 15 ton/hr mazout (no gas)
Stack temperature: 180°C
Stack gas excess O_2 concentration: 0.4%

Boiler #4
Firing 16,000 m^3/hr gas (no mazout)
Stack temperature: 120°C
Stack gas excess O_2 concentration: 0.4%

Air, water and steam temperature control were in automatic mode, with fuel and load in manual mode. The combustion flame conditions looked good. They have some type of automatic furnace safeguard system.

Operators have a chart for each load with desired process setpoints ("regime card"). They also have a big chart over the control board which shows performance losses associated with process variations from setpoint ("propaganda").

Stack emissions looked good. No. 3 boiler was down for scheduled maintenance (including installation of NOx reduction equipment, based on principle of two-stage combustion - primary and secondary air).

Overall condition of the plant is good, which appears to be clean and well maintained.

The plant needs turbine vibration analysis equipment and portable oxygen analyzers to trouble shoot and check accuracy of permanent oxygen analyzers.

[8] The system served by TETS-2 is a closed system.

2.1.1.3 Kostroma steam power station GRES

The "Order of the Red Banner of Labor" 3,600 MWe Kostroma Steam Central Power Station (GRES) is the pride of power engineers not only in Kostroma region, but all across Russia. It is one of the largest thermal power stations in Russia, and its newest unit (#9) is the largest of its kind in the whole world. It has been visited by power engineers from all over the world.

Increasing capacity and steam pressure provides improved economics and reduced fuel consumption, and the Kostroma GRES pioneered the commercial use of 300 MW units and later a 1,200 MW unit. The 1,200 MW experimental unit exceeds the electrical capacity of all of pre-revolutionary Russia. The Kostroma GRES was built as one of the main electrical generation stations in central Russia, and supplies to both 220 kV and 500 kV transmission networks.

The design of the GRES was by the Gorky branch of "Teploprojekt" institute. Plant construction began in 1968 and the first 8 units (2,400 MW total) were completed in 1973. An expansion project was begun in September 1975 which was planned to include two 1,200 MW units. Because of limitations in fuel supply, and other factors, only one 1,200 units was built. It was first run in early 1980 and commissioned in September 1980.

Some teething problems with #9, the 1,200 MW unit, especially with the generator, were experienced until 1982. Since then the unit has operated well, running nonstop between overhauls, over a range of 800-1,200 MW. The 300 MW units are very reliable. Over the course of the entire year, they experience an average of 12 forced outages (spread over 9 units), usually for boiler tube leaks. During the first 100 days of 1992, there were no forced outages.

All major equipment is Soviet-made. All boilers were made by Krasny Kotelshcik boiler works in Taganrog. All turbines were made by Leningrad Metal Works. All generators were made by Electrosyla, Leningrad.

The main fuel by design is heavy fuel oil (mazout, 2-3% sulfur), with natural gas as "back-up", but the station now runs on 75% gas. Gas is sourced from northern Russia through Tyumen and the central gas transmission piping network. The plant is served by a single gas pipeline.

Total number of employees at Kostroma GRES is 2,800, of which 1,800 work in the station and the other 1,000 support the community surrounding the plant.

The plant also provides heat to the surrounding community of Volgorechensk, with 25,000 people. The condenser cooling water is used in a fish farm (carp and sturgeon) before being returned to the Volga.

Kostroma GRES is faced with environmental concerns with water and air emissions. The high sulfur oil gives significant SO_2 emissions; stack gas is exhausted through three 250 meter tall stacks. There is mounting pressure to do something to reduce emissions, and this is one reason why gas is now the major fuel. They measure carbon monoxide and opacity. The plant is located on the Volga River, so of course wastewater emissions must be minimal.

The plant has a strong responsibility for pollution control, since it is located on the Volga River. They have a special environmental division which has done a lot of research and has made various improvements. On air pollution they have done less, except converting to gas as the primary fuel, but recently a lot of research has been done on reducing NOx emissions. GRES engineers indicated that they need better instruments for measuring both air and water pollution. For example, some Germans came once with a gas chromatograph to measure NOx emissions - they would like to have this. They would like NOx monitors and more reliable 0_2 and CO monitors.

Annual station heat rate (efficiency) was 2,198 kcal/kWh in 1991. Station use of power (about 100 MW) is 2.4% on an annual basis. The #9 unit has station use of less than 2%.

The brochure of the Kostroma GRES is provided as Appendix 4.

Phase I - Units 1-4 (300 MW Each)

The first phase of the plant consists of 4x300 MW units. Each unit has two TGMP-114 boilers, one K-300-240 turbine and one TBB-320-2 generator. Boilers are once-through reheat units each rated at 475 ton/hr at 240 bar, 540°C, with reheat at 36 bar. Turbine generators are tandem-compound 3,000 rpm with eight extractions. Generator output is at 20 kV and the generators are hydrogen cooled. Load range 120 to 300 MW. Fuel is gas and/or heavy fuel oil.

Design gross boiler efficiency (LHV) is quoted as 92%

Phase II - Units 5-8 (300 MW Each)

In the second phase of the plant, each unit has one TGMP-314 boiler, one K-300-240 turbine, and one TBB-320-2 generator. Boilers are once-through reheat units each rated at 950 ton/hr at 240 bar and 540°C, with reheat at 36 bar. Turbine generators are

tandem-compound 3,000 rpm with eight extractions. Generator output is at 20 kV and the generators are hydrogen cooled. Load range 120 to 300 MW. Fuel is gas and/or heavy fuel oil, and design gross efficiency (LHV) is quoted as 93%.

The "plan" annual power output from Units 1-8 is 15.4 million MWh (station capacity factor of 0.73). The design station use of power for auxiliaries is 2.9%. The design gross heat rate is 2,212 kcal/kWh LHV (316 g/kWh).

During the audit, Unit 7 was down for scheduled turbine generator maintenance. Eight-week inspections are on a 6-year interval. Plant engineer made a comment about changing turbine rotors. I was unable to follow this up but was led to believe they were swapping rotors out. Maybe with rebuilt spares? They are experiencing boiler leaks at rate of 10-12 per year of units 1-8. Turbine vibration monitoring looked good - measuring both velocity and displacement. The system automatically trips units on high vibration.

Phase III - Unit 9 (1,200 MW)

The third phase of the plant is the pride of the station and the entire Kostromaenergo company. The tandem compound turbine-generator set is the largest in the world. The unit consists of one TGMP-1202 boiler, one K-1200-240-3 turbine, and one TBB-1200-2 generator.

Boiler is once through reheat and rated at 3,950 ton/hr at 240 bar and 540°C, with reheat at 36 bar. Single-furnace boiler with 56 combined oil and gas burners, each with a capacity of 5 ton/hr oil and 5,500 m^3/hr gas. Turbine-driven forced draft fans and boiler feed pumps. The boiler has three regenerative air heaters, each having a rotor 13.88 meters in diameter. The superheaters are cleaned with long-retracting sootblowers. Design gross efficiency (LHV) is quoted as 94%.

Turbine generator 3,000 rpm with nine extractions. Last stage buckets made of titanium and 1.2 meters long. Generator output is at 24 kV. Generator rotor and core and hydrogen-cooled while stator windings are cooled with demineralized water system.

The "plan" annual power output from Unit 9 is 7.1 million MWh (station capacity factor of 0.68). The design station use of power for auxiliaries is 1.7%. The design gross heat rate is 2,191 kcal/kWh LHV (313 g/kWh).

Dispatching of the GRES

The 3,600 MW power station is centrally dispatched from Moscow.

Each day at 4:00pm, Kostroma GRES receives "draft" orders over the phone for the following day from Moscow, giving the expected load output for each hour. The plant engineer decides which units to run and at what load to meet the expected load output curve. As the day progresses, the plan is modified according to needs and any unexpected conditions. The GRES daily load curve for the day of the audit is presented in Appendix 5. The average station load factor for the day was 0.67, and the maximum load was 93% of available capacity.

The station output was 3,000 MW at 11:00am on April 23, 1992 the time of the audit visit. The load was split between 500 kV and 220 kV transmission feeders.

Daily load following is accomplished by modulating the load on each unit (between 120-300 MW on units #1-8 and 800-1200 MW on #9). On Saturdays and Sundays, they shut down one 300 MW unit.

The station has a rate limit on gas. they use as much as they can get, then use mazout to provide the rest of the fuel energy.

Observations during audit

Unit #9, the 1,200 MW tandem compound turbine generator was impressive. It was running smoothly at 1,200 MW, as a check of each bearing showed during the audit. On the day of the audit, the boiler was burning 75% gas and 25% oil, and combustion conditions looked good.

Unit #9 and all the other units at GRES were running fuel and load in manual while air, water and steam temperature were in automatic. Some CRT display of process parameters. Control system is analog, but has an extensive data acquisition/monitoring computer system IB-500. Good television monitoring of flame. All charts were drawing straight lines. Load range is 800 to 1200 MW all under sliding pressure with turbine valves were open. Overload has been run at 1,380 MW on this unit. Said to be very reliable and runs well from overhaul to overhaul.

As determined by KostromaEnergo accounting methods, generation cost is very low, perhaps 1 kopeck/kWh. The tariff to customers averages about 8 kopecks/kWh, but costs are rising quickly. A control operator earns 4,000 Rubles per month.

Design station efficiency is 2,198 kcal/kWh LHV (314 gram/kWh). In 1970, the heat rate at the GRES was 347.2 g/kWh, in 1983 it came down to 317 g/kWh.

The overall condition of the plant is very good. It is very well-designed and maintained, and very clean. The chief engineer and his staff are technically competent and take a lot

of pride in the facility as it is an example of what the Russian people can do. It is obvious that the GRES has been well-funded through the past years.

The plant needs vibration diagnostic equipment to help balance turbine generators upon return to service from inspection outages.

They also need a thermal imaging system to use for heat loss identification and preventative maintenance work. They have used one before which was supplied from Moscow, by an organization called DIAGNOSE, which is part of ORGRES (organization for commissioning and evaluation of steam power plants). Kostroma GRES is the most qualified facility in the region to maintain and use such a complex piece of equipment. they agree to make best use of it, for the benefit of the city and region, in the facilities of KostromaEnergo and other organizations in the city.

2.1.2 KostromaOblTeplEnergo small boilerhouses

KostromaOblTeplEnergo (Kostroma Oblast Thermal Energy, KOTE) operates a total of 170 boilerhouses, with capacities of up to 50 Gcal/hr. Their largest boilers are 25 ton/hr saturated steam generators of up to 14 bar pressure. Most of their boilers are hot water generators, rather than steam. KOTE annual heat generation is 700-800,000 Gcal/year.

KOTE not only generates heat, but also buys heat from KostromaEnergo. KOTE annual heat purchases average 900-1,000,000 Gcal/year.

KOTE does not sell heat to industry, only to civil - institutional, schools, hospitals, and residential customers.

KOTE operates 170 km of distribution lines, including branches. KOTE has a total of 1,600 employees, 750-800 of whom work in the City of Kostroma. The rest work in the six other cities in Kostroma Oblast which are served by KOTE.

The cost of heat generation by KOTE (at the time of the audit, April 1992) averaged 225 rubles/Gcal in Kostroma and 400 Rubles/Gcal outside the city. The average price of natural gas to KOTE was 250 Rubles/thousand m^3 in March 1992, but they are expecting prices to rise to 2,500 Rubles/thousand m^3 by May 1992.

The tariff by which KOTE sells heat allows KOTE to recover its cost, plus a margin. The margin averages 25%, but varies over the course of the year (margins are higher in winter, up to 40%). The tariff does not differentiate by customer class, it is the same for all Gcal. KOTE is allowed to recover its costs, and not all of the cost is passed on to consumers. A subsidy for heat supplied to consumers is borne by the city/regional government, since rents do not cover heat costs.

The fuel consumed by KOTE is all natural gas within the Kostroma city limits. Elsewhere in the region, heavy fuel oil (mazout) and coal (Kuzbaz high ash anthracite) is burned. Typical annual quantities are:

gas	55 million m^3/yr
mazout	12,000 tonnes/yr
coal	40,000 tonnes/yr

2.1.2.1 Baravaya 4 boilerhouse

The Baravaya 4 boilerhouse serves a development 15 km to the NW of the center of Kostroma. The development served includes about 25 buildings, 20 of which are residential, with approximately 7,000 residents. There are also two school buildings, a garage, kindergarten, professional training center, repair shop and public bath/sauna in the scheme.

The heating system is totally independent stand-alone. The region borders the area served by TETS-2, but the piping systems are not interconnected. The distribution is through a closed system, with a heat exchanger and secondary loop in each building. In the buildings, the heating system is mostly of the one-pipe type (radiators connected in series, no bypass). The system operates 12 months per year, to provide domestic hot water as well as heat.

The system is typical of many in Russia, especially in Kostroma region, except that it still uses some steam boilers for hot water generation[9]. In such a system, the steam passes from the boiler to a heat exchanger to generate hot water. Steam pressure is controlled manually, according to the temperature of water required. Baravaya 4 also has gas-fired hot water boilers, so it represents a good example of all Russian systems.

The capacity of Baravaya 4 is 16.4 Gcal/hr, and it feeds into a 319 mm diameter main. The fuel used is natural gas. The total circulation capacity is 250 m^3/hr, and typical make-up is 3 m^3/hr. Since the Baravaya area is a closed system, this make-up represents leakage loss (approximately 1% of output).

The boilerhouse has five boilers installed:

(3) DKVR watertube saturated steam boilers
4 ton/hr capacity
10 bar pressure

[9] Such installations are no longer being built, only fired hot water boilers. Of the KOTE installations, only about 10% have steam boilers.

design stack excess O_2 = 10-12%
stack temperature 220°C

(2) TVG gas-fired hot water boilers
4 Gcal/hr capacity
design stack excess O_2 = 6.5-8%

They have a GRAFIK for supply temperature, and decide which boilers to use according to outside air temperature. They also have regime cars that show air/fuel settings for each boiler. A special division of KOTE that comes in and performs analysis to prepare the regime card for each boiler. They use an ORSAT analyzer to test boiler combustion efficiency, about once every three years.

Natural gas consumption was about 18,000 m^3/day at the time of the audit.

During the audit, combustion tune-ups were carried out on one steam boiler and two hot water boilers, using RCG/Hagler, Bailly's portable combustion analyzers. The results showed that the efficiency of combustion in the "as-found" condition was already nearly as good as possible, given the design of the burners. Using the efficiency monitor, tune-ups were carried out to achieve optimum combustion, which was 90% LHV. The results of these tune-ups showed efficiency improvements ranging from 0.5% to 1.5%. Further reduction of combustion air was not possible without incomplete combustion (CO in stack gas). New burners would be required to increase efficiency further.

During the audit, tests of boiler water were carried out on the two steam boilers, using RCG/Hagler, Bailly's portable dissolved solids tester. These tests showed that one boiler was operating at concentration far below standard and one was normal. Through the use of these instruments, reduction in losses through boiler blowdown could improve boiler efficiency by 0.5%.

During the audit, tests of power factor (cosine phi) on district heating pumps were carried out, using RCG/Hagler, Bailly's portable. These tests showed cos phi of about 0.82, which is normal.

2.1.2.2 Susnovay Russya boilerhouse

The Susnovay Russya ("pine trees") boilerhouse serves another development near to Boravay. This 9 Gcal/hr boilerhouse is similar to 50-60 others in Kostroma, and has no steam boilers, only 9 hot water boilers. Of these, six are 0.6 Gcal/hr and three are 1.6 Gcal/hr. Susnovay Russya generates hot water at 70-95°C and feeds into 1.5 km of mains, in a stand-alone system.

Susnovay Russya has an integral water treatment system and an integral distribution system. Leaving the boilerhouse are four pipes - two for heating in a closed loop system, and two for domestic hot water (open loop).

Six small gas-fired hot water boilers
- 0.6 Gcal/hr capacity
- design stack excess O_2 = 10.6-14.2%
- design stack temperature 190°C
- design efficiency 86% (LHV)

2.2 Heat Distribution Systems

The district heating system of Kostroma is very old and was developed in stages to meet the population growth. The total length of the distribution system (with the branches) is 170 km. (pipe diameters vary from 200-600 mm.).

The district heating distribution system of Kostroma is maintained by 750-800 employees. KostromaOblTeplEnergo sells heat to industrial, commercial, institutional, residential and agricultural customers.

The piping network of the city of Kostroma district heating system transports 150°C hot water (150°C-70°C) and distributes it to customers at (95-70°C). There is a closed type system design with heat exchangers for domestic hot water in each building. The piping network is located mostly underground. There is a number of independent district heating systems with individual boiler rooms. The distribution system is designed for a peak supply temperature of 130°C-70°C (at -31°C outdoor temperature). The water temperature is reduced at house substation (at the point of ejector) to 95°C-70°C.

From the power plants the hot water and steam are distributed through the distribution piping systems to the customers.

Based on visual inspection, the piping insulation appears to be in good condition. The only areas of concern are near valves and fitting, where the insulation has cracks.

The distribution systems and substations lack instrumentation and controls and show signs of low maintenance budgets.

The heat distribution systems in the City of Kostroma are large and are mostly buried below ground in concrete tunnels. For piping above ground, insulation of 50-60 mm mineral wool is standard.

Leakage is the most pronounced problem. Approximately 1.5 km of pipeline must be replaced each year. Existing systems have no instrumentation to monitor leakage from

the system. Much of the debate concerning solutions suggests that instrumentation to detect the locations of leaks would be of prime importance. Several leak detection systems were available in the USSR market which could be implemented in a limited program to begin addressing this problem.

The second priority to enhance the effectiveness of the heat distribution system is monitoring heat loss and consumption as compared between the central plant versus the end user. The effect of degraded insulation can not be accurately determined without end user measurement capability. In the short term, installation of Gcal meters in a limited program could begin to address this problem.

Temperature control of the hot water in the distribution system is based on outside ambient temperature. Systems surveyed reset water temperature every 6 hours in response to changes in ambient air temperatures. A short term measure to modify the reset time to a maximum of every one (1) hour will provide some energy conservation capability.

Based on the problem characterization for heat distribution, the short term, low cost energy savings potential is estimated at 2-10% through limited installation of Gcal meters, leak detection equipment and temperature control modifications.

2.3 Heat Utilization Systems

The situation is worst on the consumer end, as revealed by this energy audit. There are no controls or valves on the individual end user units.

Thermal energy originating at the central plants is produced through quality control. The same quantity of water is maintained while the temperature is varied, based on the climate conditions. These plants operate on a schedule which depends on the ambient (outdoor) temperature. Water mixing is used to adjust the supply temperature. Mixing occurs at the building entrance substations.

The absence of maintenance and lack of controls for the end users, especially residential buildings, results in significant inefficiencies. The systems are not balanced with certain areas obtaining excessive heat at the expense of others. The occupants of overheated buildings often resort to open windows due to the absence of control valves. The installation of thermostatic valves, heat metering devices and temperature regulators is recommended as a first step in the short-term energy conservation effort. Proper maintenance procedures and system operation should be addressed on a long-term program.

Several problems were evident through our survey of selected end users. The presence of instrumentation and control systems was very limited. Insulation of heating equipment, piping and components was generally in a degraded state. There are no incentives for the end user to conserve energy since billing is estimated independently from actual energy consumption. No energy metering equipment is installed. Industrial customers experience high levels of electrical consumption per unit of production. The short term, low cost energy savings potential is estimated at 10-30% for industrial, institutional and residential end users through application of new controls and metering equipment.

2.3.1 Industrial - "Rabochiy Metallist" heavy mining equipment manufacturer

Rabochiy Metallist is a manufacturer of bucket excavators (heavy track-driven vehicles with a crane/shovel) used in the mining industry. The factory is 75 years old and is located on the east side of the Volga. The factory employs 2,400 workers, plus another 1,000 in a joint venture (with a British firm) nearby.

Rabochiy Metallist has the capacity to manufacture 1,200 excavators per year, but at the time of the audit was producing at only 50% of its capacity. Its main problems were a shortage of steel and diesel engines.

The technical characteristics of the boiler room of the factory Rabochiy Metallist is presented in Table 9. The factory has five (5) steam boilers (9 bar saturated steam) at 10 ton/hr capacity each, and two (2) fired hot water boilers rated at 30 Gcal/hr each. The boilers burn natural gas, with mazout as back-up.

The total hot water supply capacity for buildings is 90 Gcal/hr. Rabochiy Metallist has been converting their building heating systems from steam to hot water over the years as an energy conservation measure, and basically completed this project (95% of areas) in 1987.

Interestingly, the boilerhouse not only serves to supply heat, but also to generate CO_2, which is used in welding operations (the RCG/Hagler, Bailly team did not investigate this application). They supply 3,500 m^3/hr of CO_2-rich exhaust gas to this process. They need to generate CO_2 at the highest concentration possible, and are seeking a tight, infiltration-free boiler to do so. They measure stack gas CO_2 concentration every day using an ORSAT-type device made by KAZAN Heat Instrument Factory (USSR). They are interested in learning more about the most economical way to manufacture CO_2 - perhaps combustion is not the answer. They need to make about 2,000 tons per year of CO_2.

2.3.2 Industrial/agricultural - Kostroma City Ornamental Plant Farm (greenhouse)

A division of the Kostroma city government operates greenhouses for food production and horticulture. There are 14 ha. of greenhouses near TETS-2 which grow vegetables.

In the Ornamental Plant Farm visited by the RCG/Hagler, Bailly team, 2.5 ha. of greenhouses are in production. The main species under cultivation are roses, with some 1.5 ha. planted, which produce some 1 million long-stem roses per year, in hybrids of many beautiful colors.

A total of 36 other types of flowers are grown which relate to specific holidays, such as Easter lilies (which became known in the USSR as mother's day lilies). Potted house plants are cultivated, including various species of ferns and begonias. They have not been able to grow orchids.

Most sections of the greenhouses use single pane glass glazing, but 10 sections use polyethylene glazing. Each plastic-glazed section is approximately 40 m long x 13 m wide. The glass sections are much larger.

Table 9

TECHNICAL CHARACTERISTICS OF THE EQUIPMENT

Rabochiy Metallist

Equipment	Equipment Put in Operation 1991-1995				Equipment Put in Operation in 1996-2000			
	Amount	Type Manufacturer	Boiler Capacity		Amount	Type Manufacturer	Boiler Capacity	
			Gcal/hr	T/hr			Gcal/h	T/hr
Watertube Boilers	1	KVGM-30 Dorogob. Boiler Factory	30					
Steam Generators	2	DE-25-14 Biyskiy Boiler Factory		50				
	2	DKV-10-13		20				
	4	DKVR-10-13		40				

The heating system is hot water, supplied from TETS-2 via a 216 mm diameter line to the substation located on the greenhouse property. The substation feeds the property, on which perhaps a thousand hand-operated valves are used to control temperature in a total of 24 sections.

Auxiliary lighting is provided, which is used to extend the growing season. Lighting is mercury and incandescent, wide spectrum.

Energy consumption for the Ornamental Plant Farm in 1991 was:

Heating	16,174 Gcal	421,000 Rubles
Electricity	787,000 kWh	63,000 Rubles

The monthly heat consumption and heating load are indicated in Appendix 6. Heat consumption does not track ambient temperature very well. It could be that this is related to the need for heat by the growing process, depending on the requirements for flower production, but this growth process was not investigated during the audit.

The opportunity exists to automate the control of temperature in the greenhouses. This would require the installation of approximately 24 thermostatic valves with remote thermostats. Each valve should be sized for 40 mm pipe diameter. The existing hand valves are 21 cm long, flange-to-flange. Electric power (220 VAC) is available for the valves actuators.

Measurements during the audit indicated that the temperature of hot water supply to the greenhouse was below specifications. The supply temperature leaving TETS-2, less than 1 km away, was 85°C, but the temperature at the inlet to the substation was indicated as 72°C on the greenhouse chart recorder and measured 77°C with RCG/Hagler, Bailly's digital thermocouple. Design temperature drop is less than 3°, therefore it is evident that line losses due to inadequate insulation are excessive.

2.3.3 Institutional building - school

The three-story brick school Borovay 9 building was build in 1974 and has a gross area of 22,420 m^2 (1,348 students). The school operates from September to the middle of June. Comfort heating and domestic hot water are supplied by the KostromaOblTeplEnergo system at Borovay (see description of boilerhouse above).

The heating system operates from the beginning of October to the middle of May. The peak heating and domestic hot water load for the school is 0.633 Gcal/hour. The annual heating load is estimated to be 1,220 Gcal/year.

The hot water from the district heating system arrives at the school substation providing 130°C-70°C for heating and domestic hot water. A separate heat exchanger is installed in order to prepare domestic hot water. There is a closed loop system for heating and domestic hot water systems. The diameter of supply and return pipes is 100 mm.

The pipe line to the school substation is underground and there is no way to evaluate the condition of the pipe insulation. In school basement the insulation of the piping appears to be in good condition.

There are no controls or measuring devices at the school substation. In addition, there are no temperature controls in the school rooms. Inside temperature is regulated by opening or closing windows.

Thermostatic valves could be installed, but they must be tamper-proof.

2.3.4 Residential apartment blocks

Two identical residential buildings were chosen to perform an energy savings analysis. The building (Borovay 20) consists of 5 floors with 90 apartments. Walls are reinforced concrete panels. There is a two pipe heating system with down feed distribution.

Comfort heating and domestic hot water are supplied by the KostromaOblTeplEnergo system at Borovay (see description of boilerhouse above). Peak heating load for the building is 0.615 Gcal/Hr (estimated). Annual consumption is estimated to be 1,180 Gcal/year. The heating season is 222 days.

The windows in the building do not close properly. The domestic hot water is an closed type system. The diameter of the supply and return pipes to the apartment building is 89 mm, and the supply and return lines to the radiators is 12 mm.

Insulation of the supply and return lines to the building substation appears to be in good condition.

There are no controls or measuring devices at the building substation.

As an experiment, a Gcal meter should be installed in one building without any other energy conservation measures. In the second building thermostatic valves will be installed on each radiator, and a Gcal meter and temperature control regulator will be installed on the supply and return lines in the building substation.

CHAPTER 3: OBSERVATIONS AND FINDINGS

3.1 General Comments

District heating systems in Russia are generally large and highly centralized. Experience with these systems indicates that they have the following problems:

- Heat flows are usually not metered
- Customers have no control over their consumption of heat
- The systems may have low reliability
- It is difficult to balance the system hydraulically
- The systems are not designed for ease of maintenance
- Maintenance and operations staff lack proper tools and instruments
- In open systems, it is difficult to locate leaks in the distribution system.

Based on these indications, it appears that consideration should be made of decentralization where practical. By creating a number of smaller systems, the problems associated with maintenance and balancing can be more effectively controlled.

One of the parameters used to determine the integrity of a distribution system is the amount of leakage which occurs. In open-type district heating systems where consumption of domestic hot water is not measured at the end user, it becomes difficult to distinguish between water make-up to the system and the percentage which can be attributed to leaks in the distribution piping. Therefore, a policy of developing only closed-loop distribution systems whereby all water which is supplied to the system is returned, will enhance the ability of they system operators to monitor system leakage.

The KostromaEnergo cogeneration plants (TETS) operate at high thermal efficiency and personnel have access to well maintained controls and automation systems. The smaller

boilerhouses at KostromaOblTeplEnergo do not have access to such high technology, but they are making effective use of what equipment they do have.

Yet the heat that is efficiently produced is dumped into a system that is not metered and is not controllable. The distribution systems and substations lack instrumentation and controls and show signs of neglect. Proper maintenance procedures and system operation should be addressed immediately.

The situation is worst at the consumer end, as revealed by this energy audit. There are no controls or valves on the individual end user units. Inadequate heating system maintenance and lack of controls for the end users, especially residential buildings, results in significant inefficiencies. The systems are not balanced, with certain areas obtaining excessive heat at the expense of others, which are too cold. The occupants of overheated buildings must resort to opening windows. The installation of thermostatic valves, heat metering devices and temperature regulators must be made part of all new buildings.

The RCG/Hagler, Bailly team estimates the short-term, low-cost potential for energy efficiency improvement in the district heating system served by VIZ as about 10%, as follows:

	Short-term, low-cost energy savings potential
Heat generation	0-1%
Heat distribution	1-2%
Industrial heat use	5-10%
Institutional heat use	5-10%
Residential heat use	5-10%

Assuming conversion to a market economy for district heating commodity, the RCG/Hagler, Bailly team estimates the medium-term potential for energy efficiency improvement in the Kostroma district heating system served as about 25% (including the short-term, low-cost projects, as summarized in Exhibit 1) as follows:

	Medium-term energy savings potential
Heat generation	0-1%
Heat distribution	2-5%
Industrial heat use	10-20%
Institutional heat use	10-20%
Residential heat use	15-30%

3.2 Heat Generation

The large central heating plants surveyed are generally in good operating condition. They feature adequate instrumentation and controls and are maintained by highly qualified stuffs. It is believed that improvements to these plants should be considered for longer term programs where higher capital investment is required.

The smaller "civil" boiler plants which were surveyed, however, are not as well staffed and lack modern instrumentation and controls. A 0-1% short-term, low cost energy savings potential is estimated for enhancing the instrumentation and controls systems and monitoring equipment for the "civil" boiler plants which require attention.

3.3 Heat Distribution

The heat distribution systems in Kostroma are large, approximately 90% of which is buried below ground in concrete tunnels. Heat leakage is the most pronounced problem, as evidenced by vapor seen escaping from manhole covers.

Existing systems have no instrumentation to monitor leakage from the system. In the short term, several leak detection systems are market available which could be implemented in a limited program to begin addressing this problem.

The second priority to enhance the effectiveness of the heat distribution system is monitoring heat loss and consumption as compared between the central plant versus the end user. The effect of degraded insulation can not be accurately determined without end user measurement capability. In the short term, installation of Gcal meters in a limited program could begin to address this problem.

Temperature control of the hot water in the distribution system is based on outside ambient temperature. Systems surveyed reset water temperature every 6 hours in

response to changes in ambient air temperatures. A short term measure to modify the reset time to a maximum of every one (1) hour will provide some energy conservation.

Based on the problem characterization for heat distribution, the short term, low cost energy savings potential is estimated at 1-2% through limited installation of Gcal meters, leak detection equipment and temperature control modifications.

3.4 Heat Utilization

Several problems were evident through our survey of selected end users. The presence of instrumentation and control systems was very limited. Insulation of heating equipment, piping and components was generally in a degraded state. There are no incentives for the end user to conserve energy since billing is estimated independently from actual energy consumption. No thermal energy metering equipment is installed. The short term, low cost energy savings potential is estimated at 5-10% for industrial, institutional and residential end users through application of new controls and metering equipment.

CHAPTER 4: RECOMMENDATIONS FOR ENERGY EFFICIENCY IMPROVEMENT

In general, the RCG/Hagler, Bailly team found that the Russian standard of management of district heating systems operations and maintenance was significantly below Western standards. Many of these problems may result from the many years of Socialist system, which did not provide proper incentives for efficiency. Furthermore, the lack of an ownership mentality has prevented the traditional Russian frugality and work ethic from being reflected in the workplace - the dirty jobs are not getting done. Although optimization of operations management and improvement of maintenance may not require significant expenditure to accomplish, it nevertheless may be very difficult because it will be very difficult to change the energy-related behavior of people overnight, after these many years.

To succeed in the market economy, however, the people of Kostroma must overcome these barriers. The installation of costly capital equipment to improve energy efficiency is not the solution - the economy of Kostroma must instead invest what little capital is available to improve the quality and quantity of production of goods for export to hard currency markets.

Instead, the RCG/Hagler, Bailly team recommends that a well-organized, but low-cost, program be established in the City of Kostroma and Kostroma region to implement energy efficiency measures in the short-term. The first-step and second-step priority low-cost, market-oriented measures identified by the RCG/Hagler, Bailly team below (and described in more detail in this report) can save 30% of district heating energy, with economic benefits to Kostroma region of more than $15 million per year, with an economic payback period of one year or less.

The RCG/Hagler, Bailly Team's recommendations for energy management and efficiency improvement have been grouped in four categories:

SHORT-TERM, LOW-COST PROJECTS - FIRST STEP PRIORITY

A. Optimize Operations Management - These projects are opportunities which are recommended for immediate action, and require little or no expenditure. These projects affect management systems and techniques, rather than process equipment.

B. Improve the Standard of Maintenance - These projects call for the organization of teams to make improvements to heating equipment which are recommended for implementation in the short-term. Because of the low cost and quick payback (less than one year), these projects could be implemented from the company's annual maintenance budget.

MEDIUM-TERM, MARKET-ORIENTED - SECOND STEP PRIORITY

C. Convert Heat Supply to a Market Economy - These projects call for the installation of metering, controls and tariff systems designed to provide an economic incentive and a physical capability for heat users to modulate their energy consumption.

LONG-TERM, CAPITAL INVESTMENT - THIRD STEP PRIORITY

D. Improve Efficiency of Systems - These projects are longer term projects, requiring substantial capital investment. Such projects would require careful study, beyond the scope of this preliminary energy audit.

Projects with low cost which can be implemented in the short-term are the primary focus of the USAID Energy Efficiency and Market Reform Program for Russia. These are projects in categories A and B. In addition, recognizing the need to establish district heating as a market-oriented commodity, projects in category C will be demonstrated. Projects in category D are beyond the scope of funding under the USAID Energy Efficiency and Market Reform Program for Russia.

The recommendations are summarized below.

First Step Priority - short-term, low-cost projects

A. Optimize Operations Management

Action A.1: Improve control of supply temperature - modulate on hourly basis instead on every six-eight hours. The RCG/Hagler, Bailly team estimates that this

recommendation could save 0.2% of heating energy, which would give an economic benefit to the Kostroma region of $100,000 per year.

Action A.2: Improve control of supply temperature - optimize the GRAFIK based on trial and error procedure. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the Kostroma region of $2.5 million per year.

Action A.3: Improve combustion efficiency in small boilerhouses, maintain optimum efficiency in heat/power stations. The RCG/Hagler, Bailly team estimates that this recommendation could save 0.5% of fuel in small boilerhouses and 0.1% of fuel in power stations, which would give an economic benefit to the Kostroma region of $560,000 per year.

Action A.4: Improve control of water quality in steam boilers. This could improve boiler efficiency in industrial boilers by 0.25%.

Action A.5: Organize energy management information system for City to track trends in efficiency.

Action A.6: Organize small library of US manufacturers contacts for supply of equipment and possible joint ventures in manufacturing of high efficiency equipment.

B. Improve the Standard of Maintenance

Action B.1: Improve heat transfer effectiveness in the system - test, balance and clean heat exchangers to increase return water temperatures. Investigate temperature drop and state of flow in piping systems in buildings, and repair as indicated. The RCG/Hagler, Bailly team estimates that this recommendation could save 10% of heating energy, which would give an economic benefit to the Kostroma region of $5 million per year.

Action B.2: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping (examples - residential building, greenhouse, and school). The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the Kostroma region of $2.5 million per year.

Action B.3: Use IR scanner on thermal systems, such as boilers and distribution piping, to detect excessive heat loss - repair insulation as indicated. The RCG/Hagler, Bailly team estimates that this recommendation could save 1% of heating energy, which would give an economic benefit to the Kostroma region of $500,000 per year.

Second Step Priority - convert heat supply to a market economy

C. Medium Term - install metering and controls and revise tariff designs

Action C.1: Install Gcal metering at key points in network, and develop a loss-tracking system. The RCG/Hagler, Bailly team estimates that this recommendation could save 2% of heating energy, which would give an economic benefit to KostromaOblTeplEnergo and KostromaEnergo of $1 million per year.

Action C.2: Install Gcal metering at inlet to all buildings, and convert to a tariff based on Gcal at the building level. The RCG/Hagler, Bailly team estimates that this recommendation could save 2% of heating energy, which would give an economic benefit to Kostroma region of $1 million per year.

Action C.3: Provide heat allocation meters in individual flats - evaporative type on all radiators and flow meters on hot water taps, and convert to a tariff based on Gcal at the individual customer level. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to Kostroma region of $2.5 million per year.

Action C.4: Improve controls - install thermostatic radiator valves to control temperature in heated spaces. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to Kostroma region of $2.5 million per year.

Action C.5: Upgrade ability to provide services - organize energy audit service firms and provide them with instruments. The RCG/Hagler, Bailly team estimates that this recommendation could save 1% of heating energy, which would give an economic benefit to Kostroma region of $500,000 per year.

Action C.6: Upgrade awareness of energy efficiency - organize education and training programs. The RCG/Hagler, Bailly team estimates that this recommendation could save 1% of heating energy, which would give an economic benefit to Kostroma region of $500,000 per year.

Action C.7: Convert factories in Kostroma to produce equipment needed to improve energy efficiency.

Third Step Priority - capital investments for modernization

D. Long-Term - Improve Efficiency of Systems

D.1 Install distributed heating systems of high efficiency where applicable.

D.2 Reduce heat loads by upgrading insulation.

D.3 Improve distribution systems by using pre-insulated piping with leak-detection systems on new installations and improving drainage of existing installations.

Projects in Category D are generally beyond the scope of the AID-funded energy audit, which focused on short-term projects. Category D projects require more detailed investigations to determine their economic feasibility. Category D projects are thus recommended for further study. Some selected demonstrations of Category D projects may be suggested for the near term.

The recommendations are presented in Project Forms, which contain the following information:

Category of project (A, B, or C)
Location of project
Action code number and brief description of recommendation
Existing conditions
Recommended action
Equipment required
Expected results
Cost/benefit analysis

SUMMARY OF ENERGY EFFICIENCY EQUIPMENT PROCUREMENT RECOMMENDATIONS FOR 1992 U.S.A.I.D. PROJECT

Changes to improve operation and maintenance of existing systems will be required to realize these improvements. The hard-working technical personnel in Kostroma will need additional tools and instrumentation to achieve these goals. The RCG/Hagler, Bailly team recommends that Kostroma receive a package of equipment from USAID to assist their energy management program. The proposed procurement list and budget for Kostroma, subject to approval by USAID, is summarized in Exhibit 1. The minimum

budget will be $50,000 for equipment. Two alternates are proposed, for consideration if USAID is able to provide additional funding.

Exhibit 1
Summary of procurement recommendations

	Variant "A"	Variant "B"	Variant "C"
Small library of information on US manufacturing companies	1,000	1,000	1,000
PC-386 computer/printer for city energy management	3,000	3,000	3,000
Equipment for Kostromaoblteplenergo - heat supply & distribution			
Leak detection system	5,000	5,000	5,000
2 Thermocouple kits	2,000	2,000	2,000
2 Ultrasonic stethoscopes	3,000	3,000	3,000
2 Combustion analyzers	8,000	8,000	8,000
3 Dissolved solids water testers	1,000	1,000	1,000
6 Small combustion kits	2,000	2,000	2,000
2 Infrared pyrometers	3,000	3,000	3,000
Equipment for Gorzhiluprovenya - residential building maintenance			
Ultrasonic stethoscope	1,500	1,500	1,500
Thermocouple kit	1,000	1,000	1,000
Equipment for Rabochiy Metallist - industrial plant maintenance			
Library US contacts	200	200	200
Ultrasonic leak detector	4,000	4,000	4,000
Thermocouple kit	1,000	1,000	1,000
Small combustion kit	300	300	300
Equipment for residential buildings			
Weatherstripping	5,000	5,000	15,000
2 Gcal meters		8,000	8,000
Wall insulation			30,000
Substation temp. controller			3,000
Equipment for school			
Gcal meter	5,000	5,000	5,000
20 Thermostatic valves	1,000	1,000	1,000
Substation temp. controller			3,000
Equipment for greenhouse			
Plastic for sealing leaks	2,000	2,000	2,000
Equipment for Kostromaenergo & city to detect heat loss			
Thermal imaging vision		40,000	40,000
Equipment for Kostromaenergo			
Vibration analyzer			5,000
2 portable O2 analyzers			2,000
TOTAL BUDGET	49,000	97,000	150,000

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: Kostroma - region

Action A.1: Improve control of supply temperature - modulate on hourly basis instead on every six-to-eight hours.

Existing conditions

The temperature of the supply water is based on ambient temperature conditions, according to the standard "grafik". Adjustments are made once every six to eight hours.

The modulation every six to eight hours does not permit accurate control. The result is overshooting/undershooting of the necessary temperature. In the system of Paris France, changing to a system based on hourly control has proven to improve comfort levels, and save energy.

Recommended action

Convert to an hourly temperature control system. use telephone lines to carry out necessary control actions.

Equipment required

None.

Expected results

The RCG/Hagler, Bailly team estimates energy savings on the order of 0.2% per year.

Based on 1990 annual district heat supply in the Kostroma region of 4.6 million Gcal, savings would amount to 9,000 Gcal/year.

Cost/benefit analysis

The cost of implementing the project is estimated to be negligible. Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $110,000 million per year.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: Kostromaenergo & KOTE - region

Action A.2: Improve control of supply temperature - optimize the GRAFIK based on trial and error procedure.

Existing conditions

The temperature of the supply water is based on ambient temperature conditions, according to the standard "grafik". The grafik shows supply temperatures as follows:

For ambient temperature > 0°, supply = 70°

For ambient temperature < 0°, supply =
70° + 2.28° for every 1° ambient temperature is < 0°.

This grafik is a standard all over the USSR. Under the new market conditions, Russia may no longer be able to afford to supply heat energy in the same quantities as in the past.

The temperatures specified in the grafik are design conditions, and are not adjusted for actual installed conditions. The result is overshooting/undershooting of the necessary temperature. In the system of Tallinn Estonia, reducing the supply temperature has proven to save energy (as much as 50% in January 1992), while still maintaining adequate comfort levels (at least 20° in flats).

A study of the actual supply temperature in Ekaterinburg showed that they usually exceeded the grafik at ambient temperatures above about -10°. No such study was available in Kostroma.

Recommended action

Update the grafik for the new market conditions, based on a trial and error procedure, such as the following:

1) Select an appropriate sample of flats, based on network considerations, types of buildings, etc.

2) Measure indoor temperature in the flats at various times of the day for a period of one week. It would be best to use recording thermometers

3) Reduce the grafik. Start with a 10°C reduction in supply temperature, measure the results for one week, and evaluate the conditions.

4) Optimize the reduction/supply temperature based on the findings, and continue the experiment.

Equipment required

Recording thermometers (at least 20).

Expected results

Based on a 5°C reduction in supply temperature the RCG/Hagler, Bailly team estimates energy savings on the order of 5% per year.

Based on 1990 annual heat consumption in the Kostroma region of 4.6 million Gcal, savings would amount to 230,000 Gcal/year.

Cost/benefit analysis

The cost of implementing the project is estimated to be negligible.

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $2.76 million per year.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: Kostromaenergo and KOTE

Action A.3: Improve combustion efficiency in small boilerhouses, maintain optimum efficiency in heat/power stations.

Existing conditions

RCG/Hagler, Bailly measured combustion efficiency in several boilers of KOTE, and observed conditions at all boilers of Kostromaenergo and Rabochiy Metallist. Systems are operated as well as possible, given the tools, instruments and other equipment the engineers and technicians have now.

Recommended action

The RCG/Hagler, Bailly team recommends that:

- KOTE and Rabochiy Metallist should upgrade the standard of their combustion test equipment to improve boiler efficiency.
- Kostromaenergo should obtain portable test equipment to perform vibration analysis, thermal imaging analysis, and combustion gas analysis to maintain peak efficiency and availability of its generation units.

Expected results

The RCG/Hagler, Bailly team estimates that:

- KOTE and Rabochiy Metallist can improve boiler efficiency by 0.5% by improved combustion testing and tune-ups.
- Kostromaenergo can improve station availability by about 0.5% by using better test equipment.
- Kostromaenergo can improve station efficiency by 0.1% by using better test equipment.

Equipment required

The RCG/Hagler, Bailly team recommends the following equipment, for procurement using USAID funds:

Equipment for Kostromaoblteplenergo - heat supply & distribution	
2 Electronic combustion analyzers	8,000
6 Chemical combustion analysis kits	2,000
Equipment for Rabochiy Metallist - industrial plant maintenance	
1 Chemical combustion analysis kit	300
Equipment for Kostromaenergo & city to detect heat loss	
1 Thermal imaging vision	40,000
Equipment for Kostromaenergo	
1 Vibration analyzer	10,000
2 portable O2 analyzers	2,000

Details on the specifications of the equipment for KostromaEnergo are provided in Appendix 7.

Cost/benefit analysis

Improvement in combustion efficiency in the boilerhouses of KOTE and Rabochiy Metallist of 0.5% would save about 5,000 Gcal per year. At an economic value of natural gas of $12 per Gcal, this would provide benefits of $60,000 per year.

Improvement in the availability of the Kostroma GRES would enable this high efficiency unit to displace other units of lower efficiency on the Russian grid, with resulting energy savings.

Improvements in the efficiency of the Kostroma GRES and TETS by 0.1% would save 120,000 Gcal per year. At an economic value of natural gas of $12 per Gcal, this would provide benefits of $500,000 per year.

At a total cost of about $70,000, the payback period on the project is about one month.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: KostromaOblTeplEnergo and Rabochiy Metallist

Action A.4: Improve control of water quality in steam boilers.

Existing conditions

RCG/Hagler, Bailly tested boiler water quality in two steam boilers of KOTE using an electronic dissolved solids tester (conductivity meter indicating in ppm or mg/l), and observed that the concentration of dissolved solids in the boiler water is not optimal. The laboratory test equipment available, based on titration methods, requires more than one hour to test a sample, which is too slow to be used to control operations.

Recommended action

The RCG/Hagler, Bailly team recommends that KOTE and Rabochiy Metallist should upgrade the standard of their steam boiler water analysis equipment by using an electronic dissolved solids tester, which can carry out a test in seconds.

The results of analysis using the electronic instrument should be used to optimize blowdown quantities to achieve proper dissolved solids concentration, according to the existing published USSR standards for concentration.

Expected results

The RCG/Hagler, Bailly team estimates that KOTE and Rabochiy Metallist can improve boiler efficiency by 0.25% by improved water quality control.

Equipment required

The RCG/Hagler, Bailly team recommends the following equipment, for procurement using USAID funds:

Equipment for Kostromaoblteplenergo - heat supply & distribution	
3 Dissolved solids testers	1,000
Equipment for Rabochiy Metallist - industrial plant maintenance	
1 Dissolved solids tester	300

Cost/benefit analysis

Improvement in steam boiler efficiency in the boilerhouses of KOTE and Rabochiy Metallist of 0.25% would save about 500 Gcal per year. At an economic value of natural gas of $12 per Gcal, this would provide benefits of $6,000 per year.

At a total cost of about $1,300, the payback period on the project is less than three months.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: City of Kostroma Administration

Action A.5: Organize energy management information system for City to track trends in efficiency.

Existing conditions

Energy management in Kostroma is the responsibility of the Municipal Services Department. However, primary responsibility for energy consumption lies with the various users, which have the major energy-using equipment.

RCG/Hagler, Bailly analyzed monthly data for TETS-2 during a 24-month sample period (1990-1991). Compared to our experience in carrying out similar analyses in other plants in other countries, the data seem to indicate a poor correlation between heat supply and heat demand (heating load), for monthly performance data. Our analysis indicates that heat supply is about 20% more than expected demand (as determined by ambient temperature). Further, the situation seems to be deteriorating, as indicated by the following efficiency ratios:

	Heat supply/heat demand Gcal/degree-day[10]
1990	446
1991	480

The ratio for 1991 is significantly higher than for 1990.

Recommended action

Workers at all levels and residents must be enlisted as partners for energy conservation programs to work effectively. Saving money is more interesting than saving energy. Employees realize that the future of their jobs is now directly linked to helping the factory reduce costs.
A management information and control system (M.I.C.S.) should be installed on a personal computer to provide the information necessary for energy management. This

[10] Degree-day calculation is based on an ambient temperature of 12°, and corrected for domestic hot water supply load.

system must have software designed to calculate the necessary performance ratios and to present information to management in an easily-understandable form.

Realistic energy management targets should be set, based on improvements in performance ratios. Specific projects, operational changes, and maintenance procedures should be carried out in order to achieve these targets and success of these actions should be measured and documented by the M.I.C.S.

Equipment required

A personal computer based system should be implemented. Additional metering may be required in some areas.

MICS

Personal computer (IBM compatible):
- (1) 286, VGA, 2 MB RAM, 40 MB disk
- (1) 24-pin dot matrix wide carriage printer
- (1) spreadsheet software (Lotus 1-2-3)
- total estimated cost $3,000

Spreadsheet software development:
- local contract - $1,000

Staff training:
- local contract - $1,000

Total development cost = $5,000
- USAID to provide computer

Expected results

The precise savings that can be achieved by establishing such a program are impossible to estimate accurately, but experience has shown that up to 10 percent reduction of energy costs have been attributed by industrial plants to their energy monitoring and control monitoring programs. This is based on experiences of companies in the U.S. and Europe which have highly variable specific energy consumption before implementing such systems.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
A. Optimize Operations Management

Location of project: Kostroma city

Action A.6: Organize a small library of US manufacturers contacts for supply of equipment and possible joint ventures in manufacturing of high efficiency equipment.

Existing conditions

The quantity of production in Kostroma industry is down substantially, by 50%, or more compared to recent years[11]. There is always a substantial fixed energy consumption for running a factory, especially in a cold climate. Thus the reduced production has significantly reduced energy efficiency.

Recommended action

The RCG/Hagler, Bailly team recommends that Kostroma aggressively expand its marketing efforts on behalf of industry to build commercial relationships for both raw material supply and production sales. The marketing staff should be given a substantial budget, for training and traveling. Senior staff, especially Directors and Chief Experts of industrial enterprises, must take responsibility for much of the marketing.

A study of the needs for marketing is beyond the scope of our district heating energy audit.

RCG/Hagler, Bailly will recommend to USAID that a small library of information about US industry be provided to Kostroma.

[11] The only industrial plant visited by the audit team in Kostroma indicated that production was down by 50%.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
B. Improve the Standard of Maintenance

Location of project: Kostroma - region

Action B.1: Improve heat transfer effectiveness in the system - increase return water temperatures.

Existing conditions

The temperature of the supply water is based on ambient temperature conditions, according to the standard "grafik". The grafik shows supply temperatures as follows:

For ambient temperature > 0°, supply = 70°

For ambient temperature < 0°, supply =
70° + 2.28° for every 1° ambient temperature is < 0°.

The return temperatures are also estimated by the grafik, as follows:

For ambient temperature > 0°, return = 42°

For ambient temperature < 0°, return =
42° + 0.8° for every 1° ambient temperature is < 0°.

Actual measurements in Kostroma indicate that the return temperature is approximately 25° higher than the grafik. On a typical day with an ambient temperature of -10°, the actual delta T (difference between supply and return temperature) in the system is about 18°, as compared to a design delta T of 44°. Kostroma is believed to be similar, although no data are available.

This situation indicates very poor heat transfer effectiveness. It can be remedied by cleaning, repairing, or replacing radiators, heat exchangers (hot water boilers), and other heat transfer elements.

Some Russian heating companies would like to remedy this situation by imposing fines on heat customers who return water at temperatures higher than design. The RCG/Hagler, Bailly team does <u>not</u> agree with this approach, because it could also penalize customers who take actions designed to save energy, such as reducing heating demand.

Recommended action

1) Institute a project to test delta T across various heat exchanger elements throughout the system. Establish a crew to carry out the tests, and prepare a procedure and work plan for the crew. They should collect data and complete an evaluation form on each facility tested.

2) Where low delta T is identified, take action to repair the situation. Establish a set of priorities for evaluation, such as the following:

1) heat exchangers and substations
2) institutional buildings
3) industrial enterprises
4) residential buildings

Equipment required

1) Portable thermocouple sets for the test crew. Suggest 10 sets.
2) Various repair and replacement equipment, as required.

Expected results

The RCG/Hagler, Bailly team estimates energy savings on the order of 10% per year.

Based on 1990 annual heat consumption in the Kostroma region of 4.6 million Gcal, savings would amount to 0.5 million Gcal/year.

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $6 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $50-200 per equivalent flat in Kostroma. Taking a median figure of $100 and a population of 300,000 (100,000 equivalent flats), the cost is estimated as $10 million. However, by using locally-available personnel and equipment, the cost should be much less.

The payback period for the project is:

Payback = capital cost/net annual cost savings
$10 million/$6 million = 1.7 years

The project is very attractive, with a payback period of less than two years.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
B. Improve the Standard of Maintenance

Location of project: Residential apartment block building, schools, hospitals, other institutional buildings

Action B.2: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping

Existing conditions

Residential apartment block studied as part of energy audit has 90 apartments on 5 floors. The building uses a hot water heating system with two pipe distribution down feed. The peak heat load is 0.6 Gcal/hr, and annual heat consumption is estimated as 1,180 Gcal/yr. There are no meters and no controls on the substation in the building. No weatherstripping is installed.

The Borovay 9 school has a gross area of 20,000 m^2 and 1300 students. The heating system operates 222 days per year with a peak heat demand 0.6 Gcal/hr. Annual heat consumption is 1,220 Gcal/yr. There are no meters or controls on the heat supply substation in the school. There is no weather stripping installed.

Recommended action

Install weatherstripping in windows and hallway doors.
Use AID funds to carry out demonstration project in one residential building and the school.

Equipment required

Weatherstripping tape (locally available materials were observed by the RCG/Hagler, Bailly while in Russia - closed cell foam strip with adhesive). Expected life - one heating season.

Expected results

Weatherstripping of windows/doors is estimated to save 5% of the total annual heating energy.

Residential: 5% x (1,180 Gcal/yr) = 59 Gcal/yr.
School: 5% x (1,220 Gcal/yr) = 61 Gcal/yr.

Cost/benefit analysis

Residential building:

The cost to install weatherstripping on a typical apartment building,using Russian materials, is estimated to be $10 per apartment, or $900.

The annual benefits are 59 Gcal at the point of end-use, plus 25% for distribution and heat generation losses, or 74 Gcal/yr in natural gas.

74 gcal/yr x $12/Gcal = $900/year

The payback period for the project is:

Payback = capital cost/net annual cost savings
$900/$900 = 1 year

The payback period is one heating season. Because the payback is equal to the expected lifetime of the weatherstripping, the project is not attractive, unless lower cost or longer-life materials can be obtained.

School building:

The cost to install weatherstripping on the school, using Russian materials, is estimated to be $1,000.

The annual benefits are 61 Gcal at the point of end-use, plus 25% for distribution and heat generation losses, or 76 Gcal/yr in natural gas.

76 gcal/yr x $12/Gcal = $900/year

The payback period for the project is:

Payback = capital cost/net annual cost savings
$1,000/$900 = 1.1 year

The payback period is more than one heating season. Because the payback is equal to the expected lifetime of the weatherstripping, the project is not attractive, unless lower cost or longer-life materials can be obtained.

RECOMMENDED ACTION

SHORT-TERM PROJECT - FIRST STEP PRIORITY
B. Improve the Standard of Maintenance

Location of project: Kostroma region

Action B.3: Use IR scanner on thermal systems, such as boilers and distribution piping, to detect excessive heat loss - repair insulation as indicated.

Existing conditions

Heat loss from distribution piping appears to be excessive. The RCG/Hagler, Bailly team measure a temperature drop from 85° to 77° over a length of about 1 km.

Recommended action

Improve standard of maintenance. Use IR scanner on thermal systems, such as boilers and distribution piping, to detect excessive heat loss - repair insulation or leaks as indicated.

Equipment required

Use AID funds to provide an Infrared thermal imaging device for Kostroma. The approximate cost of the system is $40,000.

Expected results

Better diagnostics and heat loss detection, together with actions to repair trouble spots, is estimated to save 1% of the total annual heating energy, or 46,000 Gcal/year.

Cost/benefit analysis

The cost of the IR scanner is estimated to be $40,000.

The annual benefits are 46,000 Gcal in natural gas.

46,000 Gcal/yr x $12/Gcal = $550,000/year

The payback period for the project is:

Payback = capital cost/net annual cost savings

$40,000/$550,000 = 0.07 year

The payback period is 0.07 times the length of the heating season. The project is very attractive, and the IR scanner will last many years.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: Kostromaenergo and KostromaOblTeplEnergo- region

Action C.1: Install Gcal metering at key points in network and develop a loss-tracking system.

Existing conditions

There are no heat meters (Gcal meters) in place in the network to determine the level of losses (heat losses and water losses) in the network.

Recommended action

Install heat meters at key points in the network. Use the information to develop tracking systems which can identify leaks and excessive heat loss.

Equipment required

Gcal meters
Management computers for record-keeping
Increased maintenance for leak repair and insulation repair

Expected results

Installing a loss metering system will help Kostromaenergo and KOTE reduce the level of heat and water losses. If the information is used to develop a more effective maintenance program, the RCG/Hagler, Bailly team estimates that losses can be reduced by 2% of total consumption.

2% x 4.6 million Gcal/yr = 92,000 Gcal/yr

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $1.1 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $5-10,000 per Gcal meter in Kostroma. Taking a median

figure of $8,000, and assuming that some 50 meters can handle the major nodes in the network, the cost of the meters is estimated as $400,000. Other costs for computers and tools could total an additional $50,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $500,000 should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$0.5 million/$1.1 million = 0.45 year

The project is attractive, with a payback of less than six months.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: KostromaOblTeplEnergo, KostromaEnergo - region

Action C.2: Install Gcal metering at all major buildings in the heat supply system.

Existing conditions

There are no heat meters (Gcal meters) in place to determine the quantity of heat consumption by buildings.

The tariff in place is based on theoretical constructs, such as floor area of apartment (sq. meters), for heating estimate; and number of occupants, for hot water estimate.

This system assumes that all people use heat and hot water in the same way. It allows no possibility for an individual consumer, or collectively as a building, to obtain a financial benefit from taking actions which would save energy.

Further, raising energy prices without giving the customer any possibility to measure or control the quantity does not seem fair.

Recommended action

1) Develop a tariff based on metered Gcal, rather than building size.
2) Install heat meters on all large buildings served by the system.
3) Require consumers to pay for their actual consumption, rather than a theoretical quantity.

Equipment required

Gcal meters (hundreds)
Management computers for billing and record-keeping

Expected results

Installing a "pay-as-you-go" energy supply system will provide the necessary incentive for customers to take action to reduce energy consumption.

In the short-term, customers will take "no-cost" actions, such as changing behavior (using less hot water, closing valves on radiators when the room gets too hot). RCG/Hagler, Bailly estimates that through these "no-cost" actions, consumers will save from 5-10% of annual heating and hot water energy. However, metering at the collective (building level) may only achieve a small part of these potential savings.

2% x 4.6 million Gcal/yr = 92,000 Gcal/yr

In the longer-term, customers will make investments, such as upgrading insulation, installing weatherstripping, and thermostatic valves. they may need financing to carry out such projects, and perhaps Kostromaenergo can assist in arranging such financing.

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $1.1 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $3-5,000 per Gcal meter in Kostroma. Taking a median figure of $4,000, and assuming that some 300 meters can handle the major buildings in the network, the cost of the meters is estimated as $1,200,000. Other costs for computers and tools could total an additional $200,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $1.4 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$1.4 million/$1.1 million = 1.3 year

The project is very attractive, with a payback of just over one year.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: Kostroma - region

Action C.3: Provide heat allocation meters in individual flats - evaporative type on all radiators and flow meters on hot water taps.

Existing conditions

Once Action C.2 is implemented, energy will still be metered in a collective sense (at the building level).

Recommended action

Optimum incentive for energy savings will result from metering at the individual consumer level.

KostromaOblTeplEnergo should install individual heat meters for all customers on principal end-use equipment, as follows:

1) Evaporative type on all radiators

2) Flow meters on hot water taps.

KostromaOblTeplEnergo should send monthly energy bills to the building administrator or resident manager. The allocation system within each building can be worked out by the building administrator or resident manager.

Equipment required

Such metering need not be very accurate, but simply sufficient to serve as an allocation tool for distribution the measured energy consumption (at the building level) among the individual consumers.

Evaporative heat meters (thousands)
Hot water flowmeters (thousands)

Expected results

Installing a "pay-as-you-go" energy supply system will provide the necessary incentive for customers to take action to reduce energy consumption.

In the short-term, customers will take "no-cost" actions, such as changing behavior (using less hot water, closing valves on radiators when the room gets too hot). RCG/Hagler, Bailly estimates that through these "no-cost" actions, consumers will save from 5-10% of annual heating and hot water energy.

5% x 4.6 million Gcal/yr = 230,000 Gcal/yr

In the longer-term, customers will make investments, such as upgrading insulation, installing weatherstripping, and thermostatic valves. They may need financing to carry out such projects, and perhaps KostromaOblTeplEnergo can assist in arranging such financing.

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $2.7 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $10 per radiator meter and $30 per hot water meter in Kostroma. Taking an average of four radiators and two hot water taps per flat, we estimate $100 per flat. Assuming that some 40,000 flats are to be metered, the cost of the meters is estimated as $4,000,000. Other costs for computers and tools could total an additional $400,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $4.4 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$4.4 million/$2.7 million = 1.6 year

The project is attractive, with a payback of less than two years.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: Kostroma - region

Action C.4: Improve controls - install thermostatic radiator valves to control temperature in heated spaces.

Existing conditions

Once Actions C.2 and C.3 are implemented, consumers will need to upgrade the level of technology in order to save energy beyond that possible through behavioral changes.

At present there is no control of space temperature in most rooms, other than opening and closing the window. In some cases, radiator valves (hand-operated diverter valves) are installed, but are no longer functional.

Recommended action

Thermostatic radiator valves (TRVs) should be installed to control the flow of water based on the temperature inside the room.

In the case of one-pipe systems, a bypass pipe must also be installed. 3-way valves are available for these applications (at a higher cost).

Equipment required

TRVs (thousands)
tools for installation, etc.

Expected results

assuming the "no-cost" benefits from Actions C.2 and C.3 are already achieved, RCG/Hagler, Bailly estimates that TRVs can achieve a further savings of 5-10% of annual heating and hot water energy.

5% x 4.6 million Gcal/yr = 230,000 Gcal/yr

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $2.7 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $40 per TRV in Kostroma. Taking an average of four radiators per flat, we estimate $160 per flat. Assuming that some 40,000 flats are to be fitted with valves, the cost of the TRVs is estimated as $6,400,000. Other costs for computers and tools could total an additional $600,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $7 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$7 million/$2.7 million = 2.6 year

The project is attractive, with a payback of less than three years.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: Kostroma - region

Action C.5: Upgrade ability to provide services - organize energy audit service firms and provide them with instruments

Existing conditions

There is no energy efficiency service industry to speak of in Kostroma region. Implementation of any project requiring equipment or technology is difficult.

Recommended action

To implement actions in energy efficiency, firms dedicated to the task will be required. These firms will need tools and training. To provide the maximum benefit to the economy, these firms should be private sector, profit-making companies. Through the incentive for profit, they will seek to implement energy efficiency in the fastest way possible.

The RCG/Hagler, Bailly team recommends that a program be established to assist private sector firms to make a market in energy efficiency in Kostroma. This program would provide the following elements:

Training for energy auditors in technical and business aspects of energy management

Competitive tendering by the City of Kostroma or by KostromaEnergo for energy management projects - providing an initial market to a few of the most successful trainees

Equipment provided to the most successful trainees

Equipment provided to the facilities participating in the energy management program

Equipment required

Energy audit diagnostic instruments for trainees

Energy saving equipment for plants

Expected results

RCG/Hagler, Bailly estimates that the private sector firms will assist with the implementation of other projects, and on their own can achieve a further savings of perhaps 1% of annual heating and hot water energy. In addition, these firms will serve as catalyst to accelerate the implementation of the other actions mentioned above.

0.5% x 4.6 million Gcal/yr = 23,000 Gcal/yr

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $270,000 per year.

RCG/Hagler, Bailly estimates that a successful program can be developed for about $300,000, including the equipment.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$300,000/$270,000 = 1.1 year

The project is very attractive, with a payback of about one year.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: KostromaEnergo

Action C.5: Upgrade awareness of energy efficiency - organize education and training programs

Existing conditions

There is little awareness of energy-saving techniques among energy users at the industrial, institutional and residential facilities. Energy prices are changing rapidly, and energy consumers need to become aware of energy efficiency techniques.

Recommended action

The RCG/Hagler, Bailly team recommends that an energy efficiency training and education program be established as part of a "demand-side management" program at KostromaEnergo. This program would provide the following elements:

Training for energy auditors in technical and business aspects of energy management

Training for plant energy managers

Integration of energy efficiency into existing engineering curricula

Preparation of public awareness handbooks, leaflets, and other materials on energy efficiency for institutional and residential customers

Organization of seminars and exhibitions on energy efficiency

Equipment required

Energy audit diagnostic instruments for trainees

Audio/visual equipment

Expected results

RCG/Hagler, Bailly estimates that over time such a program can be credited with achieving a further savings of perhaps 1% of annual heating and hot water energy. The demand-side management program should also focus on electric energy use.

1% x 4.6 million Gcal/yr = 46,000 Gcal/yr

Cost/benefit analysis

Based on an economic value of natural gas of $12 per Gcal, the economic benefit of the project is estimated as $550,000 per year.

RCG/Hagler, Bailly estimates that a successful program can be developed for about $500,000, or less, including the equipment.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$500,000/$550,000 = 0.9 year

The project is very attractive, with a payback of less than one year.

RECOMMENDED ACTION

MEDIUM-TERM PROJECT - SECOND STEP PRIORITY
C. Convert Heat Supply to a Market Economy

Location of project: Kostroma - region

Action C.7: Convert factories to produce equipment needed to improve energy efficiency

Existing conditions

There is little availability of energy-saving equipment in Russia. There are factories in Kostroma which have manufacturing capability and need to begin producing consumer products.

Recommended action

The RCG/Hagler, Bailly team recommends that an investment program be organized to introduce U.S. energy equipment manufacturers to the facilities and capabilities of industrial enterprises in Kostroma.

Following on this program, the RCG/Hagler, Bailly team recommends that factories begin pursuing manufacture of the following products, with or without U.S. assistance:

- thermostatic radiator valves
- Gcal meters
- hot water flowmeters
- weatherstripping for windows and doors
- insulation for building exterior walls

RECOMMENDED FOR FURTHER CONSIDERATION

LONG-TERM PROJECT - THIRD STEP PRIORITY
D. Improve Efficiency of Systems

Location of project: Kostroma - region

Action D.1: Install distributed heating systems of high efficiency where applicable

Existing conditions

In large factory buildings, such as the workshops at rabochiy Metallist, convective heating systems are in use.

These heating systems have a very low thermal efficiency at the point of end use. Convective systems have lower heat transfer effectiveness than radiant systems, for large factory buildings. In the convective systems, much heat is lost through infiltration or rises to the ceiling before it can provide the needed effect for heating the workers. Radiant heat, on the other hand, transfers directly to the workers and the surfaces of factory walls, floors, and equipment. This gives an immediate benefit to the workers, and also provides a better effect, through the heat storage capacity of the equipment.

Recommended action

The RCG/Hagler, Bailly team recommends that gas-fired or electric element radiant heaters be installed in the Rabochiy Metallist workshops, first on a trial basis.

Expected results

The RCG/Hagler, Bailly team estimates that radiant heat will be able to supply needed heating requirements in the Rabochiy Metallist workshop for 30% less energy than convective heating, on an annual basis.

Installation of this equipment in factories heated by TETS will free up heating capacity from the TETS to export more heat, and thereby supply the city. This could be a more economic cost-effective solution than expanding the TETS.

RECOMMENDED FOR FURTHER CONSIDERATION

LONG-TERM PROJECT - THIRD STEP PRIORITY
D. Improve Efficiency of Systems

Location of project: Kostroma - region

Action D.2: Reduce heat loads by upgrading insulation

Existing conditions

In factory buildings, institutional buildings, and residential buildings, the standard of wall and roof insulation is insufficient to cope with heating requirements in the severe Russian winter, given the new economics of world market energy prices.

The installation of insulation on a retrofit basis has been carried out by many enterprises, and home-owners, in the U.S. and Western Europe.

Recommended action

The RCG/Hagler, Bailly team recommends that retrofit wall insulation be installed in one residential apartment building, first on a trial basis.

Expected results

The RCG/Hagler, Bailly team estimates that wall insulation will be able to save 10% of heating energy, on an annual basis.

Cost/benefit analysis

Depending on the availability of locally-manufactured insulation, the cost of installation and need for surface stucco or other treatments, and the insulating effect of the existing structure already in place, the RCG/Hagler, Bailly team estimates that the payback period for wall insulation will be about 5-10 years.

Additional detailed data is provided in Appendix 5.

RECOMMENDED FOR FURTHER CONSIDERATION

LONG-TERM PROJECT - THIRD STEP PRIORITY
D. Improve Efficiency of Systems

Location of project: KostromaOblTeplEnergo - region

Action D.3 Improve local control in individual heat substations.

Existing conditions

The temperature of supply water to buildings is determined by the heat sources (TETS or boilerhouses). There are ratio adjustments possible in the substations near the buildings, but these are manually set once at the start of the heating season.

The installation of automatic controls at the substations, based on sensing of local outside temperature, and motorized control valves, would permit more accurate control of supply temperature to individual buildings or areas.

Recommended action

The RCG/Hagler, Bailly team recommends that a retrofit automatic control system be installed in one substation, first on a trial basis.

Expected results

The RCG/Hagler, Bailly team estimates that automation at the substation could save up to 5% of heating energy, on an annual basis.

Cost/benefit analysis

Depending on the availability of locally-manufactured heat exchangers, valves and sensors, the cost of installation and need for security systems to protect the instruments, the RCG/Hagler, Bailly team estimates that the payback period for substation automation will be about 1-3 years.

RECOMMENDED FOR FURTHER CONSIDERATION

LONG-TERM PROJECT - THIRD STEP PRIORITY
D. Improve Efficiency of Systems

Location of project: KostromaEnergo and KOTE - region

Action D.4 Improve distribution systems by using pre-insulated piping with leak-detection systems on new installations and improving drainage of existing installations

Existing conditions

Corrosion is a problem in system piping, and no active leak detection systems are in use.

Drainage is also a problem, and many underground pipes are wet. This standing water causes corrosion, and also increases heat loss.

Recommended action

The RCG/Hagler, Bailly team recommends that:

- drainage systems be improved for existing piping
- new piping be installed using modern pre-insulated sections with integral leak detection systems

Expected results

The RCG/Hagler, Bailly team estimates that improving drainage in distribution could save up to 2% of heating energy, on an annual basis.

The RCG/Hagler, Bailly team estimates that, over the long run, improving the distribution system by converting to modern piping with insulation and leak detection could save a further 5% of heating energy, on an annual basis.

ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 1
BUSINESS CARDS OF CONTACTS IN RUSSIA

Kostroma Town Executive Commitee
of Soviet of People's Deputies
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Igor Vitalyevich
Head

city energy Manager

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KOSTROMAENERGO

ASSOCIATION «KOSTROMAOBLTEPLOENERGO»

Dmitriy A. ERSHOV

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MINISTRY OF POWER AND ELECTROFICATION OF THE USSR

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Kostromskay reg.

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6-16-78

Telex 129162 "Река"

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The Chairman

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928.01.16.

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Dr. Alexander A. ZHITNIKOV

Deputy Chairman of the Commission for International Humanitarian and Technical Assistance of the Government of Russian Federation
Deputy Minister of the Social Protection

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KOSTROMAENERGO

BEST AVAILABLE COPY

Victor V. NETCHAEV

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People's Deputee of the RSFSR
Victor Alexandrovich GULYASHKO
Member of the Committee for Foreign Affairs and International Economic Relations

House of the RSFSR Soviets
Moscow, Krasnopresnenskaya nab., 2
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292-61-01
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~~VICTOR~~

VIKTOR V. ~~BACHIR~~
BACHIRIKOV
(ВИКТОР В. БАЧИРИКОВ)

DEPUTY HEAD of ADMINISTRATION
of KOSTROMA OBLAST
(КОСТРОМА)

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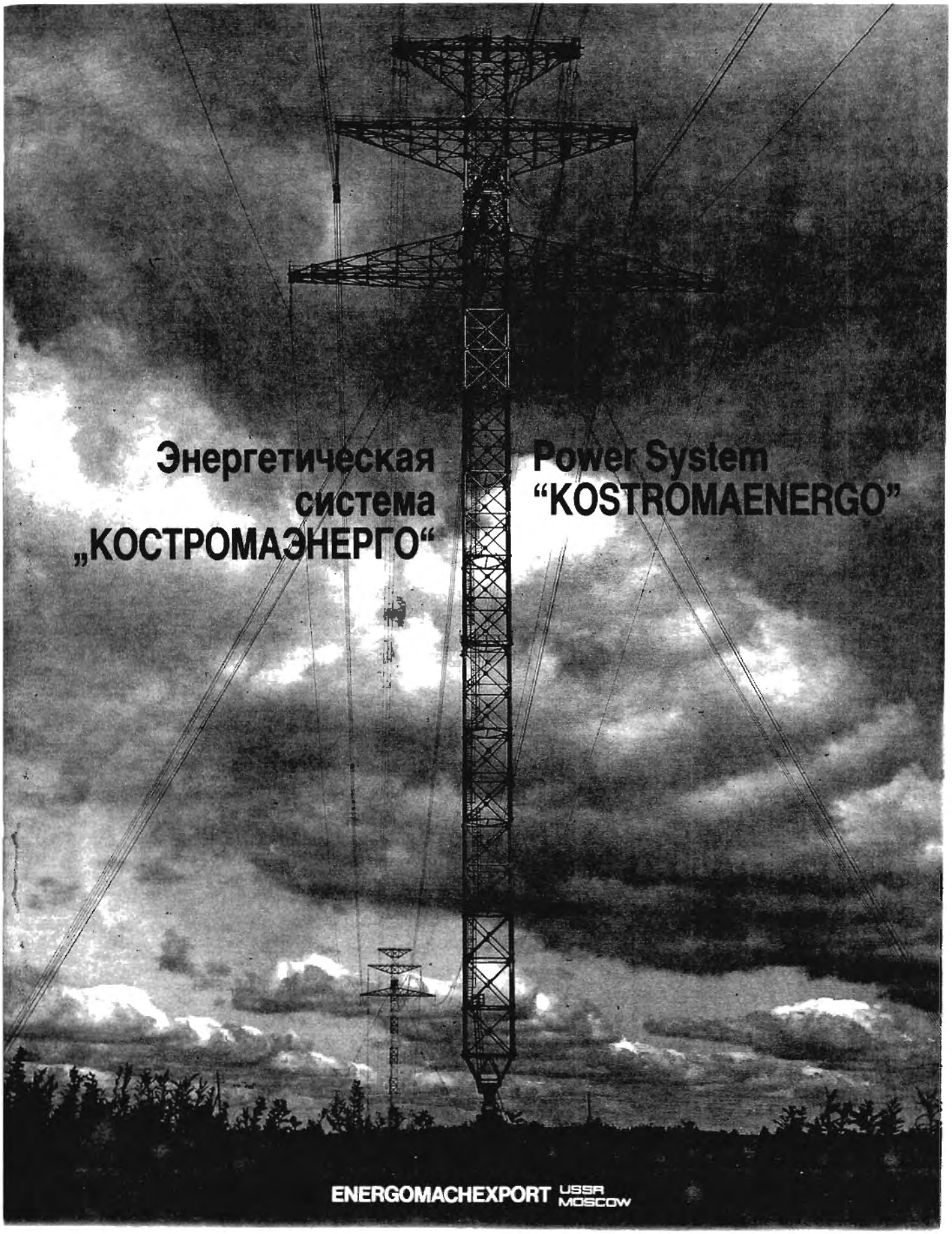
7-33-95

VIKTOR VALENTINOVICH BACHIRIKOV

ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

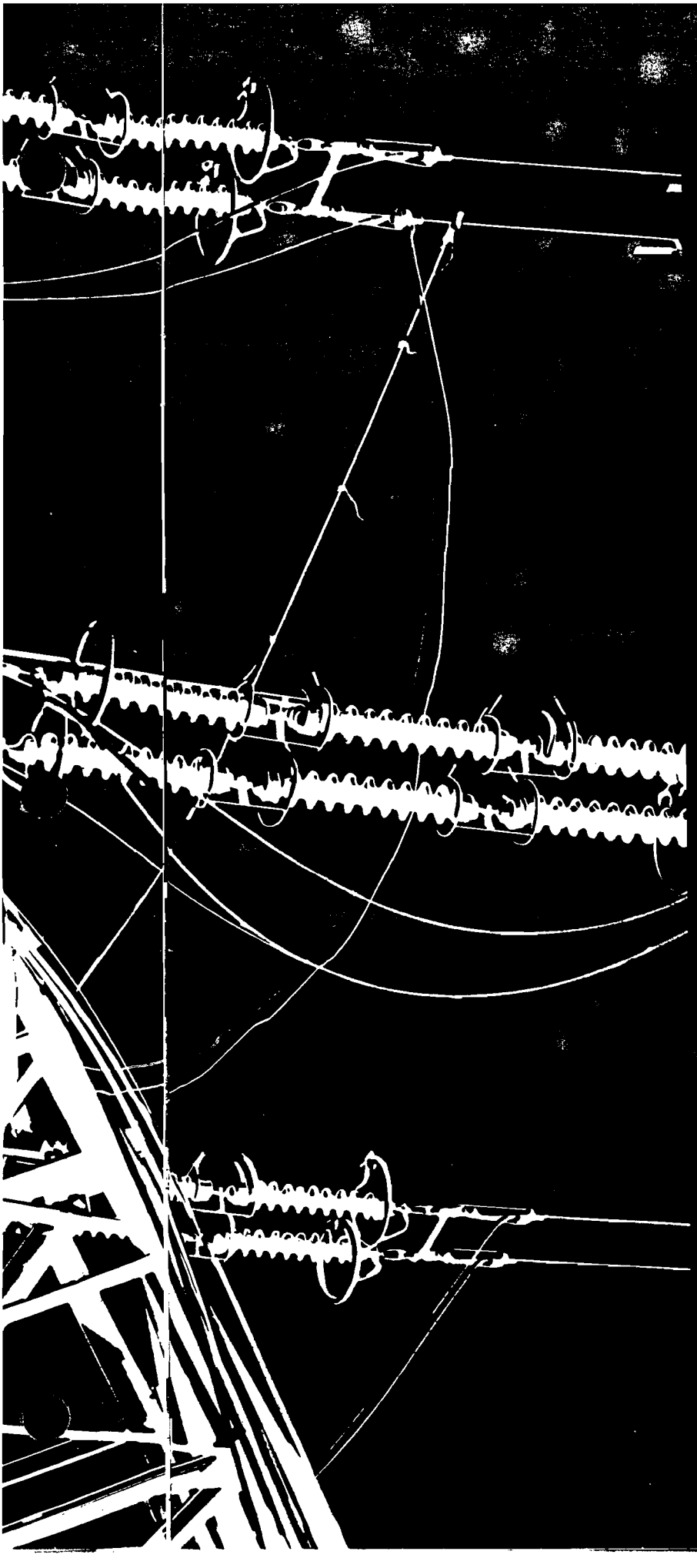
APPENDIX 2
BROCHURE OF KOSTROMAENERGO
ELECTRIC POWER AND HEAT COMPANY



Энергетическая система „КОСТРОМАЭНЕРГО“

Power System "KOSTROMAENERGO"

ENERGOMACHEXPORT USSR MOSCOW



В/О „Энергомашэкспорт" — один из крупнейших экспортеров советского оборудования для гидравлических, тепловых и дизельных электростанций, сварочного, электротермического и другого промышленного электрооборудования, электроэнергии, железнодорожного подвижного состава, путевого оборудования и инструментов, городского электрического транспорта и запасных частей.

Объединение импортирует троллейбусы, электросварочное и газорезательное оборудование, а также комплектующее оборудование для всех видов экспортируемой продукции и для строящихся объектов в других странах, а также запасные части для этого оборудования.

По желанию заказчика Объединение осуществляет шеф-монтаж, организует техническое обслуживание поставляемого оборудования, продает лицензии, „ноу-хау" и техническую документацию в тех случаях, когда они являются составной частью экспортных операций, а также оказывает ряд услуг внешнеторгового характера, связанных с экспортом товаров.

По вопросам поставки оборудования, входящего в экспортную программу В/О „Энергомашэкспорт", можно обращаться непосредственно к экспортеру, а также в советское торговое представительство или к фирме-агенту В/О „Энергомашэкспорт" в соответствующей стране.

Наш адрес:
В/О „Энергомашэкспорт", СССР,
127486, Москва, Дегунинская ул., 1/4
Телекс: 411926, 411965
Телефон: 487-31-87, 487-31-82

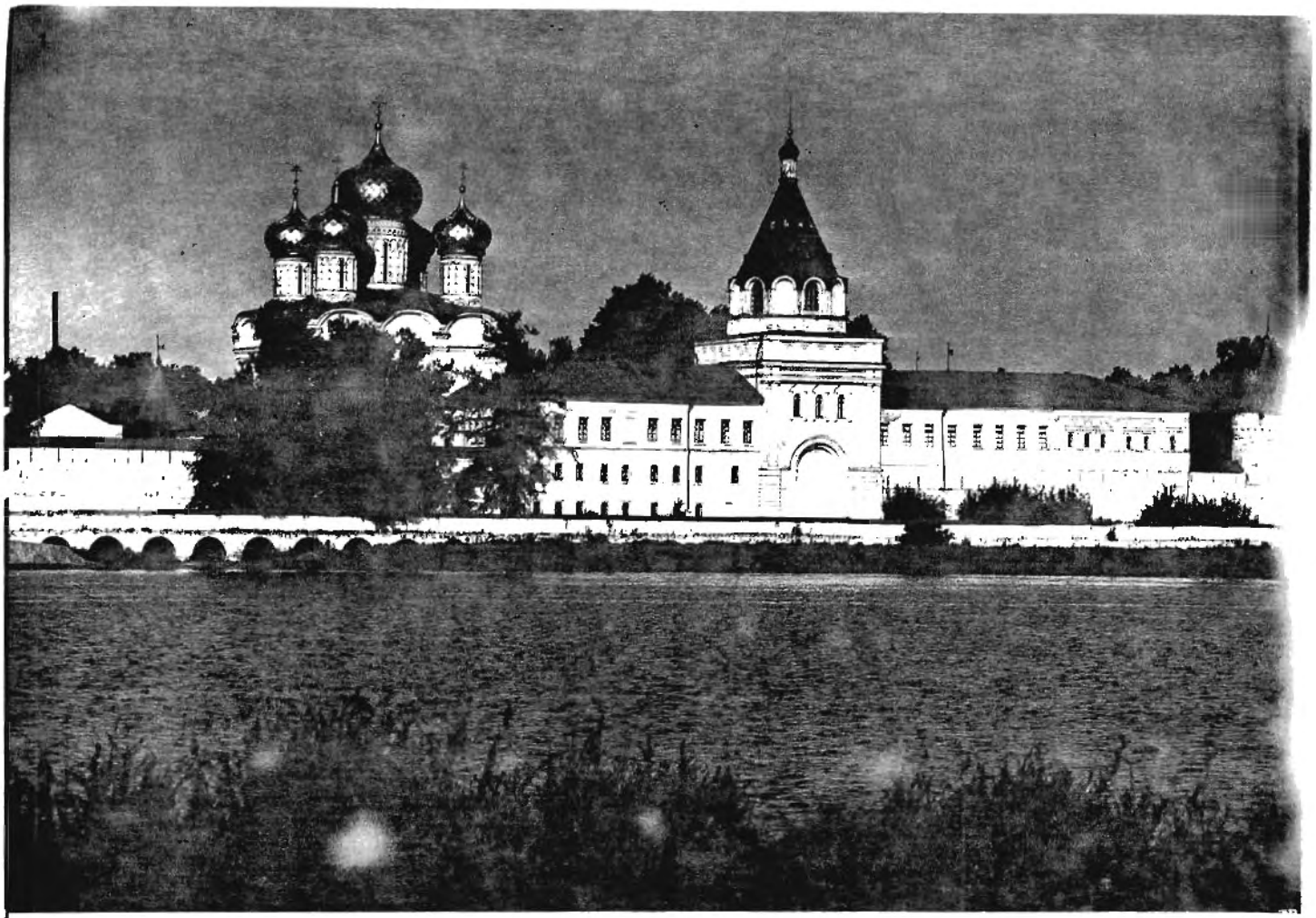
V/O "Energomachexport" is one of the largest exporters of Soviet-made equipment for hydroelectric, thermal, and diesel-electric power stations, welding, electrothermal, and other industrial electrical equipment, electrical energy, rolling stock, railway equipment and tools, electrified urban transport, and spare parts.

"Energomachexport" imports trolleybuses, electric welding and gas cutting equipment, as well as associated equipment for all kinds of exported products and projects under construction in other countries, and also relevant spare parts.

At Customer's request, V/O "Energomachexport" provides erection supervision, organizes maintenance services, sells licences, know-how and technical documentation when they come as an integral part of the export operation. V/O "Energomachexport" also renders a great variety of services related to the export of goods.

Please, send all inquiries concerned with the delivery of the equipment covered by the Export Programme of V/O "Energomachexport" directly to the Exporter, or to the Soviet trade representative or the firm-agent of V/O "Energomachexport" in your country.

Our address:
V/O "Energomachexport"
1, korpus 4, Deguninskaya ul., Moscow 127486, USSR
Telex: 411926, 411965
Telephone: 487-31-87, 487-31-82



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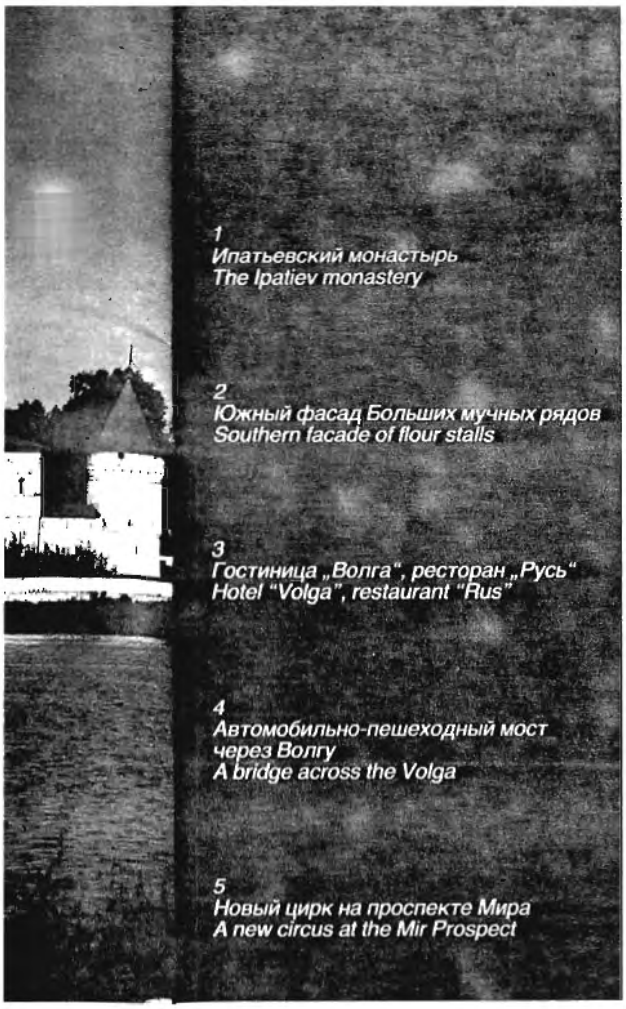


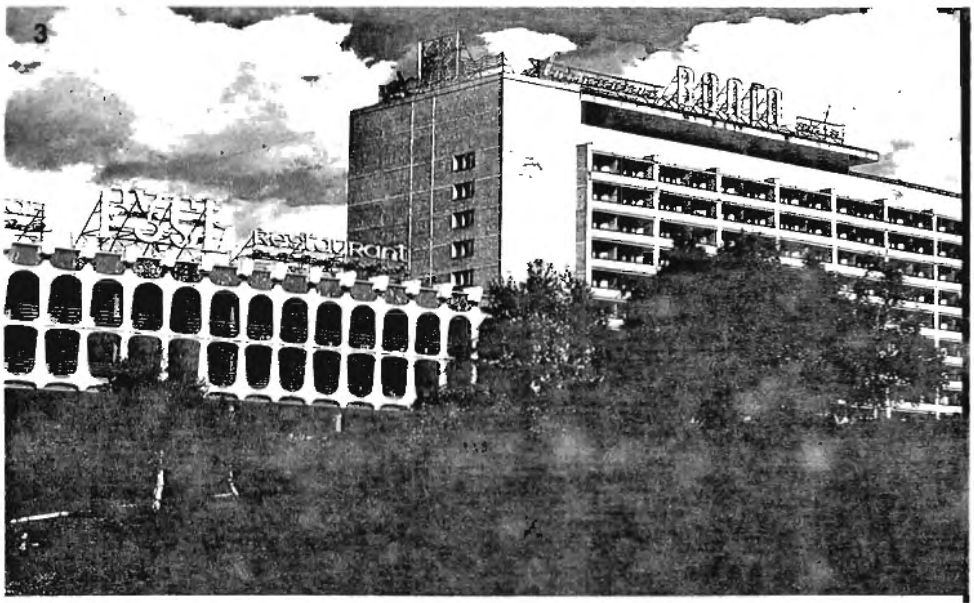
1
Ипатьевский монастырь
The Ipatiev monastery

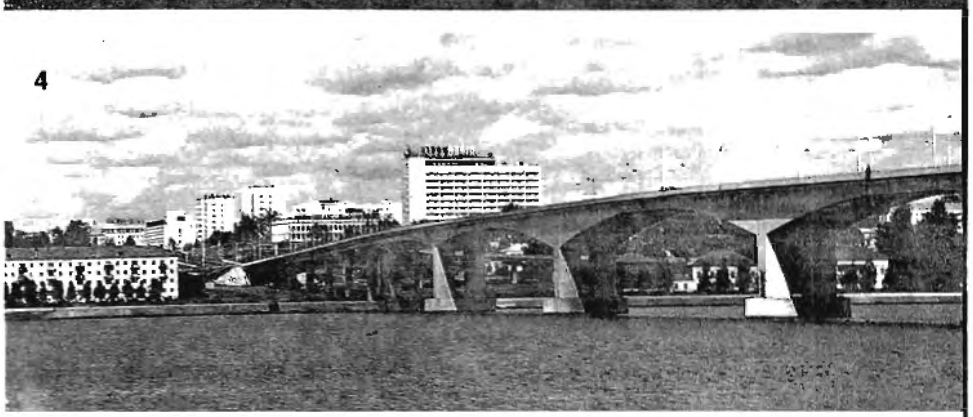
2
Южный фасад Больших мучных рядов
Southern facade of flour stalls

3
Гостиница „Волга", ресторан „Русь"
Hotel "Volga", restaurant "Rus"

4
Автомобильно-пешеходный мост через Волгу
A bridge across the Volga

5
Новый цирк на проспекте Мира
A new circus at the Mir Prospect





Кострома — древний русский город на берегах великой реки Волги. Он входит в туристский маршрут „Золотое кольцо России". Костромская область расположена на северо-востоке центральной части европейской территории СССР.

Kostroma is an ancient Russian city standing on the banks of the Great Volga River. Kostroma is included in the tourist tour called "Golden Ring of Russia". The Kostroma region is situated in the north-eastern part of the European territory of the USSR.

Территория области составляет более 60 тыс.км², население 804 тыс.чел., из которых 37 % проживает на селе. В области одиннадцать городов и восемнадцать рабочих поселков городского типа.

Интересна многовековая история Костромской области, тесно связанная с историей образования и развития Русского государства. В Костроме сохранились прекрасные памятники архитектуры, уникальные образцы народного искусства. Здесь жили и работали выдающиеся деятели отечественной культуры.

Основатель города — князь Юрий Долгорукий, поэтому Кострому называют кровной сестрой Москвы.

В 1977 г. Кострома отметила свое 825-летие и была награждена орденом Октябрьской Революции.

Герб Костромы — летящая по волнам ладья.

В XV–XVI вв. Кострома становится крупным торговым городом.

По всей Руси славились изделия костромских ремесленников — строителей, кожевников, иконописцев, кузнецов, ткачей, ювелиров.

Зодчие Костромы строили великолепные здания. Во всей красе дошел до нас архитектурный ансамбль Ипатьевского монастыря, который был основан в конце XIII в.

The Kostroma region occupies an area of over 60,000 sq.km, its population comes to 804,000. Out of this number, 37 per cent live in rural areas. The region has eleven towns and eighteen townships.

The century-old history of Kostroma is of great interest because it is closely associated with the formation and development of the Russian state. Fascinating architectural monuments and unique pieces of craftsmenship have been preserved in Kostroma. Prominent figures in the field of National culture have lived and worked here.

The city was founded by prince Dolgoruky, therefore Kostroma is called a sister of Moscow. In 1977 Kostroma celebrated its 825th anniversary and the city was awarded the Order of October Revolution.

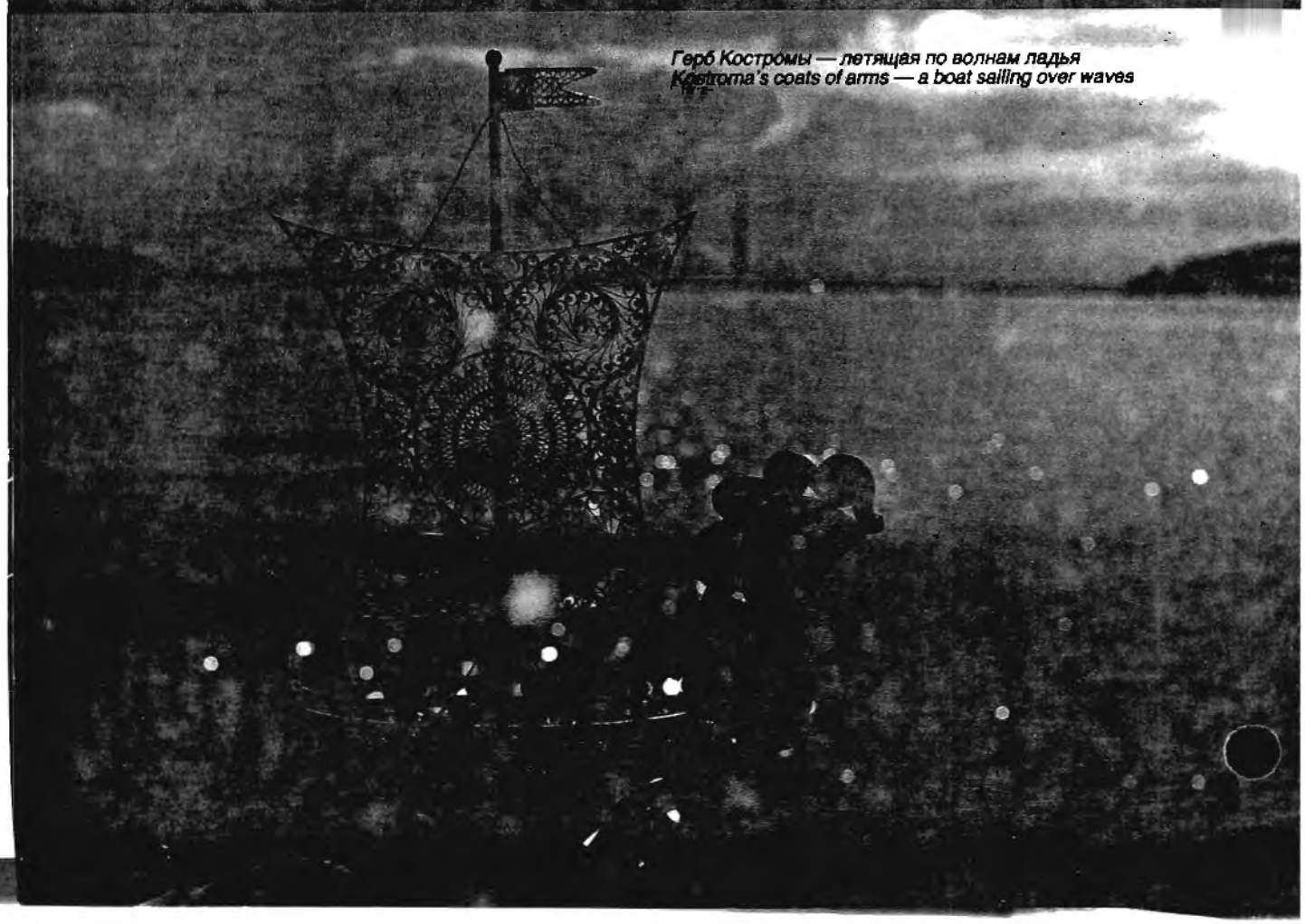
The Kostroma's coats of arms consist of a boat flying across waves.

In XV–XVI centuries Kostroma grew into a large market town.

Throughout the Russian state, the products of Kostroma artisans, such as builders, tanners, iconpainters, blacksmithes, weavers, jewellers, enjoyed high reputation.

Architects of Kostroma erected magnificent buildings.

The architectural ensemble of Ipatiev monastery founded late in XIII century has reached us in full splendour.



Герб Костромы — летящая по волнам ладья
Kostroma's coats of arms — a boat sailing over waves

За успехи, достигнутые в хозяйственном и культурном строительстве, область награждена орденом Ленина, а город Кострома — орденом Октябрьской Революции.

The region has been awarded the Order of Lenin for accomplishments in the field of economy and culture. The city of Kostroma for the same achievement has been awarded the Order of October Revolution.

Бережно храня свое прошлое, Кострома живет в современном ритме крупного промышленного центра.

На Костромской земле широко развита лесодобывающая промышленность и деревообрабатывающее производство, здесь издавна и повсеместно развивалось ткачество, способствовавшее зарождению текстильной промышленности, самые различные стройки страны обеспечиваются экскаваторами с завода „Рабочий металлист".

Великолепные ювелирные изделия костромских умельцев получали самую высокую оценку на международных выставках в Токио и Монреале.

Сельскохозяйственное производство области имеет многоотраслевой профиль. Основу его составляют зерноводство и молочное животноводство на базе костромской породы крупного рогатого скота. Некоторые районы специализируются на льноводстве. Издавна Кострома считается одним из центров русского льна, столицей непревзойденного льняного ткачества. Изделия костромских льноводов славятся не только в Советском Союзе, но и далеко за его пределами. Широко в области распространено птицеводство.

...Есть в Кремлевском кабинете Владимира Ильича Ленина карта страны, на которой кружком отмечено название костромской деревеньки Шунги. Чем она заинтересовала вождя революции?

Дело в том, что в 1920 г. крестьяне Шунгенской волости начали строить первую в стране кооперативную электростанцию мощностью 300 кВт.

А теперь Кострома снабжает электроэнергией не только свою, но и соседние области: в последние годы на берегах Волги выросли корпуса мощнейшей тепловой электростанции нашей страны — Костромской ГРЭС. Здесь впервые в практике отечественного энергостроения установлен и освоен энергоблок мощностью 1200 МВт! Турбоагрегат является самым мощным в Советском Союзе, а в одновальном исполнении — самый мощный в мире.

Preserving the relics of its past, Kostroma lives in the modern tempo of a large industrial center.

Timber felling and wood processing industries are widely developed at the Kostroma land. Here since olden times and in many places weaving has been one of the trades which helped to establish the textile industry. Many construction sites of the USSR are supplied with power shovels manufactured by the "Rabochy Metallist" factory.

Exquisite jewelry of Kostroma craftsmen won a high appraisal at international exhibitions in Tokyo and Montreal.

Agriculture is diversified. Its primary activities are grain growing and dairy farming based on the black and white cattle. Some areas are specialized in flax growing. Since olden times Kostroma has been regarded as one of flax-growing centers in Russia, the capital of unsurpassed flax weaving. The flax products from Kostroma are well known in this country and abroad. Poultry farming is also widely spread in this region.

In the Kremlin office of Vladimir Il'yich Lenin there is a map on which Shungi village of the Kostroma region is marked with a circuit. Why did this village draw the attention of the Revolution Leader? In 1920 peasants of the Shungi volost started the construction of the first cooperative power plant of 300 kW capacity.

Now Kostroma supplies electrical energy not only for its own regional needs but also exports electricity to the neighbouring regions. In recent years the largest thermal power plant has been built on the Volga River — the Kostroma steam central power station. Here the 1200 MW unit has been erected and put into service for the first time in the Soviet practice.

The turbine-generator set is the largest installation in the USSR and the largest tandem turbine-generator in the world.

Энергетика области

После XXII съезда КПСС за годы восьмой и девятой пятилеток в Костроме построены ГРЭС мощностью 2,4 млн.кВт (две очереди) и ТЭЦ-2. Костромская область с момента образования в течение почти тридцати лет являлась энергопотребляющей, но с 1969 г. стала поставлять электроэнергию в Ярославскую, Ивановскую, Владимирскую, Московскую, Вологодскую и Горьковскую области. В последующие годы на Костромской ГРЭС был построен и в 1983 г. освоен в опытно-промышленной эксплуатации экспериментальный энергоблок мощностью 1200 МВт (третья очередь станции). Производство электроэнергии за двадцать с небольшим лет (1960–1983 гг.) с 133,6 млн. возросло до 20,4 млрд. кВт·ч, то есть в 152 раза. Энергосистема „Костромаэнерго" входит в ОЭС Центра страны и межсистемными линиями электропередачи связана с пятью другими энергосистемами. В 1983 г. им было отпущено 83 % выработанной электроэнергии.

Коэффициент использования установленной мощности достиг в 1983 г. 61 %. Удельный расход условного топлива на отпущенный киловатт-ч электроэнергии в 1970 г. составил 347,2 г, а в 19[illegible] г. — 317 г с учетом экспериментального энергоблока ГРЭС.

Началом электрификации города Костромы и его промышленных предприятий, перед которыми первый пятилетний план открывал широкие перспективы развития, следует считать 1927–1930 гг., когда была построена и введена в эксплуатацию первая очередь теплоэлектроцентрали с турбиной фирмы „Шкода" мощностью 5,5 тыс. кВт и тремя котлами Ленинградского металлического завода производительностью 20 т пара в час.

В феврале 1945 г. была организована областная контора „Сельэнерго", на которую возлагалась электрификация сельского хозяйства и строительство гидроэлектростанций на малых реках области. В 1945–1956 гг. было построено 46 ГЭС общей мощностью 1,8 тыс. кВт и шесть маломощных локомобильных электростанций на местном топливе.

Power Industry of the Region

Since the 22nd Congress of the CPSU, during the 8th and 9th Five-Year Plan periods, the thermal power plant of 2400 MW (two stages) and the ТЭЦ-2 heat-electric power plant have been built in Kostroma. Over 30 years from the time of its foundation the Kostroma region used to import electrical energy, but since 1969 it has been exporting electricity to Yaroslavl, Vologda, Ivanovo, Vladimir, Moscow and Gorky regions. During the next years, a 1200 MW experimental unit (3d stage of the station) was built at the Kostroma steam central station and put into trial operation in 1983.

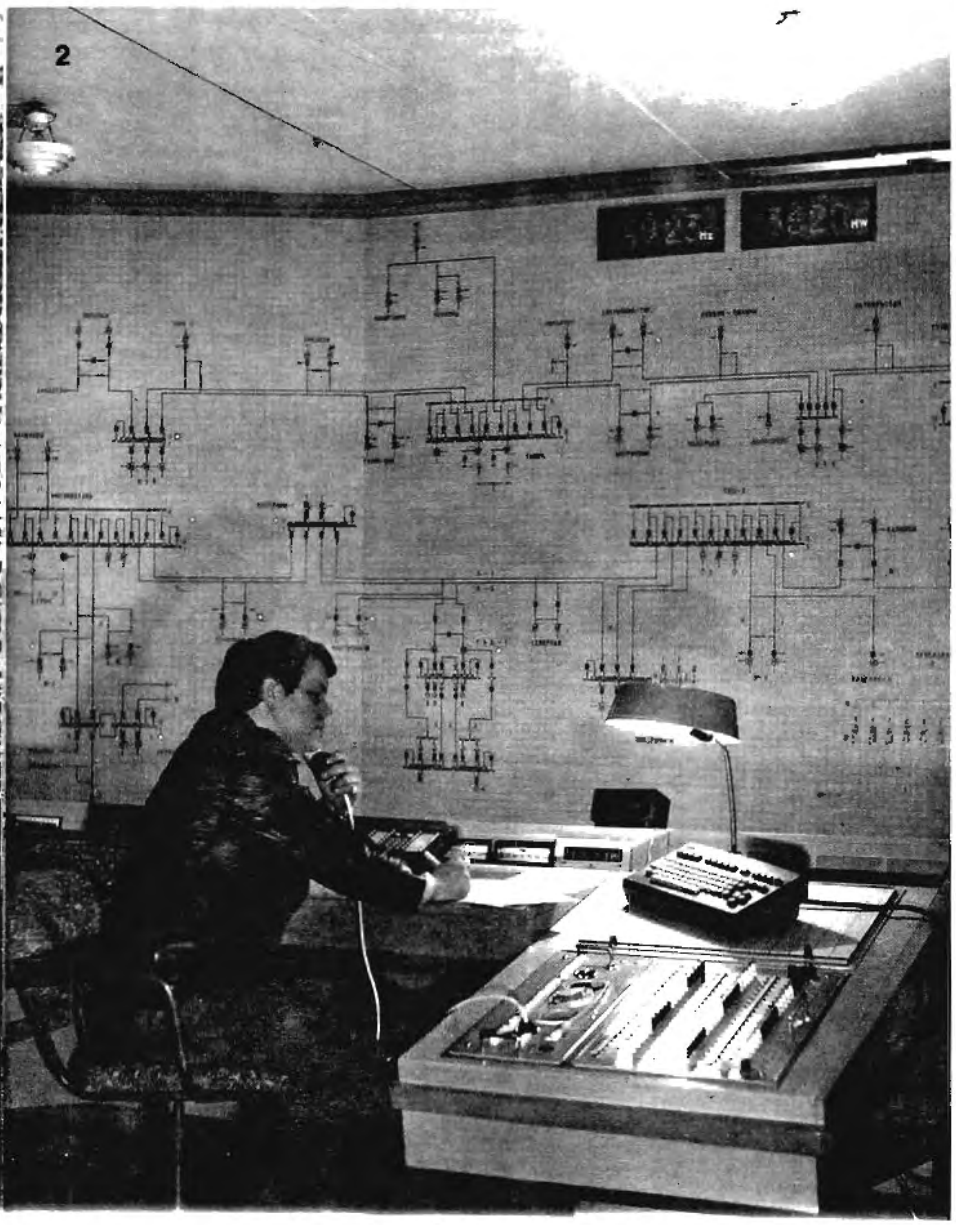
Within some twenty years (1960–1983) electrical energy production increased from $133.6 \cdot 10^6$ to $20.4 \cdot 10^9$ kWh, i.e. 152 times. The "Kostromaenergo" interconnected power system is integrated into the Interconnected Power system of the Center of the Country. The system is also linked to five other power systems through intersystem transmission lines. In 1983, 83 per cent of generated energy was exported to these systems.

In 1983 the plant's installed capacity utilization factor reached 61%.

In 1970, specific consumption of ideal fuel per generated kWh was 347.2 g, in 1983 it came down to 317 g with due regard for the experimental unit.

The years of 1927–1930, when the first stage of the combined heat and plant with a 5500 kW turbine of the Škoda firm and three boilers of 20 t/h steaming capacity from the Leningrad Metal Works, was built and commissioned, should be regarded as the beginning of electrification of Kostroma and its enterprises.

In February, 1945, a regional office "Selenergo" was set up to provide electric power supply to the agricultural sector and to build hydroelectric power plants on small stream flows. During the period of 1945–1956, 46 hydroelectric power plants with an aggregate capacity of 1,800 kW and six small locomobile-type plants firing local fuels were built.



1
Здание районного энергетического управления „Костромаэнерго"
Headoffice of regional power authority "Kostromaenergo"

2
На Центральном диспетчерском пункте „Костромаэнерго"
Regional load dispatching offise "Kostromaenergo"

3
Управляющий „Костромаэнерго" А.А Воронов
A.A. Voronov, manager of

В 1961 г. было создано районное энергетическое управление „Костромаэнерго", на которое возложили дальнейшее развитие энергетики в области. Строительство Костромской ГРЭС началось в 1963 г., в июне 1969 г. вступил в строй действующих первый, а через полгода — второй энергоблок мощностью по 300 МВт. С 1973 г. на Костромской ГРЭС действуют восемь энергоблоков и достигнута мощность 2400 МВт.

В 1974 г. введена в эксплуатацию Костромская ТЭЦ-2.

На этих электростанциях, особенно на ГРЭС, установлено отечественное оборудование высокого давления, использованы блочные схемы компоновки крупногабаритного оборудования, произведены значительные изменения в проектах его установки, позволившие существенно улучшить надежность, экономичность станций и условия труда эксплуатационного персонала. Качественно изменилось и теплоснабжение городов, особенно Костромы, где сосредоточено около трети населения области. Коммунальным службам и промышленным предприятиям в 1983 г. отпущено электростанциями тепловой энергии более 3 млн. Гкал — за 20 лет отпуск тепла возрос в 10 раз, протяженность магистральных тепловых сетей увеличилась с 8 до 73 км.

In 1961 the regional power department "Kostromaenergo" was set up to further develop the power industry of the region. Construction of the Kostroma steam central power station was started in 1963. In June, 1969 the first power unit went into service, the second unit of 300 MW capacity came on line half a year later. Since 1973 eight units have been put in service at the Kostroma steam central power station and its generating capacity has reached 2400 MW. In 1974 the TЭЦ-2 Kostroma heat-electric power plant was commissioned.

These stations, and especially the steam central power station, are fitted out with the Soviet-made high-pressure equipment, the large-size equipment was arranged following the unit concept, many modifications were introduced in the installation of the equipment to upgrade its reliability, cost-effectiveness of the station, conditions of work for the operating personnel. There have been drastic changes in the district heating system of the urban areas, especially that of Kostroma which accounts for the third of the region population.

In 1983 $3 \cdot 10^6$ Gcal of heat were supplied by the stations to the public services and various industries.

Over 20 years, the heat supply has increased as much as 10 times, the length of heat supply networks has grown from 8 to 73 km.

Основные электростанции и другие подразделения энергосистемы

Main Electric Stations and Other Divisions of the Power System

Костромская ТЭЦ-1

Со времени пуска в 1930 г. станция неоднократно реконструировалась и расширялась. Особенно большие работы проводились в 60–70 гг. В результате за последние 20 лет удельная численность персонала сократилась в три раза, валовая продукция возросла в 2,4 раза, удельный расход условного топлива сократился с 581,2 до 219,5 г/кВт·ч.

В настоящее время мощность ТЭЦ — 42 МВт. На станции установлены семь паровых котлов и три водогрейных.

Топливом для энергетических котлов служит фрезерный торф, для водогрейных — газ и мазут.

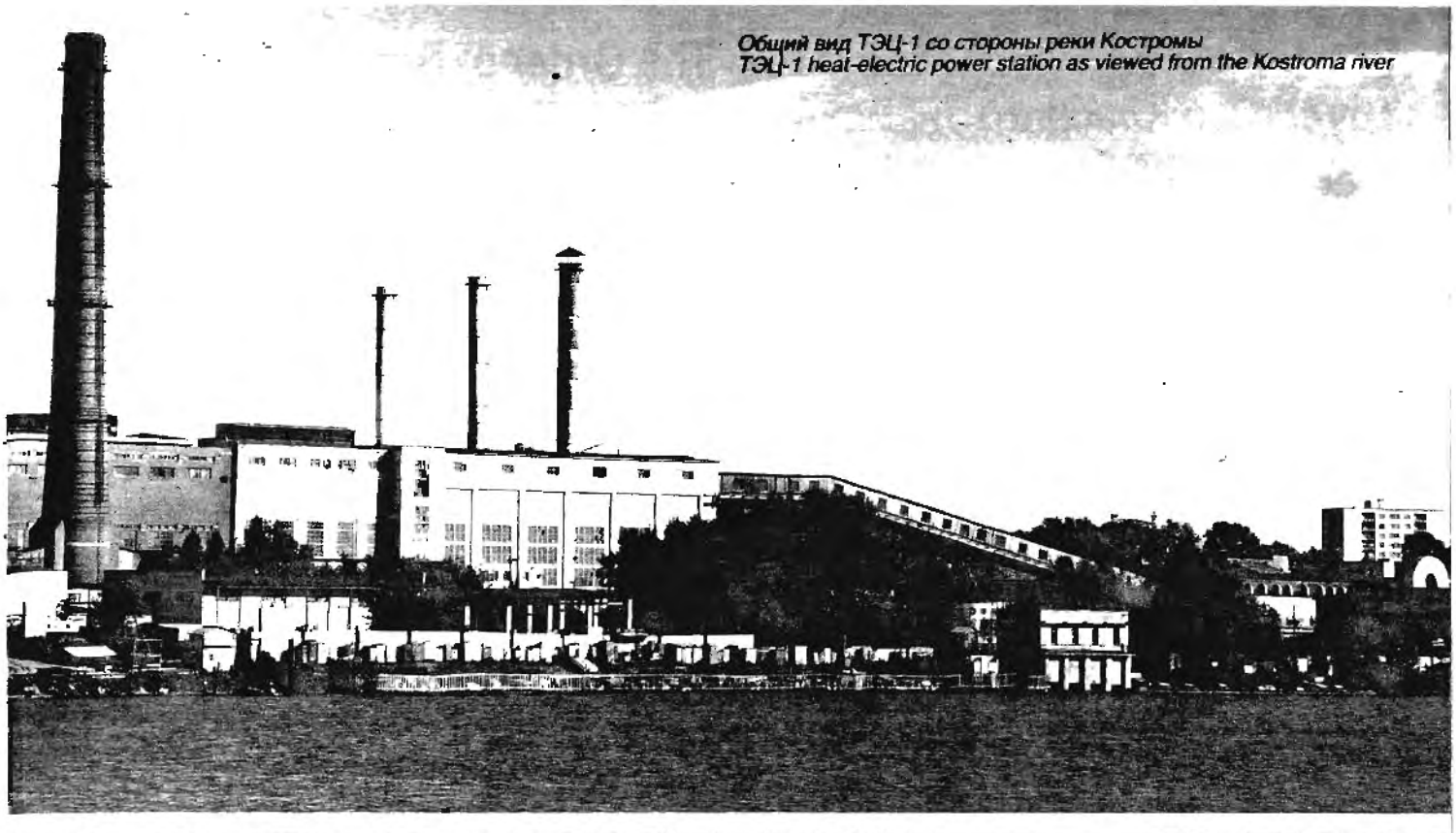
The ТЭЦ-1 Kostroma station

Since commissioning in 1930, the station has been repeatedly updated and expanded. Much effort was spent on these activities between sixties and seventies. As a result, over the last 20 years the number of personnel has reduced to one third, the gross product has increased as much as 2.4 times, while the specific consumption of ideal fuel has dropped from 581.2 to 219.5 g per kWh.

At present the station's capacity is 42 MW. The station houses seven steam generators and three water heating boilers.

The steam generators fire milled peat, while water heating boilers operate on gas and fuel oil.

Машинный зал ТЭЦ-1



Общий вид ТЭЦ-1 со стороны реки Костромы
ТЭЦ-1 heat-electric power station as viewed from the Kostroma river

Ордена Трудового Красного Знамени Костромская ГРЭС

Установленная мощность — 3600 МВт. Здесь работают четыре блока по 300 МВт с двухкорпусными котлами по 950 т/ч, четыре блока по 300 МВт с однокорпусными котлами по 950 т/ч и блок мощностью 1200 МВт с одновальной турбиной и однокорпусным котлом производительностью 3950 т/ч.

Топливом для электростанции служат мазут и газ.

Одно из важнейших направлений улучшения технико-экономических показателей в электроэнергетике — укрупнение единичных мощностей электростанций и агрегатов.

Яркий пример достижений советской электроэнергетики в этой области — Костромская ГРЭС, которая была пионером в освоении энергоблоков мощностью 300 МВт и головного уникального энергоблока с одновальной турбиной мощностью 1200 МВт.

Электростанция входит в энергетическую систему „Костромаэнерго" и через нее — в объединенную энергетическую систему центра СССР.

Строительство электростанции осуществлялось в три очереди. На первой очереди установлены четыре дубль-блока мощностью по 300 МВт с двухкорпусными газомазутными котлами паропроизводительностью 950 т/ч; на второй очереди — четыре моноблока по 300 МВт с однокорпусными газомазутными котлами паропроизводительностью 950 т/ч. В составе всех энергоблоков работают паровые турбины мощностью по 300 МВт на параметры 235 МПа (240 кгс/см^2), 540/540 °С.

The Order of Red Banner of Labour Kostroma Steam Central Power Station

The installed capacity is 3600 MW. The station has four 300 MW units with two-furnace boilers of 950 t/h steam capacity, four 300 MW units with single-furnace boilers of the same steam capacity and one 1200 MW unit with a tandem turbine-generator and a single-furnace boiler of 3950 t/h capacity.

The station fires fuel oil and gas.

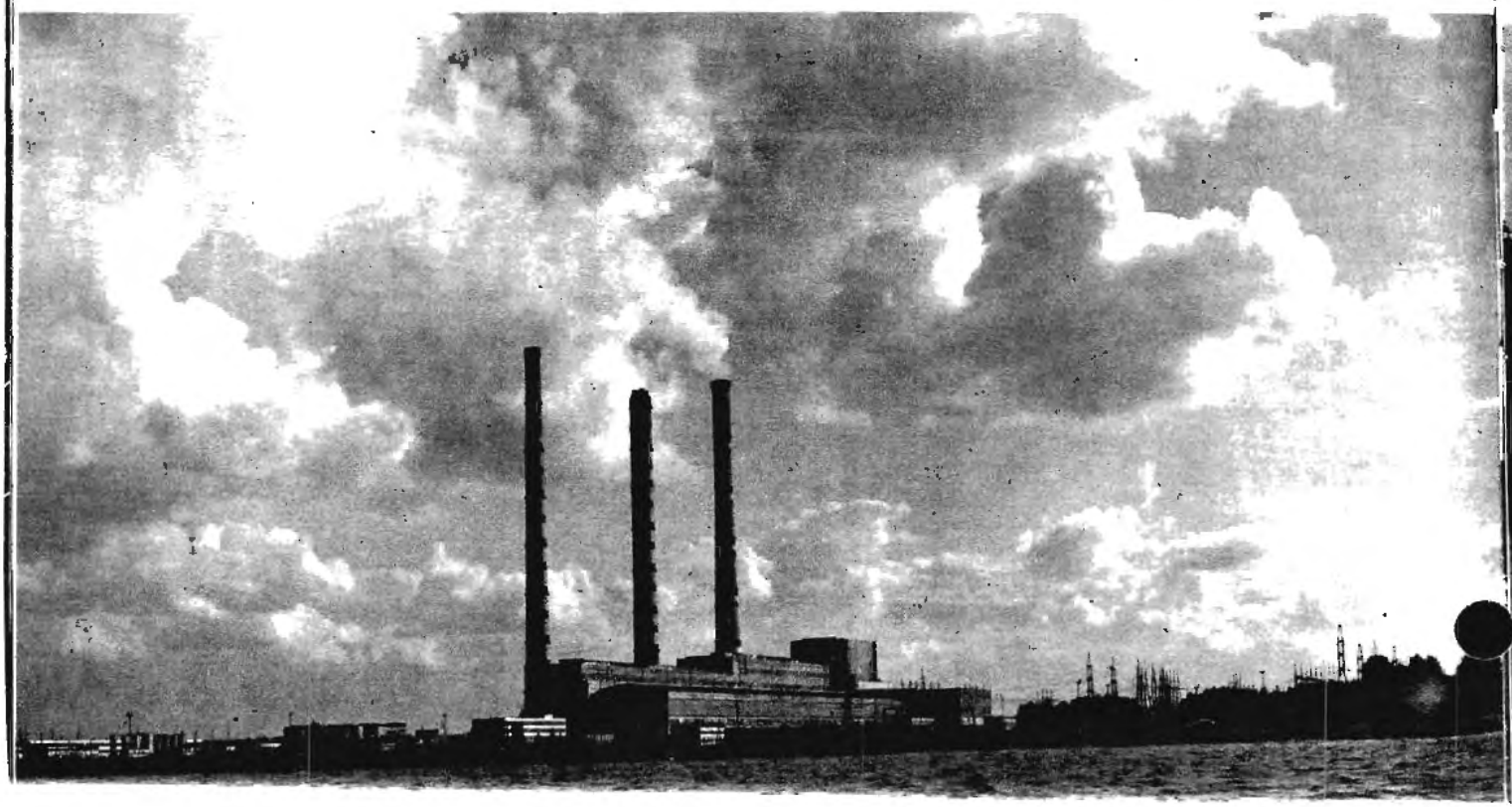
One of the major trends for the improvement of economics and performance characteristics in the power industry is to increase the capacity of the stations and power units.

The Kostroma steam central power station is an illustrative example of achievements in the Soviet power industry. It pioneered commercial use of 300 MW units and has been mastering a unique tandem turbine-generator of 1200 MW capacity.

The power station is incorporated in the "Kostromaenergo" power system which is linked to the interconnected power system of the USSR Centre.

The station has been built in three stages. During the 1st stage four 300 MW two-boiler single-turbine units with two-furnace gas-and-oil fired boilers of 950 t/h capacity were installed. During the 2nd stage, four 300 MW single units with single-furnace gas-and-oil fired boilers of 950 t/h steam capacity were erected. All the units incorporate 300 MW steam turbines rated at 235 MPa (240 kgf/cm^2, 540/540 °C).

Общий вид Костромской ГРЭС
General view of the Kostroma steam central power station

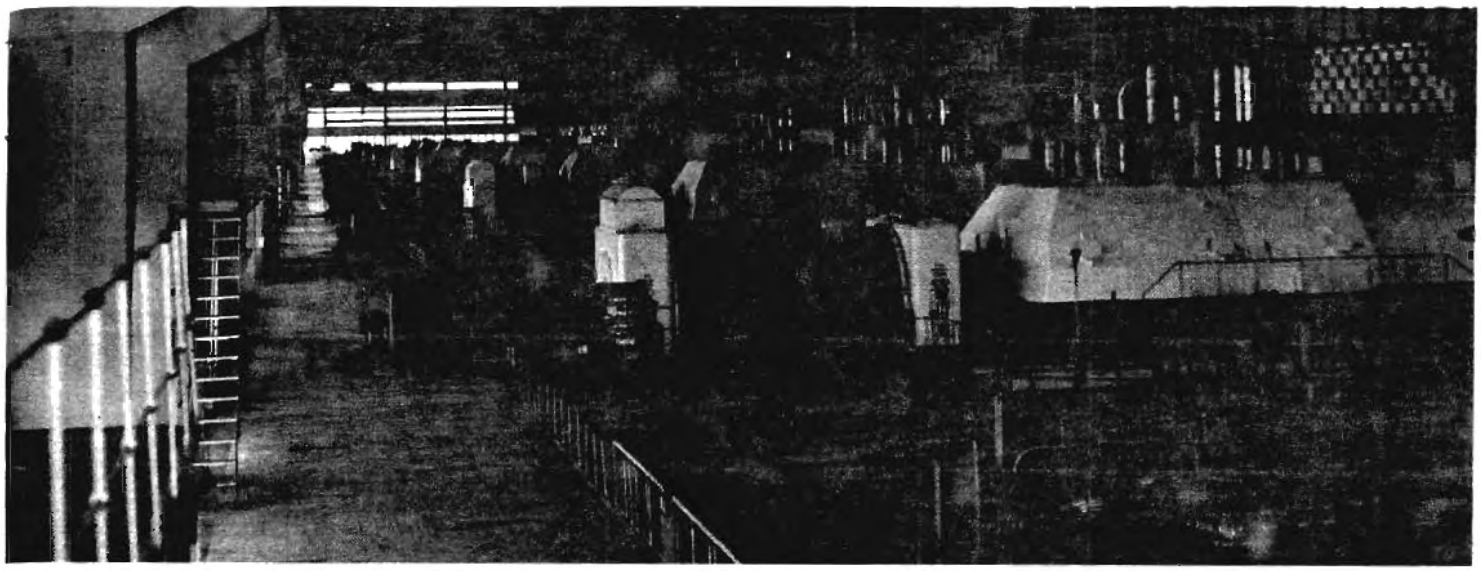


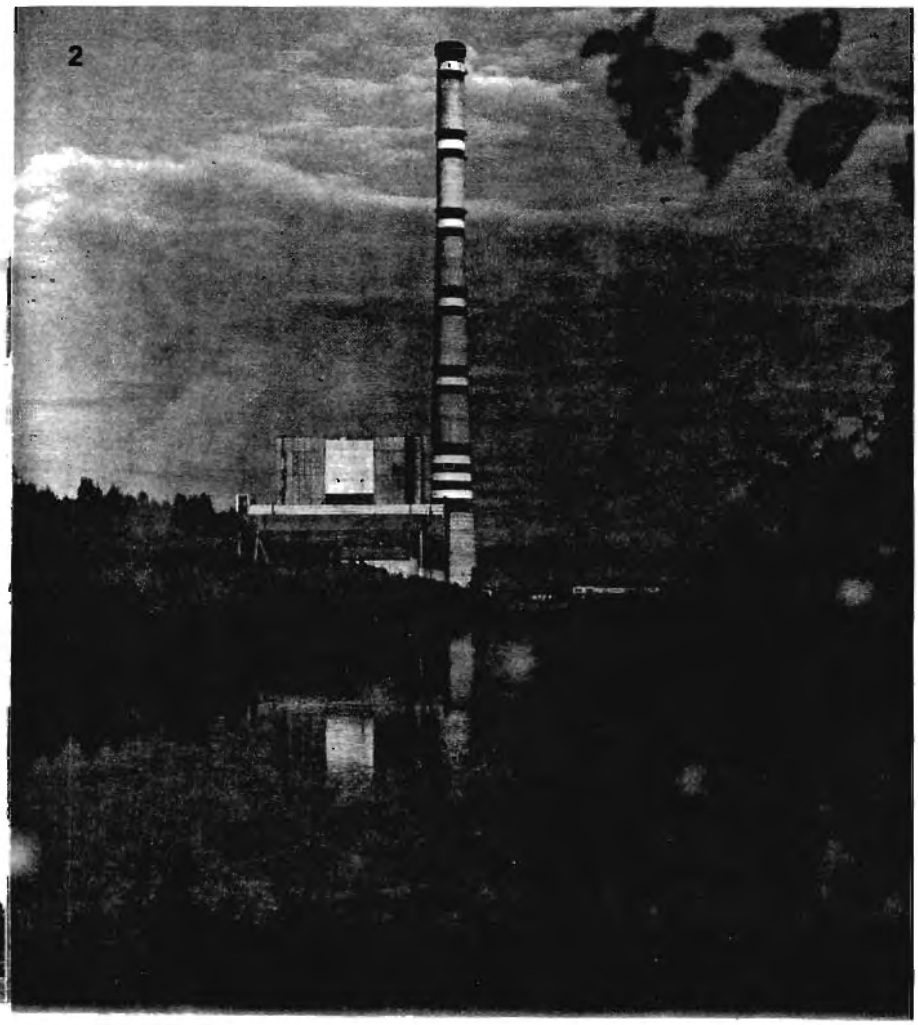
Энергоблоки мощностью по 300 МВт вводились в эксплуатацию с июня 1969 г. по июль 1973 г. На третьей очереди электростанции установлен и успешно освоен в эксплуатации уникальный головной энергоблок 1200 МВт, превышающий всю энергетическую мощность дореволюционной России.

Чтобы его построить, потребовались напряженный научный поиск и принципиально новые решения многих проблем в строительной индустрии, энергетическом машиностроении, технологии строительства и эксплуатации оборудования.

The 300 MW units were commissioned between June, 1969 and July, 1973. During the 3d stage of construction, a 1200 MW experimental unit with its capacity exceeding that of prerevolutionary Russia was erected and successfully put into commercial service.

The construction of such a unit necessitated strenuous scientific efforts and meeting the unknown challenges in the field of civil engineering, electrical machine building, construction techniques and operating practices.





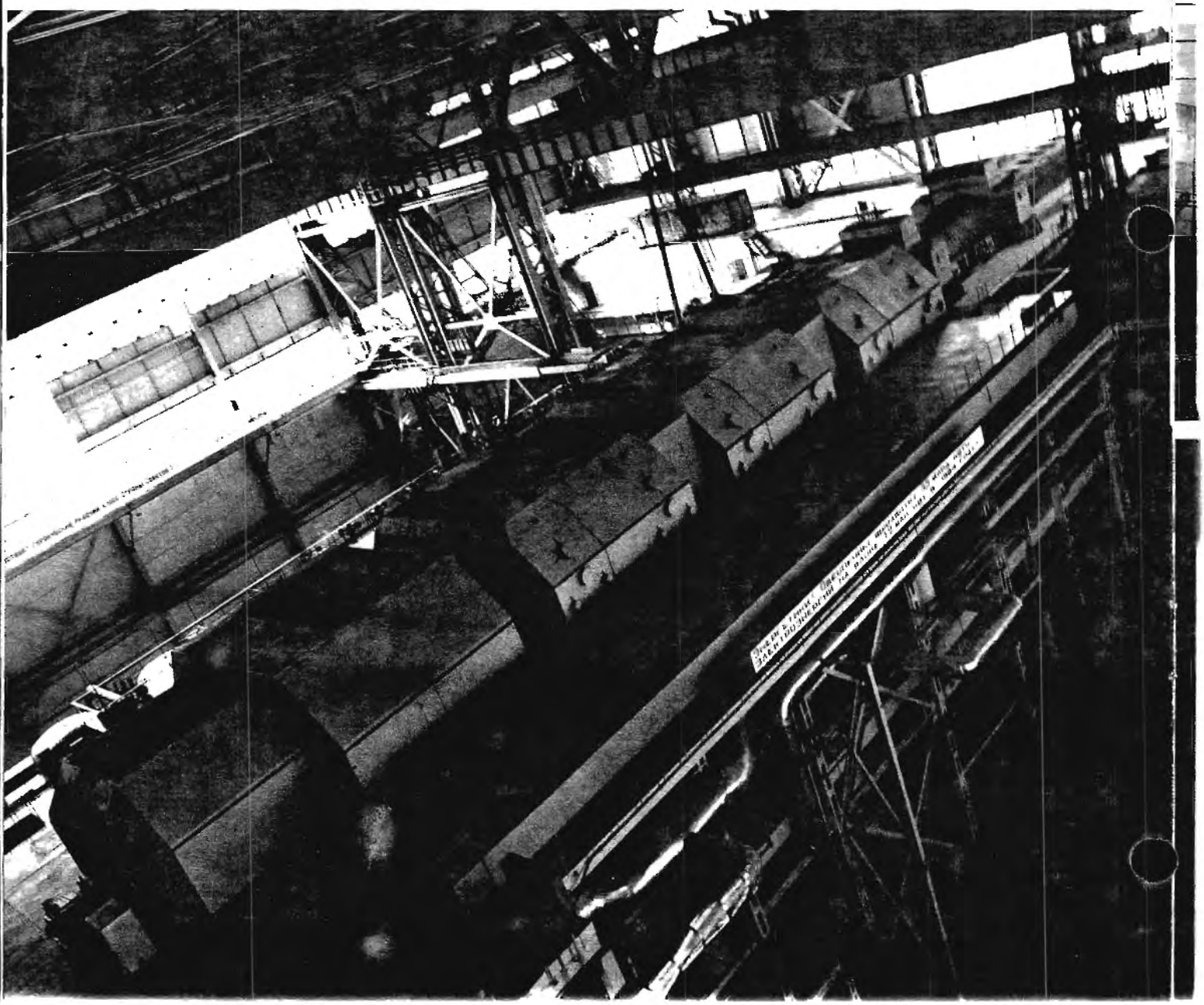
1
Машинный зал блоков 300 МВт Костромской ГРЭС
Machine room of 300 MW units at the Kostroma steam central power station

2
Общий вид главного корпуса с энергоблоком 1200 МВт
General view of main building housing 1200 MW unit

В состав энергоблока входит однокорпусный, газоплотный подвесной, газомазутный котел с промперегревом. Топочная камера котла призматическая, является восходящим газоходом. По высоте она делится на три радиационные части. Котел оборудован 56 комбинированными газомазутными горелками производительностью 5 т/ч каждая по мазуту и 5,5 x 10^3 $м^3$/ч по газу. Подача воздуха в топку и транспорт газа по газоходам котла при работе с уравновешенной тягой осуществляются тремя турбовоздуходувками и тремя дымососами с электроприводом. Котел оборудован тремя регенеративными воздухоподогревателями (РВП) с внутренним диаметром ротора 13,88 м. Для очистки поверхностей нагрева конвективной шахты от золовых отложений применена дробеструйная установка. Очистка пароперегревателей в горизонтальном газоходе осуществляется глубоковыдвижными аппаратами паровой обдувки. Котел оборудован в полном объеме контрольно-измерительными приборами, автоматикой, технологическими защитами и сигнализацией.

The power unit incorporates a single-furnace gas-tight suspended gas-and-oil fired boiler with reheat. The furnace is of a prismatic configuration and serves as an uptake gas duct. Heightwise it is divided in three radiation parts. The boiler is fitted with 56 combined gas-and-oil burners of 5 t/h oil and 5.5·10^3 cu.m/h gas capacity. Air supply to the furnace and flue gas transport over the boiler gas ducts, when operating under the balanced draft conditions, are effected by three turboblowers and three motor-driven i.d. fans. The boiler is provided with three regenerative air heaters (RAH) whose rotor is 13.88 m in inner diameter. The heating surfaces of the convection pass are cleaned of ash deposits by shot blasting. Superheaters in the horizontal flue pass are cleaned using long-retracting sootblowers. The boiler is provided with a complete set of instrumentation, automatic controls, protective systems, and alarms.

The 1200 MW condensing tandem turbine of K-1200-240-3 type is designed to operate in conjunction with the single-furnace once-through boiler of 3950 t/h capacity.



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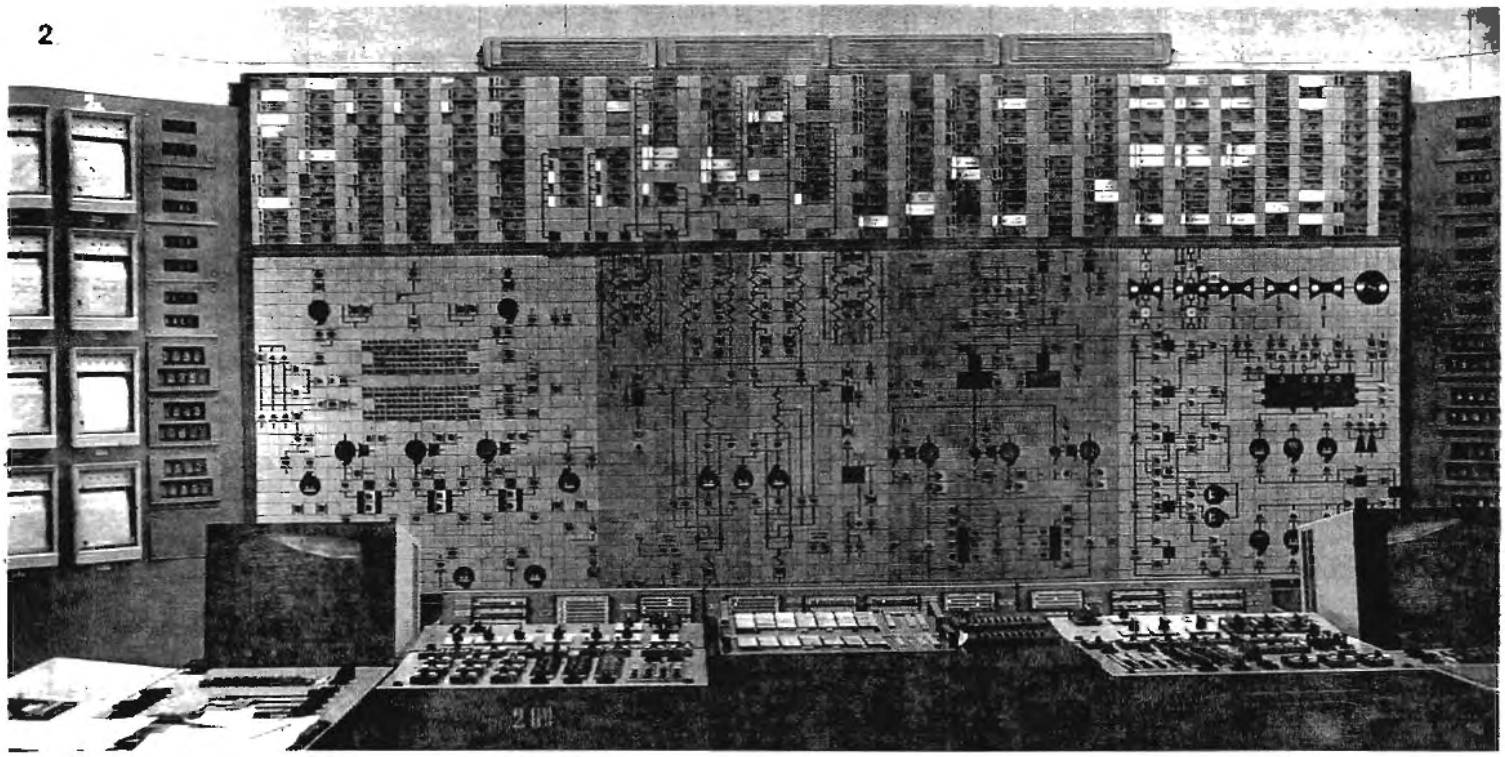
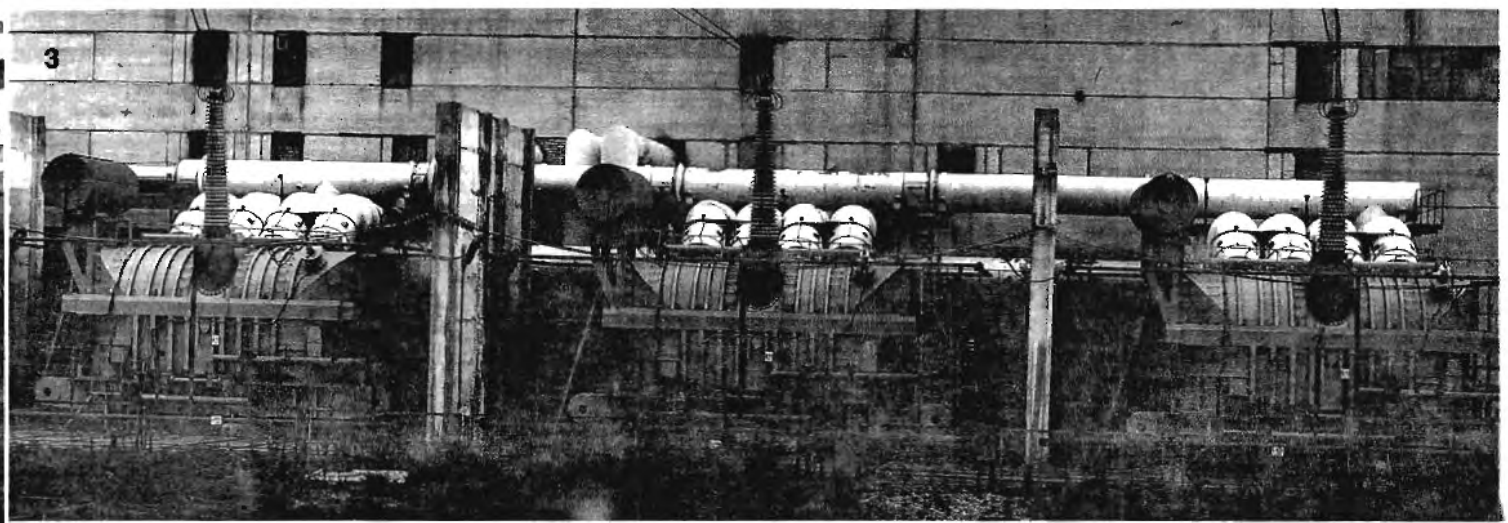




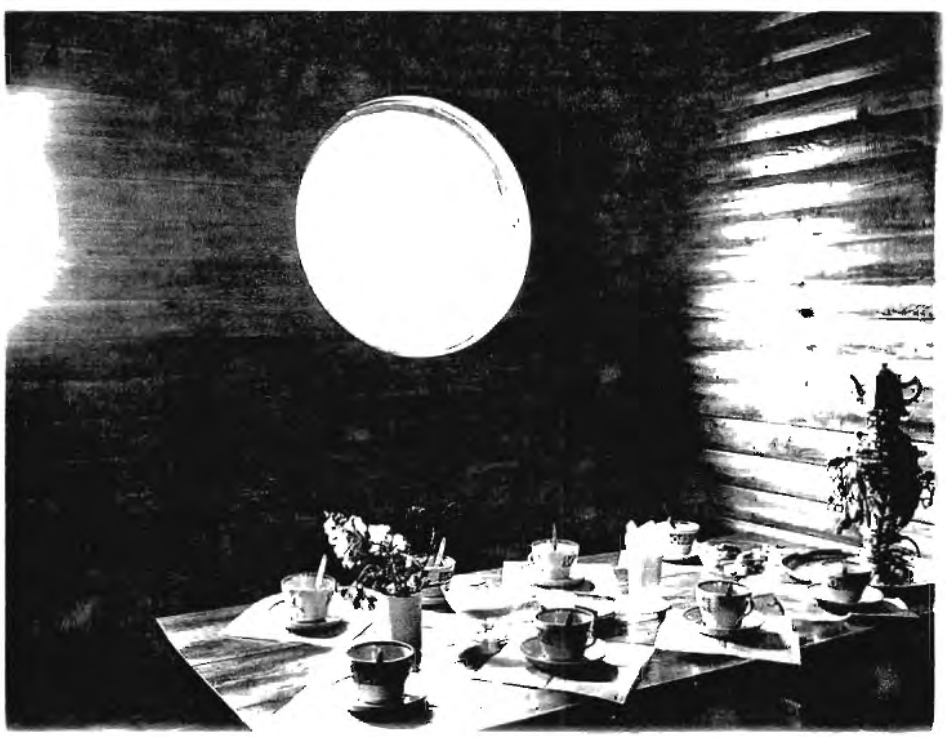
3

1
Самый мощный в мире одновальный турбоагрегат 1200 МВт
World largest tandem turbine-generator set of 1200 MW

2
Блочный щит управления энергоблока 1200 МВт
Unit control board of 1200 MW turbine-generator set

3
Повышающий трансформатор энергоблока 1200 МВт
Step-up transformer of 1200 MW unit

4
Интерьер комнаты отдыха сменного персонала Костромской ГРЭС
Rest room of shift personnel at the Kostroma steam central power station



Паровая конденсационная одновальная турбина К-1200-240-3 мощностью 1200 МВт предназначена для работы в блоке с однокорпусным прямоточным котлом паропроизводительностью 3950 т/ч.

Высота рабочих лопаток последних ступеней, изготовленных из титанового сплава, 1200 мм.

Генератор выполнен с непосредственным охлаждением обмотки статора дистиллированной водой, а обмотки ротора и активной стали статора — водородом. Ротор генератора изготовлен из цельной поковки специальной стали. Система возбуждения бесщеточная, диодная.

Выдача мощности с III очереди ГРЭС осуществляется на напряжении 500 кВ через три однофазных трансформатора, подключенных к шинам ОРУ 500 кВ.

Энергоблок создан на основе прогрессивных технических решений, направленных на обеспечение высокой надежности и экономичности, и введен в эксплуатацию в декабре 1980 г.

The height of last stage blades fabricated from titanium is 1200 mm.

The generator features direct cooling of the stator winding with demineralized water, the rotor winding and stator core are hydrogen-cooled. The generator rotor made from a single special steel forging. The brushless excitation system is built around diodes.

Electrical energy generated by the 3d stage of the central station is transmitted at 500 kV through three single-phase transformers connected to the buses of the 500 kV switchyard.

The power unit was developed using the state-of-the-art technology to ensure high operational reliability and costeffectiveness. It was commissioned in December, 1980.

Техническая характеристика основного энергетического оборудования

Characteristics of Major Power Generating Equipment

Котлоагрегаты
Boilers

Параметры Parameters	Дубль-блоки Two-boiler arrangement 300 МВт 300 MW	Моноблоки Single-boiler arrangement 300 МВт 300 MW	Моноблок Single-boiler arrangement 1200 МВт 1200 MW
Тип Type	ТГМП-114	ТГМП-314	ТГМП-1202
Изготовитель Manufacturer	Таганрогский завод „Красный котельщик" "Krasny Kotelshchik" boiler works in Taganrog		
Производительность, т/ч Capacity, t/h	950		
Давление пара, кгс/см² Steam pressure, kgf/cm²	225		
Температура пара на выходе из котла и после промежуточного перегрева, °С Steam temperature at boiler outlet and after reheat, °C	545		
Температура питательной воды, °С Feed water temperature, °C	265	265	270
Расход топлива, т/ч Fuel consumption, t/h	72	71	273
Коэффициент полезного действия (брутто), % Gross efficiency, %	92	93	94
Топливо: Fuels:			
основное main fuel	высокосернистый мазут $Q_н^р = 9500 \frac{ккал}{кг}$ high sulfur fuel oil $Q_н^р = 9500 \frac{kcal}{kg}$		

резервное back-up fuel	природный газ $Q_н^р = 8100$ ккал/нм^3 natural gas $Q_н^р = 8100 \frac{kcal}{m^3}$	
Турбины Turbines		
Тип Type	К-300-240	К-1200-240-3
Изготовитель Manufacturer	Производственное объединение турбостроения, Ленинградский металлический завод Leningrad Metal Works	
Номинальная мощность, МВт Rated power, MW	300	1200
Частота вращения, об/мин Speed, rpm	3000	3000
Максимальный расход пара, т/ч Maximum steam flow rate, t/h	930	3900
Давление пара, кгс/см^2: Steam pressure, kgf/cm^2:		
свежего live steam	240	
после промежуточного перегрева steam after reheat	36	
Температура свежего пара, °С Live steam temperature, °C	540	
Число регулируемых отборов Number of extractions	8	9
Генераторы Generators		
Тип Type	ТВВ-320-2	ТВВ-1200-2
Изготовитель Manufacturer	Ленинградское электротехническое объединение „Электросила" "Electrosyla"	
Мощность, МВт Output, MW	300	1200
Напряжение на выводах, кВ Terminal voltage, kV	20	24
Возбуждение Excitation	высокочастотное, бесщеточное, диодное high-frequency, brushless, diode	
Охлаждение Cooling	водородно-водяное water/hydrogen	

Трансформаторы Transformers			
Тип Type	ТДЦ-400000/220	ТДЦ-400000/500	ОРЦ-533000/525
Изготовитель Manufacturer	Запорожский трансформаторный завод Zaporozhye transformer works		
Мощность, МВА Capacity, MVA	400	400	533
Напряжение, кВ Voltage, kV	220/20	500/20	525/24

Основные сооружения электростанции

К основным сооружениям электростанции относятся главный корпус энергоблоков 300 МВт, главный корпус энергоблока 1200 МВт, инженерно-бытовой корпус, химводоочистка, топливное хозяйство, система технического водоснабжения, сооружения электрической части.

Главный корпус энергоблоков 300 МВт — трехпролетный: машинный зал — 45 м, деаэраторное отделение — 12 м, котельное отделение дубль-блоков — 33 м, моноблоков — 39 м. Шаг колонн — 12 м.

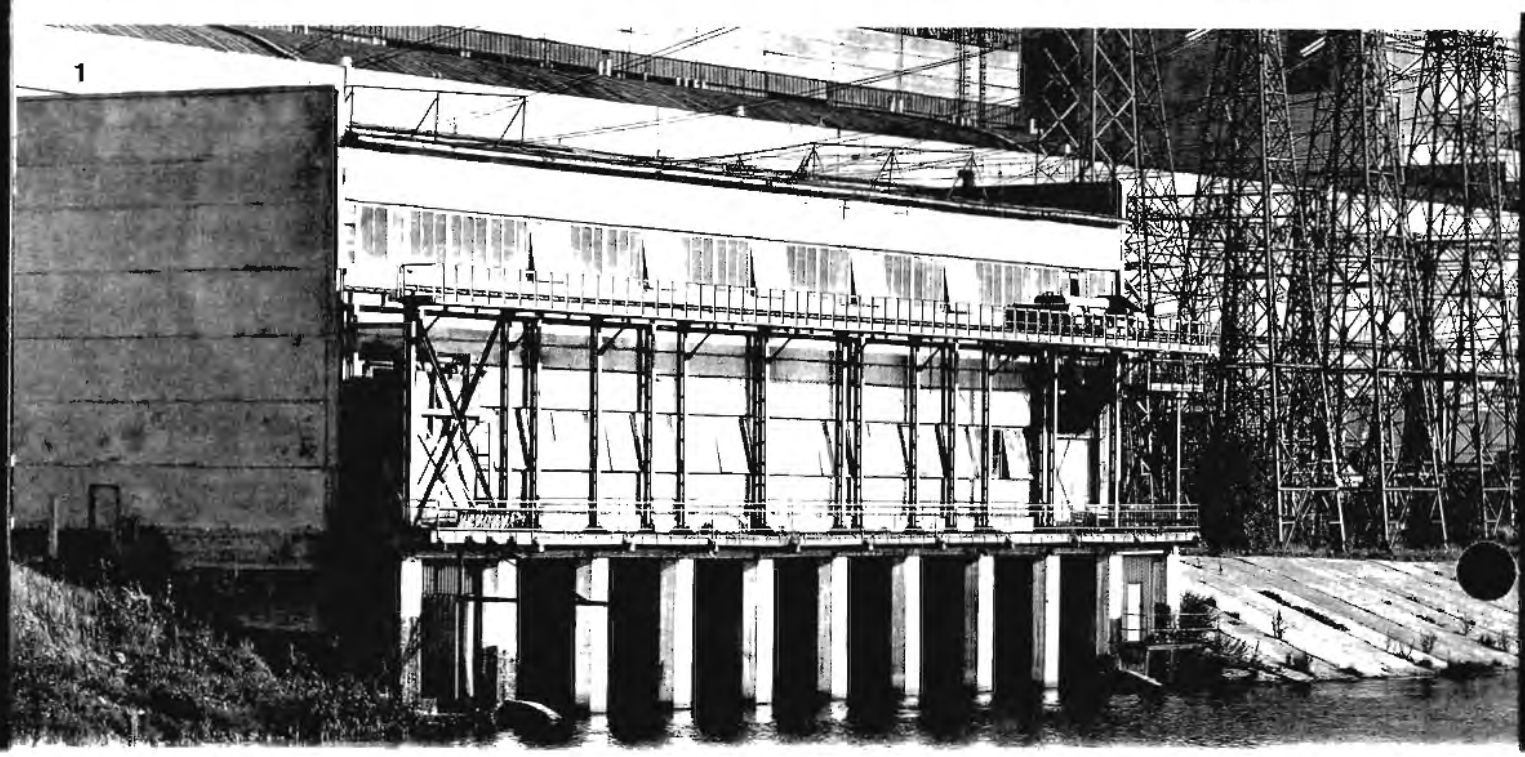
Главный корпус выполнен из сборного железобетона (за исключением металлических ферм и подкрановых балок машинного и котельного отделений) с применением новых строительных материалов и конструкций, фундаменты под колонны выполнены облегченными. Стеновое ограждение впервые в практике энергостроительства выполнено из керамзитобетонных панелей, облицован-

Main Structures

The main structures of the steam central power station are the main building accommodating 300 MW units, the main building housing 1200 MW unit, the service building, the water conditioning plant, the fuel handling facility, the service water supply system, the electrical works.

The main building which houses the 300 MW units is a three-span structure: turbine room — 45 m, deaerator bay — 12 m, boiler room for two-boiler turbine units — 33 m, boiler room for single-boiler turbine units — 39 m. The columns are spaced 12 m apart.

The main building is made of prefabricated reinforced concrete (except for steel trusses and crane track beams in the turbine boiler rooms) with the use of new building materials and structural elements. The column footings are of a lightened construction. For the first time in the power engineering practice, the walls are made of breccia-lined light-concrete panels. The window openings are filled with structural glass shapes.



1

ных брекчией. Световые проемы — из стеклопрофилита.

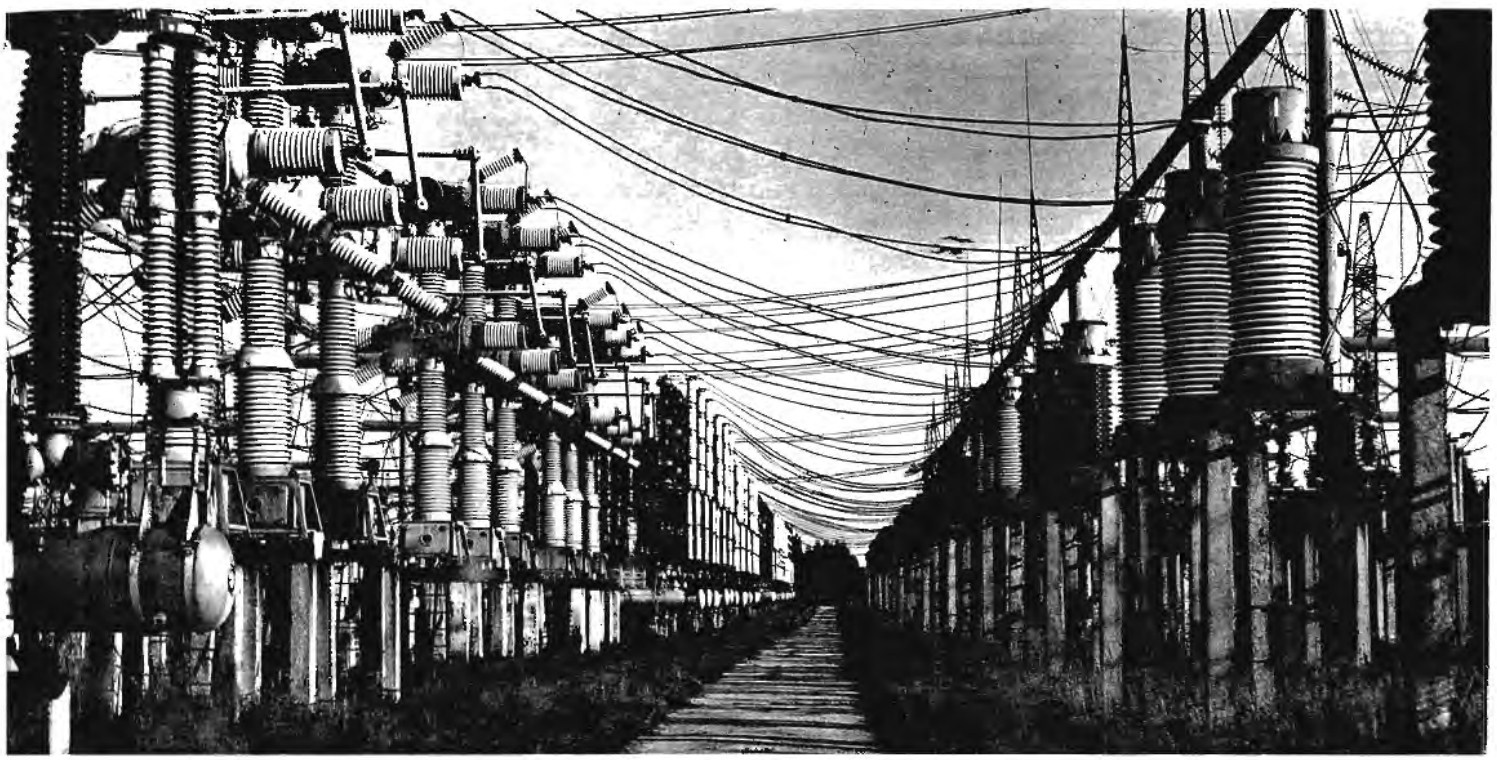
Расположение турбоагрегатов в машинном зале — поперечное. Тепловая схема — блочная.

Машинный зал обслуживают три мостовых крана грузоподъемностью по 125/20 тс, котельное отделение — три мостовых крана по 50/10 тс.

На открытой площадке за главным корпусом расположены дымососы, дутьевые вентиляторы и регенеративные воздухоподогреватели. Для отвода дымовых газов от котлоагрегатов сооружены две дымовые трубы высотой по 250 м. Дымовая труба моноблоков выполнена из несущей железобетонной оболочки, в которой установлены четыре стальных отводящих ствола, каждый из которых обслуживает один энергоблок.

The turbine-generator sets are arranged crosswise in the turbine room.

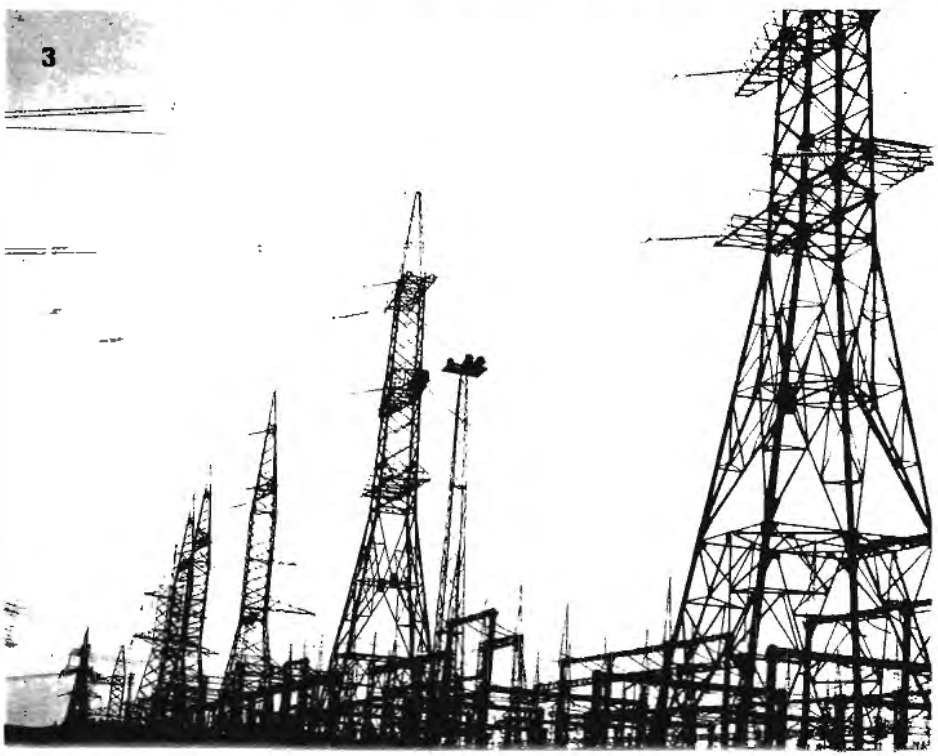
The heat cycle is of a boiler/turbine arrangement. The turbine room is serviced with three 125/20 t overhead cranes. In the boiler room, there are three 50/10 t overhead cranes. The outdoor area behind the main building accommodates the i.d., f.d. fans and regenerative air heaters. Two 250 m high stacks are built to exhaust flue gases from the boilers. The stack serving the single-boiler units is made of a reinforced concrete shell which houses four steel breeches one per power unit.



1
Береговая насосная Костромской ГРЭС
Shore pumping station of the Kostroma steam central power station

2
Открытое распределительное устройство на напряжение 220 кВ
220 kV switchyard

3
Открытое распределительное устройство на напряжение 500 кВ
500 kV switchyard



Основные технико-экономические и эксплуатационные показатели
Performance Characteristics

Параметры Parameters	Энергоблоки Power units **300 МВт** **300 MW**	Энергоблок Power unit **1200 МВт** **1200 MW**
Тип электростанции Type of steam station	конденсационная condensation	
Количество и мощность энергоблоков, шт x МВт Number and capacity of units, pes x MW	8 x 300	1 x 1200
Годовая выработка электроэнергии, млрд. кВт·ч Annual power output, 10^9 kWh	15,4	7,1
Расход электроэнергии на собственные нужды, % Power consumption for auxiliaries, %	2,9	1,66
Удельный расход условного топлива на 1 кВт·ч отпущенной электроэнергии, г Specific consumption of ideal fuel per kWh, g	316	313
Число часов использования установленной мощности Installed capacity utilization hours	6100	6000

Управление и автоматика

Управление и контроль за работой оборудования энергоблоков 300 МВт осуществляются с блочных щитов управления (один на два блока), куда вынесены приборы регулирования работы основного и вспомогательного оборудования, а также аппаратура, необходимая для пуска и останова энергоблока. Все основные технологические процессы автоматизированы. На блочных щитах установлены информационно-вычислительные машины ИВ-500, а также панели защиты и сигнализации.

Координация работы энергоблоков, а также управление оборудованием подстанций и линий электропередачи выполняются с центрального щита управления.

Автоматизированная система управления технологическими процессами (АСУ ТП) энергоблока 1200 МВт представляет собой комбинированную систему для выработки и реализации управляющих воздействий на энергоблок с применением методов оптимального управления, современных средств вычислительной техники, функционально-группового управления, автоматического регулирования, связи, а также традиционных средств контроля и управления. Это позволяет осуществлять наиболее эффективное технологическое управление на основе вводимой в АСУ ТП информации.

Автоматическое регулирование охватывает все основные и вспомогательные процессы на блоке и обеспечивает непрерывное поддержание параметров и изменение их по программам функционально-группового управления.

Костромская ГРЭС — одна из крупнейших тепловых электростанций Советского Союза. Все основное оборудование электростанции отечественного производства.

Проект разработан Горьковским отделением института „Теплоэлектропроект". Строительство осуществлялось трестами „Центрэнергострой" и „Центрэнергомонтаж" Министерства энергетики и электрификации СССР с привлечением субпод-

Automatic Controls

Operation of the 300 MW units is controlled and followed up from the unit control rooms (one per two units) which house control instruments of the main and auxiliary equipment as well as unit start-up and shut-down facilities. All the main processes are automated. The unit control boards are provided with data logging computers ИВ-500, protection and alarm panels.

The central control board coordinates operation of the units, and controls substations and transmission lines.

The computerized control system of the 1200 MW unit is an integrated system which affords control of the power unit using optimal control techniques, computer technology, functional-group control approach, servocontrol systems, communication, as well as conventional means of monitoring and control. This provides most efficient process control based on the data input.

The servocontrol systems cover all primary and secondary processes on the unit and maintain the specified parameters constant or change them according to the programs of functional group controls.

The Kostroma steam central power station is one of the Soviet largest thermal power stations. All the major pieces of equipment of the station are of the Soviet make.

The design was developed by the Gorky branch of the "Teploprojekt" institute. Construction was undertaken by the construction agencies of the Ministry of Power and Electrification employing services of some specialized contractors.

Костромская ТЭЦ-2

Установленная мощность — 170 МВт. На станции действуют два теплофикационных турбоагрегата мощностью 60 и 110 МВт, четыре паровых котлоагрегата производительностью по 210 т/ч и два водогрейных — по 100 Гкал/ч.

Станция пущена в 1974 г.

Топливом для электростанции служит мазут.

Связь с энергосистемой осуществляется на напряжении 110 кВ.

Теплоэлектроцентраль предназначена для выработки тепло- и электроэнергии для предприятий и жителей г. Костромы. Отпускает ежегодно более одного млн. Гкал тепла и вырабатывает более одного млрд. кВт·ч электроэнергии.

The ТЭЦ-2 Kostroma Station

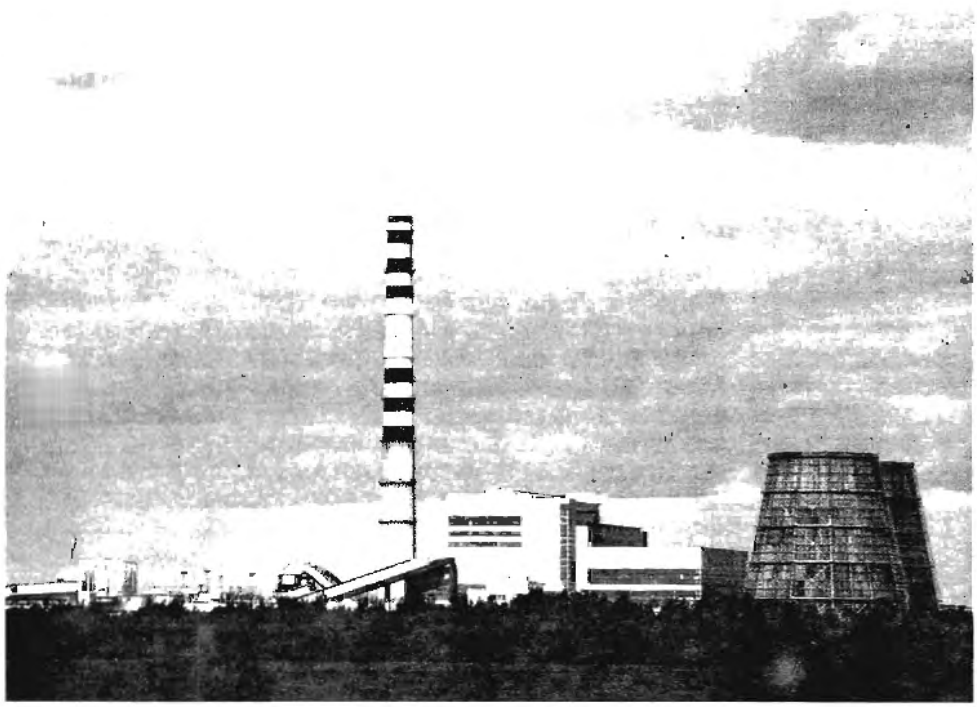
The installed capacity is 170 MW. The station is equipped with two extraction turbine-generator sets of 60 and 110 MW capacity, four steam generators of 210 t/h capacity and two water-heating boilers of 100 Gcal/h output each.

The station was commissioned in 1974.

It fires fuel oil.

Interconnections to the power system are provided through 110 kV transmission lines. The combined heat and power station is intended to produce heat and electrical energy for industrial and residential needs in the city of Kostroma. Annually it produces over one million Gcal of heat and over one billion kWh of electrical energy.

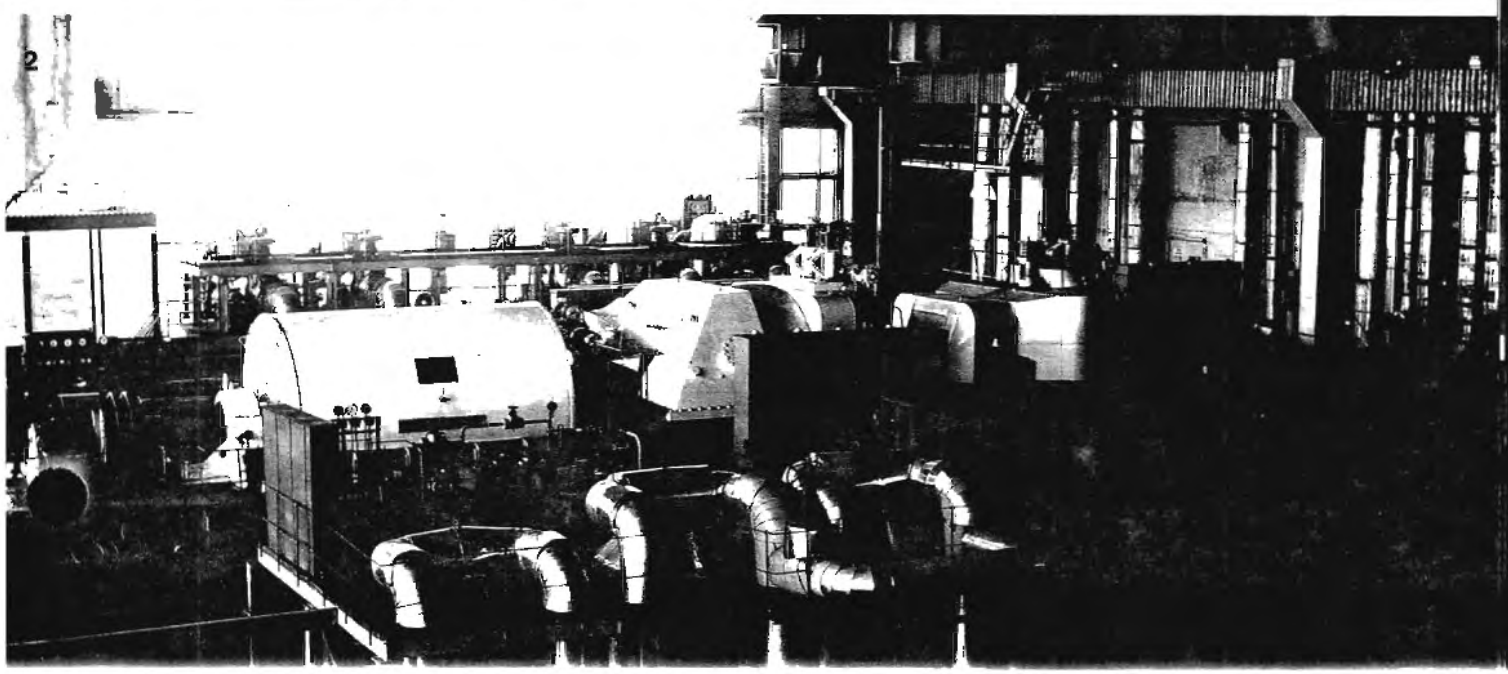
1



1
Общий вид Костромской ТЭЦ-2
General view of the ТЭЦ-2 Kostroma heat-electric power station

2
Машинный зал Костромской ТЭЦ-2 с турбиной ПТ-60-130/13 и турбогенератором ТВФ-63
Turbine room of the ТЭЦ-2 station with ПТ-60-130/13 turbine and ТВФ-63 turbine-generator unit

2



Шарьинская ТЭЦ

Установленная мощность — 24 МВт. На станции установлены три турбины: одна — 12 МВт и две по 6 МВт; действуют шесть котлов: четыре — производительностью по 35 т/ч, два — по 75 т/ч.

Введена в 1965 г.

Топливом для станции служат фрезерный торф и мазут.

Связь с энергосистемой осуществляется на напряжении 110 кВ.

The Sharinskaya Heat-Electric Power Station

The installed capacity is 24 MW. The station has three turbines — one is of 12 MW capacity, the other two are of 6 MW each. There are six working boilers — four boilers are of 35 t/h capacity each, and two boilers are of 75 t/h capacity.

The station went into service in 1965.

It fires milled peat and fuel oil.

The station is interconnected to the power system via 110-kV transmission lines.

Предприятия электрических сетей

Электросетевое хозяйство энергосистемы состоит из пяти электросетевых предприятий: Костромских, Галичских, Нейских, Шарьинских электрических сетей и Костромской горэлектросети. Объем электросетевого хозяйства превышает 90 тыс. условных единиц. Установлены и действуют подстанции 220 кВ–4 МВА (876 шт.), подстанции 110 кВ, 36 МВА (771 шт.), подстанции 35 кВ, 88 МВА (277 шт.), а также 107 опорных подстанций напряжением 10/0,4 кВ, из которых 43 действуют в автоматическом режиме.

Протяженность линий электропередачи напряжением 35–220 кВ составляет 3,4 тыс. км, из них воздушных линий 220 кВ — 297 км, ВЛ 110 кВ — 1182 км, ВЛ 35 кВ — 1909 км. Протяженность ВЛ 10 кВ — 12388 км, ВЛ 0,4 кВ — 10054 км. Линии электропередачи сельскохозяйственного назначения превышают 21 тыс.км.

Кабельные сети 10–6–0,4 кВ — 714 км.

Power Distribution

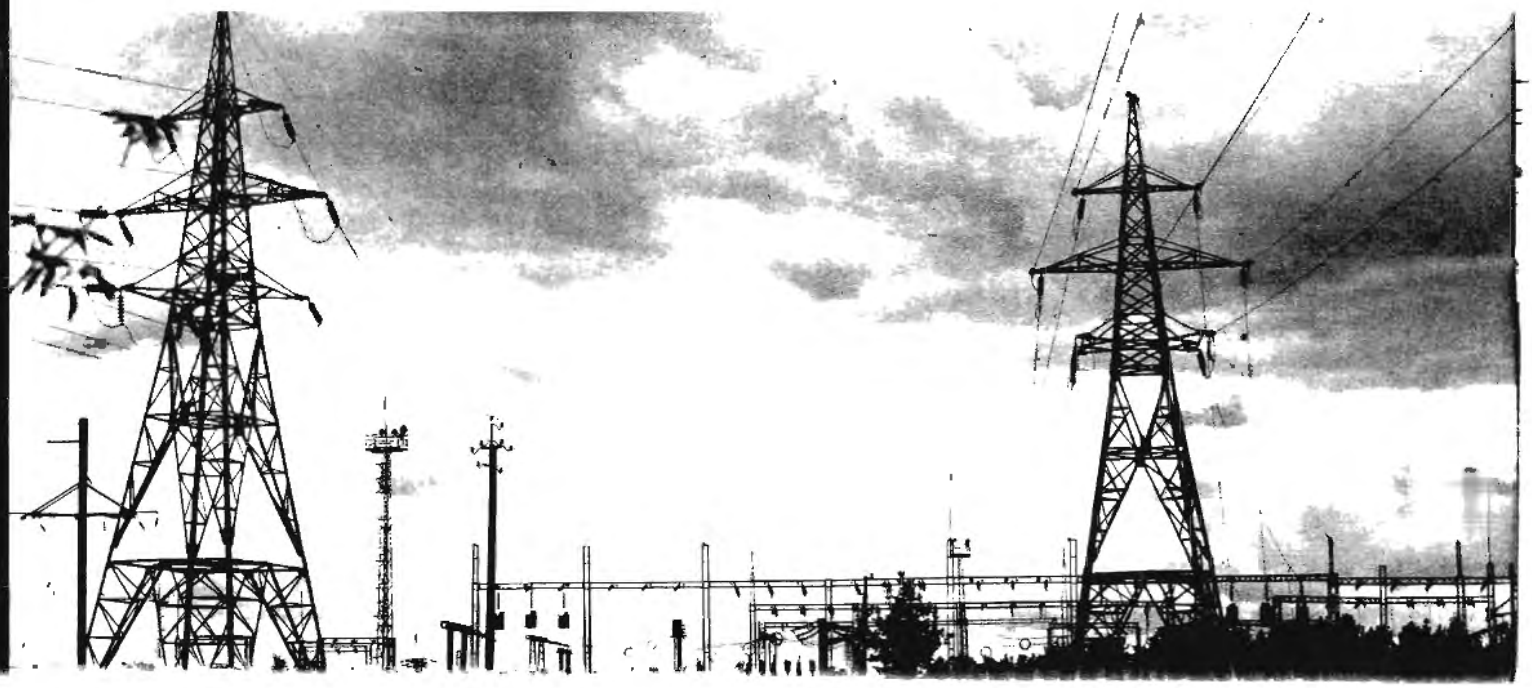
Power distribution facilities consist of five enterprises: Kostroma network, Galich network, Neya network, Sharino network and Kostroma city network. The power distribution facilities consist of over 90,000 pieces of equipment. 220 kV, 4 MVA (876 pcs), 110 kV, 36 MVA (771 pcs), 35 kV, 88 MVA (277 pcs) substations have been installed and are operational, there are also 107 10/0.4 kV distribution substations. Out of this number 43 substations run unattended.

The length of 35-220 kV-transmission lines totals 3,400 km. Out of this figure overhead 220-kV lines account for 297 km, 110-kV lines account for 1,182 km and 35-kV lines account for 1,909 km. 10-kV lines account for 12,388 km, 0.4-kV lines account for 10,054 km. The length of lines for agricultural services exceeds 21,000 km.

The cable lines at 10–6–0.4 kV are 714 km long.

Головная электроподстанция „Нея" напряжением 110/35/27,5/10 кВ предприятия „Нейские электрические сети"

Load-center 110/35/27.5/10 kV substation Neya of Neya power network



Совершенствование работы электростанций и электрических сетей „Костромаэнерго“

Одновременно с наращиванием установленной мощности рос коллектив энергосистемы и овладевал совершенными технологическими процессами, оптимальными режимами эксплуатации новейшего сложного оборудования, его надежного и экономичного использования. Повышение производственной квалификации персонала стало непреложным правилом в каждом трудовом коллективе.

Рост профессионального мастерства сопровождался улучшением технико-экономических показателей, в том числе по удельным расходам условного топлива.

На показатели семидесятых-восьмидесятых годов определяющее воздействие оказал коллектив Костромской ГРЭС, флагман энергетики страны.

Наращивание объемов производства электрической и тепловой энергии в обстановке строжайшей экономии топлива, электроэнергии на собственные нужды и других ресурсов подкреплено борьбой за надежное энергоснабжение потребителей. Электрические сети, протяженность которых в 1961 г. составляла лишь 103 км, сейчас превышают 30 тыс. км, а потребление электроэнергии народным хозяйством области с 485 млн. кВт·ч возросло до 2,3 млрд. кВт·ч.

В 1970–80 гг. проведена большая работа по повышению надежности электроснабжения сельских потребителей путем кольцевания электросетей 10 кВ и строительства опорных подстанций напряжением 10/0,4 кВ. Это позволило обеспечивать резервное электроснабжение центральных усадеб колхозов и совхозов, крупных населенных пунктов,

Improvement of Operational Practice at Power Stations and Networks of “Kostromaenergo”

Alongside with raising the installed capacity, the operating personnel of the power system mastered the advanced techniques, optimal operating conditions of new sophisticated equipment, its reliable and cost-effective use. Great emphasis is being placed on upgrading the professional skills. The upgrading of professional skills is accompanied by improvements in performances of the plant including specific consumption of ideal fuel.

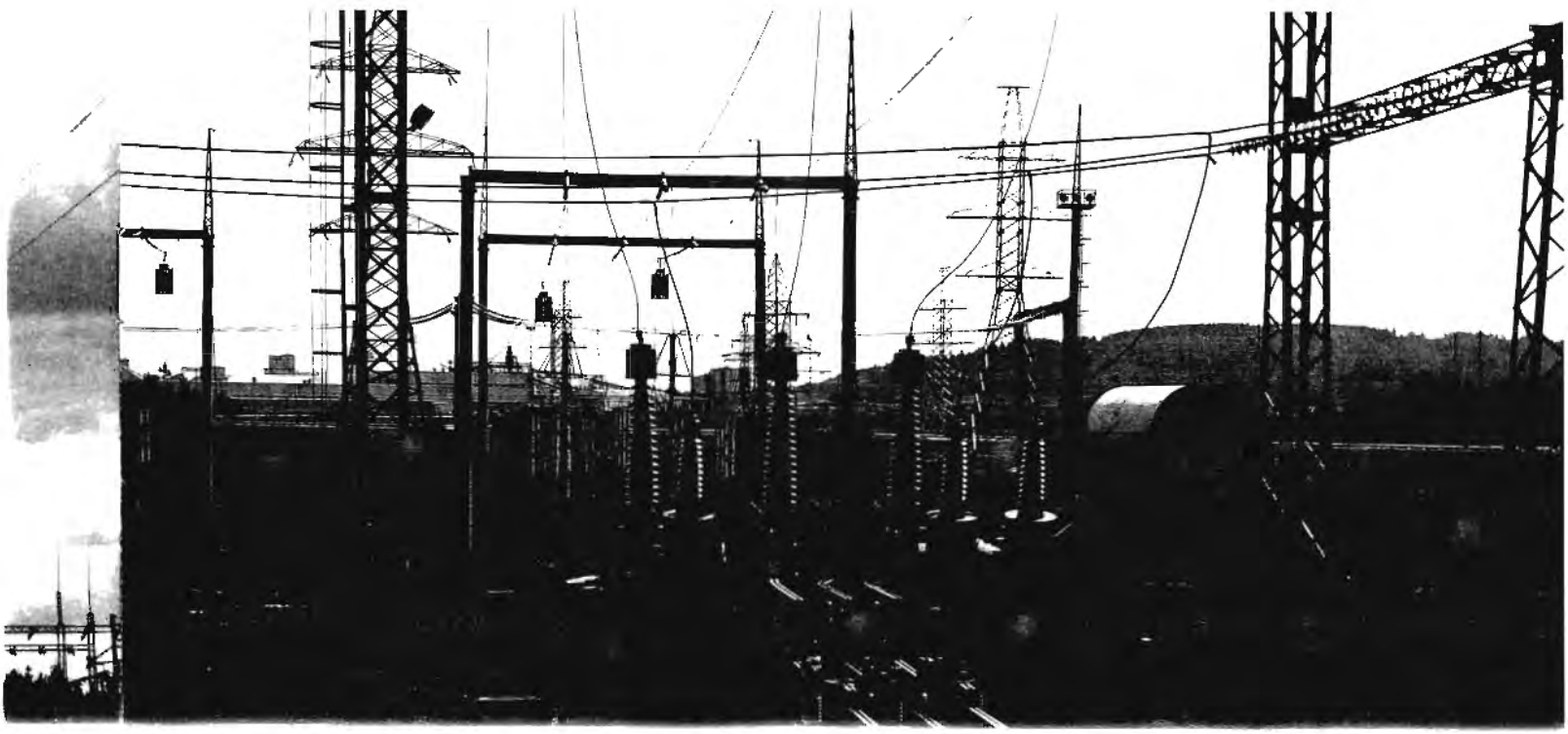
Credit for progress achieved between seventies and eighties should be primarily given to the staff of the Kostroma steam central power station, a leading power generating plant of the Soviet power industry.

Build up of electric and heat energy production, amidst stringent measures for conservation of fuel, electrical energy for station auxiliaries, and other resources, is supported by the tendency to improve uninterrupted power supply to its users. The electrical networks whose length was only 103 km in 1961, exceed now 30,000 km while electrical energy consumed by the regional economy increased from $485 \cdot 10^6$ kWh to $2.3 \cdot 10^9$ kWh.

In 1970–80 much effort was made to increase the reliability of power supply to agricultural users by forming ring circuits of 10 kV and by construction of 10/0.4 kV distribution (transformer) substations. This helped to provide stand-by power supply for rural services — collective and state farms, large rural communities, livestock complexes, poultry factories, and other agricultural facilities.

Подстанция напряжением 220/110/10 кВ „Мотор-деталь“

220/110/10 kV substation “Motor-Detail”



животноводческих комплексов, птицефабрик и других сельскохозяйственных объектов. Построено 844 км линий для кольцевания радиальных линий, при этом средняя протяженность линий 10 кВ с 48 км (1965 г.) сокращена менее чем до 25 км.

Повышению эффективности производства способствует активное участие работников энергосистемы в рационализации и изобретательстве. В одиннадцатой пятилетке рационализаторские предложения поступили от 2664 новаторов, 2992 новшества внедрены, что принесло экономический эффект свыше 3,4 млн. руб. С пуском экспериментального энергоблока новаторы Костромской ГРЭС обязались межремонтный период довести до пяти лет.

В „Костромаэнерго" (с 1974 г.) внедряется автоматизированная система диспетчерского (АСДУ) и организационно-экономического управления (АСОЭУ) на базе электронно-счетных машин третьего поколения. Начата разработка нового этапа развития АСУ — многоуровневой организационно-технологической автоматизированной системы управления.

Оперативное руководство энергосистемой осуществляется центральной диспетчерской службой. Диспетчеры с центрального диспетчерского пункта, подчиняясь непосредственно диспетчеру ЦДУ ЕЭС СССР, координируют работу всех электростанций системы. Он оснащен необходимыми средствами связи, автоматизированным информационным комплексом на базе двух ЭВМ М-6000, средствами телеизмерения и телесигнализации для контроля за электростанциями, узловыми подстанциями и линиями электропередачи. Это позволяет разрабатывать экономичные режимы работы электростанций и электросетей, обеспечивая их надежную эксплуатацию.

В энергосистеме постоянно совершенствуются средства диспетчерского и технологического управления.

844 km of lines were built to form ring circuits from the radial lines, with an average length of 10 kV lines reduced from 48 km (1965) to less than 25 km.

Important contribution to the effectiveness of the power system is being made by the system person who participate in the innovation and invention proce During the period of the 11th Five-Year Plan 2664 people lodged rationalization proposals. 2992 innovations were implemented which saved over 3,400 000 roubles. After commissioning of the experimental unit, the innovators of the Kostroma steam central power station pledged to extend the overhaul period to five years.

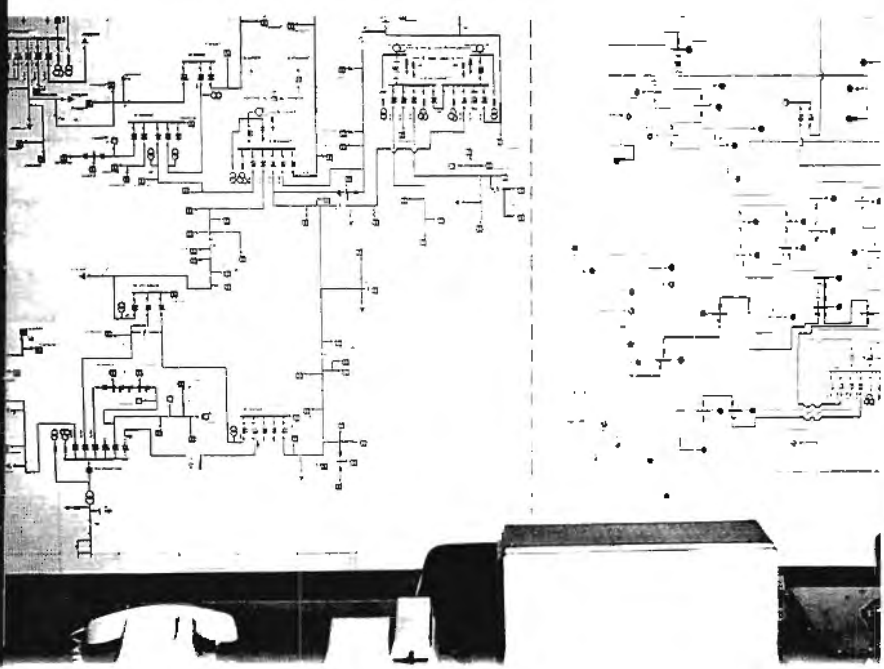
Since 1974 work is going on implementation of computerized-dispatching system and economy-management system with application of third-generation computers. A new phase of development has been initiated in the field of automatic control systems — computerized multilevel process-management system.

The power system is directly controlled from the regional load dispatching office which, being responsible to the Central Dispatching Office of the United National Grid, coordinates the operation of the power stations embraced by the interconnected power system. The regional load dispatching office is fitted with the necessary means of communication, automated information processing facilities using two M-6000 computers, telemetering and remote indication facilities to monitor the power stations, main substations and transmission lines. It enables the operating conditions to be optimized for the power stations and distribution networks ensuring their reliable performance. There is a constant tendency to improve the means of load dispatching a process controls.

At present there goes work on laying double cable lines for system and inter-system communication. Over 500 km of lines will be multiplexed by 60 channel systems, type K-60П.

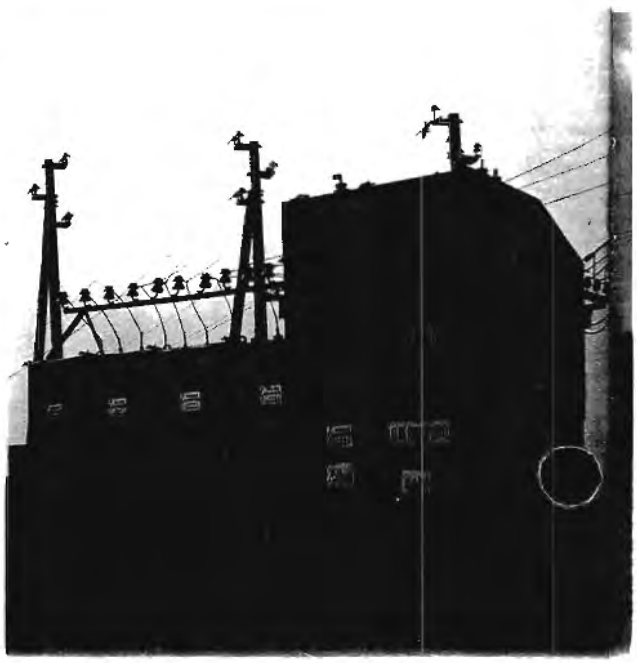
Районный диспетчерский пункт Нерехтского РЭС Костромского предприятия электрических сетей

Local load dispatching office of Nerekhta network



Опорная подстанция напряжением 10 кВ „Лаврово" в Нерехтском районе

10 kV substation Lavrovo in Nerekhta district



В настоящее время проводятся работы по прокладке двухкабельных линий связи системного и межсистемного значения, более 500 км трассы уплотняется 60-канальными системами связи типа К-60П.

Для автоматической коммутации этих каналов и существующих каналов дальней связи в настоящее время монтируется координатная АТС на 800 номеров.

Проводятся работы по усилению надежности и достоверности передачи телеметрической информации. С целью передачи большего потока телеметрической информации в энергосистеме постоянно высвобождаются старые системы и заменяются новыми, более совершенными.

В 1969 г. создана и работает своя метрологическая лаборатория по ремонту средств радиотехнических измерений и контролю за их состоянием.

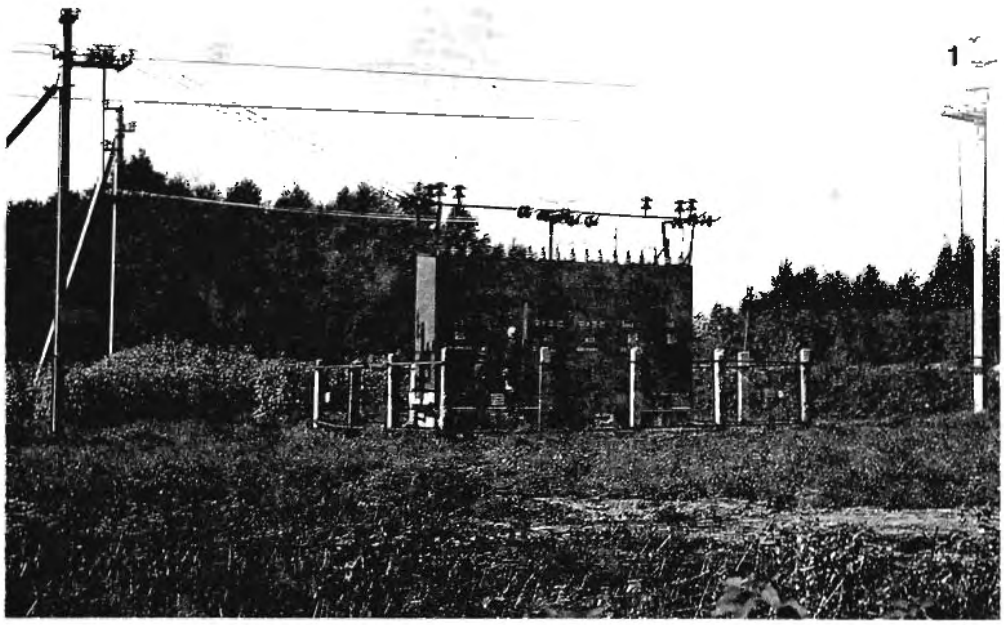
To perform automatic switching of these and existing long-distance channels, a cross-bar automatic telephone exchange for 800 numbers is being now erected.

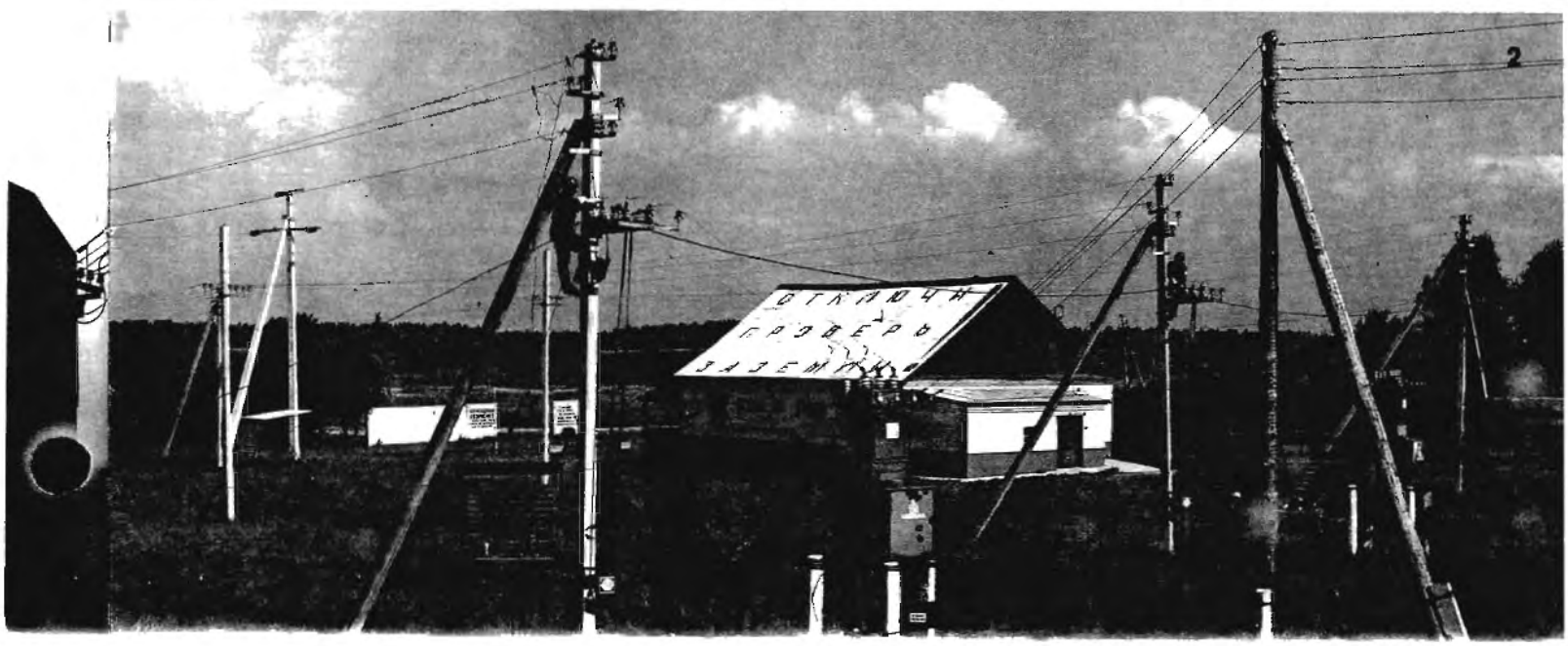
Work is also being conducted to upgrade reliability and credibility of telemetering information transfer. To increase information flow transfer, the old systems are constantly being phased out and replaced with up-to-date systems.

In 1969 a metrological laboratory was set up which is responsible for maintenance and upkeep of radio technical metering hardware.

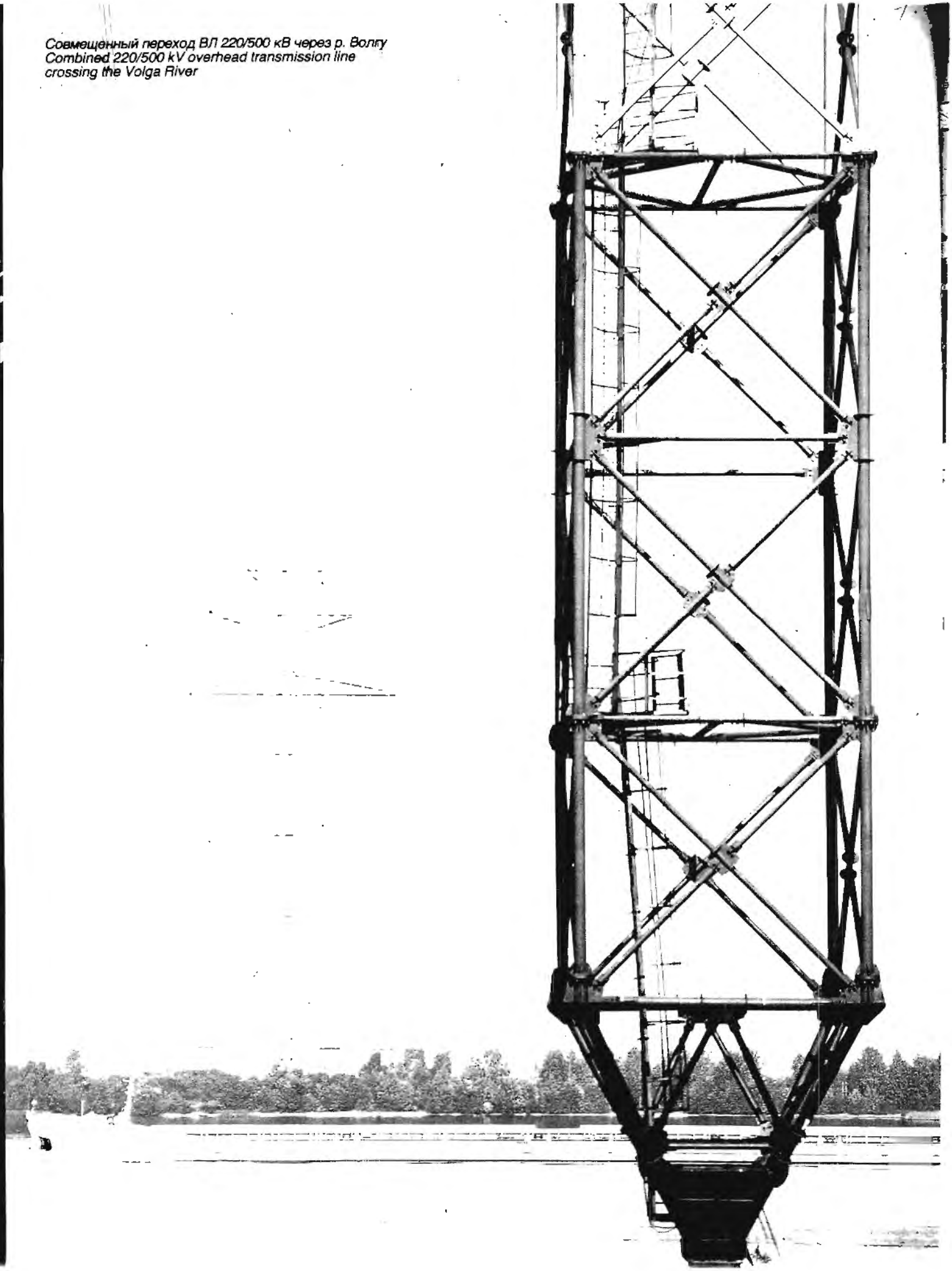
1
Распределительный пункт напряжением 10 кВ
10 kV distribution center

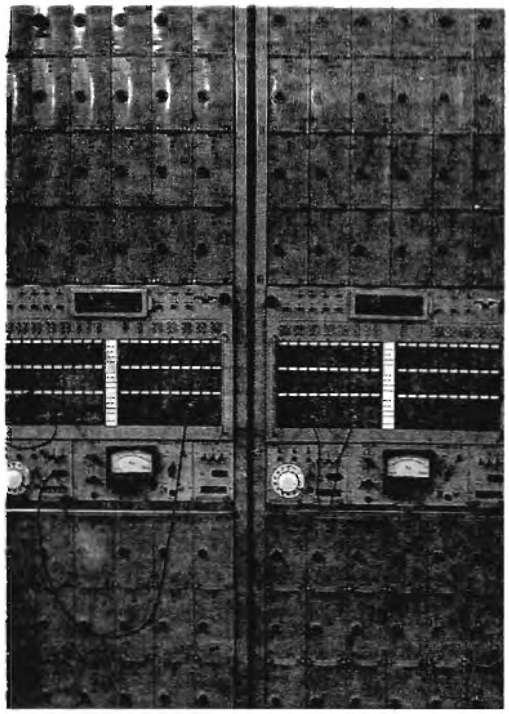
2
Учебный полигон
Training facility

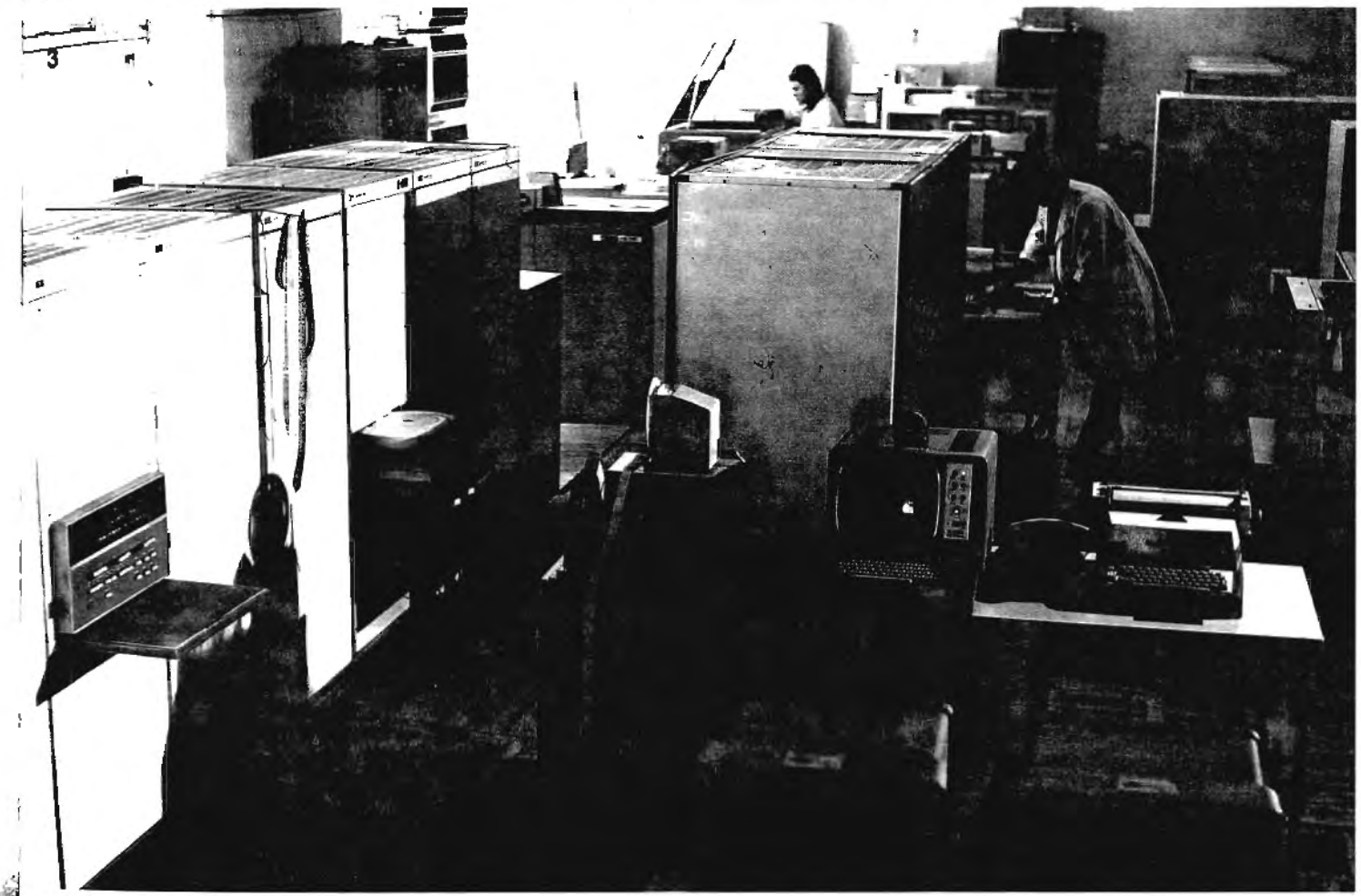




Совмещенный переход ВЛ 220/500 кВ через р. Волгу
Combined 220/500 kV overhead transmission line crossing the Volga River







1
В лаборатории радиотехнических измерений
Laboratory of radiotechnical measurements

2
В аппаратной центральной службы средств диспетчерского и технологического управления
Instrument room of load dispatching and process control service

3
В машинном зале АСУ энергосистемы
Machine room of computer based system control

4
В центральной мастерской по ремонту счетчиков проверятся качество ремонта
Current meter repair shop. Quality control

Перспективы развития энергосистемы

Энергетика области в ближайшие годы получит дальнейшее развитие, которое пойдет по нескольким направлениям. Во-первых, продолжится совершенствование экспериментального энергоблока и отработка оптимальных режимов его работы, которые позволят эксплуатировать блок с проектными показателями.

Уникальный энергоблок мощностью 1200 МВт олицетворяет энергетику будущего, представляет собой весомый практический шаг по пути технического прогресса. Среднегодовой удельный расход условного топлива стал ниже норматива при освоении блока на 12,3 г/кВт·ч, что дало экономию 54,2 тыс.т условного топлива. В 1985 г. намечено достигнуть проектного расхода условного топлива — 313 г/кВт·ч. При сооружении некоторых его объектов заложены возможности для установления на Костромской ГРЭС второго энергоблока мощностью 1200 МВт.

В настоящее время возводится Костромская АЭС, суммарная мощность которой составит 6 млн. кВт.

В ближайшие годы предстоит также расширить все теплоэлектроцентрали. На ТЭЦ-1 в 1987 г. планируется ввести восьмой котел паропроизводительностью 75 т/ч, на ТЭЦ-2 вступят в строй три водогрейных котла мощностью по 100 Гкал/ч, на Шарьинской ТЭЦ — два таких же котла, первый из которых вводится в 1985 г. Будет продолжено развитие тепловых и электрических сетей, осуществление организационно-технических мероприятий.

Стремительное нарастание энергетических мощностей „Костромаэнерго" происходило при высокой культуре производства, на основе передовых приемов труда. Благодаря этому, Костромская ГРЭС вскоре после ввода второй очереди стала одной из лучших электростанций Минэнерго СССР, добилась выдающихся результатов в освоении и эффективной эксплуатации оборудования. Это послужило добрым примером для других предприятий энергосистемы и помогло ей, подтянув другие подразделения до уровня передовика, стать одной из лучших энергосистем страны.

Работникам электростанций и сетевых предприятий „Костромаэнерго" созданы необходимые условия для плодотворного труда, представлены широкие возможности благополучно устроить свой быт и отдых. Рядом с Костромской ГРЭС построен поселок из многоэтажных домов со всеми коммунально-бытовыми удобствами, с торговыми, лечебными, детскими и культурными учреждениями. В Костроме для работников теплоэлектроцентралей и сетей возведены ведомственные жилые дома и детские дошкольные учреждения, а в новых микрорайонах, удачно преображающих старинный город, новоселья в отведенных им домах справляют и энергетики. В Шарьинском, Галичском, Нейском, Нерехтском и других районах электрических сетей в условиях сельской местности при РЭС выросли производственные базы и благоустроенные поселки городского типа, в которых работникам электрических сетей предоставлены квартиры и коммунально-бытовые услуги.

Построено рыбоводное хозяйство на теплых сбросных водах Костромской ГРЭС. Сейчас оно выросло в производственное-экспериментальное

Vistas of Power System Development

During the years to come the development of power industry in the region will follow several trends. First, work will continue on perfection of the experimental unit and optimization of its operating conditions which will ensure performance of the unit at the design ratings.

The unique 1200 MW unit embodies the future of the power industry and is an important contribution to the technological progress. The average annual specific consumption of ideal fuel dropped by 12.3 g/kWh against the level adopted at the commissioning of the unit into commercial service which saved 54,200 t of ideal fuel. In 1985 it is planned to reach the design fuel consumption of 313 g/kWh. When building some station facilities provision was made for the installation of the second 1200 MW unit.

At present, the Kostroma nuclear power plant of 6000 MW capacity is under construction.

In the nearest future, it is planned to expand all the heat-electric power stations. There are plans to install the eighth boiler of 75 t/h capacity at the ТЭЦ-2 station in 1987. Three more water heating boilers of 100 Gcal/h will come on stream at the ТЭЦ-2 station. Two similar boilers will be put in service at the Sharinskaya station. The first boiler will go into service in 1985. Work will go on to expand district heating and power networks and implementations of organizational and technological measures.

Rapid build-up of generating capacities in the "Kostromaenergo" power system took place in the environment of high professional efficiency based on advanced methods of work. On completion of the second stage, the Kostroma steam central power station became one of the best power stations in the USSR Ministry of Power and Electrification and achieved outstanding results in the operation and maintenance of power generating equipment. It has served a stimulating example for other system divisions to improve their operational efficiency and helped the power system to become one of the best in the country.

The system divisions provide an environment which encourages creative work of the employees and offers opportunities for enjoyable living and recreation. A high-rise township complete with all public services (such as shopping, health, and children's care centers, cultural and recreation facilities) was built in the vicinity of the Kostroma steam central power station. In Kostroma the station-owned dwelling houses and children's day care centers are built for the personnel employed at the heat-electric plants and distribution networks. Dwelling accommodations are also provided for the power system employees in the newly-built neighbourhoods which favourably fit into the old town setting. In the rural areas of Sharino, Galich, Neva, Nerechta and other districts, support facilities and modern townships for the operating personnel are built at the power stations.

A fish farm was set up to utilize the waste hot water discharges from the Kostroma steam central station. At present, it has grown into a pilot commercial enterprise with an annual fish yield of 1200 t. The basic product is carp. Experiments are being made, however, with breeding high-value fish, such as trout, sturgeon, silver carp, bester.

Fresh vegetables are being grown round the year in the green house complex which also utilizes the waste

2

3

4

1
Поселок энергетиков Костромской ГРЭС — Волгореченск
Volgorechensk, the township of the Kostroma steam central power station

2
Санаторий-профилакторий Костромской ГРЭС
Health-care centre of the Kostroma steam central power station

3
Танцевальный ансамбль работников Костромской ГРЭС
Dancing ensemble of the Kostroma steam central power station workers

4
Полносистемное рыбоводное хозяйство на теплых водах Костромской ГРЭС, бассейновое хозяйство
Fish farm using waste hot water from the Kostroma steam central power station; fish ponds

5
На экспериментальной базе рыбоводного хозяйства производятся рыбы различных ценных пород. Осетры
Experimental facility for breeding high-value fish. Sturgeon

6
Тепличное хозяйство
Green houses

предприятие, дающее ежегодно свыше 1200 т рыбы. Основу продукции составляет карп, на экспериментальной базе разводят ценные породы рыб: форель, осетр, толстолобик, бестер.

Свежие овощи выращиваются круглогодично в тепличном хозяйстве, построенном на тепле Костромской ГРЭС. Здесь производят томаты, огурцы, кабачки, редис, салат, лук и другую зелень.

Предмет постоянной заботы об энергетиках — их здоровье, высокая работоспособность, хороший настрой. В Волгореченске много лет действует санаторий-профилакторий, где ежегодно сотни тружеников энергосистемы лечатся и отдыхают в живописной местности под наблюдением квалифицированных врачей и медицинских сестер. На Костромской ГРЭС и на других предприятиях энергосистемы работают здравпункты и специализированные кабинеты, регулярно, в установленные сроки проводятся профилактические профессиональные медосмотры. Нуждающиеся получают путевки для санаторного и курортного лечения — бесплатно или за треть действительной стоимости (остальную часть оплачивают профсоюзы).

Большое внимание энергетики уделяют воспитанию своих детей. Для них построены красивые и удобные детские ясли и садики, игровые площадки при домах, школы, открыты студии музыкального и изобразительного искусства, спортивные секции, гимнастические залы, стадионы, лыжные базы. Летом дети энергетиков имеют возможность отдохнуть и укрепить здоровье в пионерских лагерях на лоне природы. На Костромской ТЭЦ-1 для детей работников станции построен пионерский лагерь „Березка", где все лето не умолкают звонкие детские голоса. Неподалеку от Волгореченска, на солнечной поляне в окружении вековых елей и сосен, поднимаются жилые корпуса и служебные помещения пионерского лагеря Костромской ГРЭС и энергостроителей. Ежегодно детей костромских энергетиков можно встретить во всесоюзных пионерских здравницах „Артек" и „Орленок" на песчаных пляжах Черного моря.

heat of the Kostroma steam central station. It produces tomatoes, cucumbers, vegetable marrow, salat, radish, spring onions and other vegetables.

Health care, ability to work efficiently and good spirits are of constant concern. A health care center functioning in Volgorechensk for many years. Hundreds of power system workers get medical treatment and rest in the picturesque setting under control of competent medical personnel. The Kostroma steam central station and other enterprises of the power system have medical stations and specialized medical service rooms. Occupation-oriented medical checkouts are conducted on a regular basis and those needing sanatorium or spa-treatment get it free of charge or at one third of the actual cost (the balance is paid by the trade unions).

Much attention is being given to children. Comfortable day-care centers, playing grounds, schools, sporting and recreation facilities are built for children. In summer time, they are offered opportunity to rest in the pioneer camps in the country-side. At the ТЭЦ-1 Kostroma plant a pioneer camp called "Berjezka" has been built for the children of the station personnel whose clear voices ring here all summer long. Dormatries and service buildings of the pioneer camp for the Kostroma steam central station personnel and builders stand at a sun-lit clearing surrounded by century-old pines and spruces not far away from Volgorechensk. Children of power workers from Kostroma are also sent to the all-Union pioneer resorts "Artek" and "Orlenok" at sand beaches of the Black sea shore.

Изо дня в день, круглые сутки, по линиям электропередачи передается из Костромы во все соседние области ток высокого напряжения. День за днем пишутся трудовые биографии костромских энергетиков — тружеников ведущей отрасли народного хозяйства. В труде и радости проходит их жизнь — жизнь большого накала и высокого духовного уровня.

Day by day round the clock, electric power at high tension is being transmitted by overhead lines from Kostroma to neighbouring regions. Working biographies of Kostroma power workers, the toilers of the leading industry, are being written day after day. In labour and joy passes their life, the life which is highly active and spiritually meaningful.

1
Служебно-бытовой корпус
Service building

2, 3
Детский комбинат Костромской ТЭЦ-2
Day-care complex of the ТЭЦ-2 Kostroma station

4
В столовой ТЭЦ-2
Canteen of the ТЭЦ-2 station

FOREIGN TRADE
ORGANISATION
ENERGOMACHEXPORT
MOSCOW USSR

ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 3
KOSTROMAENERGO
COMBINED HEAT AND POWER STATION TETS-2
PERFORMANCE DATA

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
27-Apr-92 1. Heating Load

		AVG TEMP C	DEG-DAYS (12 basis)
1990	1/90	-9.8	676
	2	-1.4	375
	3	-0.5	388
	4/90	7.3	141
	5	8.9	96
	6	14.4	0
	7/90	17.8	0
	8	15.8	0
	9	8.5	105
	10/90	3.4	267
	11	-2.9	447
	12	-5.3	536
1991	1/91	-5.3	536
	2	-7.9	557
	3	-3.4	477
	4/91	6.3	171
	5	13.2	0
	6	18.6	0
	7/91	17.5	0
	8	15.1	0
	9	9.7	69
	10/91	6.2	180
	11	0.0	360
	12	-6.1	561

ANNUAL TOTALS

1990	3,031
1991	2,912

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
27-Apr-92 2. Electricity Generation

		GROSS MWh	NET MWh	Station Use
1990	1/90	119600	108400	9.4%
	2	109900	100200	8.8%
	3	120800	109900	9.0%
	4/90	90600	81500	10.0%
	5	63200	56800	10.1%
	6	45900	40800	11.1%
	7/90	67400	61200	9.2%
	8	88100	80200	9.0%
	9	107900	98400	8.8%
	10/90	118300	107800	8.9%
	11	114500	103600	9.5%
	12	122500	110900	9.5%
1991	1/91	124700	112600	9.7%
	2	111900	101100	9.7%
	3	125500	114000	9.2%
	4/91	92800	83000	10.6%
	5	85500	77500	9.4%
	6	76700	69800	9.0%
	7/91	60600	55300	8.7%
	8	74700	68700	8.0%
	9	81500	73800	9.4%
	10/91	116100	106100	8.6%
	11	117100	106400	9.1%
	12	123100	111500	9.4%
AL TOTALS				
	1990	1168700	1059700	9.4%
	1991	1190200	1079800	9.2%

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
28-Apr-92 3. Heat Sales

		TETS-2 Gcal
1990	1/90	250,000
	2	190,500
	3	209,600
	4/90	152,800
	5	104,100
	6	69,400
	7/90	56,800
	8	64,400
	9	136,900
	10/90	182,500
	11	215,900
	12	241,300
1991	1/91	282,000
	2	255,400
	3	234,800
	4/91	176,800
	5	109,400
	6	60,300
	7/91	53,700
	8	59,600
	9	112,400
	10/91	155,000
	11	198,600
	12	259,100

AL TOTALS

1990	1,874,200
1991	1,957,100

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
27-Apr-92 4. Fuel Consumption

		Oil tons	Gcal	Gas m3	Gcal	Total Gcal	TYI USSR
1990	1/90	35163	334049	13971000	113165	447214	64944
	2	19166	182077	22046000	178573	360650	51964
	3	18050	171475	26062000	211102	382577	54945
	4/90	10393	98734	22585000	182939	281672	40211
	5	6834	64923	17265000	139847	204770	29250
	6	8104	76988	9870000	79947	156935	22600
	7/90	5459	51861	18628000	150887	202747	28879
	8	10713	101774	18630000	150903	252677	36236
	9	15743	149559	19390000	157059	306618	44145
	10/90	18662	177289	23137000	187410	364699	52409
	11	30779	292401	13571000	109925	402326	58192
	12	28973	275244	21828000	176807	452050	65156
1991	1/91	31131	295745	24027000	194619	490363	70974
	2	31174	296153	17919000	145144	441297	64071
	3	17991	170915	33525000	271553	442467	63585
	4/91	14306	135907	22530000	182493	318400	45569
	5	10099	95941	21026000	170311	266251	38108
	6	4743	45059	23165000	187637	232695	33048
	7/91	2314	21983	21446000	173713	195696	28262
	8	7042	66899	20371000	165005	231904	33215
	9	10089	95846	21420000	173502	269348	38657
	10/91	16537	157102	24970000	202257	359359	51867
	11	21270	202065	21607000	175017	377082	54410
	12	30961	294130	19800000	160380	454510	65724
AL TOTALS							
	1990	208039	1976371	226983000	1838562	3814933	548931
	1991	197657	1877742	271806000	2201629	4079370	587490

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
28-Apr-92

5. Performance ratios

		Heat Rate USSR g/kWh	Heat Rate Euro kcal/kWh	Station Use for elec gen	Station Use for dist htg kWh/Gcal
1990	1/90				
	2				
	3				
	4/90				
	5				
	6				
	7/90				
	8				
	9				
	10/90				
	11				
	12				
1991	1/91	202.1	1,415	2.6%	31.7
	2	201.8	1,413	2.5%	31.3
	3	205.5	1,439	3.2%	32.0
	4/91	183.8	1,287	3.0%	36.1
	5	250.2	1,751	5.1%	33.6
	6	250.8	1,756	6.5%	32.3
	7/91	345.4	2,418	6.2%	30.0
	8	335.4	2,348	5.8%	25.9
	9	263.5	1,845	5.1%	31.7
	10/91	239.2	1,674	4.4%	31.6
	11	192.2	1,345	3.7%	32.2
	12	192.1	1,345	3.2%	30.0
AL TOTALS					
	1990				
	1991	238.5	1,670	4.3%	31.5

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
28-Apr-92

6. Efficiency ratios
Corrected (see below)
Gcal/degday

1990	1/90	281
	2	348
	3	386
	4/90	658
	5	459
	6	
	7/90	
	8	
	9	732
	10/90	459
	11	349
	12	338
1991	1/91	414
	2	351
	3	366
	4/91	683
	5	
	6	
	7/91	
	8	
	9	759
	10/91	528
	11	385
	12	355

AL TOTALS

1990	446
1991	480

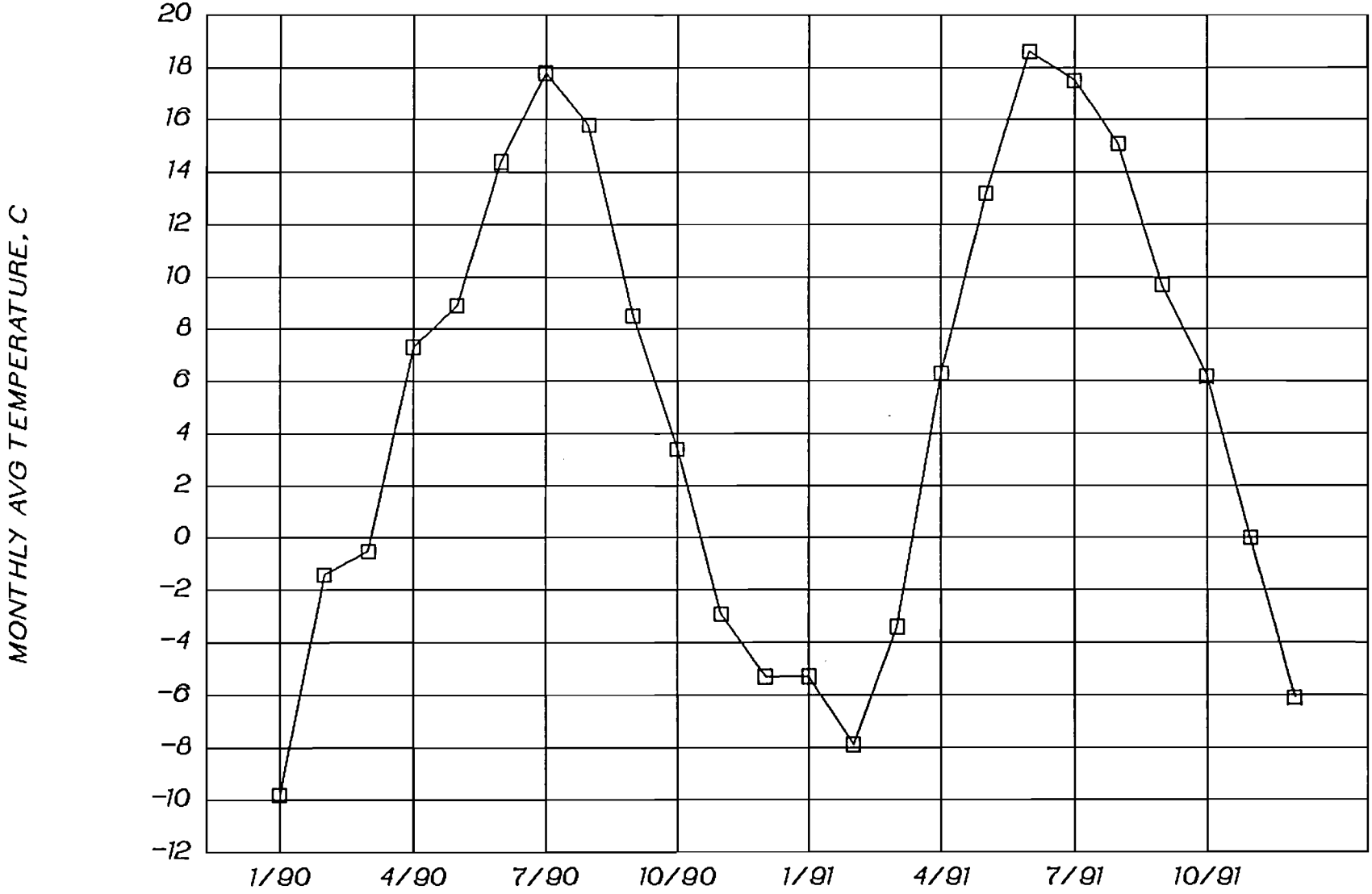
Corrected - Gcal supply minus 60,000 Gcal/month
to account for fixed losses and domestic water htg

KOSTROMAENERGO COMBINED HEAT AND POWER STATION NO. 2 (TETS-2)
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
27-Apr-92

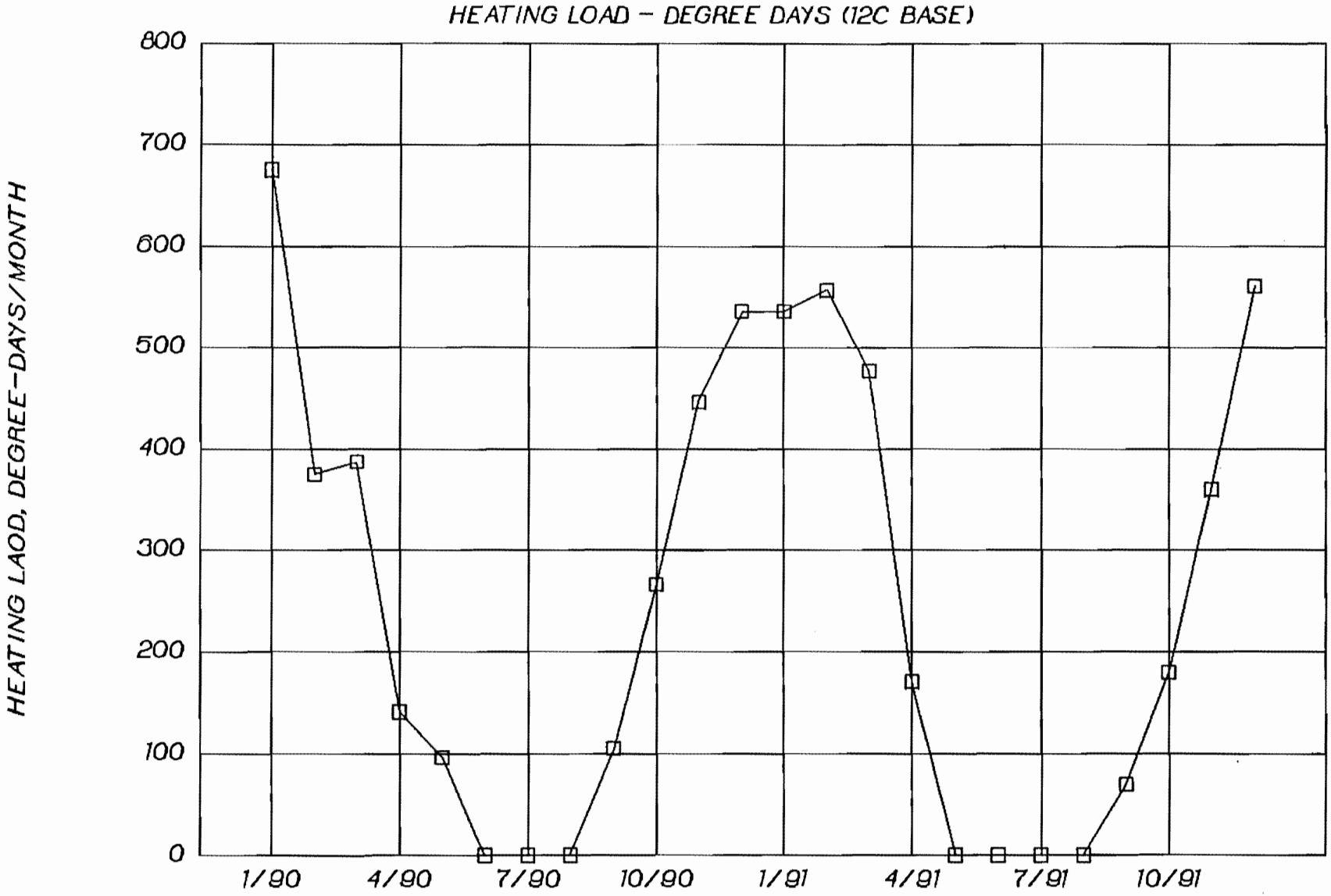
		6. Efficiency ratios	7. Normalized supply/demand		
			SUPPLY	DEMAND	
		Gcal/degday			
1990	1/90	281	0.887	1.000	
	2	348	0.676	0.629	
	3	386	0.743	0.644	
	4/90	658	0.542	0.341	
	5	459	0.369	0.285	
	6		0.246	0.167	
	7/90		0.201	0.167	
	8		0.228	0.167	
	9	732	0.485	0.296	
	10/90	459	0.647	0.495	
	11	349	0.766	0.718	
	12	338	0.856	0.828	
1991	1/91	414	1.000	0.828	
	2	351	0.906	0.854	
	3	366	0.833	0.755	
	4/91	683	0.627	0.378	
	5		0.388	0.167	
	6		0.214	0.167	
	7/91		0.190	0.167	
	8		0.211	0.167	
	9	759	0.399	0.252	
	10/91	528	0.550	0.388	
	11	385	0.704	0.611	
	12	355	0.919	0.859	
AL TOTALS					
	1990	446	0.554	0.478	1.16
	1991	480	0.578	0.466	1.24

KOSTROMA DISTRICT HEATING

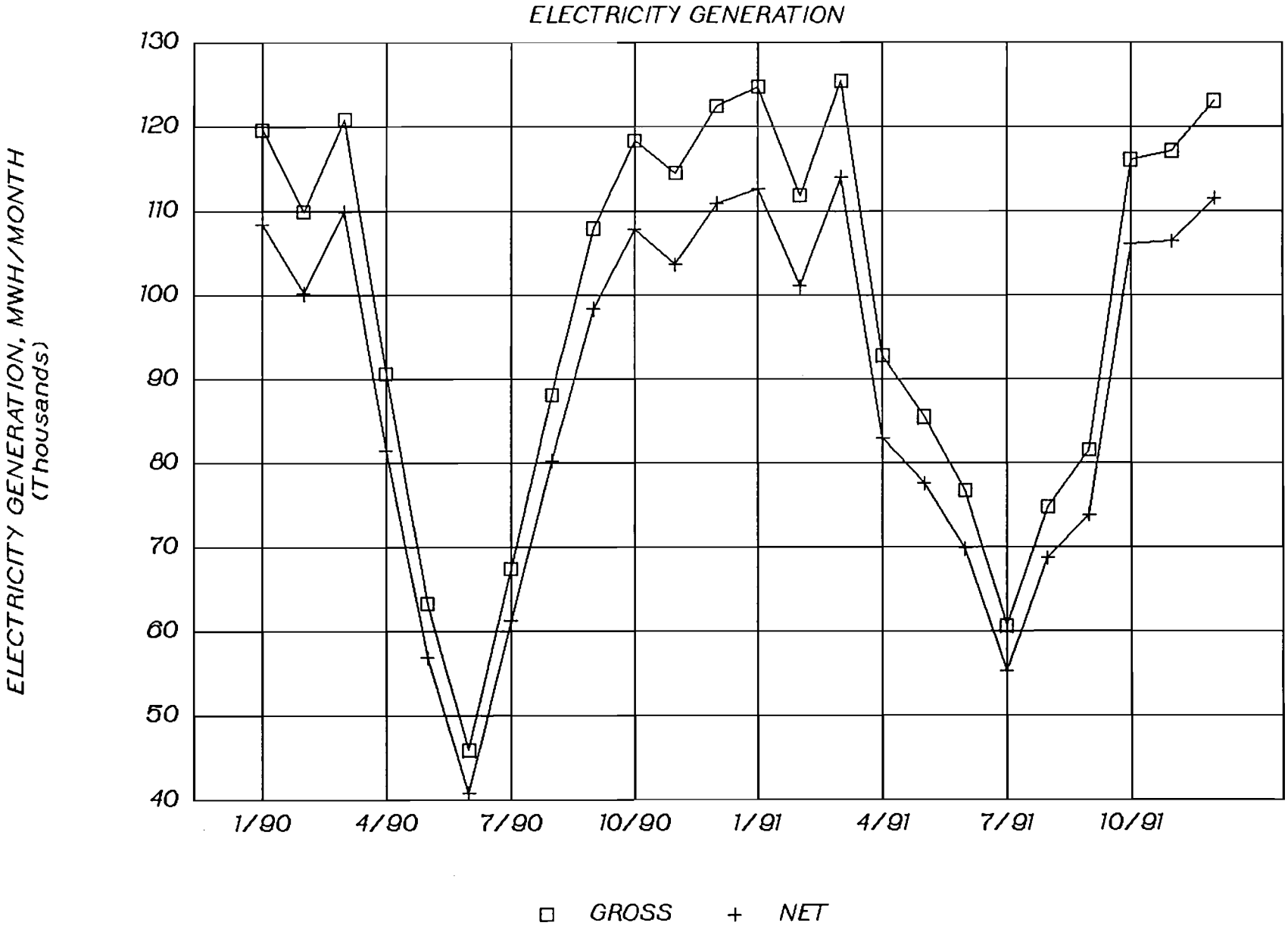
HEATING LOAD – AVG AMBIENT TEMPERATURE



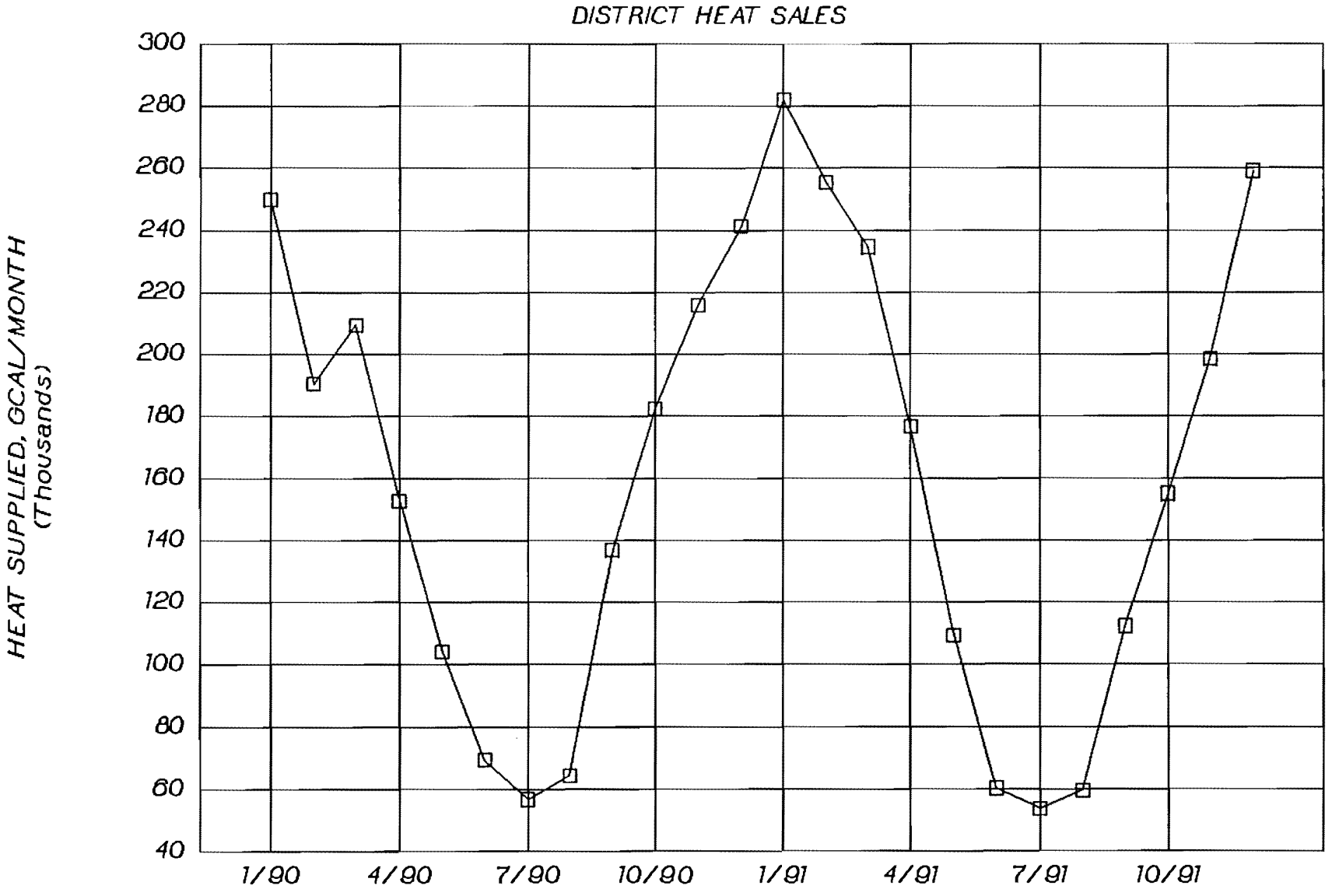
KOSTROMA DISTRICT HEATING



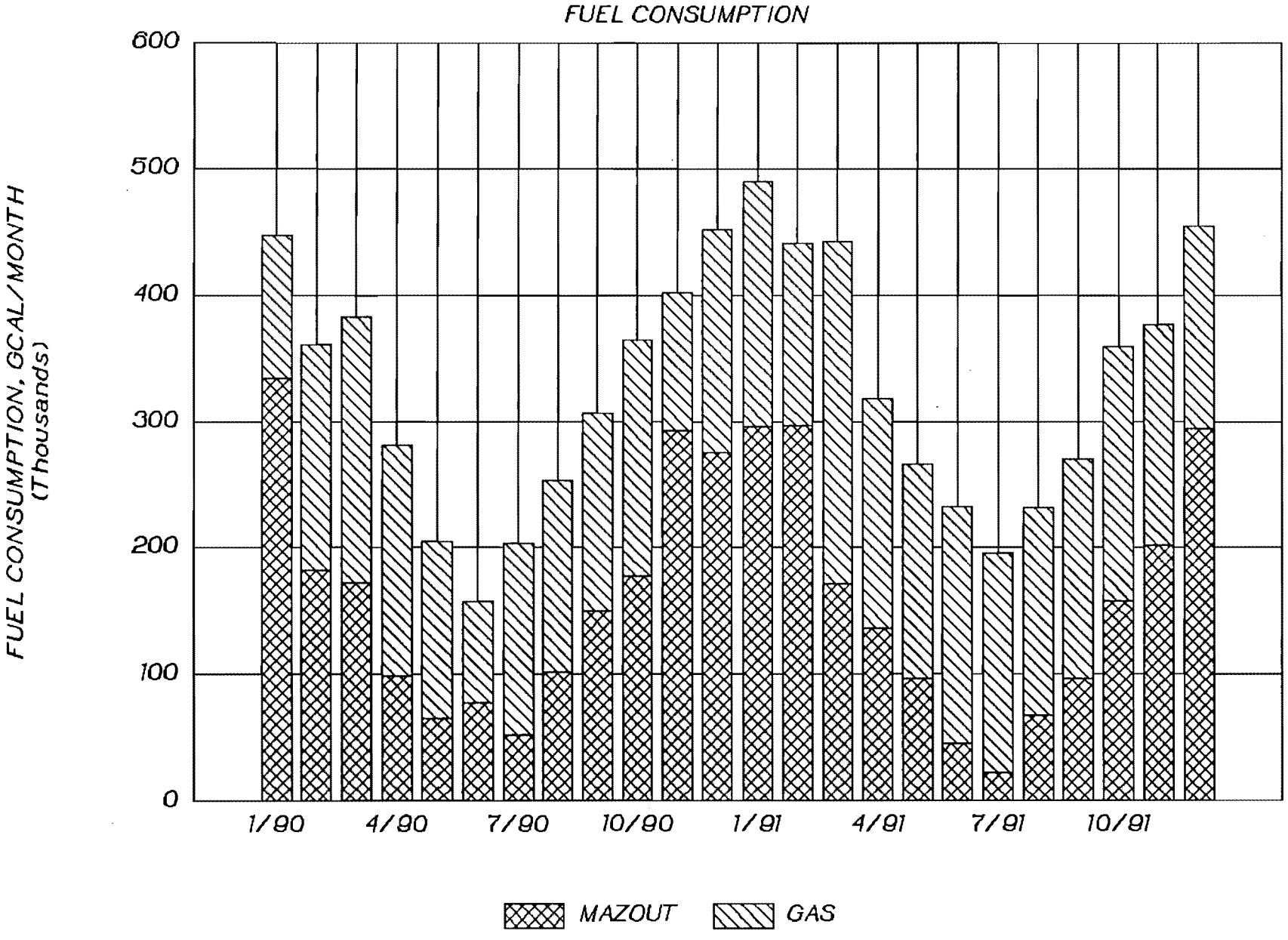
KOSTROMA DISTRICT HEATING - TETS-2



KOSTROMA DISTRICT HEATING - TETS-2

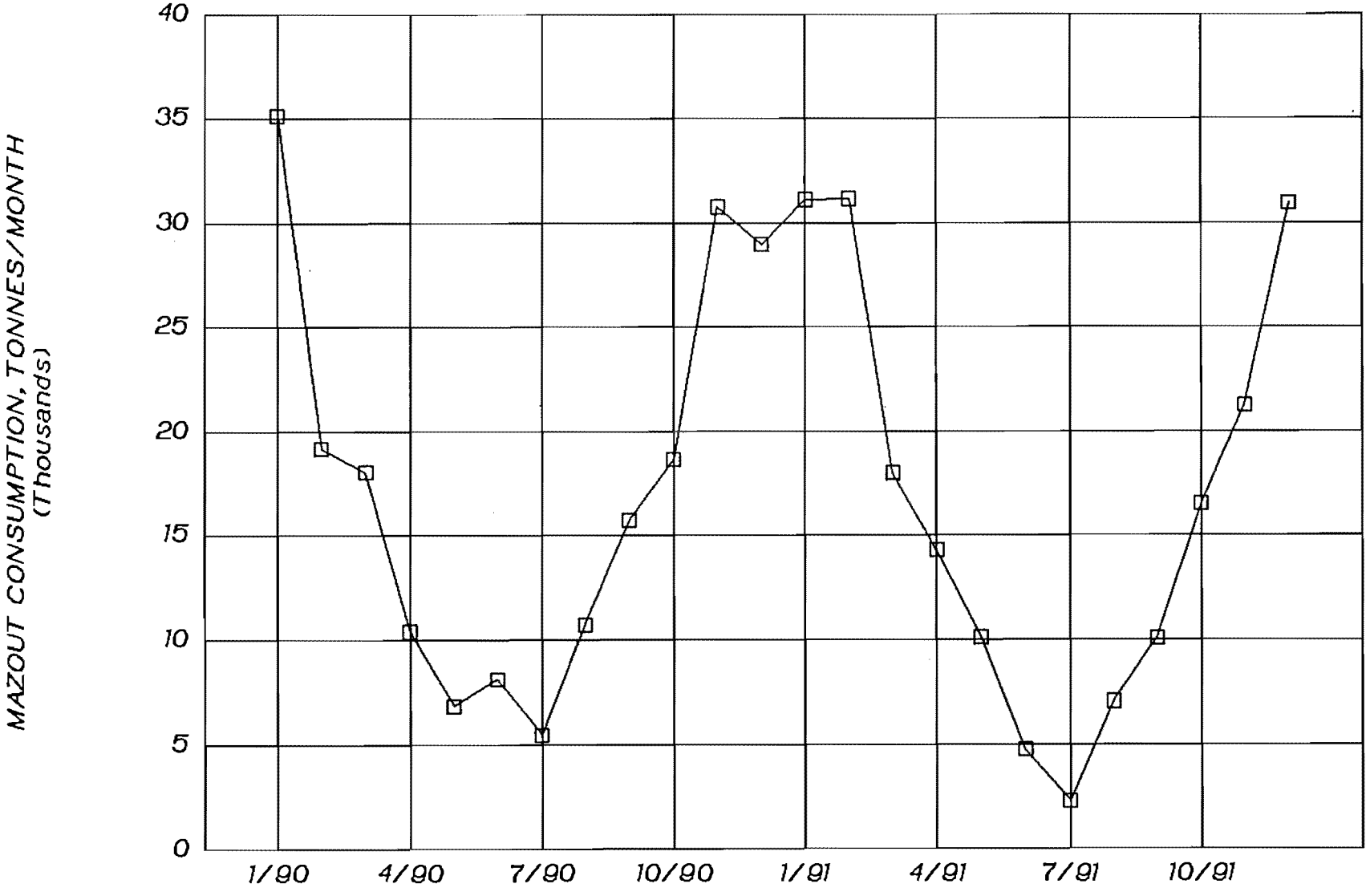


KOSTROMA DISTRICT HEATING - TETS-2



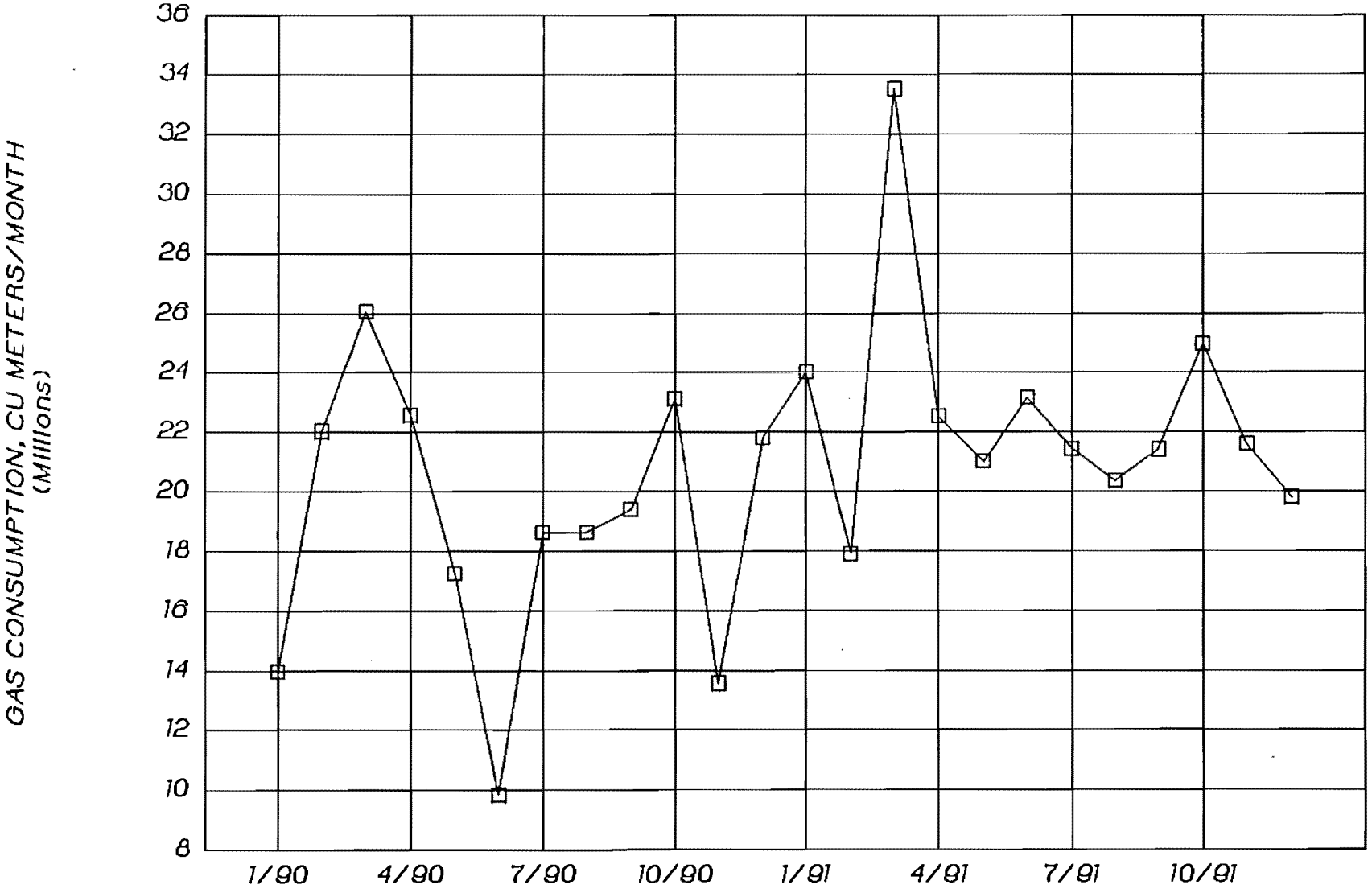
KOSTROMA DISTRICT HEATING - TETS-2

FUEL CONSUMPTION: HEAVY FUEL OIL

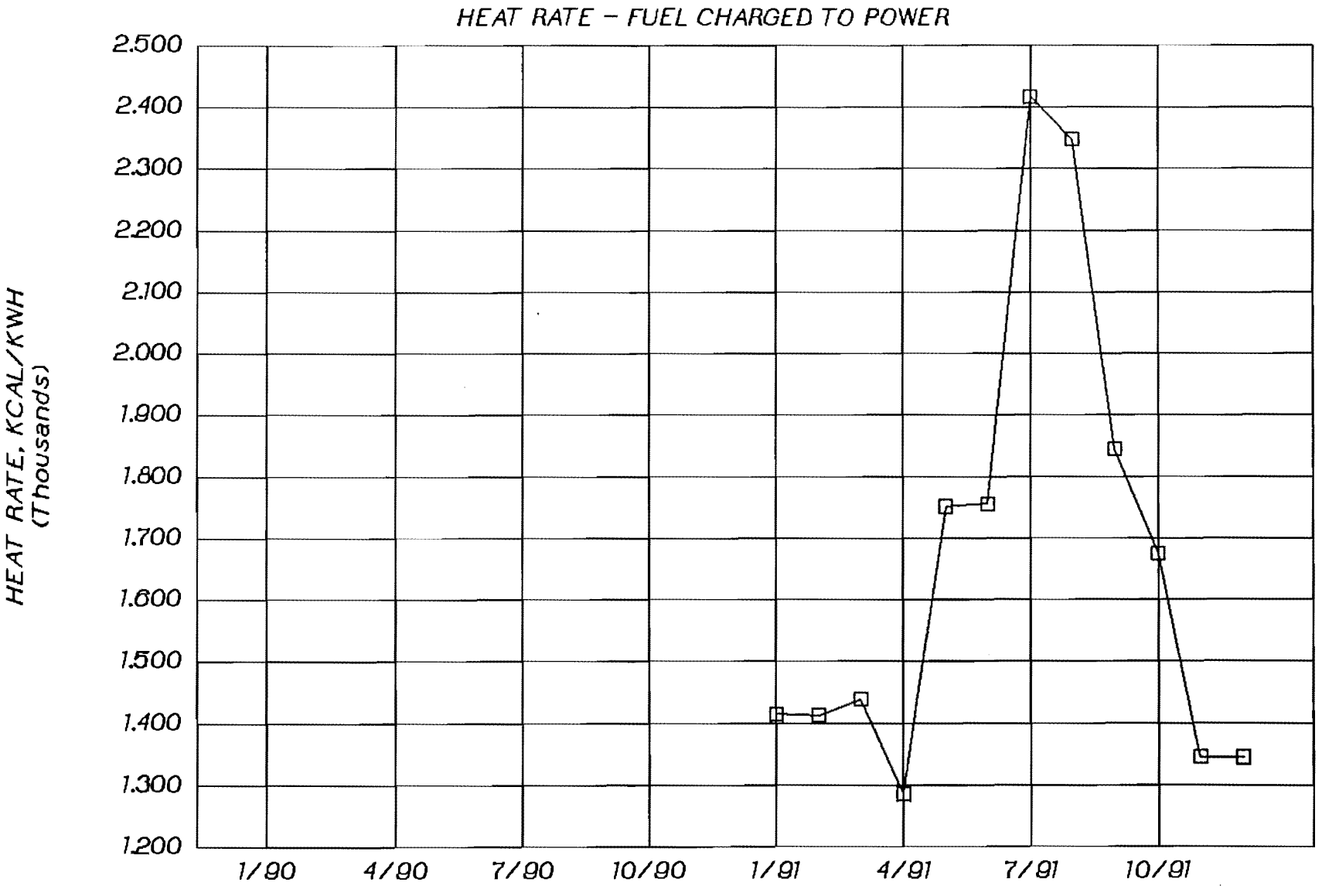


KOSTROMA DISTRICT HEATING - TETS-2

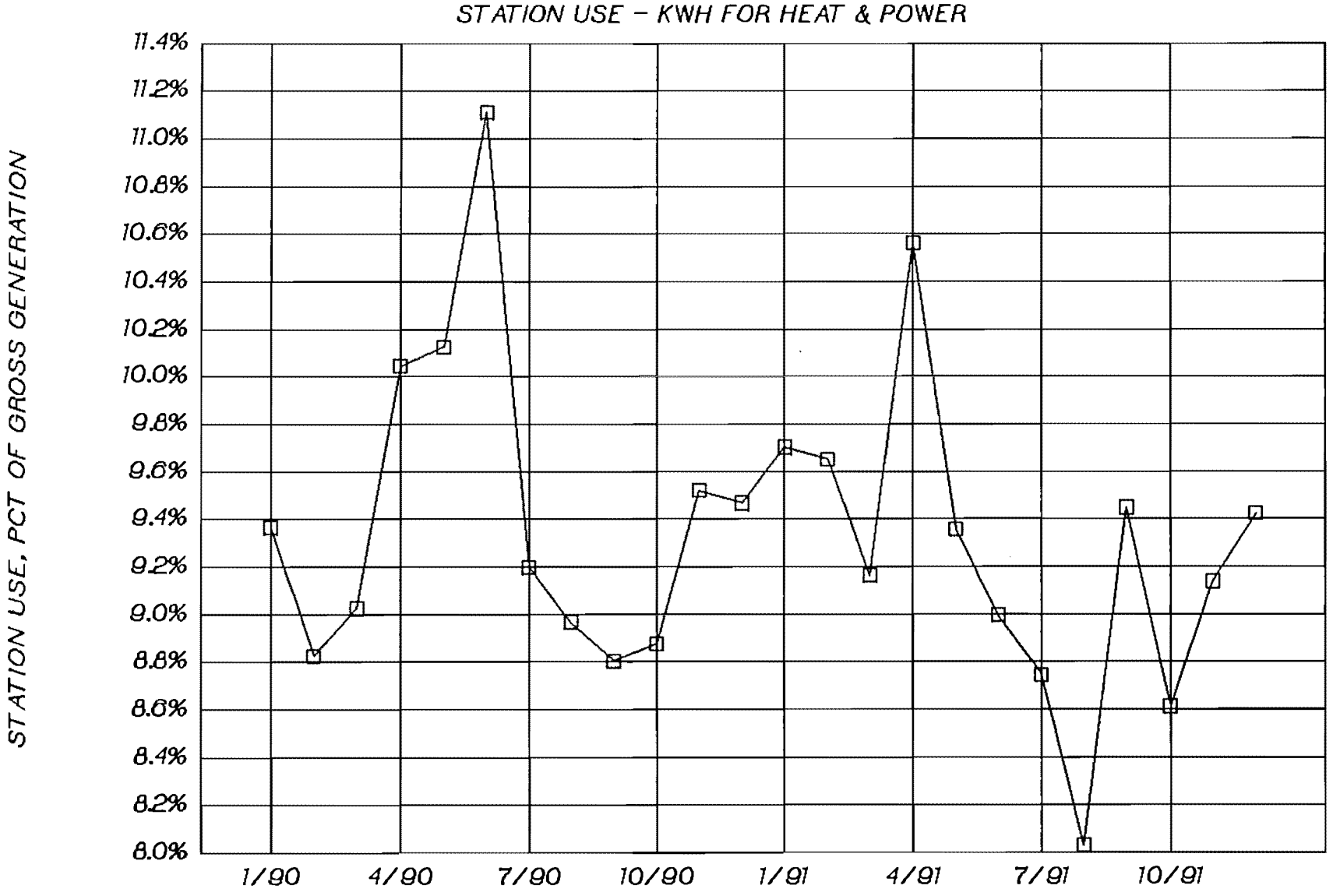
FUEL CONSUMPTION: NATURAL GAS



KOSTROMA DISTRICT HEATING - TETS-2

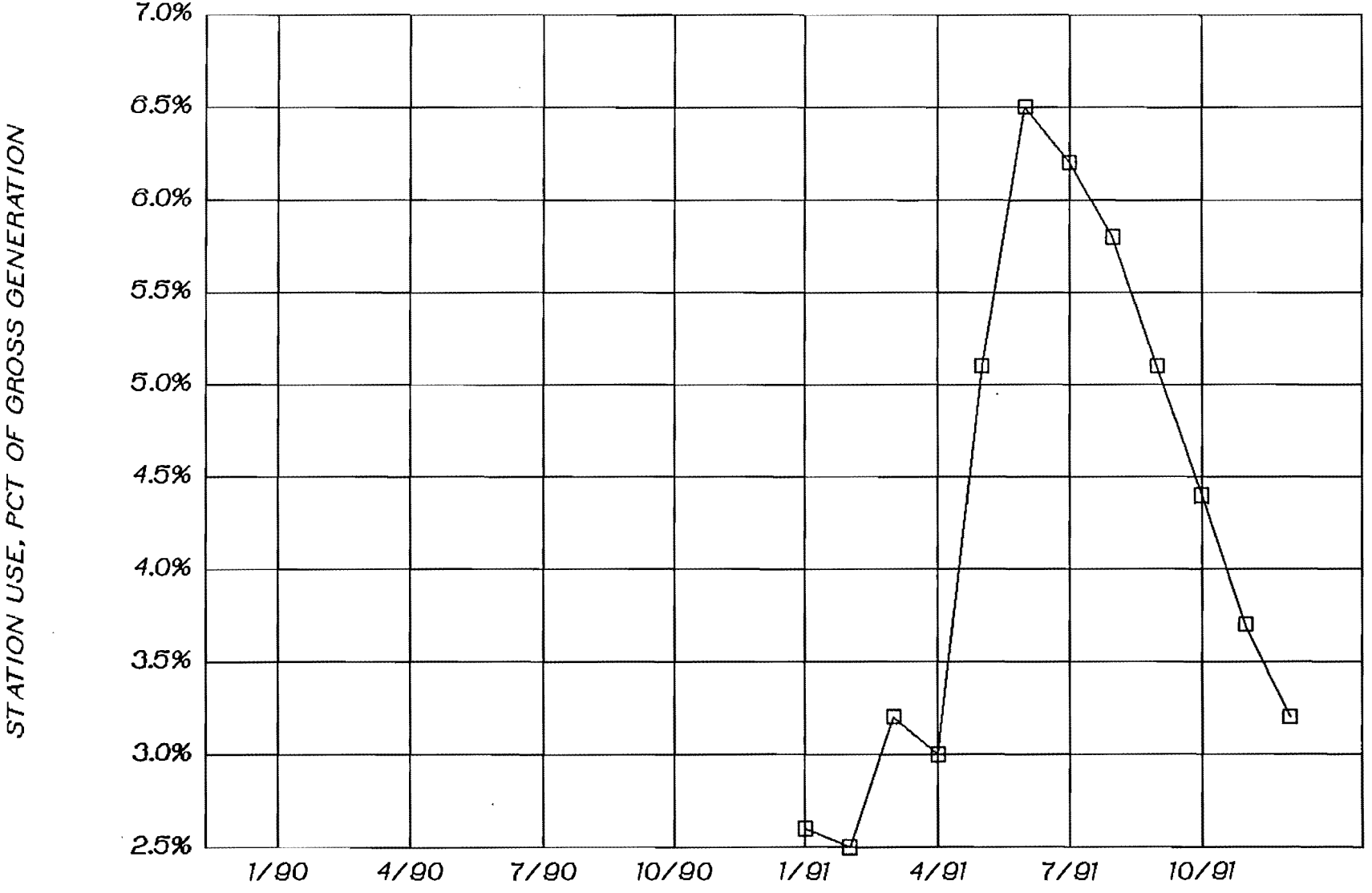


KOSTROMA DISTRICT HEATING - TETS-2

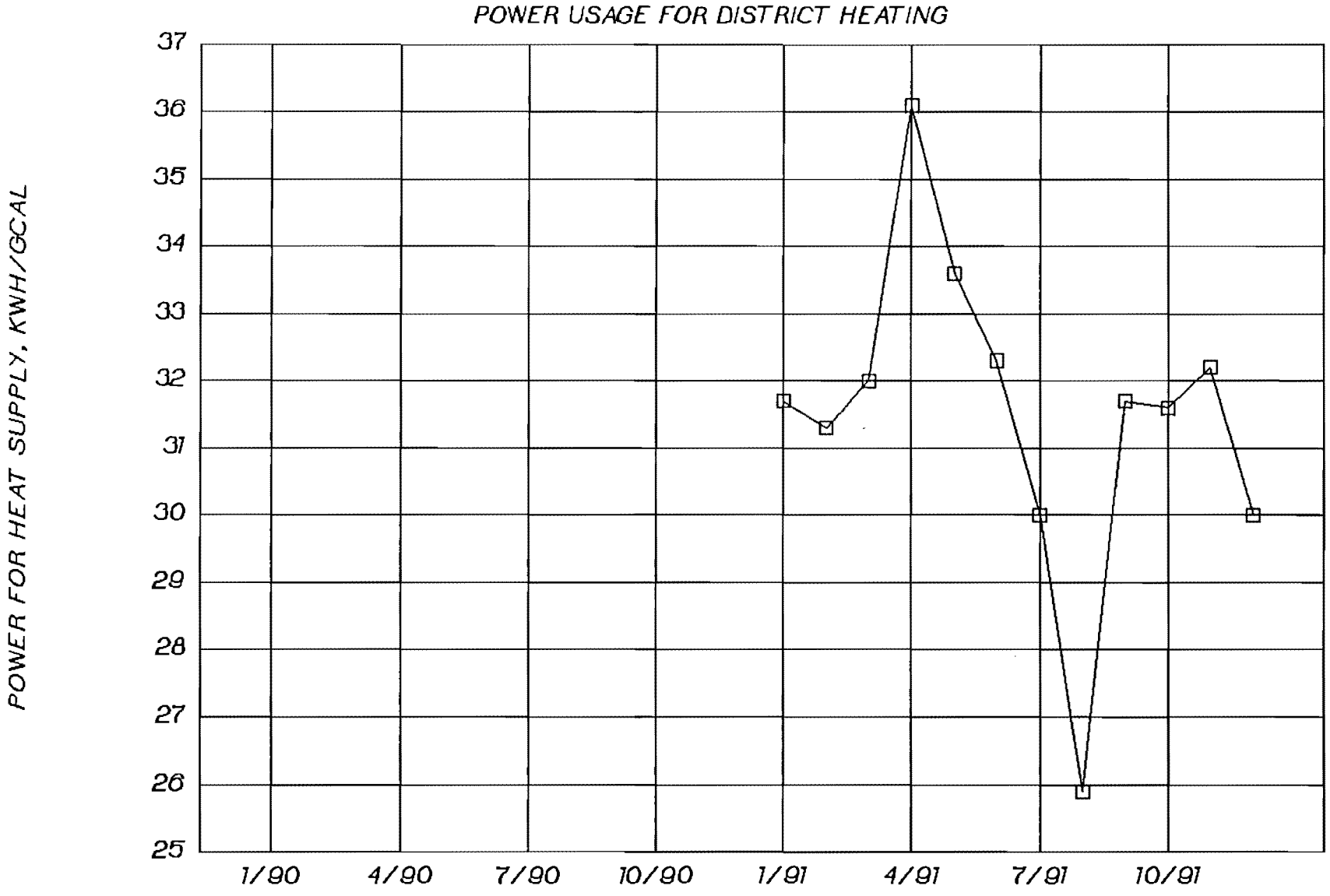


KOSTROMA DISTRICT HEATING - TETS-2

STATION USE OF ELECTRICITY FOR POWER

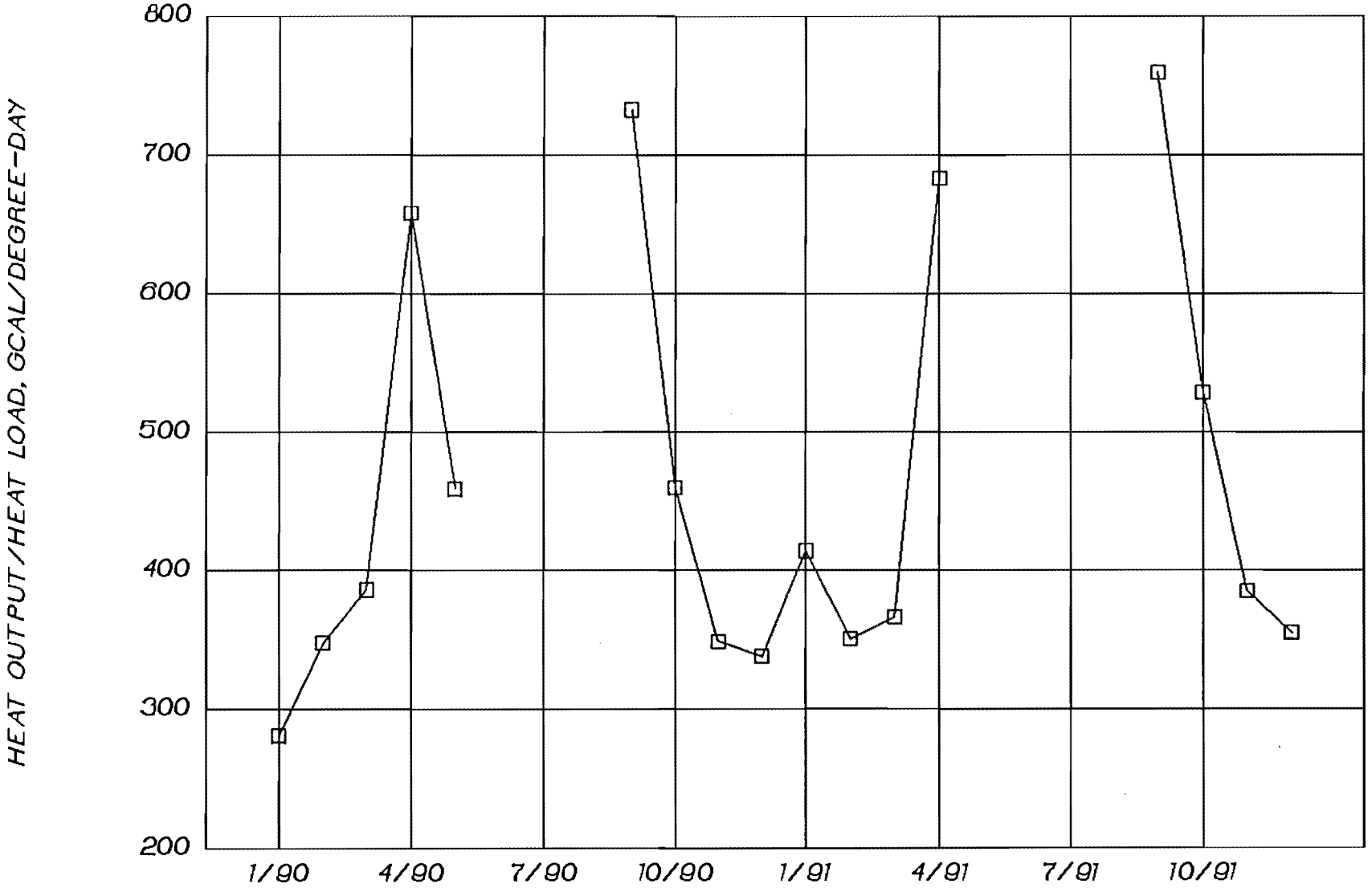


KOSTROMA DISTRICT HEATING - TETS-2



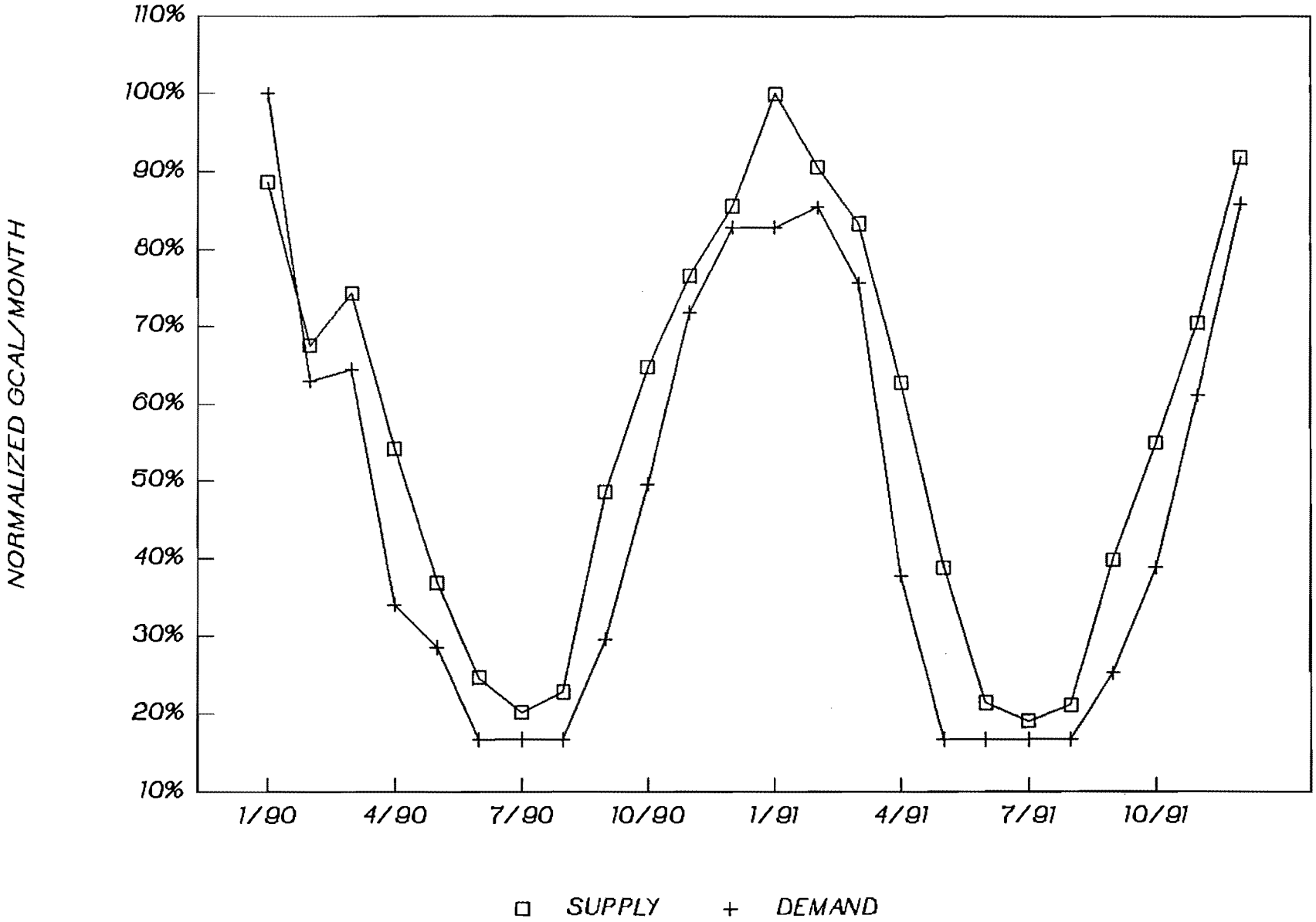
KOSTROMA DISTRICT HEATING - TETS-2

HEATING EFFICIENCY: HEAT SUPPLY/DEMAND



KOSTROMA DISTRICT HEATING - TETS-2

HEATING EFFICIENCY: HEAT SUPPLY/DEMAND



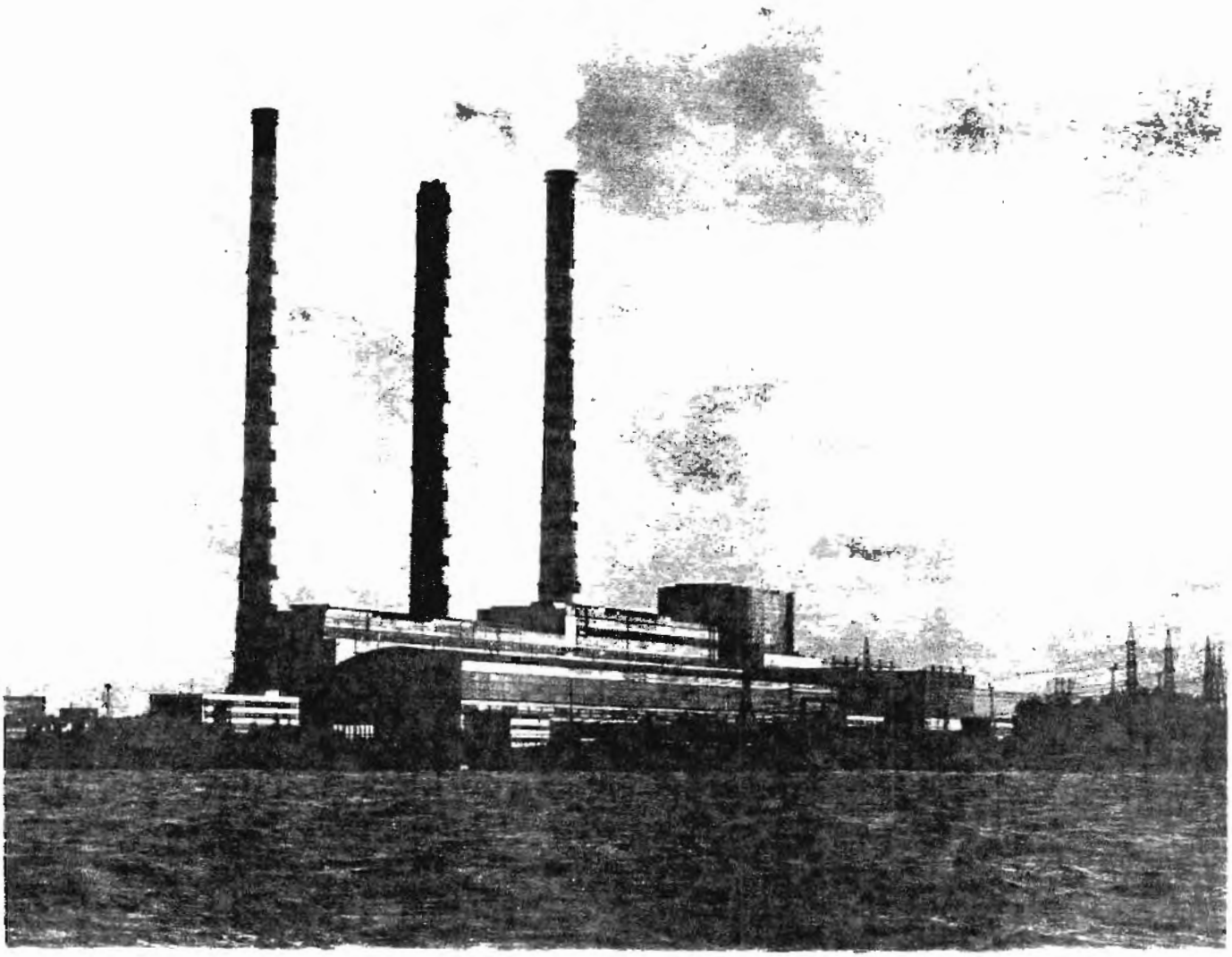
ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

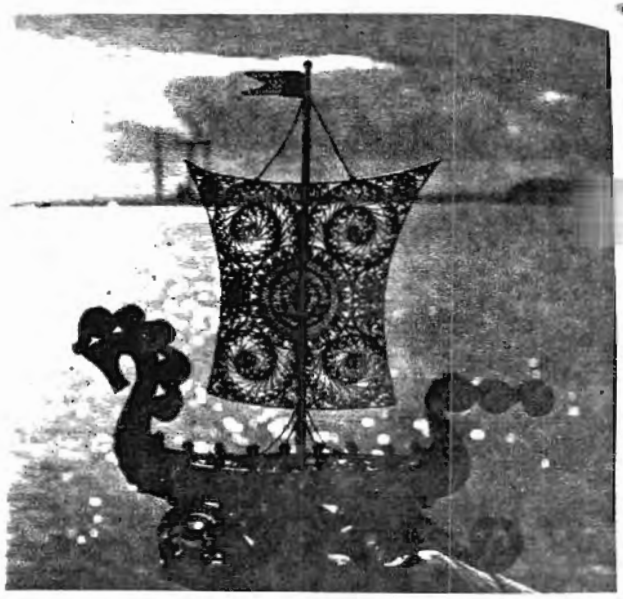
APPENDIX 4
BROCHURE OF KOSTROMAENERGO GRES
3,600 MW STEAM POWER STATION

Костромская тепловая электростанция

Kostroma Thermal Power Station

Centrale termo-électrique de Kostroma





Ипатьевский монастыь – один из ценнейших памят-ников стаоины. основан в XIII в

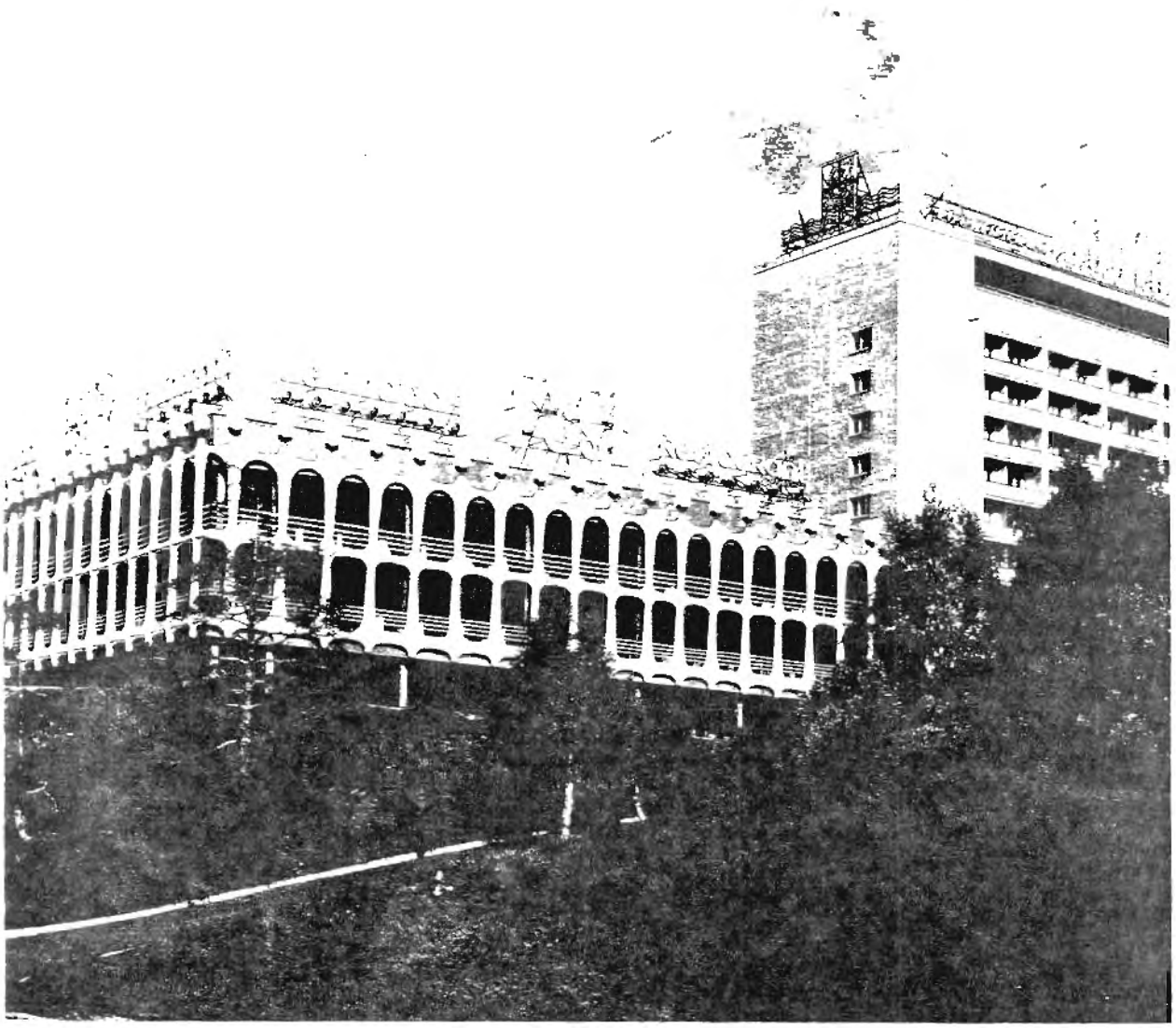
Ipatiev monastery – one of the most valued ancient monuments founded in the XIIIth century

Monastere d'Ipatiev – un des plus precieux monuments du passe. fonde au XIII s

Древней Костроме исполнилось более 830 лет, но сейчас город, да и вся Костромская область снова переживают период юности. Этому во многом способствовало сооружение Костромской тепловой электростанции и нового города энергетиков Волгореченска.

The ancient city of Kostroma is over 830 years old, but the city itself and the Kostroma region are going through the period of rejuvenation. This is in a great measure due to the construction of the Kostroma steam central power station and a new town of the station's personnel named Volgorechensk.

L'ancienne Kostroma est âgée de plus de 830 ans mais pourtant la ville et toute la région de Kostroma retrouvent leur période de jeunesse, ce qui a été favorisé en grande partie par la construction de la centrale thermo-électrique de Kostroma et de la jeune Cité du personnel exploitant, Volgoretchensk.



Гостиница «Волга», ресторан «Русь». Бережно сохраняя приметы прошлого, костромичи находят интересные архитектурные решения.

Hotel «Volga», restaurant «Rus». Preserving tokens of the past, Kostromites find interesting architectural solutions.

Hôtel «Volga», restaurant «Russie». Tout en conservant soigneusement les signes du passé, les Kostromites trouvent des solutions architecturales intéressantes.

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Костромская тепловая электростанция

Одним из важнейших направлений улучшения технико-экономических показателей в электроэнергетике является укрупнение единичных мощностей электростанций и агрегатов.

Яркий пример достижений советской электроэнергетики в этой области представляет собой Костромская ГРЭС мощностью 3600 МВт, которая была пионером в освоении энергоблоков мощностью 300 МВт и головного уникального энергоблока с одновальной турбиной мощностью 1200 МВт.

Электростанция входит в энергетическую систему Костромаэнерго и через нее – в объединенную энергетическую систему центра СССР.

Строительство электростанции осуществлялось в три очереди. В первой очереди установлены четыре дубль-блока мощностью по 300 МВт с двухкорпусными газомазутными котлами паропроизводительностью 950 т/ч; во второй очереди – четыре моноблока по 300 МВт с однокорпусными газомазутными котлами паропроизводительностью 950 т/ч. В составе всех энергоблоков работают паровые турбины мощностью по 300 МВт на параметры пара 240 кгс/см², 540/540 °С.

Энергоблоки мощностью по 300 МВт вводились в эксплуатацию с июня 1969 г. по июль 1973 г. На третьей очереди электростанции установлен и успешно освоен в эксплуатации уникальный головной энергоблок 1200 МВт, превышающий всю энергетическую мощность дореволюционной России.

Kostroma Thermal Power Station

One of the basic ways to upgrade performance characteristics in the power industry is to increase the capacity of the power stations and units.

The Kostroma steam central power station of 3600 MW capacity is a vivid example of Soviet accomplishments in this field. The Kostroma station pioneered commercial use of 300 MW units and the experimental tandem turbine-generator unit of 1200 MW.

The station is integrated into the "Kostromaenergo" power system which is linked to the Interconnected power system of the USSR Centre.

The station has been built in three stages. During the 1st stage four 300 MW two-boiler single-turbine units with two-furnace gas-and-oil-fired boilers of 950 t/h capacity were installed. During the 2nd stage four 300 MW single units with single-furnace gas-and-oil-fired boilers of 950 t/h capacity were installed. All the units incorporate 300 MW steam turbines designed for steam pressure of 240 kgf/cm² and temperature of 540/540 °C.

The 300 MW units were commissioned between June, 1969 and July, 1973. During the 3d stage of construction a 1200 MW unique experimental unit with its capacity exceeding the aggregate capacity of prerevolutionary Russia was erect-

Centrale thermo-électrique de Kostroma

L'une des principales orientations pour améliorer les caractéristiques techniques et économiques de la production d'énergie électrique consiste dans l'augmentation de la puissance unitaire des centrales et des groupes.

Un exemple remarquable des progrès en matière de production d'énergie électrique obtenus en URSS est la centrale thermo-électrique de Kostroma d'une puissance de 3600 MW, pionnier dans la mise en service de tranches thermiques de 300 MW et la première tranche de 1200 MW, unique de ce genre, avec une turbine à une seule ligne d'arbre.

La centre est couplée au réseau de Kostroma et à travers de celui-ci au réseau d'interconnexion du Centre d'URSS.

La centrale a été construite en trois étapes. En première étape, quatre tranches doubles de 300 MW chacune ont été installées avec chaudières à deux corps, d'un débit de vapeur de 950 t/h, chauffées au mazout et au gaz; en deuxième étape, quatre tranches simples de 300 MW chacune, avec chaudière à corps unique de 950 t/h chauffées au mazout et au gaz naturel. Toutes ces tranches sont équipées de turbines à vapeur d'une puissance de 300 MW pour les caractéristiques de vapeur de 240 kg/cm² et 540/540 °C.

Les tranches thermiques de 300 MW ont été mises en service de juin 1969 à juillet 1973. En troisième étape de construction de la centrale, a été mise en service et a fonctionné avec succès la tranche thermique de 1200 MW, unique de ce genre et dont la puissance est supérieure au total de la puissance de la Russie d'avant révolution.

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План расположения основных сооружений электростанции:
1 – главный корпус энергоблоков 300 МВт; 2 – главный корпус энергоблока 1200 МВт;
3 – дымовые трубы; 4 – инженерно-бытовой корпус; 5 – мазутное хозяйство; 6 – береговые насосные станции;
7 – подводящий канал;
8 – сбросные каналы;
9 – очистные сооружения;
10 – ОРУ 220 кВ;
11 – ОРУ 500 кВ; 12 – стройбаза

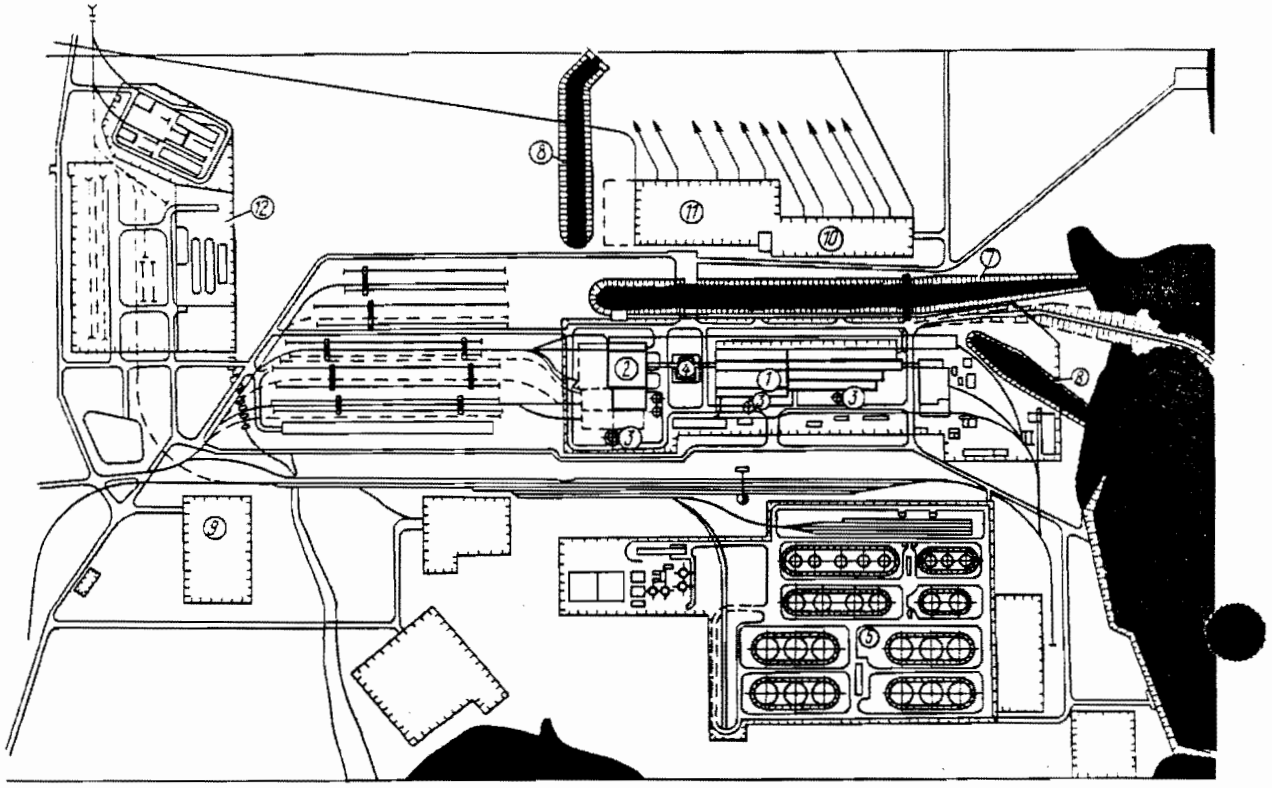
Layout of power station main structures:
1 – main building accommodating 300-MW units; 2 – main building for 1200-MW unit;
3 – stacks; 4 – service building;
5 – fuel handling facility;
6 – shore pump plants; 7 – intake canal; 8 – discharge canals;
9 – waste disposal plant;
10 – 220-kV switchyard;
11 – 500-kV switchyard;
12 – building facility

Plan des ouvrages principaux de la centrale thermique:
1 – bâtiment principal des tranches 300 MW; 2 – bâtiment principal de la tranche 1200 MW;
3 – cheminées; 4 – bâtiment de commande; 5 – parc à mazout;
6 – stations de pompage en bord de l'eau; 7 – canal d'amenee; 8 – canaux de rejet;
9 – installations d'epuration;
10 – poste exterieur 220 kV;
11 – poste exterieur 500 kV;
12 – installations du chantier

Машинный зал энергоблоков 300 МВт

Turbine room of 300-MW units

Salle des machines des tranches 300 MW



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блоков

N units

tranches

Главный корпус с энергоблоками 300 МВт. Поперечный разрез

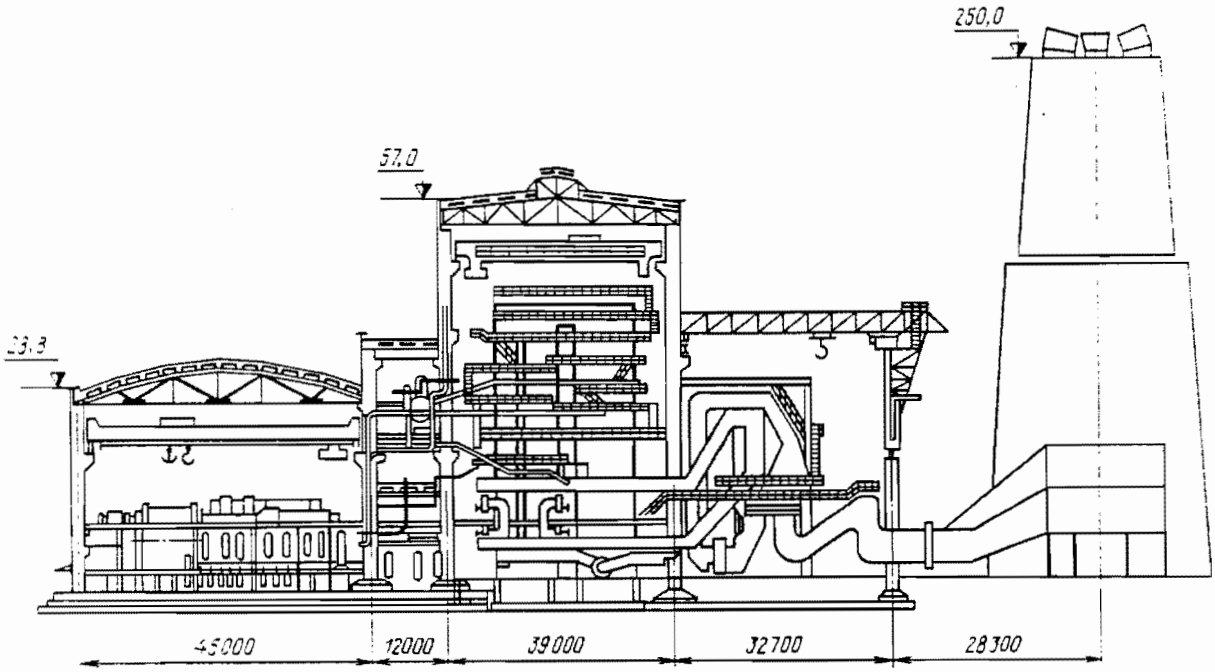
Main building accommodating 300-MW units. Sectional view

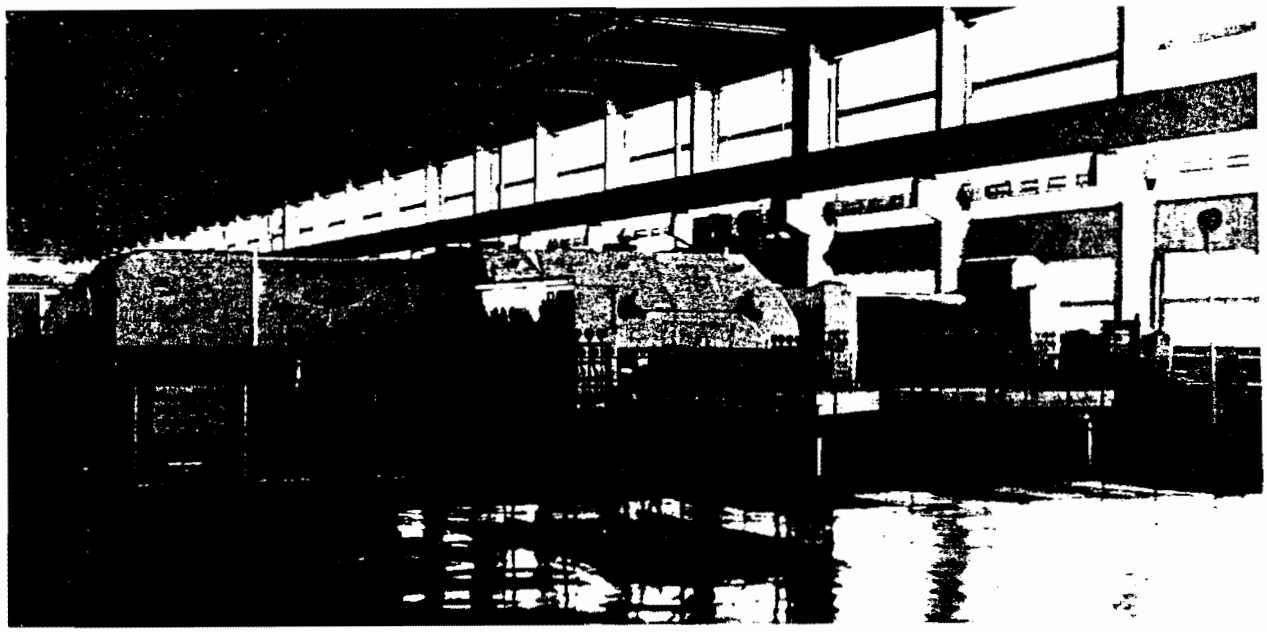
Bâtiment principal des tranches 300 MW. Coupe en travers

Одновальный турбоагрегат энергоблоков 300 МВт

Tandem turbine unit of 300 MW

Turbine à une seule ligne d'arbre des tranches 300 MW





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Щит управления энергоблока 300 МВт

Control board of 300 MW units

Tableau de commande d'une tranche 300 MW

Чтобы его построить, потребовались напряженный научный поиск и принципиально новые решения многих проблем в строительной индустрии, энергетическом машиностроении, технологии строительства и эксплуатации оборудования.

В состав энергоблока входит однокорпусной, газоплотный, подвесной, газомазутный котел с промперегревом. Топочная камера котла – призматическая, является восходящим газоходом. По высоте она делится на три радиационные части. Котел оборудован 56 комбинированными газомазутными горелками производительностью 5 т/ч каждая по мазуту и $5,5 \times 10^3$ м³/ч по

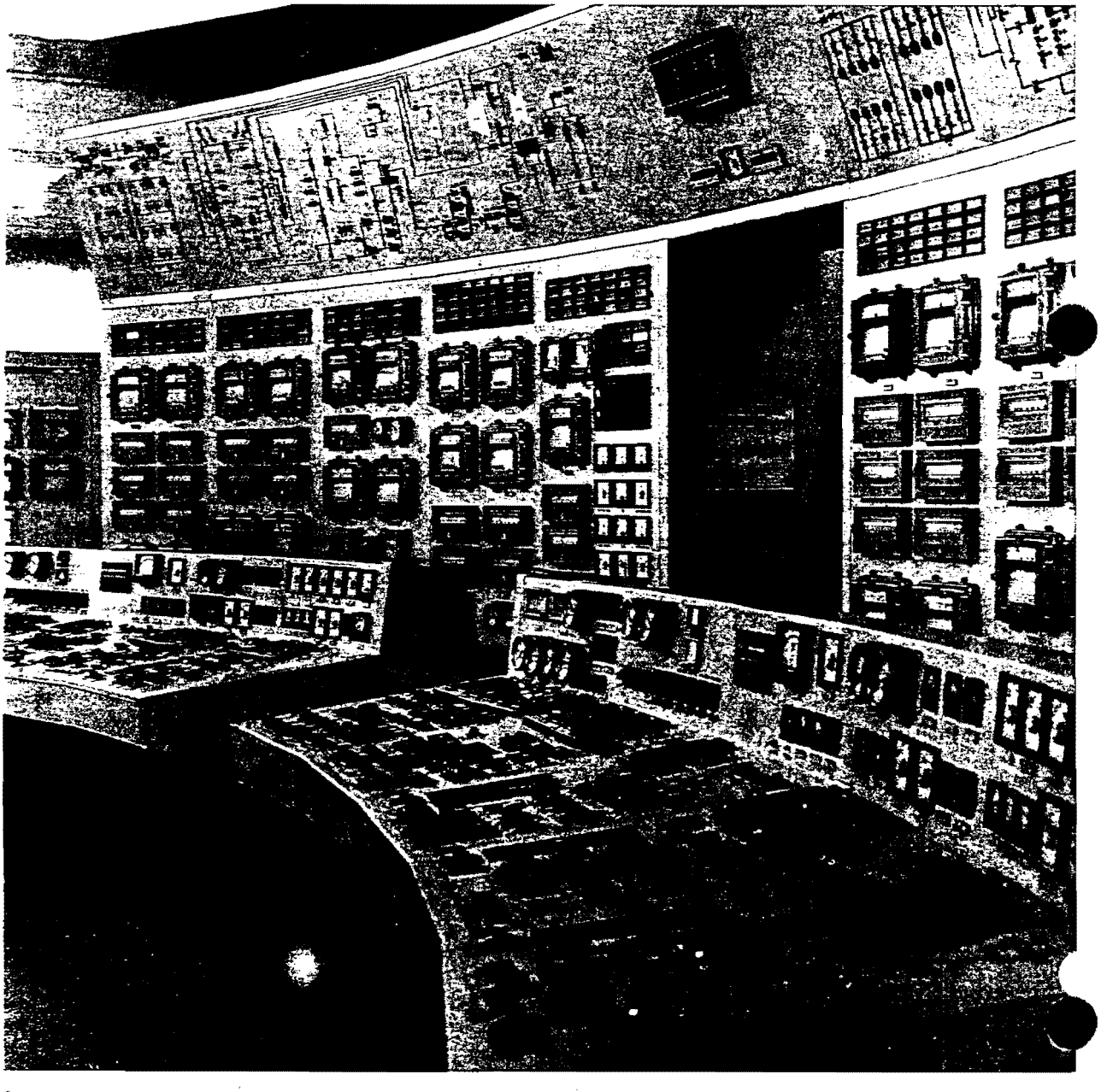
ed and put successfully in commercial service.

The construction of such a unit necessitated strenuous scientific efforts and meeting of unknown challenges in the field of civil engineering, electrical machine building, construction technique and operating practices.

The power unit incorporates a single-furnace gas-tight suspended gas-and-oil-fired boiler with reheat. The furnace is of a prismatic configuration and serves as an uptake gas duct. Heightwise it is divided in three radiation parts. The boiler is fitted with 56 combined gas-and-oil burners of 5 t/h oil and

Pour la création de cette tranche, il a fallu procéder à des recherches scientifiques intenses et adopter des solutions nouvelles en principe, de plusieurs problèmes posés dans l'industrie du bâtiment, dan construction électromecani la technologie de constructio l'exploitation du matérie

La tranche thermique est constituée par une chaudière à resurchauffe, à corps unique suspendu, avec chambre de combustion étanche, chauffée au gaz et au mazout. La chambre de combustion est de forme prismatique et sert de carneau à parcours ascendant des gaz de combustion. En hauteur, elle est divisée en trois parties à rayonnement. La chaudière est équipée de 56 brûleurs combinés



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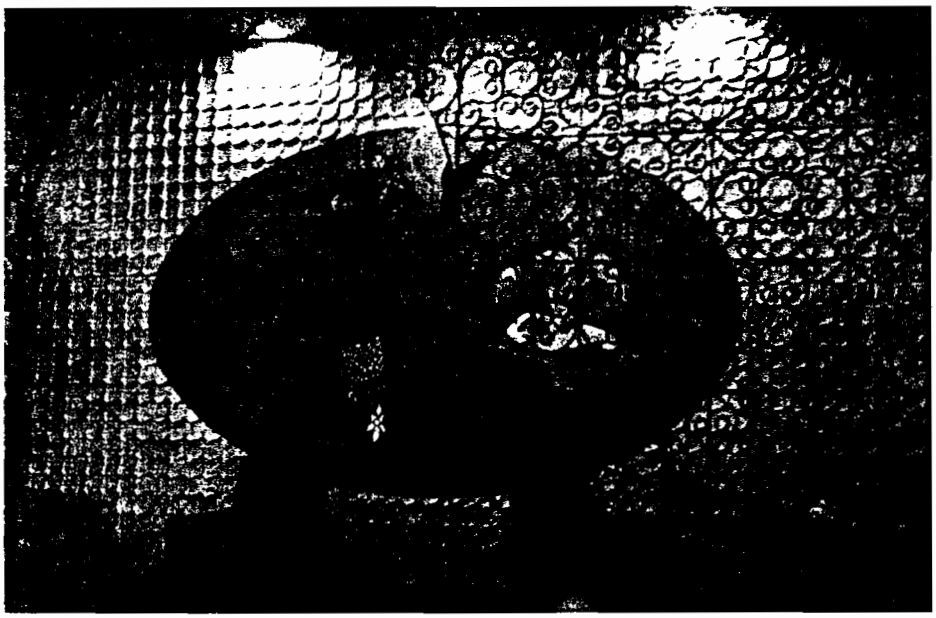
газу. Подача воздуха в топку и транспорт газа по газоходам котла при работе с уравновешенной тягой осуществляется тремя турбовоздуходувками и тремя дымососами с электроприводом. Котел оборудован тремя регенеративными воздухоподогревателями РВП с внутренним диаметром ротора 13,88 м.

Для очистки поверхностей нагрева конвективной шахты от золы применены [illegible] на дробеструйная установка. Очистка пароперегревателей в горизонтальном газоходе осуществляется [illegible] дальнобойными аппаратами паровой обдувки. Котел оборудован в полном объеме контрольно-измерительными

5.5×10^3 cu.m/h gas capacity. Air supply to the furnace and flue gas transport over the boiler gas ducts, when operating under the balanced draft conditions, are effected by three turbine blowers and three motor-driven id. fans. The boiler is provided with three regenerative air heaters (RAH) whose rotor is 13.88 m in inner diameter. The heating surfaces of the convection pass are cleared of ash deposits by shot blasting. Superheaters in the horizontal flue pass are cleaned using long-retracting sootblowers. The boiler is provided with a complete set of instrumentation, automatic

à gaz et mazout, d'un debit de 5 t/h de mazout et de $5.5 \cdot 10^3$ m³/h de gaz chacun. L'amenee d'air à la chambre de combustion et le transport des gaz de combustion à travers les carneaux de la chaudière, lors du fonctionnement avec tirage equilibre, sont realises à l'aide de trois turbo-soufflantes et de trois ventilateurs de tirage à commande electrique. La chaudiere est equipee de trois rechauffeurs d'air regeneratifs d'un diametre interieur de 13,88 m.

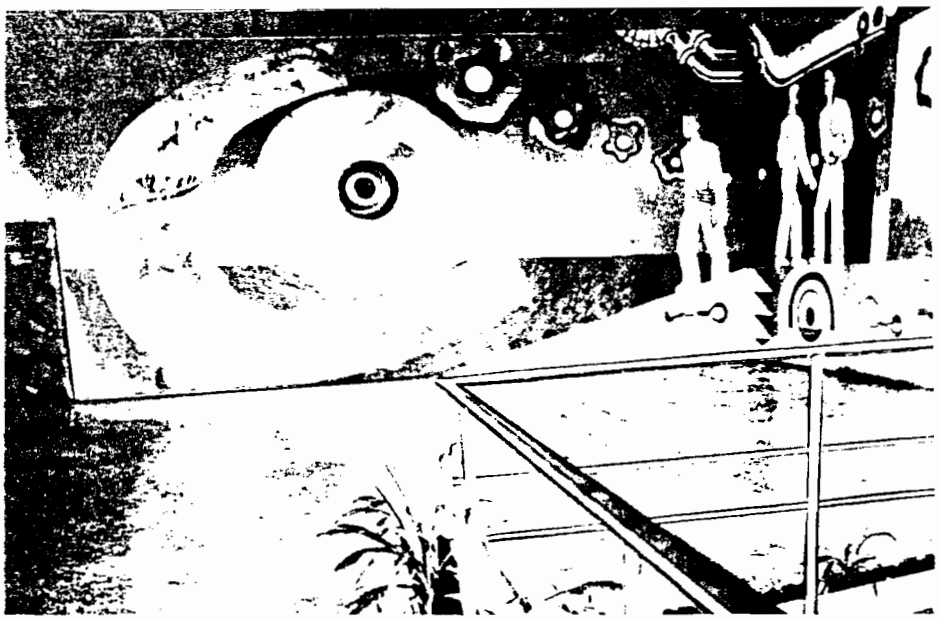
Pour l'elimination des cendres deposees sur les surfaces d'echange placees dans le carneau vertical à convection, une installation de grenaillage est utilisee. Le nettoyage des surchauffeurs situes dans le car-



Интерьер комнаты отдыха сменного персонала

Rest room of shift personnel

Vue interieure de la chambre de repos du personnel de quart



Интерьер машинного зала

Interior of machine room

Vue interieure de la salle des machines

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Общий вид главного корпуса с энергоблоком 1200 МВт

General view of the main building accommodating 1200-MW unit

Vue générale du bâtiment principal de la tranche 1200 MW

Котлоагрегат энергоблока 1200 МВт

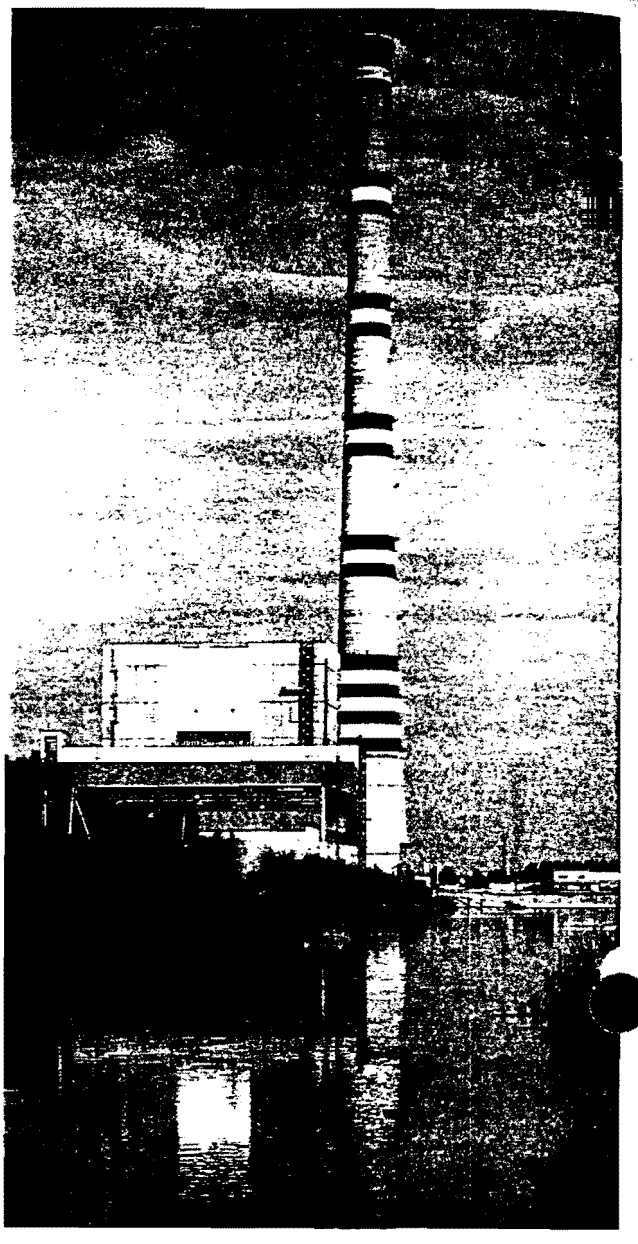
Boiler of 1200-MW unit

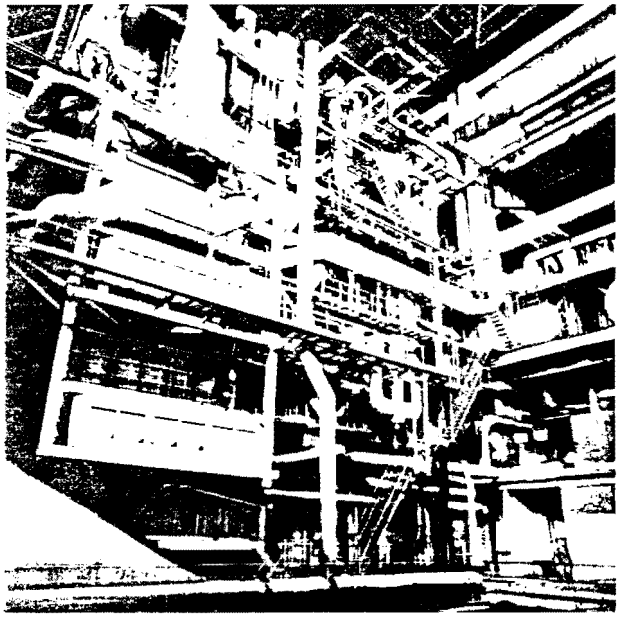
Generateur de vapeur de la tranche 1200 MW

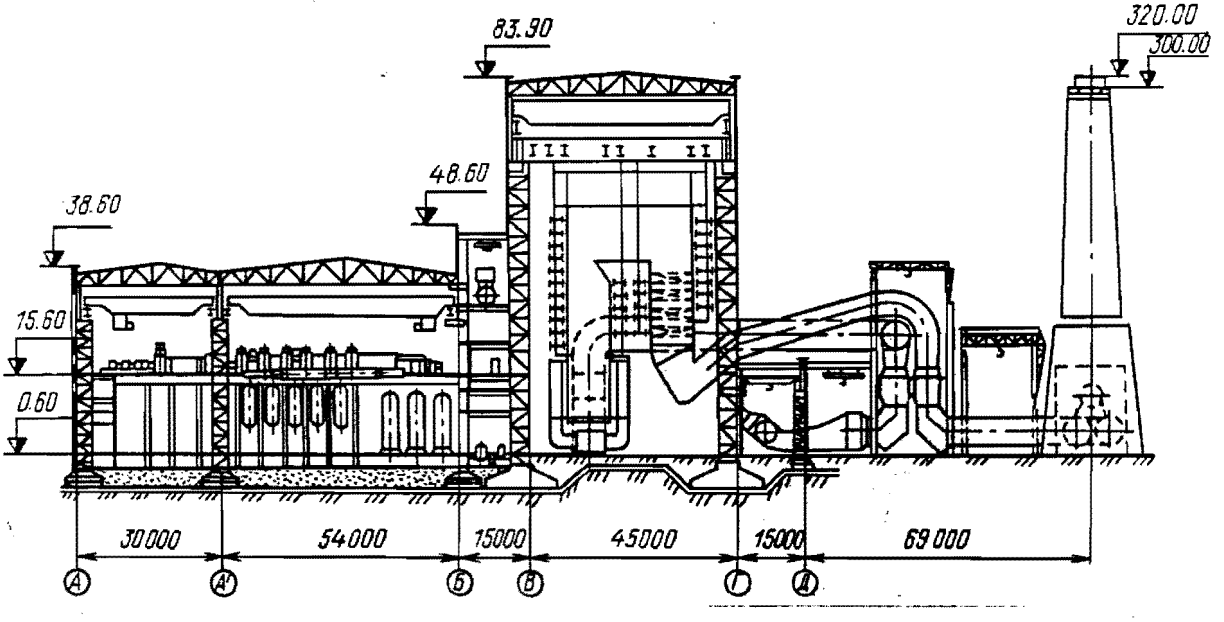
Главный корпус с энергоблоком 1200 МВт. Поперечный разрез

Main building accommodating 1200-MW unit. Sectional view

Bâtiment principal de la tranche 1200 MW. Coupe en travers







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приборами автоматикой, технологическими защитами и сигнализацией.

Паровая, конденсационная, одновальная турбина предназначена для работы в блоке с однокорпусным прямоточным котлом паропроизводительностью 3950 т/ч.

Турбина является самой мощной отечественной турбиной, а с учетом возможной перегрузки до 1380 МВт — самой мощной в мире.

Высота рабочих лопаток последних ступеней, изготовленных из титанового сплава, — 1200 мм.

Генератор выполнен с непосредственным охлаждением обмотки статора дистиллированной водой, а обмотки со-

controls, protective systems, and alarms.

The tandem condensing turbine is designed to operate in conjunction with a single-furnace once-through 3950 t/h capacity boiler.

The turbine is the Soviet largest machine as to its rating, and if we take into account its permissible overload capacity of up to 1380 MW, it is the largest turbine in the world.

The height of last-stage blades fabricated from titanium is 1200 mm.

The generator features direct cooling of the stator winding with demineralized water, the

neau horizontal s'effectue à l'aide de souffleurs retractiles à vapeur de longue course. La chaudiere est equipée de l'ensemble d'appareils de contrôle et mesure, d'automatisme, de securite de fonctionnement et de signalisation.

La turbine à vapeur, à une seule ligne d'arbre, est prevue à fonctionner en bloc avec une chaudière à corps unique, à flux continu, d'un débit de vapeur de 3950 t/h.

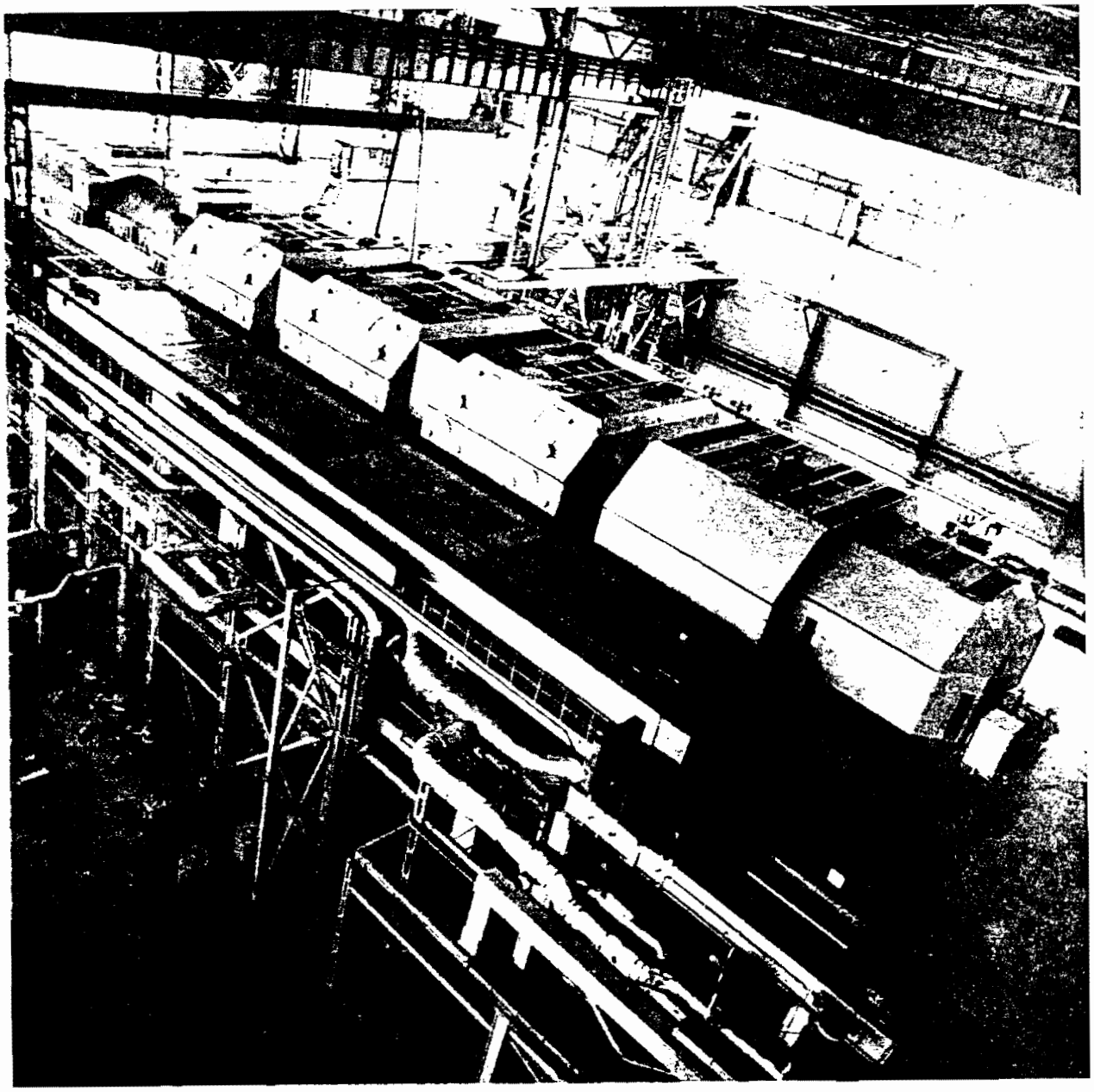
La turbine est la plus puissante en URSS, mais compte tenu de la possibilite de la marche en surcharge, jusqu'à 1380 MW, elle est la plus puissante dans le monde.

La hauteur des aubes mobiles des derniers etages, en alliage de titane, est de 1200 mm.

Самый мощный в СССР одновальный турбоагрегат 1200 МВт

Soviet largest tandem turbine of 1200 MW

Turbine de 1200 MW à une seule ligne d'arbre, la plus puissante en URSS



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Управление работой основного и вспомогательного оборудования энергоблока 1200 МВт производится с блочного щита

Main and auxiliary equipment of 1200-MW unit is controlled from the unit control board

La commande du materiel principal et auxiliaire de la tranche 1200 MW est realisee a partir du tableau de la tranche

тора и активной стали статора – водородом. Ротор генератора изготовлен из цельной поковки специальной стали. Система возбуждения бесщеточная, диодная.

Выдача мощности с III очереди ГРЭС осуществляется на напряжении 500 кВ через три однофазных трансформатора, подключенных к шинам ОРУ 500 кВ.

Энергоблок создан на основе прогрессивных технических решений, направленных на обеспечение высокой надежности и экономичности, и введен в эксплуатацию в декабре 1980 г.

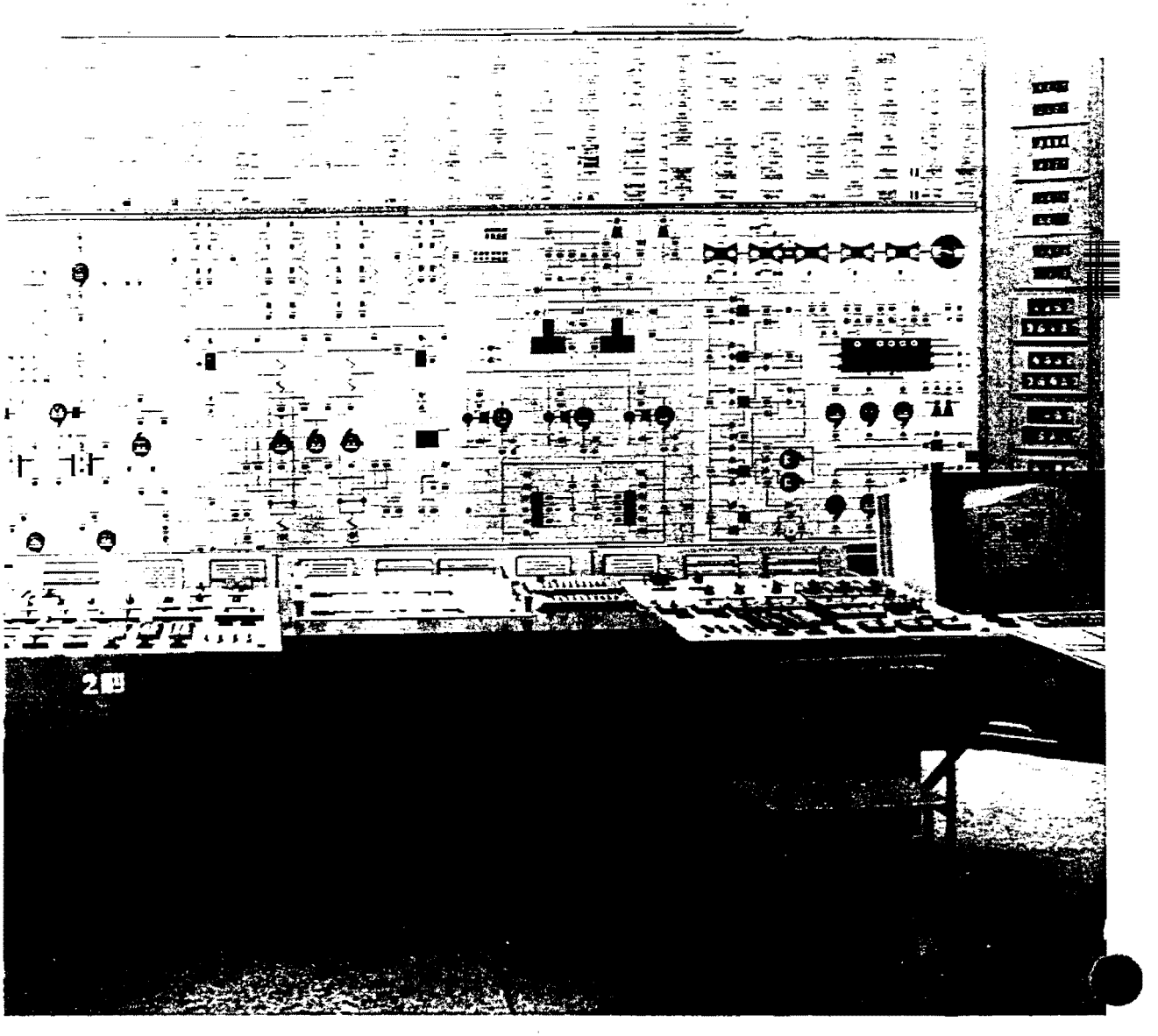
rotor winding and stator core are hydrogen-cooled. The brushless excitation system is built around diodes. Electrical energy generated by the 3d stage of the steam central power station is transmitted at 500 kV through three single-phase transformers connected to the buses of the 500 kV switchyard.

The power unit was developed using the state-of-the-art technology to ensure high operational reliability and cost-effectiveness. It was commissioned in December, 1980.

L'alternateur est a refroidissement direct de l'enroulement statorique par eau distillee, et de l'enroulement rotorique et du fer actif par hydrogene. L'arbre de rotor est en acier forge special d'une seule piece. Le systeme d'excitation est sans balais, a diodes.

L'evacuation d'energie de la tranche 1200 MW est realisee a la tension 500 kV a travers un banc de trois transformateurs monophases couples sur les barres 500 kV du poste exterieur.

La tranche thermique 1200 MW a ete conclue a base de solutions techniques d'avant-garde visant a assurer le haut degre de securite et de rentabilite et mise en service en decembre 1980



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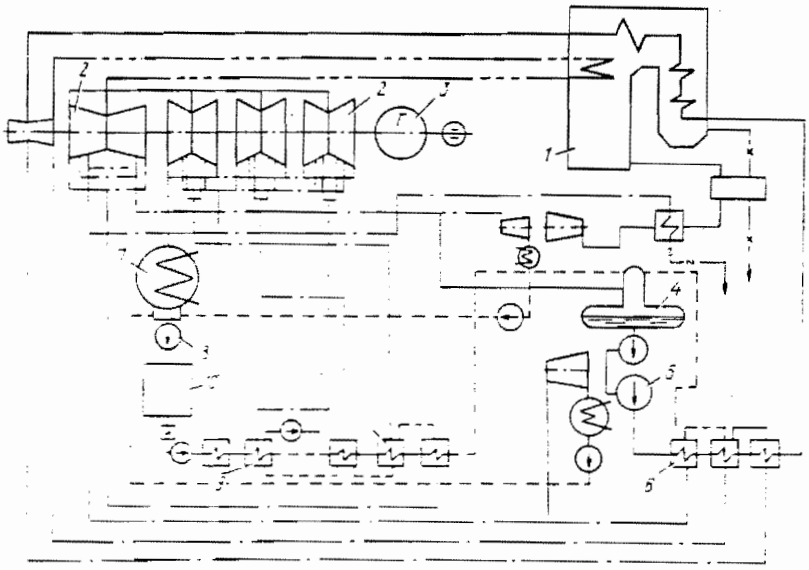

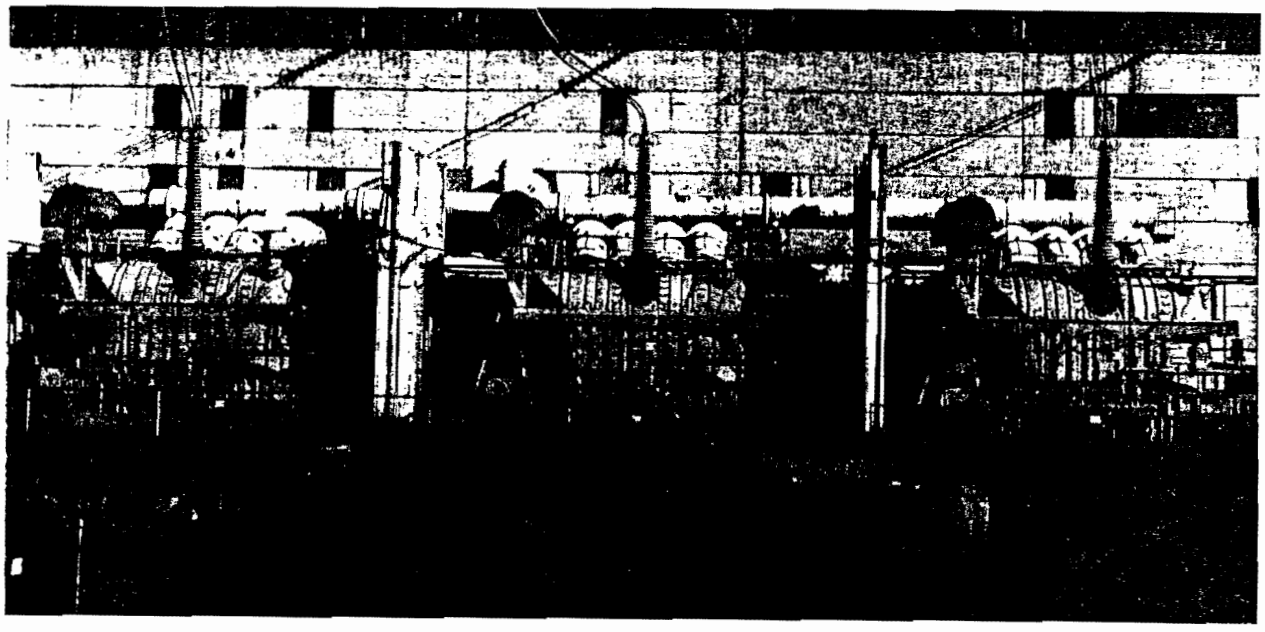

Принципиальная тепловая схема энергоблока 1200 МВт:
1 – котел; 2 – турбина; 3 – генератор; 4 – деаэратор; 5 – питательный насос; 6 – подогреватель высокого давления; 7 – конденсатор; 8 – конденсатный насос; 9 – подогреватель низкого давления; 10 – блочная обессоливающая установка

Heat cycle diagram of 1200 MW unit:
1 – boiler; 2 – turbine; 3 – generator; 4 – deaerator; 5 – feed pump; 6 – high-pressure heater; 7 – condenser; 8 – extraction pump; 9 – low-pressure heater; 10 – unit polishing plant

Schema thermique de principe de la tranche 1200 MW:
1 – chaudière; 2 – turbine; 3 – alternateur; 4 – dégazeur; 5 – pompe d'alimentation; 6 – rechauffeur haute pression; 7 – condenseur; 8 – pompe d'extraction; 9 – rechauffeur basse pression; 10 – poste de demineralisation

Повышающий трансформатор энергоблока 1200 МВт

Step-up transformer of 1200-MW unit

Transformateur elevateur de la tranche 1200 MW

Комната отдыха сменного персонала энергоблока 1200 МВт

Rest room for shift personnel of 1200-MW unit

Chambre de repos du personnel de quart de la tranche 1200 MW

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Техническая характеристика основного энергетического оборудования
Characteristics of Major Power Generating Equipment
Caractéristiques techniques du matériel énergétique principal

Котлоагрегаты **Boilers** **Générateurs de vapeur**	Дубль-блоки 300 МВт Two-boiler arrangement 300 MW Tranches doubles 300 MW	Моноблоки 300 МВт Single-boiler arrangement 300 MW Tranches simples 300 MW	Моноблок 1200 МВт Single-boiler arrangement 1200 MW Tranche simple 1200 MW
Тип Type Type	ТГМП-114	ТГМП-314	ТГМП-1202
Изготовитель Manufacturer Constructeur	Таганрогский завод «Красный котельщик» "Krasny Kotelshchik" boiler works in Taganrog Usine «Krasny Kotelschik» de Taganrog		
Производительность, т/ч Capacity, t/h Debit de vapeur, t/h	950		3950
Давление пара, кгс/см² Steam pressure, kgf/cm² Pression de vapeur, kg/cm²	255		
Температура пара на выходе из котла и после промперегрева, °С Steam temperature at boiler outlet and after reheat, °C Température de la vapeur surchauffée et resurchauffée, °C	545		
Температура питательной воды, °С Feed water temperature, °C Température de l'eau d'alimentation, °C	265		270
Расход топлива, т/ч Fuel consumption, t/h Consommation de combustible, t/h	72	71	273
Коэффициент полезного действия (брутто), % Gross efficiency, % Rendement (brut), %	92	93	94
Топливо: Fuel: Combustible:			
основное main de service	Высокосернистый мазут $Q_н^р$ = 9500 ккал/кг High sulfur fuel oil $Q_н^р$ = 9500 kcal/kg Mazout à teneur élevée en soufre P.C.I. = 9500 kcal/kg		
резервное back-up de secours	Природный газ $Q_н^р$ = 8100 ккал/нм³ Natural gas $Q_н^р$ = 8100 kcal/nm³ Gaz naturel P.C.I. = 8100 kcal/nm³		

Турбины **Turbines** **Turbines**		
Тип Type Type	К-300-240	К-1200-240-3
Изготовитель Manufacturer Constructeur	Производственное объединение турбостроения, Ленинградский металлический завод Leningrad Metal Works Usine de turbines de Léningrad, LMZ	
Номинальная мощность, МВт Rated power, MW Puissance nominale, MW	300	1200
Частота вращения, об/мин Speed, rpm Vitesse de rotation, tr/mn	3000	

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Максимальный расход пара, т/ч Maximum steam flow rate, t/h Debit de vapeur maximum, t/h	930	3900
Давление, кгс/см²: Steam pressure, kgf/cm²: Pression, kg/cm²:		
свежего пара live steam vapeur vive	240	
после промежуточного перегрева after reheat vapeur resurchauffée	36	
Температура свежего пара, °C Live steam temperature, °C Température de la vapeur vive, °C	540	
Число регулируемых отборов Number of extractions Nombre de soutirages à pression constante	3	9

Генераторы **Generators** **Alternateurs**		
Тип Type Type	ТВВ-320-2	ТВВ-1200-2
Изготовитель Manufacturer Constructeur	Ленинградское электротехническое объединение «Электросила» Electrosila Usine de materiel electrique «Electrossila» de Leningrad	
Мощность, МВт Output, MW Puissance, MW	300	1200
Напряжение на выводах, кВ Terminal voltage, kV Tension aux bornes, kV	20	24
Возбуждение Excitation Excitation	Высокочастотное бесщеточное, диодное High-frequency, brushless, diode Haute frequence, sans balais, à diodes	
Охлаждение Cooling Refroidissement	Водородно-водяное Water-hydrogen Eau-hydrogene	Водородно-водяное Water-hydrogen Eau-hydrogene

Трансформаторы **Transformers** **Transformateurs**			
Тип Type Type	ТДЦ-400000/220	ТДЦ-400000/500	ОРЦ-533000/525
Изготовитель Manufacturer Constructeur	Запорожский трансформаторный завод Zaporozhie Transformer Work Usine de transformateurs de Zaporojié		
Мощность, МВА Capacity, MVA Puissance, MVA	400	533	
Напряжение, кВ Voltage, kV Tension, kV	220/20	500/20	525/24

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Основные сооружения электростанции

К основным сооружениям электростанции относятся главный корпус энергоблоков 300 МВт, главный корпус энергоблока 1200 МВт, инженерно-бытовой корпус, химводоочистка, топливное хозяйство, система технического водоснабжения, сооружения электрической части.

Главный корпус энергоблоков 300 МВт – трехпролетный. В нем находятся: машинный зал – 45 м, деаэраторное отделение – 12 м, котельное отделение дубль-блоков – 33 м, моноблоков – 39 м. Шаг колонн – 12 м.

Главный корпус выполнен из сборного железобетона (за исключением металлических ферм и подкрановых балок машинного и котельного отделений) с применением новых строительных материалов и конструкций, фундаменты под колонны выполнены облегченными. Стеновое ограждение впервые в практике энергостроительства выполнено из керамзитобетонных панелей, облицованных брекчией. Световые проемы – из стеклопрофилита.

Расположение турбоагрегатов в машинном зале – поперечное. Тепловая схема – блочная.

Машинный зал обслуживают три мостовых крана грузоподъемностью по 125/20 тс, котельное отделение – три мостовых крана по 50/10 тс. На открытой площадке за главным корпусом расположены дымососы, дутьевые вентиляторы и регенеративные воздухоподогреватели. Для отвода дымовых газов от котлоагрегатов сооружены две дымовые трубы высотой по 250 м. Дымовая труба моноблоков выполнена из несущей железобетонной оболочки, в которой [illegible] четыре стальн[illegible] ствола, каждый [illegible] обслуживает один энергоблок. Такая конструкция применена в СССР впервые.

Главный корпус энергоблока 1200 МВт – пятипролетное здание. Машинный зал имеет два пролета – 30 и [illegible] деаэраторная – 15 м, кот[illegible]ное отделение – 45 м, п[illegible]щение турбовоздуходувок – 15 м. Каркас главного корпуса запроектирован в металлических конструкциях, что обусловлено большими нагрузками на колонны котельного отделения от подвесного котла, который опирается на хребтовые балки с шагом 6 м. Стеновое ограждение принято комбинированным с применением напряженно-армированных керамзитобетонных панелей и комплексных панелей из стального профилированного листа с синтетическим утеплителем. Междуэтажные перекрытия выполнены сборными железобетонными, оконные проемы – из световых панелей в металлических переплетах и стеклопрофилита.

Машинный зал обслуживают четыре мостовые крана грузоподъемностью по 125/20 тс, котельное отделение – два крана по 100/10 тс.

Дымососы и регенеративные воздухоподогреватели расположены на открытой площадке за главным корпусом. Для выброса дымовых газов сооружена дымовая труба [illegible] той 320 м с кремнебетон[illegible] газоотводящим стволом [illegible] лезобетонной оболочке. Дымовая труба оборудована подъемником наружной установки.

Инженерно-бытовой корпус расположен между главными корпусами энергоблоков 300 и 1200 МВт. Он состоит из нескольких блокированных зданий. В нем размещаются центральный щит управления, цехи и отделы электростанции, зал заседаний и столовая. Инженерно-бытовой [illegible]пус соединяется переход[illegible]ми галереями с главными [illegible]пусами.

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Main Structures

The main structures of the steam central power station are the main building accommodating 300 MW units, the main building housing the 1200 MW unit, the service building, the water conditioning plant, the fuel handling facility, the service water supply system, the electrical works.

The main building which houses the 300 MW units is a three-span structure: turbine room – 45 m, deaerator bay – 12 m, boiler room for two-boiler turbine units – 33 m, boiler room for single-boiler turbine units – 39 m. The columns are spaced 12 m apart.

The main building is made of prefabricated reinforced concrete except for steel trusses and crane track beams in the turbine and boiler rooms) with the use of new building materials and structural elements. The column footings are of a light-shed construction. For the first time in the power-engineering practice, the walls are made of prestressed light-concrete panels. The window openings are filled with structural glass shapes.

The turbine-generator sets are arranged crosswise in the turbine room. The heat cycle is of a boiler-turbine arrangement.

The turbine room is serviced with three 125/20 t overhead cranes. In the boiler room, there are three 50/10 t overhead cranes. The outdoor area behind the main building accommodates the induced draft fans and regenerative air heaters. Two 250-m high stacks are built to exhaust flue gases from the boilers. The stack serving the single-boiler units is made of a reinforced concrete shell which houses four steel breeches – one per power unit. Such a configuration has found application in the USSR for the first time.

The main building of the 1200 MW unit is a five-span structure. The turbine room has two spans – 30 and 54 m, the deaerator bay span is 15 m, the boiler room span is 45 m, the span of the air turboblowers room is 15 m. The main building framework is made of structural steel to take heavy thrusts imparted to the columns of the boiler room from the boiler which is carried by the beams spaced 6 m apart. The wall cladding is made of prestressed reinforced light-concrete panels and composite panels of shaped steel sheet with synthetic thermal insulation. The floors are made of precast reinforced concrete slabs; the window openings are provided with steel sashes and filled with glass shapes.

The turbine room is serviced with four 125/20 t overhead cranes; the boiler room is provided with two 100/10 t overhead cranes.

The induced draft fans and regenerative air heaters are located on the outdoor area behind the main building. Flue gases are exhausted through a 320 m high stack with the flue made of silicon-concrete and enclosed in a reinforced concrete shell. The stack is provided with an outside elevator.

The service building is located between the main buildings of 300 and 1200 MW units. This building consists of several interconnected buildings and it houses the central control room, shops, station departments, conference room and canteen. The service building communicates through galleries with the main buildings.

Общий вид Костромской ГРЭС со стороны р. Волги

Ouvrages principaux de la centrale

Parmi les ouvrages principaux de la centrale se trouvent le bâtiment principal des tranches thermiques 300 MW, le bâtiment principal de la tranche thermique 1200 MW, le bâtiment de commande, le poste de traitement d'eau, le parc à combustible, le système d'approvisionnement en eau crue, les installations électriques.

Le bâtiment principal des tranches 300 MW est à trois travées: salle des machines d'une longueur de 45 m, salle des dégazeurs de 12 m, chaufferie de tranches doubles, de 33 m et celle des tranches simples, de 39 m. L'espacement des poteaux est de 12 m.

Le bâtiment principal est en éléments de béton armé préfabriqués (sauf les charpentes métalliques et les poutres de roulement des ponts roulants de la salle des machines et de la chaufferie) avec emploi de matériaux de construction et de charpentes de conception nouvelle, les massifs de fondation des poteaux sont du type allégé. Les murs sont en panneaux de béton à gravillons d'argile expansée revêtus de conglomérats, utilisés pour la première fois dans la construction des bâtiments de centrales. Les carreaux de fenêtres sont en verre profilé.

Les groupes turbo-alternateurs dans la salle des machines sont à implantation transversale. Le circuit thermique est conçu en forme de bloc.

La salle des machines est desservie par trois ponts roulants d'une force de levage de 125/20 t chacun, la chaufferie par trois ponts roulants de 50/10 t chacun.

Sur une plate-forme extérieure, à l'arrière du bâtiment, sont disposés les ventilateurs de tirage et de soufflage et les réchauffeurs d'air régénératifs. Pour le rejet des gaz de combustion des générateurs de vapeur, deux cheminées sont construites d'une hauteur de 250 m chacune. La cheminée des tranches simples est constituée d'une enveloppe portante en béton armé renfermant quatre conduits métalliques dont chacun est affecté à une tranche thermique. C'est pour la première fois que cette construction a été utilisée en URSS.

Le bâtiment de la tranche thermique 1200 MW est à cinq travées. La salle des machines est à deux travées de 30 et 54 m, la salle des dégazeurs de 15 m, la chaufferie de 45 m et la salle des turbo-soufflantes de 15 m.

L'ossature du bâtiment est en charpentes métalliques étant donnée les charges importantes appliquées aux poteaux de la chaufferie par la chaudière suspendue s'appuyant sur des poutres posées de chant et espacées de 6 m. Les murs sont de construction composite en panneaux de béton à gravillons d'argile expansée, armés et contraints, et en panneaux de tôle profilée avec calorifugeage synthétique. Les planchers entre étages sont en éléments de béton armé préfabriqués, les fenêtres sont en panneaux vitrés dans des chassis métalliques et en verre profilé.

La salle des machines est desservie par quatre ponts roulants de 125/20 t, la chaufferie par deux ponts roulants de 100/10 t chacun.

Les ventilateurs de tirage et les réchauffeurs d'air régénératifs sont disposés sur une plate-forme extérieure, à l'arrière du bâtiment. Pour le rejet des gaz de combustion, il y a une cheminée d'une hauteur de 320 m constituée par un fût en béton siliceux dans une enveloppe en béton armé. La cheminée est équipée d'un ascenseur extérieur.

Le bâtiment de commande est situé entre les bâtiments des tranches 300 MW et de la tranche 1200 MW. Le bâtiment représente un bloc de plusieurs bâtiments. Dans le bâtiment se trouvent la salle de commande, des ateliers et services de la centrale, une salle de conférences et un réfectoire. Le bâtiment de commande communique par des galeries de passage avec les bâtiments des tranches.

Vue générale du côté de la Volga de la centrale thermo-électrique de Kostroma

Kostroma steam central power station as viewed from the Volga River

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Химводоочистка

В связи с пуском энергоблока 1200 МВт введена в эксплуатацию расположенная в отдельно стоящем здании химводоочистка производительностью 600 т/ч, обеспечивающая потребность всей электростанции в обессоленной воде. Она работает по схеме коагуляции в осветлителях и трехступенчатого обессоливания ионитов по схеме противоточного. Все процессы получения обессоленной воды полностью автоматизированы. Для нейтрализации сточных вод химводоочистки и электростанции предусмотрены сооружения промышленных отстойников, работающие с полным обезвреживанием и частичным повторным использованием в цикле станции.

Топливное хозяйство

Топливом для электростанции является высокосернистый мазут и природный газ. Мазут доставляется по железной дороге и в период навигации и водным путем по р. Волге. Он хранится в железобетонных резервуарах полуподземного типа.
Разогрев мазута в железнодорожных цистернах производится открытым паром. Мазут к форсункам котлоагрегатов подается под давлением 47 кг/см² с температурой 125 °С.
Подача природного газа осуществляется от магистрального газопровода. Газовое хозяйство включает газораспределительную станцию, откуда газ под давлением 10 кг/см² подается к газораспределительному пункту электростанции.

Водоснабжение

Система технического водоснабжения — прямоточная. Источником водоснабжения является Горьковское водохранилище на р. Волге. Подводящий канал открытый — земляной, с укрепленными бетонными бермами. Водозабор циркуляционной воды — глубинный, осуществляется тремя береговыми насосными станциями, где установлены вертикально-пропеллерные циркуляционные насосы.
Отводящие каналы выполнены двух видов: закрытые — из сборного железобетона и открытые — земляные.
На базе тепловых сбросных вод организовано полносистемное рыбоводное хозяйство по производству ценных пород рыбы и мальков.

Сооружения электрической части

Выдача электрической мощности от электростанции про-

Water Treatment Plant

The water treatment plant of 600 t/h output housed in a separate building was put into service in connection with the commissioning of the 1200 MW unit. This water treatment plant provides demineralized water for all station needs. The water treatment process provides for coagulation in clarifiers and three-stage demineralization in banks of filters. The water conditioning process is fully automated. Waste water from the water treatment plant and other station systems is neutralized in the waste water treatment system and is partly recycled for the station needs.

Fuel Handling Facility

The station fires high-sulfur fuel oil and natural gas. Fuel oil is shipped by rail and during navigation by water, the Volga river. Fuel oil is kept in reinforced concrete storage tanks of a half-buried type.
In the rail cars, fuel oil is heated up by open steam. Fuel oil is delivered to the burners at a pressure of 47 kgf/cm² and heated up to a temperature of 125 °C.
Natural gas is supplied from the main gas line. The gas handling system consists of a gas distributing station from which it is fed at a pressure of 10 kg/cm² to the gas distribution center of the station.

Water Supply

The service water supply is a direct flow system. Water is taken from the Gorky storage reservoir on the Volga river. The intake channel is an open earth structure with concrete-protected banks. Cooling water is taken from low levels by three shore pumping stations equipped with vertical propeller-type circulating pumps.
The discharge channels are of two types – closed channels are made of prefabricated reinforced concrete and open channels are earth structures. Waste hot water is used for fish farming – hatching and high value fish production.

Electrical Connections

Electrical energy generated by the station is transmitted by 220 and 500 kV lines.
The 300 MW units are connect-

Poste de traitement d'eau

Avec la mise en service de la tranche 1200 MW, il a été établi, dans un bâtiment à part, un poste de traitement d'eau d'une capacité de 600 t/h qui satisfait les besoins en eau déminéralisée de toute la centrale. Le poste fonctionne d'après un schéma de floculation dans des décanteurs et de déminéralisation dans un bloc d'échangeurs à trois étages. Pour la neutralisation des eaux de rejet du poste de traitement et de la centrale il a été prévu un ouvrage d'épuration des eaux usées industrielles avec décontamination complète des eaux et neutralisation partielle de celles-ci dans le circuit de la centrale.

Parc à combustible

La centrale électrique est chauffée au mazout avec une teneur élevée en soufre et au gaz naturel. Le mazout est acheminé par voie ferrée ou, pendant la période de navigation, par voie fluviale sur la Volga, et stocké dans des réservoirs en béton armé du type semi-enterrés. Le réchauffage du mazout dans les wagons-citernes s'effectue à jet de vapeur libre. Le mazout est amené aux brûleurs des générateurs de vapeur sous une pression de 47 kg/cm² et à une température de 125 °C.
L'amenée du gaz naturel est réalisée à partir d'un gazoduc. Le réseau du gaz comporte une station de répartition de gaz d'où le gaz sous une pression de 10 kg/cm² est amené au poste de distribution de gaz de la centrale.

Système d'approvisionnement en eau

Le système d'approvisionnement en eau crue est à circuit ouvert, avec prise dans la retenue de Gorki sur la Volga. Le canal d'amenée est à ciel ouvert, en terre, avec les berges protégées par des dalles en béton. La prise en profondeur de l'eau de circulation est réalisée par trois stations de pompage implantées au bord de l'eau et équipées de pompes de circulation à hélice à axe vertical. Les canaux de rejet sont de deux types: couvert, en éléments de béton armé préfabriqués et à ciel ouvert, en terre.
A base d'effluents thermiques, il a été organisé un aménagement piscicole pour l'élevage d'alevins et de poissons de valeur.

Installations électriques

L'énergie électrique produite à la centrale est évacuée aux ten-

Пульт управления химводоочистки

Control room of water treatment plant

Tableau de commande du poste de traitement chimique d'eau

На ГРЭС имеется комплекс лабораторий, обеспечивающий надежный контроль работы оборудования. В лаборатории химического цеха

The station is provided with a range of laboratories ensuring reliable monitoring of the equipment in operation. Laboratory in chemical shop

La centrale thermique dispose d'un ensemble de laboratoires assurant le contrôle efficace du fonctionnement du matériel. Laboratoire chimique

Мазутонасосная станция энергоблока 1200 МВт

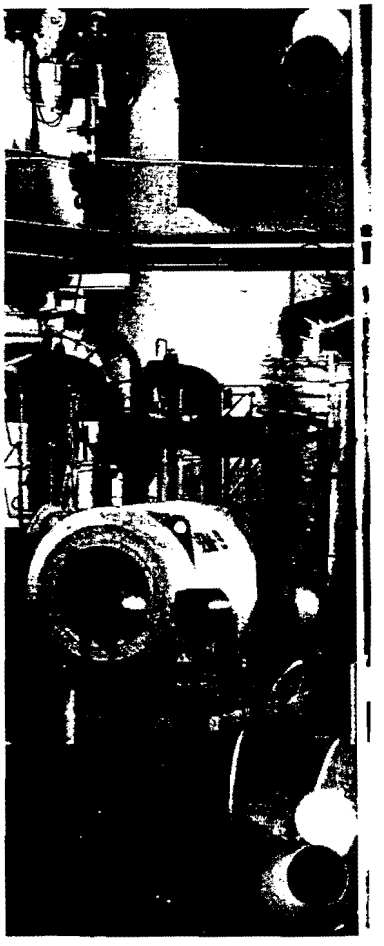
Fuel oil pumping plant in 1200-MW unit

Station de pompage de mazout de la tranche 1200 MW

Береговая насосная станция

Shore pumping plant

Station de pompage d'eau de circulation



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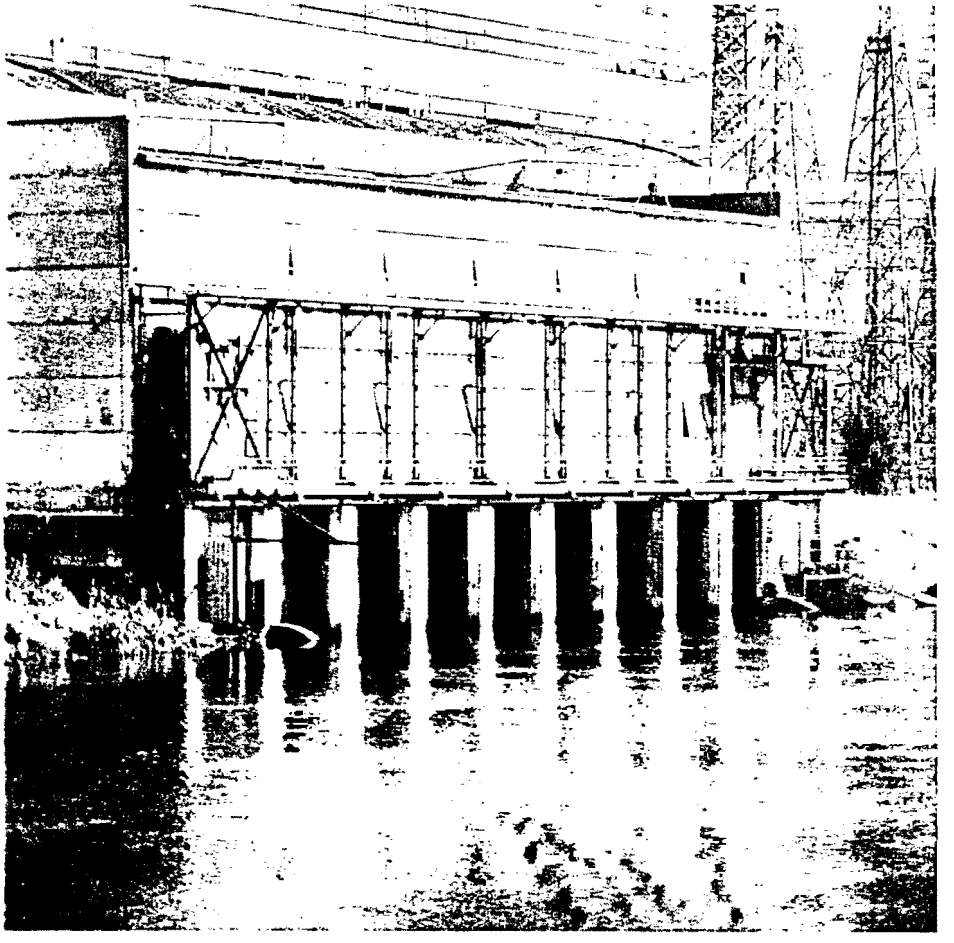

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изводится на напряжениях 220 и 500 кВ. Энергоблоки 300 МВт через трехфазные повышающие трансформаторы мощностью 400 МВА соединяются с ОРУ 220 и ОРУ 500 кВ.

ОРУ 220 кВ выполнено с двумя системами шин и обходной системой шин. ОРУ 500 кВ выполнено по схеме три выключателя на два присоединения с секционированием одной системы шин.

Связь между ОРУ 220 и ОРУ 500 кВ осуществляется через [illegible] автотрансформаторов суммарной мощностью 801 МВА, которая одновременно служит для выдачи мощности [illegible] из дубль-блоков 300 МВт.

Собственные нужды энергоблоков 300 МВт покрываются на напряжении 6 кВ от трансформаторов мощностью 25 МВА, энергоблока 1200 МВт – от трансформатора мощностью 40 МВА.

Для энергоблоков 300 МВт имеются два резервных трансформатора напряжением 220/6 кВ мощностью по 32 МВА, для энергоблока 1200 МВт – мощностью 63 МВА.

На ТЭЦ имеется комплекс лабораторий, мастерских, обеспечивающих надежную работу оборудования.

ed through step-up three-phase 400 MVA transformers to the 220 and 500 kV switchyards.

The 220 kV switchyard has a double-bus scheme of connections with a bypass bus system. The 500 kV switchyard arrangement incorporates three circuit breakers for two connections with one sectionalized bus system.

The 220- and 500 kV switchyards are interfied through a bank of autotransformers with an aggregate capacity of 801 MVA, which serves at the same time to transmit power from one of the 300 MW two-boiler single-turbine units.

Auxiliaries of the 300 MW units are supplied with power at 6 kV from 25-MVA transformers. Auxiliaries of the 1200-MW unit are supplied with power from the 40-MVA transformer.

The 300-MW units are provided with two back-up 220/6 kV 32 MVA transformers. The 1200-MW unit is backed up by a 63-MVA transformer.

The steam central power station is provided with laboratories, workshops to ensure reliable operation of the equipment.

sions 220 kV et 500 kV. Les tranches thermiques 300 MW sont raccordées au poste extérieur 220 kV et au poste extérieur 500 kV par l'intermédiaire de transformateurs élévateurs de 400 MVA.

Le poste 220 kV comporte deux jeux de barres et un jeu de barres transfert, le poste 500 kV est exécuté suivant le schéma à un disjoncteur et demi et avec un jeu de barres sectionné.

La connexion entre les postes 220 et 500 kV est réalisée à travers un banc d'autotransformateurs d'une puissance totale de 801 MVA qui sert à la fois à évacuer l'énergie électrique de l'une des tranches doubles 300 MW.

Les services auxiliaires sont alimentés à 6 kV par les transformateurs de 25 MVA, deux de la tranche 1200 MW, par un transformateur de 40 MVA.

Pour les tranches thermiques 300 MW il y a deux transformateurs de secours 220/6 kV d'une puissance de 32 MVA chacun, pour la tranche 1200 MW, d'une puissance de 63 MVA.

La centrale thermo-électrique dispose d'un ensemble de laboratoires et d'ateliers qui assurent le bon fonctionnement du matériel.

Повышающий трансформатор энергоблока 300 МВт

Step-up transformer of 300-MW unit

Transformateur élévateur d'une tranche 300 MW

Открытое распределительное устройство 220 кВ

220-kV switchyard

Poste extérieur 220 kV

Открытое распределительное устройство 500 кВ [illegible] компоновки с подвешенными разъединителями

500-kV switchyard with [illegible] arrangement of equipment and suspended type disconnecting switches

Poste extérieur 500 kV à disposition améliorée, avec sectionneurs suspendus

Линии электропередачи напряжением 500 кВ, обеспечивающие выдачу электроэнергии в Единую Энергосистему Центра СССР

500 kV transmission lines supplying power to the interconnected system of USSR Center

Lignes 500 kV transportant l'énergie électrique au réseau d'interconnection du Centre de l'URSS

Основные технико-экономические и эксплуатационные показатели
Performance Characteristics
Principales caractéristiques techniques, économiques et d'exploitation

	Энергоблоки 300 МВт 300-MW power units Tranches thermiques 300 MW	Энергоблок 1200 МВт 1200-MW power unit Tranche thermique 1200 MW
Тип электростанции Type of station Type de centrale	Конденсационная Condensing A condensation	
Количество и мощность энергоблоков, шт × МВт Number and capacity of units, pcs × MW Nombre et puissance de tranches thermiques, unité × MW	8×300	1×1200
Годовая выработка электроэнергии, млрд. кВт·ч Annual generation, 10^9 kWh Production annuelle, 10^9 kWh	15,4	7,1
Расход электроэнергии на собственные нужды, % Power consumption for auxiliaries, % Consommation d'énergie propre, %	2,9	1,66
Удельный расход условного топлива на 1 кВт·ч отпущенной электроэнергии, г Specific consumption of ideal fuel per kWh, g Consommation de combustible moyen par kWh d'énergie produite, g	316	313
Число часов использования установленной мощности Installed capacity utilization hours Nombre d'heures d'utilisation de la puissance installée	6100	6000

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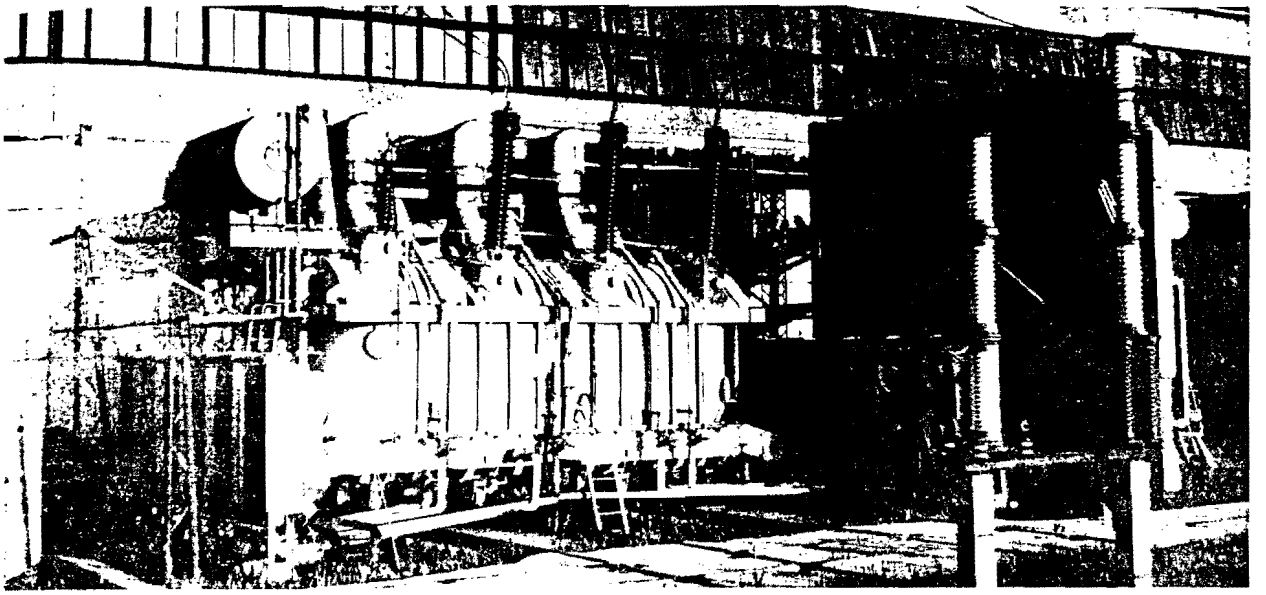

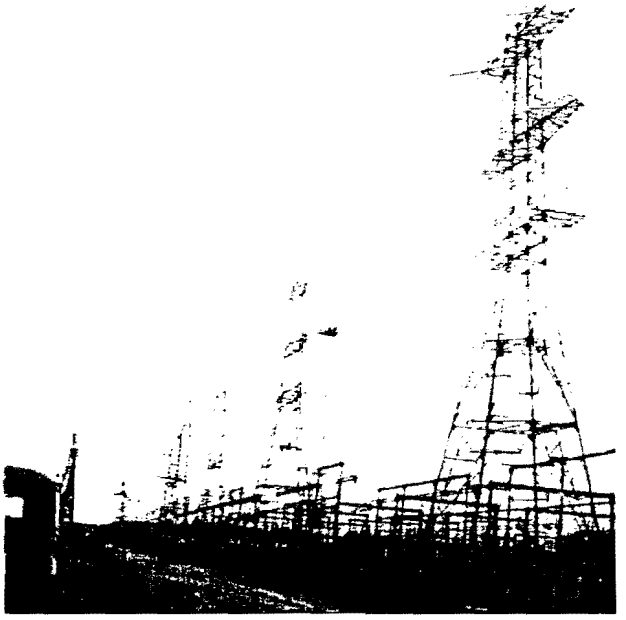

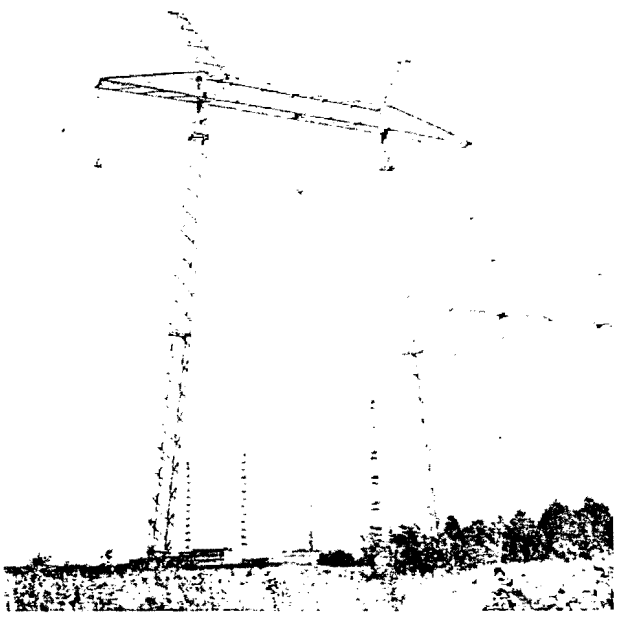

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Управление и автоматика

Управление и контроль за работой оборудования энергоблоков 300 МВт осуществляются с блочных щитов управления (один на два блока), куда вынесены приборы регулирования работы основного и вспомогательного оборудования, а также аппаратура, необходимая для пуска и останова энергоблока. Все основные технологические процессы автоматизированы. На блочных щитах установлены информационно-вычислительные машины ИВ-500 а также панели защиты и сигнализации.

Координация работы энергоблоков, а также управление оборудованием подстанций и линий электропередачи выполняются с центрального щита управления.

Автоматизированная система управления технологическими процессами АСУ ТП) энергоблока 1200 МВт представляет собой человеко-машинную систему для выработки и реализации управляющих воздействий на энергоблок с применением методов оптимального управления, современных средств вычислительной техники, функционально-группового управления, автоматического регулирования, связи, а также традиционных средств контроля и управления. Это позволяет осуществлять наиболее эффективное технологическое управление на основе вводимой в АСУ ТП информации. Основным способом представления информации является индикация на цветных и черно-белых электронно-лучевых индикаторах (ЭЛИ). С помощью ЭЛИ обеспечивается:

– индикация графиков значений параметров;
– индикация по вызову таблиц и фрагментов мнемосхемы с динамической информацией значений параметров;
– индикация положения арматуры и механизмов;
– индикация отклонений параметров.

Информация о работе устройств логического управления функциональных групп поступает на черно-белые электронно-лучевые трубки. Кроме информации о работе оборудования, агрегатная система вычислительной техники производит расчеты технико-экономических показателей энергоблока: регистра-

Automatic Controls

Operation of the 300-MW units is controlled and followed up from the unit control rooms (one per two units) which house control instruments of the main and auxiliary equipment as well as unit start-up and shut-down facilities. All the main processes are automated. The unit control boards are provided with data logging computers, type ИВ-500, protection and alarm panels.

The central control board coordinates operation of the units and controls substations and transmission lines.

The computerized control system of the 1200-MW unit is a man-machine interfaced system affording the control of power generating unit using optimal control techniques, up-to-date computer technology, functional-group controls, servo-control systems and communication technologies, as well as conventional means of follow-up control. This provides most efficient process control based on data inputs. The main means of data presentation are colour and black-and-white CRT displays.

The CRT displays provide:
– indication of parameter in graphical format;
– indication, on demand, of tabulations and mimic diagram fragments with data on parameter trending;
– status indication of valves and mechanisms;
– indication of parameter deviations.

Information on the operation of logic controllers is displayed on the black-and-white CRT's.

In addition to the information on the operation of equipment, the unit computer-based system makes calculations of power unit performance characteristics, affords parameters logging, alarm event logging, recommendations for optimal operating conditions, analysis of perform-

Commande et automatisme

La commande et le contrôle du fonctionnement de l'equipement des tranches thermiques 300 MW sont effectues à partir des tableaux de commande des tranches (un par deux tranches), où sont installés les appareils de regulation du fonctionnement du materiel principal et auxiliaire ainsi que l'appareillage necessaire au demarrage et à l'arrêt des tranches thermiques. Toutes les operations technologiques principales sont automatisees. Les tableaux de tranches sont equipes de machines informatrices-calculatrices ИВ-500 ainsi que de panneaux de protection et de signalisation.

La coordination du fonctionnement des tranches et la commande de l'equipement des postes de transformation et des lignes haute tension sont realisees a partir de la salle de commande.

Le système de commande automatise des processus technologiques de la tranche 1200 MW represente un systeme machine – homme elaborant et envoyant les signaux de commande à la tranche, avec utilisation de procedes de commande optimale, de techniques de calcul modernes, de la commande des groupes fonctionnels, de la regulation automatique, de la liaison, ainsi que de moyens de contrôle et de commande traditionnels. Cela permet de realiser la commande technologique la plus efficace a base des donnees introduites au systeme de commande automatise.

Le moyen principal de representer l'information est l'affichage sur des indicateurs a rayons cathodiques en couleurs et en noir et blanc. A l'aide des indicateurs a rayons cathodiques, on obtient:
– affichage des courbes des differentes grandeurs;
– affichage a la demande de tableaux et de schemas synoptiques partiels, avec l'information dynamique sur les grandeurs;
– affichage de la position de la robinetterie et des organes;
– affichage d'écarts de grandeurs.

Les données sur le fonctionnement des dispositifs de commande logique des groupes fonctionnels sont affichees sur les indicateurs a rayons cathodiques en noir et blanc.

En plus de l'information sur le fonctionnement de l'équipement, le système général de calcul réalise le calcul des caracteristiques techniques et éco-

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[illegible] параметров регистрация аварийных ситуаций, выдачу советов машинисту блока для оптимального ведения режимов, анализ технико-экономических показателей и выявление причин их отклонений, прогнозирование расходных характеристик в зависимости от режима работы блока, диагностика состояния оборудования.

[illegible]

Блок [illegible] ТЭЦ — одна из крупнейших тепловых электростанций Советского Союза. Все основное оборудование электростанции и станционного производства Горьковского завода Тяжэкскаватор. Проектирование института Теплоэлектропроект.

Строительство осуществляется генподрядными [illegible] энергетики и электрификации СССР с привлечением субподрядных специализированных организаций.

ance characteristics and cause of their deviations, forecasting of consumption characteristics as a function of the unit operating conditions, diagnostics of the station equipment.

The servo control systems cover all main and auxiliary processes on the unit and provide continuous maintenance of specified parameters or their change according to the programs of automatic group control.

The Kostroma steam thermal power station is one of the Soviet largest thermal power stations. All the main pieces of equipment of the station are of the Soviet make.

The design was developed by the Gorky branch of the Teploelectroproject Institute. Construction was undertaken by the construction agencies of the USSR Ministry of Power and Electrification employing services of some specialized contractors.

nomiques de la tranche thermique, enregistrement des caractéristiques et des incidents, affichage des recommandations à l'opérateur pour le choix du régime optimum, analyse des caractéristiques techniques et économiques et mise en évidence des causes des écarts, prévision des courbes de débits en fonction des régimes de fonctionnement de la tranche, prévision de l'état du matériel.

La régulation automatique comprend toutes les opérations principales et auxiliaires sur une tranche et assure le maintien constant des caractéristiques et la variation de celles-ci suivant les programmes de commande des groupes fonctionnels.

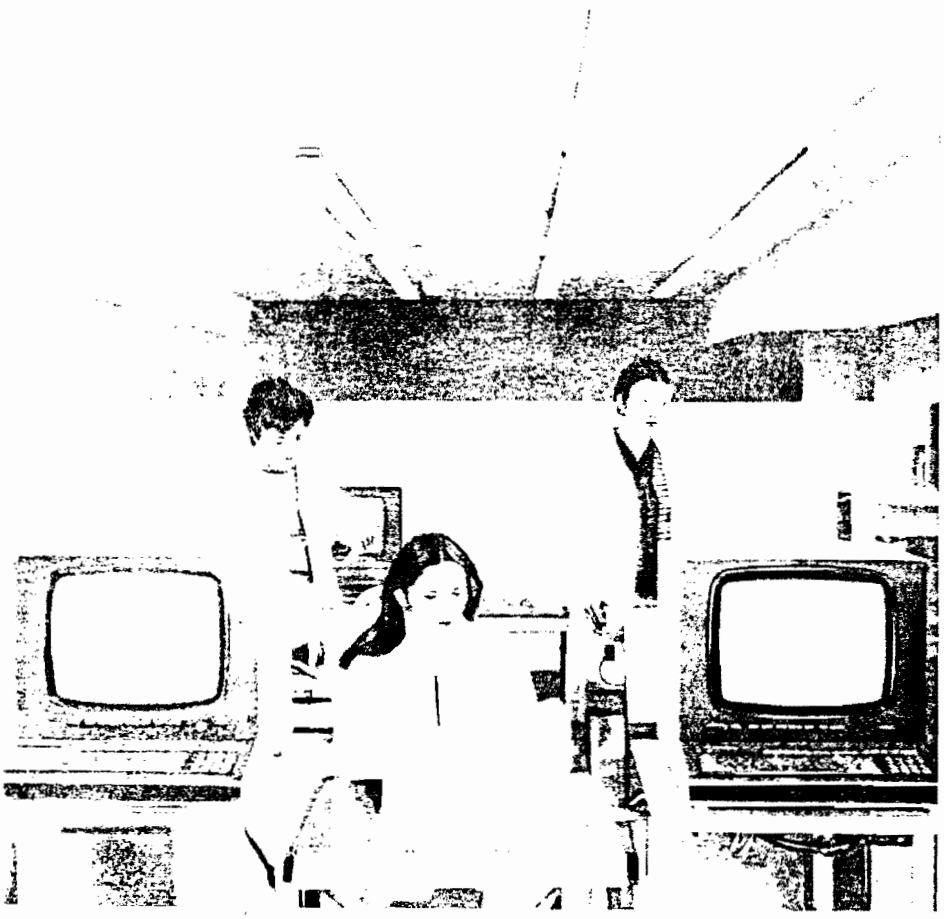
La centrale thermoélectrique de Kostroma est une des plus importantes centrales thermiques en Union Soviétique. Tout le matériel principal de la centrale est de fabrication soviétique.

Le projet a été élaboré par la filiale de Gorki de l'Institut «Teploelectroproject». La construction a été réalisée par les entreprises «Tsentrenergostroy» et «Tsentrenergomontage» du Ministère de l'Energie et de l'Electrification de l'URSS avec participation d'entreprises spécialisées comme sous-traitants.

[illegible] блока в [illegible] обеспечивает [illegible] линии автоматического [illegible] групповых [illegible] и управления.

Coordination of the [illegible] power units and [illegible] stations and [illegible] are effected [illegible] Control Room.

La coordination du [illegible] ment des machines [illegible] à la commande de [illegible] des groupes fonctionnels [illegible] sent à partir de la salle de commande.



Информационно-вычислительный комплекс автоматизированной системы управления технологическими процессами энергоблока 1200 МВт

Computerized process-control system of 1200-MW unit

Machine informatique-calculatrice du système de commande automatisée des processus technologiques de la tranche 1200 MW

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Труд, быт и отдых

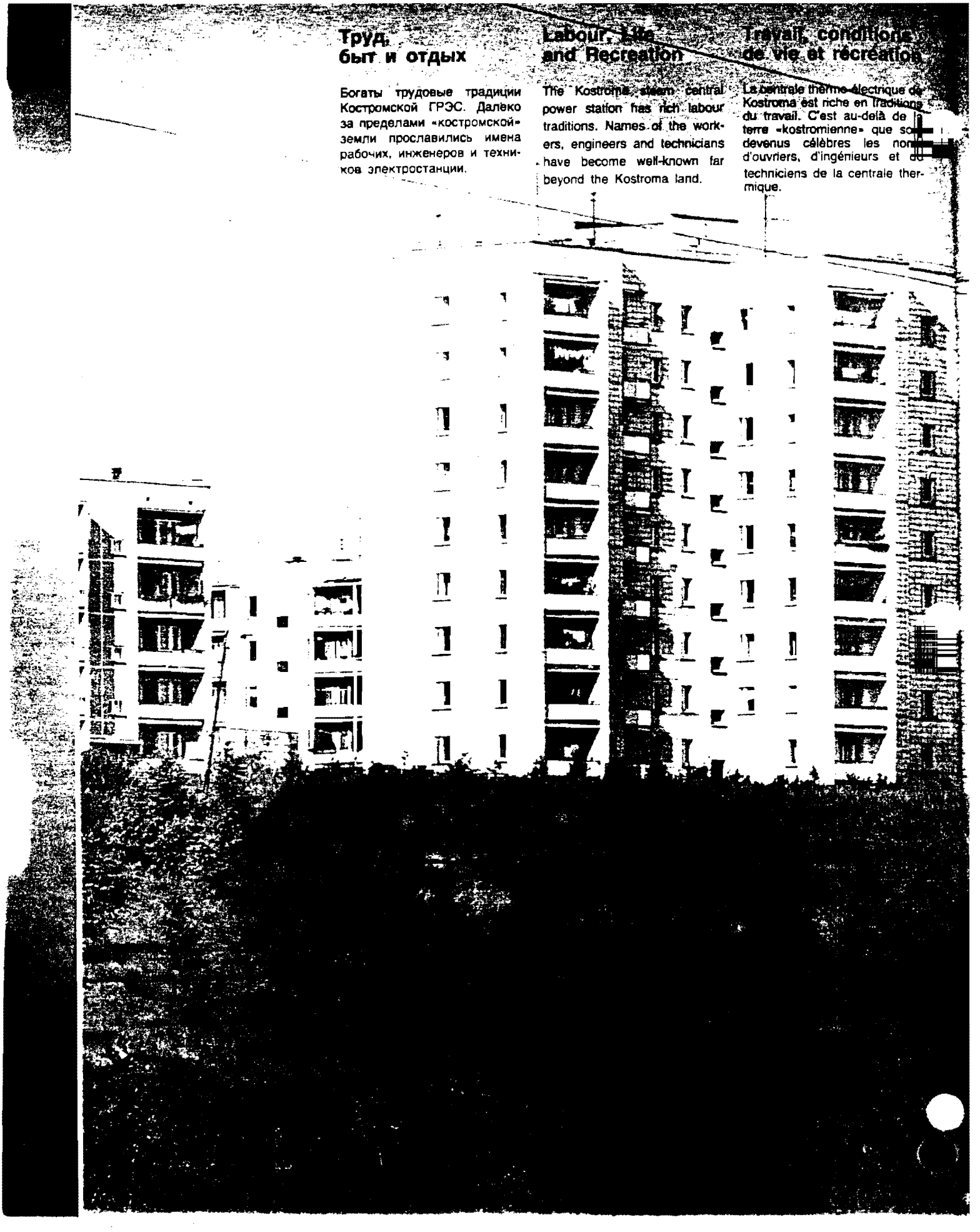
Богаты трудовые традиции Костромской ГРЭС. Далеко за пределами «костромской» земли прославились имена рабочих, инженеров и техников электростанции.

Labour, Life and Recreation

The Kostroma steam central power station has rich labour traditions. Names of the workers, engineers and technicians have become well-known far beyond the Kostroma land.

Travail, conditions de vie et récréation

La centrale thermo-électrique de Kostroma est riche en traditions du travail. C'est au-delà de la terre «kostromienne» que sont devenus célèbres les noms d'ouvriers, d'ingénieurs et de techniciens de la centrale thermique.



Коллектив электростанции постоянно добивается лучших показателей по экономичности среди однотипных предприятий. В 1984 г. удельный расход топлива по энергоблокам 300 МВт составил 316 г/кВт·ч.

Передовой опыт коллектива постоянно пропагандируется на Выставке достижений народного хозяйства СССР. Одновременно со строитель-

The Kostroma station staff are in constant drive for better economical performances among similar thermal power plants. In 1984 specific fuel consumption for the 300 MW units reached 316 g of coal equivalent per kWh.

Its progressive methods are publicized at the Exhibition of Economic Achievements.

La centrale obtient toujours les meilleures performances économiques parmi les établissements du même genre. En 1984, la consommation spécifique de combustible moyen a été de 316 g par kWh pour les tranches 300 MW.

L'expérience d'avant-garde du personnel de la centrale est l'objet de la propagande permanente à l'Exposition des réalisations de l'économie nationale de l'URSS.

Дома энергетиков, построенные в красивой зеленой роще

Blocks of appartments for station personnel built in a grove

Immeubles d'habitation pour les travailleurs de la centrale, construits dans un joli bosquet vert

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Дети энергетиков имеют ясли и детские сады с заботливыми нянями и воспитателями. Игровая площадка одного из детских садов

Children of power station workers are blessed with competent nursing personnel. Playing ground in one of the private kindergarten centers

Les enfants des travailleurs ont leurs crèches et jardins avec bonnes et éducatrices attentives. Terrain de jeux d'un des jardins d'enfants

ством электростанции возводился Волгореченск – поселок энергетиков и энергостроителей, названный по имени великой реки-труженицы. В двух километрах от главного корпуса ГРЭС, на возвышении, заросшем березняком, один за другим поднимались многоэтажные жилые дома со всеми современными коммунально-бытовыми удобствами и здания культурно-хозяйственного назначения. Сейчас жилой массив представляет собой многочисленные благоустроенные кварталы, часть которых обращена в сторону Волги, а другие вплотную подступают к заповедному лесу. Между домами и вокруг них разрослись березы, липы и тополя, много цветов и клумб, детских и спортивных площадок. Для снабжения жителей Вол-

The township of Volgorechensk for builders and operation personnel of the station was built simultaneously with the construction of the thermal power station. The township was named Volgorechensk after the great Russian river.

High-rise blocks of appartments with all conveniences and public services were springing up on the hill grown with berch-trees two kilometers from the main building of the station. Now the residential area consists of numerious blocks of appartments, some of them facing the Volga river, others coming up to the forest reserve. Birch and lime trees, poplars grow up round the buildings, there are many

En même temps que la construction de la centrale a été construit Volgorechensk, cité ouvrière et du personnel exploitant portant le nom du grand fleuve laborieux. A deux kilomètres du bâtiment principal de la centrale thermique, sur un terrain élevé couvert de bouleaux apparaissaient un après l'autre des immeubles d'habitation de plusieurs étages avec tout le confort moderne et des bâtiments de culture et de services publics. Actuellement la cité comporte de nombreux quartiers bien aménagés dont une partie est orientée vers la Volga et l'autre partie touche de près un bois de défence. Des bouleaux, des tilleuls et des peupliers entourent les édifices. Il y a beaucoup de fleurs, de parterres, de terrains pour enfants, de terrains de sports.

Des installations d'adoucissement ont été construites en profitant des eaux chaudes de rejet de la

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К услугам трудящихся электростанции замечательный Дом культуры, в котором работают различные кружки и студии. Танцевальный ансамбль работников ГРЭС

Palace of Culture provides various cultural and recreation attractions for the station staff. Dancing company of the station personnel

Les travailleurs de la centrale ont à leur disposition une magnifique maison de la culture dans laquelle différents cercles et studios amateurs sont ouverts. Ensemble de danse composé de travailleurs de la centrale

Большое внимание уделяют профсоюзная организация и дирекция медицинскому, санаторно-курортному обслуживанию трудящихся и их семей. Санаторий-профилакторий Костромской ГРЭС

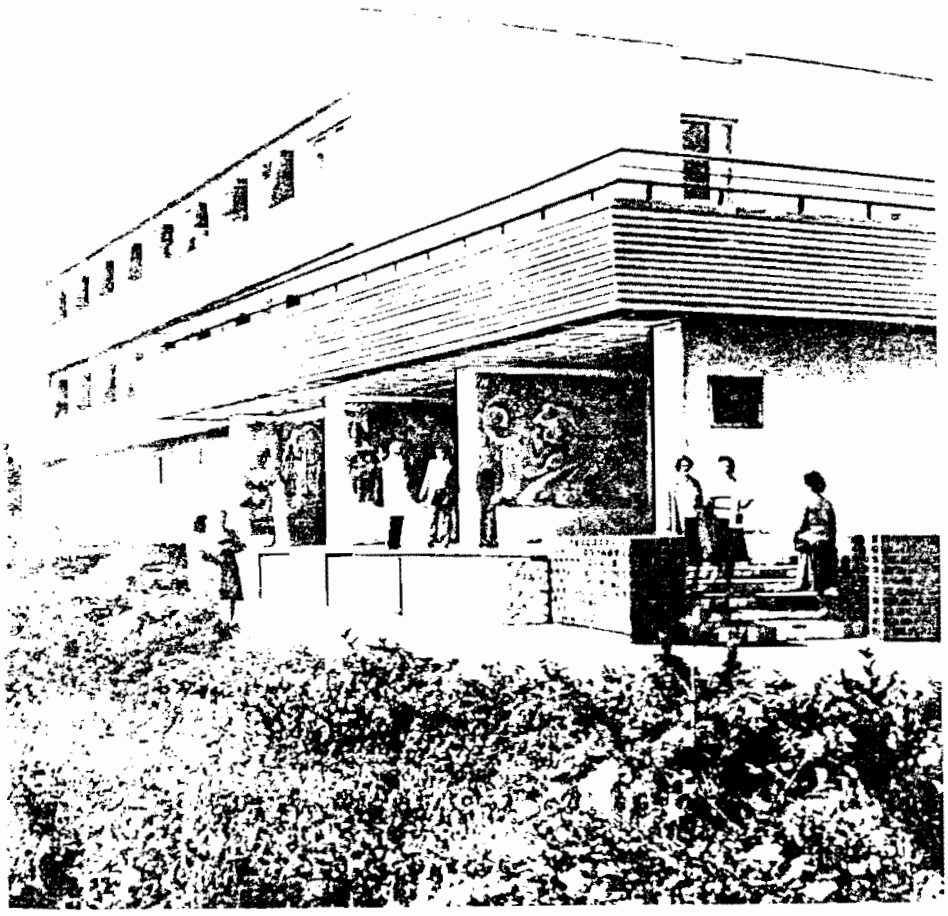
Водолечебница

A great emphasis is being placed by the station management and trade union on the comprehensive medical service of the station personnel, their families, health care center of the station personnel

Bainean.

La direction et le comité syndical de la centrale attachent une grande importance à assurer des services médicaux à leurs travailleurs et leurs familles. Sanatorium-dispensaire

Etablissement hydrothérapique



Интерьер столовой санатория-профилактория

Interior of canteen in health care center

Vue intérieure du réfectoire dans le sanatorium-dispensaire

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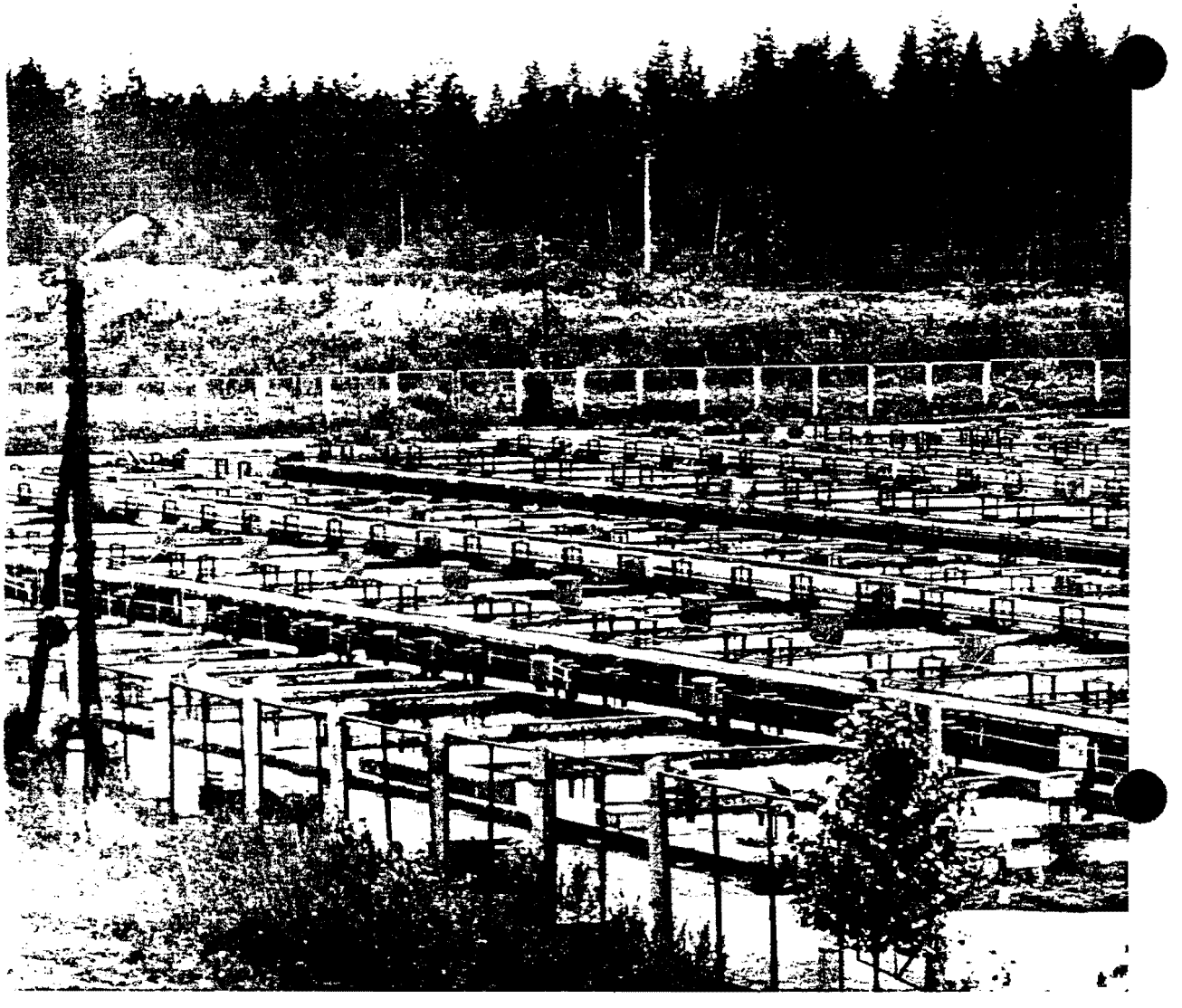

Тепличное хозяйство

Green house complex provides fresh vegetables round the year

Les habitants de la cité ont sur leurs tables des légumes frais toute l'année. Serre

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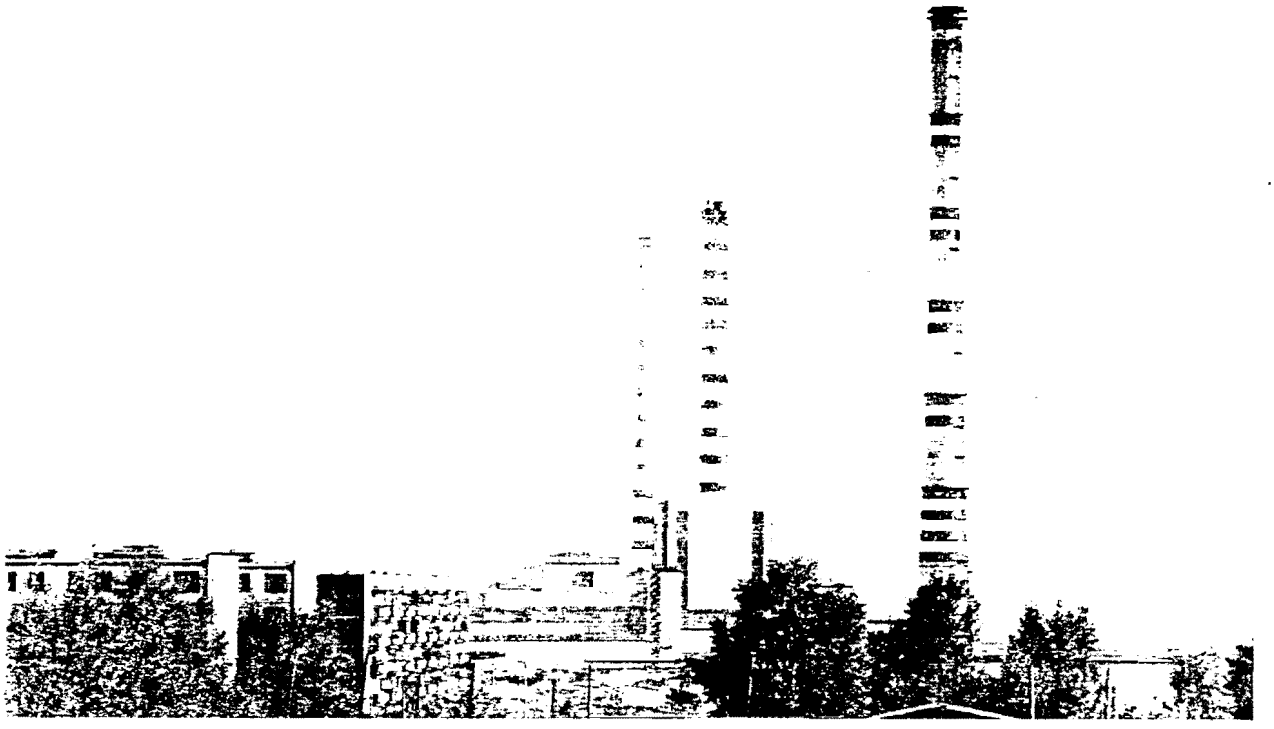

[illegible] свежей рыбой на тепловых водах Костромской ГРЭС построено рыбоводное хозяйство. В настоящее время оно выросло в крупное [illegible] предприятие, дающее ежегодно свыше 1200 т рыбы.

[illegible] на отходах тепличного комбината свежие овощи круглогодично снабжает город Костромской ГРЭС. Тепличное комплексное хозяйство производит томаты, огурцы, кабачки, редис, салат, петрушку, лук и другие овощи.

[illegible] поселок энергетиков растет и хорошеет. Регулярное сообщение связывает его с городами Костромой и Ростовлем, с Владимиром, Ивановом и Москвой, с соседними городами Кинешмой, Фурмановым и другими. Ежегодно справляются новоселия в сдаваемых жилых домах. Все больше вокруг поселка появляется коллективных садов. Волгореченцы трудятся с полной отдачей сил, с высоким мастерством, прочно удерживая звание одного из лучших предприятий отрасли.

towers and spawning and child rearing grounds.

A fish farm using the station waste hot water is built to supply fresh fish for the residents of the township. Now it has grown into a bio-commercial enterprise producing annually over 1200 t of fish. Round the year the green house complex using the station waste heat supplies fresh vegetables. The green house complex grows tomato cucumbers, vegetable marrow, radish, salat, parsley and other vegetables.

Year after year the township grows and gets better.

Bus service links it with Kostroma, Yaroslavl, Vladimir, Ivanovo, Moscow and neighbouring towns – Privolzhsk, Furmanov. Annually hundreds of people move into new dwelling houses. Numerous collective orchards appear around the township.

People of Volgorechensk, the township built with their own hands, live in good spirits, work hard at a high professional level holding one of the leading places among enterprises of the power industry.

centrale thermique de Kostroma, pour approvisionner les habitants de la cite de Volgorechensk en poissons frais. Actuellement, des installations sont devenues un etablissement experimental produisant plus de 1200 tonnes de poissons par an.

Sur toute l'annee, les habitants de la cite ont sur leurs tables des legumes frais en provenance des serres chauffees par la chaleur de la centrale thermique de Kostroma. Les serres, colonisees entierement par des abeilles, produisent des tomates, des concombres, des courges, des radis, des laitues, des persils, des oignons et d'autres plantes potageres.

La cite du personnel exploitant grandit et devient encore plus belle d'annee en annee. Des lignes d'autocars font etablir la communication de la cite avec les villes de Kostroma, Iaroslavl, de Vladimir et de Moscou, ainsi qu'avec les villes proches telles que Provolsk, Fourmanov et d'autres. Chaque annee, des centaines d'installations dans de nouveaux logements sont fetees. Des jardins fruitiers collectifs se multiplient toujours autour de la cite.

Les habitants de la cite, qui ils ont construite eux-même, vivent avec bonne humeur et travaillent avec plein rendement et grande hadiete en retenant sûrement le nom de l'un des meilleurs etablissements dans ce domaine.

Полносистемное рыбное хозяйство на тепловых водах Костромской ГРЭС. Вид на рыбное хозяйство.

Fish farm using waste hot water from Kostroma station. Fish pond system.

Installations piscicoles utilisant les eaux chaudes de la centrale. Bassin d'alevinage.

На экспериментальном рыбоводном хозяйстве выращивают ценных осетровых рыб. Осетры.

Experimental fish farm produces high value fish. Sturgeon.

Dans l'installation piscicole experimentale on pratique l'elevage de poissons de valeur. Esturgeons.

Панорама поселка энергетиков Волгореченска.

Volgorechensk, the town of station's personnel.

Vue generale de la cite de Volgorechensk.

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ENERGOMACHEXPORT

В/О «Энергомашэкспорт» один из крупнейших экспортеров советского оборудования для гидроэлектрических, тепловых и дизельных электростанций, сварочного, электротермического и другого промышленного электрооборудования, электроэнергии, железнодорожного подвижного состава, путевого оборудования и инструмента, городского электрического транспорта и запасных частей. Объединение импортирует троллейбусы, электросварочное и газорезательное оборудование, а также комплектующее оборудование для всех видов экспортируемой продукции и для относящихся объектов в других странах, а также запасные части для этого оборудования.

По желанию Заказчика объединение осуществляет шеф-монтаж, организует техническое обслуживание поставляемого оборудования, продает лицензии, «ноу-хау» и техническую документацию в тех случаях, когда они являются составной частью экспортных операций, а также оказывает ряд услуг внешнеторгового характера, связанных с экспортом товаров.

По вопросам поставки оборудования, входящего в экспортную программу В/О «Энергомашэкспорт», можно обращаться непосредственно к экспортеру, а также в Советское торговое представительство или к фирме – агенту В/О «Энергомашэкспорт» в соответствующей стране.

Наш адрес: СССР, Москва,
127486, Дегунинская, 1/4
Телефон: 487-31-87, 487-31-82
Телекс: 411926, 411965

BEST AVAILABLE COPY

V O "Energomachexport" is one of the largest exporters of Soviet-made equipment for hydroelectric, thermal and diesel-electric power stations, welding electromechanical and other industrial electrical equipment, electrical energy, rolling stock, railway equipment and tools, electrified urban transport, and spare parts.

V O "Energomachexport" imports trolleybuses, electric welding and gas cutting equipment, as well as associated equipment for all kinds of exported products, and for exports under construction in other countries, and also relevant spare parts.

At Customer's request, V O "Energomachexport" provides erection supervision, organizes maintenance services, sells licences, know-how and technical documentation, which forms as an integral part of the export operation. V O "Energomachexport" also renders a great variety of services related to the export of goods.

La Centrale Sovietique V O «Energomachexport» [illegible] l'un des plus gros exportateurs de materiels [illegible] pour les centrales hydroelectriques, thermiques [illegible] sel, de materiels electriques de soudage, mecaniques et autres equipements electriques industriels de [illegible] electrique, de materiels roulants ferroviaires, de materiels et outillages de voie, de vehicules electrifies urbains et de pieces de rechange.

La Centrale importe des trolleybus, des materiels de soudage electrique et de coupage aux gaz, ainsi que des composants pour tous les genres de materiels exportes et pour les grands ouvrages construits dans d'autres pays, ainsi que des pieces de rechange pour ces materiels.

Sur demande du Client, la Centrale assure la supervision du montage, organise l'entretien des materiels, fournit, vend les licences, le savoir-faire et les documents techniques afferents aux operations d'exportation, [illegible] une serie de prestations liees aux exportations de materiels.

Please send all inquiries concerned with the delivery of the equipment covered by the Export Programme of V O "Energomachexport" directly to the Exporter, or to the Soviet trade representative or the firm-agent of V O "Energomachexport" in your country.

Pour tous renseignements concernant la fourniture de materiels qui fait partie du programme d'exportation de V O «Energomachexport», adressez-vous directement a l'exportateur, ainsi qu'a la representation commerciale sovietique ou à l'agence de V O «Energomachexport» dans le pays correspondant.

Address: 1/4, Deguninskaya, Moscow, 127486, USSR
Telephone: 487-31-87, 487-31-82
Telex: 411926, 411965

Adresse postale: 1/4, Degouninskaia, 127486, Moscou, URSS
Telephone: 487-31-87, 487-31-82
Telex: 411926, 411965

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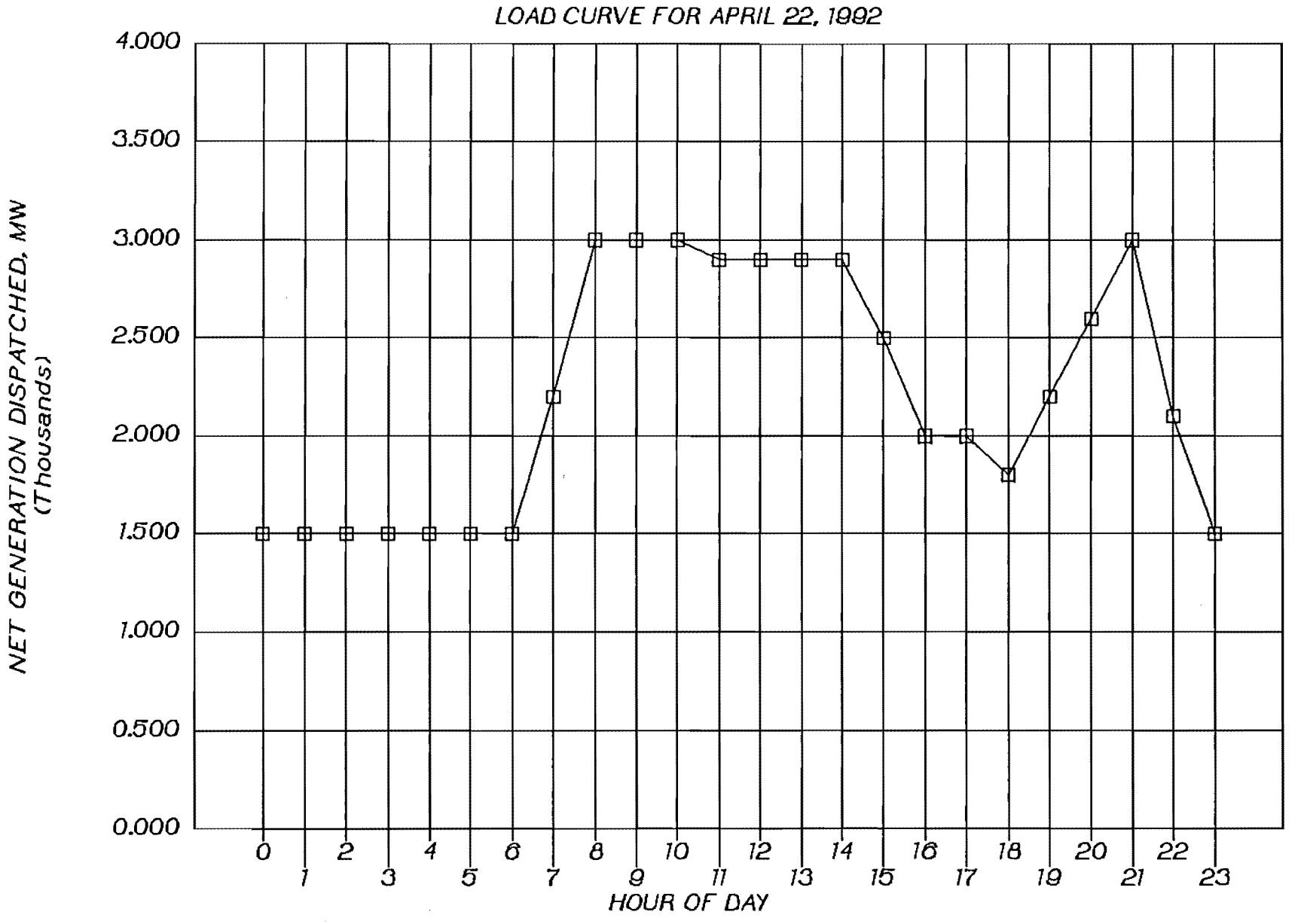
ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 5
KOSTROMAENERGO GRES
3,600 MW STEAM POWER STATION
LOAD CURVE FOR APRIL 22, 1992

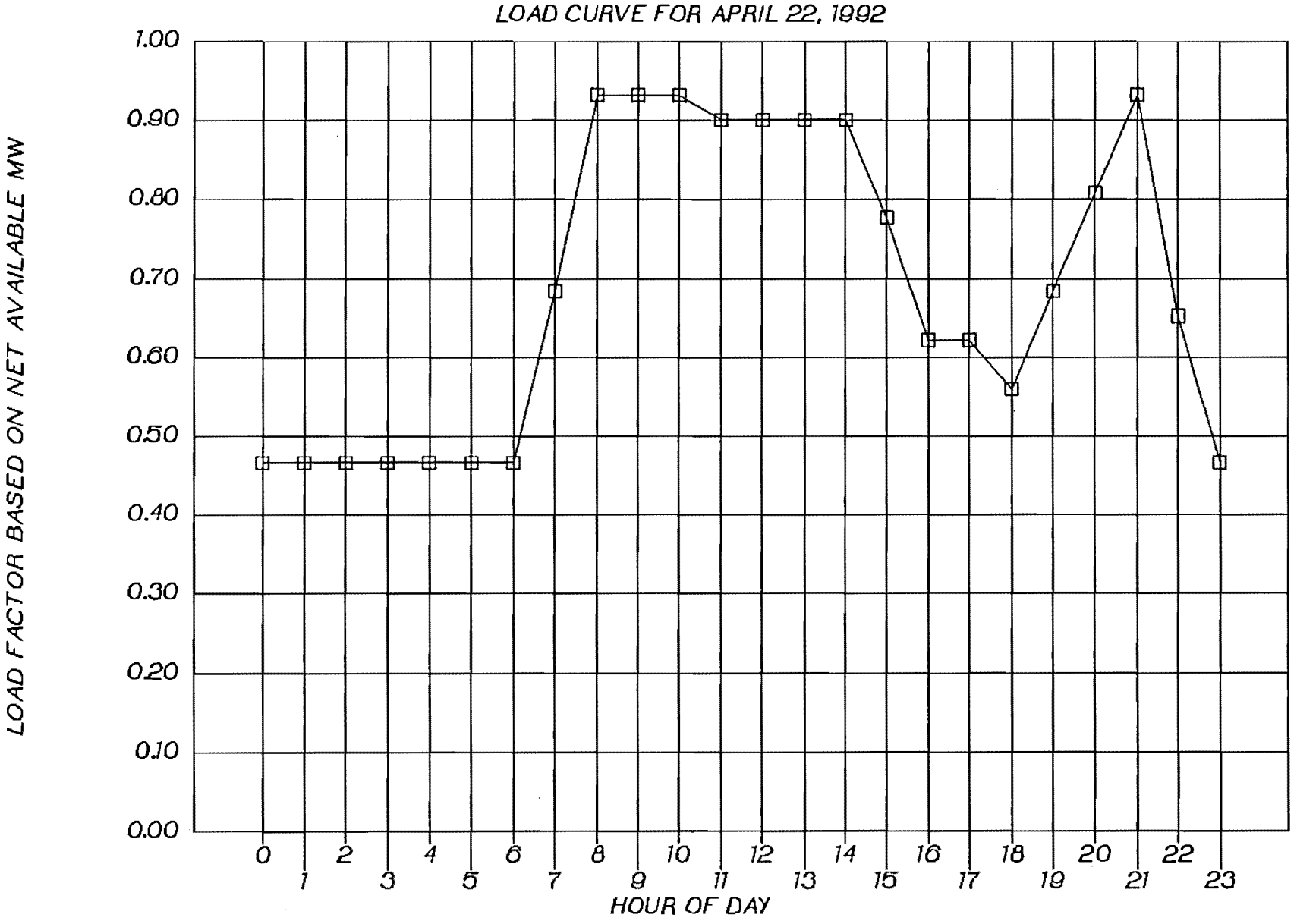
KOSTROMA 3600 MW GRES STEAM POWER STATION
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC

DATA FOR:		Electric Load MW	LF based on net available capacity
22-Apr-92			
Plant capacity (gross):		3,600	
Available capacity (net of station use):		3,218	
Load duration curve by hour of day:			
Time:	0	1,500	0.47
	1	1,500	0.47
	2	1,500	0.47
	3	1,500	0.47
	4	1,500	0.47
	5	1,500	0.47
	6	1,500	0.47
	7	2,200	0.68
	8	3,000	0.93
	9	3,000	0.93
	10	3,000	0.93
	11	2,900	0.90
	12	2,900	0.90
	13	2,900	0.90
	14	2,900	0.90
	15	2,500	0.78
	16	2,000	0.62
	17	2,000	0.62
	18	1,800	0.56
	19	2,200	0.68
	20	2,600	0.81
	21	3,000	0.93
	22	2,100	0.65
	23	1,500	0.47
Total generation:		51,600 MWh	
Average load:		2,150 MW	
Average load factor, based on plant available:			0.67
Average capacity factor, based on 3,600 MW:			0.60

KOSTROMA 3600 MW STEAM POWER STATION



KOSTROMA 3600 MW STEAM POWER STATION



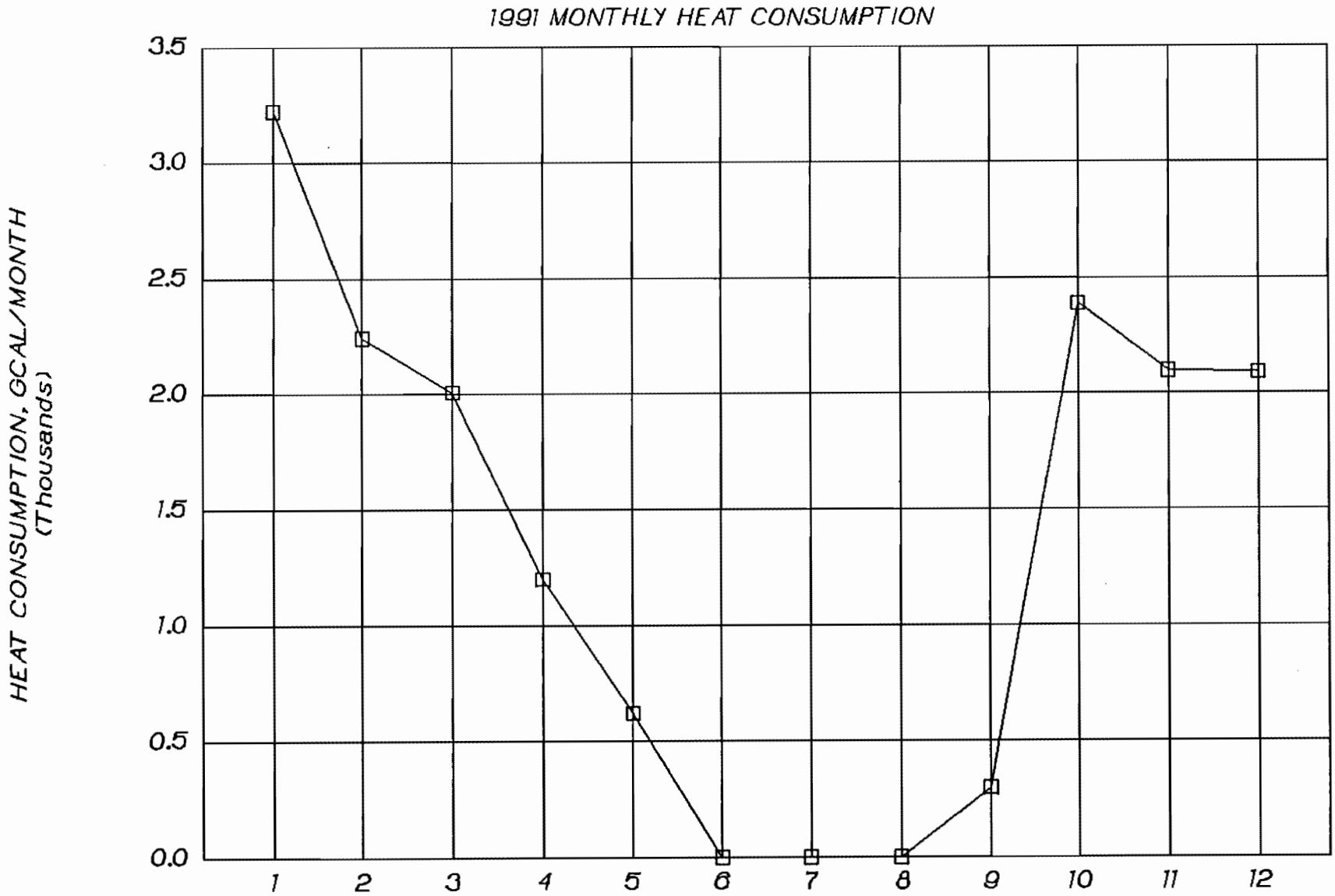
ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 6
KOSTROMA ORNAMENTAL PLANT FARM
1991 HEATING PERFORMANCE DATA

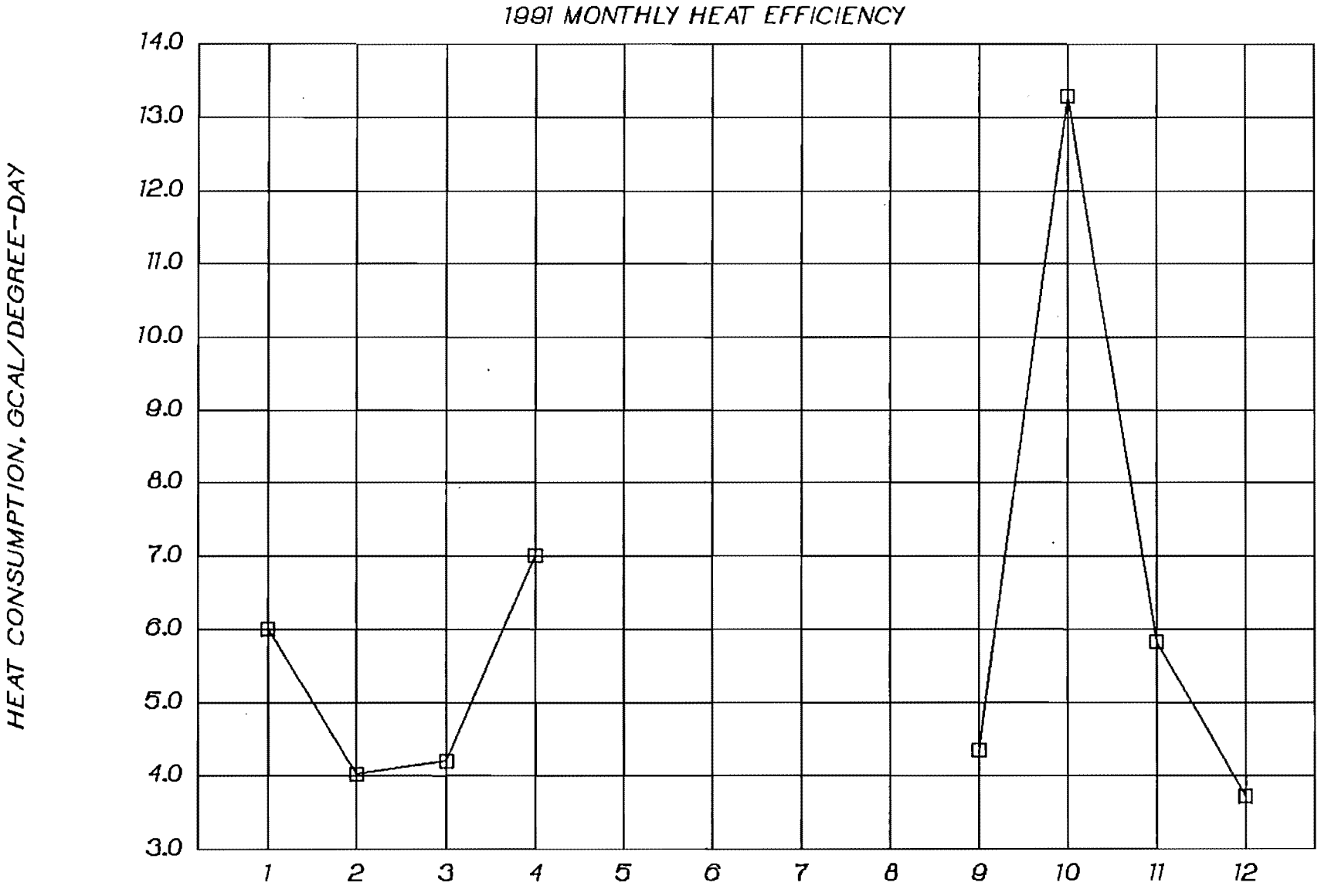
KOSTROMA ORNAMENTAL PLANT FARM
KOSTROMA, RUSSIA
RCG/HAGLER, BAILLY, INC
28-Apr-92

		1. Heating Load		2. Heating Consumption	3. Performance	4. Supply/demand	
	MONTH	AVG TEMP C	DEG-DAYS (12 basis)	GCAL	GCAL/ DEG-DAYS	SUPPLY	DEMAND
1991	1	-5.3	536	3222	6.01	1.00	0.96
	2	-7.9	557	2245	4.03	0.70	0.99
	3	-3.4	477	2008	4.21	0.62	0.85
	4	6.3	171	1199	7.01	0.37	0.30
	5	13.2	0	622		0.19	0.00
	6	18.6	0	0		0.00	0.00
	7	17.5	0	0		0.00	0.00
	8	15.1	0	0		0.00	0.00
	9	9.7	69	300	4.35	0.09	0.12
	10	6.2	180	2390	13.29	0.74	0.32
	11	0.0	360	2097	5.83	0.65	0.64
	12	-6.1	561	2091	3.73	0.65	1.00
1992	1			2120			
	2			2473			
	3			1687			
TOTAL	1991		2,912	16,174	6.06	5.02	5.19

KOSTROMA ORNAMENTAL PLANT FARM

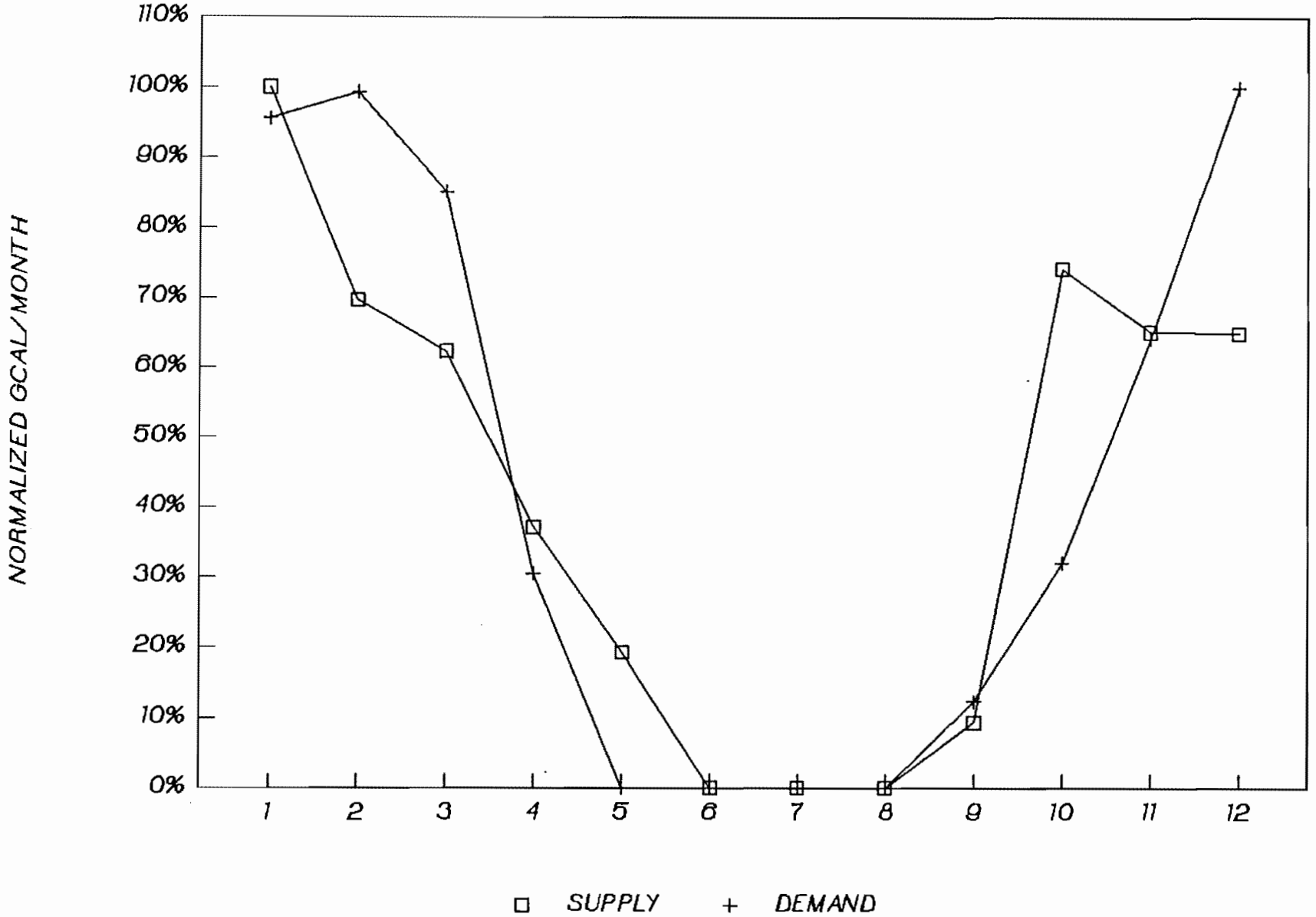


KOSTROMA ORNAMENTAL PLANT FARM

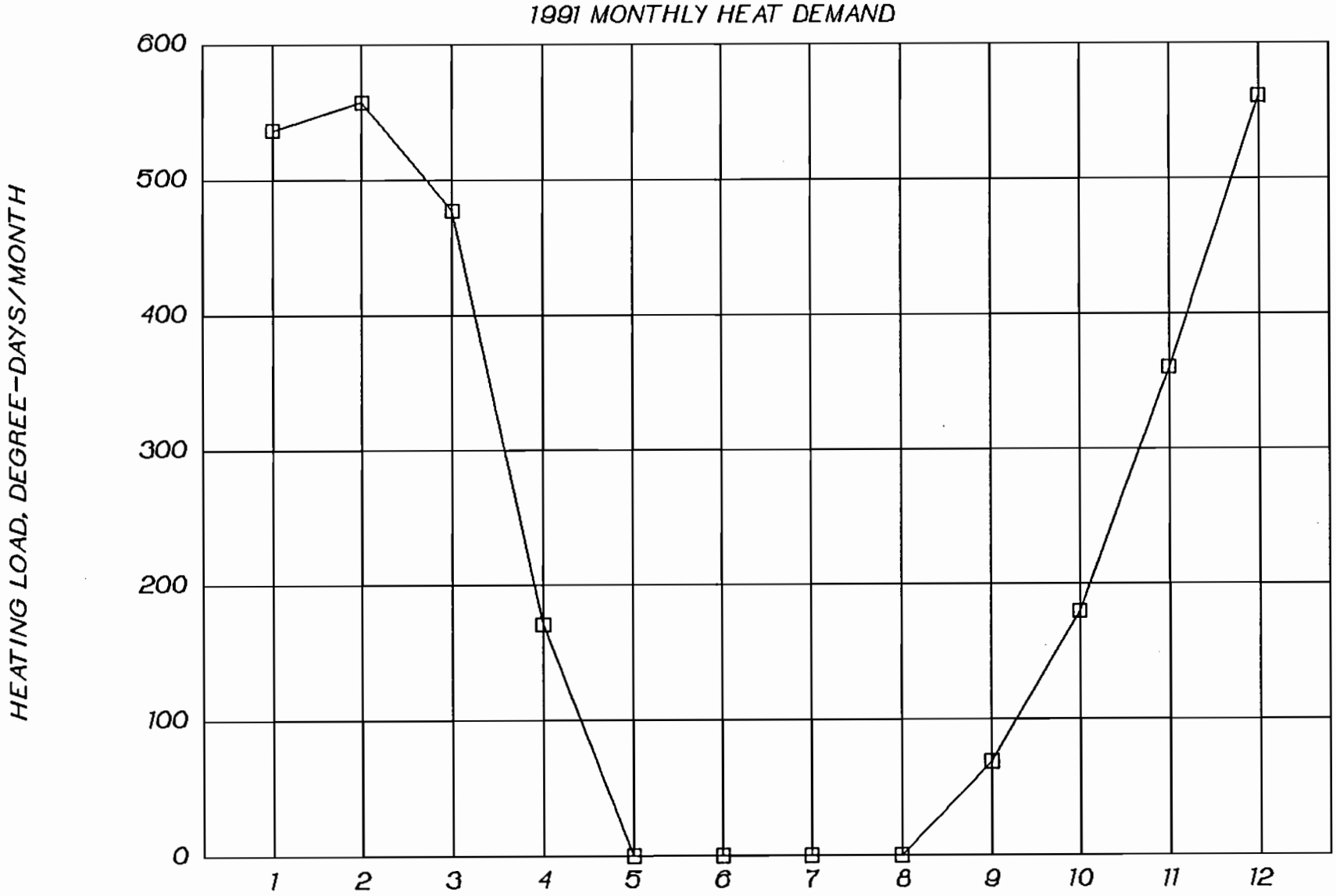


KOSTROMA ORNAMENTAL PLANT FARM

1991 MONTHLY HEAT EFFICIENCY



KOSTROMA ORNAMENTAL PLANT FARM



ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 7
RECOMMENDED EQUIPMENT FOR KOSTROMAENERGO

THERMAL IMAGING SYSTEM 5/4/92

I DISCUSSED WITH DAVID SMIALEK OF INFRAMETRICS OUR PROJECT AND WHAT THE NEED WAS. I EXPLAINED WHERE THE EQUIPMENT WAS GOING AND ASKED HIM TO SEND YOU A QUOTATION ON 5/4/92.

WE RECENTLY PURCHASED THEIR 760 THERMAL IMAGING SYSTEM FOR USE IN OUR FOSSIL STATIONS ($65K). I EXPLAINED OUR BUDGET FOR THIS PROJECT WAS ONLY $40K. HE INDICATED WE HAD A 600 SYSTEM AT OUR OCONEE NUCLEAR STATION THAT IS WITHIN THAT BUDGET. THIS IS WHAT HE WILL BE QUOTING ON. HE HAD SOME QUESTIONS ABOUT WHO WOULD BE PURCHASING THE SYSTEM AND I REFERRED HIM TO WENDI NOT KNOWING IF IT WAS RCG OR AID DIRECTLY.

WE LOOKED AT 6 MANUFACTURERS BEFORE WE SETTLED ON INFRAMETRICS FOR OUR LATEST PURCHASE. THE PERSON WHO BOUGHT THIS IS VERY THOROUGH SO I HAVE CONFIDENCE THAT INFRAMETRICS IS A GOOD COMPANY.

INFRAMETRICS, INC.
16 ESQUIRE ROAD
NO. BILLERICA, MA 01862-2598
508-670-5555

MARK.

inframetrics

Model 600L
Infrared Imaging Radiometer

With the system worn in the man-portable mode, the 600L is ready to go anywhere. Technician checks hot spot on switch disconnect.

A portable system for industrial applications.

- Direct temperature readout
- Measurement from -20° to +1500°C
- Microprocessor based
- Electric cooling
- 8-12, 3-5 or 3-12 μm spectral bands
- TV rate scanning
- Remote focus
- Emittance & background correction

The Model 600L is a TV-compatible, multipurpose real time infrared imaging radiometer for field and laboratory use. It offers total system versatility at reasonable cost, without compromising the superior spatial and thermal resolution for which Inframetrics is well known.

Standard TV output derives from the fastest scan rate commercially available, and provides easy interface with video printing devices, VCR's and video monitors. Real time thermal images are stored on videotape, with hard copy from video printers, 35mm or Polaroid cameras.

For in-depth data analysis, the 600L can be used with computer-based thermal image processing programs such as ThermaGRAM®, available only from Inframetrics.

Model 600L long wave systems produce excellent detail and avoid the inherent image degradation from solar reflections often encountered in daylight work with short waveband (3.0-5.0μm) systems.

Available options include electric cooling, image averaging, remotely controlled optical filters and man-portable or cart transportable packages.

Man-portable configuration

ThermaGRAM® is a registered trademark of Thermoteknix Systems Ltd., Cambridge, England.

inframetrics

May 6, 1992

RCG - Hagler, Bailly
1530 Wilson Blvd.
Suite 900
Arlington, VA 22209

Attn: Mr. David Kieth

Dear Mr. Kieth:

Inframetrics is pleased to submit the attached quotations for price and delivery of our Model 600L High Performance TV Compatible Thermal Imaging Radiometer with standard accessories. Attachment 1 details price and delivery for our Model 600L, Package ALC with electric cooling. Attachment 2 details price and delivery for our Model 600L, Package ALN with liquid nitrogen (LN2) cooling. The LN2 cooled system would be recommended if budget constraints prevent the purchase of an electrically cooled model.

The Model 600L is highly versatile and unique systems that combines ultra-high resolution imaging with precision temperature measurement, in a compact field rugged instrument. The powerful microprocessor controlled electronics is lightweight, battery powered and field proven. Built-in high speed measurement modes make it easy to measure temperatures quickly and accurately.

The patented scanner design incorporates a dual resonant galvanometer scanning mechanism which produces image fields faster than any other commercially available system. This unique feature assures proper documentation of transient events through the use of standard video recording equipment.

The Model 600L detailed in Attachment 1 includes our unique closed cycle microcooler-detector module eliminating the need to cool with liquid nitrogen. The closed cycle microcooler will bring the detector down to operating temperature within three minutes and requires only three watts of input power.

The Inframetrics closed cycle microcooler as well as LN2 cooling allow the Model 600L to operate in the long wave region (8-12um) which is highly desirable for sensitive measurements of ambient (<400 deg. C) temperature targets. The longwave region is also recognized as the wavelength region of choice for applications which call for outside imaging and temperature measurement during daylight hours as well as imaging in humid environments (indoors or outdoors).

The Infrared Specialists

Inframetrics, Inc.
16 Esquire Road, No. Billerica, MA 01862-2598
TEL: (508) 670-5555 • TWX: 710-326-0659
FAX #'s: COMM. (508) 667-2702 • MIL. (508) 667-1046 • PCH. (508) 667-1460

The Model 600L is a highly portable system. The system is powered by a small 12 volt DC battery that will provide four hours of continuous operation. The 600L scanner, control electronics and 5 inch monitor can all be conveniently mounted on the two wheel transporter cart provided with the package configurations quoted. The transporter cart also has provisions for mounting the video recorder included in the package.

In the options section I have listed our 600 Series Man Portability Package. The Man-Portability Package utilizes the new Sony Video Walkman which combines a 4 inch color LCD display with an 8mm video recording unit. The Sony unit, the 600L scanner and the system electronics mount conveniently onto the lightweight mounting vest included in the package.

The 600 Series man-portable system is ideal for users with hard-to-get-at targets. The separately held scanner allows users to reach targets difficult to access with shoulder mount systems. The 8mm video recorder allows the user to document thousands of frames of video and record events dynamically. The package also includes a rugged shipping case with foam cutouts for the Model 600L and all man-portability accessories.

All Inframetrics manufactured items are produced in the United States at our facility in Billerica, MA. At this facility, Inframetrics maintains a fully staffed customer service department that can generally provide turnaround on most service and or repairs inside two weeks. For users who require quicker turnaround, we offer premium service (5 day turn around) that is requested at the time of service or annual maintenance plans guaranteeing 24 hour or 5 day turnaround.

All Inframetrics manufactured items are covered by a standard one year warranty. Other items purchased for resale with minor modifications may carry a shorter warranty. A copy of our warranty policy is enclosed for your review. In addition, Inframetrics offers an extended warranty plan that would cover your system for an additional year.

If you have any questions or require additional information, please don't hesitate to contact us at any time. We thank you for the opportunity to respond to this request and look forward to the prospect of working with you in the near future.

Sincerely,

David C. Smialek
Sales Engineer, Commercial Products

enc.

inframetrics

TO: RCG - Hagler, Bailly
1530 Wilson Blvd.
Suite 900
Arlington, VA 22209

ATTN: Mr. David Kieth

QUOTE: 0592-04A
DATE: 06 MAY 92
FOB: N. Billerica, MA
TERMS: Net 15, Subject To Inframetrics Credit Approval
PAGE: 1 of 2

ATTACHMENT 1
ELECTRICALLY COOLED
MODEL 600L THERMAL IMAGING SYSTEM

ITEM	QTY	DESCRIPTION	AMOUNT

1	1	**Model 600L Package ALC High Performance TV Compatible Thermal Imaging Radiometer** (04418-222), *Includes:*
		
		* Model 600L Electrically Cooled System (04418-222), *Including:*
		  * Scanner With Inframetrics Closed Cycle Microcooler
		  * Control Electronics
		  * 5 Inch Black and White and Color Monitor
		  * AC Power Supply
		  * Interconnecting Cables
		  * System Shipping/Carrying Case
		
		* 600 Accessory Kit (05097-200) *Including:*
		  * Battery Kit
		  * Video Cassette Recorder, *with:*
		  - Power Supply
		  - Remote Control
		  - 2 Video Tapes
		  - Two VCR Batteries
		  - Color Photo Shroud
		  * Polaroid Camera and Film
		  * One Liter Dewar
		  * Interconnecting Cables
		  * Shipping/Carrying Case
		
		* Two Wheel Transporter Cart (007331-200)
		
		* 5 Liter LN2 Container (02681-000)
			$44,000.00

		TOTAL:	**$44,000.00**

The Infrared Specialists

Inframetrics, Inc.
16 Esquire Road, No. Billerica, MA 01862-2598
TEL: (508) 670-5555 • TWX: 710-326-0659
FAX #'s: COMM. (508) 667-2702 • MIL. (508) 667-1046 • PCH. (508) 667-1460

TO: RCG - Hagler, Bailly
ATTN: Mr. Kieth

DATE: 06 MAY 92

ITEM	QTY	DESCRIPTION	AMOUNT
		OPTIONS	
A	1	600 Series Man-Portability Package (06870-200) *Includes:* * Sony GV Series Walkman With 4" LCD Color Display and Integrated 8mm VCR * Sun Shield for the Sony Walkman * Scanner Pistol Grip * System Mounting Vest With Scanner Shoulder Strap * Two 4.5 AHR Nickel Cadmium Batteries With Chargers and Power Cords * Detachable GV8 Mounting Brackets * Shipping/Carrying Case With Cutouts For The Model 600 Electronics and Scanner	$3,700.00

DELIVERY: All items listed can be delivered within 90 days after receipt of order.

WARRANTY: All Inframetrics manufactured items are covered by a standard one year warranty. Other items purchased for resale with minor modifications may carry a shorter warranty. A copy of our warranty policy is enclosed for your review.

SERVICE CONTRACTS: Enclosed please find a brief description of the service agreements available for this equipment. These contracts provide yearly coverage of the system repairs and maintenance. All Inframetrics manufactured items are covered. Three levels of service agreements are available with varying guaranteed turn-around times. (please refer to the attached literature).

TRAINING: A three day formal training course for one person, conducted here at our facility in Billerica, is included with a system purchase.

VALIDITY: This quotation is valid for a period of 60 days.

David C. Smialek, Sales Engineer
Commercial Products

Thomas J. Scanlon, National Sales Manager, Commercial Products

inframetrics

TO: RCG - Hagler, Bailly
1530 Wilson Blvd.
Suite 900
Arlington, VA 22209

ATTN: Mr. David Kieth

QUOTE: 0592-04B
DATE: 06 MAY 92
FOB: N. Billerica, MA
TERMS: Net 15, Subject To Inframetrics Credit Approval
PAGE: 1 of 2

ATTACHMENT 2
LIQUID NITROGEN COOLED
MODEL 600L THERMAL IMAGING SYSTEM

ITEM	QTY	DESCRIPTION	AMOUNT

1	1	**Model 600L Package ALN High Performance TV Compatible Thermal Imaging Radiometer** (04418-202), *Includes:*
		
		* Model 600L Liquid Nitrogen Cooled System (04418-202), *Including:*
		  * Scanner and Control Electronics
		  * 5 Inch Black and White and Color Monitor
		  * AC Power Supply
		  * Interconnecting Cables
		  * System Shipping/Carrying Case
		
		* 600 Accessory Kit (05097-200) *Including:*
		  * Battery Kit
		  * Video Cassette Recorder, *with:*
		  - Power Supply
		  - Remote Control
		  - 2 Video Tapes
		  - Two VCR Batteries
		  - Color Photo Shroud
		  * Polaroid Camera and Film
		  * One Liter Dewar
		  * Interconnecting Cables
		  * Shipping/Carrying Case
		
		* Two Wheel Transporter Cart (007331-200)
		
		* 5 Liter LN2 Container (02681-000)
			$36,000.00

		TOTAL:	**$36,000.00**

The Infrared Specialists

Inframetrics, Inc.
16 Esquire Road, No. Billerica, MA 01862-2598
TEL: (508) 670-5555 • TWX: 710-326-0659
FAX #'s: COMM. (508) 667-2702 • MIL. (508) 667-1046 • PCH. (508) 667-1460

TO: RCG - Hagler, Bailly
ATTN: Mr. Kieth

DATE: 06 MAY 92

ITEM	QTY	DESCRIPTION	AMOUNT
		OPTIONS	
A	1	600 Series Man-Portability Package (06870-200) *Includes:* * Sony GV Series Walkman With 4" LCD Color Display and Integrated 8mm VCR * Sun Shield for the Sony Walkman * Scanner Pistol Grip * System Mounting Vest With Scanner Shoulder Strap * Two 4.5 AHR Nickel Cadmium Batteries With Chargers and Power Cords * Detachable GV8 Mounting Brackets * Shipping/Carrying Case With Cutouts For The Model 600 Electronics and Scanner	$3,700.00

DELIVERY: All items listed can be delivered within 30 days after receipt of order.

WARRANTY: All Inframetrics manufactured items are covered by a standard one year warranty. Other items purchased for resale with minor modifications may carry a shorter warranty. A copy of our warranty policy is enclosed for your review.

SERVICE CONTRACTS: Enclosed please find a brief description of the service agreements available for this equipment. These contracts provide yearly coverage of the system repairs and maintenance. All Inframetrics manufactured items are covered. Three levels of service agreements are available with varying guaranteed turn-around times. (please refer to the attached literature).

TRAINING: A three day formal training course for one person, conducted here at our facility in Billerica, is included with a system purchase.

VALIDITY: This quotation is valid for a period of 60 days.

David C. Smialek, Sales Engineer
Commercial Products

Thomas J. Scanlon, National Sales Manager, Commercial Products

MAY 4, 1992

TO: ROGER LYMAN
JOHNSTON, INC.
P.O. DRAWER 1075
MATTHEWS, NC 28106
FAX: 704-847-7228

FROM: MARK LANDSEIDEL
DUKE POWER COMPANY
P.O. BOX 306
CLIFFSIDE, NC 28024

SUBJECT: TELEDYNE OXYGEN ANALYZER

PLEASE SUBMIT A FIRM QUOTATION TO: RCG/HAGLER BAILLY, INC.
DAVID KEITH
1530 WILSON BLVD
SUITE 900
ARLINGTON, VA 22209
703-351-0300

FOR 2 EACH TELEDYNE PORTABLE FLUE GAS ANALYZER 320P WITH 220VAC 50 HZ CHARGING CIRCUIT, CARRYING CASE C-416, SPARE MICRO-FUEL CELL, ADDITIONAL INSTRUCTION MANUAL, AND FLOW-THRU ADAPTER P/N 9913.

PLEASE ATTACH 320P BROCHURE AND PRICE SHEET TO QUOTATION.

THIS EQUIPMENT WILL BE SHIPPED TO KOSTROMA, RUSSIA AND GIVEN TO THE ENERGY AUTHORITIES THERE FOR THEIR USE AS PART OF U.S. FOREIGN AID.

PLEASE COPY ME ON THE QUOTATION.

THANKS, MARK.

JOHNSTON, INC.

136 E. CHARLES ST. / P.O. DRAWER 1075 / MATTHEWS, NORTH CAROLINA 28106 / 704-847-3107 / FAX NO. 704-847-7228

April 30, 1992

Mr. Mark Landseidal
DUKE POWER CO.
P.O. Box 306
Cliffside, NC 28023

Dear Mr. Landseidal:

Attached is information and pricing on Teledyne's Model 320P and 320P/D Portable Flue Gas Oxygen Analyzers. Normally delivery is 1-4 weeks. Any order should be addressed to:

TELEDYNE ANALYTICAL INSTRUMENTS
c/o JOHNSTON, INC.
P.O. Drawer 1075
Matthews, NC 28106

Please call if any questions arise.

Best regards,

JOHNSTON, INC.

Roger Lyman
President

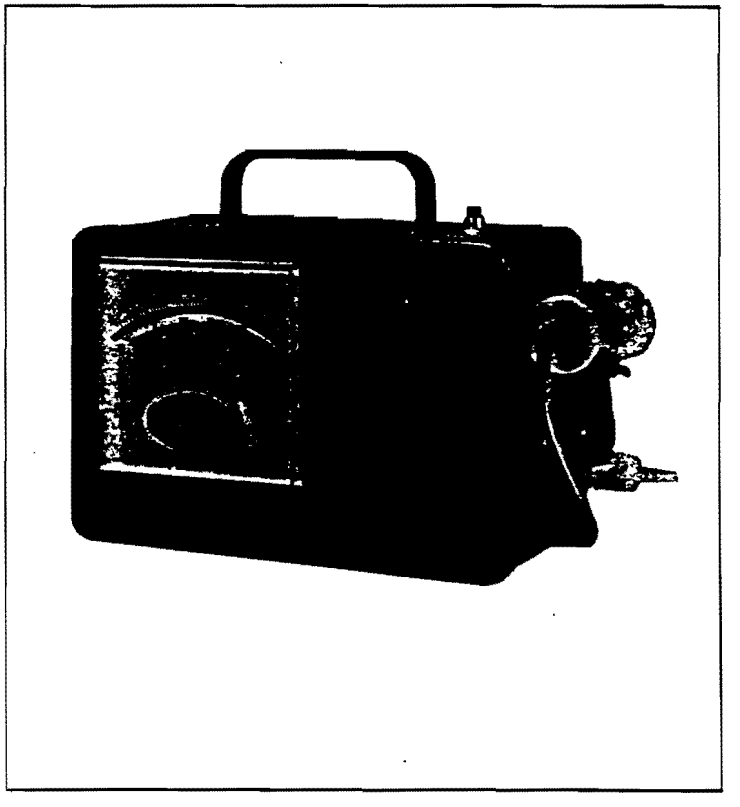
RL:dg

Encls.

cc: Curtis Helms

Model 320P

Portable Flue Gas Oxygen Analyzer
(with built-in pump)



Features:

- Accurate analysis
- Maintenance free sensor
- Three ranges standard: 0-5, 0-10, 0-25% oxygen (optional ranges available)
- Fast response and recovery
- Built-in pump
- All solid state electronics
- Low maintenance
- Air calibration
- No zero or other support gases required
- Unique disposable Cell-saver feature to extend cell life
- Rugged construction

Method of Analysis:

The new Model 320P portable oxygen analyzer utilizes TAI's patented Micro-fuel Cell*. The cell is specific for oxygen, has an absolute zero and produces a linear output from zero through 100 percent oxygen.

*U.S. Pat. Numbers 3,429,796 and 3,767,552

Printed in U.S.A.

TELEDYNE ANALYTICAL INSTRUMENTS

A HIGH TECHNOLOGY COMPANY

The Micro-fuel Cell is a sealed electrochemical transducer with no electrolyte to change or electrodes to clean. It is completely maintenance free. When the cell reaches the end of its useful life, it is merely discarded and replaced as one would replace a battery in a flashlight.

Advantages of Using the Model 320P Portable Analyzer:

- 1) Completely portable, powered by permanently mounted rechargeable batteries. The Model 320P is always ready for making a quick spot check analysis and requires no warm-up period.
- 2) Integral pump to extract a sample when there is no positive pressure.
- 3) Calibration, using atmospheric air. The Model 320P does not require any zero or span gases, which is a cost saving.
- 4) Accuracy: ±1% of full scale. The 320P is fast becoming a standard in many areas requiring high accuracy.
- 5) Reliable readability of 0.1% oxygen variations and three ranges: 0-5, 0-10, 0-25% oxygen.
- 6) Designed for rugged use as a portable instrument, the Model 320P has demonstrated its ability to be a more reliable convenient instrument for use on typical applications.
- 7) Fast response time of 90% in less than 6 seconds.

Air Calibration: The Model 320P is designed to be standardized against ambient air. Air is allowed to diffuse into the sensing probe at which time the span control is rotated until the meter needle coincides with the red calibration mark at 20.9% on the 0-25% range.

Cell-Saver: The Model 320P incorporates TAI's unique Cell-saver. With the Cell-saver cap in place, the cell will consume the oxygen in the trapped gas space and the output will drop off toward zero. This feature keeps oxygen away from the cell when the instrument is not in use, thereby, prolonging the life of the cell.

Typical Applications:

Boilers, fireboxes and process streams. Used in power plants, refineries, chemical plants, and steel-making processes. Also in air pollution control for analyzing automobile exhaust.

Requirements for Boilers and Fireboxes. The amount of oxygen (excess air) in flue gases is significant in defining the status of a combustion process.

- 1) Too much oxygen (excess air) will lower the efficiency of the process by absorbing heat and carrying it out the stack to waste. Fuel would have to be added to maintain the heat level, increasing the cost.
- 2) Insufficient oxygen (excess air) can result in incomplete combustion. Combustible gases will build producing a potential hazard which could result in an explosion.
- 3) Low values of oxygen (excess air) at the correct level will give optimum combustion efficiency. Under these conditions, there is little heat loss, lowering fuel requirements. Savings on fuel can add up to many thousands of dollars per month.

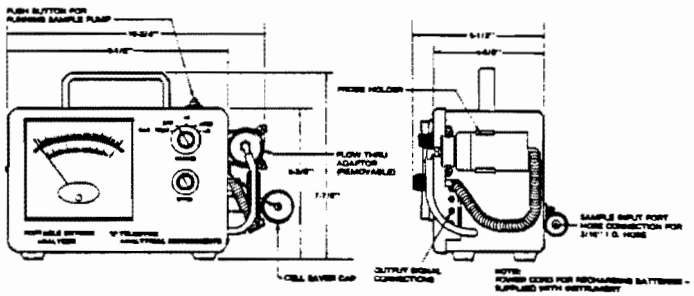
SPECIFICATIONS:

Three Ranges Standard: 0-5, 0-10 and 0-25% oxygen (optional ranges available)
Sensitivity: 0.5% of full scale
Accuracy: ±1% of full scale at constant temperature; ±5% of reading or ±1% of full scale, whichever is greater, throughout the operating temperature range
Operating Temperature: 32-125°F
Response Time: 90% in less than 6 seconds.
Signal Output: Internal, high resolution meter; External, 0-100 mv DC full scale (others available)
Micro-fuel Cell: Class B-1. Expected cell life is 80,000%-hrs. (6 months in air). Cell is warranted for 80,000%-hrs. or 1 year, whichever occurs first. With Cell-saver, life is dependent upon duty cycle (e.g. 2.5 years, assuming 10% duty cycle in air)
Power Requirements: — NiCad rechargeable batteries. — Battery life expectancy 5 yrs. (min). Batteries fully charged provide over 1 month's continuous operation. Charging time - overnight (14 hrs.) Built-in charger requires 115 VAC, 50-60 Hz power. (220 VAC, 50-60 Hz - optional).

Pump Specifications:

Type: Diaphragm
Duty: Designed for intermittent use
Power: 2½ VDC supplied by NiCad rechargeable batteries (30-40 hrs. per charge)
Max. Vacuum: 48" water column

OUTLINE DIAGRAM



In addition to the Model 320P Portable Flue Gas Oxygen Analyzer, Teledyne Analytical Instruments also manufactures thermal conductivity analyzers, near infrared analyzers, flame ionization analyzers, ultraviolet analyzers and the industry's most complete and comprehensive line of oxygen analyzers.

TELEDYNE AN NTS

333 WEST MISSION DRIVE SAN GABRIEL, (

Represented by:
JOHNSTON, INC.
P.O. Drawer 1075
Matthews, NC 28106
Telephone: 704/847-3107
Fax Number: 704/847-7228

589-1605

The Micro-fuel Cell is a sealed electrochemical transducer with no electrolyte to change or electrodes to clean. It is completely maintenance free. When the cell reaches the end of its useful life, it is merely discarded and replaced as one would replace a battery in a flashlight.

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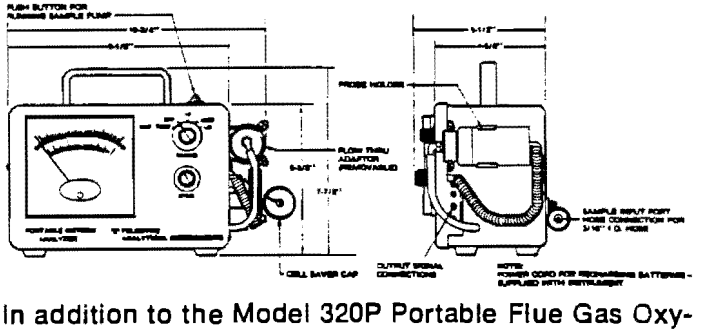
Pump Specifications:

Type: Diaphragm
Duty: Designed for intermittent use
Power: 2½ VDC supplied by NiCad rechargeable batteries (30-40 hrs. per charge)
Max. Vacuum: 48" water column

OUTLINE DIAGRAM



In addition to the Model 320P Portable Flue Gas Oxygen Analyzer, Teledyne Analytical Instruments also manufactures thermal conductivity analyzers, near infrared analyzers, flame ionization analyzers, ultraviolet analyzers and the industry's most complete and comprehensive line of oxygen analyzers.

TELEDYNE AN NTS

333 WEST MISSION DRIVE SAN GABRIEL, (

Represented by:

JOHNSTON, INC.
P.O. Drawer 1075
Matthews, NC 28106

Telephone: 704/847-3107
Fax Number: 704/847-7228

589-1605

TELEDYNE ANALYTICAL INSTRUMENTS
16830 CHESTNUT STREET, CITY OF INDUSTRY, CA 91749
(213) 961-9221 • 283-7181 TWX 910-1887 TDYANYL COID

PRICE INFORMATIC

Model No.	Description	Price
320P	Oxygen (O2) analyzer supplied standard with the following:	$ 895.00

- Built-in sampling system with integral, pushbutton-actuated sample pump
- Three linear ranges: 0-5, 0-10, 0-25% O2 (switch selectable)
- Local meter display (direct readout)
- Deep-drawn aluminum case
- Battery-powered (rechargeable NiCad batteries with 110 VAC, 50/60 Hz charging circuit)
- Micro-Fuel Cell: Class B-1 (calibrated with ambient air) - 6 month warranty
- 90% response in 7 seconds (B-1 cell)
- Cell saver cap
- Operating temperature range: +32 degrees F to +122 degrees F (0 degrees C to +50 degrees C)
- 0-100 mVDC output
- Battery charging power cord
- Instruction manual

NO-CHARGE OPTIONS:

- 100 VAC, 50/60 Hz battery charging circuit
- 220 VAC, 50/60 Hz battery charging circuit

PRICE-ADDER OPTIONS:

- Special ranges	Contact Factory
- Carrying case (C-416) - aluminum/steel clad, foam interior	203.50
- Spare Micro-Fuel Cell: Class B-1	70.00

PRICES SUBJECT TO CHANGE WITHOUT NOTICE
EFFECTIVE DATE DECEMBER 1, 1989

Model No.	Description	Price
320P PRICE-ADDER OPTIONS (cont.)		
	- Additional instruction manual	11.00
	- Flow-thru adapter: (P/N 9913)	16.50

320P/D	Same as 320P except:	1,200.00
	- Integral liquid-crystal digital display	
	- Linear range: 0% to 100% O2	

TO: MARC E. SHERMAN
IRD MECHANALYSIS, INC.
SUITE 110
500 WEST DUTTON'S MILL ROAD
ASTON, PA 19014
215-497-4449
215-497-4451 FAX

FROM: MARK LANDSEIDEL
DUKE POWER COMPANY
P.O. BOX 306
CLIFFSIDE, NC 28024
704-657-6314

SUBJECT: IRD MODEL 880

PLEASE SUBMIT A FIRM QUOTATION TO: RCG/HAGLER BAILLY, INC.
DAVID KEITH
1530 WILSON BLVD
SUITE 900
ARLINGTON, VA 22209
703-351-300

FOR 1 EACH IRD MODEL 880 MICROPROCESSOR ANALYZER-BALANCER. 220 VAC 50 HZ. SCALES IN METRIC. 1 EXTENSION CABLE FOR STROBE LIGHT (12FT P/N 28836). 1 EXTENSION CABLE FOR MODEL 970 PICKUP (50FT P/N 21048).

PLEASE ATTACH 880 BROCHURE AND OPTION SHEET TO QUOTATION.

THIS EQUIPMENT WILL BE SHIPPED TO KOSTROMA, RUSSIA AND GIVEN TO THE ENERGY AUTHORITIES THERE FOR THEIR USE AS PART TO U.S. FOREIGN AID.

PLEASE COPY ME ON THE QUOTATION.

THANKS. MARK.

BEST AVAILABLE COPY

IRD Mechanalysis

May 1, 1992

Mr. Mark Landseidel
Duke Power Company
P.O. Box 306
Cliffside, NC 28024

Dear Mr. Landseidel:

As per our conversation of today, I am confirming that it would be acceptable for Duke Power Company to purchase IRD instrumentation (i.e., Model 880/Model 885) and ship same to Russia to further help the foreign aid package that is currently aiding the Russian Utility Industry.

I have enclosed literature regarding the above-referenced instruments for your review. After you have had the opportunity to examine this material, please contact me with your questions and comments.

Thank you for your interest in our company. I look forward to hearing from you soon.

Sincerely yours,
IRD MECHANALYSIS, INC.

Marc E. Sherman

Marc E. Sherman
District Manager

MES/pw
Encs. (per above)

ply to Northeast Region Office:
IRD Mechanalysis, Inc.
Suite 110
500 West Dutton's Mill Road
Aston, Pennsylvania 19014
215/497-4449
FAX: 215-497-4451

BEST AVAILABLE COPY

Corporate Headquarters:
IRD Mechanalysis, Inc.
6150 Huntley Road
Columbus, Ohio 43229
614/885-5376
Telex 24-5318
FAX: 614-885-7668

Model 880

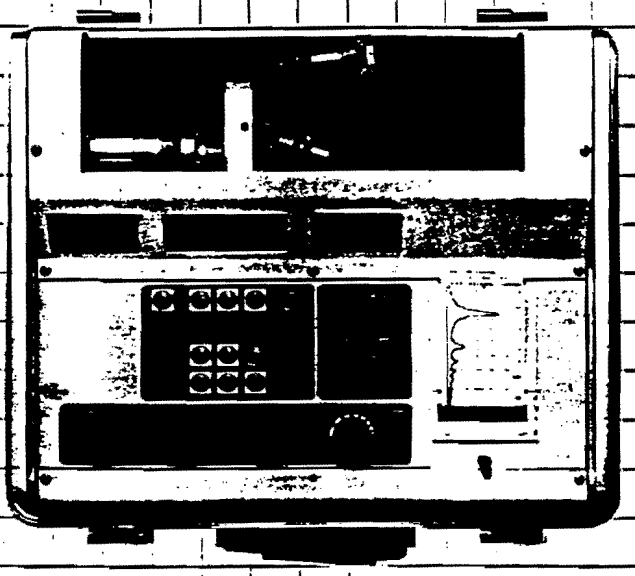
Microprocessor Analyzer-Balancer **EFFECTIVE: Dec 1991**

DESCRIPTION

The Model 880 microprocessor analyzer-balancer is a rugged, self-contained, portable diagnostic tool, designed to be taken directly to the machine for vibration spectrum analysis and in-place balancing.

Pressing a single switch generates a completely annotated hard-copy frequency spectrum from 600-600,000 cpm in only 25 seconds. You can also obtain low frequency measurements to 60 cpm.

A single sensor measures machinery vibration in displacement, velocity acceleration and Spike Energy™ units.



FEATURES

- Digital amplitude or frequency display provides a high precision readout for balancing and analysis.
- Analog amplitude and frequency meters supplement the digital displays and aid in analyzing unsteady signals.
- Automatic tabular listing of spectrum frequency peaks and amplitudes.
- Chart speed selector with three time-plot speeds records short transients and slowly changing vibration over a number of hours.
- Automatic "order" indication of the spectrum frequency peaks to show harmonic relationships of frequency peaks to rpm.
- Diagnostic capability includes hard-copy tabular readout of the most likely causes of vibration.
- Prints out AVERAGE, MINIMUM, and MAXIMUM overall values for both spectrum and amplitude vs. time plots.
- Event marking feature prints a short vertical line to indicate the precise time of events on amplitude vs. time plots.

60 to 600,000 cpm (1 to 10,000 Hz).

TUNABLE FILTER RANGE
60 to 600,000 cpm in two ranges 60 to 60,000 cpm and 600 to 600,000 cpm.

TUNABLE FILTER CHARACTERISTICS
Broad filter: 10% BW (Q = 10) for fast plotting.
Sharp filter: 5% BW (Q = 20) for high resolution.
Balance filter: 3.25% (two cascaded Q = 20) for balancing.
Automatic filter sweep: 60 to 600,000; 600 to 600,000 cpm.
Manual filter tune: 60 to 60,000; 600 to 600,000 cpm.

INTERNAL OSCILLATOR RANGE
60 to 600,000 cpm in two ranges; 60 to 60,000 cpm; 600 to 600,000 cpm.

STROBOSCOPIC LIGHT
High intensity strobe.
One flash per cycle up to 15,000 cpm; submultiple firing up to 600,000 cpm.

DISPLACEMENT RANGES (see note*)
English: 0 to 100 mils in eight full-scale overlapping ranges; 0 to .03; 0 to .1; 0 to .3; 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 mils pk-pk.
Metric: 0 to 3,000 µm in eight full-scale overlapping ranges: 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100; 0 to 300; 0 to 1,000; 0 to 3,000 µm pk-pk.

VELOCITY RANGES (see note*)
English: 0 to 100 in/s in eight full-scale overlapping ranges; 0 to 0.3; 0 to .1; 0 to .3; 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 in/s peak.
Metric: 0 to 3,000 mm/s in eight full-scale overlapping ranges: 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100; 0 to 300; 0 to 1000; 0 to 3000 mm/s peak (or rms factory option).

ACCELERATION RANGE (with Model 970)
English and metric: 0 to 100 g in eight full scale overlapping ranges: 0 to .03; 0 to .1; 0 to .3; 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 g peak (1g = 386 in/s², or 9.8 m/s²).

SPIKE ENERGY UNITS RANGE
English and metric: 0 to 100 g in eight full-scale overlapping ranges: 0 to .03; 0 to .1; 0 to .3; 0 to .1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 g with special circuits designed to detect and analyze Spike Energy units.

TEST SIGNAL
Internally generated test signal operates on AC or battery power to check circuit operation in test. Test signal is synchronous to and in phase with the line power when switched to AC power.

BATTERY CHECK
Digital LO BATT indicator; analog meter display of battery voltage to indicate remaining battery operating time in BATT CK; analog meter of battery voltage when charging power switch off to indicate charge condition.

OUTPUTS
Built-in XY printer/plotter with annotated frequency and time plots.
Diagnostic tabular print-out to aid data interpretation.
Harmonic markers on spectrum plots to aid identification of harmonic vibrations.
Display and printout of rpm.
Printout of overall amplitude: average, maximum and minimum levels over six-second sample period at start of frequency plots.
Printout of overall amplitude average, minimum and maximum levels at the end of amplitude vs. time plot.
Event marker.
Spike Energy (8-sample average) signature in broad high-band mode
Printout of prompting messages to guide operator through single-plane and two-plane balancing.
DC power output (-24 V) to drive non-contact signal sensors.
Analog amplitude meter and analog frequency meter.
Digital amplitude meters; covers range 3-1/2 digits (.0000-1500 — English, or .0000 – 15 k metric).
Digital frequency meter; covers range of 60-600,000 cpm.
Digital display of measurement units:
English: mils pk-pk, in/s pk, (or rms factory option), g pk.
Metric: µm pk-pk, mm/s pk, (or rms factory option), g pk.
Scope/tape recorder.
Strobe light output receptacle.
Signal overscale indication.

Two input channels, switch selectable for analysis and balancing with four transducers (544, 560, 970 or non-contact inputs of 200 mV/mil 8 mV/µm), or acoustic input from Model 308 vibration/sound level meter.

WEIGHT
Analyzer (built-in battery): 32 lb (14.5 kg).
Analyzer (built-in battery and standard accessories): 36 lb (16.4 kg).

TEMPERATURE RANGE
5° - +122°F (-15° - +50°C)

OVERALL DIMENSIONS
Analyzer: 17 in x 14 in x 6-1/2 in (432 mm x 356 mm x 165 mm).

POWER REQUIREMENTS
AC power: 50-400 Hz; 90-250 V, 25 W.
Battery power: Built-in, replaceable, sealed, rechargeable Gel Cel battery pack; 10-hour operation capacity; 2-hour minimum continuous operation of strobe at maximum flash rate.
Battery charger: Automatic charge whenever on AC power with circuit to prevent overcharge. Maximum charging rate available when power switch is turned off.

STANDARD ACCESSORIES
- 1 Model 970 accelerometer - P/N 19697
- 1 Straight probe - P/N 1103
- 1 12 ft (3.7 m) pickup cable for Model 970 - P/N 20431
- 1 Model 571 stroboscopic light - P/N 28830
- 1 12 ft (3.7 m) strobe cable for Model 571 strobe - P/N 28836
- 1 Power cable - P/N 19643
- 8 Rolls thermal printer paper - P/N 24444
- 2 Fuses for 220 V AC operation - P/N 28578
- 1 Self training module - P/N 29177
- 1 Operating instructions manual - P/N 28838

OPTIONAL ACCESSORIES
- Model 544 vibration velocity pickup - P/N 4526
- 12 ft (3.7 m) pickup cable for Model 544 - P/N 20433
- Magnetic pickup holder for Model 544 and Model 970 - P/N 4332
- Magnetic shield for Model 544 transducer - P/N 10449
- Non-contact displacement accessories:
  Single channel - P/N 29093
  Dual channel - P/N 29094
- 12 ft (5.7 m) extension cable for strobe light - P/N 28836
- 25 ft (7.6 m) extension pickup cable for Model 970 accelerometer - P/N 21044
- 25 ft (7.6 m) extension pickup cable for Model 544 transducer - P/N 21045
- 50 ft (15.2 m) extension pickup cable for Model 970 accelerometer - P/N 21048
- 50 ft (15.2 m) extension pickup cable for Model 544 transducer - P/N 21049
- 12 ft (3.7 m) non-contact monitor pickup cable with BNC connector for non-contact monitor output with sensitivity of 200 mv/mil (8 mv/um) - P/N 24809
- 12 ft (3.7 m) non-contact signal sensor pickup cable with spade lugs for connect to non-contact signal sensors with sensitivity of 200 mV/mil (8 mV/µm) - P/N 22874
- 12 ft (3.7 m) non-contact signal sensor pickup cable with spade lugs for non-contact signal sensor - P/N 29030. Similar to P/N 22874 but with an added wire and spade lug to apply power (-24V) to the signal sensor.
- ★ Model 560 low-frequency velocity transducer - P/N 24957
- 12 ft (3.7 m) pickup cable for Model 560 - P/N 25136
- 25 ft (7.6 m) extension pickup cable for Model 560 - P/N 25137
- 50 ft (15.2 m) extension pickup cable for Model 560 - P/N 25138
- Model 308 vibration/sound level meter
- Chart paper (sold in lots of 48 rolls) - P/N 24444
- Calibrator - P/N 21073
- Vibration chart storage notebook with 50 filler sheets - P/N 25864
- Notebook filler sheets (package of 100) - P/N 25865
- Accessory case - P/N 25345
- Service instruction manual - P/N 29359

★ **NOTE: For displacement or velocity readings below 200 cpm, optional low-frequency pickup (Model 560) is recommended.**

IRD Mechanalysis - U.S.A.
IRD Mechanalysis, Inc.
6150 Huntley Road
Columbus, OH 43229-9851
Phone: 614/885-5376
Telex: 24-5318
FAX: 614/885-7668

IRD Mechanalysis - Canada
IRD Mechanalysis, Ltd.
877 Barton Street East
Stoney Creek, Ontario L8G 4S1
Phone: 416/643-4284
FAX: 416/643-1143

IRD Mechanalysis - U.K.
IRD Mechanalysis (UK), Ltd.
Bumpers Lane
Sealand Industrial Estate
Chester CH1 4LT
Phone: (44) 0244 374914
Telex: 617034
FAX: (44) 0244 379870

IRD Mechanalysis - Belgium
IRD Mechanalysis, N.V.
Excelsiorlaan, 39 Box 2
1930 Zaventem (Zoning Keiberg)
Phone: (2) 721.28.33
Telex: 61258
FAX: (2) 725.00.17

IRD Mechanalysis - India
IRD Mechanalysis, Ltd.
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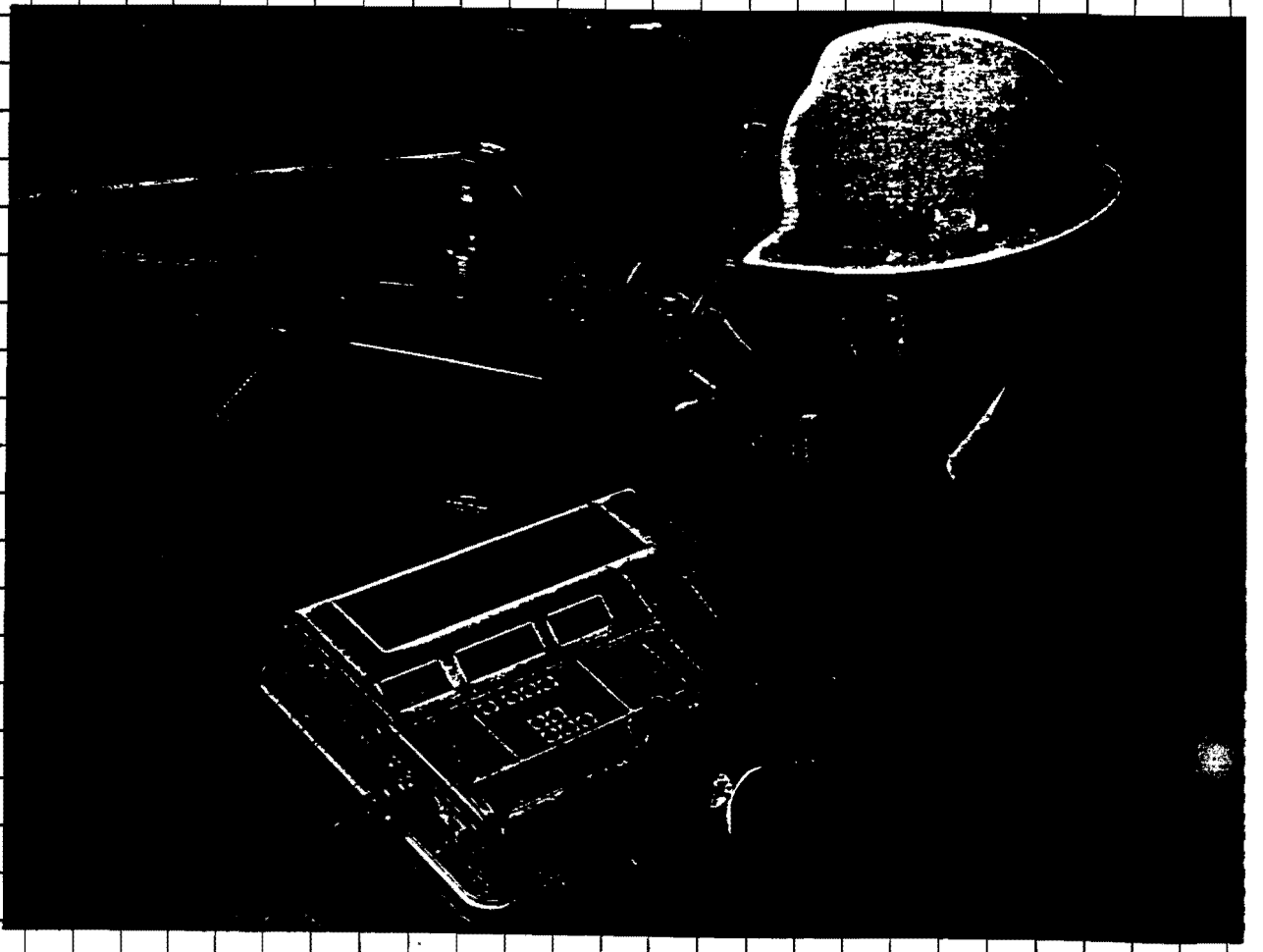
L02023

FORM # 2255C

$10,450.00 + X

DAVID,
SORRY I WAS LOW
ON THIS ESTIMATE.
MARK

MODEL 880
Analyzer-Balancer



IRD Mechanalysis

Model 880 Analyzer-Balancer

Model 880 has developed a reputation as a rugged, versatile instrument. Now IRD has made the 880 even more powerful - adding new diagnostic capabilities that makes machinery condition analysis easier and more accurate.

The Model 880 Microprocessor Analyzer-Balancer is a self-contained, portable diagnostic instrument designed to be taken directly to the machine for vibration spectrum analysis and in-place balancing.

The 880 is an important tool in a Predictive Maintenance Program. It is the perfect complement to your portable vibration measuring instruments or your automated data collection and machinery condition surveillance systems. Its versatility allows you to perform four important PMP functions with ease and accuracy.

Baseline Signatures

The 880 can be used to establish baseline vibration s[illegible] res. This permanent record serves as a "finger-p[illegible]gainst which future signatures can be compared to detect and diagnose machine faults.

Repair Confirmation

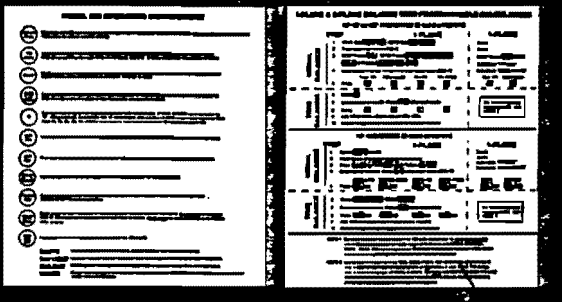
When a machine has been repaired, the 880 can be used to run a comparison vibration signature to insure the repairs were performed properly.

Fault Diagnostics

When a PMP periodic check indicates a possible problem, the 880 will confirm the existence of the problem, and then be used to identify defects such as unbalance, misalignment, mechanical looseness, bent shafts, bad bearings and worn gears.

In-Place Balancing.

If unbalance is found, the 880 can perform in-place single and two-plane balancing.



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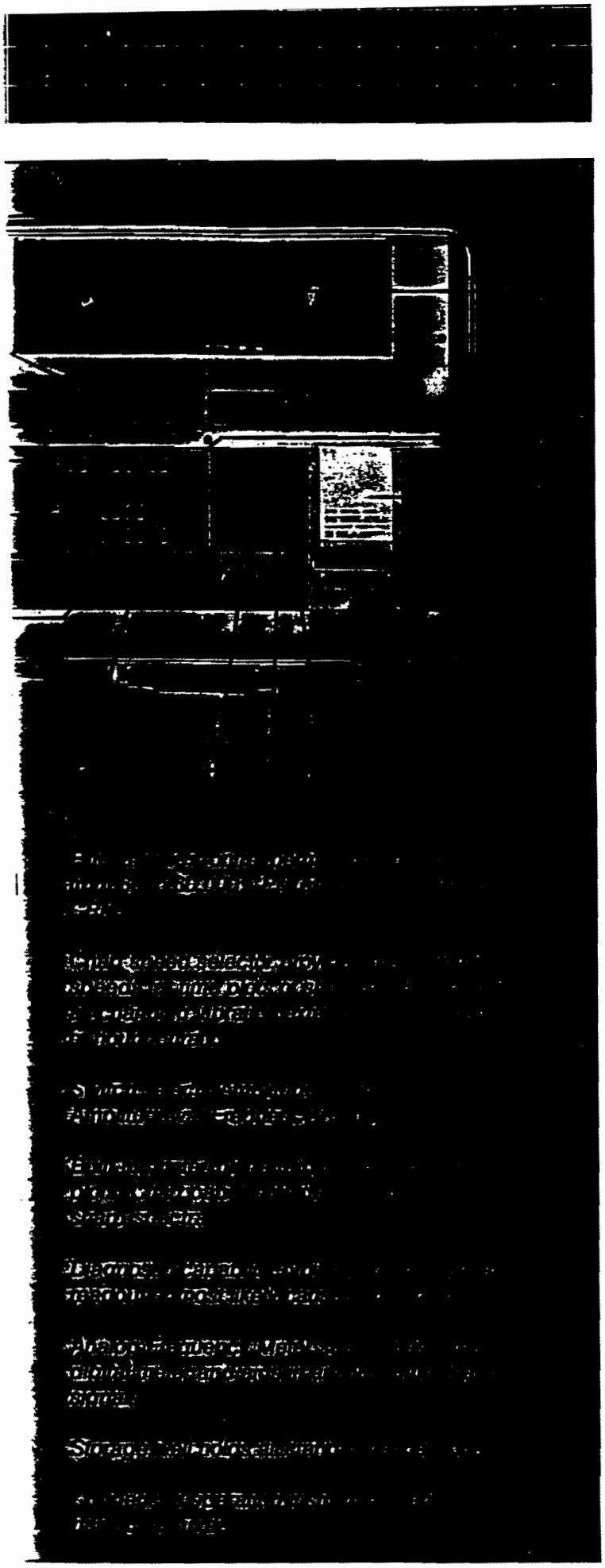

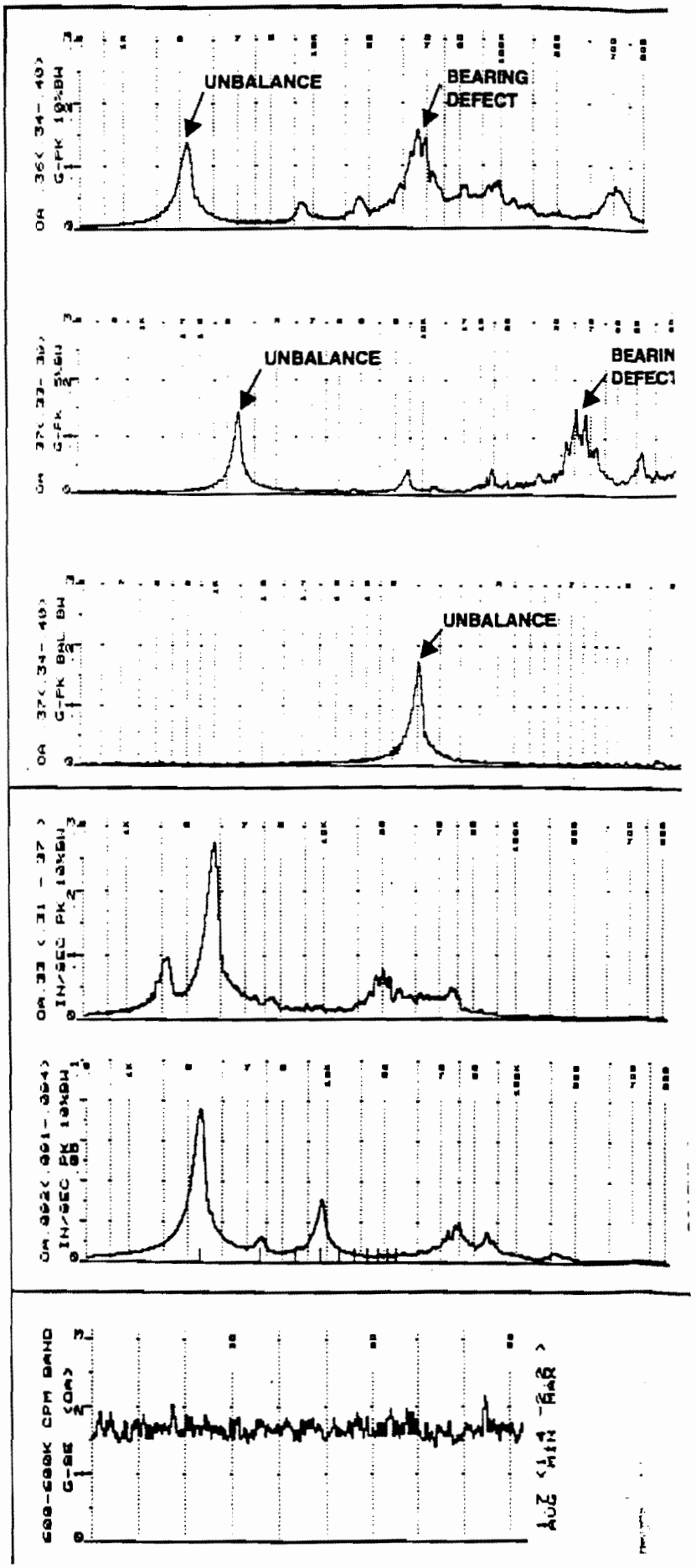

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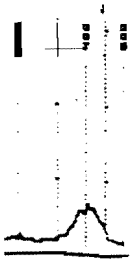
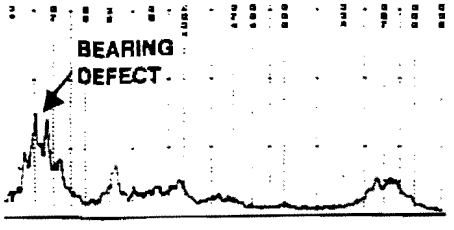
Model 880 Signature Examples



Broad Signature



Sharp Signature

Signature Bandwidth Selection

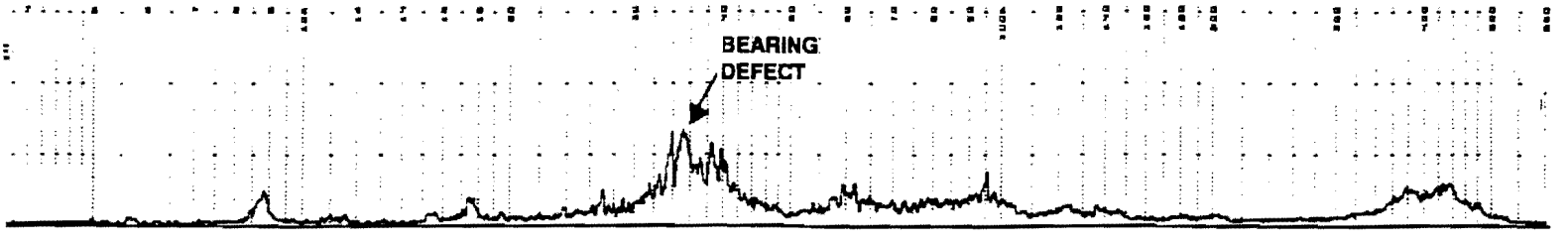
Three bandwidth selections are provided for observing individual frequency components of the vibration signal. Each provides filtering with a different degree of tuning selectivity.

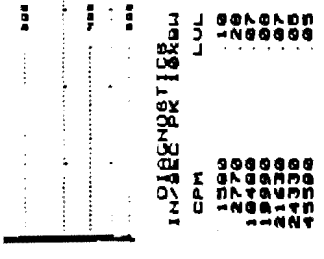
The **BROAD** signature (10% bandwidth) allows fast tuning. Frequency scales are automatically printed. Plot generated in 35 seconds.

The **SHARP** signature (5% bandwidth) is used for detailed analysis of frequency peaks. Plot generated in 95 seconds.

The **BALANCE** signature (2.8% bandwidth) provides still higher frequency resolution necessary for fine analysis and balancing. Plot generated in 210 seconds.

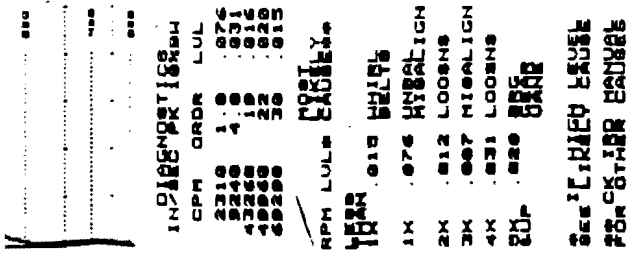
Balance Signature





Automatic tabular Listing and Diagnostic Indication

An automatic tabular listing or spectrum frequency peaks and their amplitudes (peak-picking) is printed immediately following the graphic signature and simplify analysis.

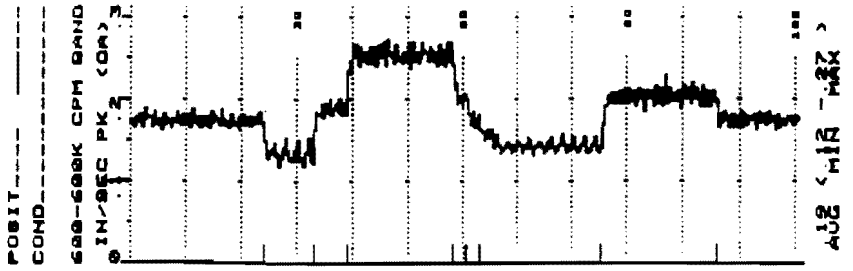


By entering RPM information into the 880's memory, the "order" will be added to the tabular listing. The amplitudes and most probable causes of harmonic frequency peaks are also indicated.

Average, Minimum & Maximum Values

On Amplitude vs. Time plots, an automatic printout of average, minimum and maximum values is provided.

Machine Operating Cycle

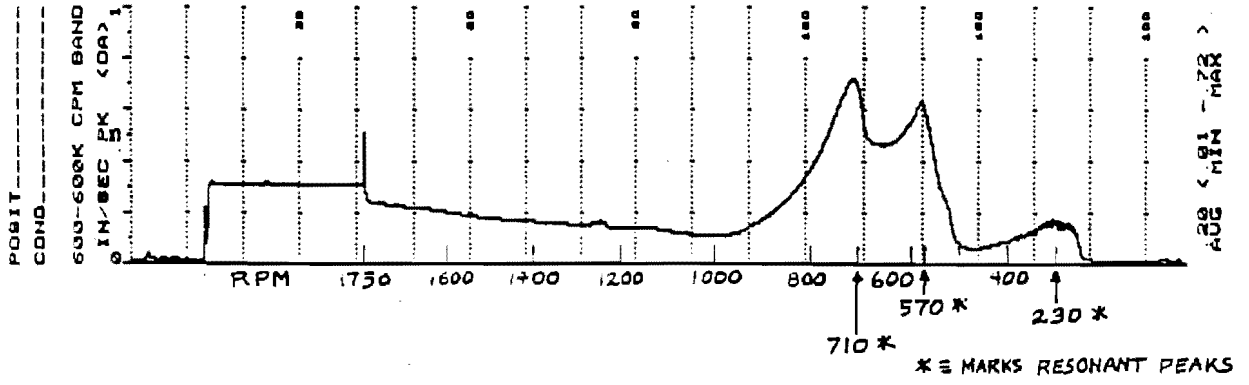


Event marks can be used to indicate change in machine operating modes

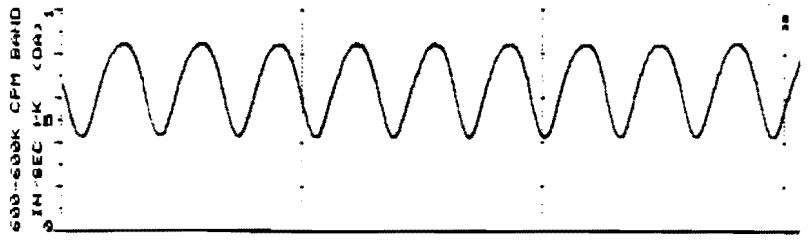
Event Marking

A printout of short vertical lines on Amplitude vs. Time plots can be used to manually indicate precise time of specific events.

Machine Coast-Down

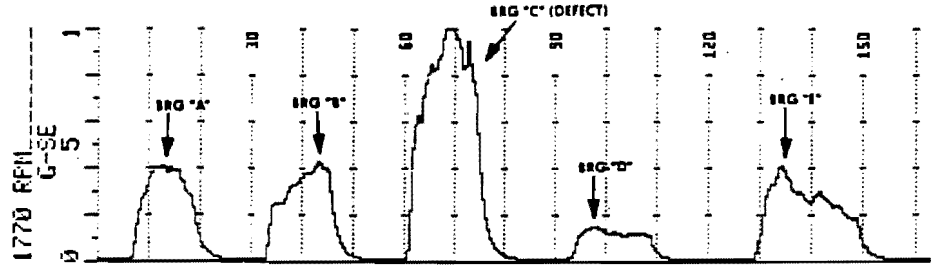


Event marks can be used to indicate RPM (obtained with tachometer) in relation to machine vibration levels during machine coast-down.

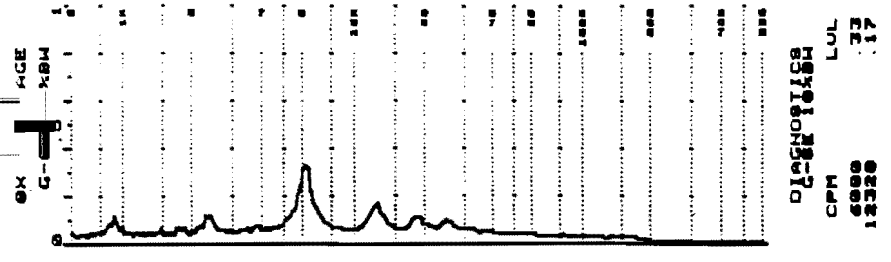


Beat Vibration

Beat frequency time signature caused by operation of two induction motors on the same baseplate.



Spike Energy Amplitude vs. Time Signature



Spike Energy Amplitude vs. Frequency Signature

Spike Energy Measurements

The 880's Spike Energy detection circuits are designed to sense microscopic flaws in bearing or gear elements. A high frequency broad band filter mode is provided to enhance frequency peaks which would otherwise be obscured by unbalance, misalignment and other similar vibrations.

Frequency analysis of these high frequency signals aids in determining the source of the Spike Energy signal (i.e., bearings, gears, rubbing, etc.).

Balancing Prompting

Single and two-plane balance prompting messages provided by the Model 880 guide the operator through each step of the balancing procedure.

A step-by-step reference is provided for assistance when balancing with programmable calculators.

Sample Two-Plane Balancing Messages

```
BALANCE <2 _ PL>
MACH_FAN #102_____
SPIN ROTOR
ORIGINAL BAL
NEAR END
___63___DEG*    1
___9.6___MILS   2
FAR END
__206___DEG*    7
___6.5___MILS   8
*MEAS CW FROM
 STATNRY REF MRK
 TO ROTOR REF MRK
STOP ROTOR
```

1

```
SAFE TWT <OZ-IN>
= RTR WT IN LBS
 17.7(RPM/1000)*
1 OZ = 28.35 GM
1ST TW (NR END)
___270___DEG** 13
____2____OZ-GM 14
____5____RAD
**MEAS CW FROM
  ROT REF MRK
  TO TW POS
```

2

```
SPIN ROTOR-------
NR END TW BAL
NEAR END
___123___DEG*   3
___5.9___MILS   4
FAR END
___228___DEG*   9
___4.5___MILS  10
STOP ROTOR
REMOVE TW
```

3

```
2ND TW (FR END)--
___180___DEG** 15
____2____OZ-GM 16
____6____RAD
```

4

```
SPIN ROTOR-------
FR END TW BAL
NEAR END
___36___DEG*    5
___6.2___MILS   6
FAR END
___162___DEG*  11
___10.4___MILS 12
STOP ROTOR
REMOVE TW
```

5

```
CALCULATE CORR WT
CORRECTION WT
NEAR END
-146.61_DEG**   B
__2.15__OZ-GM   A
____5____RAD
FAR END
__-65.40_DEG**  D
___1.03__OZ-GM  C
____6____RAD
```

6

```
SPIN ROTOR-------
CORRECTION BAL
NEAR END
___22___DEG*   17
___1.1___MILS  18
FAR END
___124___DEG*  19
__0.72___MILS  20
STOP ROTOR AND
CALCULATE CORR WT
IF REQUIRED
```

7

```
TRIM WT----------
NEAR END
-100.05_DEG**   B
__0.366__OZ-GM  A
____5____RAD
FAR END
__45.29_DEG**   D
__0.167__OZ-GM  C
____6____RAD
```

8

```
SPIN ROTOR-------
CORRECTION BAL
NEAR END
___37___DEG*   17
__0.64___MILS  18
FAR END
___156___DEG*  19
__0.51___MILS  20
STOP ROTOR AND
CALCULATE CORR WT
IF REQUIRED
```

9

CORPORATE HEADQUARTERS

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6150 Huntley Road
Columbus, Ohio 43229
614/885-5376
Fax: 614/885-7668

Form # 2130B

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ENERGY AUDIT
CITY OF KOSTROMA
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 8
CALCULATIONS ON EFFECT OF INSULATION

INSULATION AND WEATHERSTRIPPING

During our visit several buildings under construction were observed. Although a close inspection was not made, there did not appear to be any insulation in the outer walls of the buildings. Also, many older buildings exist which are not insulated. Mr. A.V. Kaftanov, a Moscow architect, indicated in a conversation with Mr. Oliker that some buildings are insulated and some are not.

All fenestration had double, or storm, windows in every building observed including residential log cabins. The quality of the window installation was poor from the viewpoint of both an engineering and workmanship. The two lights of glass were usually about 20 cm apart permitting convection currents between the interior surfaces. Also, there were many cracks and poor fits at all joints. The distance between the lights cannot be easily changed, but the cracks can be addressed with caulking and weatherstripping.

There are many manufacturers of systems of exterior insulation in the United States and a few sample specifications are attached. A computer simulation was performed to evaluate the economic effectiveness of exterior insulation and weatherstripping. The output for three alternatives is attached and the results summarized below.

Alternative Identity	Conditions	Annual cost $	Annual kBTU	Annual MJ
Moscow 0	No insul No W.S.	44,971	3,779,745	3,987,843
Moscow 1	Add W.S. No Insul	38,613	3,269.506	3,449,512
Moscow 2	Add W.S. Add Insul	26,657	2,179,977	2,299,989

Note: W.S. is weatherstripping.

The table shows that adding weatherstripping to the sample building will save $6,358 per year. The cost of weatherstripping for this building would be less than $1000, for a payback of about two months.

The installation of insulation on the exterior of the building has the potential of saving $12,000 per year. The installation cost is estimated at $162,000 for a payback of 14 years. Although the payback is long in this case, there will be renovations of existing buildings and construction of new buildings. At that time the installation of insulation can be incorporated in the construction and have a payback of two to four years. The lever here lies in technology transfer to influence future construction.

ENERGY BUDGET <A>

Building : MOSCOW O — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program —

****

TABLE 1. ANNUAL LOADS

Component	(kBTU)	(kBTU/sqft)*
Cooling Loads *	0	0.000
Heating Loads *	2,824,401	47.473

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(kBTU)	(kBTU/sqft)*
Air System Fans	498,782	8.384	498,782	8.384
Cooling Plants	0	0.000	0	0.000
Heating Plants	2,824,402	47.473	2,824,402	47.473
Pumps	23,124	0.389	23,124	0.389
>> HVAC Total	3,346,307	56.245	3,346,307	56.245
Lights	106,849	1.796	106,849	1.796
Other Electric	53,424	0.898	53,424	0.898
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	273,165	4.591	273,165	4.591
>> Non-HVAC Total	433,438	7.285	433,438	7.285
>> GRAND TOTAL	3,779,745	63.530	3,779,745	63.530

* Notes: 1. Site energy is the actual energy consumed.
2. Source energy accounts for electrical generating inefficiencies. For this study:
Electric generating efficiency =100.0 %
3. Energy per unit floor area is based on the gross building floor area. For this building:
Gross floor area = 59,495 sqft
Conditioned floor area = 59,495 sqft
4. Annual cooling load is the sum of all cooling plant loads.
5. Annual heating load is the sum of all primary and auxiliary heating plant loads. It does not include the domestic water heating load.

****

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ENERGY BUDGET <B>

Building : MOSCOW 0 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program — Page 1 of 1

****

TABLE 1. ANNUAL LOADS

Component	(kBTU)	(kBTU/sqft)*
Cooling Loads *	0	0.000
Heating Loads *	2,824,401	47.473

****

TABLE 2. ENERGY BY ENERGY COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(kBTU)	(kBTU/sqft)*
Electric	521,906	8.772	521,906	8.772
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	2,824,402	47.473	2,824,402	47.473
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	3,346,308	56.245	3,346,308	56.245
Electric	160,273	2.694	160,273	2.694
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	273,165	4.591	273,165	4.591
>> Non-HVAC Total	433,438	7.285	433,438	7.285
>> GRAND TOTAL	3,779,745	63.530	3,779,745	63.530

* Notes:
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3. Energy per unit floor area is based on the gross building floor area. For this building:
   Gross floor area = 59,495 sqft
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ENERGY BUDGET <A>

Building : MOSCOW 0 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program —

****

TABLE 1. ANNUAL LOADS

Component	(MJ)	(MJ/sqm)*
Cooling Loads *	0	0.000
Heating Loads *	2,979,902	539.128

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Air System Fans	526,243	95.208	526,243	95.208
Cooling Plants	0	0.000	0	0.000
Heating Plants	2,979,902	539.128	2,979,902	539.128
Pumps	24,397	4.414	24,397	4.414
>> HVAC Total	3,530,542	638.750	3,530,542	638.750
Lights	112,731	20.395	112,731	20.395
Other Electric	56,366	10.198	56,366	10.198
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	288,204	52.142	288,204	52.142
>> Non-HVAC Total	457,301	82.735	457,301	82.735
>> GRAND TOTAL	3,987,843	721.486	3,987,843	721.486

* Notes: 1. Site energy is the actual energy consumed.
2. Source energy accounts for electrical generating inefficiencies. For this study:
Electric generating efficiency =100.0 %
3. Energy per unit floor area is based on the gross building floor area. For this building:
Gross floor area = 5,527 sqm
Conditioned floor area = 5,527 sqm
4. Annual cooling load is the sum of all cooling plant loads.
5. Annual heating load is the sum of all primary and auxiliary heating plant loads. It does not include the domestic water heating load.

****

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ENERGY BUDGET <B>

Building : MOSCOW 0 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program —

****

TABLE 1. ANNUAL LOADS

Component	(MJ)	(MJ/sqm)*
Cooling Loads *	0	0.000
Heating Loads *	2,979,902	539.128

****

TABLE 2. ENERGY BY ENERGY COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Electric	550,640	99.622	550,640	99.622
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	2,979,902	539.128	2,979,902	539.128
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	3,530,542	638.750	3,530,542	638.750
Electric	169,097	30.593	169,097	30.593
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	288,204	52.142	288,204	52.142
>> Non-HVAC Total	457,301	82.735	457,301	82.735
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ENERGY BUDGET <A>

Building : MOSCOW 1 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program — Page 1 of 1

****

TABLE 1. ANNUAL LOADS

Component	(kBTU)	(kBTU/sqft)*
Cooling Loads *	0	0.000
Heating Loads *	2,433,554	40.904

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(kBTU)	(kBTU/sqft)*
Air System Fans	379,634	6.381	379,634	6.381
Cooling Plants	0	0.000	0	0.000
Heating Plants	2,433,554	40.904	2,433,554	40.904
Pumps	22,880	0.385	22,880	0.385
>> HVAC Total	2,836,068	47.669	2,836,068	47.669
Lights	106,849	1.796	106,849	1.796
Other Electric	53,424	0.898	53,424	0.898
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	273,165	4.591	273,165	4.591
>> Non-HVAC Total	433,438	7.285	433,438	7.285
>> GRAND TOTAL	3,269,506	54.954	3,269,506	54.954

* Notes:
1. Site energy is the actual energy consumed.
2. Source energy accounts for electrical generating inefficiencies. For this study:
   Electric generating efficiency =100.0 %
3. Energy per unit floor area is based on the gross building floor area. For this building:
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ENERGY BUDGET <B>

Building : MOSCOW 1 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program —

****

TABLE 1. ANNUAL LOADS

Component	(kBTU)	(kBTU/sqft)*
Cooling Loads *	0	0.000
Heating Loads *	2,433,554	40.904

****

TABLE 2. ENERGY BY ENERGY COMPONENT

Component	<----- Site Energy -----> (kBTU)	(kBTU/sqft)*	<----- Source Energy -----> (kBTU)	(kBTU/sqft)*
Electric	402,514	6.766	402,514	6.766
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	2,433,554	40.904	2,433,554	40.904
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	2,836,068	47.669	2,836,068	47.669
Electric	160,273	2.694	160,273	2.694
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	273,165	4.591	273,165	4.591
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ENERGY BUDGET <A>

Building : MOSCOW 1 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program — Page 1 of 1

****

TABLE 1. ANNUAL LOADS

Component	(MJ)	(MJ/sqm)*
Cooling Loads *	0	0.000
Heating Loads *	2,567,536	464.522

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Air System Fans	400,535	72.465	400,535	72.465
Cooling Plants	0	0.000	0	0.000
Heating Plants	2,567,536	464.522	2,567,536	464.522
Pumps	24,140	4.367	24,140	4.367
>> HVAC Total	2,992,211	541.355	2,992,211	541.355
Lights	112,731	20.395	112,731	20.395
Other Electric	56,366	10.198	56,366	10.198
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	288,204	52.142	288,204	52.142
>> Non-HVAC Total	457,301	82.735	457,301	82.735
>> GRAND TOTAL	3,449,512	624.090	3,449,512	624.090

* Notes:
1. Site energy is the actual energy consumed.
2. Source energy accounts for electrical generating inefficiencies. For this study:
   Electric generating efficiency =100.0 %
3. Energy per unit floor area is based on the gross building floor area. For this building:
   Gross floor area = 5,527 sqm
   Conditioned floor area = 5,527 sqm
4. Annual cooling load is the sum of all cooling plant loads.
5. Annual heating load is the sum of all primary and auxiliary heating plant loads. It does not include the domestic water heating load.

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TABLE 2. ENERGY BY ENERGY COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Electric	424,675	76.833	424,675	76.833
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	2,567,536	464.522	2,567,536	464.522
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	2,992,211	541.355	2,992,211	541.355
Electric	169,097	30.593	169,097	30.593
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
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Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program — Page 1 of 1

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TABLE 1. ANNUAL LOADS

Component	(kBTU)	(kBTU/sqft)*
Cooling Loads *	0	0.000
Heating Loads *	1,444,920	24.286

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<------ Site Energy ------>		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(kBTU)	(kBTU/sqft)*
Air System Fans	280,880	4.721	280,880	4.721
Cooling Plants	0	0.000	0	0.000
Heating Plants	1,444,920	24.286	1,444,920	24.286
Pumps	20,740	0.349	20,740	0.349
>> HVAC Total	1,746,540	29.356	1,746,540	29.356
Lights	106,849	1.796	106,849	1.796
Other Electric	53,424	0.898	53,424	0.898
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	273,165	4.591	273,165	4.591
>> Non-HVAC Total	433,438	7.285	433,438	7.285
>> GRAND TOTAL	2,179,977	36.641	2,179,977	36.641

* Notes:
1. Site energy is the actual energy consumed.
2. Source energy accounts for electrical generating inefficiencies. For this study:
   Electric generating efficiency =100.0 %
3. Energy per unit floor area is based on the gross building floor area. For this building:
   Gross floor area = 59,495 sqft
   Conditioned floor area = 59,495 sqft
4. Annual cooling load is the sum of all cooling plant loads.
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Heating Loads *	1,444,920	24.286

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TABLE 2. ENERGY BY ENERGY COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(kBTU)	(kBTU/sqft)*
Electric	301,620	5.070	301,620	5.070
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	1,444,920	24.286	1,444,920	24.286
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	1,746,540	29.356	1,746,540	29.356
Electric	160,273	2.694	160,273	2.694
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	273,165	4.591	273,165	4.591
>> Non-HVAC Total	433,438	7.285	433,438	7.285
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****

TABLE 1. ANNUAL LOADS

Component	(MJ)	(MJ/sqm)*
Cooling Loads *	0	0.000
Heating Loads *	1,524,471	275.809

****

TABLE 2. ENERGY BY SYSTEM COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Air System Fans	296,344	53.615	296,344	53.615
Cooling Plants	0	0.000	0	0.000
Heating Plants	1,524,472	275.809	1,524,472	275.809
Pumps	21,882	3.959	21,882	3.959
>> HVAC Total	1,842,697	333.383	1,842,697	333.383
Lights	112,731	20.395	112,731	20.395
Other Electric	56,366	10.198	56,366	10.198
Misc. Electric	0	0.000	0	0.000
Dom. Hot Water	288,204	52.142	288,204	52.142
>> Non-HVAC Total	457,301	82.735	457,301	82.735
>> GRAND TOTAL	2,299,998	416.119	2,299,998	416.119

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Cooling Loads *	0	0.000
Heating Loads *	1,524,471	275.809

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TABLE 2. ENERGY BY ENERGY COMPONENT

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(MJ)	(MJ/sqm)*	(MJ)	(MJ/sqm)*
Electric	318,226	57.574	318,226	57.574
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Heating	1,524,472	275.809	1,524,472	275.809
Remote Cooling	0	0.000	0	0.000
>> HVAC Total	1,842,697	333.383	1,842,697	333.383
Electric	169,097	30.593	169,097	30.593
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
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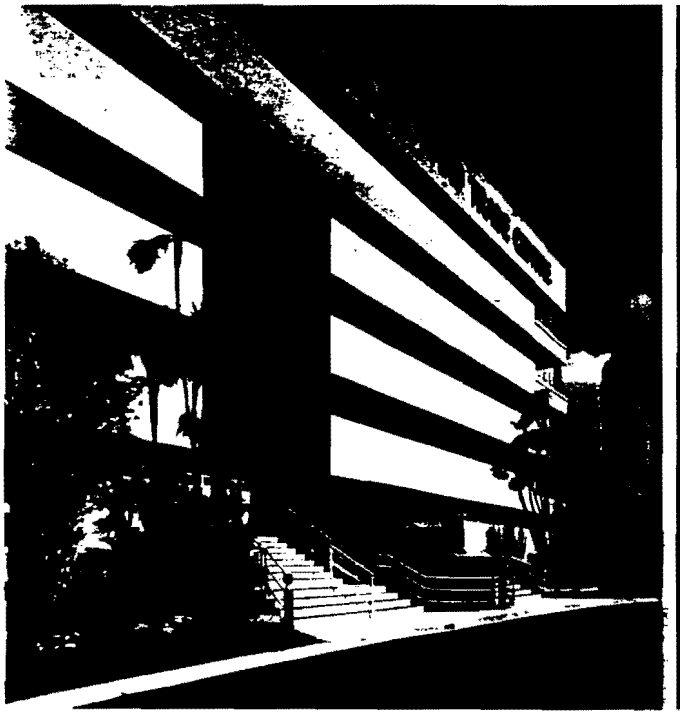
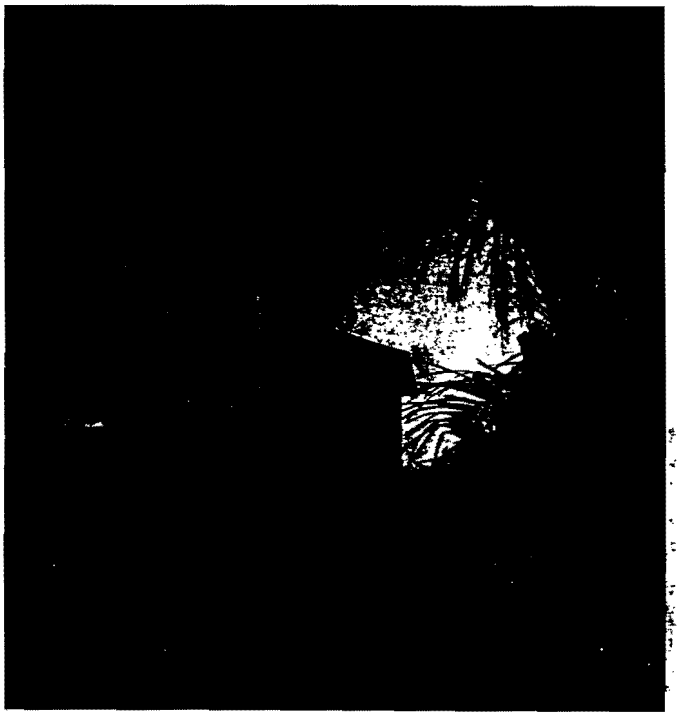
SUREWALL®
PRODUCTS & SYSTEMS

Surface Bonding Cement, High Stress Grade, Bonding Adhesive, Finish Coat, SBC Insulation System, FRP Insulation System





SUREWALL®
PRODUCTS & SYSTEMS

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MR MANUFACTURER

W. R. Bonsal Company of Charlotte, North Carolina, established in 1895, is the licensor of the SUREWALL® formulae, systems, trademark and methods.

SUREWALL® Surface Bonding Cement and related products are available nationally from licensed manufacturers.

PP PRODUCT PRESENTATION

SUREWALL Surface Bonding Cement was originally designed to be used in lieu of mortar in the construction of drystacked concrete block walls. In addition to SUREWALL Surface Bonding Cement, a line of complementary products are also available to improve strength and/or adhesion, and as coatings over SUREWALL Surface Bonding Cement to obtain specific surface textures. Applications for SUREWALL products include:

- Retrofitting existing masonry and concrete structures.
- Racquetball and handball court construction.
- Stucco applications for superior finish.
- Below-grade masonry construction.
- Exterior insulation and wall finish systems.
- Decorative, weather-resistant finish system.

SUREWALL Surface Bonding Cement is a proprietary brand. During the last 10 years, more than 90 wall panels have been tested by independent testing laboratories. These tests form the basis for the product's formulation, wall design criteria, and specific product data. They also form the basis for Building Code recognition.

ADVANTAGES

SUREWALL Surface Bonding Cement

- Provides decorative impact-resistant finish over many substrates including expanded polystyrene insulation board.
- Reduces cracking associated with conventional stucco/plaster.
- Results in textured, stucco-like finish. Integral pastel colors eliminate the need for paint.
- Provides a durable water-resistant coating fulfilling the need for damp-proofing.
- Results in greater flexural and tensile strength than conventional mortar construction.
- Increases per man hour productivity when drystacking blocks.
- Contributes to a through-wall cost savings.
- Provides excellent safety factor because it is non-combustible, has a zero flame spread and emits no toxic fumes.

STRUCTURAL PRODUCTS

SUREWALL Surface Bonding Cement

A patented, portland cement, glass fiber and special chemical mixture applied in a one-coat bonding application approximately 1/8" thick (minimum) to both sides of drystacked concrete block walls. This stucco-like coat of SUREWALL Surface Bonding Cement results in structural walls that are, in many cases, stronger than concrete block walls built with mortar.

SUREWALL® High Stress Grade

A glass fiber-reinforced cement mixture designed for below-grade masonry construction, i.e., basements, retaining walls, and projects requiring high early strength development and increased lateral load resistance (back-filling). Available in grey and white.

NON-STRUCTURAL PRODUCTS

SUREWALL® Finish Coat

A portland cement finishing plaster (no glass fibers), designed as a decorative water-resistant finish over masonry, base coat plaster, concrete, exterior sheathing and SURFACE BONDED CONCRETE MASONRY. It may be used as a high-strength water-resistant bed mortar in mortarless wall construction.

SUREWALL® Bonding Adhesive

An acrylic polymer emulsion specifically formulated as an admixture for SUREWALL® Cement Products. It provides superior bond to questionable substrates such as old masonry, poured-in-place concrete, rigid foam insulation board, brick or precast concrete columns and beams.

INSULATION SYSTEMS

SUREWALL® SBC Insulation System

The SUREWALL SBC Insulation System is an integrated system of structural surface bonding cement applied to expanded polystyrene insulation boards which are mechanically attached to exterior wall surfaces. It can be attached to the exterior walls of most types of new construction. It can also be used for the renovation/retrofitting of existing structures. The system is composed of selected insulation boards, fasteners and accessories. Its exposed finish offers exceptional weather and impact resistance through glass fiber cement reinforcing technology and polymeric bonding agents.

SUREWALL® FRP Insulation System

The SUREWALL FRP Insulation System is an integrated exterior insulation and wall-finish system. The system was originally designed for use over open stud-wall construction, however, it can be applied to the exterior walls of virtually any type of new construction or for renovating/retrofitting existing structures. This system is composed of fiber-reinforced polymer-modified plaster applied over woven wire lath which secures the rigid insulation board.

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UA USES, APPLICATIONS

Commercial

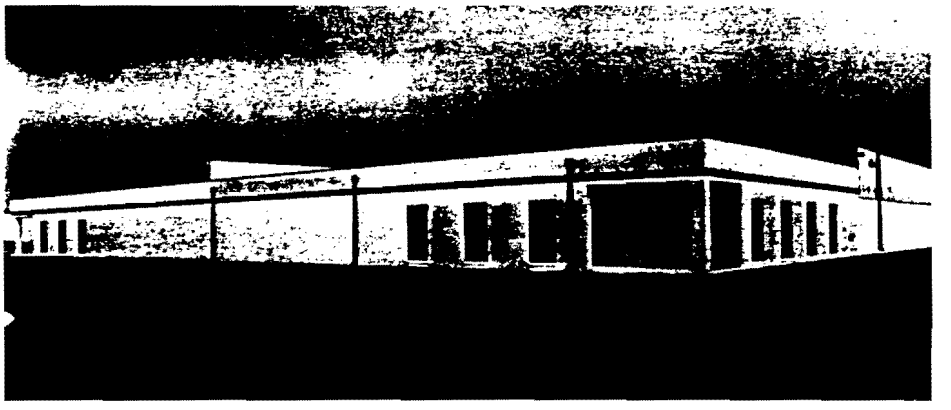
The durability of walls drystacked with one coat per side of SUREWALL® Surface Bonding Cement makes it an especially good choice for high traffic and/or high abuse buildings such as shopping centers and warehouses, of one to two stories, where economical and attractive finishes are important. In addition to durability and economy of construction, its zero-flame spread makes it ideal for use in minipublic storage facilities and other high-risk storage facilities.

The SUREWALL® SBC Insulation System provides both exterior insulation and a durable, impact-resistant exterior wall while greatly decreasing HVAC needs.

Industrial

The durability of wall finishes achieved when drystacking with fiber-reinforced SUREWALL Surface Bonding Cement makes it a strong choice for construction of one to two story manufacturing facilities, especially where machinery is manufactured or heavy machinery used, such as print shops, textile plants, etc.

The superior exterior insulation envelope achieved with the SUREWALL SBC Insulation System makes it ideal where temperature regulation is important and where HVAC loads are heavy.



Residential

Where the ease and economy of erecting high-strength masonry walls is important, drystacking with one coat of SUREWALL Surface Bonding Cement can solve many problems at once in single and multi-family construction, especially where stucco, adobe, masonry or plaster finishes are designed in. Extremely quiet, zero-flame spread privacy walls can be drystacked quickly and easily in a variety of one-coat finishing techniques, virtually anywhere they're needed. In solar and earth sheltered housing, SUREWALL Surface Bonding Cement drystacked walls combine desired thermal mass of masonry construction with water-resistant, crack-resistant, fiber-reinforced walls with flexural strength superior to conventional block and mortar construction.

Attractive, finished, exterior insulation envelopes can be created in one coat by utilizing the wire mesh-reinforced SUREWALL® FRP Insulation System. Seamless, monolithic walls up to 30 feet long are possible. It allows architectural design freedom. The economy of open-stud construction can be realized in either single or multi-family construction.

Renovation

One coat of fiber-reinforced SUREWALL Surface Bonding Cement will both improve the structural integrity of old masonry, and provide an attractive, impact-resistant finish. These are desirable qualities in most retrofitting/renovation projects. SUREWALL Surface Bonding Cement's ability to transpose virtually any substrate into a consistent, clean, textured finish means that roof, door and window treatments are virtually all that are needed to transform a variety of individually-styled buildings and storefronts, etc. into a project with a consistent overall exterior theme.

The SUREWALL FRP Insulation System can also be valuable in renovating. Thermal leaks, common to older buildings, can be virtually eliminated with the SUREWALL FRP Insulation System. And, you get a tough, weather-resistant and attractively finished exterior. Exterior insulation also leaves all interior walls and beams "as is" for decorative use or refinishing. Ideal for retrofitting old hospitals, schools, hotels, motels, apartments and condo conversions, etc. SUREWALL® Bonding Adhesive is added to increase integral strength and provides bond to most common substrates.

Drystacking with SUREWALL® Surface Bonding Cement for more economical, structurally superior walls.

Advantages

Compared to conventional block and mortar construction, drystacking blocks and coating each side with fiber-reinforced SUREWALL Surface Bonding Cement to create attractive, finished walls, not only saves time and labor, but it also creates a structurally superior wall (see structural properties chart, next page). The washable, impact-resistant finish also saves maintenance dollars for the user/owner for years to come. Surface bonding is a money-saving construction technique for use where the thermal mass, structural strength, and aesthetic value of masonry construction is desired.

New Construction

A ASSEMBLY AND INSTALLATION

On concrete pad or foundation, set first row of concrete blocks in bed of mortar, or for additional bonding strength, a bed of SUREWALL Surface Bonding Cement. Following block courses are simply stacked to form desired walls. Door and window openings are shaped and then supported by traditional masonry construction methods. (Technical drawings on this page show foundation, corner and intersecting wall techniques.)

First Coat

SUREWALL Surface Bonding Cement is mixed on site with clean water to a plaster consistency. Apply mixture to both sides of wall surfaces with hand trowel or spray equipment to a minimum thickness of 1/8 inch. Level wall surface and fill all voids.

Complete one entire section without interruption to avoid cold joints or lap marks.

Second Coat

A second application is sometimes necessary to plane the walls true and level, or achieve the specified finish and texture. The second coat may be applied as soon as the first coat has set firmly enough to carry the weight.

SUREWALL Surface Bonding Cement or SUREWALL® Finish Coat may be used depending on the texture desired.

Additional Uses

The SUREWALL® Court System for racquetball, handball and squash court walls goes up faster and more economically than conventional systems, offers fast, true play and requires minimal maintenance. (Request brochure entitled "The SUREWALL® Court System.")

SUREWALL Surface Bonding Cement can also be used for fire walls, tennis practice walls, non-load-bearing curtain walls, sound barrier walls and fences.

Painting

Properly cured SUREWALL finishes may be painted. Paint must be limeproof and designed for applications over portland cement plaster products.

Short Form Specification

Description

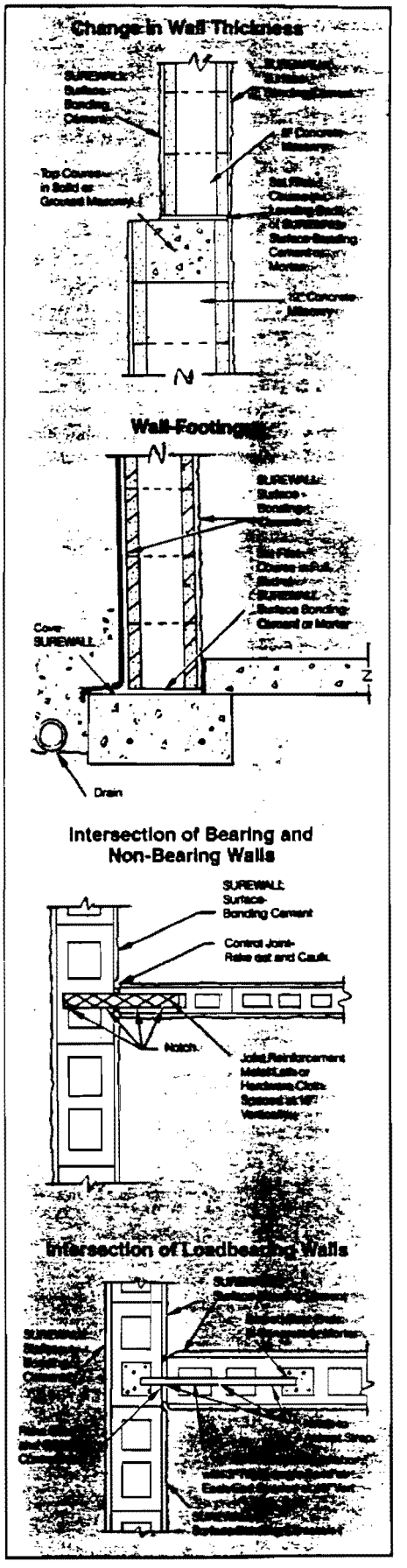
The surface bonding cement shall be SUREWALL Surface Bonding Cement, a factory prepared mixture that needs only the addition of water and meets ASTM-C-887.

Execution

The first course of concrete masonry shall be set and leveled in a bed of SUREWALL Surface Bonding Cement or mortar without buttering the ends of the block. Each side of the block shall be troweled with SUREWALL Surface Bonding Cement to a thickness of 1/8" according to mixing, application and curing instructions on each bag. Installation shall be in accordance with ASTM-C-946.

Additional Information

The following literature is available upon request: "Building with SUREWALL® Surface Bonding Cement," "SUREWALL® Guide Specifications," and "The SUREWALL® Court System."



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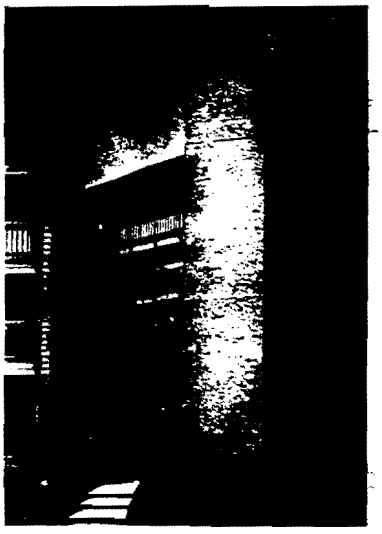


STRUCTURAL PROPERTIES*—Unreinforced Wall Assemblages

SUREWALL® Surface Bonding Cement ⅛" thickness over block VS. Mortar, conventional construction.

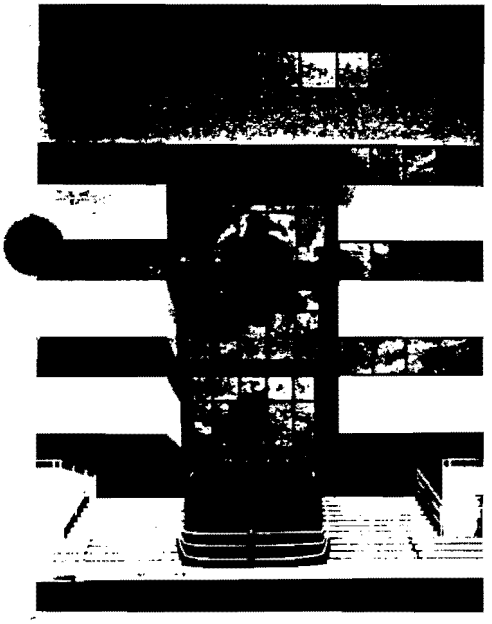
Type Construction	Block Thickness	Height/Thickness	Block Strength Gross Area	Ultimate Wall Strength—Gross Area psi	kips
Compressive—Axial Loading					
Mortar, Type N (4 walls tested)	8"	9.0 H / T	960 psi	570	204
SUREWALL (3 walls tested)	8"	11.9 H / T	980 psi	410	148
Compressive-Eccentric Loading T/6 ASTM E-72					
Mortar, Type S (3 walls tested)	8"	25.0 H / T	1516 psi	542	196
SUREWALL (4 walls tested)	8"	24.7 H / T	1516 psi	189	68
SUREWALL (3 walls tested)	8"	11.9 H / T	1010 psi	302	109
Racking		Wall Size			
				Horizontal Shear Lbs. Per Ft. of Wall Lgth.	
Mortar, Type N (ASTM-E-72)	8"	8' x 8'	1100 psi	2,970	
SUREWALL (ASTM E-519)	8"	4' x 4'	980 psi	3,230	
Flexural—Vertical Span ASTM E-72					
				Maximum Uniform Load. Lbs./Sq. Ft.	
Mortar, Type S (5 walls tested)	8"	4' x 8'	1100 psi	35.0 lbs.	
SUREWALL (2 walls tested)	8"	4' x 8'	1150 psi	71.0 lbs.	
Mortar, Type S (3 walls tested)	8"	4' x 16'	1516 psi	11.5 lbs.	
SUREWALL (3 walls tested)	8"	4' x 16'	1516 psi	15.8 lbs.	
Impact-Vertical ASTM E-72					
Mortar, Type S (3 walls tested)	8"	4' x 8'	1330 psi	170 ft. / lb.	
SUREWALL (3 walls tested)	8"	4' x 8'	1330 psi	230 ft. / lb.	
SUREWALL (1 wall tested)	12"	4' x 8'	1320 psi	380 ft. / lb.	

*Independent lab test available upon request. The values shown in this table are ultimate loads, not the allowable design load, and must be reduced with adequate safety factors.

SUREWALL® SBC Insulation System

SYSTEM PRESENTATION

The SUREWALL® SBC Insulation System is an integrated system of structural surface bonding cement applied to rigid insulation boards which are mechanically attached to exterior wall surfaces. It was designed primarily for use in industrial/commercial applications where extensive exterior surfaces are to be insulated and where a durable, yet attractive, finish is required. The system allows freedom of architectural design and permits construction of attractive, fuel-efficient buildings at favorable costs. It is applied to the exterior walls of virtually any type of new construction. It is also used for the renovation/retrofitting of existing structures. The system is composed of SUREWALL® Surface Bonding Cement, selected insulation boards, fasteners and accessories.



ADVANTAGES

The SUREWALL® SBC Insulation System has several distinct advantages over conventional in-wall insulation methods:

- Voids and air infiltration are virtually eliminated because the rigid insulation boards form an air-tight envelope.
- The building mass remains at a more stable temperature inside the insulation envelope. Heating and air-conditioning are more efficient because HVAC cycling is minimized and not consumed for heating and cooling of the building mass during outside temperature fluctuations. Investment in HVAC equipment is therefore reduced.
- The use of low density insulation boards and resilient adhesives allows a building to move normally without cracking the surface coating of the system.
- The possibility of dangerous smoke inhalation caused by fire is reduced by placing combustible insulation materials on the wall's exterior.
- SUREWALL® Surface Bonding Cement, containing glass fibers combined with an acrylic bonding agent, eliminates the need for reinforcements such as lathing with metal or glass mesh.
- The system does not use valuable interior space since it is applied to the outside of walls.
- All of the mass is available for passive energy utilization when installed over concrete and masonry.

SYSTEM COMPONENTS

SUREWALL® Surface Bonding Cement

A patented, proprietary mixture of portland cement, glass fibers and special chemicals. This product, combined with SUREWALL® Bonding Adhesive and applied to foam board, provides weather and impact resistance. The product is non-combustible, damp-proof, and comes in a variety of colors.

SUREWALL® Bonding Adhesive

An acrylic polymer emulsion designed as an admixture for SUREWALL cement products to provide superior bond to EPS Insulation Board and other substrates. SUREWALL Bonding Adhesive is water resistant. It improves the performance of the SYSTEM in severe climatic and corrosive exposures.

SUREWALL® EPS Insulation Board

Specially cured, flame retardant, low density, expanded polystyrene, rigid board available from certified manufacturers. A highly effective insulator. Meets Federal Specifications HH-1-524C. Available in 3/4", 1", 1½" and 2" thicknesses. Can be cut to different sizes.

SUREWALL® EPS Adhesive

A rubber emulsion formulated to adhere EPS Board to a variety of surfaces and remains resilient even at below freezing temperatures.

SUREWALL® Fastener Clip

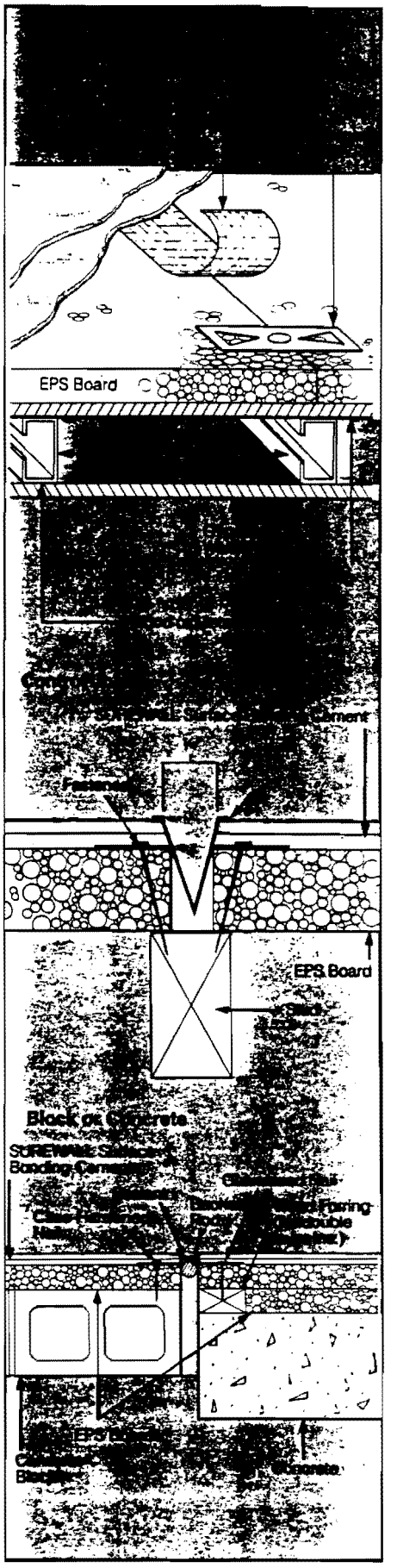
A pronged, 20 gauge patented, galvanized metal clip, used with standard screws or nails for mechanical fastening.

SUREWALL® Joint Reinforcement Tape

Self-adhering, woven glass mesh for reinforcing corners and joints. 4" or 6" widths and 100' length.

Trim Accessories

Corner beads, casing beads, plaster stops, control joints and weep base stop. Designed for thin veneer plaster. Manufactured from exterior grade PVC plastic or zinc alloy metal.



[A] ASSEMBLY AND INSTALLATION

Installation should be performed by certified, factory-trained contractors only. The system is applied directly to exterior wall surfaces. The system uses adhesive *and* mechanical fasteners. The board thickness is preselected commensurate to the desired insulation values.

1. EPS Board is cut to size and pressed in place using SUREWALL EPS Adhesive. Panel dimensions within control joints are limited to 144 square feet with no length exceeding 12'. SUREWALL® Fastener Clips are spaced 12" o.c. on the perimeter of the board and no more than 24" o.c. in the field of each EPS panels. Fasteners must penetrate into the structural member of the building.
2. Accessories are placed where required. Board joints are taped with Joint Reinforcement Tape. Accessories are glued or stapled directly to EPS Board.
3. SUREWALL® Surface Bonding Cement is applied in two layers, each coat 1/8" thick. The Base coat is modified with SUREWALL Bonding Adhesive and cured 3 days. The Second coat may be finished to the desired texture. The combined thickness of the two coats must not be less than 1/4 inch. Application must be made above 40°F and hand troweled. Control joints are raked clean.

Panelization

The off-site construction of building panels using the SUREWALL® SBC Insulation System provides large projects with increased design flexibility, improved energy efficiency, greater durability, lower production costs, and controlled environmental conditions.

SHORT FORM SPECIFICATIONS

Description

Exterior Insulation System to be *SUREWALL® SBC Insulation System*, consisting of mechanically and chemically attached expanded polystyrene board, reinforced with glass netting over all joints and covered with polymer modified SUREWALL® Surface Bonding Cement.

Execution

All materials in this section are to be installed by a factory-trained, certified contractor in strict compliance with the manufacturer's printed procedures.

LONG FORM SPECIFICATIONS

Contact SUREWALL® Producers Council. (See page 12.) Code approvals. (See page 11.)

TECHNICAL PERFORMANCE DATA

ENVIRONMENTAL

Test Description	Method	Results
Large Scale Fire Test	ASTM-E-108 (3 inches EPS board)	a) did not contribute to Flame Spread on exterior. b) capable of preventing flame intrusion into the wall cavity and prevents fire involvement of the polystyrene insulation core. c) no fall-off of the surface coating during the test.
Fire Hazard Classification	ASTM-E-84 (2 inches EPS board)	**Without Plastic Acces.** / **With Plastic Acces.** Flame Spread: 5 / 15 Fuel Contribution: 10 / 0 Smoke Development: 20 / 275
Heat Transmission	ASTM-C-236 (2 inches EPS board) 2 x 4 stud (24" o.c.) Gypsum Wallboard	**No Insulation In Studs**: U = 0.119, R = 8.4 **R-11 Bats in Studs**: U = 0.058, R = 17.2
Accelerated Weathering	ASTM-C-23	(U.V. only) No effect after 1500 hours
Salt Spray Resistance	ASTM-B-117	No corrosion after 300 hours
Mildew Resistance	MIL-F-8261 (method 508)	No support for mildew
Sand Abrasion	ASTM-D-968	No effect after 500 liters
Uniform Lateral Load Resistance	ASTM-E-72	(vertical) wood studs 24" o.c.
	(2 coats Surface Bonding Cement)	136 psf
Impact Resistance	ASTM-E-72	(vertical) wood studs 24" o.c.
	(2 coats Surface Bonding Cement)	58" = 240 ft. lbs.
Dynamic Impact	Free Falling, steel ram Max height of drop =	Weight 5.5 lbs. 7 ft. lbs. first crack
Resistance to Indentation	(Slow compression 1.13 inch diam. mandrel at loading rate of .1 inch per minute)	
	2 coats SBC	97 psi
Tensile Bond	Bonsal Laboratories Method Before exposure	24-30 psi Failure in EPS
	After U.V. Exposure 1500 Hours	24-30 psi Failure in EPS
Negative Wind Load Resistance	ASTM-E-72	Passed 100 psf

*Copies of Independent Testing lab available on request.

SUREWALL® FRP and FRP Insulation System

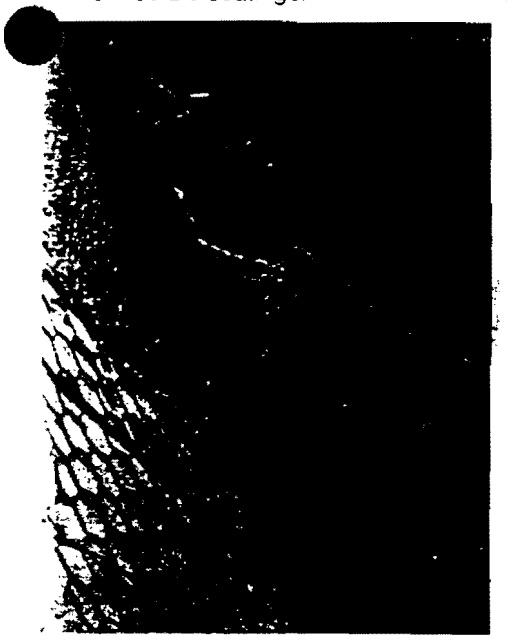
SYSTEM PRESENTATION

The SUREWALL FRP Insulation System is an integrated exterior insulation and wall-finish system. It was designed primarily for residential use, to provide an exterior insulation shell and create an attractive, seamless finish on exterior wall runs of up to 30 feet. This allows freedom of architectural design and permits cost-effective construction of attractive, energy-efficient buildings. It is applied directly to exterior open stud wall framing or any type of existing wall construction for renovation/retrofitting. The system is composed of SUREWALL® Fiber-Reinforced Plaster, selected polystyrene insulation boards, conventional woven wire lath and accessories. The finish is a fiber-reinforced, weather-resistant, polymer-modified portland cement plaster.

ADVANTAGES

The SUREWALL® FRP Insulation System has distinct advantages over conventional in-wall insulation methods at a cost competitive to lath and plaster.

- The installation is faster because plaster is applied in one application which eliminates waiting for curing of intermediate coatings.



- Cracking associated with stucco and plaster is reduced by the combination of a stress-absorbing substrate and the high strength of the fibered plaster and wire reinforcement.
- The possibility of dangerous smoke inhalation from fire is reduced by placing the combustible insulation materials on the exterior.
- R-19 thermal resistance can be achieved with standard 4" wood stud walls in combination with R-11 batt insulation.
- Thermal resistance is greatly improved because voids and air infiltration are significantly reduced through the continuous air-tight exterior envelope.
- Investment in HVAC equipment is reduced because the building mass remains at a more stable temperature inside the insulation envelope.
- Heating and air conditioning are more efficient because the HVAC cycling is minimized.
- Full use of the MASS factor is realized for passive energy utilization, when the system is used over concrete or masonry.
- The system conserves valuable interior space since it is applied to the outside of the wall.

SYSTEM COMPONENTS

SUREWALL® Fiber-Reinforced Plaster (FRP)

A glass fiber-reinforced, portland cement plaster, which when mixed with SUREWALL® Bonding Adhesive, produces a durable, weather and impact-resistant finish in one application over insulation board.

SUREWALL® Bonding Adhesive

This acrylic polymer emulsion is designed as an admixture for SUREWALL FRP. It provides superior bond to the polystyrene insulation board and gives impact resistance, strength and durability to the plaster.

Polystyrene Insulation Board

This is a specially-cured, flame-retardant, polystyrene board stock. Available from selected manufacturers in various thicknesses and sizes. Meets Federal Specification HH-1-524C at 1.5 lbs. density.

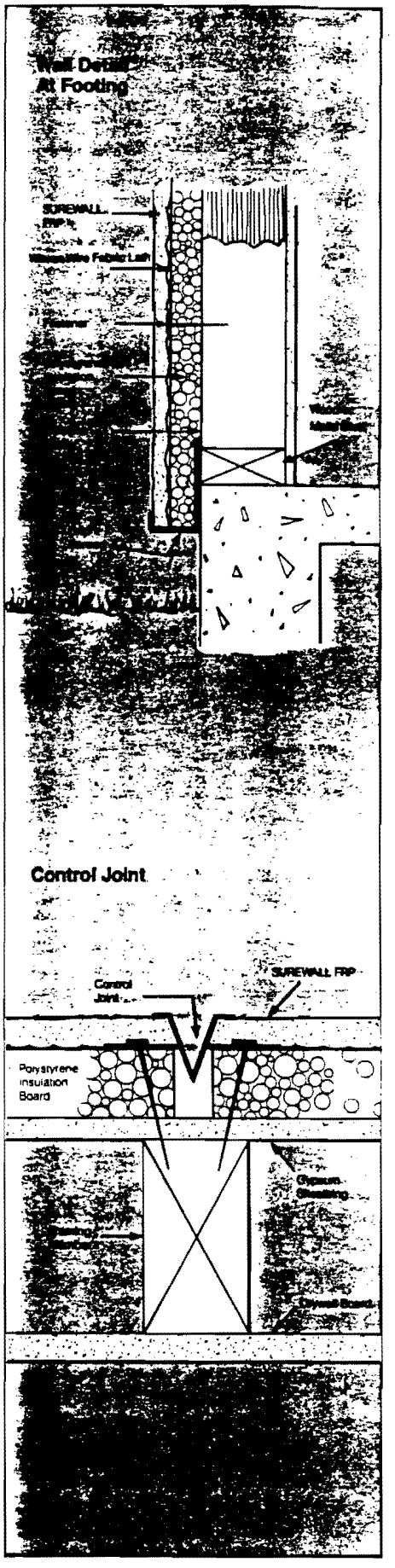
Accessories

Accessories used in the system are conventional and readily available.

Lath - Woven wire fabric lath, 1 inch, 20 gauge galvanized.

Trim - Corner beads, casing beads, plaster stops, control joints, and weep bases may be selected from zinc, galvanized metal or exterior grade PVC plastic.

Fasteners - Roofing nails, large-head screws, or staples are selected for length and depth of penetration to meet code requirements.



A ASSEMBLY AND INSTALLATION

Installation should only be performed by qualified applicators. The application described is for use on the exterior of wood or steel stud framing (maximum 24" o.c.). On masonry or concrete substrates the requirements for fastening of the polystyrene board are different. Contact manufacturer for details.

1. Stud spacing, bracing, and sheathing, when required, as per local codes. Where fire barriers are required, exterior grade gypsum sheathing must be applied first. Where moisture barriers are necessary, install water-resistant paper or polyethylene over studs or sheathing.
2. The polystyrene insulation board is installed horizontally. Vertical butt joints are staggered and must coincide with the framing member.
3. Woven wire lath, galvanized, is placed over the insulation board and mechanically attached through the board into the studs with staples, nails or screws. The fasteners must catch the wire lath and must be of sufficient length to penetrate the stud a minimum of 3/4". The fasteners are used at 6" spacing on all framing members. The woven lath is placed horizontally with a minimum of 4" overlap. The wire lath is discontinued at control joints.
4. Accessories are attached mechanically through the foam into the framing member.
5. SUREWALL® FRP is mixed with SUREWALL® Bonding Adhesive and water to trowel consistency and directly applied to polystyrene board and wire lath. The required thickness of 3/8" minimum can be obtained in one application using a double-back method. Textures may be applied immediately following application. SUREWALL FRP is available in a variety of factory-blended colors, and grey or white concentrate.

FRP as Stucco

SUREWALL® Fiber Reinforced Plaster when used with metal lath or poultry netting has proven to be a viable substitute for 3-coat stucco. This process greatly reduces labor cost and expedites completion of the project.

SHORT FORM/SPECIFICATIONS

Description

Exterior insulation and finishing systems, to be SUREWALL® FRP Insulation System, consisting of mechanically attached polystyrene insulation board, woven wire fabric lath, and covered with SUREWALL® FRP, modified with SUREWALL® Bonding Adhesive.

Execution

All materials are to be installed in strict compliance with manufacturer's printed procedures.

Backing boards and all structural members shall be provided by other trades in compliance with code requirements. Installation is not permitted in temperatures below 40°F.

LONG FORM/SPECIFICATIONS

Contact SUREWALL Producers Council. (See page 12.) Code approvals. (See page 11.)

TECHNICAL PERFORMANCE DATA:

SUREWALL® FRP Insulation System has been extensively tested by Independent Testing Laboratories. Test reports are available upon request.

TEST DESCRIPTION	METHOD	RESULTS
Water penetration, percolation (3/8" FRP Plaster)	ICBO	No loss of 4 feet water pressure after 48 hours.
Uniform Transverse load (over wood studs 24" o.c.)	ASTM-E-72	Max. load to failure 80.4 lbs./sq. ft.
Impact resistance (over wood studs 24" o.c.)	Dynamic Impact 0.5 lb. - 1½" diameter	No damage or delamination from 3-foot drop.
Freeze-Thaw Resistance (water saturated)	-10°F-ambient each 1½ hours.	No adverse effect after 75 cycles.
Tensile bond strength (over EPS Board)	3" x 3" tensile pull	47 psi, failure in EPS Board.
Large Scale Fire Testing (vertical position)	ASTM-E-108 (mod) (with and without core exposed)	Passed 15 minute requirement.
Thermal Transmission SUREWALL® FRP Plaster	ASTM-C-177 at 3/8 inch	R = 0.06.
*Polystyrene Ins. Board	at 1 inch	Average R = 3.6.
Negative Wind Load Resistance	ASTM-E-72	Passed 100 psf

*Actual values for Polystyrene Insulation Board are delivered with the board and may be different, depending on source.

Renovating/Retrofitting with SUREWALL® Surface Bonding Cement

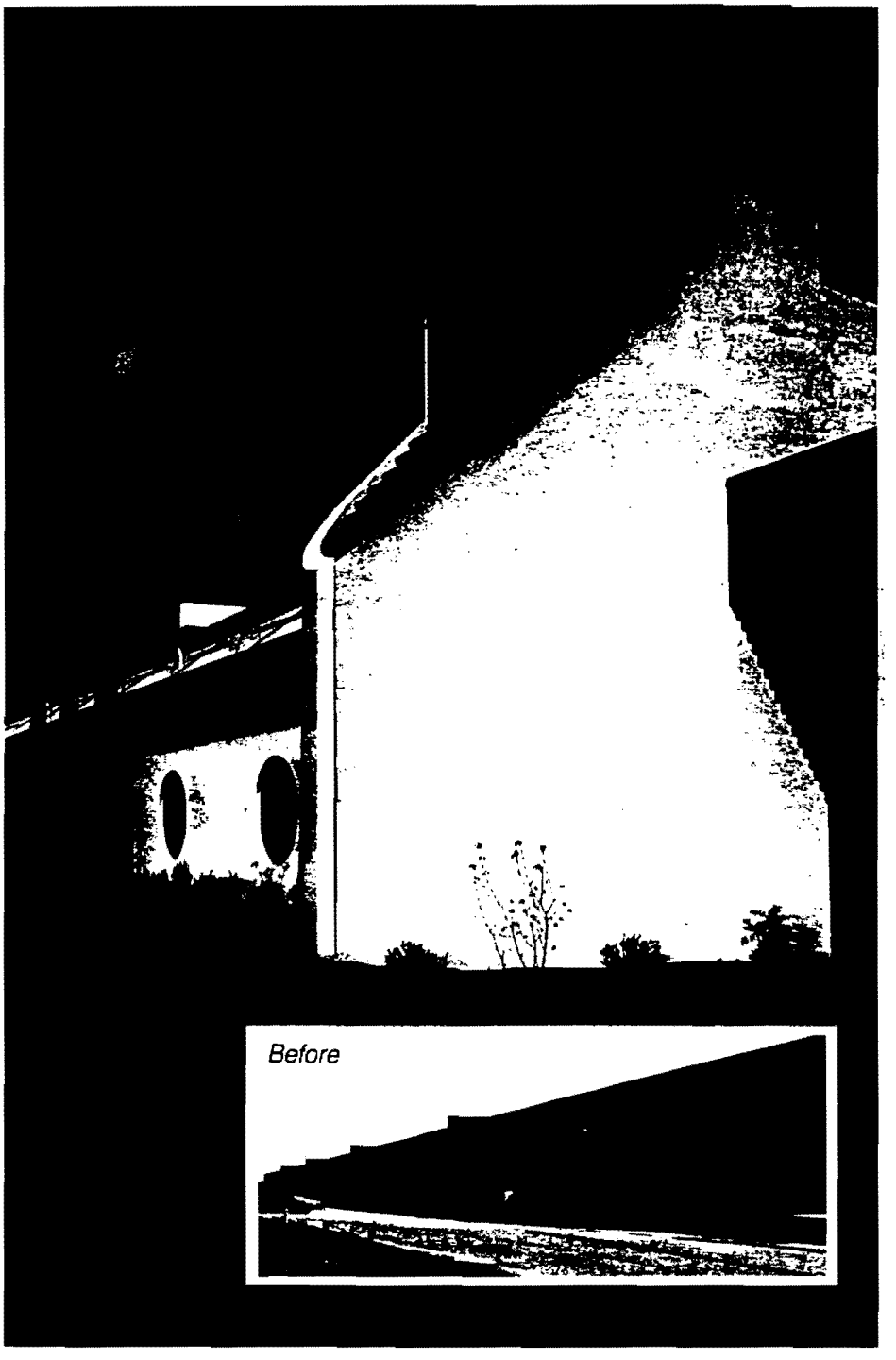
Although SUREWALL Surface Bonding Cement was created to save time and costs in new concrete block construction, its unique and broad range of uses has made it an extremely valuable, money-and-time-saving tool in renovating and retrofitting existing structures.

Interiors

Inside existing structures, new impact-resistant walls and partitions can quickly and easily be created by drystacking blocks and coating them with SUREWALL Surface Bonding Cement. Old masonry, plaster and concrete walls can be rejuvenated, usually with one coat. Many decorative textures are possible using SUREWALL Surface Bonding Cement or SUREWALL® Finish Coat.

Exteriors

Exterior use of SUREWALL Surface Bonding Cement has several unique advantages in renovation applications. On old masonry and concrete exteriors, it creates a new water-resistant finish which [illegible]uces cracking associated with [illegible]nventional stucco. One 1/8" coating [illegible] turn old masonry into a finished, durable, moisture-resistant, textured exterior wall. Fiber-reinforced SUREWALL Surface Bonding Cement actually increases the structural strength of the exterior wall even in earthquake prone areas. It can be applied to most substrates. Thus, in a project area composed of buildings of various ages, materials and architectural styles, its stucco-like finish offers an economical way to create an overall look from a variety of styles, colors and finishes.



A1 ASSEMBLY, INSTALLATION

Renovation of Old Masonry Walls, Plaster or Concrete:

Remove old paint, cracked and unsound plaster. Fill cracks and voids, flush with the existing surface, using a sand/cement patching compound. Maintain all existing expansion joints. Apply SUREWALL® Surface Bonding Cement modified with 1 qt. of SUREWALL® Bonding Adhesive as outlined under Installation Procedures for New Construction. Generally, a second coat is necessary, and it should be [illegible]lied in the same manner as the first [illegible]t. A textured finish, rather than a [illegible]eled or float finish, works best for hiding mortar joints.

Over Wood or Panelled Walls:

When panels cannot be removed, SUREWALL Surface Bonding Cement can be installed over these panels. The proper installation is to first nail paper-backed diamond mesh lath to the entire panel surface. The lath is then covered with a scratch coat of portland cement plaster (or a minimum 1800 psi prepared mortar, Type S), to a total thickness of 1/2 inch (minimum 3/8 inch). After the plaster has cured (normally 7 days), SUREWALL Surface Bonding Cement is applied.

SUREWALL® Products

SHELF LIFE

One year from the date stamped on the bag, when stored unopened on pallets in a dry location.

PACKAGING

PRODUCT	CONTAINER
SUREWALL® Surface Bonding Cement SUREWALL® Finish Coat SUREWALL® High Stress Grade	50-lb. multi-ply paper bags with a polyethylene moisture barrier
SUREWALL® Bonding Adhesive	1 and 5-gal. pails
SUREWALL® Fiber-Reinforced Plaster	80-lb. multi-ply paper bags with a polyethylene moisture barrier

LIMITATIONS

1. Material should be used within a temperature range of 40°F (5°C) and 100°F (38°C). Do not apply when temperature is expected to drop below freezing within 24 hours.
2. Do not add any foreign materials (anti-freeze, lime, sand, etc.), as the chemical balance and structural performance could be adversely affected.
3. Unsupported walls should not exceed 2 stories or 16' in height.
4. Do not use structurally in chimneys, kilns, or areas that maintain high temperatures (150°F) and high humidity (80%).
5. Use only masonry paints specifically recommended for use over alkaline surfaces such as fresh concrete, stucco or masonry.

WARRANTY

Consult manufacturer for specific warranty statement for systems described in this brochure.

Technical Support

SUREWALL® Systems have been extensively tested by independent testing agencies. Data is available upon request including fire testing, structural performance and accelerated weathering.

CC CODE APPROVALS
(Surface Bonding)
Southern 71145
South Florida #75-049-704
North Carolina
New Mexico
Wisconsin
Connecticut BMR 005-74
New York State 424-75-MC
Indiana
BOCA #74-11
ICBO #2985
New York City BSA 600-77-SM
HUD/FHA Materials Release 906, 907, 908
Farm Home Administration
Ontario, Canada 78-7-15
(SBC Insulation System)
National Research Board NRB-184
(FRP Insulation System)
ICBO #3959

PATENTS

U.S. - 4,090,884; 4,115,135; 4,359,849;
U.K. - 1,411,653; 1,516,053;
CANADA - 965,805;
MEXICO - 169,571

SUREWALL® EPS INSULATION BOARD—CALCULATED VALUES

	No. Insulation		1" Thickness		2" Thickness		3" Thickness		4" Thickness	
Construction Type:	R_t	U	R_t	U	R_t	U	R_t	U	R_t	U
Wood Studs* 2" x 4"	3.27	0.31	7.51	.13	11.71	0.09	15.91	0.06	20.11	0.05
Metal Studs*	2.60	0.38	6.84	.15	11.04	0.09	15.24	0.07	19.44	0.05
8" Concrete Block**	2.12	0.47	6.36	.16	10.56	0.09	14.76	0.07	18.96	0.05
6"—Precast Concrete***	1.68	0.60	5.92	.17	10.12	0.10	14.32	0.07	18.52	0.05

NOTE: Actual R Value of the SUREWALL EPS Board is shown inside the package. The K Value for SUREWALL® Surface Bonding Cement = 7.01 BTU/in/h/ft²/°F.

*Includes exterior 1/2" gypsum sheathing as backing for SBC System and 3/8" gypsum drywall base as interior finish. No insulation batten inside studs. 20% Framing

**Average Light Weight C.M.U. 80 lb./cu. ft., no insulation in the cores

***Average Normal Weight Concrete

SUREWALL® Colors and Finishes

Colors

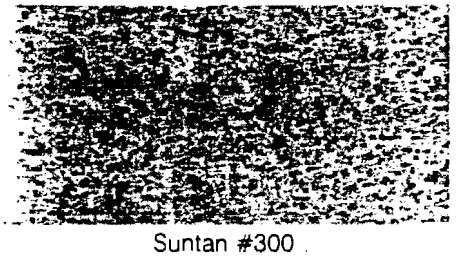
The 7 colors as shown (actual colors may vary due to printing limitations), along with Natural Grey #100 and Super White #225, are available in SUREWALL® Surface Bonding Cement and SUREWALL® Finish Coat.

All colors are factory blended and colored integrally using mineral oxide pigments to insure light fastness and fade resistance.

Caution: *The finished color and appearance can vary considerably on the wall depending on the suction of the block, weather conditions, workmanship and curing.* ***No warranty*** *or guarantee of any sort is made as to color uniformity and appearance of the product on the wall.*

Pearl Grey #150

Pale Yellow #500



Suntan #300

Natural White #200

Antique White #275

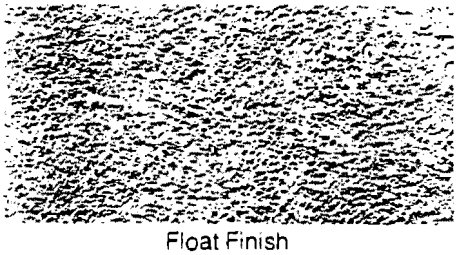
White Jade #400

Sandstone #310

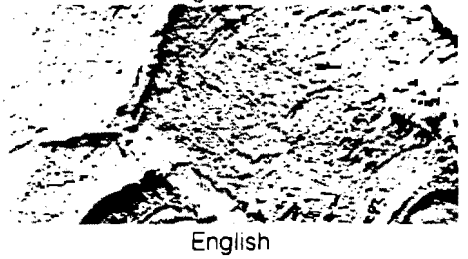
Textured Finishes

Light Lace

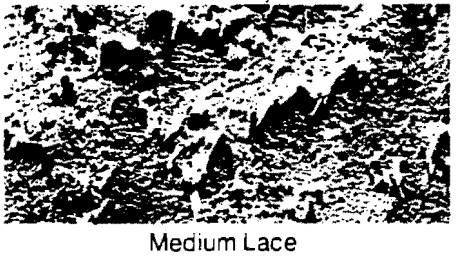
Monterey



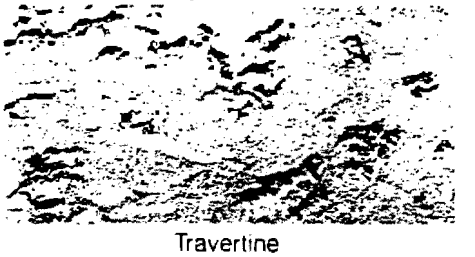
Float Finish



English



Medium Lace



Travertine

SUREWALL® Producers Council

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Charlotte, NC 28224
704/525-1621

Barrett Industries*
Route 3, Box 211B1
San Antonio, TX 78218
512/651-6550

Inca Company*
Stanton & Empire Streets
Wilkes-Barre, PA 18702
717/822-2191

Sparfil International*
5 Veronica Street
Cobourg, Ontario K9A4K5
416/372-8550

United Products*
P. O. Box 642
Columbus, NE 68601
402/564-8576

W. R. Bonsal Company
P. O. Box 241148
Charlotte, NC 28224
704/525-1621
Telex: 802037

W. R. Bonsal Company
111 N. Vineland Ave. at Pitchess Place
City of Industry, CA 91746
213/333-2217 (Area code changes 1/4/84: 818)

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S4 126

SPEC DATA®

This Spec-Data sheet conforms to editorial style prescribed by The Construction Specifications Institute. The manufacturer is responsible for technical accuracy.

1. PRODUCT NAME

STO SYSTEMS:
SYSTEM I, SYSTEM II, M-SYSTEM, TOUGHWALL, BELOW GRADE SYSTEM, PREFABRICATED PANEL

2. MANUFACTURER

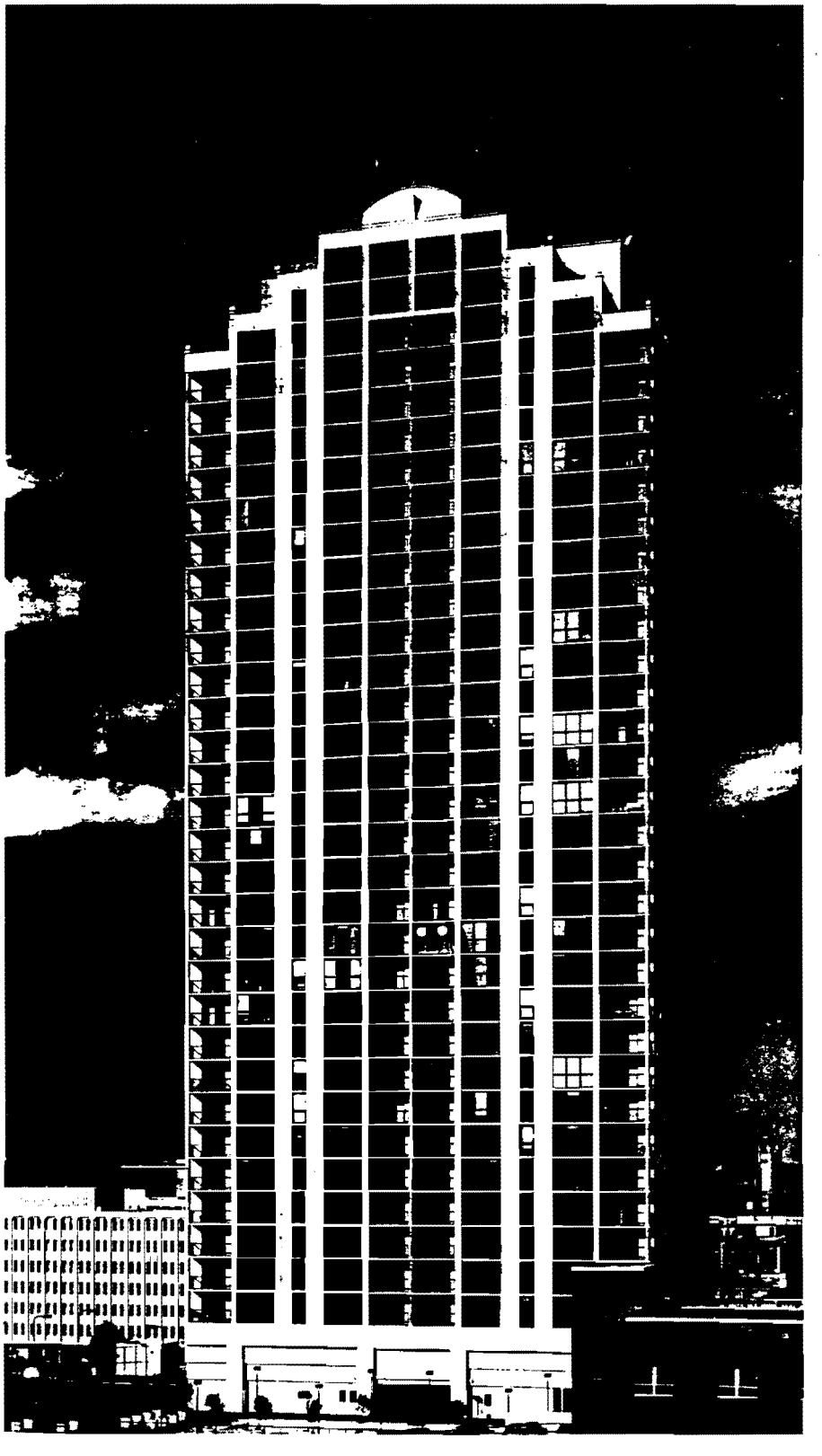
STO Industries
6175 Riverside Drive, S.W.
Atlanta, Georgia 30331
Phone: (404) 346-3666
(800) 221-2397
FAX: (404) 346-3119

A division of STO Corp.,
the Systems Technology Organization

3. PRODUCT DESCRIPTION

Basic Use: STO Full Thermal Systems are used to insulate, protect and decorate the exterior of a building structure with the most technologically advanced methods of insulating. Regardless of its age or wall composition, nearly any type of building can be insulated without using any interior floor space. All systems are lightweight and vapor permeable to prevent condensation problems. In addition, they are highly energy efficient and provide a virtually maintenance free exterior. An extensive choice of STO Finishes and over 350 colors provide for a variety of combinations. These, as well as four different adhesives, a mechanical fastening system and several protecting/reinforcing systems allow for many design possibilities.

Limitations: The STO materials described should never be applied if ambient and surface temperatures cannot be kept above 38°F during application and drying period. The stored materials should be protected from sun and frost. All materials should be installed by certified STO Applicators. The holder of the STO



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EXTERIOR INSULATION AND FINISH SYSTEMS
7
STO Industries
February 1990
(Supersedes November 1988)

Certification has been trained by approved STO Instructors in all phases of the correct application and handling of all STO materials. However, the certified applicator is an independent contractor, and STO Industries cannot control the manner of his work and cannot guarantee its certified applicator will correctly apply and handle all STO materials.

Composition and Materials: STO Exterior Insulation Systems are constructed using 5 separate parts, or layers, which must be physically and chemically compatible with each other. In order to provide alternatives for individual building needs, while maintaining compatibility between materials, STO manufactures various products for each of the basic parts.

The following are the 5 basic parts of an exterior insulation system, with the individual STO products that may be used in each.

PART 1: SUBSTRATE CONDITIONERS (FOR EXISTING WALL SURFACE)

STO PLEX W

Water-base, clear conditioner/sealer for dry or dusty surfaces; adhesion intermediary on painted surfaces.

STO GRUNDEX

Mineral spirit base, clear penetrating substrate hardener and sealer. Used to seal very absorptive surfaces and solidify sanding surfaces.

STO PRIMER

Water-base white or tinted primer (contains fine sand). NOTE: STO PRIMER may be used to provide uniform absorption and prevent efflorescence.

PART 2: FASTENERS

Adhesives

STO DISPERSION ADHESIVE

Ready-to-use adhesive with high strength and flexibility, used to laminate EPS (expanded polystyrene) insulation boards to properly prepared smooth/level surfaces.

STO ADH-B

A heavy-type, polymer-based adhesive and/or leveler when mixed 4:1 with water (4 parts STO ADH-B to 1 part clean water). As an adhesive, use for laminating EPS boards to unpainted masonry surfaces.

STO BTS-B

A heavy-type polymer-based adhesive, ground coat or leveler (mix with 7–9 quarts of clean water for each 60 lb. bag of STO BTS-B). As an adhesive, use for a more flexible, less alkaline adhesive to laminate EPS boards to unpainted or painted masonry surfaces or gypsum sheathing.

STO FLEXYL

A copolymer-based waterproofer, adhesive (for bonding extruded polystyrene insulation boards or 2 lb. EPS boards to suitable substrates in below grade applications), and ground coat. (Mix one part Type 1 Portland Cement to one part STO FLEXYL.)

Mechanical Fastening

STO M-SYSTEM

Used over substrates which will not support an adhesive, require excessive leveling or require extensive pretreatment such as sandblasting, chipping or scraping. The following are components of the STO M-System:

- Starter Track—used horizontally at the bottom of the wall—8′ lengths.
- Holding Track—used horizontally between each course of insulation board—8′ lengths.
- T-Splines—used vertically to join the insulation boards together—22″ lengths.
- M-Board—pregrooved 2′ × 2′ expanded polystyrene boards in thicknesses from 2 to 4 inches as manufactured according to STO Specifications.
- Fasteners—STO approved fasteners that will securely anchor the starter and holding tracks to the substrate. Fastener used will depend on the substrate material and design and are placed 12″ o.c. at all horizontal tracks. (Example: Hilti Metal-Hit or equal for masonry substrates)

(STO TOUGHWALL SYSTEM)
STO FASTENER DISK

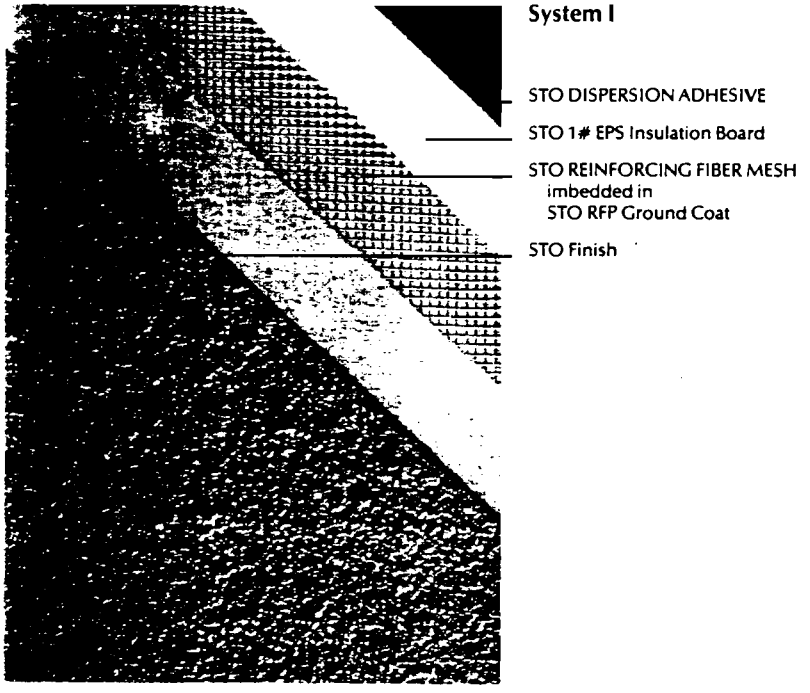
A specially designed plastic disk specifically designed for the STO Toughwall System and furnished by STO Industries.

PART 3: INSULATION

Above Grade

STO EPS BOARD

1 lb. density EPS (expanded polystyrene) manufactured according to STO Specifications and meeting ASTM C578-85 Type 1, Class A requirements. The maximum width and length of each board shall be 2′ × 4′ and the thickness (minimum ¾″) is determined by wall U-factor requirements.



DOW STYROFOAM INSULATION BOARD

2 lb. density Dow Styrofoam manufactured to ASTM C578-85 Type IV requirements. The maximum width and length of each board shall be 2' × 8' and thickness to be determined by wall U-factor requirements.

Below Grade

Extruded polystyrene insulation boards or 2 lb. density EPS (expanded polystyrene) shall be used.

PART 4: REINFORCEMENT LAYER (GROUND COAT WITH MESH)

Ground Coats

STO RFP

A ready-to-use, 100% acrylic copolymer, fiber-reinforced ground coat. STO RFP is a creamy off-white paste (may be tinted to match finish color) used as a ground coat when applied (with STO MESH) directly to the prepared insulation board. STO RFP dries to form a tough, flexible, water-resistant coating. NOTE: STO RFP curing time (by evaporation) will vary depending on climatic conditions.

STO BTS-B

A polymer-based adhesive, ground coat and leveler (mix with 7–9 quarts of clean water for each 60 lb. bag of STO BTS-B). STO BTS-B is used as a ground coat when applied (with STO MESH) directly to the prepared insulation board. Use where leveling is necessary and/or during cool, wet climatic conditions. Due to cement content of STO BTS-B, this ground coat must be primed with STO PRIMER prior to any finish application.

STO FLEXYL

A copolymer-based waterproofer, adhesive and ground coat (mix one part Type 1 Portland Cement to one part STO FLEXYL). STO FLEXYL is used as a ground coat when applied (with STO MESH) directly to the prepared insulation board. Use where waterproofing is necessary. Due to the cement content of STO FLEXYL, this ground coat must be primed with STO PRIMER prior to any finish application.

STO TOUGHWALL

A polymer-modified, cementitious glass fiber-reinforced ground coat when a 60 lb. bag is mixed with 7–9 quarts of clean water. STO TOUGHWALL ground coat is specifically designed for the STO Toughwall System.

Reinforcing Mesh

STO MESH

A coated, interwoven fiberglass mesh specifically designed for use as a ground coat reinforcement.

STO ARMOR MAT

A heavy-duty, interwoven fiberglass mat for high impact resistance. Specifically developed for maximum impact protection in high traffic or vandal prone areas.

STO MESH-C

A coated, interwoven fiberglass mesh specifically designed for use as a ground coat reinforcement for the STO Toughwall System.

PART 5: FINISH LAYER

This part of the system provides a protective coating over the system that is weather resistant, washable, fade and mildew resistant, crack resistant, and vapor permeable. Any STO Finish designed for exterior use may be applied over the reinforcing ground coat layer. Following is a list of STO Finishes:

STOLIT
Pebbled Texture (troweled); 1, 1.5, 2 mm Stone

STOLIT R
Rilled Pattern Texture; 1, 1.5, 2 mm Stone

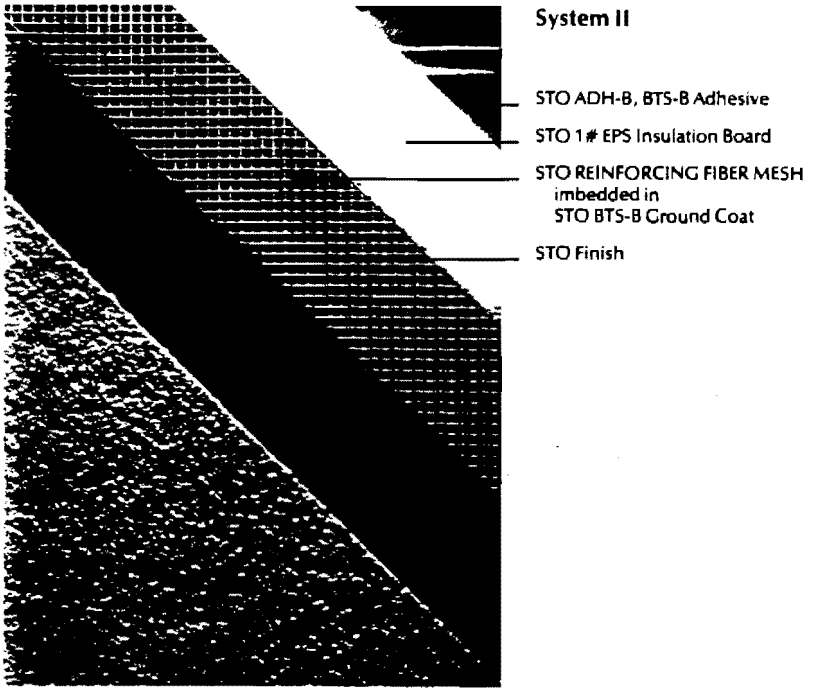
STO SPRAYPLASTER
Pebbled Texture (sprayed)

STOCO M
Freestyle Stucco Pattern Texture; fine sand

STO SUPERLIT
Exposed Aggregate; 2, 4 mm Stone

STO MARBLE SUPERLIT
Exposed Aggregate; 15 mm Stone

STO STONE MATRIX
Tinted compound used for imbedding various stones



4. TECHNICAL DATA

The products described are used together to form a composite insulating system that covers the exterior (in whole or part) of the building. The Insulation Value Chart is given to provide a general reference of properties that may be achieved. Refer to Table 1. Interested parties should contact STO for wall analysis, dew point, heat loss, permeability and freeze point calculation services for their individual building. For information call the STO Technical Department at (802) 775-4117 in Rutland, Vermont.

Applicable Standards: Extensive tests have been done on individual STO materials and the STO Full Thermal System resulting in the code approvals listed in Table 2 (additional code approvals and test results are available upon request).

5. INSTALLATION

NOTE: All materials in this section shall be installed according to the "Limitations" stated under "3-Product Description."

Preparation of the Wall Surface: For the standard adhesive system application on sheathing (exterior gypsum board, plywood, flakeboard, wood, cement asbestos board) or fully cured, uncoated masonry walls, no special preparation is needed. Sheathing must be firmly secured with appropriate fasteners 8" o.c. at the perimeter and 12" o.c. at the intermittent studs. All surfaces shall be clean, dry, level (no irregularities greater than ¼") and sound. For adhering to other substrates (painted, sealed, irregular, old sanding masonry, etc.) consult the STO Information Manual or a STO Technical Representative.

Adhesive System—Above Grade

(Refer to Part 2 of "Composition and Materials")

STO DISPERSION ADHESIVE

Ready-mixed, DO NOT MIX with cement or other additives. Apply STO DISPERSION ADHESIVE to back of EPS boards using a 1/16" u-notched trowel.

STO ADH-B

Mix 4:1 (by weight) with clean water. Apply STO ADH-B to back of EPS boards using a ⅝" notched trowel.

Insulation Value Chart

Type of Construction	No Insulation R	No Insulation U	1" Insulation R	1" Insulation U	2" Insulation R	2" Insulation U	3" Insulation R	3" Insulation U	4" Insulation R	4" Insulation U
Metal Stud	2.72	.37	6.57	.15	10.42	.10	14.27	.07	18.12	.06
8" Concrete Block	1.96	.51	5.81	.17	9.66	.10	13.51	.07	17.36	.06
8" Precast Concrete	1.49	.51	5.34	.19	9.19	.11	13.04	.08	16.89	.06
Wood Stud	2.90	.35	6.75	.15	10.60	.09	14.45	.07	18.30	.05

NOTE: To determine "R" and "U" for other thicknesses of insulation, use R = 3.85 for each 1 inch, U = 1/R.

Table 1

Code Approvals

International Conference of Building Officials Report No. 3906

Building Officials Code Administrators International Research Report No. 83-19

Southern Building Code Congress International Report No. 8378

U.S. Dept. of Housing & Urban Development Materials Release No. 1020a

Metropolitan Dade County, Florida, Acceptance No.: 83-0603.1(80)R

New York State Division of Housing & Community Renewal, Certificate of Acceptability No. 490-82-M & MC

New York City Department of Buildings, Report of Material & Equipment Acceptance Division, MEA 277-83-M

New York City Department of Buildings, Report of Material & Equipment Acceptance Division, MEA 278-83-M

New York Department of Buildings Report of Material & Equipment Acceptance Division, MEA 6-82-M

Boston Massachusetts State Building Code Approval

State of Connecticut Certificate of Compliance

Wisconsin Building Material Approval #810303

City of Phoenix, Arizona File No. M-2-85-B

State of Rhode Island, Dept. of Community Affairs, Building Commissioner, July 3, 1985.

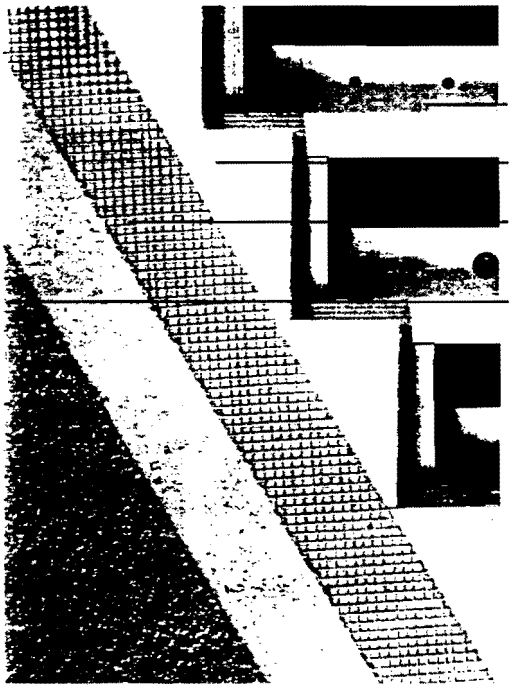
City of Los Angeles, Research Report No. RR 24708

City and County of San Francisco Bureau of Building Inspection, Approval No. 200S102.1

California State Fire Marshal Listing No. 2160-1089; 100

Ontario Building Code 85-9-87

Table 2



M-System

Mechanically Fastened STO Track System

STO Pre-Grooved 1# EPS Insulation Board

STO REINFORCING FIBER MESH imbedded in STO RFP Ground Coat

STO Finish

STO BTS-B

Mix with 7–9 quarts of clean water for each 60 lb. bag of STO BTS-B. Apply STO BTS-B to back of EPS board using a ⅝" or ½" notched trowel.

STO INSULATION BOARD

(Refer to Part 3 of "Composition and Materials")

Apply to vertical surfaces; begin at the base from a firm, permanent or temporary support. Adhesion shall be made to a clean load-bearing surface as described under "Preparations of the wall surface". Precut insulation board to fit around openings, projections, etc. Stagger vertical joints and interlock all corners. Apply adhesive to the insulation board using the proper size notched trowel to form ribbons. Immediately place the board on the wall using firm pressure over entire surface of the board to insure uniform contact and high initial grab. Abut all joints tightly. All areas where the system joins other materials or terminates at roof lines, window jambs, heads and sills, etc. must be protected (caulked) to assure that no water can penetrate behind STO Insulation Board. Fill any gaps between insulation boards with slivers of EPS insulation and rasp the entire surface smooth/level with a STO RASPING BOARD.

STO RFP AND REINFORCING FIBER MESH

(Refer to Part 4 of "Composition and Materials")

No cement or any other additives shall be mixed with the ready-mixed STO RFP. A small amount of clean water may be added to help workability. Using a stainless steel trowel, apply a ground coat of STO RFP over the EPS boards to a uniform thickness of approximately 1/16 inch. Work horizontally or vertically in strips of 40 inches, and immediately imbed the fiberglass mesh into the wet ground coat. STO REINFORCING FIBER MESH shall be continuous at all corners and overlapped not less than 2½ inches at mesh joints. Double wrap corners. Avoid wrinkles in the mesh.

The finish thickness of the ground coat and reinforced fiberglass mesh shall be such that the mesh is fully imbedded. Allow this application to fully dry before applying finish. (Approx. 24 hrs.)

NOTE: STO BTS-B and reinforcing STO MESH may be used as an alternate ground coat to STO RFP. Follow STO Specifications for proper mixing and application of STO BTS-B ground coat. (Refer to Part 4 of "Composition and Materials")

STOLIT FINISH

(Refer to Part 5 of "Composition and Materials")

Thoroughly stir the factory prepared material with a high speed, rust-free mixer until a uniform workable consistency is obtained. A small amount of clean water may be added to aid workability. Avoid application in direct sun. Always work to a wet edge. Use a clean, stainless steel trowel to apply an even coat, slightly thicker than the largest aggregate size, in an upward motion. Next, using a horizontal motion, level the initial application to a finish thickness no greater than the largest aggregate of the material. The final texture is achieved by applying light pressure in a circular motion, using a stainless steel trowel.

Any other STO Exterior Finish may be used in place of STOLIT Finish depending on desired pattern and texture.

Adhesive System—Below Grade

(Refer to Part 2 of "Composition and Materials")

Mix STO FLEXYL per STO Specifications, trowel STO FLEXYL onto the wall surface in a 3/16" thick continuous layer and immediately press extruded polystyrene boards or 2 lb. EPS boards into the wet STO FLEXYL. (Porous substrate must be primed with diluted STO FLEXYL. Dilute STO FLEXYL up to 15–20% with water and apply with a roller, before application of STO FLEXYL as adhesive/waterproofer). Stagger vertical joints, interlock corners, and keep adhesive from between board joints. Fill any gaps between insulation boards with slivers of insulation and rasp the surface smooth to a point 12" below grade, using a STO RASPING BOARD. Apply STO FLEXYL with STO MESH to the prepared insulation board to a point approximately 12" above finish grade (splash area). Apply 2 coats of STO PRIMER over the STO FLEXYL application (to prevent color bleed through) prior to application of STO Finish.

NOTE: If expanded polystyrene is used, the entire surface must be covered with a ground coat of STO FLEXYL.

STO M-System

(Refer to Part 2 of "Composition and Materials")

Establish a horizontal line at the base of the substrate. Install starter track with special screws 12" o.c. and install the 2' × 2' EPS boards with groove into tracks. Place a vertical T-Spline between each EPS board.

Below Grade System

- Masonry Substrate
- Diluted STO FLEXYL Sealer
- STO FLEXYL Adhesive/Waterproofer
- STO 2# EPS or Extruded Insulation Board
- STO REINFORCING FIBER MESH imbedded in STO FLEXYL Ground Coat
- STO PRIMER (2 coats)
- STO Finish

Start second and continuing rows with holding tracks and T-Splines as in first row. Unevenness is corrected with shims placed between substrate and tracks. Fill, rasp and level the EPS board surface as described under the adhesive system (above grade). Apply ground coat with mesh (refer to Part 4 of "Composition and Materials"), then finish (refer to Part 5 of "Composition and Materials" as described under the adhesive system—above grade).

Prefabrication of Insulated Panels

The prefabricated panels will be of steel framing and exterior grade gypsum sheathing. For the proper specification and construction, refer to a reputable manufacturer or a steel fabricating company.

Apply STO DISPERSION ADHESIVE to the face of the gyp sheathing using a 3/16" u-notched trowel to form ribbons. Press EPS insulation boards firmly into the adhesive and allow to dry, achieving a permanent bond. Fill any gaps between insulation boards with slivers of EPS insulation and rasp the surface of the EPS insulation boards smooth using a STO RASPING BOARD; remove any loose insulation particles. Apply ready-mixed STO RFP to the EPS insulation board surface and edges of the panel in a uniform layer approximately 1/16" thick. Imbed STO MESH firmly into the wet STO RFP ground coat and trowel smooth so the mesh is fully imbedded. The mesh and ground coat shall extend onto the steel framing to provide a continuous, reinforced, weather resistant panel. Allow this application to dry completely and apply any STO Finish over the ground coat layer according to STO Specifications.

After the finish has cured, the panels are transported from the place of manufacture to the job site, where they are raised in place by crane and attached to the structure by welding or bolting.

Toughwall System

DOW STYROFOAM INSULATION BOARD

The insulation board shall be applied in a running bond pattern with the eight foot dimension applied horizontally. Preliminary attachment of the insulation board is achieved by applying a minimum of three mechanical fasteners through the insulation board and into the structural substrate. The fasteners are located 12" up from the bottom of the insulation board and 16" from both ends over stud spacing of 16" o.c. and masonry, and 24" from both ends over stud spacing of 24" o.c. Vertical joints shall be staggered and insulation boards interlocked at corners. Joints of insulation shall be butted tightly. Surfaces of adjacent boards shall be flush at joints.

STO TOUGHWALL AND STO MESH-C

STO REINFORCING FIBER MESH-C shall be applied mechanically over the insulation board with the STO Fastener Disks spaced not more than 12" vertically and not more than 16" or 24" horizontally, depending on the stud spacing. The mesh shall be overlapped a minimum of 3". A total of 12 STO Fastener Disks shall be used for a 2' × 8' insulation board. (See STO Fastener Disk Technical Bulletin.)

STO TOUGHWALL shall be mixed with 7–9 quarts of clean water per each 60 lb. bag and stirred to a uniform consistency. Apply ground coat, using proper spray equipment or a stainless steel trowel, in a coat of approximately 3/16" thickness, to match the height of the trim accessories. Level the ground coat to achieve a smooth, uniform surface. Allow ground coat to thoroughly dry before applying finish.

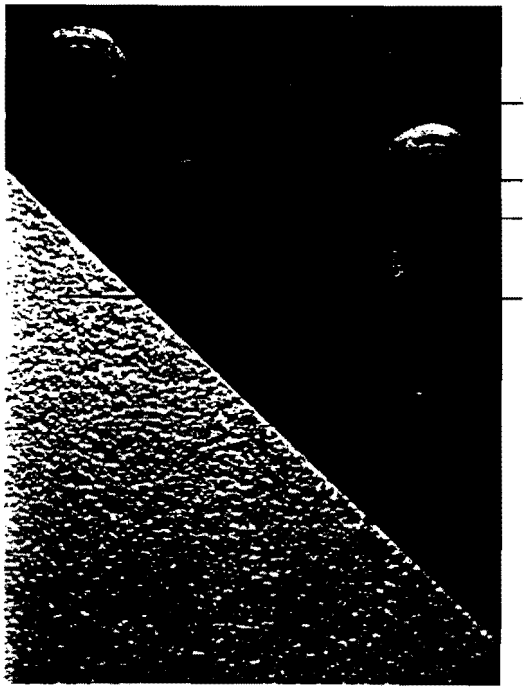
STOLIT FINISH

(Refer to Part 5 of "Composition and Materials")

Thoroughly stir the factory prepared material with a high speed, rust-free mixer until a uniform workable consistency is obtained. A small amount of clean water may be added to aid workability. Avoid application in direct sun. Always work to a wet edge. Use a clean stainless steel trowel to apply an even coat slightly thicker than the largest aggregate size in an upward motion. Next, using a horizontal motion, level the initial application to a finish thickness no greater than the largest aggregate of the material. The final texture is achieved by applying light pressure in a circular motion using a stainless steel trowel.

Any other STO Exterior Finish may be used in place of STOLIT Finish, depending on desired pattern and texture.

Precautions: In addition to the "Limitations" listed in Part 3 under "Product Description", the substrates and installed insulation system must be protected from water penetration during and after application. Caulking details should be properly constructed to permanently seal the system. Follow STO caulking detail specifications.



Toughwall System

- STYROFOAM* Brand Insulation
- STO Fastener Disk
- STO MESH-C imbedded in STO TOUGHWALL Ground Coat
- STO FINISH

*STYROFOAM is a trademark of The Dow Chemical Company

6. AVAILABILITY AND COST

STO materials are manufactured in Rutland, Vermont, Atlanta, Georgia, and Phoenix, Arizona, and are purchased by certified STO Applicators through STO Distributors located throughout the U.S. Contact the main office in Atlanta, Georgia (Phone: (800) 221-2397).

Contact a local STO Distributor to obtain a current list of qualified applicators for pricing information.

7. WARRANTY

STO Industries warrants that the products of its manufacture, when properly applied according to STO's specifications and procedures and when used in combination with STO Industries' other products according to STO's specifications and procedures, shall be free from defects in material and workmanship for a period of five (5) years for STO Exterior Insulation Systems applied according to STO Specifications #A100, A200, A300, A400, D100, D200, M100, or for a period of three (3) years for STO Specification E-1000, from date of invoice. No warranty stated herein shall be effective until the goods subject to said warranty have been paid for in full.

STO Industries makes no other express warranty with respect to its products. STO INDUSTRIES MAKES NO OTHER WARRANTY OF MERCHANTABILITY. STO INDUSTRIES MAKES NO WARRANTY THAT THE PRODUCTS OF ITS MANUFACTURE ARE FIT FOR ANY PARTICULAR PURPOSE.

Defects caused by misuse, mishandling, improper storage, improper application, improper combination with the goods of STO or others, or failure to follow STO's specifications and procedures are not warranted under any circumstances. STO Industries shall not be responsible for incidental or consequential damages as those terms are defined in Section 2-715 of the Uniform Commercial Code, or other applicable law, regardless of cause.

STO Industries shall not be responsible for damage or injury caused by materials not produced by or sold by STO Industries under the name of STO, nor damage nor injury caused by acts of God, structural movement, injury caused in whole or in part by insufficient or defective waterproofing between the STO materials and non-STO materials, nor any other damage or injury not directly caused or related to the STO products or application of those products by contractor.

STO Industries' sole responsibility and liability under this warranty shall be to supply replacement goods for any goods shown to be defective within three (3) or five (5) years for STO Exterior Insulation Systems as described herein from the date of invoice. This is BUYER's sole remedy under this warranty.

This warranty may not be transferred or assigned by the BUYER. Since the goods are building materials and are not intended to be sold to a "consumer" except as part of real estate or as a major addition thereto, this warranty is not intended to apply to any party constituting a "consumer" as defined by the Magnuson-Moss Warranty Act.

8. MAINTENANCE

All STO Finishes and Systems are virtually maintenance free. Airborne contaminants and other dirt and residue may be cleaned from the finished surfaces with warm water and mild detergent using pressure wash and/or a soft brush. Periodic inspections should be made at all caulk and expansion joints and any other penetrations through the insulation and/or finish system to verify integrity of the sealant material.

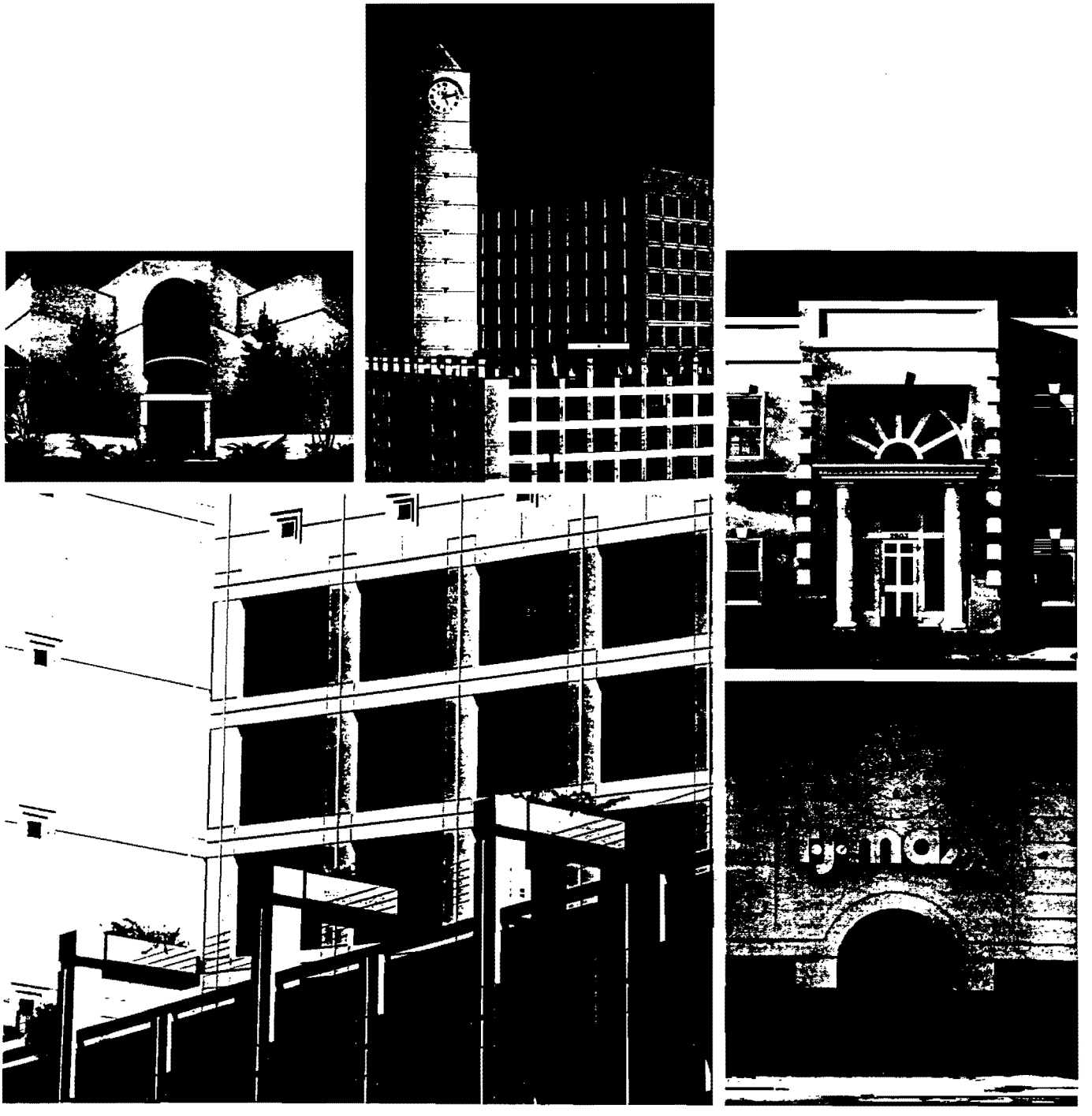
9. TECHNICAL SERVICES

STO Industries provides technical information through STO Information Manuals, instructional seminars and job site visitations by STO Technical Representatives. Wall analysis calculations and other specific information is available by phoning your local STO Distributor or STO Industries (Phone: (802) 775-4117).

10. FILING SYSTEMS

SPEC-DATA® II
Sweets' Architectural Catalog File
No. 07240/STO

sto



2-90-2082

SPEC DATA®

This Spec-Data sheet conforms to editorial style prescribed by The Construction Specifications Institute. The manufacturer is responsible for technical accuracy.

1. PRODUCT NAME

FUL-O-MITE® IDF
Exterior Insulation Finish System

2. MANUFACTURER

TEC Incorporated,
an H.B. Fuller company
315 S. Hicks Road
Palatine, IL 60067
Phone: (708) 358-9500
(800) 323-7407

3. PRODUCT DESCRIPTION

FUL-O-MITE IDF Exterior Insulation Finish System is a lightweight, flexible, reinforced coating system for new and renovation construction. It can be site applied or prefabricated using metal stud panels. The **FUL-O-MITE** IDF Coating is vapor permeable to minimize condensation problems.

FUL-O-MITE IDF is a low-maintenance exterior wall insulation finish system.

Limitations:

- Temperatures should be a minimum of 40°F for 24 hours before and after installation.
- Finished work must be protected from moisture, frost or freezing temperatures until cured (approximately 24-72 hours).
- Use minimum 1" expanded polystyrene (EPS) foam insulation board. Maximum thickness of board must comply with applicable building code and TEC Incorporated specifications.
- Not for horizontal application, 6/12 minimum slope required.
- Installed by applicators registered by TEC.
- Products must be protected from freezing during shipment and in storage.

Composition & Materials:

3.1 Binder/Primer

3.1.1 BC-370—used as an adhesive and base coat—freeze-thaw stable (before combining with portland cement) proprietary modified acrylic copolymer ad-mix.

3.1.1.1 Portland Cement—ASTM C150, Type I, fresh and free from lumps.

3.1.2 BC-360—One Step Latex Modified as an adhesive and base coat-dry powder mixture to be combined with water.

3.2 Clear, clean, and potable water.

3.3 EPS Foam Insulation Board—Expanded polystyrene (EPS) foam board; foam molder must label and certify that the board complies with the following specifications:

3.3.1 ASTM C578-87a, Type I

3.3.2 Maximum length per sheet: 48" ± 1/16", max. deviation per foot of length.

3.3.3 Maximum width per sheet: 24" ± 1/16", max. deviation per foot of width.

3.3.4 Thickness: as specified 1" min. ± 1/16".

3.3.5 Edges to be square, max. deviation 1/32" per foot.

3.3.6 Density: 1.0 pcf ± .1

3.3.7 Cure of board in billet:

3.3.7.1 4 to 6 weeks air cure in a heated ventilated area or,

3.3.7.2 5 days vented cure at 140°F or,

3.3.7.3 3 days vented cure at 158°F.

3.3.8 Flame spread values per ASTM E84.

3.3.8.1 Flame spread of 25 or less.

3.3.8.2 Smoke density of 450 or less.

3.4 Mesh Embedment base coat—must be a hard, breathing-type bonding layer comprised of those materials described in 3.1, and 3.2 of this document.

3.5 TEC Brand Reinforcing Mesh:

3.5.1 BC-970 Standard Reinforcing Mesh—alkali-resistant, balanced weave, compatible with the Mesh Embedment base coat of the System.

3.5.2 BC-975 Medium Reinforcing Mesh—for moderate impact resistance, alkali-resistant, balanced weave, compatible with the Mesh Embedment base coat of the System.

3.5.3 BC-971 Heavy Duty Reinforcing Mesh—for higher impact resistance, alkali-resistant, compatible with the Mesh Embedment base coat of the System. Installation must follow exact instructions from TEC Incorporated.

3.6 Finish Coat:

3.6.1 BC-371 Finish Coat—a proprietary, acrylic copolymer coating, air curing, available in various colors and textures.

Finish Coat must be protected from freezing during shipment and in storage.

3.6.2 Forms a breathing-type coating fully bonded and compatible with the Mesh Embedment base coat to which it is applied.

3.6.3 The textured acrylic Finish Coat color is factory-mixed. Color and texture must comply with the approved job sample.

Applicable Standards:

• ICBO	4565
• BOCA	88-22
• SBCCI	8883
• HUD	MR#1107
• State of Wisconsin	DILHR #890007-I
• Dade County	

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EXTERIOR INSULATION AND FINISH SYSTEMS
7
TEC Incorporated
August 1989
(Supersedes May 1985)

Florida	#86-0602.3
• City of New Orleans	(per project)
• U.L. Classified File	#R10914

4. TECHNICAL DATA

Extensive tests have been conducted on the **FUL-O-MITE®** IDF System to comply with Federal, State and local requirements. Copies of actual laboratory reports are available upon request.

Physical Properties: Data is available on tensile bond strength, water vapor transmission, accelerated weathering, resistance to impact, mildew, salt spray, moisture, wind-driven rain, chemicals, and absorption-freeze.

Windload performance per ASTM E330 ± 100 psf

Fire performance of System per UBC-17-6, SWRI Full Scale Fire test—Pass

Fire performance of System per modified ASTM E108—Pass

Fire performance of coating per ASTM E84-0 smoke development, 0 flame spread

5. INSTALLATION

Preparatory Work: Inspection of substrates to determine suitability to accept **FUL-O-MITE** IDF System.

New concrete must have 28-day minimum cure.

Gypsum sheathing that has not been adversely affected by weather exposure, meeting ASTM-79, and be type, grade and thickness specified.

Dew point calculations, flashings, weeps, vapor retarders, and expansion provisions is the responsibility of the architect or the design engineer.

Protect adjacent work by others.

Workmanship: Mix BC-370 Binder/Primer with 44 pounds Type I portland cement per 60 pound unit (3.1.1).

Mix BC-360 Binder/Primer with 5 quarts of water per 50 lb. bag (3.1.2).

Apply mixed Binder/Primer to completely cover insulation board using 5/32" V-notch trowel, (for smooth surfaces, i.e., exterior-grade gypsum sheathing). Or, apply mixed Binder/Primer in ribbon and dab pattern for uneven substrates, i.e., masonry.

EPS Foam Insulation Board, as supplied by others, must be installed with all edges tightly butted, vertical joints staggered, and corners of board edges interlocked. Foam Board joints should not be placed over joints in the substrate(s). Allow to set a minimum of 12 hours.

Apply mixed Binder/Primer to face of insulation and embed reinforcing mesh into wet base coat; lap fabric edges 2"-4"; double wrap all corners, edges, and termination points; allow to cure for 12 hours minimum.

Mix Finish Coat BC-371 a minimum of 3 minutes with a low speed mixer; apply to cured reinforced primer layer using a trowel; texture as required to match job approved sample.

Joints between panels, expansion joints, or where **FUL-O-MITE** IDF System abuts other materials, require closed cell backer rod or bond breaker and sealants as specified by others.

Detailed application instructions are available for standard application described above as well as a high-impact resistant application.

Precautions: Do not dilute Binder/Primer beyond proper mixing instructions, nor alter its cement to Binder/Primer ratio.

Substrate systems must be clean, dry, and structurally sound.

Cap flashing must be installed immediately after installing the System, or temporary protection must be provided.

All joints must be sealed 24 hours after installing the System, or temporary protection provided.

Observe all requirements/restrictions given in manufacturer's current installation instructions and complete specifications.

6. AVAILABILITY AND COST

Availability: Binder/Primer BC-370 or BC-360, Finish Coat BC-371 and Reinforcing Meshes BC-970, BC-971, BC-975 and BC-979 available nationally through TEC Incorporated Architectural Products Distributors. Call TEC Headquarters in Palatine, IL (708) 358-9500, or (800) 323-7407.

EPS Foam Insulation Board is secured through approved sources, listed by TEC Incorporated.

Cost: F.O.B. Palatine, Illinois. Contact TEC Incorporated or local **FUL-O-MITE** IDF Distributor for more information.

7. WARRANTY

Specific warranties are available from TEC Incorporated. Contact TEC Incorporated Headquarters in Palatine, IL (708) 358-9500, or outside IL (800) 323-7407.

Labor warranties secured through Registered Applicators.

8. MAINTENANCE

Damaged areas may be repaired following **FUL-O-MITE** IDF repair instructions.

A **FUL-O-MITE** IDF maintenance kit is to be kept on the job site and stored where directed. It includes one unit each of Binder/Primer, Finish Coat and proper amounts of other materials used within the System. Product containers must be unopened.

9. TECHNICAL SERVICES

TEC Incorporated provides technical information in the form of **FUL-O-MITE** IDF information manuals, instructional seminars and field sales representative assistance. Inhouse technical assistance is also available by calling our headquarters in Palatine, IL (800) 323-7407 (outside IL), or (708) 358-9500 (in IL).

10. FILING SYSTEMS

SPEC-DATA® II
Sweet's 07240
TEC Incorporated Architectural Catalog
Additional information available upon request.

Clotex

The Very Best

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 6

To DAVID KEITH	From MAZIA ANTIC
Co. RCG/H-B	Co. JWISC
Dept.	Phone # 813 873 4245
Fax # 703 351 0342	Fax # 813 873 4287

Note: The following application recommendations are for design information only. See EIFS manufacturer for detailed application instructions.

Thermax® Quik-R™ Wall Insulation Means Easy Installation

Many insulation substrates are difficult to install because they are fragile, cumbersome or heavy. They may also be difficult to shape, cut or form. These problems can slow work down and even reduce the effectiveness of the product.

But Celotex Thermax Quik-R Wall Insulation is different!

Quik-R is lightweight. A 1" x 4' x 8' board of Celotex Quik-R weighs only about 4½ pounds. That means one person can easily lift and carry a good size stack of boards.

Easy to cut and shape. Celotex Quik-R can be easily cut with a utility knife to any shape needed to conform to irregular wall angles or to fit the sheathing snugly around windows, doors or other projections. In addition, it is easily fabricated to provide for architectural accents such as arches, flower boxes, scallops and special window treatments. The possibilities are endless!

Easy fastening. The Celotex Quik-Cap washer, with conventional fasteners, simplifies board attachment by allowing placement of the washer on the board before the fastener is driven.

Celotex Thermax Quik-R Wall Insulation requires no special handling. As with any insulation, common sense should be exercised in handling and installing Thermax Quik-R Wall Insulation.

APPLICATION INSTRUCTIONS

General Information

Storage: Thermax Quik-R Wall Insulation should be stored and protected from weather.

Thermax Quik-R Wall Insulation is not a structural load bearing product; acceptable corner bracing must be used. All board joints (vertical or horizontal) must be over framing blocking or solid backing.

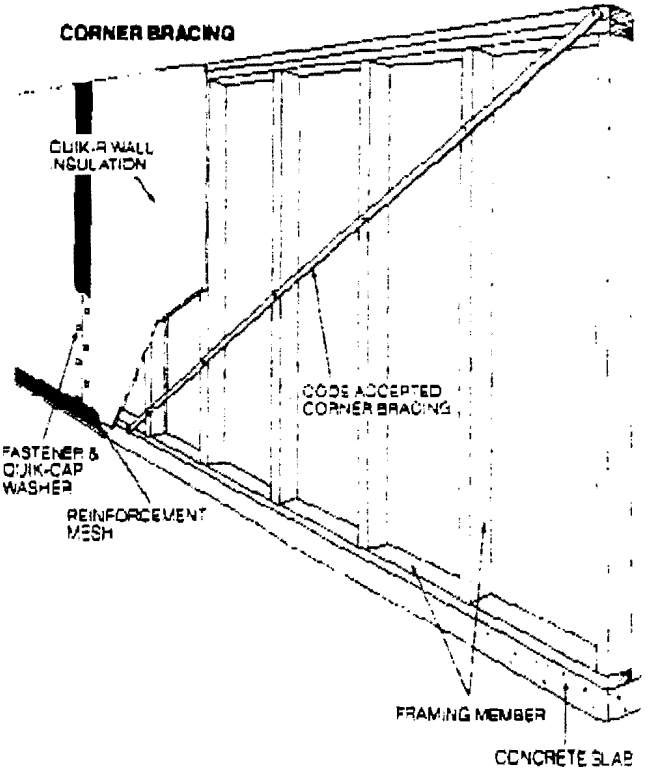
Quik-R must be mechanically fastened by placing corrosion-resistant fasteners through a Celotex Quik-Cap Washer. This washer is specifically designed for use with Celotex Thermax Quik-R Wall Insulation. Quik-Cap Washers are available in hot dipped galvanized steel or plastic.

Before application of EIFS coating begins, suitable caulking materials shall be used to seal irregular trim cuts/board joints and irregular wall penetrations to provide a level and closed surface. All Quik-R edges and joints between Quik-R and other materials shall be protected from water penetration. Caulking specifications shall be as required by the EIFS manufacturer.

Type and design, location and installation specifications for expansion and/or contraction joints shall be in accordance with the requirements and recommendations of the EIFS manufacturer to deal with mechanical movement anticipated in the structural/framing system or thermal expansion/contraction responses.

Large wall areas can be aesthetically enhanced by installing "architectural breaks" such as a strip of Quik-R applied horizontally over the wall surface.

In the event of rain after Thermax Quik-R Wall Insulation has been installed, allow exterior insulation board surfaces to air dry before applying exterior finish coatings.



Corner Bracing: While Quik-R Wall Insulation is a rigid and exceptionally sturdy board, it does require the use of corner bracing. Adequate diagonal wall bracing can be achieved with wood let-ins or other building code accepted materials and methods.

Within 14 days after the application of Thermax® Quik-R™ Wall Insulation, a EIFS base coat shall be trowel-applied over the insulation board surface. If application will begin after 14 days, protect the Quik-R from the weather. If the 14 day limit will be exceeded, the EIFS manufacturer and their applicator must determine the proper protection for the Quik-R. Before applying base coat, all roofing materials should be evenly distributed on the roof. Gypsum board or other interior finish materials should be distributed on the interior to prevent setting cracks. Thickness of base coat application shall be as specified by the EIFS manufacturer or minimum ⅛" maximum ¼". Prior to full base coat application, glass fiber reinforcement mesh as specified by the coating manufacturer must be embedded into freshly applied base coat over all insulation board joints, all corners and edges including bottom edge, door and window openings. Spot each Quik-Cap Washer and fastener with base coat. Plastic or corrosion-resistant metal corner beads and starter strips as alternates to glass fiber reinforcement mesh are acceptable. After the EIFS finish coat is applied, caulk around penetrations such as doors, windows, vents, electric or plumbing to prevent weather intrusion.

Fastening Details

All trim cuts shall be made with a sharp knife and straight edge, using care and good workmanship, smooth and straight trim cuts will avoid unnecessary caulking expense and permit good mechanical attachment.

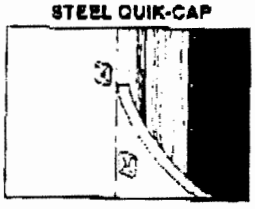
NOTE: Quik-R must be mechanically fastened with the fastener pattern as shown in this literature. Celotex does not assume any responsibility for other fastening patterns or fastening methods recommended by others.

Fasteners

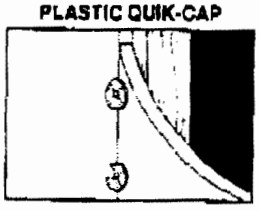
Corrosion-resistant mechanical fasteners should be used to fasten Quik-R Wall Insulation to framing and masonry substrates. Each mechanical fastener shall be installed through a Celotex Quik-Cap Washer.

Care should be taken to avoid overdriving the fasteners. The mechanical fastener should not protrude above the surface plane of the Thermax Quik-R Wall Insulation. Steel Quik-Cap Washers must not be used to bridge two insulation boards at the joint.

STEEL QUIK-CAP



PLASTIC QUIK-CAP



Quik-Cap Washer

Labor Saving — Just push into the board face ... makes positioning fasteners quick and easy.

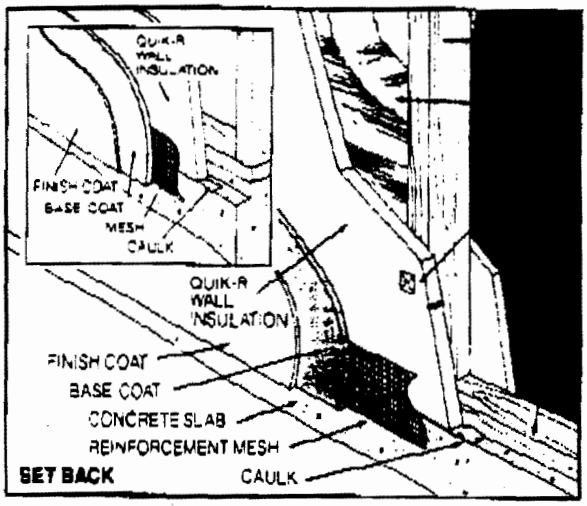
Versatile — Works easily with commonly available mechanical fasteners.

Convenient packaging

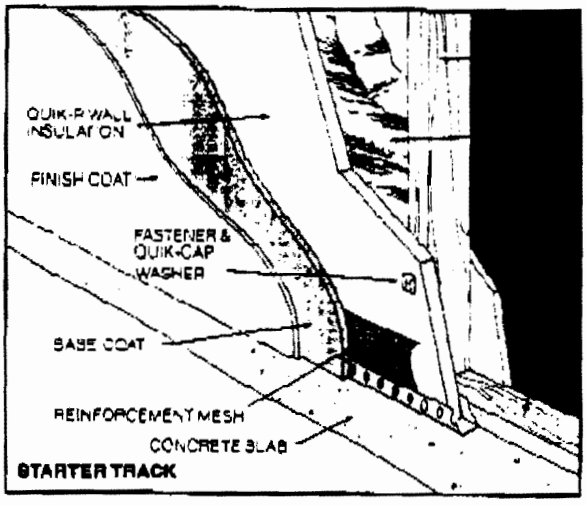
The insulation board is affixed directly to the concrete with the fastener, followed by the reinforcement mesh and finished with stucco.

Installation Details

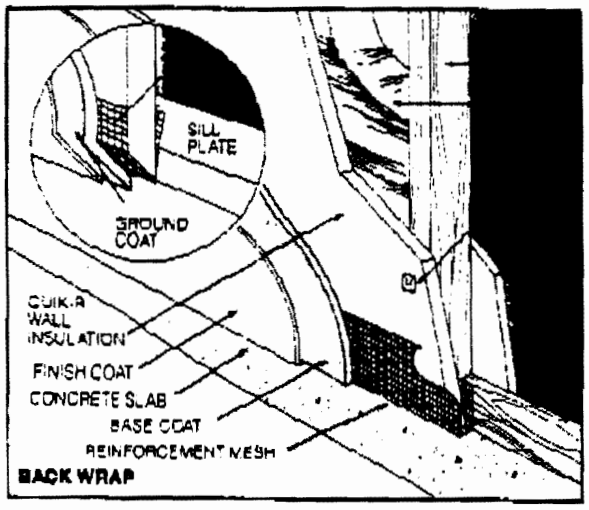
Thermax Quik-R Wall Insulation can be installed using a set back wall section, starter track, or back wrapping.



SET BACK



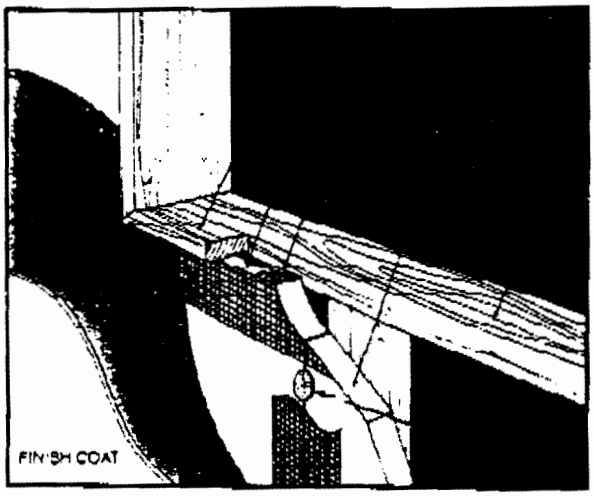
STARTER TRACK

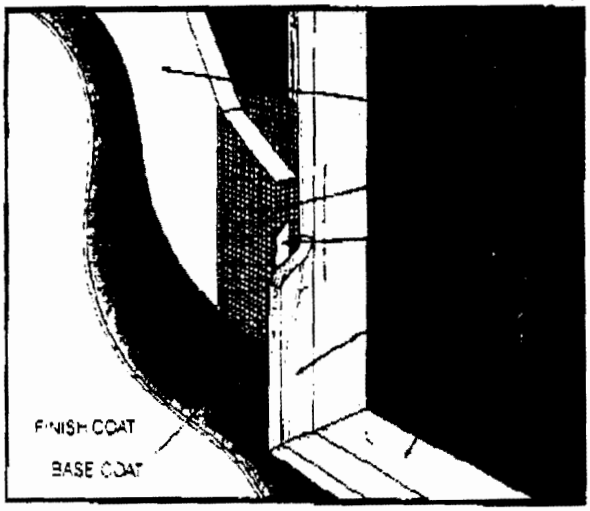


BACK WRAP

Window/Door Details

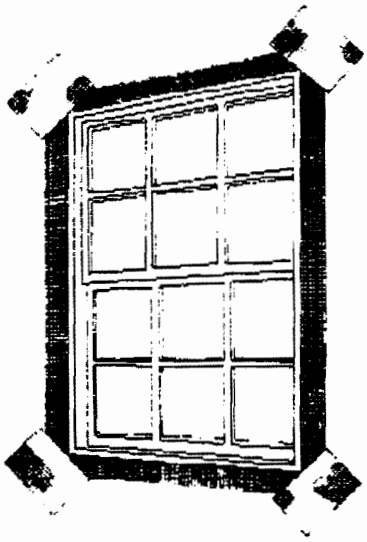
Thermax® Quik-R™ Wall Insulation can be easily installed around windows and doors. It can be trimmed with a sharp knife and straight edge. All cut edges shall be wrapped with reinforcement mesh.

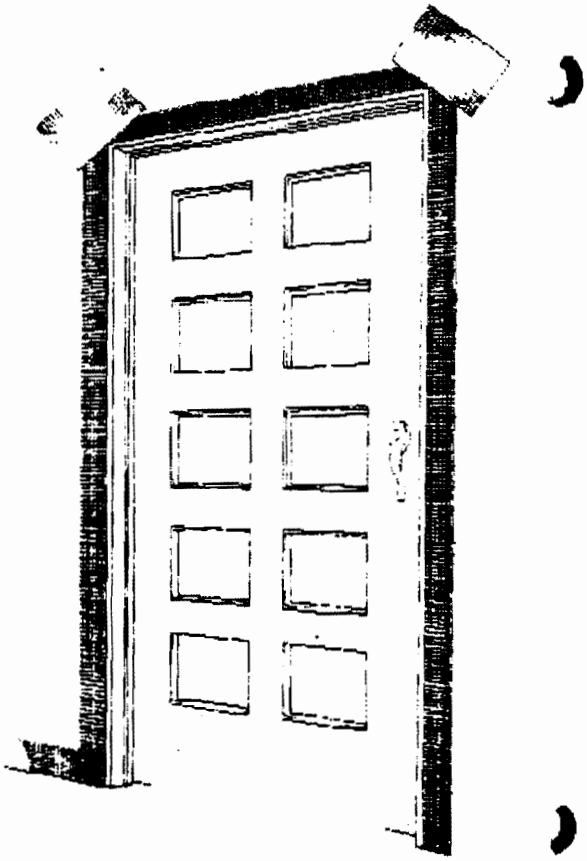




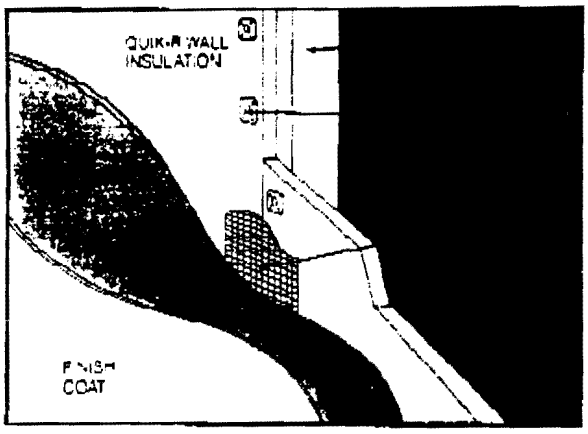
Band Aid Details

To minimize settling cracks at corners of windows and doors, apply strips (band-aids) of reinforcement at 45° angle as illustrated. It will also insure the reinforcing mesh will be lapped at the corners.





Wood or Steel Frame Construction



Place Thermax® Quik-R™ Wall Insulation Boards vertically, with long-dimension edges running parallel to and over maximum 16" o.c. framing with each board spanning a minimum of 3 studs. In spanning 24" o.c. framing, minimum ½" gypsum sheathing is required over the framing before application of the Quik-R Wall Insulation. The printed board side (THIS SIDE DOWN/IN) shall be in contact with the framing. Joints shall consist of two insulation board edges, neatly butted over the center of framing members. To minimize horizontal joints and job site waste, Thermax Quik-R Wall Insulation is available in 4'x8', 4'x9', 4'x10' and 4'x12' standard sizes.

Mechanical Fasteners

Place corrosion-resistant mechanical fasteners through steel Quik-Cap Washer 12" o.c. around the entire perimeter of each insulation board and along each field stud in order to anchor board to framing. Fasteners used with plastic Quik-Cap Washer should be placed 8" o.c. at perimeter, spanning the joint and 12" o.c. in the field of the board.

Fastening To Wood Framing

a) Minimum 12 gauge smooth shank (or equivalent improved anchoring shank design) hot-dipped galvanized nails shall have minimum 1" penetration into wood framing.

b) Minimum 12 gauge ring shank (or equivalent improved-anchoring shank design) hot-dipped galvanized nails shall have minimum 1" penetration into wood framing.

c) Minimum 12 gauge stainless steel wood screw (or equivalent) fasteners shall have minimum 1" penetration into wood framing.

Fastening To Steel Stud

a) Buildex S12 self-tapping corrosion-resistant screws or equivalent. Fastener length must be sufficient to allow ¾" penetration into steel stud.

Calculated System Design Insulation Values for Wood Frame and Steel Stud Systems

Nominal Board Thickness	¾"	¾"	1"	1½"	2"
System R-Value	15.8	15.5	17.9	20.7	23.5
System U-Value	.063	.061	.056	.048	.042

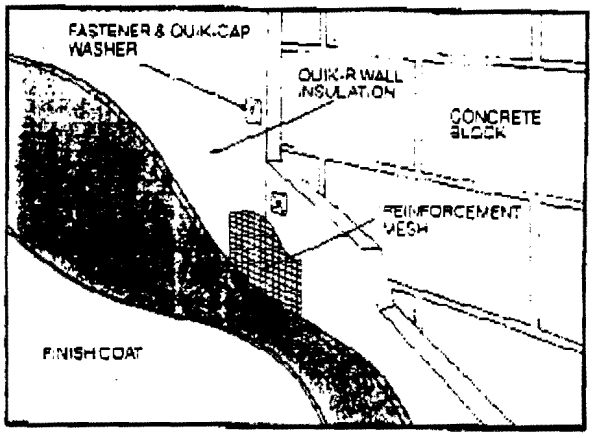
System calculations are through cavity and in accordance with ASHRAE Handbook Fundamentals and stabilized R-values at 75°F mean temperature.

Wood Frame System consists of ½" gypsum board, 2x4 wood studs, R-11 glass fiber batt in stud cavity, Thermax Quik-R Wall Insulation.

Steel Stud System consists of ½" gypsum board, 3½" steel stud, R-11 glass fiber batt in stud cavity, Thermax Quik-R Wall Insulation.

*R means resistance to heat flow. The higher the R-value, the greater the insulating power. Ask your seller for the fact sheet on R-values.

Masonry Wall Construction



Thermax Quik-R Wall Insulation Boards may be placed either vertically or horizontally with the printed board side (THIS SIDE DOWN/IN) in contact with the masonry surface. Joints shall consist of two insulation board edges neatly butted, with all joints supported by the masonry substrate.

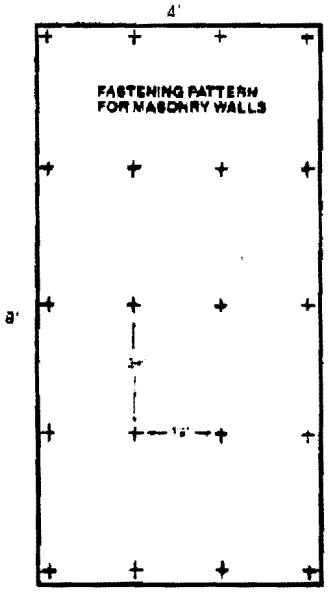
Mechanical Fasteners

Space corrosion-resistant mechanical fasteners with Quik-Cap Washers 24" vertically and 16" horizontally o.c. around the entire perimeter and in the field of each insulation board in order to anchor board to masonry substrate.

Fasteners For Masonry Walls

a) ITW Buildex "TAPCON" fasteners or equivalent. Fastener length must be sufficient to allow 1" penetration into the masonry.

b) Aerosmith (ERICC) fasteners or equivalent. Use smooth shank fastener with 1" penetration into the masonry.



NOTE: Quik-R must be mechanically fastened with the fastener pattern as shown in this literature. Celotex does not assume any responsibility for other fastening patterns or fastening methods recommended by others.

Celotex Recommendations For Condensation Moisture Control

Quik-R™ Wall Insulation must not be left exposed and must be installed behind minimum ½" gypsum board or its equivalent interior finish.

Much like other Celotex polyisocyanurate foam sheathing board products, such as foil-faced Thermax Sheathing and Tuff-R Insulating Sheathing, the use of Thermax Quik-R Wall Insulation on exterior wall surfaces can effectively keep the wall temperature warmer under cold winter conditions. Insulation value located outside the wall acts to shield it from outside weather temperature variations while interior side temperatures moderate the temperature of the wall. Increasing wall temperature also decreases the likelihood of winter moisture condensation occurring within the cavity.

Celotex believes that, for optimum homeowner comfort, all insulated walls should contain a properly installed vapor retarder rated at 1 perm or less, such as a 2 to 6 mil polyethylene film. Celotex makes the following recommendations regarding proper placement of the vapor retarder (Consult your weather bureau or local utility for degree day information specific to your area):

Area I: Below 2000 Winter Degree Days

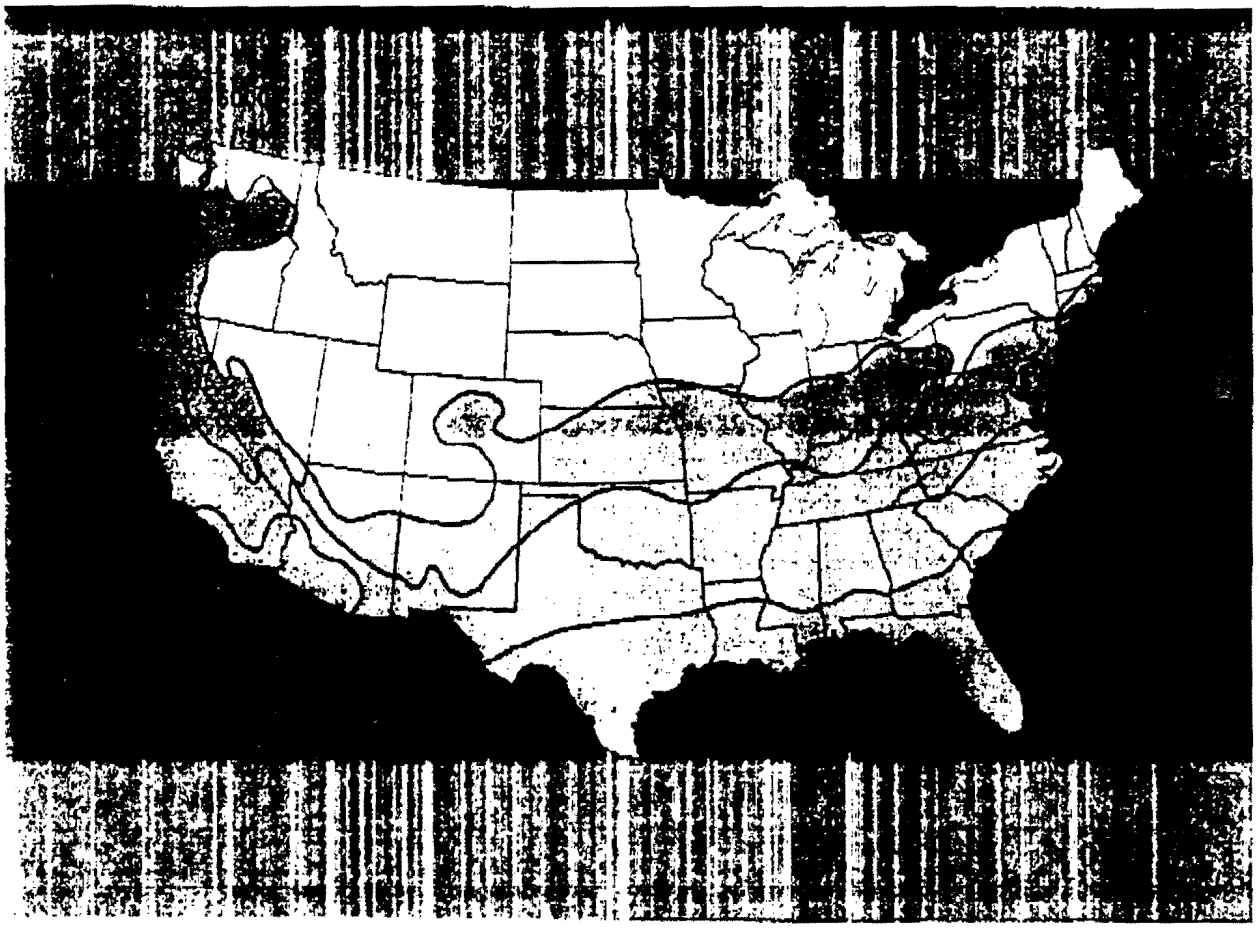
In the Sunbelt, exterior humidity is often higher than interior humidity, and while moisture condensation within the wall may be minimal and not sufficient to affect its insulation value, the use of a vapor retarder rated at 1 perm or less such as a 2 to 6 mil polyethylene film, installed between Thermax Quik-R Wall Insulation and the exterior side of the wall should increase occupant comfort.

Area II: Between 2000 to 4000 Winter Degree Days

Condensation conditions which lead to moisture accumulation in the wall continue to be minimal. Here, vapor retarders rated at 1 perm or less such as a 2 to 6 mil polyethylene film, properly installed on the interior side of the wall can provide satisfactory moisture control characteristics to these insulated wall constructions.

Area III: Between 4000 to 8000 Winter Degree Days

Condensation moisture buildup in the wall cavity might be a problem. A properly installed 4 to 6 mil polyethylene vapor retarder greatly reduces the potential for condensation moisture accumulation. Other properly installed vapor retarders rated at one perm or less may be used.



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