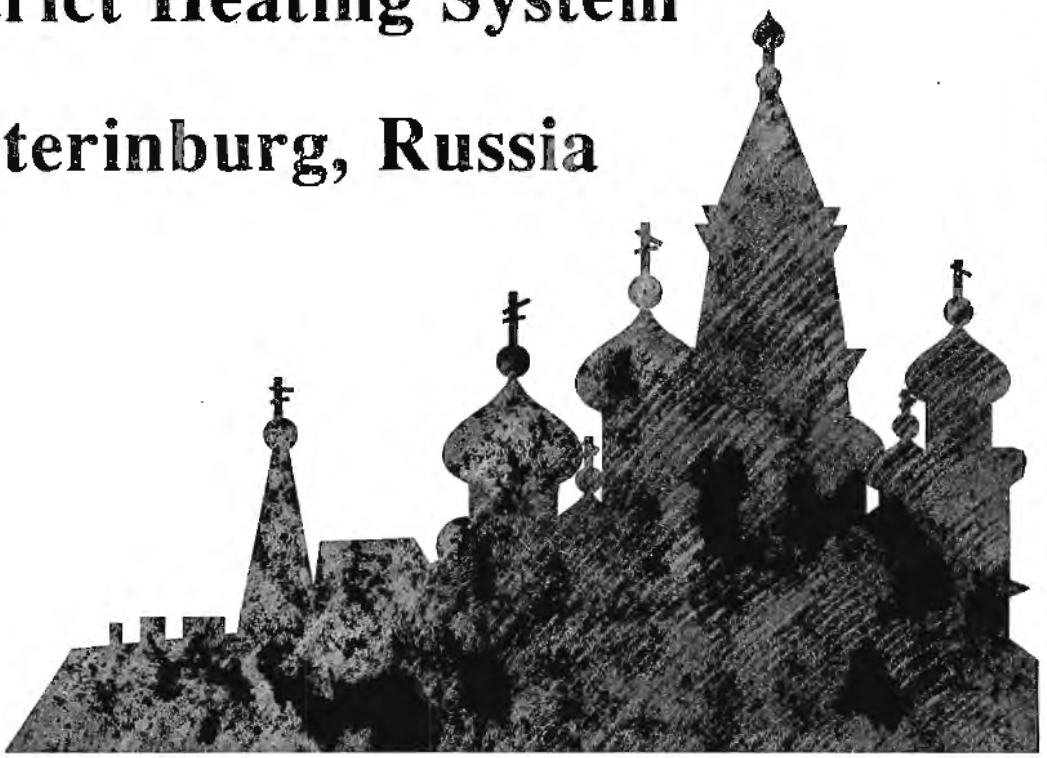
Energy Audit
District Heating System

Ekaterinburg, Russia



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Prepared by:

RCG/Hagler, Bailly, Inc.
Joseph Technology Corporation
K&M Engineering & Consulting
URAL-ESON

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DRAFT
June 1992

ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

Prepared for:

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June 1992

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QUALITY ASSURANCE STATEMENT

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 Ekaterinburg, 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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Vladimir Ivanovich FILIPOV	Chief Energetics, VIZ
Nikolai Mihailovich DONCHENKO	Deputy Chief Energetics, VIZ
Yuri Victorovich SOKOLOV	Deputy Director for Economics, VIZ
Alexander Petrovich MARTUCHEV	Chief Engineer, Sverdlovskenergo
Dr. Simon Isakovich SPEKTER	Director, World War II Veterans Hospital

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David KEITH	Principal Engineer/Project Director RCG/Hagler, Bailly, Inc.
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Leonid Davidovich GITELMAN	Project Manager Director, Ural-ESON, Ltd.
Vladimir Yuriovich NECHITAILOV	Senior Engineer Deputy Director, Ural-ESON, Ltd.

Finally, we acknowledge the contribution of our translators from Urals Pedagological University, Lena Zheberlayeva and Jeanna. Without your help, this project would not have been possible.

EXECUTIVE SUMMARY

A team of engineers led by RCG/Hagler, Bailly, Inc. carried out site activities in the city of Ekaterinburg, Russia from April 7-17, 1992. Their objective was to work with officials from the Government of Sverdlovsk Region, City of Ekaterinburg, Urals Polytechnical Institute, Sverdlovskenergo, Energonadzor, and the Verch-Isetskiy Metallurgical Plant (VIZ) to examine the state of the district heating system and to identify opportunities for improvements in energy efficiency of the district heating systems.

Based on the recommendation of the officials, the project was centered at VIZ, to illustrate a representative sample of the system which was of a size appropriate for the resources available to the project. VIZ has a combined heat and power system (TETS), peaker boiler, industrial boiler, heat distribution substations, and industrial heat use in process and for building heating. VIZ also supplies heat to the western side of Ekaterinburg, mainly to residential areas. The primary energy forms used at VIZ are natural gas and electricity.

Energy prices in Russia at the time of the 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
electric power	$60 per MW per year
electric energy	$0.05 per kWh
district heat	$20 per Gcal at source (TETS)
district heat	$30 per Gcal at end-use

Based on energy consumption in 1991 and European market energy prices, the total economic cost to the economy of Russia for fuel and electric energy consumed at VIZ is estimated as $66 million per year. The total economic energy costs for 1992 at VIZ are estimated as follows:

Energy supplied to VIZ -

Natural gas:
350 million m^3 per year (11 PJ/year[1]),
at an economic value of $33 million per year

Energy supplied by VIZ to its customers-

net generated electric power:
100 MW peak demand,
at an economic value of $6 million per year
net generated electric energy:
520 million kWh per year (520 GWh/year),
at an economic value of $26 million per year.
heat supplied to factory:
1.8 million Gcal per year (7 PJ/year)
at an economic value of $36 million per year.
heat supplied to City of Ekaterinburg
0.88 million Gcal per year (3.5 PJ/year)
at an economic value of $18 million per year.

Other energy purchased by VIZ for industrial process-

purchased electric power:
100 MW peak demand,
at an economic value of $6 million per year
purchased electric energy:
650 million kWh per year (650 GWh/year),
at an economic value of $33 million per year.

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%

[1] 3 Pcal or 3 million Gcal

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 district heating system served by VIZ as about 25% (including the short-term, low-cost projects) 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%

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 a 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 Ekaterinburg must overcome these barriers. The installation of costly capital equipment to improve energy efficiency is not the solution - the economy of Ekaterinburg 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 Ekaterinburg and Sverdlovsk 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 up to 30% of district heating energy, with economic benefits to the Sverdlovsk region of more than $350 million per year, with an economic payback period of one year or less.

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 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 Sverdlovsk region of $2 million 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 Sverdlovsk region of $51 million per year.

Action A.3: Restructure the energy and production departments at VIZ to reflect a market economy for energy. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to VIZ of $1.2 million per year.

Action A.4: Organize a water saving program to address the deficit of treated hot water. The RCG/Hagler, Bailly team estimates that simple, quick, low-cost actions can completely eliminate the deficit of hot water in Ekaterinburg.

Action A.5: Improve VIZ marketing to increase production and spread fixed energy consumption over more units of production.

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. The RCG/Hagler, Bailly team estimates that this recommendation could save 10% of heating energy, which would give an economic benefit to the Sverdlovsk region of $102 million per year.

Action B.2: Improve heat exchanger maintenance & balancing at VIZ - organize efficiency teams with instruments to test, balance and clean heat exchangers. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to VIZ of $1.2 million per year.

Action B.3: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping (examples - residential building and hospital). The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the Sverdlovsk region of $51 million per year.

Action B.4: Provide tools to assist hospital staff improve operating efficiency of equipment. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the World War II Veterans Hospital of $9,000 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 Sverdlovskenergo of $21 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 Sverdlovsk region of $21 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 Sverdlovsk region of $51 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 Sverdlovsk region of $51 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 0.5% of heating energy, which would give an economic benefit to Sverdlovsk region of $5 million 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 0.5% of heating energy, which would give an economic benefit to Sverdlovsk region of $5 million per year.

Action C.7: Convert factories in Ekaterinburg 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 Convert to closed system in distribution network, and improve local control in individual heat substations.

D.5 Improve distribution systems by using pre-insulated piping with leak-detection systems on new installations and improving drainage of existing installations.

D.6 Expand VIZ cogeneration system (TETS) to achieve balance between electrical and thermal energy requirements.

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 Ekaterinburg will need additional tools and instrumentation to achieve these goals. The RCG/Hagler, Bailly team recommends that VIZ and Ekaterinburg receive a package of equipment from USAID to assist their energy management program. The proposed procurement list and budget for VIZ, 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 2 provides a brief summary of information on the district heating systems in Ekaterinburg.

Exhibit 1
Summary of procurement recommendations

	Estimated Procurement Budget Funding Variants		
	A	B	C
A.3 Energy management computers	2,000	2,000	2,000
A.5 US manufacturers information	1,000	1,000	1,000
B.2 Instruments for VIZ	10,000	10,000	10,000
B.3 Weatherstripping for hospital	5,000	5,000	5,000
B.3 Weatherstripping for residential			7,000
B.4 Instruments/tools for hospital	5,000	5,000	5,000
C.1/C.2 Fixed thermal energy meters:			
outlet VIZ to city	8,000	8,000	8,000
inlet to hospital	7,000	7,000	7,000
inlet to 2 residential buildings		10,000	10,000
residential heat allocation meters			7,000
C.4 Thermostatic radiator valves			
residential			18,000
C.5 Energy auditors kit(s)	14,000	24,000	24,000
C.6 Equipment, energy auditors kit(s)			21,000
D.1 Infrared radiant heaters VIZ		10,000	10,000
D.2 Insulation board for windows VIZ/apt. bldg.		10,000	40,000
D.3 Automate one substation			25,000
TOTAL BUDGET	52,000	92,000	200,000

Exhibit 2
Summary of background information on heat and power systems

	1990 Data
Ekaterinburg metropolitan area	
Population	2.2 million
Installed electric capacity	8,300 MW
Installed thermal capacity	8,900 Gcal/hr
Maximum electric load	7,800 MW
Electricity supplied (net)	51 million MWh
Heat supplied	31 million Gcal
Fuel consumption	
Ekibaztuz coal	23 million tonnes
natural gas	8.3 billion cubic meters
heavy fuel oil	470,000 tonnes
Specific fuel consumption	
Electric heat rate	337 g/kWh (USSR units[2])
	9,361 Btu/kWh (eq. USA units)
Thermal generation	167 kg/Gcal (USSR units)
	85.5% efficiency based on LHV
Employment	22,000 people
Main heat lines	339 km
City of Ekaterinburg	
Population	1.5 million
Maximum heat load	3,300 Gcal/hr
Annual growth rate of heat load	3%
Heat distribution system	170 km
Pipe size	400-1220 mm
System type	open predominates
Pumping stations	10
Hot water storage capacity	60,000 m^3

[2] Based on ton coal equivalent, at 7,000 kcal/kg

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 Ekaterinburg'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

Sverdlovsk Regional (Oblast) Administration (SRA), Department of Energetics -
Oleg Pavlovich DARINZEV, Deputy Head of Department

City of Ekaterinburg, City Executive Committee -
Victor Petrovich SHTAGER, Deputy Chairman

Verch-Isetsky Metallurgical Plant (VIZ) -
Vladislav Mihailovich KAVTREV, Director
Vladimir Ivanovich FILIPOV, Chief of Energetics
Yuri Victorivich SOKOLOV, Deputy Director for Economics

It was determined by Sverdlovsk Oblast and the City of Ekaterinburg that the project should be centered at VIZ, 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, VIZ 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, VIZ 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 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 project are:

- Joseph Technology Corporation (district heating efficiency)
- K&M Engineering and Consulting (district heating efficiency)

<u>RCG/Hagler, Bailly, Inc.</u>

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, ASEAN, 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 MDBs. 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). These programs included energy audits, training courses, policy studies, and the preparation of handbooks and other published materials.

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. Mr. 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.

K&M Engineering and Consulting

K&M Engineering and Consulting Corporation is an international firm based in Washington, D.C. K&M was founded in 1987 by two highly experienced and successful former Bechtel executives. The company has grown rather rapidly during the first few years of operations, and currently has 20 full-time employees and over 50 senior associates who have worked together in the past and form the core of K&M's technical expertise and managerial talent.

Edward Permar, P.E. - Senior Engineer
Edward Permar, a senior consultant to K&M Engineering, is a specialist in district heating system design and operation. Since 1972, he has served as Manager of the Facilities Management Dept. of the University of Pittsburgh and Chairman of the Steam Line Management Committee of the Bellevue Steam Distribution System. In this capacity, he manages the operations of one of the largest district heating systems in the U.S., serving more than 100 buildings. Permar is an expert on system operation and optimization, including thermal energy metering and steam pipelines. He has carried out consulting assignments for district heating system upgrading in Pennsylvania and Maryland.

Ural-ESON, 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. Ural-ESON serves as partner for the project in Ekaterinburg.

Ural-ESON is an emerging firm which was launched recently by a number of professionals dedicated to energy efficiency. The firm is headed by Dr. Leonid Davidovich Gitelman, a Professor at Urals Polytechnic Institute, and head of the Department of Energy Economics. The Deputy Director of Ural-ESON is Vladimir Yuriyovich Nechitailov, who is also Director of Energonadzor, the energy inspectorate.

Ural-ESON 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

Ekaterinburg is located in Sverdlovsk Oblast (region), in the Urals Mountains in central Russia. Ekaterinburg is 40 km on the Asia side of the continental divide (at 56° 49' North Latitude and 60° 38' East Longitude), and is two time zones east of Moscow (10 hours ahead of Washington DC). Sverdlovsk Oblast has an area of 182,800 sq. km, which is about the size of Nebraska. The population in the Sverdlovsk region is 2.2 million.

The City of Ekaterinburg covers an area of 500 square kilometers, extending 33 km from north to south and 29 km from East to West. Located near the City of Ekaterinburg are the towns of Belogorsky, Verchnay Pishma, and Sredne Uralsk which host large industrial complexes. The population of the City of Ekaterinburg is 1.5 million.

The climate of Ekaterinburg is characterized by a long cold winter and a brief summer. The climatological profile includes:

- an average temperature for the coldest five days (temperature used for heating design) of -35°C.
- an average temperature for a colder period (temperature used for ventilation) of -20°C.
- The average temperature for the coldest month is -15.3°C.
- The average temperature for the heating season is -6.4°C.
- The length of the heating season is 228 days.

- The annual heating load for 1989 was 3,973 degree-days (degrees in °C), based on 12°C as a reference point[3]. The annual heating load for 1990 was 3,495 degree-days. The annual heating load for 1991 was 3,435 degree-days.

1.8 Energy Supply/Demand Situation

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

The only fuel now used for heat generation in Ekaterinburg city limits is gas. Outside the city limits, gas-fired boilers have heavy fuel oil (mazout) as supplementary or stand-by fuel.

Hot water in Ekaterinburg 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.

There is a shortage of hot water in Ekaterinburg, and during the audit there were rotating outages (water lock-offs) occurring in the city. The principle reason for the shortage was not a shortage of energy (or heat) but rather a shortage of treated water. In the open system, responsibility for water treatment rests with the heat generation utility (VIZ, in the case we studied). As more and more water is drawn off (or as leaks grow), the capacity becomes exhausted.

Electricity for Ekaterinburg is generated in several TETS (combined heat and power stations), GRES (thermal electric station), and also is supplied from the nearby 600 MW Belarskiy Atomic Power Station (fast neutron, liquid sodium cooled, breeder-type).

[3] 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 total installed thermal capacity in Sverdlovsk region is 8,900 Gcal/hr. The amount of heat supplied to the metropolitan area is 31 million Gcal per year. Maximum heat load in the City of Ekaterinburg is 3,300 Gcal/hr. Annual growth rate of heat load is 3%.

Electrical consumption for the customers in the Sverdlovsk Region is presented in Table 1. Heat use structure in the Sverdlovsk Region is presented in Table 2.

Table 1
1990 Electrical Consumption in the Sverdlovsk Region

1. Industrial	62%
2. Transportation	7%
3. Agricultural	4%
4. Residential, Institutional, & Commercial	12%
5. Losses & Station Use of Power	15%

Table 2
Heat Use Structure in the Sverdlovsk Region

Name of Head	1990	
Functional Area	Million Gcal	%
1. Industrial	63.7	73.9
2. Residential, Commercial, Institutional, Agricultural	22.4	26.1
Annual Consumption	86.1	

The operation and maintenance of the heat sources and primary distribution network in Ekaterinburg is performed by Sverdlovskenergo personnel. The Sverdlovskenergo Company employs 22,000 people.

The district heating system of the Ekaterinburg Region is very old and was developed in stages to meet the population growth. The district heating systems of the Sverdlovsk Region consist of 339 km of transmission mains. The Sverdlovsk district heating systems include the first Russian system, SUGRES, with transmission mains in excess of 30 km. The heat supplied by the system in 1990 was 31 million Gcal/year. A diagram of the heat load is provided in Figure 1.

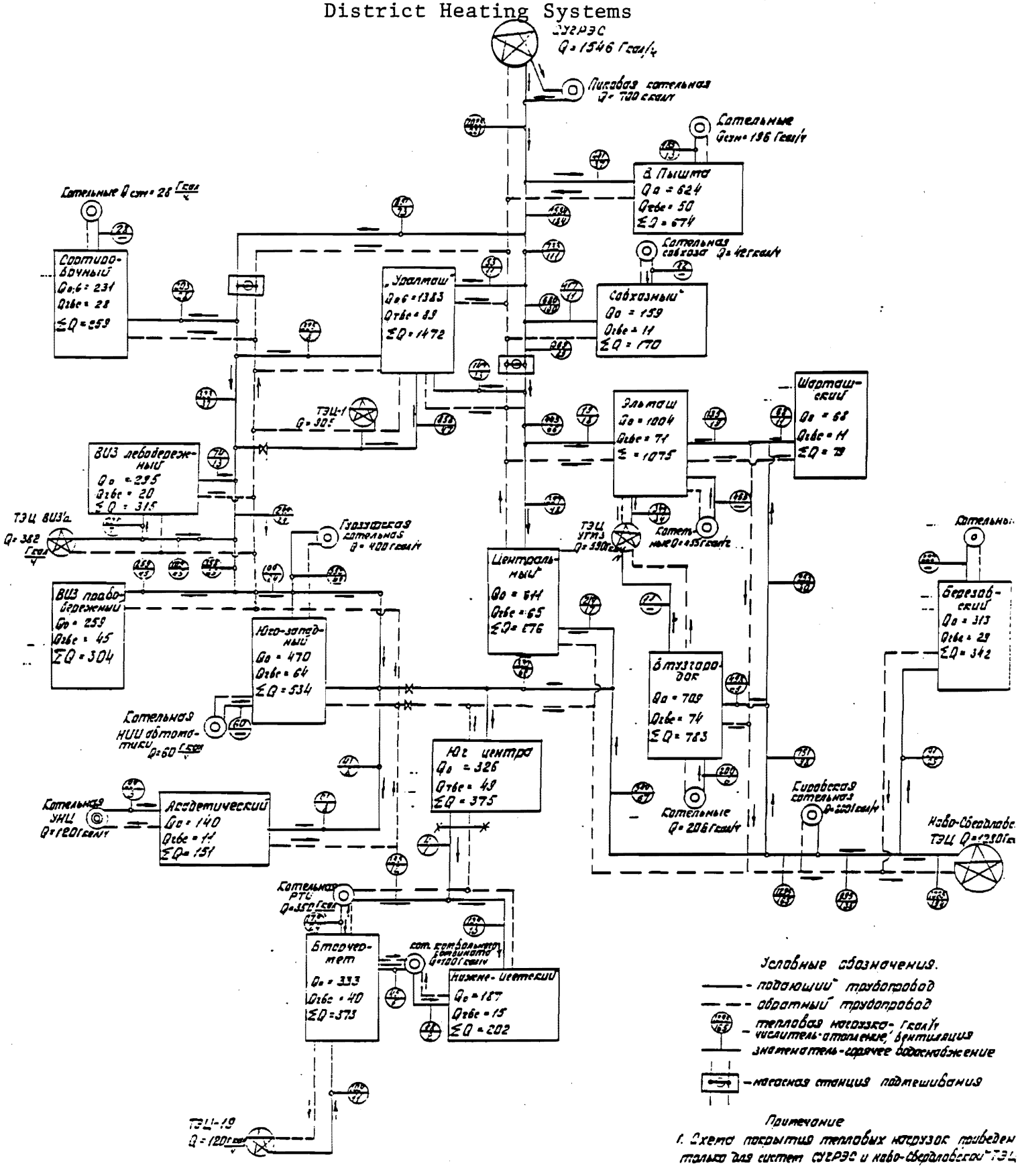
The total length of the distribution system in the City of Ekaterinburg is 170 km (pipe diameters vary from 400 to 1,220 mm). The annual system growth rate is about 3%.

The district heating distribution system of Ekaterinburg is maintained by 350 permanent and 150 temporary employees. Sverdlovskenergo sells heat to industrial, commercial, institutional, residential and agricultural customers.

The piping network of the Ekaterinburg district heating system transports 150°C hot water (150°C-70°C) and distributes it to customers at 130°C (130°C-70°C). The open type system design requires large quantities of make-up water which is not always available. The piping system can accommodate future growth. However, according to the Sverdlovskenergo plant assessment, the system capacity is nearly 100% utilized. The piping network is located 90% underground (See Figure 2) and 10% above ground. The distribution system is designed for a peak supply temperature of 150°C-70°C (at -35°C outdoor temperature). The water temperature is reduced to 130°C-70°C at substation level and further reduced in-house (at the point of ejector) to 95°C-70°C. The pressure in the system is approximately 16 kg/cm^2.

The distribution system includes 10 large pumping stations, and 60,000 m^3 of hot water storage capacity.

Figure 1
Heat Load Diagram for SUGRES and Noro-Sverdlovskay TETS
District Heating Systems



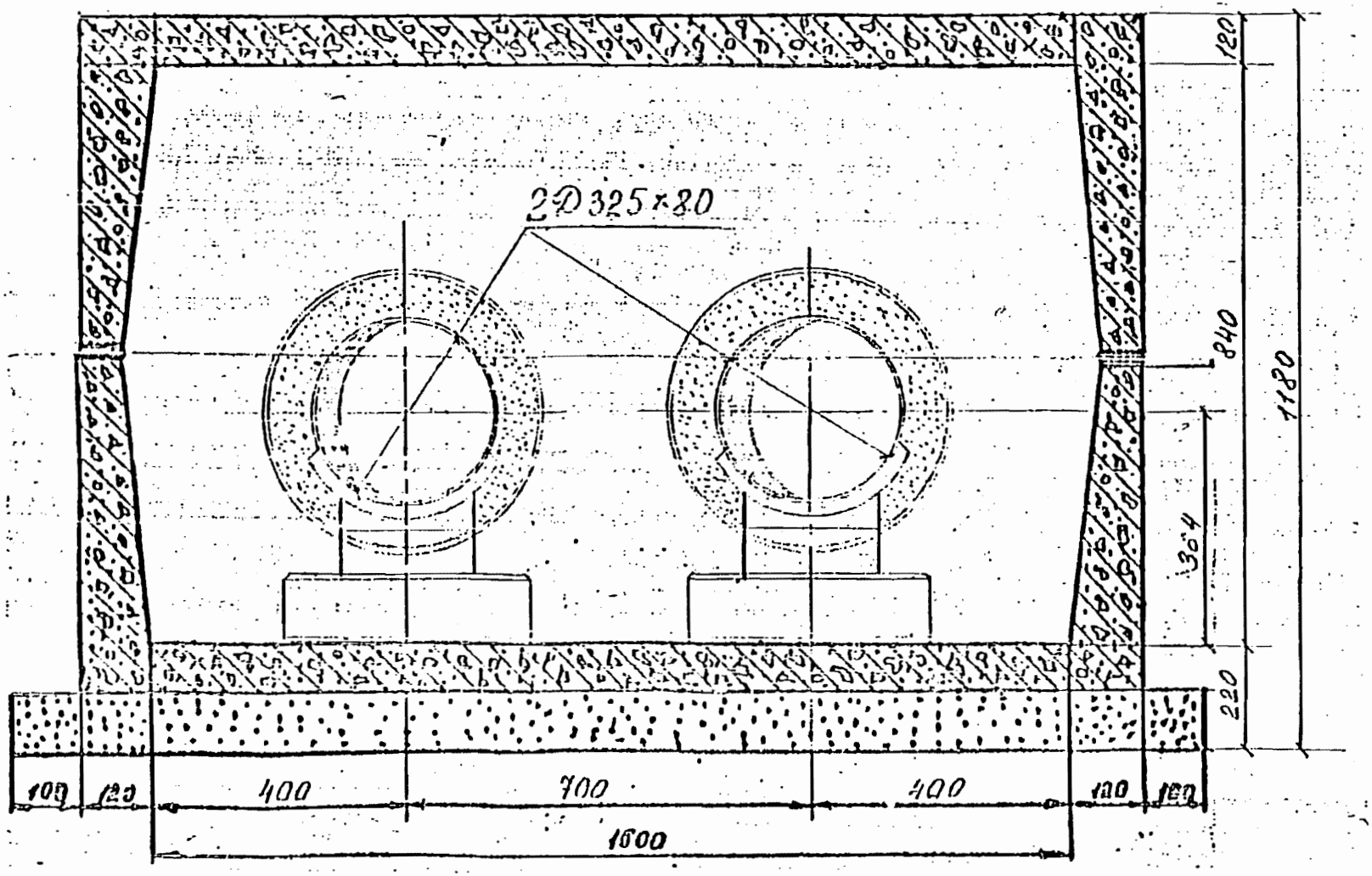


Figure 2

Typical underground piping installation

Table 3: Main Heat Sources of Ekaterinburg and Neighboring Town

Name	Capacity		Fuel	
	MWe	Heat-Gcal/H	Main	Secondary
Cogeneration Plants				
1. Skednevralsckad GRES	1224	1502	Oil (2)	
2. Novo-Sverdlovskay TETS	550	1457	Gas	Oil
3. Sverdlorskay TETS-1	31.6	1110	Gas	Oil
4. TETS VIZ	100	563	Gas	Oil
5. TETS TMZ	24	396	Gas	Oil
Boiler Rooms of Subregions				
1. Gurzufskay	--	400	Gas	Gas
2. Kilovskay	--	300	Gas	Gas
Industrial Boiler Rooms in City of Ekaterinburg				
1. Uralmash	--	486	Gas	Oil
2. PTE	--	376	Gas	Oil
3. Camholniy Factory	--	136	Gas	Oil
4. Compressor Factory	--	96	Gas	Oil
5. Factory ZBE	--	132	Gas	Oil
6. Factory UAMZ	--	103	Gas	Oil
7. Uralelectrotazmash	--	152	Gas	Oil
8. GPZ-6	--	85	Gas	Oil
9. UNZ	--	92	Gas	Oil
10. UPI	--	148	Gas	Oil
11. VIZ	--	24	Gas	Oil
Large Industrial Boiler Room of the Cities of Large Pishma & Beresovskiy				
1. Uralmed Combination	--	190	Gas	Oil
2. Experimental Factory GEDEAMET	--	64	Gas	Oil
3. Chemical Factory	--	67	Gas	Oil
City of Benesovskiy				
1. BASK	--	138	Gas	Oil
2. UZPS	--	127	Gas	Oil
3. Central boiler room	--	65	Gas	Oil
4. Repair-Mechanical Shop	--	58	Gas	Oil

1.9 Energy Price Regime

Energy prices in Russia at the time of our visit were changing rapidly. In Ekaterinburg the price of heat and electricity production increased by a factor of 15-20 from 1991 until our visit in April, 1992.

At the time of our visit (April 14) the prices of district heat and domestic hot water were as follows:

- To industrial customers 533 R/Gcal
- To residential customers 23 R/Gcal
- To residential cooperatives 4 R/Gcal
- To greenhouses 11 R/Gcal
- To government "budget" institutions[4] 70 R/Gcal
- To heat resellers (wholesale) 187 R/Gcal
- To hotels, garages 16 R/Gcal

Prices for natural gas were 3.5 R/1000 nm^3 (on April 10) and 12 R/1000 nm^3 on April 17.

Prices of electricity had changed from 0.01 Ruble/KWh in 1991 to 0.16 R/kWh in April 1992. Prices for sale of power from Sverdlovskenergo to VIZ for May 1992 are more than 1 Ruble/kWh.

1.10 Audit Type/Methodology/Scope

The audit focused on a specific case study, or "system slice", centered at VIZ. This system slice included TETS (combined heat and power station), boilerhouses, distribution lines, and end-users (industrial, hospital, and residential). In addition to specific activities in the VIZ subsystem, the RCG/Hagler, Bailly team held meetings with City and Regional officials and collected key data relative to the characteristics of the other parts of the Ekaterinburg district heating system. This information is useful to expand the results of the audit.

[4] For example, hospitals, schools, government buildings

The RCG/Hagler, Bailly Team worked in Ekaterinburg from April 7 - 17, 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 30 engineers from various companies and the Urals Polytechnic Institute. The participants are listed in Appendix 2.

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 to be attempted for operating boilers which are found to be operating with high excess combustion air or insufficient air, in order to achieve measurable energy savings as part of the audit. No boilers were found in such condition at Ekaterinburg.

7. Computer database and graphical analysis was developed using VIZ 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 plant management.

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

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

The following activities are planned for Ekaterinburg, 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 Ural-ESON (or VIZ) via air freight.

5. Partner firm (Ural-ESON) delivers to plants and give any training required.

6. Plants install 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. Conference 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 VIZ SYSTEM

Based on the recommendation of the City and Regional and Sverdlovskenergo officials, the Sharokaryachka ("white river") section of the city, centered around the Verch - Isetskiy Metallurgical Plant (VIZ) was selected as the site for the energy efficiency program.

The RCG/Hagler, Bailly audit team divided into two groups to inspect (1) the VIZ TETS and shops, and (2) the VIZ Industrial Boiler Room, the Hospital, the residential building, and distribution system.

Two seminars were presented by the RCG/Hagler, Bailly team on energy management, instrumentation used in energy audits, and short-term energy conservation measures. A list of the specialists from the City of Ekaterinburg, VIZ, Ural Polytechnical Institute, Sverdlovskenergo and Energonadzor who attended these seminars is included as Attachment 3.

According to the Deputy Mayor of Ekaterinburg, the hot water deficit is now one of the city's greatest problems. Energy pricing is now one of the most critical issues in Russia. At the meeting of the Sverdlovsk regional administration held April 7, 1992 (the day the audit started), energy prices and the hot water deficit dominated the discussion. This problem is critical because no new heat sources are planned for the next five years. The deficit of water is 9,000 m^3/day, and the city has requested VIZ to build a new 2,000 m^3/day water treatment system to supply the city.

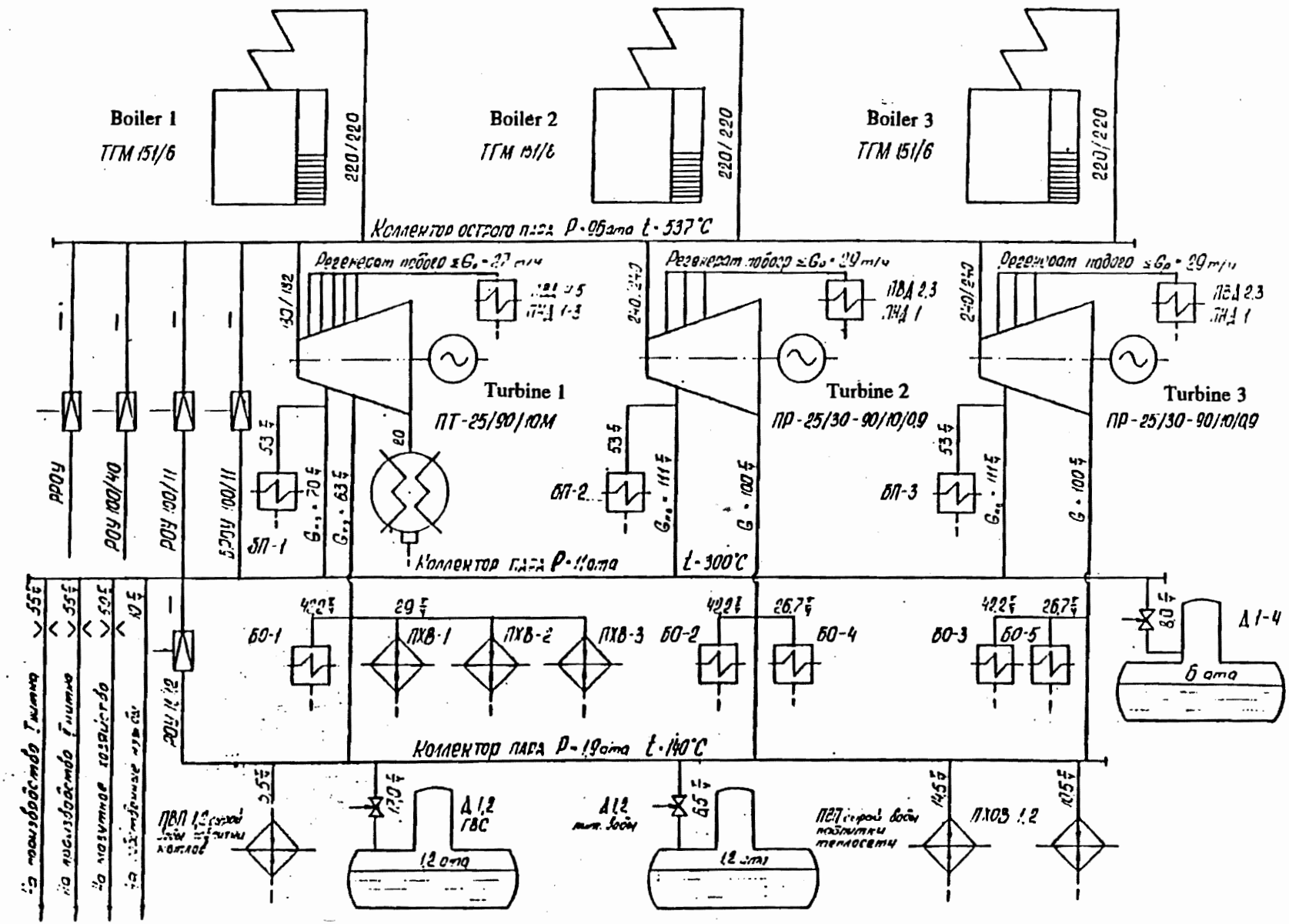
2.1 Heat Generation Systems

The VIZ facility is equipped with a 100 MWe cogeneration plant (TETS), peaking boilers and industrial boiler room and a steam to hot water substation. The cogeneration plant produces heat for process and district heating use. The substation converts steam to hot water production. The steam flow diagram for the VIZ cogeneration plant is presented in Figure 3.

Natural gas is used as the primary fuel the cogeneration plant (99.7%) and heavy oil (0.3%) as a secondary fuel. The technical data on the steam generators is presented in Table 4. The heat capacity of the cogeneration plant is 415 Gcal/hr with an additional 250 Gcal/hr provided by the peaking boilers.

Fi 3

Steam Flow Diagram for the VIZ Cogeneration Plant



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The three turbines in the cogeneration plant were modified within the last three years. The technical data on the turbines is presented in Table 5. The electrical output of the cogeneration plant is 100 MW.

The boilers and the turbines are located in separate buildings. The boilers are covered with asbestos insulation. The source of feed water is the Verch-Isetsk Water Pond. The steam generators, three water-tube boilers, three steam turbines, district heating pumps, and a substation for conversion from steam to hot water are located in the TETS Building.

The steam from the turbine extraction for district heating is directed to the substation. The technical characteristics of the heat exchangers, turbines and steam generators are presented in Tables 4, 5 and 6, respectively.

Pipelines carry heat from TETS to the facilities of the end-users. Part of the heat is directed to the buildings of the VIZ plant itself. The rest is piped into the distribution network of Sverdlovskenergo.

2.2 Heat Distribution Systems

For the City of Ekaterinburg, there are two main heating sources, located 25 km and 10 km from the city. Other smaller heating sources (such as VIZ TETS) are located in the city. There are 10 pumping stations, 5 of which are supplementary. The system has 60 different diameters of pipeline. There are 170 km of main lines, at 400-1,200 mm diameter.

Total peak heating load is 3,300 Gcal/hr, and is growing by about 100 Gcal/hr per year due to new construction. Storage capacity is 60,000 m^3. The total circulation is about 30,000 m^3/hr, and total make-up averages 6,500 m^3/hr. This make-up represents leaks plus consumption. The standard for leaks is 700 m^3/hr, but tests have shown that leaks are much more, perhaps 2,000 m^3/hr. There are accumulators which provide storage in the system, so the quantity of make-up is more or less levelized throughout the day.

The heating season lasts approximately 228 days in Ekaterinburg, including all of October - April and some days in September and May. The system is started if for three consecutive days the minimum temperature is less than 8°C. The system is stopped if for three consecutive days the minimum temperature is greater than 8°C. However, the standard is not rigidly followed.

The regulation of the system is centralized, and is based on temperature control, not variable flow. The transmission feed from the heat sources is at 190/70°. The heat sources supply the temperature according to a regime schedule (or "grafik"), illustrated in Figure 4. The transmission water is mixed with some return water at the pumping

Table 4

Technical Characteristics of the VIZ Substation Heat Exchangers

	Heat Exchangers Type	Heat Surface m^2	Number of Passes	Estimated Water Flow T/h	Tube Material	Main Parameters				
						Estimated Pressure KC/cm^2		Temperature °C		Pressure loss in the tubes by estimated load
						Water	Steam	Water	Steam	
1	PCV-500-3-23 BO-1 BO-2 BO-3	500	2	1500	L-68	23	3	130	400	5.5
2	PCV-315-14-23	315	2	1130	L-68	23	14	180	400	4.8
3	PCV-500-14-23 BP-1 BP-2 BP-3	500	2	1500	L-68	23	14	180	400	6.0

Table 5

Technical Characteristics of Turbines

Type of Turbine	Manufacturers	Nominal Power MW	Parameters of fresh steam		Maximum Consumption of Steam t/h.	The limits of regulation of pressure on extractions kg/cm^2		Nominal heating loads from extraction	
			Pressure kg/cm^2	temperature °C		Industrial Extraction	Heating Extraction	Industrial t/h	heating t/h/gcal/h
PT-25-90/10M	KTZ	35	90	535	182	8-13(10)	0.7-2.5	120	$^{50}/_{27}$
PR-25/30-90/10/0.9	WTMZ	35	90	535	190	8-13(10)	0.7-2.5	90	$^{70}/_{37.8}$
PR-25/30-90/10/0.9	UTMZ	35	90	535	240	8-13(10)	0.7-2.5	110 (120 max)	$^{100}/_{54}$ (135 max)

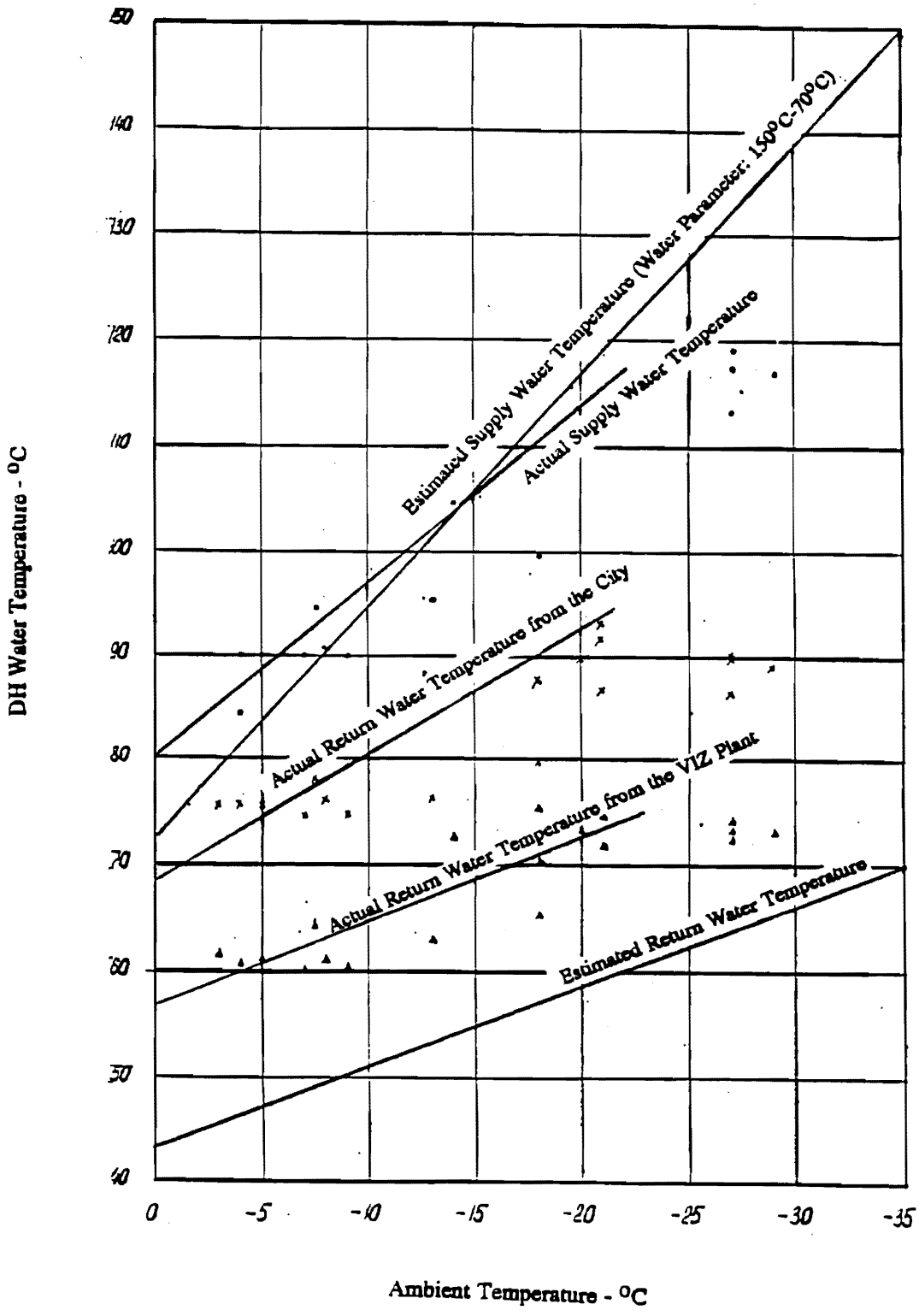
Table 6

Technical Characteristics of the Steam Generators

Modification	Year of Installation	Steam Pressure in the Drum KG/cm^2	Temp. of Super Heated Steam °C	Capacity T/h	Type	Heating Surface m^2	Air Blow Fan	Induced Draft Fan	Fuel
TGM-151 (E220/100)	1973	110/115	540	220	Vertical, Water-tube, One drum	Total screen surface is 2660m^2 Superheater surface 2630m^2 Water economizer surface 2130m^2 Hot portion RVP surface 2 x 5068m^2	VDH-18-P9 Capacity 115,000/85,000 m^3/h. Press. 365/210 mm. w.g. RPM 750/1000 Power 280/85 KW.	A-18 x 2 Capacity 180,000/143,000 m^3/h. Press. 330/208 mm w.g. RPM 750/580 power 320/160KW.	Gas Oil
TGM-151	1974								
TGM-151	1975								

Figure 4

District Heating System Operating Temperature Regime for the City of Ekaterinburg and the VIZ Plant



stations to achieve the primary distribution temperature of 150/70°. Finally, in the substations of the local system, further mixing is done to achieve the secondary distribution supply temperature of 95/70°, which enters the buildings. The temperature regulation is done based on outside air temperature, and is done only at the heat sources. The ratio of mixing at the pumping stations and substations is fixed and constant throughout the heating season. Typical schematics for these systems are as shown in Appendix 3.

The standard for the system in Ekaterinburg is the so-called open system. In this case, the mass flow rate of supply is greater than the flow rate of return, not only by the amount of leakage but also by the amount of domestic hot water drawn off through the taps. Thus the heat generation facilities also have responsibility for supplying treated make-up water in sufficient quantity. In Ekaterinburg today, there is a deficit of treated water, and as a result Sverdlovskenergo has begun installing closed systems in some cases.

The commercial structure for collecting revenues is as follows:

VIZ TETS sells heat to Sverdlovskenergo
Sverdlovskenergo resells heat to Municipal Heating Authority
Municipal Heating Authority resells heat to JKO-Community Housing
JKO-Community Housing bills residential consumer for heat, as part of rent

The contract between VIZ and Sverdlovskenergo is for one year, and prices are fixed for the year. So VIZ is selling heat for 90 rubles/Gcal, and Sverdlovskenergo is able to resell the heat for as much as 500 rubles/Gcal. If VIZ needs to buy heat from Sverdlovskenergo, it would have to pay 533 rubles/Gcal.

Sverdlovskenergo has tested their distribution lines for heat loss with the help of a thermal imaging device (teplovisor, supplied by engineering society from Leningrad) and helicopter. They determine leaks by means of pressure tests, which are carried out 5-6 times every summer before the heating season starts. The working pressure in the system is about 16 bar, and the test are carried out at 25 bar. Leaks are repaired as they are found.

The maintenance staff for the distribution system consists of 350 full-time employees, and additional 150-200 workers in summer, when the major maintenance is done.

The main difficulties Sverdlovskenergo is experiencing at present are:

1. Deficit of supply capacity, which is basically a deficit of treated supply water, not heat or energy per se, at the present time.

2. Corrosion of distribution pipes. This corrosion is occurring from the outside of the pipes. the pipes have no active corrosion protection, only passive surface treatment. There are substantial leaks in the system, but it is not possible to determine the quantity.

3. Absence of any measuring devices at the customer end to bill for the quantity consumed or to account for leakage. Once they tried to encourage customers to install meters, but without results, but now there is an economic imperative. These meters are not made in USSR. There is also a problem of the security of basements, and hence meters. These areas are used as shelter by homeless people.

4. There is no control of temperature, pressure or flow at the consumer's end.

Based on visual inspection by the RCG/Hagler, Bailly team, the piping insulation appears to be adequate and in good condition. Approximately 50 mm of mineral wool insulation is applied to large pipes (such as a 426 mm pipe observed under construction). The only areas of concern are near valves and fitting, where the insulation has cracks.

2.3 Heat Utilization Systems

2.3.1 Industrial - VIZ steel plant

2.3.1.1 General description

Verch - Isetskiy Metallurgical Plant is basically a cold-rolled steel mill which employs 7,000 people. Of these, approximately 1,000 are engineering and support staff and more than 1,400 work in energetics (heat, power and other utilities).

The turnover (annual sales) of VIZ was about 3 billion rubles in 1991. One of VIZ greatest problems is cashflow - they have outstanding accounts receivable of 700 million Rubles. This seems like a manageable figure, but VIZ has no bank overdraft or working capital, as would be normal in a Western enterprise. Financing of projects is difficult if not impossible. Commercial bank's charge interest on loans at 50-75% per annum, as of April 1992. Prices of most goods and services increased by a factor of 5x in the first three months of 1992. Today, all factories owe each other money and there is no liquidity in the system.

VIZ primary products are electrical steel. These are oriented, magnetic steels used in laminations for transformers and electric motors. There are some other finished consumer products in production (toys, utensils, etc.), and VIZ is seeking to expand into this area. VIZ produces carbon steels, but not specialty steels (such as stainless steel). Because the factory is located in the city, they cannot run the risk of environmental damage from heavy metals, such as might result in specialty steel production.

VIZ sells oriented transformer steel and steel section for export. For the Russian market, they sell isotropic non-oriented electrical steel (used for laminations for motors). VIZ has exported steel to many countries in Europe (several in western Europe) and Asia, and has plans to export to South America. They sell steel through agents, but would like to begin direct marketing to cut out the middleman. VIZ is now entering to a joint venture with a Russian magnet wire manufacturer to produce or market higher value products, such as motors and transformers.

VIZ Production
- Cold-rolled electrical steel - 300,000 tons/year
  - economic value $1,250/ton
- hot-rolled billet - 120,000 ton/year
  - economic value - $180/ton

VIZ is developing a two-year technical, economic, and management action program to improve competitiveness, mainly in the areas of quality control and electrical energy consumption for the steel-making process. VIZ estimates that $30 million in investment is needed to modernize the factory to achieve competitive world standards, plus another $45-50 million investment at their hot-rolled steel supplier in Chelyabinsk.

VIZ management believes that about 1/3 of the staff is redundant. They have severe problems with a lack of motivation and mobilization of resources. The Directors of VIZ see privatization and foreign joint ventures as the solution to these problems, and plans to privatize the factory by autumn 1992. VIZ has guaranteed to give its workers 3 months notice before any layoffs. VIZ cannot fire its workers because they would be in a terrible position (there is no unemployment insurance or other safety net). So VIZ decided long ago to adopt a policy of a freeze on hiring.

VIZ operates in the barter system for commercial transactions. Because of the tax situation, barter makes them much more competitive. In the current currency regime, the government makes them turn in 40% of their hard currency at 45 R/$, plus 10% at 90 R/$. This leaves them with only 50% of their hard currency earnings to use for imports. In the barter system, they can use all of it.

VIZ pays income taxes of about 32% on profits. Within their production cost there are other taxes, such as social security tax (38% of labor cost), central investment fund (11% of costs), land taxes, environmental taxes, and a value added tax (28% of production cost).

VIZ marketing department consists of 15 people, and they also have a firm handling VIZ exports which has 10 people who travel about half-time. They are just now publishing a brochure. For two years they have been trying to enter the American market, but so far no orders.

Inventories are overloaded, mainly because customers cannot pay. VIZ is seeking to diversify into other cold-rolled products, such as automotive sheet metal. VIZ quality meets world standards.

Energy is 10-12% of manufacturing cost at VIZ.

2.3.1.2 Organization

The highest 3 levels of the organization are as indicated below:

- Director
  - Assistant Director for Metallurgical Production
  - Assistant Director for Economics
  - Assistant Director for Commercial/Financial
  - Assistant Director for Consumer Products
  - Assistant Director for Capital Construction
  - Assistant Director for Social Services Enterprise
  - Chief Engineer
    - Chief Mechanical
    - Chief Energetics
    - Chief of Technical Process
    - Chief of Design Engineering
    - Chief of Data Processing and Automation
    - Chief of Ecology

The plant contains the following main departments:

- Engineering, administration, support (1,000 members of staff)
- Energetics (1,400)
  - TETS (180)
  - Gas Production (hydrogen, nitrogen, oxygen) plant (180)
  - Water supply and water treatment plant (230)
  - Boilerhouses (130)
  - Substation/transformers (80)
  - Electrical repair (110)
  - Controls, instruments, automation (200)
  - Dispatching, communications (70)
  - Maintenance for energetics dept (260)
- Cold Rolled Steel Production (2,000)
- Hot Rolled Steel Production (600)
- Consumer products (250)
- Die-casting (toys, medallions) (150)
- Maintenance (300)
- Construction (trucks, cranes)
- Social (farm, fishery, kindergarten, resort camp)

2.3.1.3 Process technology

VIZ factory is spread over an area approximately 4 km long and 0.5 km wide. The largest building at VIZ, the cold-rolled electrical steel shop, is 1 km long and 0.35 km wide. In the huge and modern cold-rolled shop, hot-rolled steel strip (purchased from another factory located in Chelyabinsk) is re-rolled, carbon-impregnated, surface treated, annealed, and oriented for the desired magnetic properties. The shop includes large electric rolling mills and electrically-heated furnaces. The furnaces maintain the steel in a hydrogen or nitrogen atmosphere at 1000°C for 24 hours or longer.

VIZ also has two old electric arc furnaces (25 tons per heat) which process scrap, producing 130,000 tons per year of hot-rolled steel section and concrete reinforcing bar. The process is old, using billet casting. The power consumption is 630 kWh/ton, which is about 25% higher than modern EAFs achieve. The EAFs emit large quantities of dust during the melting process. VIZ has a plan to reduce pollution by 80% by installing a new EAF with a gas cleaning system, which can limit emissions to 10 mg/m^3. The total investment for these measures is some 50 million Rubles, but without it the hot-rolled shop must be closed.

The VIZ gas production department provides the factory with inert and atmospheric gases for metallurgical processes. The department consists of three shops:

- Water electrolysis units (18 cells with a capacity of 500 m^3/hr each) to produce hydrogen of 99.99% purity at the normal rate of 4-5,000 nm^3/hr. The hydrogen is used as protective atmosphere in furnaces making oriented magnetic steel. There is H_2 storage of 9,000 m^3. The unit also generates oxygen at 99.99% purity. The oxygen is used mainly in the fish farm. The rest of the oxygen is vented to the atmosphere

- Cryogenic air liquefaction units (3 units with a capacity of 6,000 m^3/hr each) to produce nitrogen of 99.995% purity at the normal rate of 15-17,000 nm^3/hr. The nitrogen is used as protective atmosphere in furnaces making non-oriented magnetic steel. There is N_2 storage of 52,000 m^3. From the liquid air they also obtain oxygen which is bottled in 40 liter cylinders at 150 atm. and used for welding and oxy/acetylene torch.

- Gas compressor station which boosts pressure of natural gas supply to TETS and also compresses hydrogen and nitrogen for supply to the metallurgical process.

The specific energy consumption of the H_2 electrolysis process is 5.3 kWh/nm^3 The electrical consumption is 800-900 MWh/month. The specific energy consumption of N_2 production is 0.33 kWh/nm^3. The coordination between gas production and steel production could be improved.

The VIZ water treatment plant receives 1800 m^3/hr of drinking water from the city. They also take 25,000 m^3/hr from the canal, for industrial uses (mainly cooling). The technology for cleaning industrial water consists of settling and filtration.

The VIZ wastewater treatment system has a peak demand of 3 MW for a treatment capacity of 2400 m^3/hr, and includes several process trains:

- continuous process (capacity 25 m^3/hr) for cleaning sulfuric acid (5 g/l) and $FeSO_4$ (18 g/l) from cooling water for CRS acid bath. Process consists of neutralization, settling tank, filter, landfill

- continuous process (capacity 60 m^3/hr) for cleaning oil in suspension (5 g/l) from cooling water for CRS rolling mills. Process consists of settling tank, floatation tank, incineration

- continuous process (settling) for treating hardness (5 g/l MgO)
- batch process (chemical and incineration)
- evaporation sludge concentration system, using 30 ton/hr steam for evaporation

VIZ installed the concentration system in 1991, consisting of 6 vertical column (1.5 m diameter x 8 m tall) evaporative-type systems. The settled sludge (at 10% moisture content) is sent via rail car to landfill application out of the city.

2.3.1.4 Energy systems - technology and plans

The VIZ 100 MW TETS has three boilers (220 ton/hr each) and three turbines (35 MW each). Steam is supplied to the turbines at 90 bar, 535°C. As a cogeneration (combined heat and power) system, the TETS generates electricity very efficiently. The fuel chargeable to power (heat rate) for 1991 was 196 g/kWh[5] at VIZ TETS, compared to 310 g/kWh[6] in thermal power plants of Sverdlovskenergo.

The peak demand of VIZ was more than 200 MW at full production. Demand in 1992 is down to about 175 MW. The main electrical demand is from the orientation/annealing furnaces (hydrogen or nitrogen atmosphere) for cold-rolled metallurgical steel, at about 100 MW. Another large load is the hydrolysis system (the largest hydrogen producing system in the USSR) at 35 MW.

VIZ sells heat to Sverdlovskenergo, SW region, which in turn distributes the heat to the city. the approximate area of influence of the VIZ TETS extends some 7-8 km, with the World War II Veterans Hospital being the extreme point. The price the city pays for the heat covers only approximately 30% of the cost VIZ incurs to supply the heat.

Besides the TETS, the VIZ Industrial boiler room supplies heat to the town with a population of 20,000 people. The VIZ district heating system uses a closed type design (domestic hot water is raised in heat exchangers).

[5] The USSR system uses a coal equivalent fuel, with a LHV of 7,000 kcal/kg. Thus 196 g/kWh is equivalent to 1,372 kcal/kWh or 5,444 Btu/kWh (LHV). The system in the US usually quotes higher heating value (HHV), and in the US system the heat rate of the VIZ TETS would be about 6,000 Btu/kWh.

[6] System heat rate of 2,170 kcal/kWh LHV, equivalent to about 9,500 Btu/kWh HHV

VIZ intends to expand the capacity of the TETS, because the factory must purchase significant quantities of electricity from Sverdlovskenergo and because the city has an urgent need for additional heat supplies. In the past 20 years there has been no new development of boilerhouses in the city, but apartment construction has continued.The TETS has been a very successful development for VIZ, and they are proud of it. However, its capacity is too small to generate all the electricity needed by the factory. VIZ is seeking support and financing to expand the TETS from its current capacity of 100 MW to about 340 MW and 2.2 million Gcal/year. There are two or three variants on the expansion program for the TETS, depending on the city needs, but the base expansion plan envisages:

build 3x320 ton/hr boilers
build 2x130 MW turbines
replace 2x35 MW turbines by 1x100 MW turbine

2.3.1.5 Energy systems - audit observations on technology

The following tables summarize the observations by the RCG/Hagler, Bailly team, April 8-10, 1992.

Ambient conditions observed:
-10°C ambient temperature on April 8, 1992
-5°C ambient temperature on April 8, 1992
+2°C ambient temperature on April 8, 1992

TETS cogeneration system
Boiler/turbine #1 commissioned in 1972
63 MW total electric generation from TETS April 8 at 1400

TETS Boiler #1
230 ton/hour steam generation
100 bar steam pressure
540°C steam temperature
3% O_2 in stack gas (3% on boiler #2, 1.5% boiler #3)
0 ppm CO in stack gas
uA meter installed (calculated combustion efficiency)
280°C exhaust gas temperature after economizer, before air preheater
110°C exhaust gas temperature after air preheater (rotary regenerator type)
30° air inlet to air preheater, after calorifier (steam/air heater)

TETS Turbines
#1 fully condensing (has two extractions but not in use), 2944 rpm
inlet steam: 64 ton/hr, 89 bar, 530°C
condensing outlet: -0.87 bar vacuum, 53°C
#2 backpressure (1 bar) with four extractions (19, 16, 8.8, 2 bar)
extraction 23 ton/hr at 8.8 bar/250°C
extraction 40 ton/hr at 2 bar
#3 backpressure (1 bar) with four extractions (19, 16, 8.8, 2 bar)
extraction 33 ton/hr at 8.8 bar/265°C
extraction 43 ton/hr at 2 bar
Summer operation: #1 condensing, either #2 or #3 shut down

TETS Electric - district heating pumping station
Station use of power approximately 9-14% (up to 8MW), including pumps for district heating
6x630 MW pumps, in parallel
1,200 m^3/hr pumping flow (ea pump)
140 meter pumping head
Heat exchangers (district heating supply)
inlet water 56°
outlet water 86°
Hot water mass flow balance:
3,100 m^3/hr supply to city
2,900 m^3/hr supply to heating factory buildings
450 m^3/hr supply to factory process heat
6,150 m^3/hr return
300 m^3/hr make-up

Peaker boilerhouse
#1 capacity 50 Gcal/hr
#2 and #3 capacity 100 Gcal/hr each
#2 under reconstruction
operation in winter only, depending on many factors

Peaker boiler #3 operating
number of burners in operation: 6 (out of 15)
inlet water 76°
outlet water 90°
stack temperature 85°
no oxygen meter

Industrial boilerhouse
First built 1905 with Babcock & Wilcox and Sterling boilers (U.K.)
Replaced by TC-20 boilers (USSR) in 1957-58
Was main heat source before TETS was built
Converted to gas in 1964 (mazout as reserve)
2 boilers
- 40 ton/hr capacity each,
- 17 bar maximum steam pressure
- 350°C steam temperature
- 48 Gcal/hr heating capacity

winter - two boilers operated as peaking, summer one operating
supplies steam for factory use (dryers, heating, air curtains) to common header from TETS
supplies hot water to neighboring city buildings (20,000 people):
- from 2x200 m^2 heat exchangers, 400 m^3/hr flow capacity each
- 24 Gcal/hr capacity
- steam 2-7 bar to heat exchanger (2 bar for 70°, 7 bar for 130° water)
- typical flow winter 700 m^3/hr, summer 300 m^3/hr
- typical loss/make-up 5 m^3/hr

Boiler #5 in operation:
- steam flow: 40 ton/hr
- gas flow: 3,200 nm^3/hr
- steam pressure: 10.5 bar
- stack temperature: 140°C
- stack gas: 3% O_2 (meter installed)
- blowdown: intermittent, based on chem lab
- hot water flow to city: 740 m^3/hr at 82°

2.3.1.6 Heat utilization

In the large cold-rolled steel building (350 m wide x 1,000 m long x 25 m high), VIZ has some 20 km of heating system piping feeding about 150 fan-coil air handling heating units and 150 heated ventilation units. The normal hot water flow rate through the system is 2,600 tons/hour and the maximum capacity is 100 Gcal/hr. The reinforced concrete building envelope includes some 30,000 m^2 of double pane glazing and 50 mm of insulation in the roof (none in the walls). The building also has air conditioning in some sections (72 evaporative cooling units. The building uses 6 tons/hr 8 bar steam to heat the sulfuric acid bath (surface etching) and up to 24 ton/hr steam for other uses, including air curtains.

VIZ is carrying out a study of heating utilization effectiveness and opportunities for heat recovery, assisted by the firm "Ekologi"[7]. This study indicates that the supply temperature is close to standards, but the return temperature is far above design (12-15°C over for return from the city and 25° over design for return from the factory). Based on this study, VIZ is carrying out projects designed to increase delta T in the factory.

2.3.1.7 Energy prices and costs

Energy prices as of April 8, 1992 were:

natural gas[8] (March 1992):
- 80% is priced at 260 rubles/000 m^3
- 20% is priced at 1,300 rubles/000 m^3

natural gas (April 1992): not yet announced, expected 1,000-1,600 rubles/000 m^3
heavy fuel oil (mazout): 1,100 rubles/ton
heat sold by VIZ to city (1991): 6 rubles/Gcal
heat sold by VIZ to city (April 1992): 90 rubles/Gcal
electric: 1.58 R/kW/month (demand/capacity) + 1.34 R/kWh (energy)
heat, sold by city to industrial: 901 R/Gcal

[7] The RCG/Hagler, Bailly team met with the Director of Ekologi, Ludmilla Ejova, who described their work and showed us their first report.

[8] The net calorific value (lower heating value) of the gas supplied to VIZ averages 7,945 kcal/m^3

Cost of energy generation at VIZ (March 1992):
- Electricity, average cost[9]: 0.257 rubles/kWh
- Electricity, marginal cost (fuel only): 0.080 rubles/kWh
- Heat, average cost: (effective April 6, 1992):
  - from TETS - 96 rubles/Gcal
  - from boilerhouse - 118 Rubles/Gcal
- Heat, marginal cost (fuel only): 37 rubles/Gcal

2.3.1.8 Energy and environmental protection

VIZ pays a fee for its emissions (more than 2 million Rubles per year), and must pay fines which amount to 5-10 times more if they exceed standards. VIZ TETS boilers have begun retrofit to reduce NOx emissions. Technology used is a two-stage burning process developed by Tashkent Research Institute. It has been installed in boiler #1 and has cut NOx emissions in half. Because these systems pay for themselves in less than one year, VIZ plans to install the system on the other boilers next.

As noted above, VIZ has also made substantial investments in recent years to reduce wastewater emissions.

2.3.1.9 Energy performance data

VIZ provided performance data for its energy systems for the years 1989, 1990, and 1991. These data are presented in tables and graphs shown in Appendix 4. The data is summarized below.

Ekaterinburg weather data
- 1989 - 3,973 heating degree-days[10]
- 1990 - 3,495 heating degree-days
- 1991 - 3,435 heating degree-days

[9] Includes all fixed costs, such as labor, amortization, capital development, and taxes

[10] In degrees C, based on 12°C

1. VIZ Total natural gas consumption
   1989 - 331 million m^3
   1990 - 326 million m^3
   1991 - 349 million m^3

2. VIZ total electricity consumption
   1989 - 1.29 million MWh
   1990 - 1.26 million MWh
   1991 - 1.17 million MWh

3. VIZ total heat supplied to factory
   1989 - 1.68 million Gcal
   1990 - 1.80 million Gcal
   1991 - 1.80 million Gcal

4. VIZ total heat supplied to factory and city
   1989 - 2.58 million Gcal
   1990 - 2.67 million Gcal
   1991 - 2.72 million Gcal

5. Average fuel-to-heat efficiency of boiler systems

	TETS	Industrial	Peaker
1989 -	88.1%	91.9%	89.4%
1990 -	87.1%	91.4%	87.7%
1991 -	88.1%	92.0%	94.0%

6. Average fuel-to-electric efficiency (heat rate) of TETS

	Fuel charged to power[11]	All fuel[12]
1989 -	1,206 kcal/kWh[13]	4,699 kcal/kWh
1990 -	1,149 kcal/kWh	5,347 kcal/kWh
1991 -	1,212 kcal/kWh	4,534 kcal/kwh

[11] According to the allocation system used at VIZ

[12] Assuming all fuel is charged to power, heat as a free good

[13] Kcal is net calorific value (lower heating value)

7. Annual average efficiency performance ratio (Gcal of heat supplied[14] divided by heating load in degree-days)

	Heat supplied to VIZ	Heat supplied to city
1989 -	337 Gcal/°-day	278 Gcal/°-day
1990 -	413 Gcal/°-day	271 Gcal/°-day
1991 -	460 Gcal/°-day	328 Gcal/°-day

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

	Heat supplied to VIZ	Heat supplied to city
1989 -	197 Gcal/°-day	137 Gcal/°-day
1990 -	230 Gcal/°-day	147 Gcal/°-day
1991 -	243 Gcal/°-day	152 Gcal/°-day

9. Estimated inefficiency (losses) in system

Because of deficiencies in the design of the system, the district heating system in Ekaterinburg 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.

Based on the 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 VIZ to the city, as follows:

1989 - 51%
1990 - 46%
1991 - 54%

Based on 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 VIZ to the city, as follows:

1989 - 12%
1990 - 22%
1991 - 24%

[14] Corrected for domestic hot water supply

2.3.2 Institutional - World War II Veterans Hospital

The 240-bed World War II Veterans Hospital was established in 1982. Originally there were 4 hospitals for veterans of the great war, but now this is the only one in all of Russia specializing in neurological treatment. The hospital treats those who had wounds of head and neck or those who had brain surgery or mental/behavioral deviations.

The hospital has floor space of 20,000 m^2. The current occupancy is 760 beds, far above capacity of only 240 beds. This overloaded condition began during the conflict in Afghanistan. They are now building another wing of 300 more beds, according to a futuristic-looking design.

The hospital includes two buildings with 6 floors each and one building with 2 floors, and operates 365 days per year. The hospital has some eight departments, including diagnosis, operating rooms, intensive care, urology, chemical therapy, physical therapy, stomatology, and social - 250-seat cultural club, 300-seat canteen, and laundry.

There are 126 doctors and 862 total staff. The maintenance personnel pool consists of 134 individuals, 40 of which are dedicated to the HVAC System.

About 100 patients die in the hospital every year. On average, the hospital performs about two limb amputations per week. There are special problems with the Afghanistan veterans - many are shell-shocked (post-traumatic stress disorder).

The cost of operating the hospital amounts to some 1,690 Rubles per day per patient[15]. But the hospital does not take money from patients, its services are paid by the state. Heating is an important part of costs, and the hospital administration is very concerned that these costs are increasing. The hospital's heating cost for the first quarter of 1992 was 704,000 rubles.

The hospital received a shipment of medical supplies as part of U.S. humanitarian assistance in March 1992, and is very grateful.

Comfort heating and domestic hot water are supplied by the Ekaterinburg Central District Heating System. The hospital is located some 6 km from VIZ, and represents the farthest reach of the heat from the VIZ TETS.

[15] Note that at the time of the audit this was about equal to a good monthly salary in Russia.

The hot water from the district heating system arrives at the hospital substation providing 150°C-70°C for heating/ventilation and 115°C-70°C for heating/domestic hot water.

The peak heating and domestic hot water load for the hospital is estimated by the RCG/Hagler, Bailly team to be 5.65 Gcal/hour. The annual heating load is estimated by the RCG/Hagler, Bailly team to be 12,300 Gcal/year.

Three electric boilers are installed in the hospital substation to offer domestic hot water back-up when the district heating system is shut down for repairs. The electric boilers, each with capacity 100 MW, were installed in 1989.

There are two air conditioning units installed for the hospital surgery rooms. However, at time of audit, they were shut down because of the excessive noise levels and their constant failure. The hospital laundry and sterilizers operate on electricity.

The pipe line to the hospital substations is above ground in many areas; the insulation appears to be in good condition.

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

The hospital laundry has a capacity of 5 tons/month. However, with the overcrowding the capacity needed is now 18 tons/month. Also because the laundry is not based on steam it is not possible to achieve the needed level of sanitation. This laundry quantity/quality problem is a serious concern for the hospital, and would be a good area for future humanitarian aid.

2.3.3 Residential Apartment Blocks

Two residential buildings were chosen to perform energy analysis. Each building is practically identical, consisting of 9 floors and 162 apartments. Each apartment contains 4 radiators and a window area of approximately 40 m^2. Walls are made of reinforced concrete panels.

There is a two-pipe heating system (header/collector with radiators in parallel). The system uses down-feed distribution (hottest water goes to upper floors).

The peak heating load for the building is estimated by the RCG/Hagler, Bailly team as 1.8 Gcal/hr. Annual consumption is estimated by the RCG/Hagler, Bailly team to be 3,900 Gcal/year.

The domestic hot water is an open 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.

The windows in the building do not close properly. These cracks cause drafts, which can be substantial on cold, windy days. This heat loss from excessive infiltration not only wastes energy but results in indoor temperatures which are below design.

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.

3.0 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:

- Low reliability
- Difficult to balance the system hydraulically
- Difficult to maintain
- In open systems, it is difficult to locate leaks in the distribution system.

Based on these indications, it is recommended that such systems should attempt to decentralize 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, longer term programs to create 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 VIZ cogeneration plant (VIZ TETS) operates at high thermal efficiency and personnel have access to well maintained controls and automation systems. The distribution systems and substations with boilers lack instrumentation and controls and show signs of neglect. The situation is worse on the consumer end, as revealed by this energy audit. There are no controls or valves on the individual end user units.

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.

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 district heating system served by VIZ 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 appear neglected in many instances. They lack modern instrumentation and controls and appear poorly maintained.

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 Ekaterinburg are large, approximately 90% of which is buried below ground in concrete tunnels. Leakage is the most pronounced problem evidenced by makeup water requirements which are increasing at near alarming rates. Existing systems have no instrumentation to monitor leakage from the system. Much of the debate concerning solutions suggests that converting these open systems to a closed loop arrangement would enable tighter control. 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 capability.

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 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 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 Ekaterinburg must overcome these barriers. The installation of costly capital equipment to improve energy efficiency is <u>not</u> the solution - the economy of Ekaterinburg 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 Ekaterinburg and Sverdlovsk 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 the Sverdlovsk region of more than $350 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 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 Sverdlovsk region of $2 million 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 Sverdlovsk region of $51 million per year.

Action A.3: Restructure the energy and production departments at VIZ to reflect a market economy for energy. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to VIZ of $1.2 million per year.

Action A.4: Organize a water saving program to address the deficit of treated hot water. The RCG/Hagler, Bailly team estimates that simple, quick, low-cost actions can completely eliminate the deficit of hot water in Ekaterinburg.

Action A.5: Improve VIZ marketing to increase production and spread fixed energy consumption over more units of production.

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. The RCG/Hagler, Bailly team estimates that this recommendation could save 10% of heating energy, which would give an economic benefit to the Sverdlovsk region of $102 million per year.

Action B.2: Improve heat exchanger maintenance & balancing at VIZ - organize efficiency teams with instruments to test, balance and clean heat exchangers. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to VIZ of $1.2 million per year.

Action B.3: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping (examples - residential building and hospital). The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the Sverdlovsk region of $51 million per year.

Action B.4: Provide tools to assist hospital staff improve operating efficiency of equipment. The RCG/Hagler, Bailly team estimates that this recommendation could save 5% of heating energy, which would give an economic benefit to the World War II Veterans Hospital of $9,000 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 Sverdlovskenergo of $21 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 Sverdlovsk region of $21 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 Sverdlovsk region of $51 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 Sverdlovsk region of $51 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 0.5% of heating energy, which would give an economic benefit to Sverdlovsk region of $5 million 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 0.5% of heating energy, which would give an economic benefit to Sverdlovsk region of $5 million per year.

Action C.7: Convert factories in Ekaterinburg 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 Convert to closed system in distribution network, and improve local control in individual heat substations.

D.5 Improve distribution systems by using pre-insulated piping with leak-detection systems on new installations and improving drainage of existing installations.

D.6 Expand VIZ cogeneration system (TETS) to achieve balance between electrical and thermal energy requirements.

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 Ekaterinburg will need additional tools and instrumentation to achieve these goals. The RCG/Hagler, Bailly team recommends that VIZ and Ekaterinburg receive a package of equipment from USAID to assist their energy management program. The proposed procurement list and budget for VIZ, 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

	Estimated Procurement Budget Funding Variants		
	A	B	C
A.3 Energy management computers	2,000	2,000	2,000
A.5 US manufacturers information	1,000	1,000	1,000
B.2 Instruments for VIZ	10,000	10,000	10,000
B.3 Weatherstripping for hospital	5,000	5,000	5,000
B.3 Weatherstripping for residential			7,000
B.4 Instruments/tools for hospital	5,000	5,000	5,000
C.1/C.2 Fixed thermal energy meters:			
outlet VIZ to city	8,000	8,000	8,000
inlet to hospital	7,000	7,000	7,000
inlet to 2 residential buildings		10,000	10,000
residential heat allocation meters			7,000
C.4 Thermostatic radiator valves			
residential			18,000
C.5 Energy auditors kit(s)	14,000	24,000	24,000
C.6 Equipment, energy auditors kit(s)			21,000
D.1 Infrared radiant heaters VIZ		10,000	10,000
D.2 Insulation board for windows VIZ/apt. bldg.		10,000	40,000
D.3 Automate one substation			25,000
TOTAL BUDGET	52,000	92,000	200,000

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - region

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

The modulation every 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 heat consumption in the Sverdlovsk region of 86.1 million Gcal, savings would amount to 170,000 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 $2.0 million per year.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - 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).

In fact, as indicated in Figure 4, the actual supply temperature in Ekaterinburg exceeds the grafik at ambient temperatures above about -10°.

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 Sverdlovsk region of 86.1 million Gcal, savings would amount to 4.3 million 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 $51 million per year.

RECOMMENDED ACTION

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

Location of project: VIZ Metallurgical Plant

Action A.3: Introduce a market-based energy management information and control system. Organize energy department as a profit center. Make production departments responsible for their energy consumption.

Existing conditions

In the system of management information and control in place at VIZ, production is based on plans, and management exercises control over the process to see that the plan is carried out. These plans set performance targets, which are based on input and output quantities.

VIZ currently monitors some of the important energy consumption and conversion parameters vital to the efficient operation of the plant. Electrical energy consumption and heat energy consumption by the plant are currently recorded on a monthly basis. Likewise, production figures for various portions of the plant are currently collected and reported on a monthly basis. A few meters are in place to assist the program.

Energy management at VIZ is the responsibility of the Energy Department. However, primary responsibility for energy consumption lies in the Production Departments (and the outside users of heat sold by VIZ), which have the major energy-using equipment. This system limits the ability of the Energy Department to improve energy efficiency in the plant. There is no "market" for energy in the plant, such as a transfer pricing system for heat or electricity.

Bailly analyzed monthly data during a 36-month sample period (1989-1991). Compared to our experience in carrying out similar analyses in other plants in other countries, the data indicate a poor correlation between heat supply and heat demand (heating load), for monthly performance data. Our analysis indicates that heat supply is about 23% more than expected demand (as determined by ambient temperature), on average over the past three years. Further, the situation seems to be deteriorating, as indicated by the following efficiency ratios:

	Heat supply/heat demand Gcal/degree-day[16]	
	VIZ	CITY
1989	337	278
1990	413	271
1991	460	328

The ratio for 1991 is significantly higher than for previous years, for both VIZ and the heat supplied to the city.

Recommended action

Workers at all levels must be enlisted as partners for energy conservation programs to work effectively. The RCG/Hagler, Bailly team recommends that:

1. A market-based pricing system be established for energy usage in VIZ.

2. An active management control system be established, based on the market system. Incentives should be used if necessary.

1. Establish a market-based pricing system for energy

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. If a market-based system is established in the plant, employees will learn the cost of certain actions and behavior, and can be motivated to improve behavior.

There are several steps required to establish a market for energy at VIZ. RCG/Hagler, Bailly suggests:

Step 1 - The Energy Department should be established as a separate profit center or service company. The Energy Department should calculate its cost of doing business, including fuel and electricity purchases from energy suppliers, plus the cost of service provided by the Energy Department, as measured by amortization of capital equipment, cost of labor, and cost of maintenance. A decision should be made on an appropriate level of profit. Some plants may wish to treat their Energy Departments as a non-profit center.

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

Step 2 - Based on the cost of service and the profit decision, the price of key energy forms should be calculated on a weekly basis by the Energy Department. These forms include gas, hot water, and electricity. A weekly list of energy prices should be circulated at the beginning of the week to Directors, heat customers, all production managers and posted for employees[17].

Step 3 - Energy (electricity, heat, and gas) should be "sold" to the various departments on the basis of these prices. Meters should be installed at the borders of the various Departments (and heat customers), and used to perform the transaction. Daily, or shift, reading of meters should be integrated into weekly figures, corresponding to the energy prices.

Step 4 - Energy "bills" should be calculated by the Energy Department each month, and submitted to the Economics Department. These energy costs will be used as part of the cost of production calculation.

2. Establish a management information and control system

The RCG/Hagler, Bailly team recommends that collection and analysis of energy consumption data be done on at least a daily basis, and preferably on a shift by shift basis. Shift supervisors from each of the major energy producing and consuming areas of the plant should report specific energy consumption figures (i.e. kWh per ton of steel from machine #1, etc.). These data should be compared as to day-to-day performance, and the results of operating or equipment changes should be documented and reported back to operating personnel. At first, only overall measurements will be possible because metering equipment is not available for individual areas of the plant. Nevertheless, some comparisons can be made for analysis. Electric consumption should be most closely correlated with production, quantity and quality.

Plant management needs to be able to obtain the information needed quickly enough to exercise the control required to improve efficiency in the use of energy and other valuable inputs. There are several steps required to achieve closed loop control for efficiency.

Step 1 - The daily report should be modified to include energy consumption (in each form - gas, heat, and electric) and a calculation of the ratio of the appropriate energy consumption form to the load (kWh per ton of a certain type of steel; heat related to outside temperature (per degree-day), etc.).

[17] RCG/Hagler, Bailly suggests that VIZ might wish to consider listing two prices in the report, financial costs paid by VIZ (as determined by the Ruble prices prevailing during the week) and economic costs as would be paid by an equivalent factory in Europe (using the economic prices shown in this report).

Step 2 - 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 system must have software designed to calculate the necessary performance ratios and to present information to management in an easily-understandable form.

Step 3 - Management must use the information to make short-term management decisions which lead to control actions (changes) which affect plant operations. A plant-wide management control system should be developed on a daily basis.

Step 4 - 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.

Phase I - 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

Phase II - additional metering as required and determined by MICS team

Expected results

The precise savings that can be achieved by establishing such a program are impossible to estimate accurately, but experience has shown that from 2-10 percent reduction of energy costs have been attributed by other plants to their monitoring programs. This is based on experiences of similar companies in the U.S. and Europe which have highly variable specific energy consumption before implementing such systems. Given the variability of the data collected at VIZ, we expect that a figure near the upper end of this range is possible. If we choose a conservative figure of 5% savings of heat energy, savings of $25,000 per year are estimated:

Thermal (gas for heating):
5% x 1.8 million Gcal/yr = 90,000 Gcal/yr
90,000 Gcal/yr x (1/90%) x $12/Gcal = $1,200,000/yr

Cost/benefit analysis

The investment required to implement the program is minimal. VIZ already has installed sufficient instrumentation to begin a rudimentary program. Over time, additional equipment must be purchased for submetering of steam and electricity consumption by various equipment, financed from the savings generated by conservation projects. The payback period for the project is:

Payback = capital cost/net annual cost savings

$100,000/$1,200,000 = 1 month

RECOMMENDED ACTION

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

Location of project: Ekaterinburg citywide

Action A.4: Organize a water saving program to address the deficit of treated hot water.

Existing conditions

The quantity of hot water available for city residents is less than demand, because of a shortage of treated water. This has caused a crisis in City utilities management.

Recommended action

The RCG/Hagler, Bailly team recommends that the City aggressively pursue a program to save water, and in this way make more treated water available for the hot water supply.

The elements of this program should include:

- reducing flow of water for toilets by installing common brick in water tanks.
- reducing flow of water from showers by installing flow restrictor (orifice or washer) in the shower head.
- increasing efforts to repair leaks at water taps and in system lines.
- restrictions on the use of water for non-critical purposes.

Expected results

It is estimated that this program will enable the existing treated water supply to stretch to satisfy hot water demand. It may cause energy demand in the city to increase by 1-2% to meet the unsatisfied hot water demand.

RECOMMENDED ACTION

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

Location of project: VIZ Metallurgical plant

Action A.5: Improve marketing to increase production and spread fixed energy consumption over more units of production.

Existing conditions

The quantity of production at VIZ is down substantially, by as much as 40% compared to recent years[18]. At the same time, heat consumption appears to have increased (especially when compared to the weather) and electrical energy consumption has reduced slightly.

Clearly there is a high fixed energy consumption for running a factory so large as VIZ. Thus the reduced production has significantly reduced energy efficiency.

Recommended action

The RCG/Hagler, Bailly team recommends that VIZ aggressively expand its marketing efforts to build commercial relationships for both raw material supply and production sales. The existing staff of some 10-15 is too small to handle the job adequately. The marketing staff should be given a substantial budget, for training and traveling. Senior staff, especially Directors and Chief Experts, 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.

[18] Detailed production data were requested by the RCG/Hagler, Bailly team, but VIZ declined to release the exact figures.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - 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 the city system, as indicated in Figure 4, 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°.

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.

Sverdlovskenergo 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 Sverdlovsk region of 86.1 million Gcal, savings would amount to 8.6 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 $102 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 Ekaterinburg. Taking a median figure of $100 and a population of 2 million (1 million equivalent flats), the cost is estimated as $100 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
$100 million/$102 million = 1 year

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

RECOMMENDED ACTION

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

Location of project: VIZ metallurgical plant

Action B.2: Improve heat exchanger maintenance & balancing at VIZ - organize efficiency teams with instruments to test and clean heat exchangers

Existing conditions

Actual measurements in the VIZ system, as indicated in Figure 4, 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°.

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.

Recommended action

1) Institute a project to test delta T and air flow 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 energy audit kits for the test crew, including:
   thermocouple set
   infrared pyrometer
   velometer (air velocity meter)
   electric volt/ohm/ampere/cosphi/kW meter

2) Various repair and replacement equipment, as required.

Expected results

The RCG/Hagler, Bailly team estimates annual energy savings on the order of 5-10% are feasible by the end of the program.

Based on 1990 annual heat consumption at VIZ of 1.8 million Gcal, savings would amount to 0.1 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 $1.2 million per year.

Based on European or US market costs, the cost of implementing the project is estimated to be approximately $500,000. However, by using locally-available personnel and equipment, the cost could be much less.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$500,000/$1.2 million = 0.41 year

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

NOTE: World War II Veterans Hospital

A similar project is suggested for the hospital, and the RCG/Hagler, Bailly team recommends that tools and instruments be provided for this effort. A listing of recommended tools for the hospital is included in Appendix 6.

RECOMMENDED ACTION

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

Location of project:
Residential apartment block building
World War II Veterans Hospital
Other institutional buildings

Action B.3: Reduce infiltration of cold air through windows - plug leaks and install weatherstripping

Existing conditions

Residential apartment block studied as part of energy audit:

- 162 apartments, 9 floors.
- Hot water heating system with two pipe distribution down feed.
- Heat load, 1.8 Gcal/hr.
- Annual heat consumption: 3900 Gcal/yr.
- No meters and no controls on the substation in the building.
- No weatherstripping.

The veterans' hospital has a gross area of 20,000 m^2 and was designed for 240 beds. They have a current occupancy of 760 beds. There are two buildings, one with six floors and one with two floors. The hospital operates 365 days per year and the heating system operates 228 days per year with a peak heat demand 5.65 Gcal/hr. Annual heat consumption is 12,300 Gcal/yr. There are no controls on the heat supply substation in the hospital. 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 hospital.

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 (3900 Gcal/yr) = 195 Gcal/yr.
Hospital: 5% x (12,300 Gcal/yr) = 615 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 $1,620.

The annual benefits are 195 Gcal at the point of end-use, plus 25% for distribution and heat generation losses, or 243 Gcal/yr in natural gas.

243 gcal/yr x $12/Gcal = $2,900/year

The payback period for the project is:

Payback = capital cost/net annual cost savings
$1,620/$2,900 = 0.55 year

The payback period is 0.55 times the length of the heating season. Because the payback is less than one heating season (the expected lifetime of the weatherstripping), the project is attractive.

Hospital building:

The cost to install weatherstripping on the hospital, using Russian materials, is estimated to be $4,000.

The annual benefits are 615 Gcal at the point of end-use, plus 25% for distribution and heat generation losses, or 769 Gcal/yr in natural gas.

769 gcal/yr x $12/Gcal = $9,200/year

The payback period for the project is:

Payback = capital cost/net annual cost savings
$4,000/$9,200 = 0.43 year

The payback period is 0.43 times the length of the heating season. Because the payback is less than one heating season (the expected lifetime of the weatherstripping), the project is attractive.

RECOMMENDED ACTION

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

Location of project:
World War II Veterans Hospital

Action B.4: Provide tools to assist hospital staff improve operating level of equipment

Existing conditions

The veterans' hospital has a gross area of 20,000 m^2 and was designed for 240 beds. They have a current occupancy of 760 beds. There are two buildings, one with six floors and one with two floors. The hospital operates 365 days per year and the heating system operates 228 days per year with a peak heat demand 5.65 Gcal/hr. Annual heat consumption is 12,300 Gcal/yr. There are no controls on the heat supply substation in the hospital. There is no weather stripping installed.

The hospital maintenance staff is very poorly equipped with tools. It does not have even basic mechanics tools.

Recommended action

Improve standard of maintenance. Use better tools to repair and adjust electrical and heating equipment to reduce energy consumption.

Equipment required

Use AID funds provide a set of tools and energy diagnostic instruments for the hospital maintenance staff, including:

- mechanics tools
- pipe-wrenches and related tools for heating systems
- thermocouple set
- electric kW meter

Expected results

Better maintenance is estimated to save 5% of the total annual heating energy.
Hospital: 5% x (12,300 Gcal/yr) = 615 Gcal/yr.

Cost/benefit analysis

The cost of the tools is estimated to be $5,000.

The annual benefits are 615 Gcal at the point of end-use, plus 25% for distribution and heat generation losses, or 769 Gcal/yr in natural gas.

769 Gcal/yr x $12/Gcal = $9,200/year

The payback period for the project is:

Payback = capital cost/net annual cost savings

$5,000/$9,200 = 0.55 year

The payback period is 0.55 times the length of the heating season. The project is attractive, since the tools will last many years.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - 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.

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

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.

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

Equipment required

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

Expected results

Installing a loss metering system will help Sverdlovskenergo 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 86.1 million Gcal/yr = 1.7 million 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 $21 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 Ekaterinburg. Taking a median figure of $8,000, and assuming that some 100 meters can handle the major nodes in the network, the cost of the meters is estimated as $800,000. 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 $1 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$1 million/$21 million = 0.05 year

The project is extremely attractive, with a payback of less than one month.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - 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 (thousands)
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 86.1 million Gcal/yr = 1.7 million 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 Sverdlovskenergo 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 $20 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 Ekaterinburg. Taking a median figure of $4,000, and assuming that some 2,000 meters can handle the major buildings in the network, the cost of the meters is estimated as $8,000,000. Other costs for computers and tools could total an additional $1,000,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $10 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$10 million/$20 million = 0.5 year

The project is very 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: Sverdlovskenergo - 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.

Sverdlovskenergo 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.

Sverdlovskenergo 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 86.1 million Gcal/yr = 4.3 million 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 Sverdlovskenergo 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 $51 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 Ekaterinburg. Taking an average of four radiators and two hot water taps per flat, we estimate $100 per flat. Assuming that some 400,000 flats are to be metered, the cost of the meters is estimated as $40,000,000. Other costs for computers and tools could total an additional $1,000,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $45 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$45 million/$51 million = 0.88 year

The project is 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: Sverdlovskenergo - 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 86.1 million Gcal/yr = 4.3 million 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 $51 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 Ekaterinburg. Taking an average of four radiators per flat, we estimate $160 per flat. Assuming that some 400,000 flats are to be fitted with valves, the cost of the TRVs is estimated as $64,000,000. Other costs for computers and tools could total an additional $1,000,000. However, by using locally-available personnel and equipment, the cost could be much less. A total budget of $65 million should be conservative.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$65 million/$51 million = 1.3 year

The project is attractive, with a payback of a little more than one year.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - 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 in Sverdlovsk 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 Ekaterinburg. This program would provide the following elements:

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

Competitive tendering 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.

0.5% x 86.1 million Gcal/yr = 0.4 million 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 $5 million per year.

RCG/Hagler, Bailly estimates that a successful program can be developed for about $1 million, including the equipment.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$1 million/$5 million = 0.2 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: Sverdlovskenergo - region

Action C.6: 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 institutional and residential levels. While VIZ has strong interest and awareness, there are other industries where additional training would be beneficial.

Recommended action

The RCG/Hagler, Bailly team recommends that an energy efficiency training and education program be established at Urals Polytechnic Institute in Ekaterinburg. 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.

0.5% x 86.1 million Gcal/yr = 0.4 million 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 $5 million per year.

RCG/Hagler, Bailly estimates that a successful program can be developed for about $1 million, or less, including the equipment.

The payback period for the project is:

Payback = capital cost/net annual cost savings

$1 million/$5 million = 0.2 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: Sverdlovskenergo - 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 several factories in Ekaterinburg which have manufacturing capability and need to produce consumer products. There is strong willingness among the leaders of the Ekaterinburg community to pursue opportunities to convert these factories to produce equipment designed to save energy.

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 Ekaterinburg.

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: Sverdlovskenergo - region

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

Existing conditions

In large factory buildings, such as the cold-rolled steel shop at VIZ, convective heating systems are in use.

These heating systems have high thermodynamic efficiency because they use heat derived from cogeneration (TETS), however they 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 VIZ 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 VIZ workshop for 30% less energy than convective heating, on an annual basis. Installation of this equipment will permit VIZ TETS to export more heat, and thereby supply the city.

RECOMMENDED FOR FURTHER CONSIDERATION

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

Location of project: Sverdlovskenergo - 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 Ekaterinburg environment, 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 a VIZ workshop and 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: Sverdlovskenergo - region

Action D.3 Convert to closed system in distribution network, and improve local control in individual heat substations.

Existing conditions

The temperature of supply water to buildings is determined by the heat sources (TETS). 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 distribution system is based on the open system design, which has disadvantages in that it requires the heat sources to treat and pump large volumes of water. Thus the lack of water treatment capacity has resulted in a deficit of hot water in Ekaterinburg. The closed system would have lower pumping energy requirements, and also lower heat loss.

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 also recommends that the program to convert the distribution system in Ekaterinburg be continued, and that the pace of conversion be accelerated.

The RCG/Hagler, Bailly team also 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 conversion to the closed system and 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 conversion to closed system and 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: Sverdlovskenergo - 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.

RECOMMENDED ACTION

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

Location of project: Sverdlovskenergo - region

Action D.5 Expand VIZ cogeneration system (TETS) to achieve balance between electrical and thermal energy requirements

Existing conditions

The VIZ TETS has been a successful development, but it is too small to serve the entire electrical load at the VIZ factory, and there is need for additional heating capacity in the city. There is property available for expansion of the facility.

Recommended action

The RCG/Hagler, Bailly team recommends that VIZ proceed with its plans to expand the TETS.

The RCG/Hagler, Bailly team recommends that the analysis of options be expanded to include gas turbine - steam turbine (combined cycle) systems, and that U.S. manufacturers of such systems be considered as possible joint venture partners in the development of the new TETS.

The study of this large development is beyond the scope of the energy audit.

ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

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ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 2
LIST OF PEOPLE WHO ATTENDED SEMINAR ON ENERGY AUDITING AND INSTRUMENTATION FOR ENERGY EFFICIENCY

LIST OF SPECIALISTS PARTICIPATED IN THE ENERGY SEMINAR

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Professor	L. D. Gitelman
Doctor	U. N. Fedorenco
Professor	A. G. Bascakov
Doctor	B. U. Shuvalov
Doctor	E. I. Eliseev

SVERDLOVENERGO

Ass. Director	B.A. Discin

ENERGONADZOR

Director	V.U. Nechitailov
Ass. Director	T.S. Yaremenko

VIZ

Chief Energetic	V.I. Filipov
Ass. Director O & M	V.F. Kozlov
Ass. Chief Energetic	N.M. Donchenko
Engineer	N.N. Utkin
Director TETS	V.I. Fosposhniy
Director of Electrical Shop	U.B. Cherednichenko
Director of TETS Chemical Plant	A.Z. Chramzova
TETS Instrumentation Director	M.V. Sokolov
Ass. TETS Director	P.V. Kuznezov
Chief Supervisor	I.V. Pachomov
Supervisor	D.V. Petrovskich
Process Engineer	A.B. Bartova
Water Treatment Plant Energetic	A.S. Rusinov
Energy Savings Group Manager	V.F. Krushatin

ECOLOGY

Director	L.V. Ejova

DISTRICT HEATING COMPANY OF EKATERINBURG

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Chief Supervisor	V.V. Volchkov
Chief Supervisor	C.V. Ulyanov
Chief Supervisor	I.F. Ponomarev
Chief Supervisor	Rassolova
Chief Supervisor	Kalushina
Chief Supervisor	Glazkova
Chief Supervisor	A.C. Yalin
Chief Supervisor	A.N. Vorobei

ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 3
SCHEMATICS OF TYPICAL DISTRICT HEATING SYSTEM PIPING DESIGNS

APPENDIX 5

SYSTEM SCHEMATICS

Schematics 1 through 6 showing typical Russian hot water heating distribution systems are attached. Schematics 1 through 5 were made from systems observed in Ekaterinberg. Schematic 6 was found in a literature search. It is included for comparison to show how the ideal Russian system would be configured, controlled and metered.

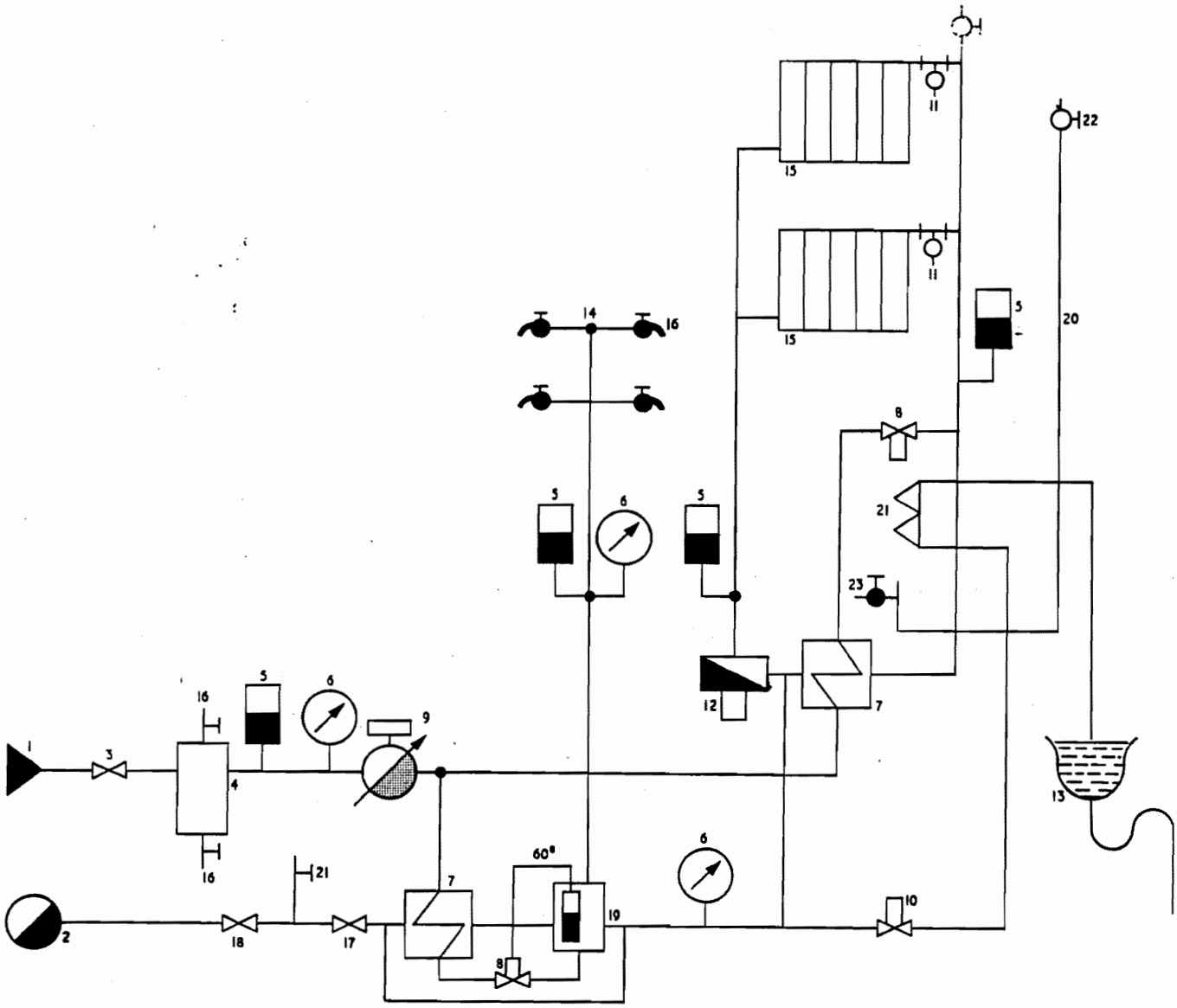
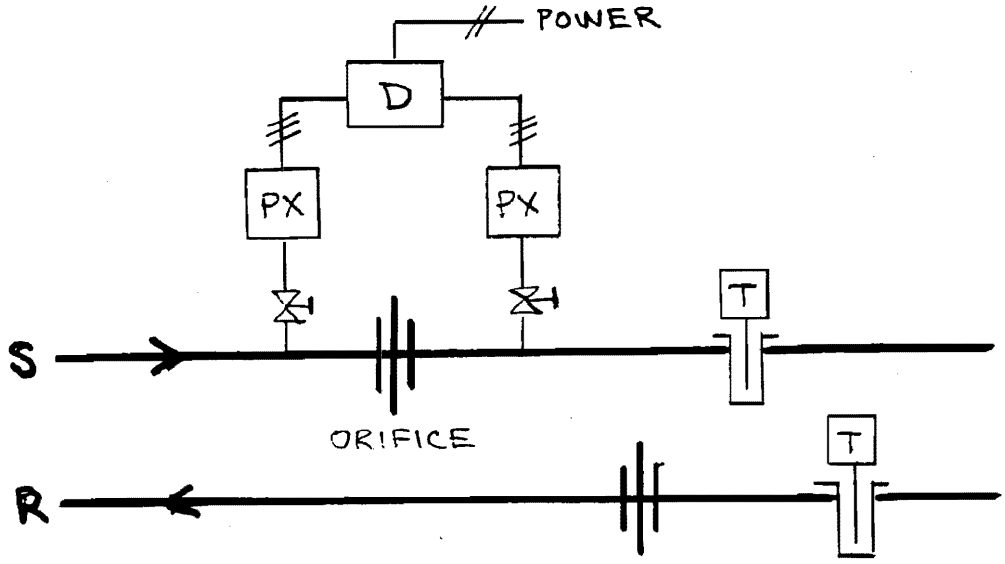


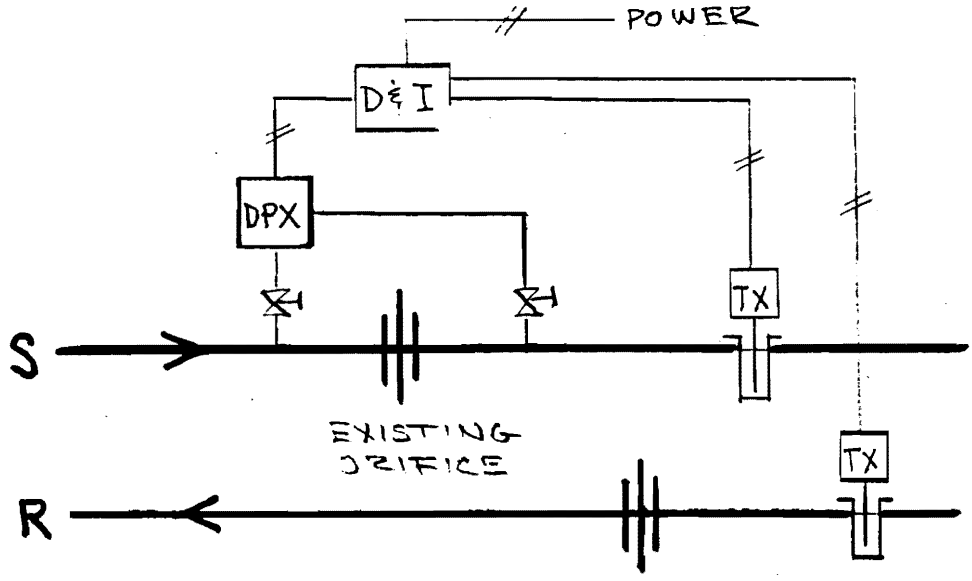
FIG. 10.11. Layout of the Soviet single pipe system as used in the consumer's circuit. 1. heating network; 2. water main; 3. valve; 4. sediment tank; 5. thermometer; 6. pressure gauge; 7. water cooler, e.g. from 200° to 150°C (3 m³ per 1,000 inhabitants); 8. regulating valve; 9. calorimeter; 10. hydrostatic head valve; 11. automatic room temperature regulator; 12. low pressure pump; 13. drain line; 14. hot water supply system; 15. radiators; 16. taps; 17. return valve; 18. valve in the water main; 19. gas cylinder with boiling liquid (butane); 20. oil-filled pipe; 21. feedback; 22. oil filling valve; 23. valve for release of oil and for compressed air

FIG 6



TYPICAL EXISTING METER INSTALLATION

FIG 1



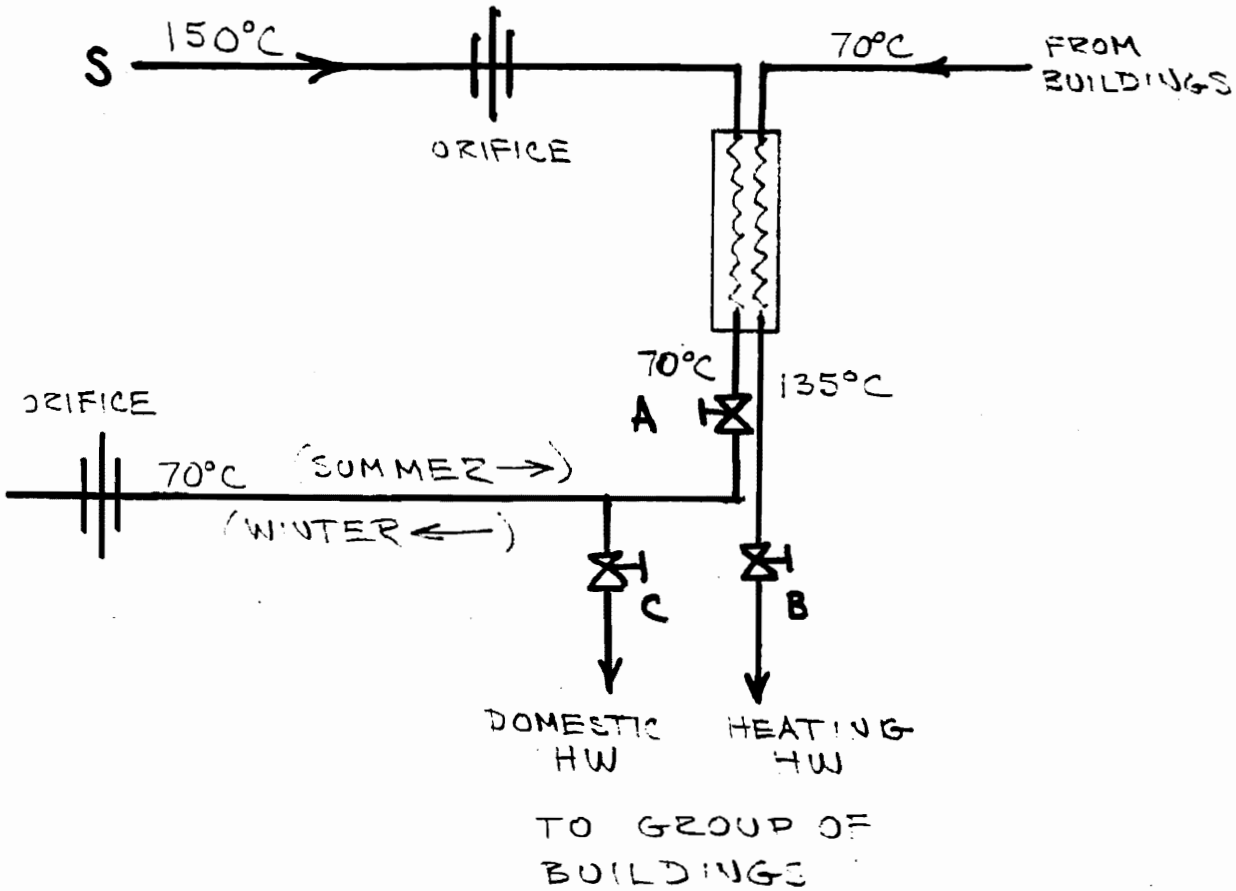
RECOMMENDED METER INSTALLATION ALL LOCATIONS

FIG 2

LEGEND

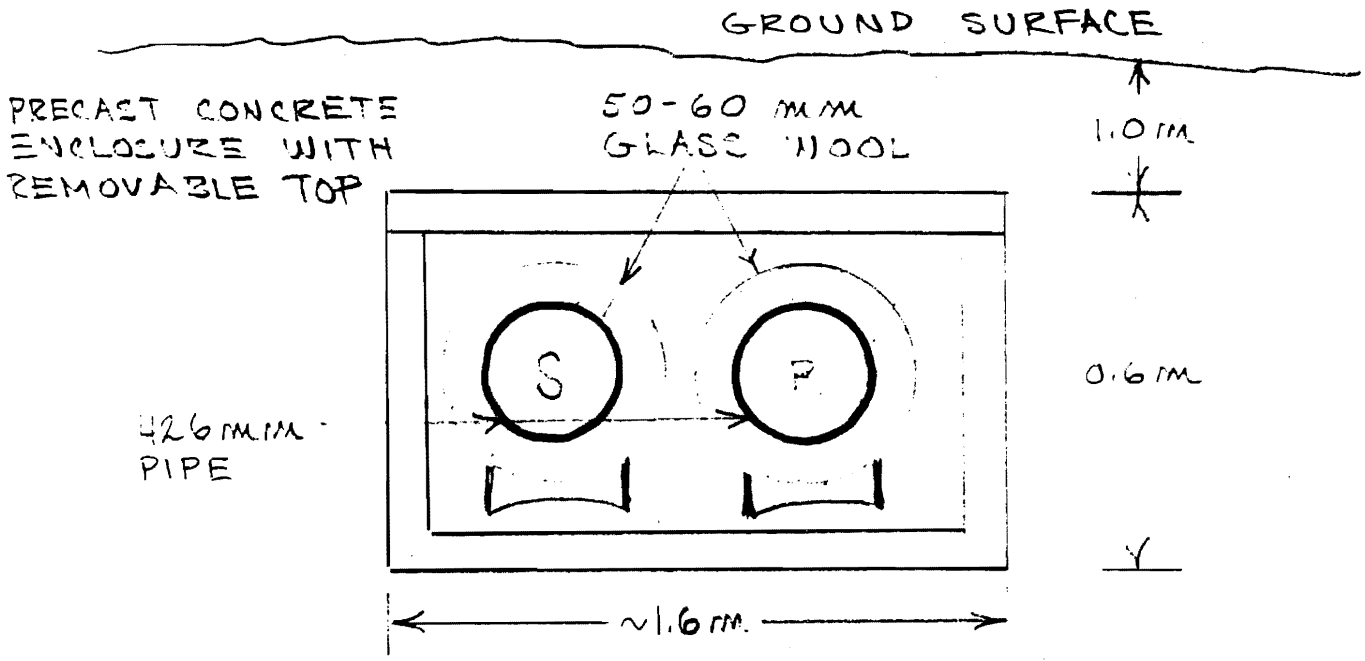
- T — THERMOMETER
- TX — TEMP TRANSMITTER
- PX — PRESSURE TRANSMITTER
- D — INSTANTANEOUS FLOW DISPLAY
- D&I — INSTANTANEOUS FLOW DISPLAY AND INTIGRATOR.
- DPX — DIFFERENTIAL PRESSURE TRANSMITTER

	A		B		C	
	OPEN	CLOSED	OPEN	CLOSED	OPEN	CLOSED
SUMMER		X		X	X	
WINTER	X		X			X



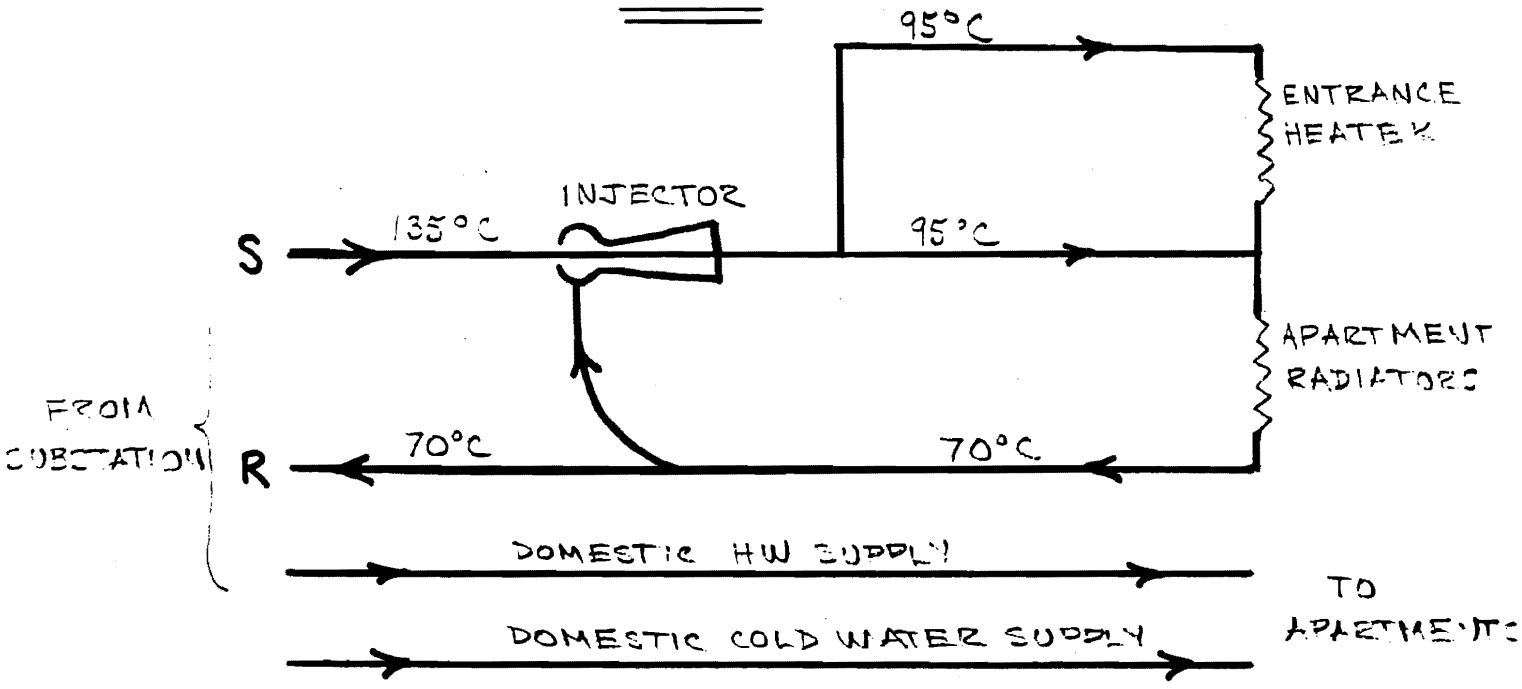
SUBSTATION PIPING

FIG 3



TYPICAL DISTRIBUTION SYSTEM PIPING

FIG 4



OBSERVED APARTMENT CONNECTION TO DISTRICT HEATING SYSTEM

FIG 5

ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 4
ENERGY PERFORMANCE DATA PROVIDED BY VIZ

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92

		Heating Load		1. Natural Gas Consumption				
		AVG TEMP	DEG-DAYS	TETS	PKR BLR	IND BLR	OTHER	TOTAL
		C	(12 basis)	M3	M3	M3	M3	M3
1989	1/89	-14.2	812	31774000	7595000	2665000	1667000	43701000
	2	-10.1	619	30308000	3604000	2303000	1538000	37753000
	3	-1.9	431	32163000	38000	2279000	1646000	36126000
	4/89	0.5	345	24238000	775000	2769000	1562000	29344000
	5	10.5	47	17490000	754000	1168000	1169000	20581000
	6	20.0	0	11493000	27000	906000	1972000	14398000
	7/89	20.8	0	10996000	0	520000	1662000	13178000
	8	13.6	0	10325000	0	792000	1722000	12839000
	9	8.6	102	15746000	0	935000	1762000	18443000
	10/89	-3.0	465	25696000	0	1871000	2076000	29643000
	11	-3.7	471	32293000	127000	1891000	1967000	36278000
	12	-10.0	682	30049000	382000	3046000	5412000	38889000
1990	1/90	-13.8	800	30367000	5015000	3010000	1532000	39924000
	2	-7.1	535	26848000	977000	3393000	1614000	32832000
	3	-0.9	400	27384000	1204000	2480000	1634000	32702000
	4/90	4.3	231	22624000	508000	2193000	2117000	27442000
	5	9.4	81	20125000	0	2555000	1458000	24138000
	6	17.7	0	14012000	0	1980000	1093000	17085000
	7/90	20.9	0	12781000	0	1524000	1672000	15977000
	8	18.0	0	10685000	0	1961000	1574000	14220000
	9	9.4	78	18119000	0	2400000	1497000	22016000
	10/90	1.6	322	24736000	1748000	2430000	-118000	28796000
	11	-3.2	456	28703000	3547000	2493000	-795000	33948000
	12	-7.1	592	31971000	3952000	2906000	-2009000	36820000
1991	1/91	-11.6	732	35900000	3434000	3650000	1689000	44673000
	2	-10.6	633	32432000	1792000	4060000	1458000	39742000
	3	-6.9	586	33200000	947000	3884000	1607000	39638000
	4/91	9.0	90	24318000	0	1988000	1465000	27771000
	5	16.1	0	16843000	0	852000	1288000	18983000
	6	21.8	0	13365000	0	973000	1247000	15585000
	7/91	17.5	0	12403000	0	0	1850000	14253000
	8	14.0	0	10312000	0	960000	1679000	12951000
	9	10.1	57	15644000	0	1621000	1552000	18817000
	10/91	7.1	152	28634000	185000	1665000	1707000	32191000
	11	-2.3	429	33830000	1349000	2643000	1584000	39406000
	12	-12.4	756	39254000	1362000	2820000	1556000	44992000
1992	1/92	-10.8	707					
	2	-8.8	603					
	3	-4.2	502					
	4/92							
ANNUAL TOTALS								
	1989		3,973	272571000	13302000	21145000	24155000	331173000
	1990		3,495	268355000	16951000	29325000	11269000	325900000
	1991		3,435	296135000	9069000	25116000	18682000	349002000

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92 2. Electricity

		TETS GEN MWH	SE PURCH MWH	TOTAL MWH
1989	1/89	57671	58308	115979
	2	53993	50497	104490
	3	56321	54954	111275
	4/89	43188	69844	113032
	5	30072	75582	105654
	6	20199	81466	101665
	7/89	19899	83071	102970
	8	18892	85811	104703
	9	25933	59631	85564
	10/89	40367	64195	104562
	11	53851	61653	115504
	12	39591	81183	120774
1990	1/90	37240	77803	115043
	2	34695	75346	110041
	3	36150	81171	117321
	4/90	35446	75674	111120
	5	32739	72590	105329
	6	27780	69477	97257
	7/90	23869	87767	111636
	8	19278	89830	109108
	9	32449	70117	102566
	10/90	34836	60978	95814
	11	36542	70129	106671
	12	38636	43048	81684
1991	1/91	57644	46127	103771
	2	53559	42565	96124
	3	56043	58396	114439
	4/91	37001	58955	95956
	5	33378	82770	116148
	6	28523	64924	93447
	7/91	19814	74343	94157
	8	18973	59733	78706
	9	27299	59492	86791
	10/91	53282	50562	103844
	11	60722	35707	96429
	12	70103	20036	90139
1992	1/92			
	2			
	3			
	4/92			

ANNUAL TOTALS

1989	459977	826195	1286172
1990	389660	873930	1263590
1991	516341	653610	1169951

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92 3. Heat Supply to factory

		TETS GCAL	PKR BLR GCAL	IND BLR GCAL	TOTAL GCAL
1989	1/89	158973	55889	19398	234260
	2	176636	23683	16830	217149
	3	165131	269	16796	182196
	4/89	134440	5600	20129	160169
	5	92838	5392	8588	106818
	6	58907	193	6550	65650
	7/89	52940	0	3795	56735
	8	45734	0	5866	51600
	9	76070	0	6797	82867
	10/89	133970	0	13597	147567
	11	164827	907	13755	179489
	12	175053	2734	22131	199918
1990	1/90	187859	29641	21764	239264
	2	170259	6941	24605	201805
	3	157166	8606	18002	183774
	4/90	130649	3631	15897	150177
	5	113206	0	18697	131903
	6	62061	0	14367	76428
	7/90	61200	0	11087	72287
	8	47735	0	14242	61977
	9	88598	0	17410	106008
	10/90	139400	12500	17645	169545
	11	148568	25362	18136	192066
	12	165940	28260	21153	215353
1991	1/91	193583	23917	27583	245083
	2	175781	12819	29510	218110
	3	183232	6768	28165	218165
	4/91	138800	0	14484	153284
	5	82934	0	6207	89141
	6	60718	0	7131	67849
	7/91	62193	0	0	62193
	8	44960	0	7018	51978
	9	76435	0	11829	88264
	10/91	145600	1500	12116	159216
	11	175135	9650	19185	203970
	12	208178	11291	20479	239948
1992	1/92				
	2				
	3				
	4/92				

ANNUAL TOTALS

1989	1435519	94667	154232	1684418
1990	1472641	114941	213005	1800587
1991	1547549	65945	183707	1797201

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92 4. Total Heat Supply

		VIZ GCAL	CITY GCAL	TOTAL GCAL
1989	1/89	238803	135817	374620
	2	200319	108816	309135
	3	187136	99880	287016
	4/89	158551	86383	244934
	5	108696	56270	164966
	6	69115	18930	88045
	7/89	59694	14050	73744
	8	54693	7952	62645
	9	86138	39139	125277
	10/89	151577	73776	225353
	11	183152	94994	278146
	12	228135	121492	349627
1990	1/90	243752	127416	371168
	2	206207	97365	303572
	3	188580	84783	273363
	4/90	152772	72638	225410
	5	134558	53913	188471
	6	79079	17860	96939
	7/90	74687	17493	92180
	8	65899	8698	74597
	9	110714	51187	161901
	10/90	172668	84724	257392
	11	194975	97255	292230
	12	218462	112243	330705
1991	1/91	248776	125152	373928
	2	220759	109381	330140
	3	221101	106225	327326
	4/91	156844	80402	237246
	5	92393	53941	146334
	6	70332	22353	92685
	7/91	67107	20370	87477
	8	57512	11830	69342
	9	91728	38509	130237
	10/91	162516	85406	247922
	11	206994	103199	310193
	12	243448	124649	368097
1992	1/92			
	2			
	3			
	4/92			

ANNUAL TOTALS

1989	1726009	857499	2583508
1990	1842353	825575	2667928
1991	1839510	881417	2720927

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92

5. Water Consumption

		IND M3	DOMESTIC M3	TOTAL M3
1989	1/89	704000	67000	771000
	2	645000	62000	707000
	3	706000	65000	771000
	4/89	728000	65000	793000
	5	641000	63000	704000
	6	771000	63000	834000
	7/89	834000	68000	902000
	8	629000	73000	702000
	9	629000	68000	697000
	10/89	733000	70000	803000
	11	683000	72000	755000
	12	756000	76000	832000
1990	1/90	774000	65000	839000
	2	674000	61000	735000
	3	747000	69000	816000
	4/90	715000	66000	781000
	5	722000	69000	791000
	6	790000	55000	845000
	7/90	743000	59000	802000
	8	658000	62000	720000
	9	723000	59000	782000
	10/90	667000	56000	723000
	11	775000	50000	825000
	12	774000	53000	827000
1991	1/91	658000	51000	709000
	2	693000	59000	752000
	3	758000	53000	811000
	4/91	769000	53000	822000
	5	806000	54000	860000
	6	878000	44000	922000
	7/91	781000	54000	835000
	8	661000	54000	715000
	9	592000	52000	644000
	10/91	743000	51000	794000
	11	782000	52000	834000
	12	887000	54000	941000
1992	1/92			
	2			
	3			
	4/92			
ANNUAL TOTALS				
	1989	8459000	812000	9271000
	1990	8762000	724000	9486000
	1991	9008000	631000	9639000

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC

15-Apr-92

6. TETS - Fuel Charged to Power

		GAS->ELE M3	GAS->HEAT M3	TOTAL M3	GAS->ELE GCAL	GAS->HEAT GCAL
1989	1/89	8133000	23641000	31774000	64617	187828
	2	7551000	22757000	30308000	59993	180804
	3	7909000	24254000	32163000	62837	192698
	4/89	5693000	18545000	24238000	45231	147340
	5	3886000	13604000	17490000	30874	108084
	6	3085000	8408000	11493000	24510	66802
	7/89	3463000	7533000	10996000	27514	59850
	8	3797000	6528000	10325000	30167	51865
	9	4788000	10958000	15746000	38041	87061
	10/89	6244000	19452000	25696000	49609	154546
	11	8268000	24025000	32293000	65689	190879
	12	4699000	25350000	30049000	37334	201406
1990	1/90	4303000	26064000	30367000	34187	207078
	2	3791000	23057000	26848000	30119	183188
	3	4781000	22603000	27384000	37985	179581
	4/90	4587000	18037000	22624000	36444	143304
	5	4366000	15759000	20125000	34688	125205
	6	4717000	9295000	14012000	37477	73849
	7/90	4096000	8685000	12781000	32543	69002
	8	3809000	6876000	10685000	30263	54630
	9	5473000	12646000	18119000	43483	100472
	10/90	4127000	20609000	24736000	32789	163739
	11	4920000	23783000	28703000	39089	188956
	12	5957000	26014000	31971000	47328	206681
1991	1/91	8673000	27227000	35900000	68907	216319
	2	7700000	24732000	32432000	61177	196496
	3	8250000	24950000	33200000	65546	198228
	4/91	4752000	19566000	24318000	37755	155452
	5	4860000	11983000	16843000	38613	95205
	6	4565000	8800000	13365000	36269	69916
	7/91	3471000	8932000	12403000	27577	70965
	8	3823000	6489000	10312000	30374	51555
	9	4600000	11044000	15644000	36547	87745
	10/91	7474000	21160000	28634000	59381	168116
	11	8642000	25188000	33830000	68661	200119
	12	8904000	30350000	39254000	70742	241131
1992	1/92					
	2					
	3					
	4/92					
ANNUAL TOTALS						
	1989	67516000	205055000	272571000	536415	1629162
	1990	54927000	213428000	268355000	436395	1695685
	1991	75714000	220421000	296135000	601548	1751245

VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC
15-Apr-92

7. Efficiency ratios

		TETS HR kcal/kWh (charged)	TETS HR kcal/kWh (total)	ETS BLR %	IND BLR %	PKR BLR %
1989	1/89	1,120	4,377	84.6%	91.6%	92.6%
	2	1,111	4,460	97.7%	92.0%	82.7%
	3	1,116	4,537	85.7%	92.8%	89.1%
	4/89	1,047	4,459	91.2%	91.5%	90.9%
	5	1,027	4,621	85.9%	92.5%	90.0%
	6	1,213	4,521	88.2%	91.0%	90.0%
	7/89	1,383	4,390	88.5%	91.9%	
	8	1,597	4,342	88.2%	93.2%	
	9	1,467	4,824	87.4%	91.5%	
	10/89	1,229	5,057	86.7%	91.5%	
	11	1,220	4,764	86.4%	91.6%	89.9%
	12	943	6,030	86.9%	91.4%	90.1%
1990	1/90	918	6,479	90.7%	91.0%	74.4%
	2	868	6,148	92.9%	91.3%	89.4%
	3	1,051	6,018	87.5%	91.4%	90.0%
	4/90	1,028	5,071	91.2%	91.2%	90.0%
	5	1,060	4,884	90.4%	92.1%	
	6	1,349	4,007	84.0%	91.3%	
	7/90	1,363	4,254	88.7%	91.6%	
	8	1,570	4,404	87.4%	91.4%	
	9	1,340	4,436	88.2%	91.3%	
	10/90	941	5,642	85.1%	91.4%	90.0%
	11	1,070	6,241	78.6%	91.6%	90.0%
	12	1,225	6,574	80.3%	91.6%	90.0%
1991	1/91	1,195	4,948	89.5%	95.1%	87.7%
	2	1,142	4,811	89.5%	91.5%	90.0%
	3	1,170	4,707	92.4%	91.3%	90.0%
	4/91	1,020	5,222	89.3%	91.7%	
	5	1,157	4,009	87.1%	91.7%	
	6	1,272	3,723	86.8%	92.2%	
	7/91	1,392	4,973	87.6%		
	8	1,601	4,318	87.2%	92.0%	
	9	1,339	4,553	87.1%	91.8%	
	10/91	1,114	4,270	86.6%	91.6%	102.1%
	11	1,131	4,426	87.5%	91.4%	90.0%
	12	1,009	4,449	86.3%	91.4%	104.3%
1992	1/92					
	2					
	3					
	4/92					
ANNUAL TOTALS						
	1989	1,206	4,699	88.1%	91.9%	89.4%
	1990	1,149	5,347	87.1%	91.4%	87.7%
	1991	1,212	4,534	88.1%	92.0%	94.0%

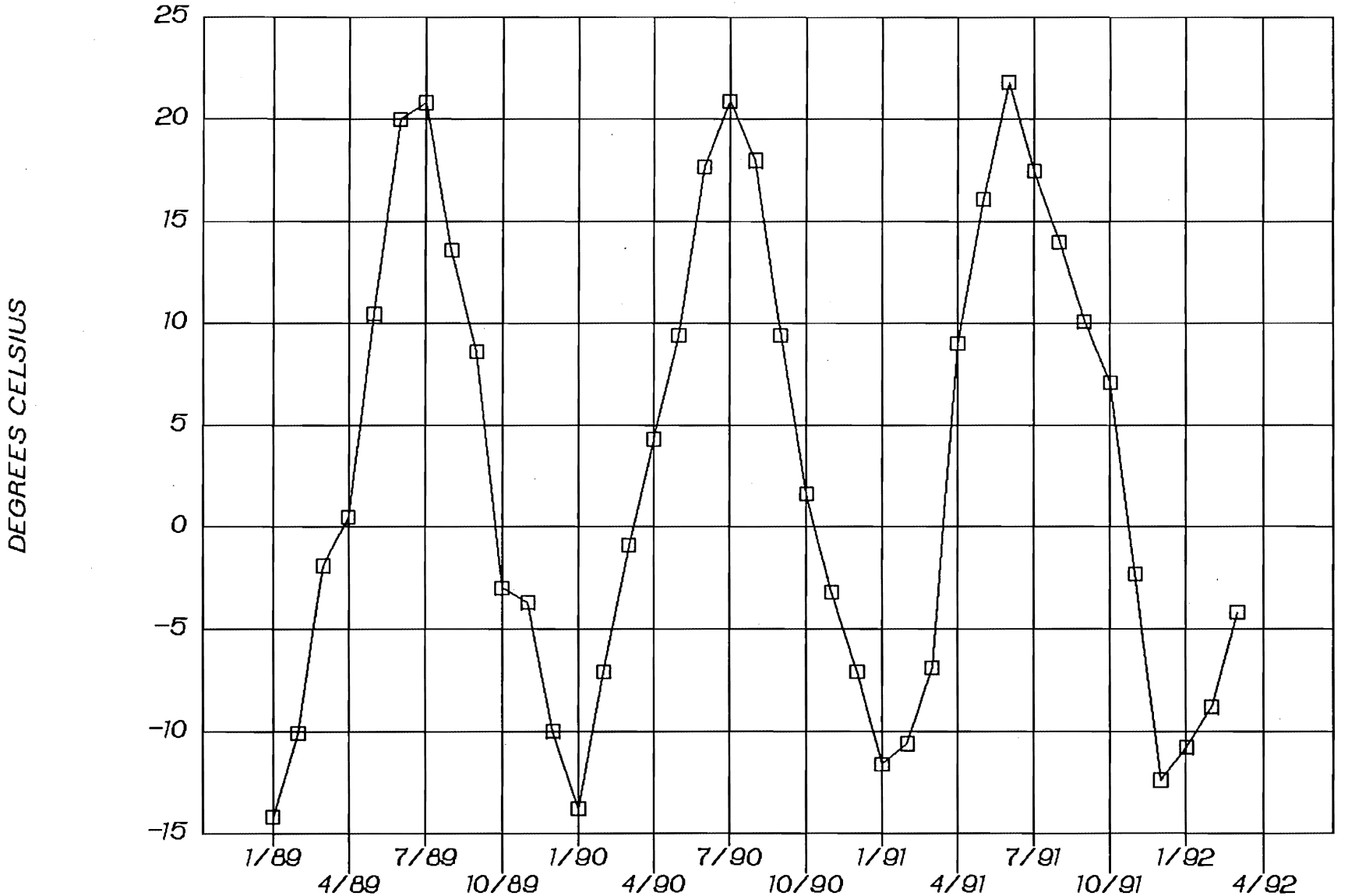
VERCH-ISETSKY METALLURGICAL PLANT (VIZ)
EKATERINBURG, RUSSIA
RCG/HAGLER, BAILLY, INC
15-Apr-92

8. Efficiency ratios

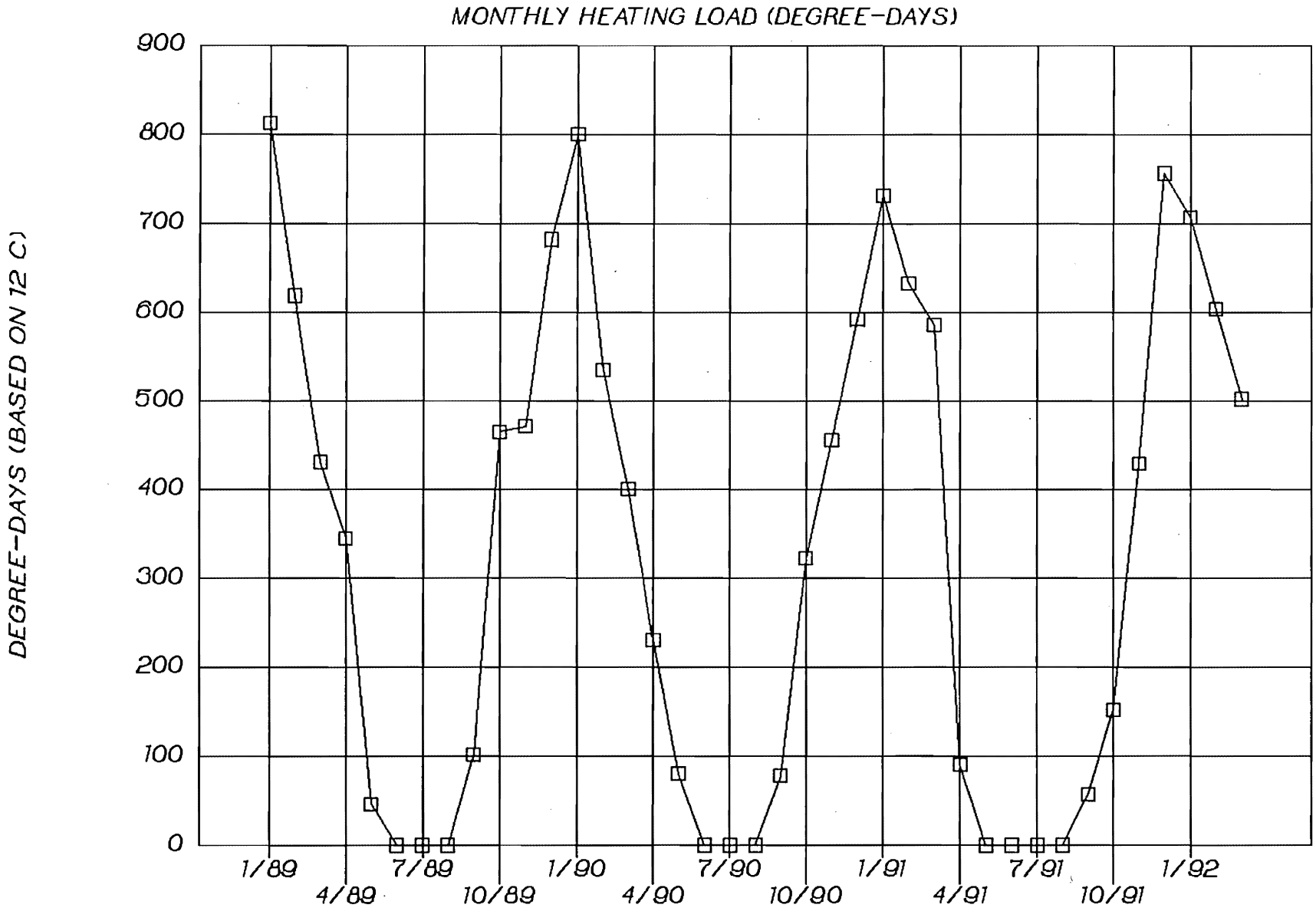
		VIZ Gcal/degday	CITY Gcal/degday
1989	1/89	220	155
	2	227	160
	3	295	209
	4/89	286	221
	5	1047	995
	6		
	7/89		
	8		
	9	256	286
	10/89	197	137
	11	261	180
	12	247	163
1990	1/90	230	147
	2	273	163
	3	322	187
	4/90	402	271
	5	925	545
	6		
	7/90		
	8		
	9	650	528
	10/90	349	232
	11	296	191
	12	268	173
1991	1/91	258	157
	2	254	157
	3	275	164
	4/91	1076	782
	5		
	6		
	7/91		
	8		
	9	557	500
	10/91	675	496
	11	343	217
	12	243	152
1992	1/92		
	2		
	3		
	4/92		
ANNUAL TOTALS			
	1989	337	278
	1990	413	271
	1991	460	328

EKATERINBURG DISTRICT HEATING

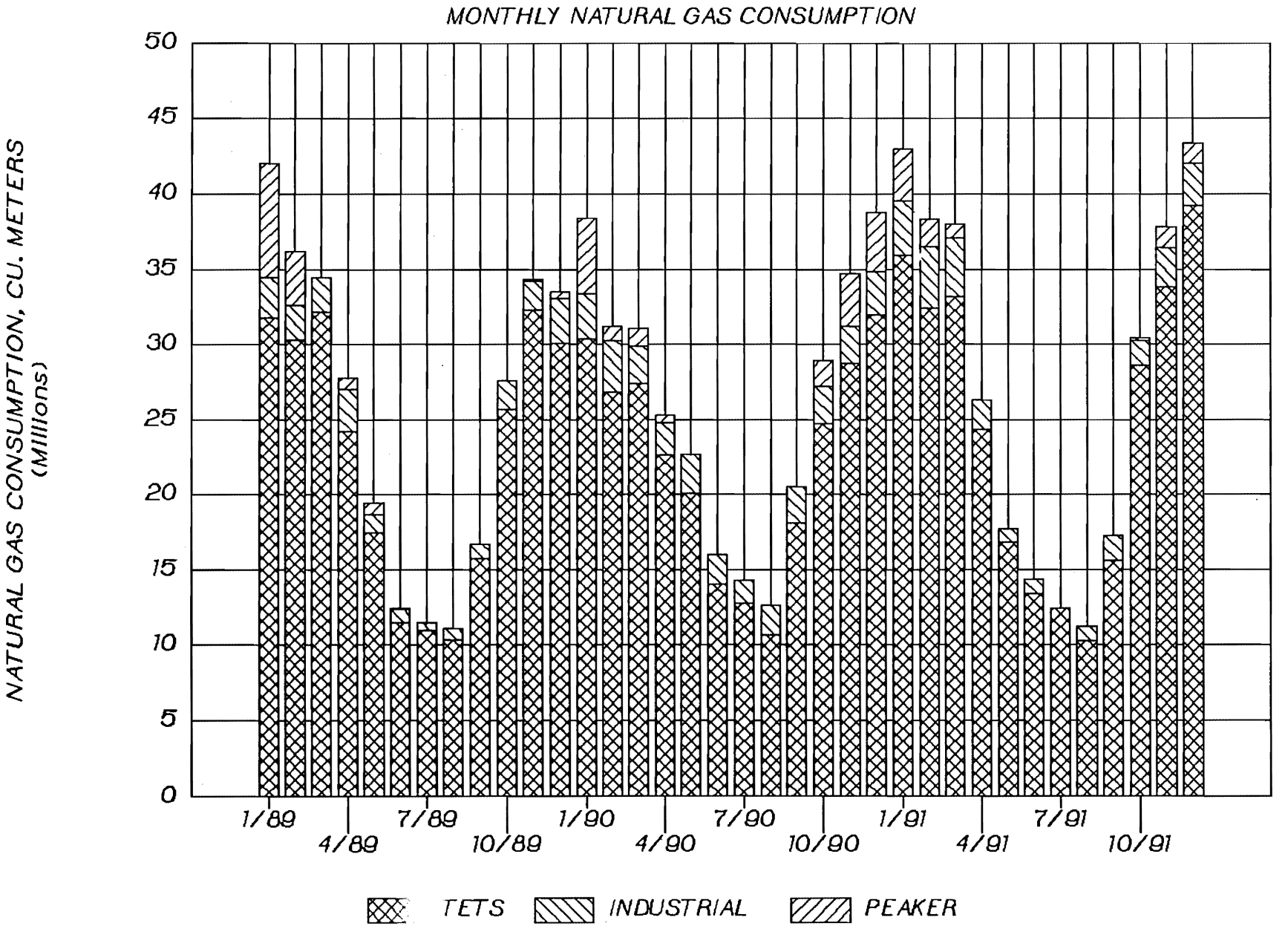
MONTHLY AVERAGE AMBIENT TEMPERATURE



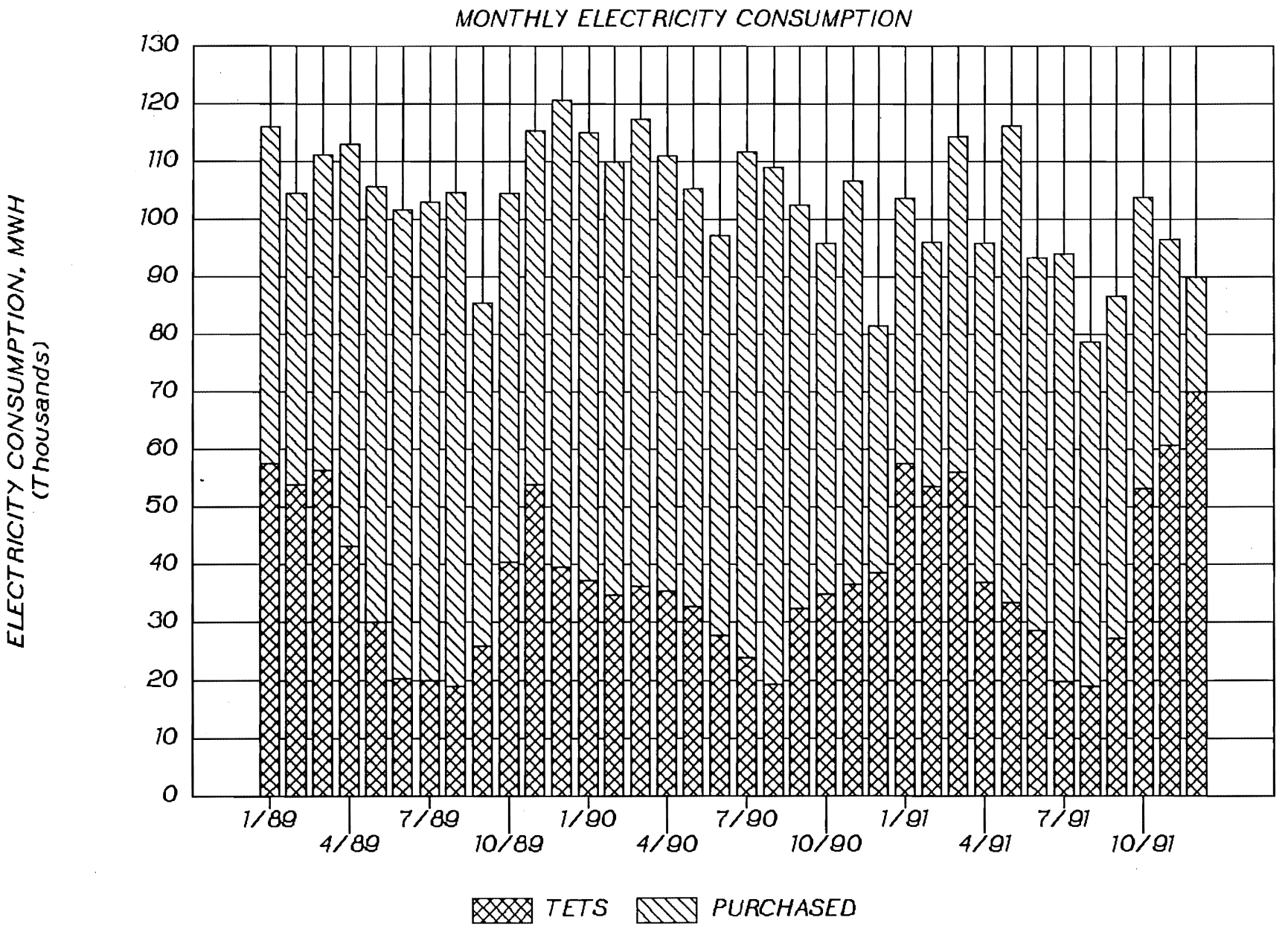
EKATERINBURG DISTRICT HEATING



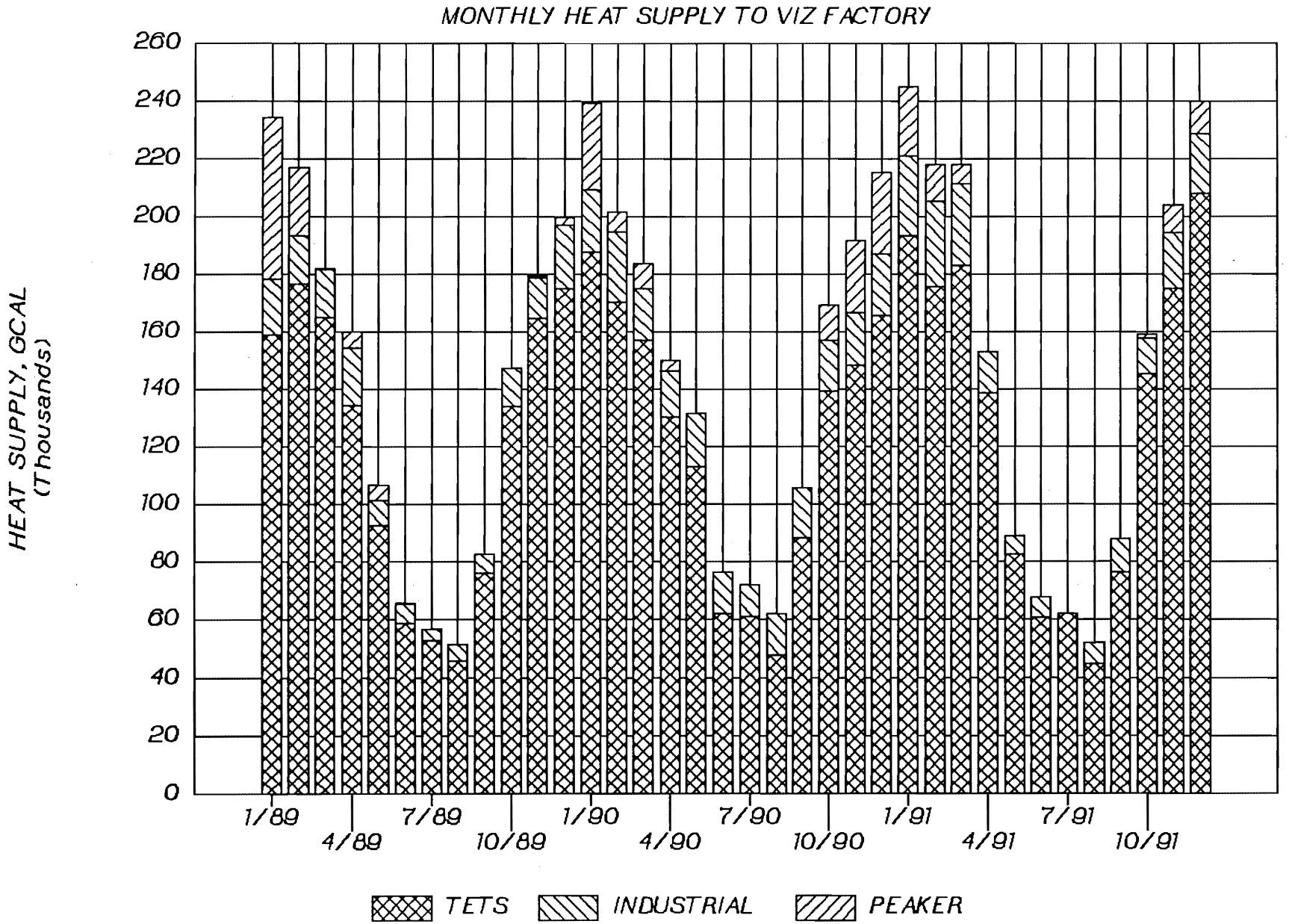
EKATERINBURG DISTRICT HEATING - VIZ



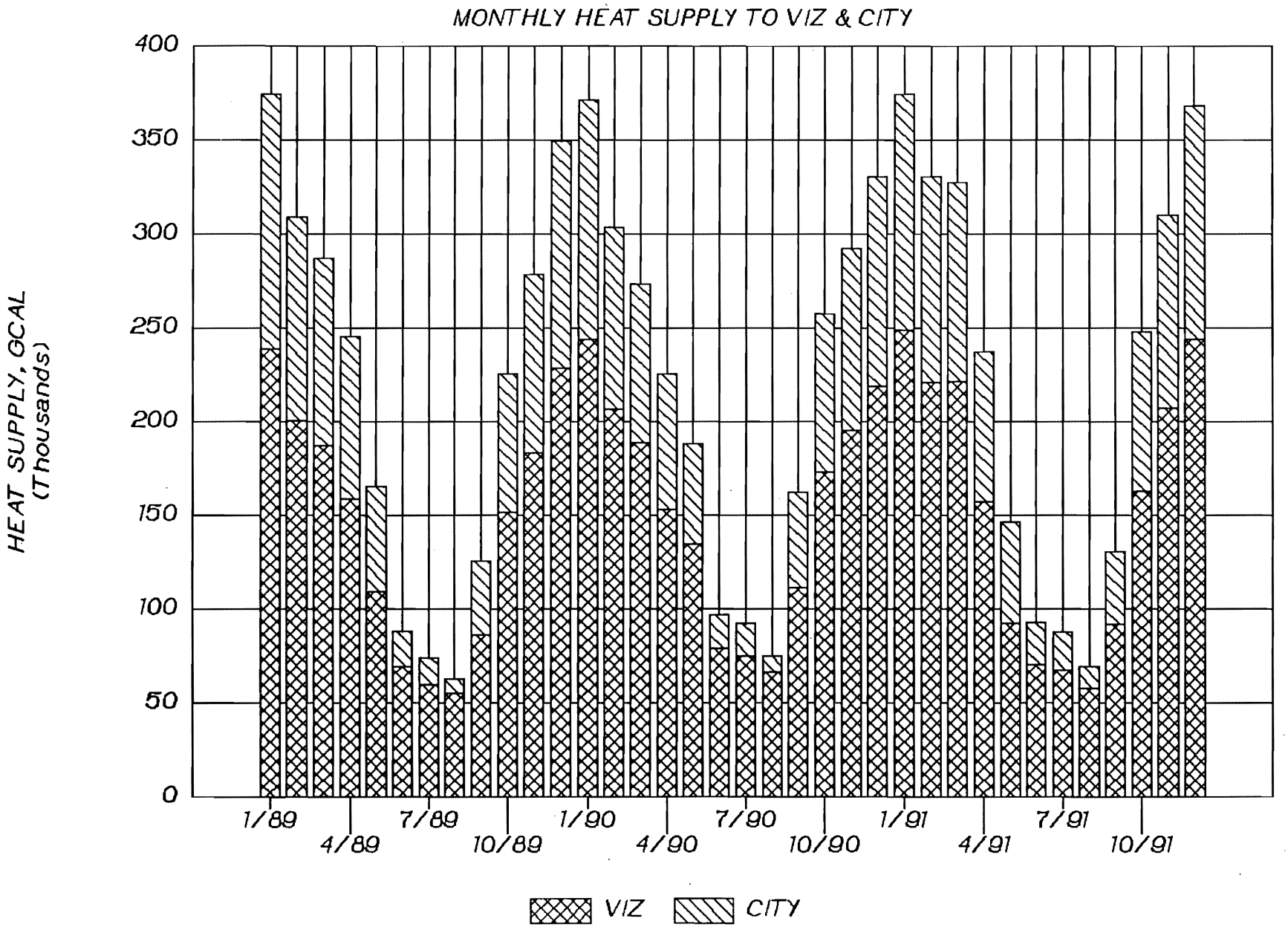
EKATERINBURG DISTRICT HEATING - VIZ



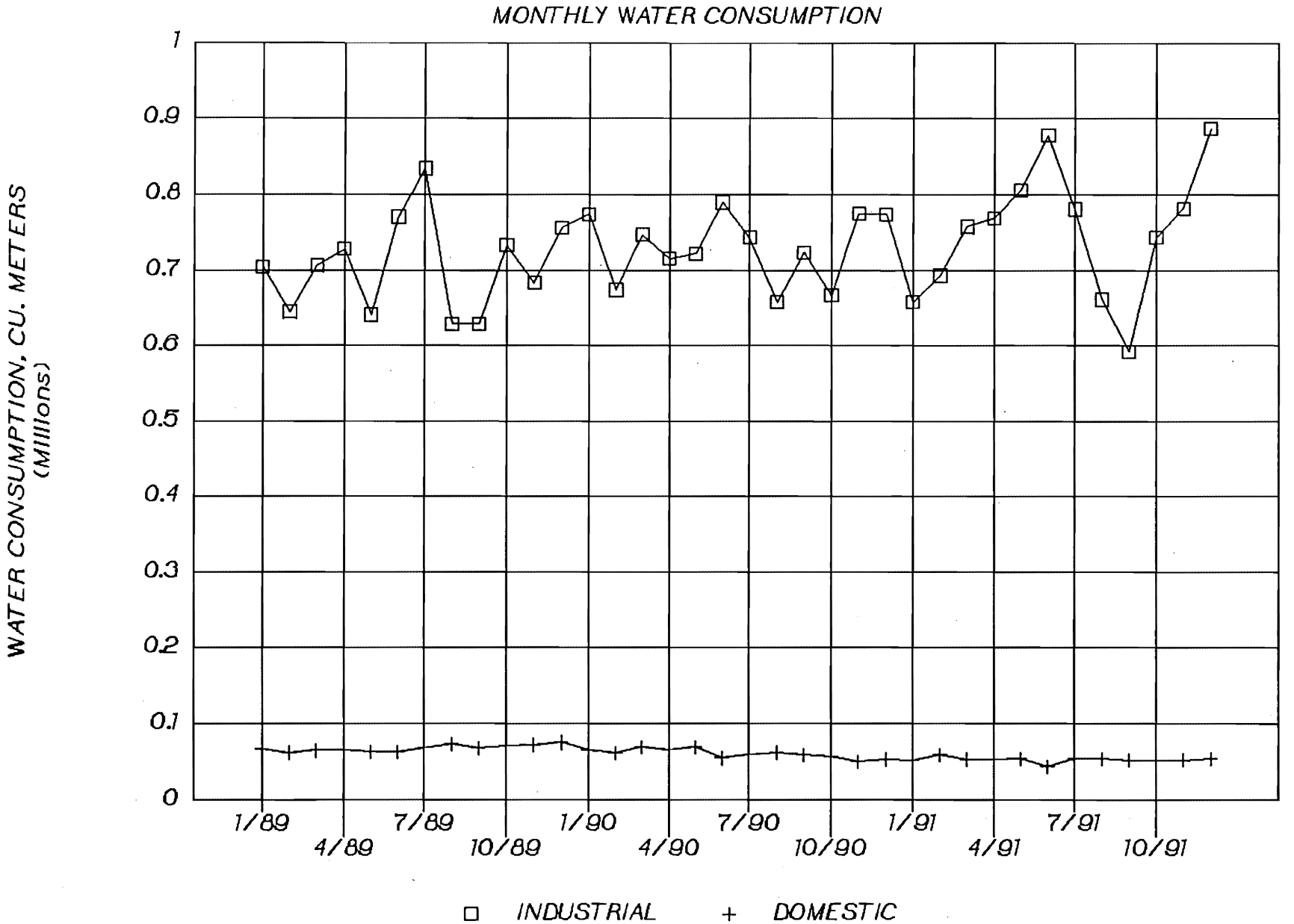
EKATERINBURG DISTRICT HEATING - VIZ



EKATERINBURG DISTRICT HEATING - VIZ



EKATERINBURG DISTRICT HEATING - VIZ



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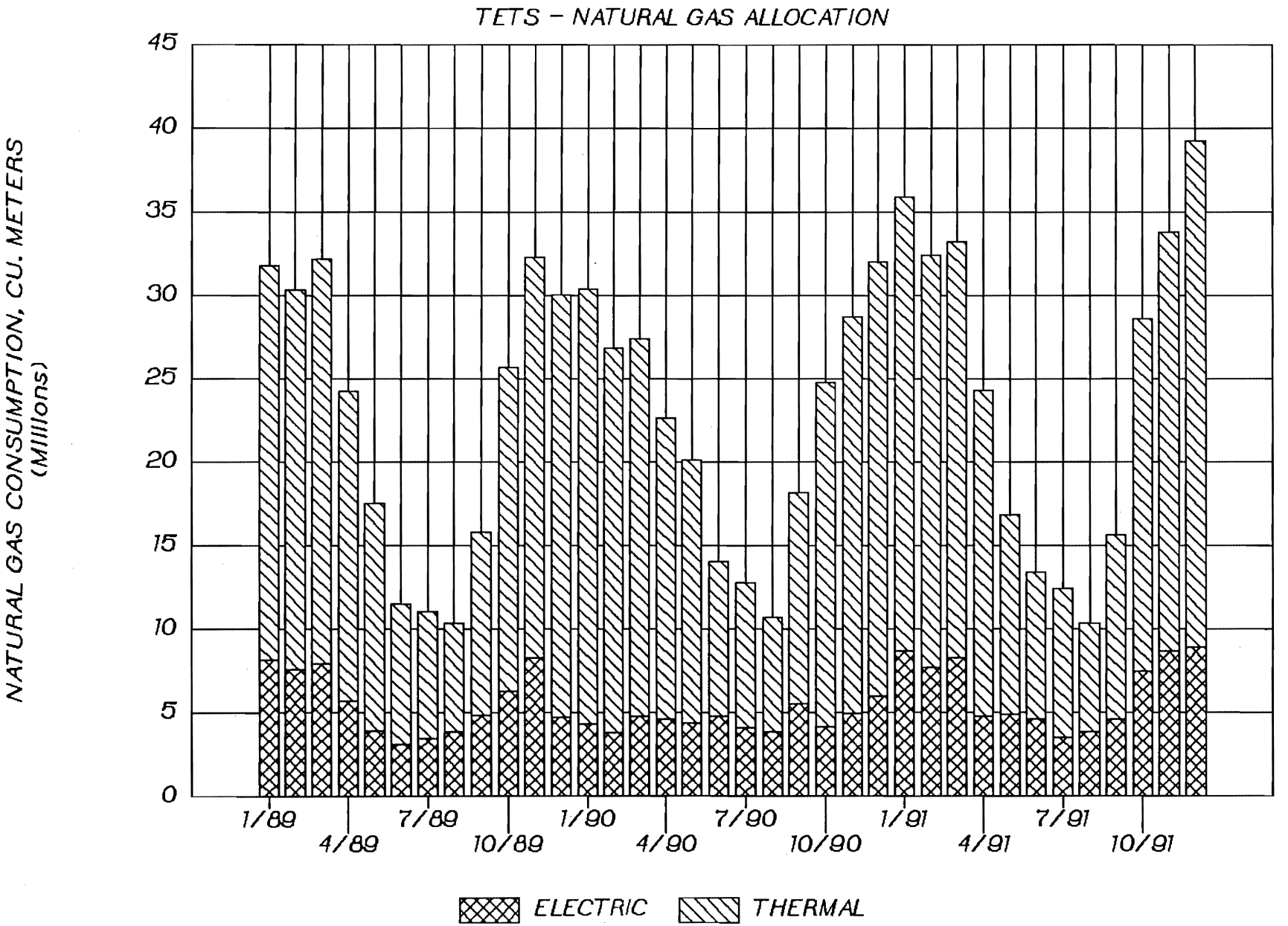

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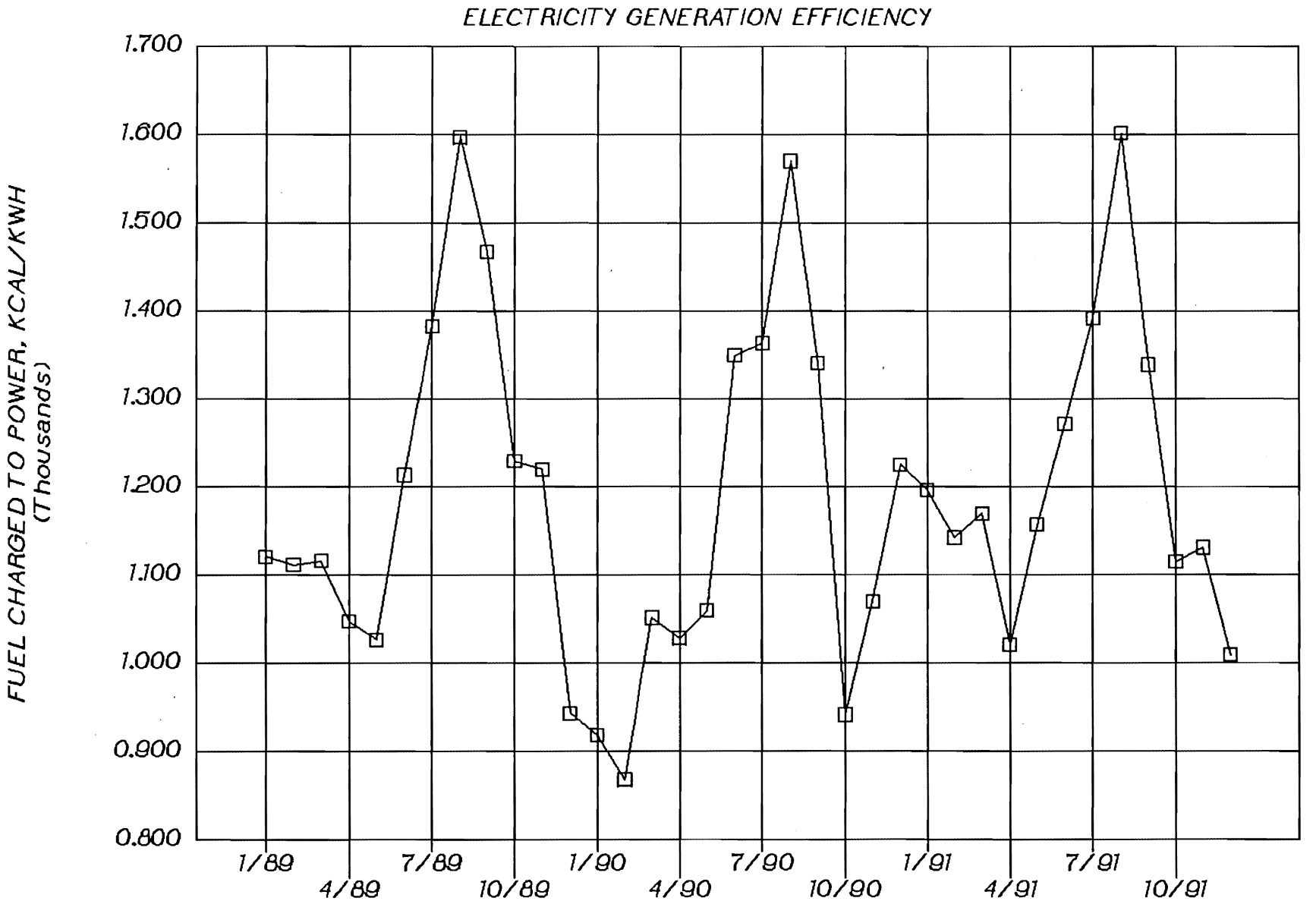

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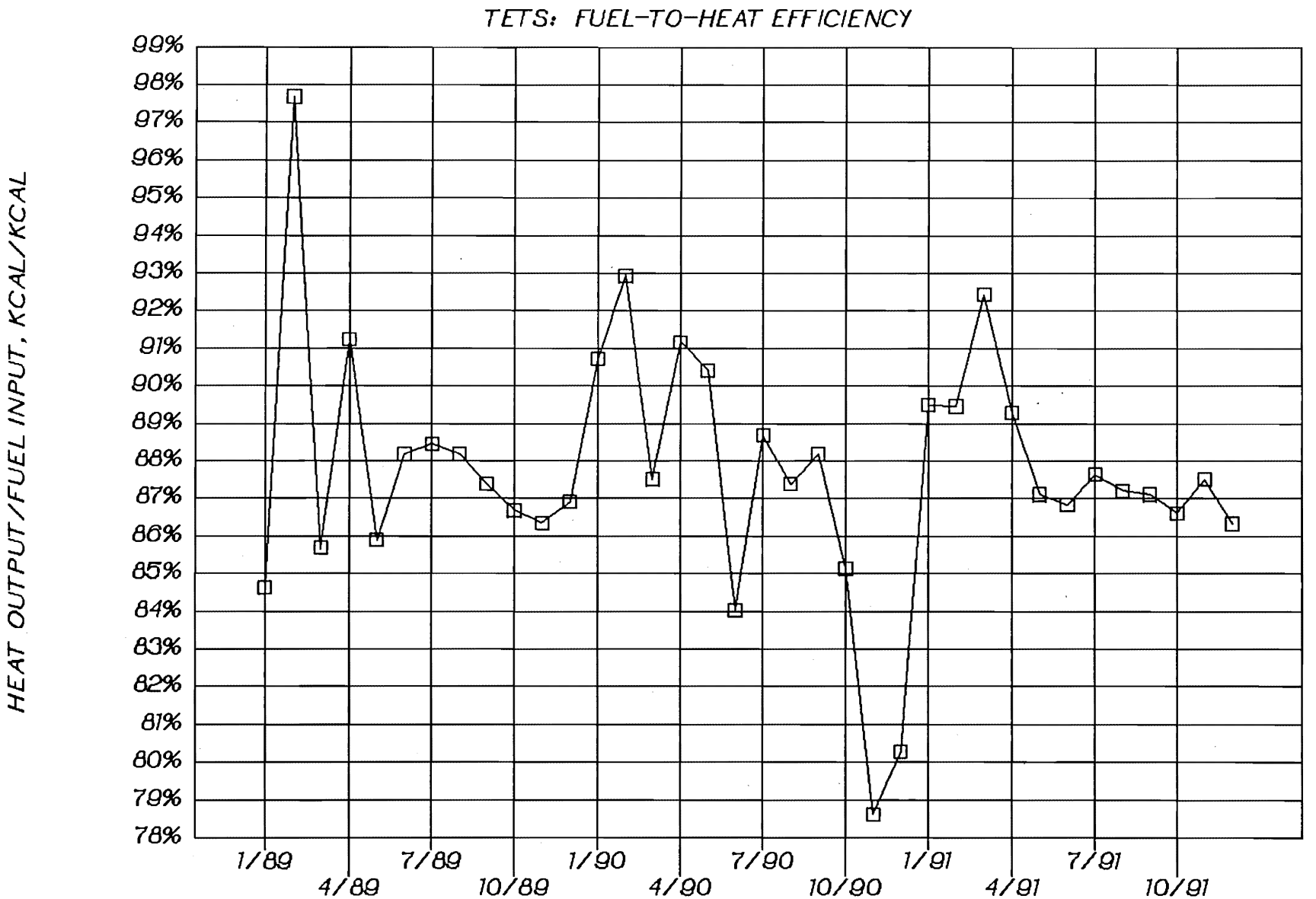

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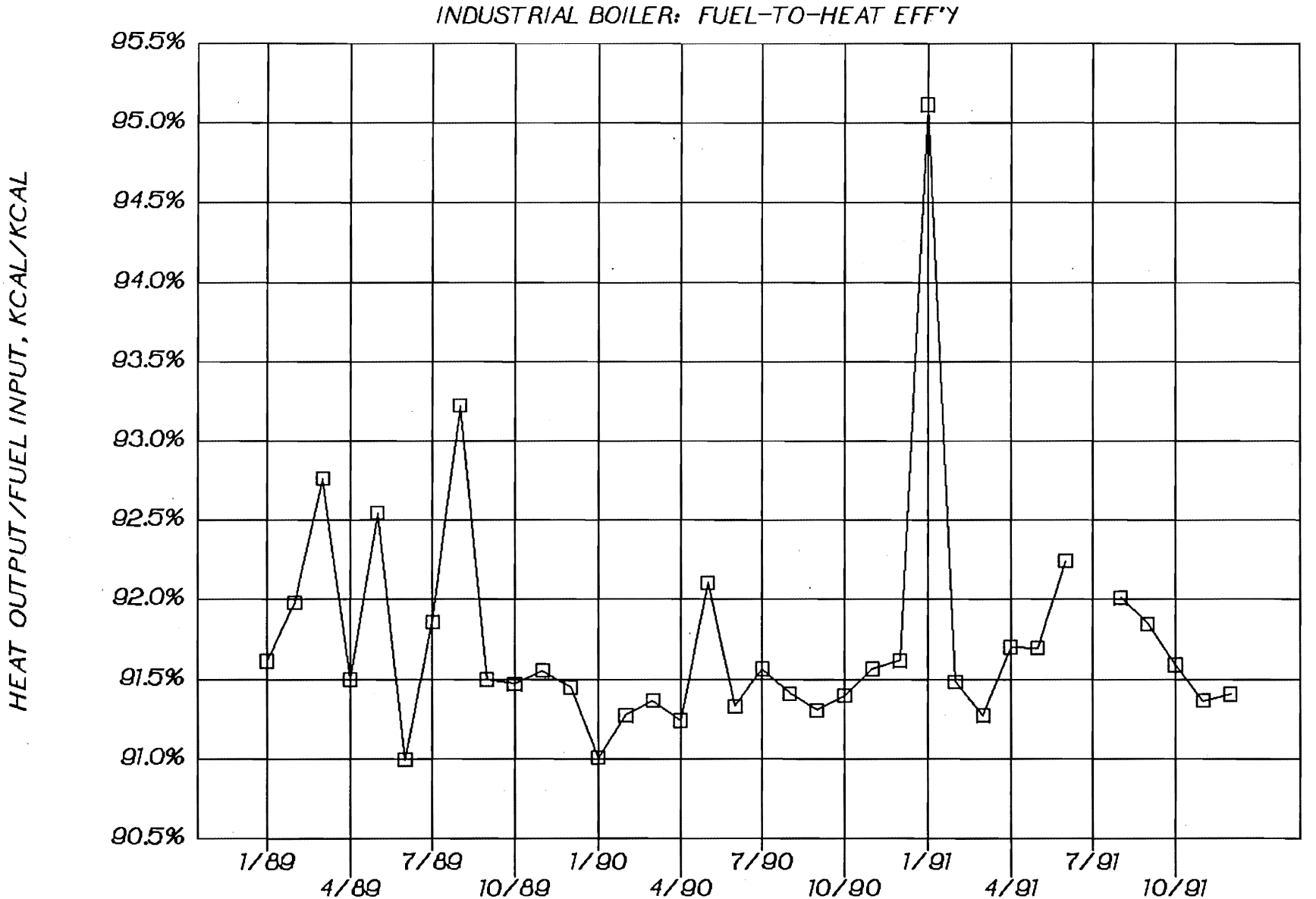

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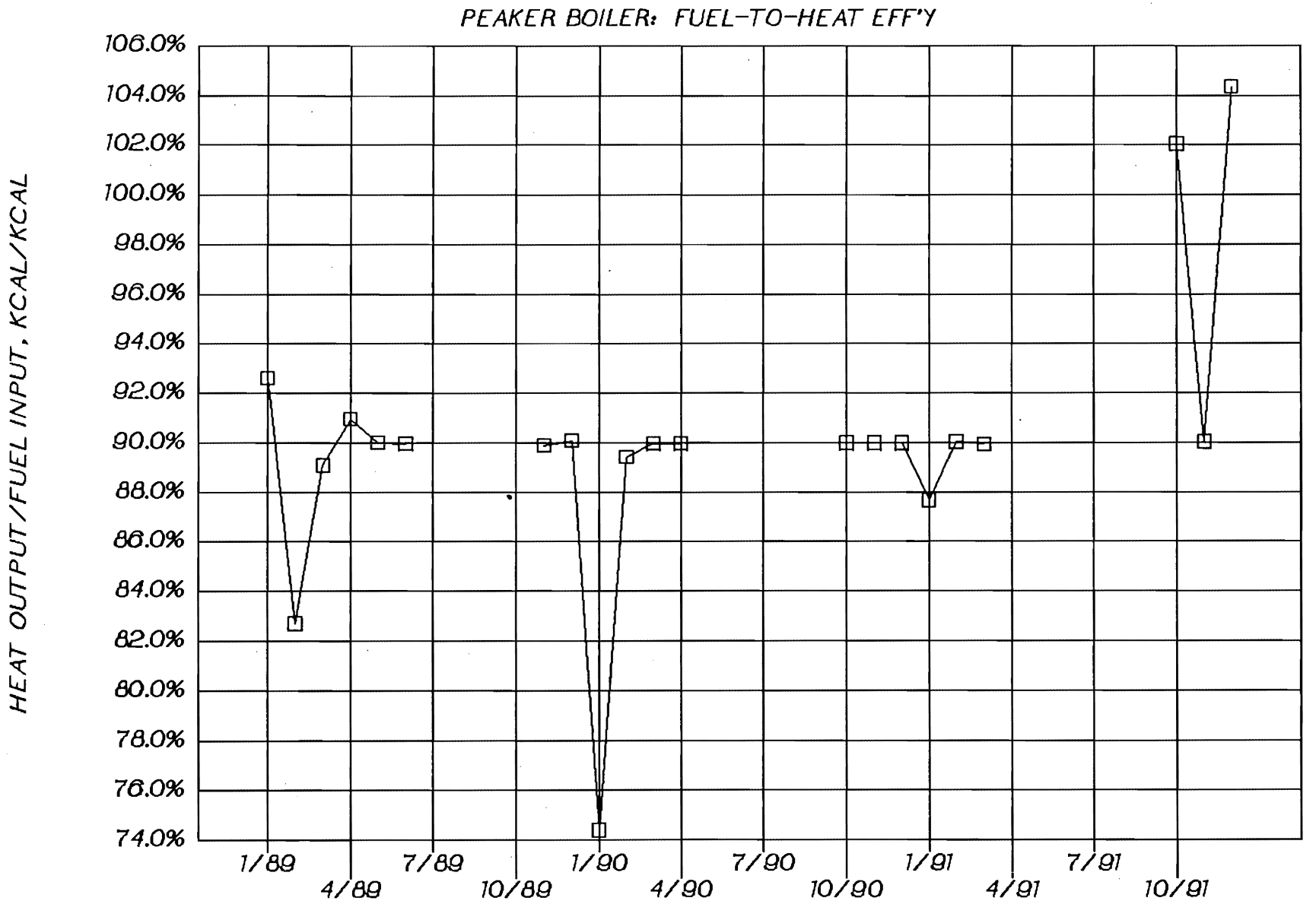

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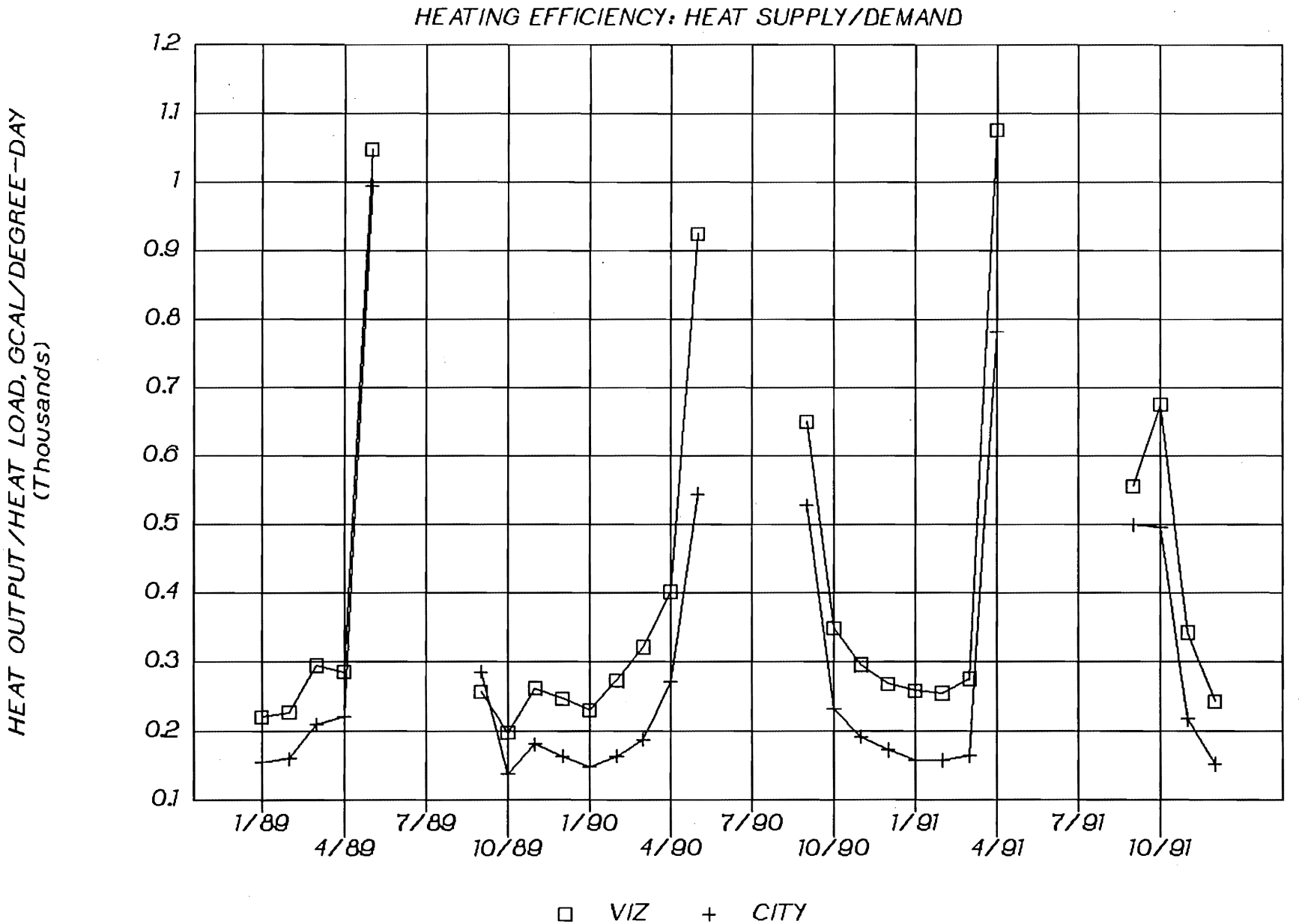

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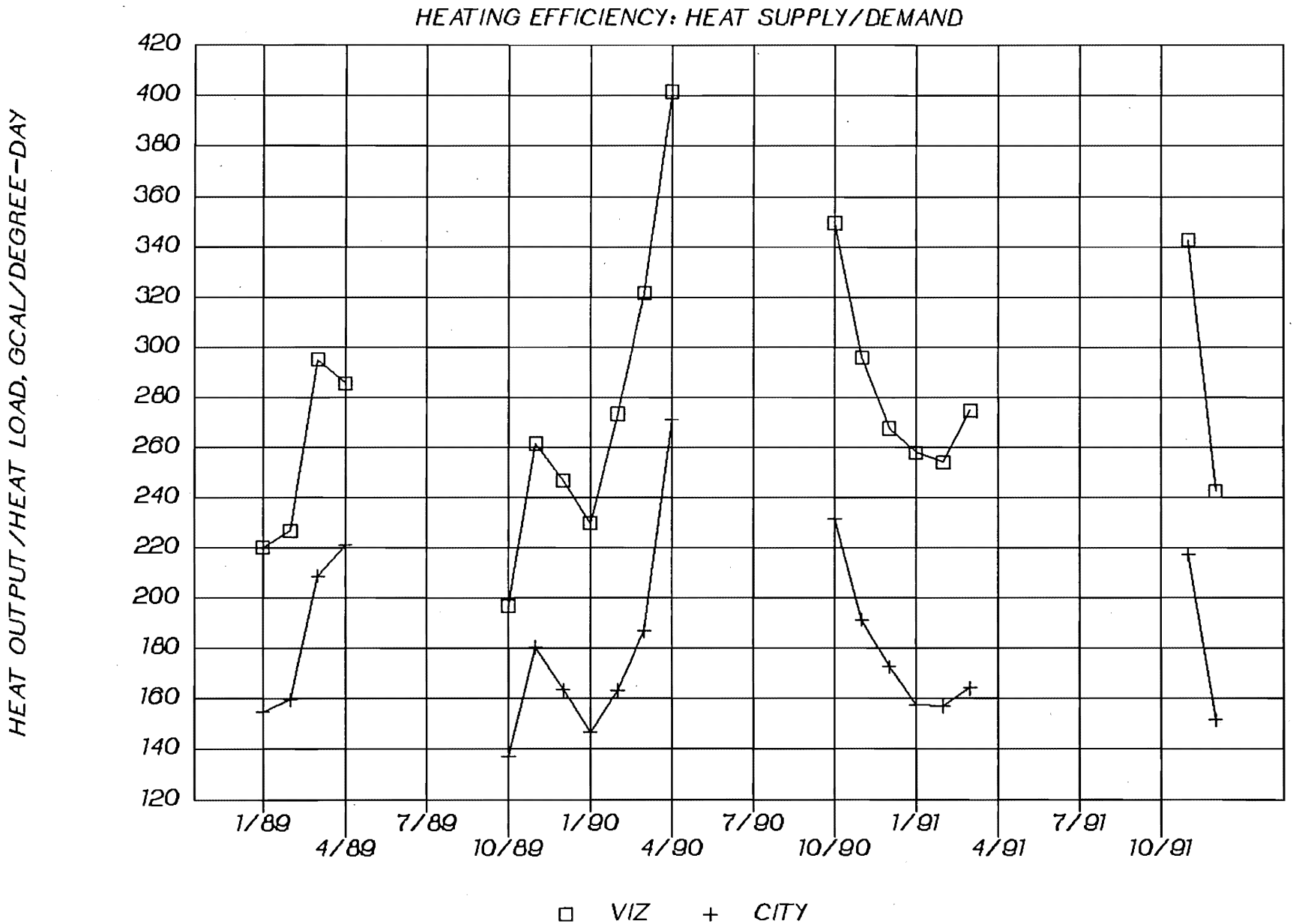
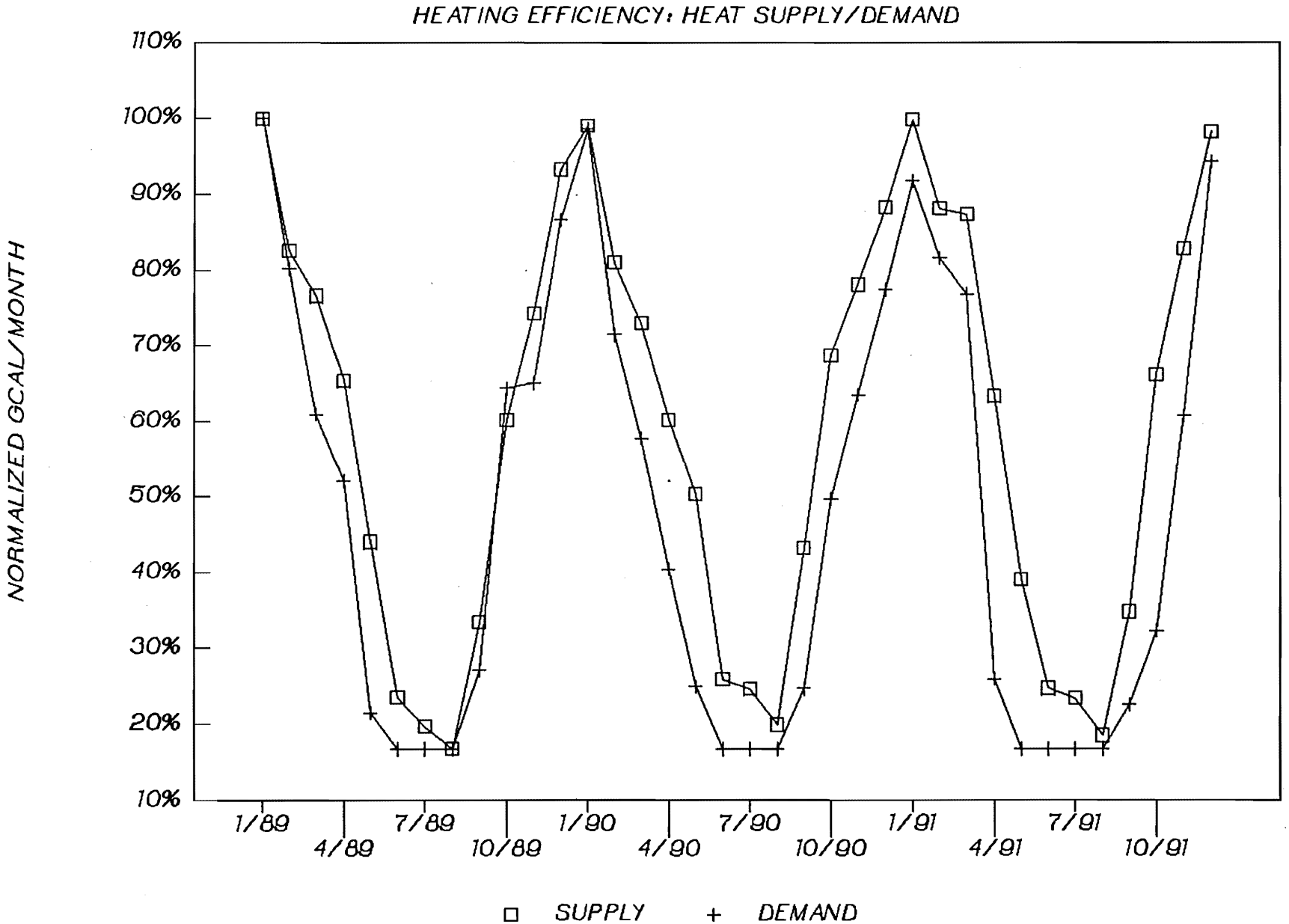


EKATERINBURG DISTRICT HEATING - VIZ



ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 5
CALCULATIONS ON EFFECT OF INSULATION
BY UNIVERSITY OF PITTSBURGH

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 — Page 1 of 1

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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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BEST AVAILABLE COPY

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
uel Oil	0	0.000	0	0.000
ropane	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:
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 <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.
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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

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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:
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   Gross floor area = 59,495 sqft
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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

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ABLE 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

	<----- Site Energy ----->		<---- Source Energy ---->	
Component	(kBTU)	(kBTU/sqft)*	(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
uel Oil	0	0.000	0	0.000
ropane	0	0.000	0	0.000
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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 —

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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 %
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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 — Page 1 of 1

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TABLE 1. ANNUAL LOADS

Component	(MJ)	(MJ/sqm)*
Cooling Loads *	0	0.000
Heating Loads *	2,567,536	464.522

****

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
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 2 — 25-05-92
Site : Helsinki, Finland — 6100190202
Prepared By : UNIVERSITY OF PITTSBURGH
Carrier Hourly Analysis Program —

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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:
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ENERGY BUDGET <B>

Building : MOSCOW 2 — 25-05-92
Site : Helsinki, Finland — 6100190202
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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 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
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ENERGY BUDGET <A>

Building : MOSCOW 2 — 25-05-92
Site : Helsinki, Finland — 6100190202
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Carrier Hourly Analysis Program —

****

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

****

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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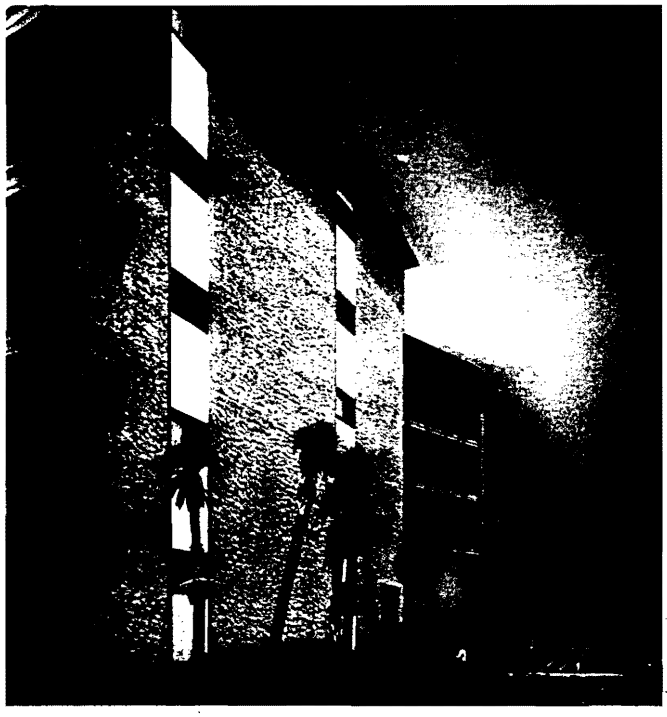
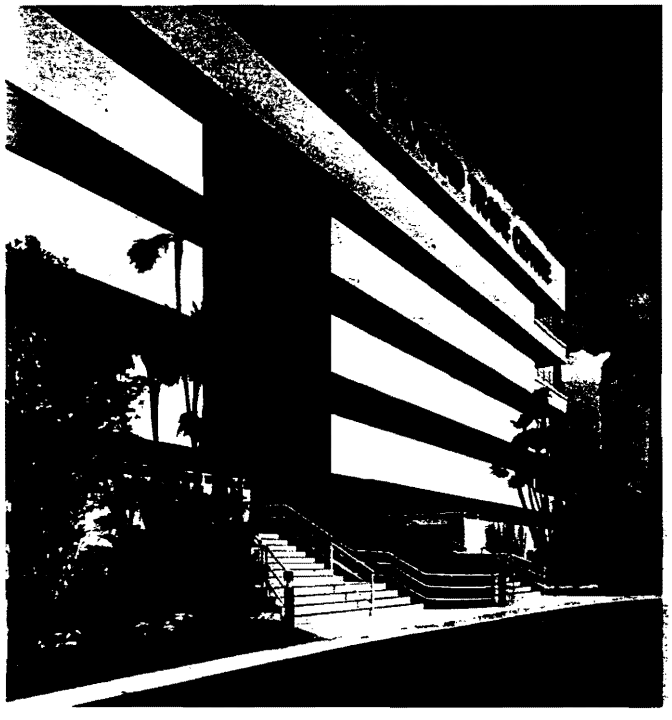
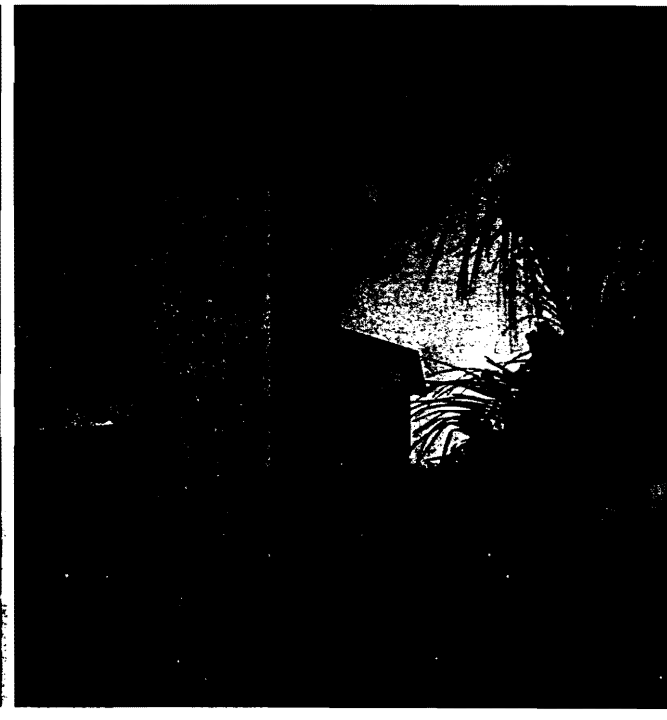
SUREWALL®
PRODUCTS & SYSTEMS

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 [illegible] in lieu of mortar in the construction [illegible]ystacked 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.

[illegible]/ANTAGES

[illegible]REWALL 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

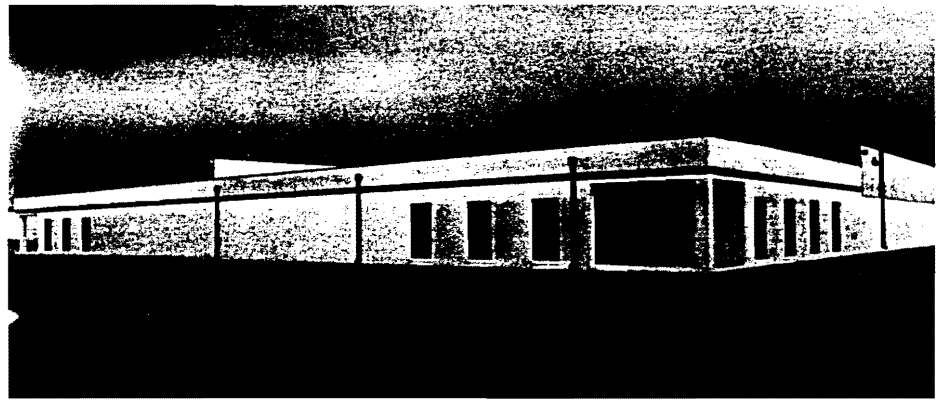
The durability of walls drystacked with one coat per side of SUREWALL® Surface Bonding Cement makes it an especially good choice for high traffic and/or high abuse buildings such as shopping centers and warehouses, of one to two stories, where economical and attractive finishes are important. In addition 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.

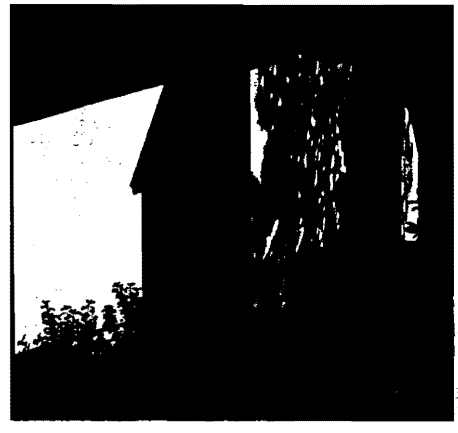
The superior exterior insulation envelope achieved with the SUREWALL SBC Insulation System makes it ideal where temperature regulation is important and where HVAC loads are heavy.



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.

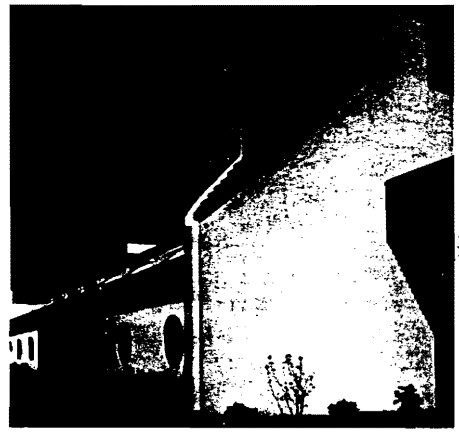
Attractive, finished, exterior insulation envelopes can be created in one coat by utilizing the wire mesh-reinforced SUREWALL® FRP Insulation System. Seamless, monolithic walls up to 30 feet long are possible. It allows architectural design freedom. The economy of open-stud construction can be realized 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

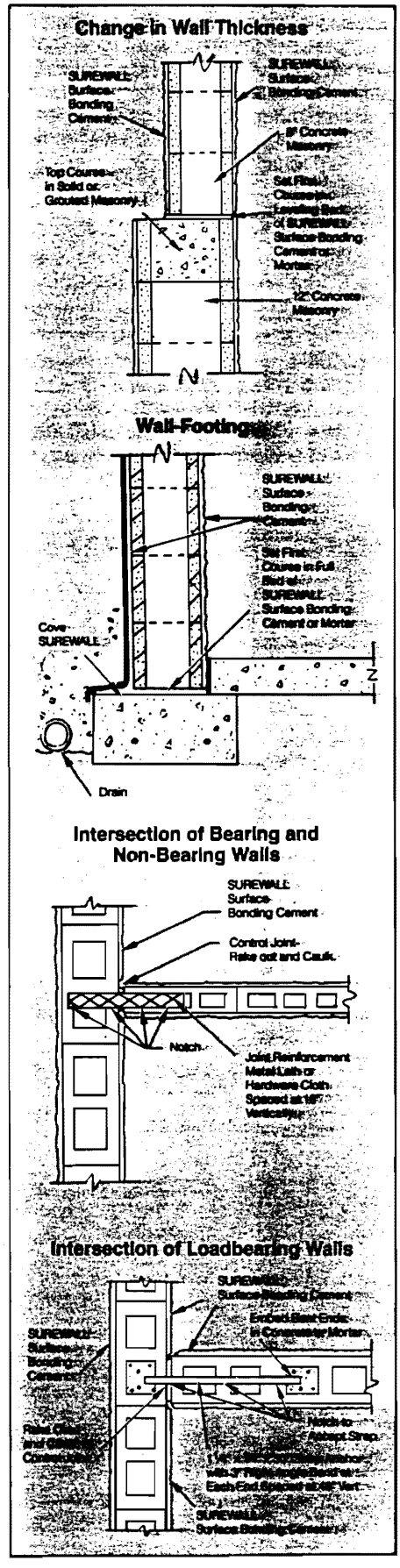
The surface bonding cement shall be SUREWALL Surface Bonding Cement, a factory prepared mixture that needs only the addition of water and meets ASTM-C-887.

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."



STRUCTURAL PROPERTIES*—Unreinforced Wall Assemblages

SUREWALL® Surface Bonding Cement ⅛" thickness over block VS. Mortar, conventional construction.

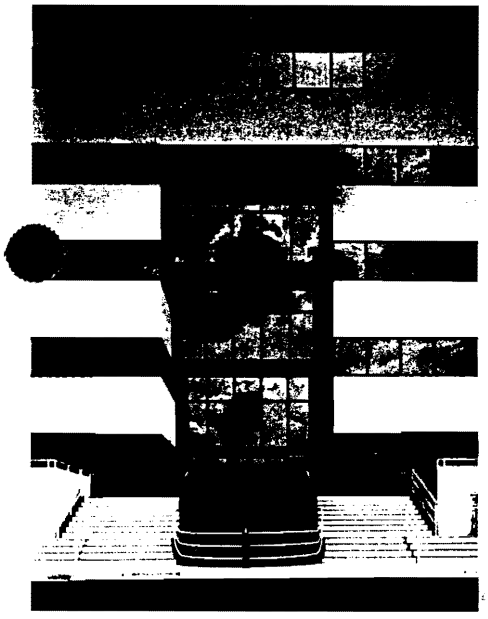
Type Construction	Block Thickness	Height/Thickness	Block Strength Gross Area	Ultimate Wall Strength—Gross Area psi	kips
Compressive—Axial Loading					
Mortar, Type N (4 walls tested)	8"	9.0 H / T	960 psi	570	204
SUREWALL (3 walls tested)	8"	11.9 H / T	980 psi	410	148
Compressive-Eccentric Loading T/6 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

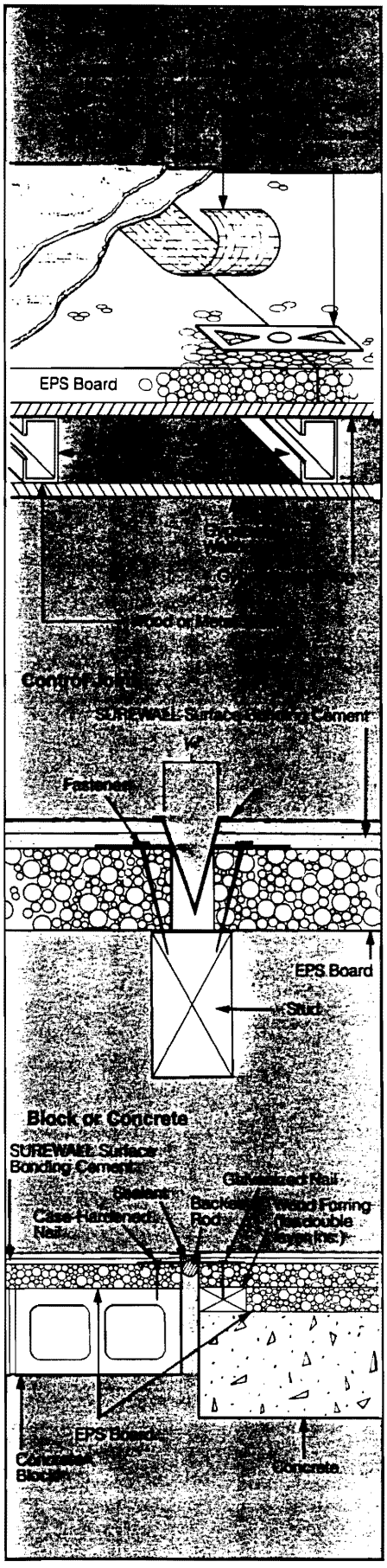
A pronged, 20 gauge patented, galvanized metal clip, used with standard screws or nails for mechanical fastening.

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

STEM 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.

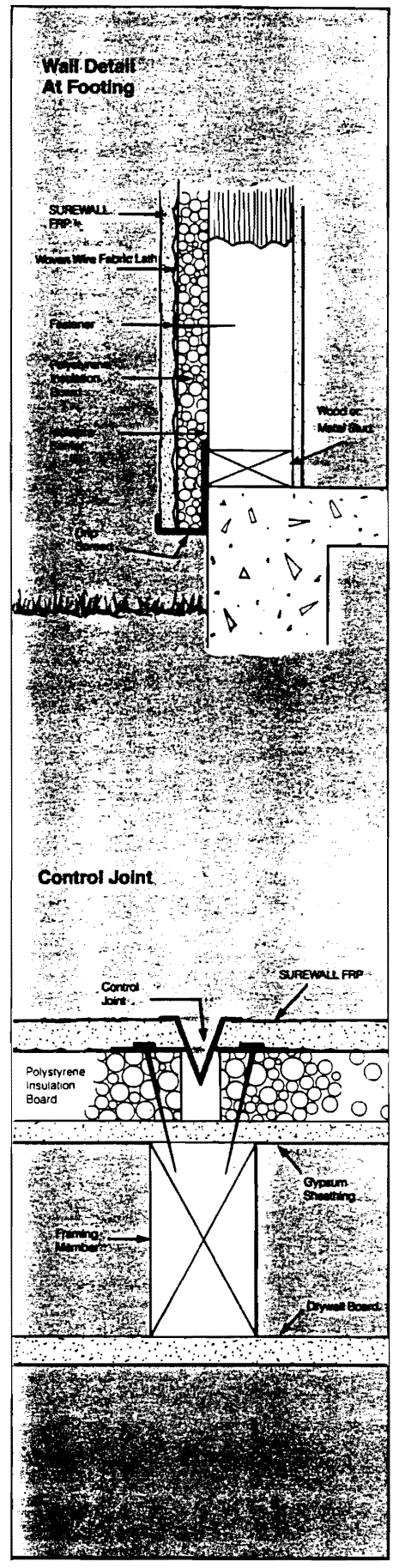
Accessories

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.



[AI] 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

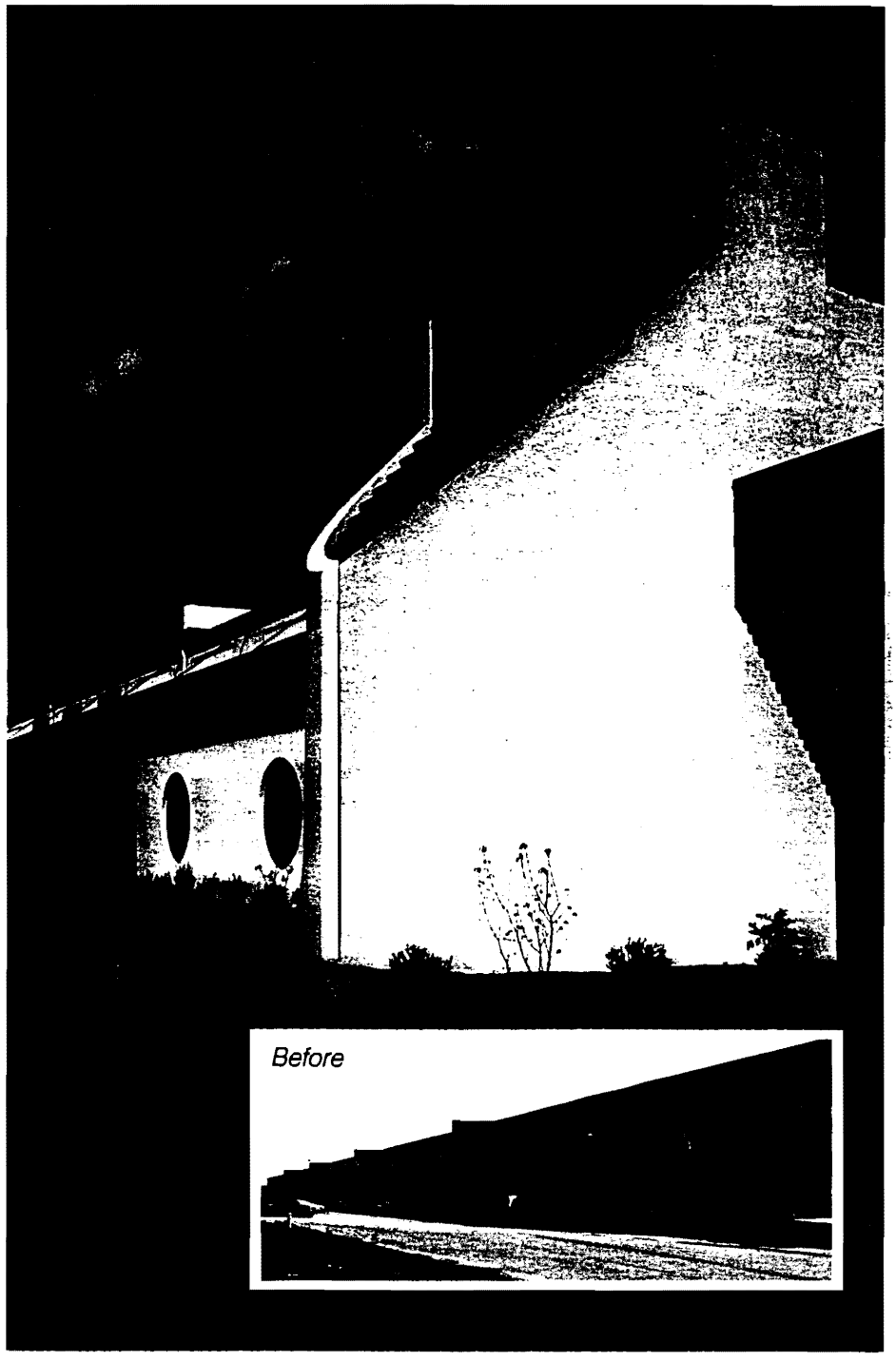
Although SUREWALL Surface Bonding Cement was created to save time and costs in new concrete block construction, its unique and broad range of uses has made it an extremely valuable, money-and-time-saving tool in renovating and retrofitting existing structures.

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 reduces cracking associated with conventional stucco. One 1/8" coating 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.



Al 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 applied in the same manner as the first coat. A textured finish,rather than a troweled 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

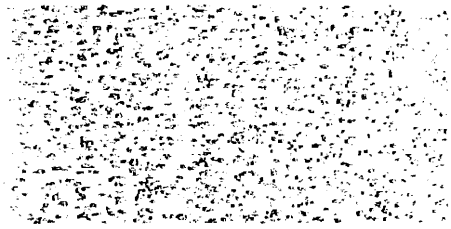
SUREWALL® Colors and Finishes

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.

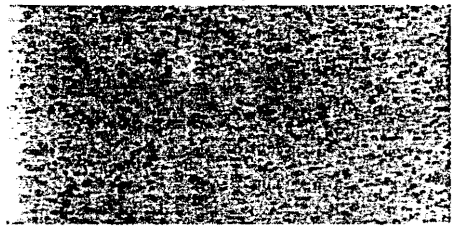
All colors are factory blended and colored integrally using mineral oxide pigments to insure light fastness and fade resistance.

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.*



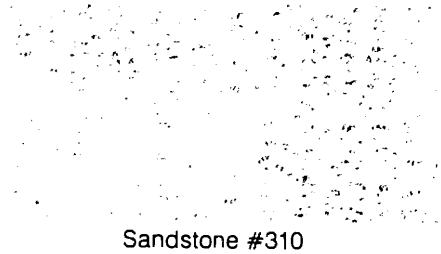
Pearl Grey #150

Pale Yellow #500



Suntan #300

Natural White #200

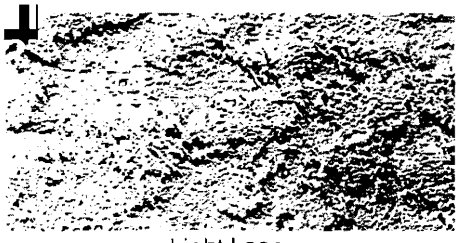


Antique White #275

White Jade #400

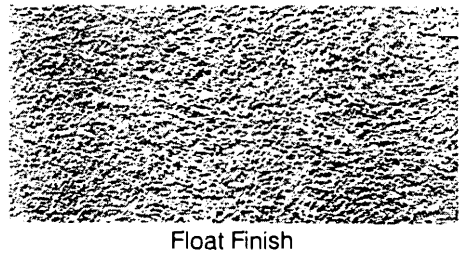
Sandstone #310

Textured Finishes



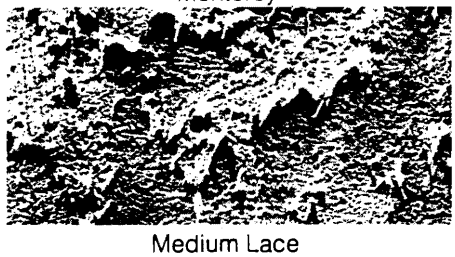
Light Lace

Monterey

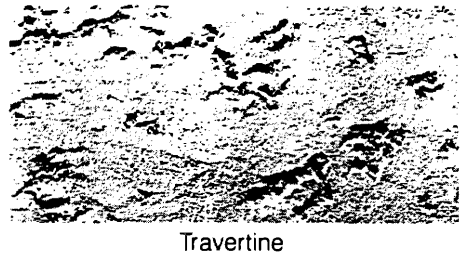


Float Finish

English



Medium Lace



Travertine

SUREWALL® Producers Council

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512/651-6550

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416/372-8550

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111 N. Vineland Ave. at Pitchess Place
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*LICENSED PRODUCERS

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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

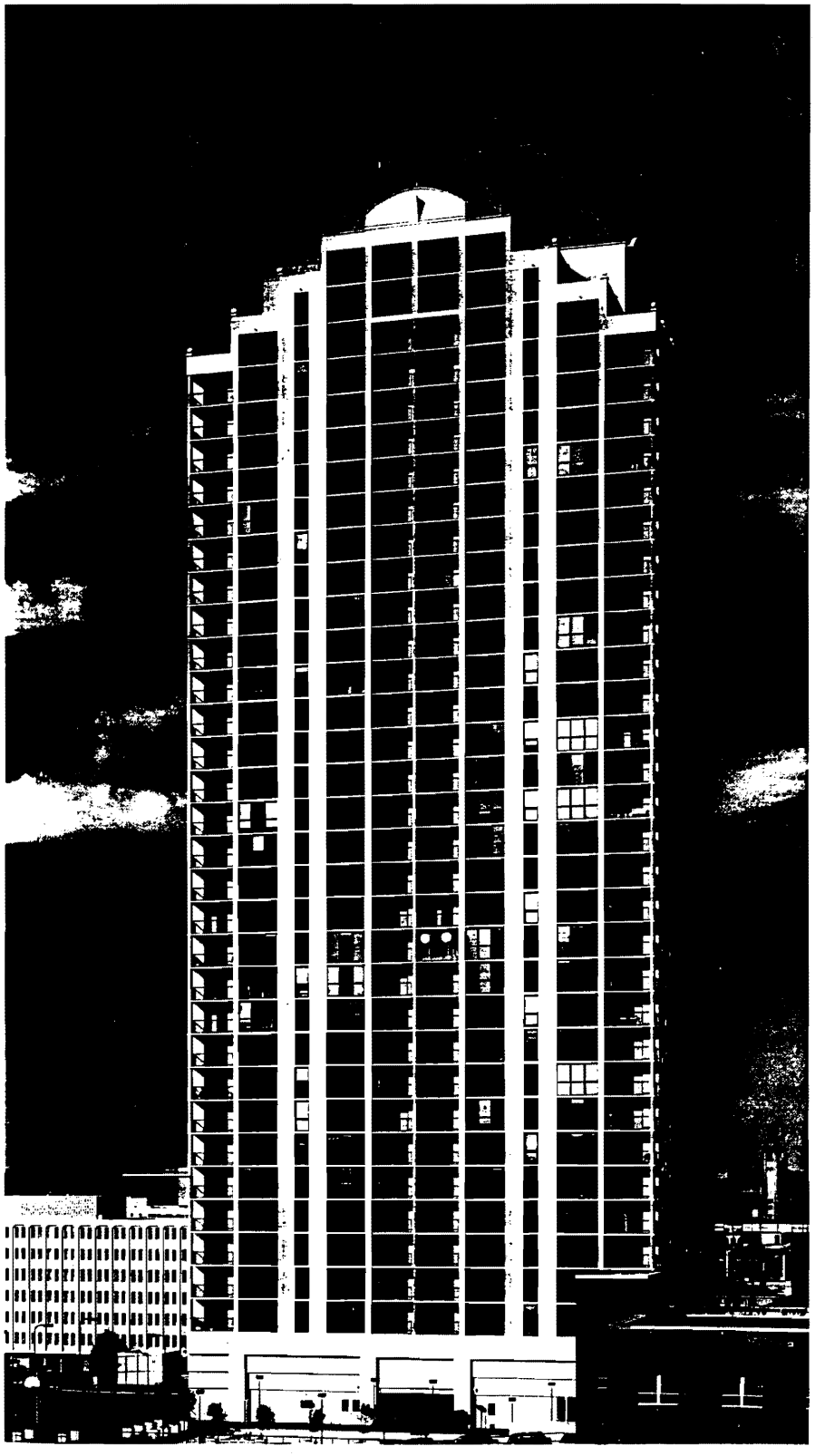
STO Industries
6175 Riverside Drive, S.W.
Atlanta, Georgia 30331
Phone: (404) 346-3666
(800) 221-2397
FAX: (404) 346-3119

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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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

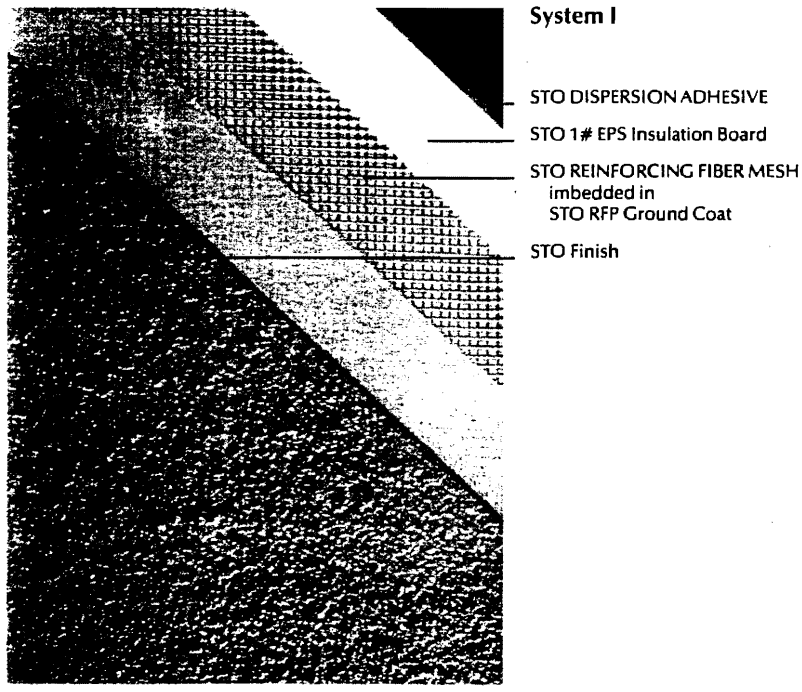
A specially designed plastic disk specifically designed for the STO Toughwall System and furnished by STO Industries.

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

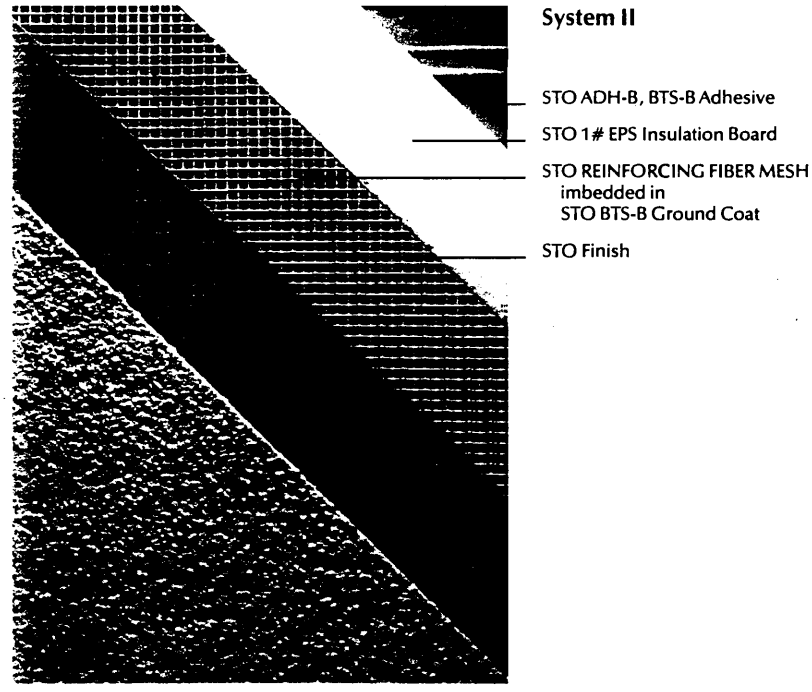
STO SPRAYPLASTER
Pebbled Texture (sprayed)

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.

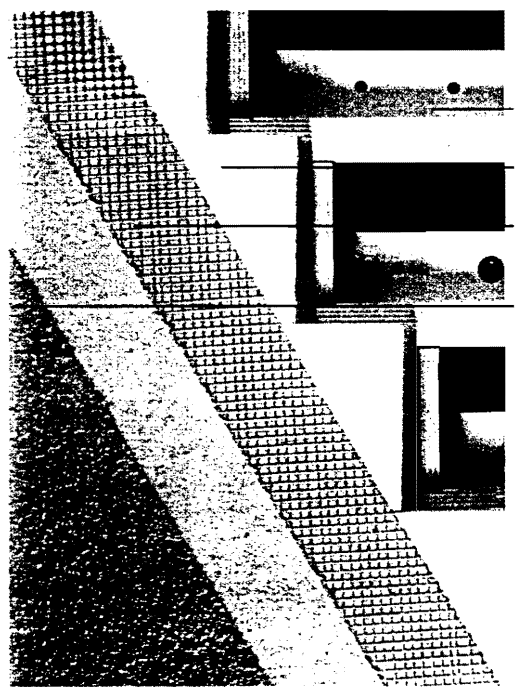
City of Los Angeles, Research Report No. RR 24708

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.

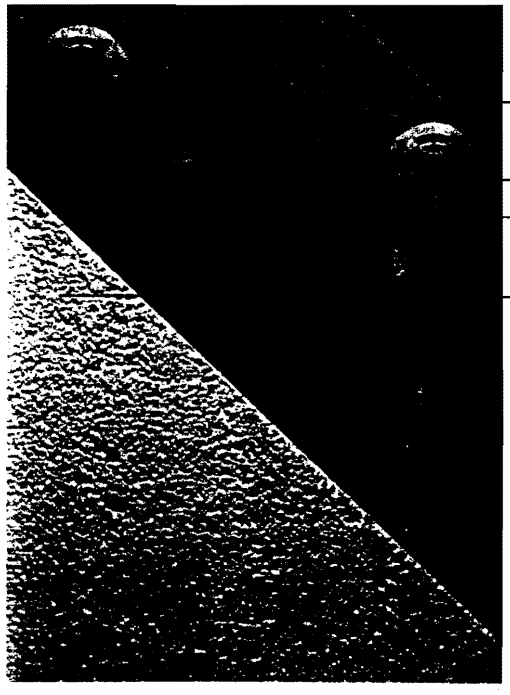
STOLIT FINISH

(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
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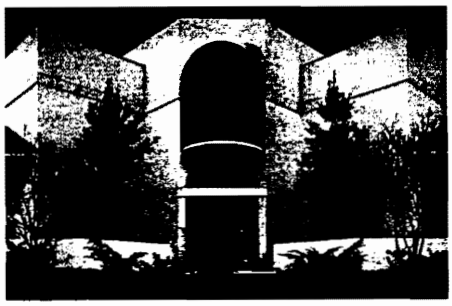

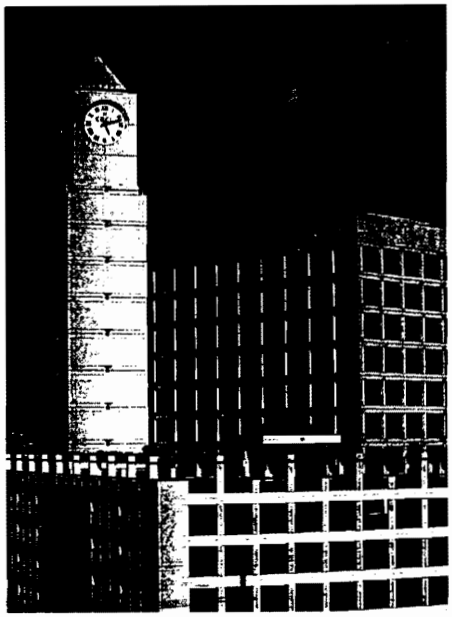

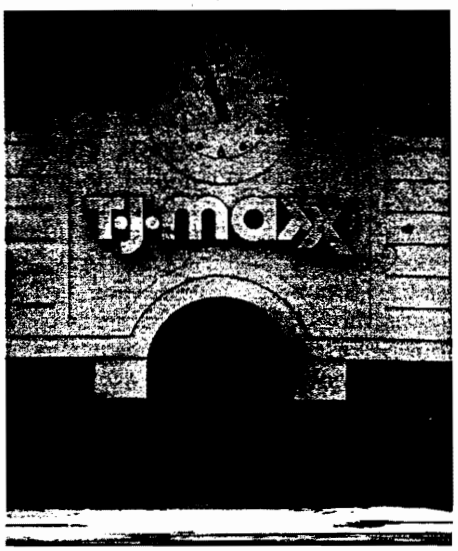

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SPEC-DATA®

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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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

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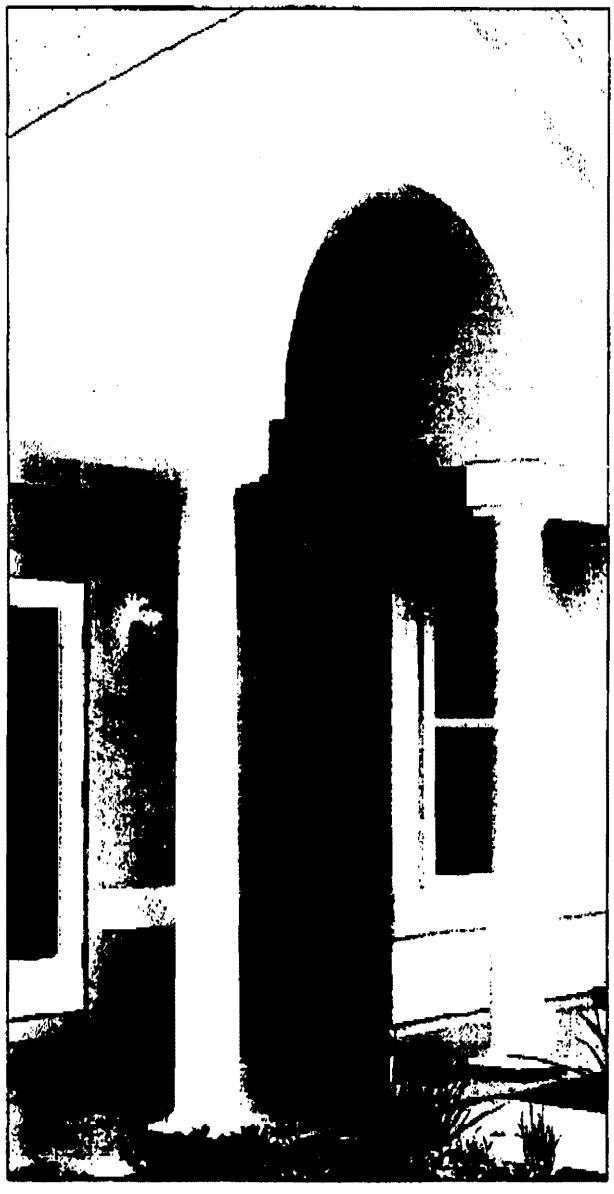
TEC Incorporated Architectural Catalog
Additional information available upon request.



Celotex

They're Very Best

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 6

To DAVID KEITH	From MAZIA ANTIO
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 fabricted 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.

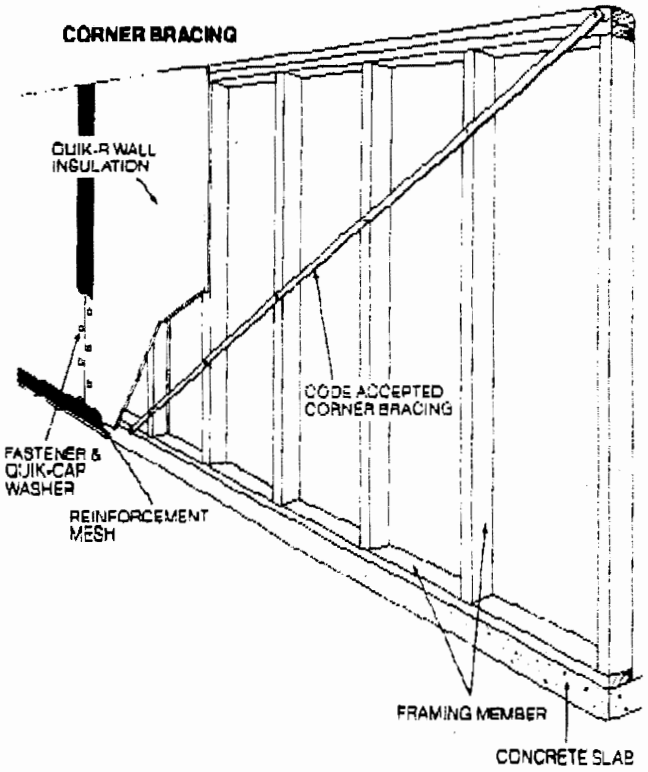
Quik-R must be mechanically fastened by placing corrosion-resistant fasteners through a Celotex Quik-Cap Washer. This washer is specifically designed for use with Celotex Thermax Quik-R Wall Insulation. Quik-Cap Washers are available in hot dipped galvanized steel or plastic.

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 settling 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.

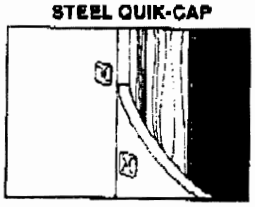
NOTE: Quik-R must be mechanically fastened with the fastener pattern as shown in this literature. Celotex does not assume any responsibility for other fastening patterns or fastening methods recommended by others.

Fasteners

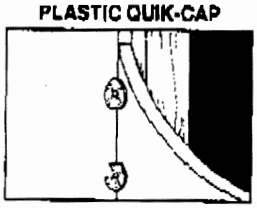
Corrosion-resistant mechanical fasteners should be used to fasten Quik-R Wall Insulation to framing and masonry substrates. Each mechanical fastener shall be installed through a Celotex Quik-Cap Washer.

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.

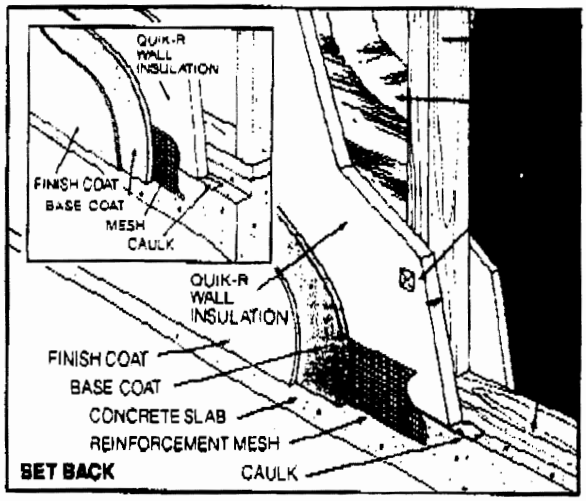
Versatile — Works easily with commonly available mechanical fasteners.

Convenient packaging

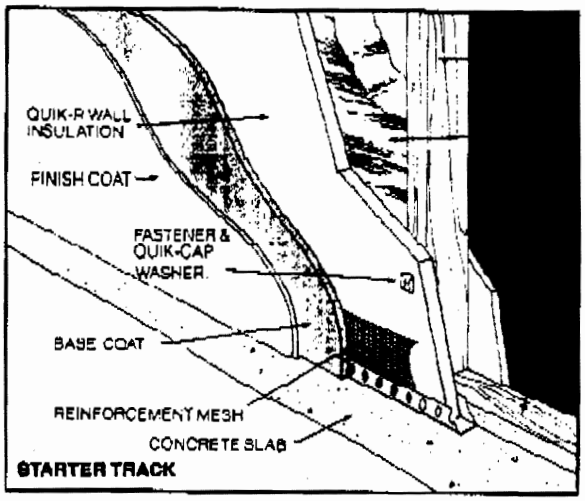
The insulation board is applied directly to the concrete with the fastener, followed by the reinforcement mesh and finished with stucco.

Foundation Details

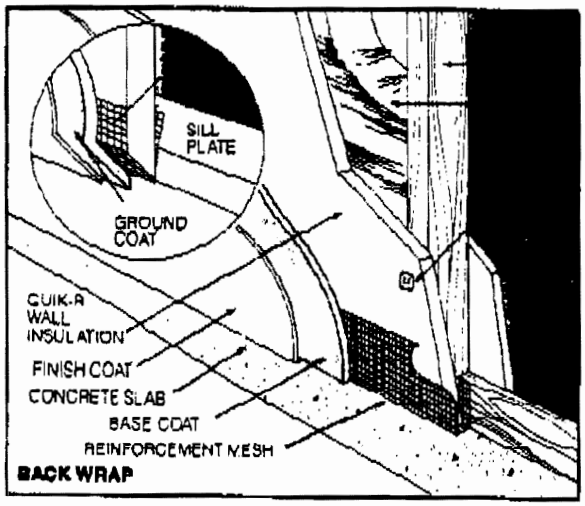
Thermax Quik-R Wall Insulation can be installed using a set back wall section, starter track, or back wrapping.



SET BACK



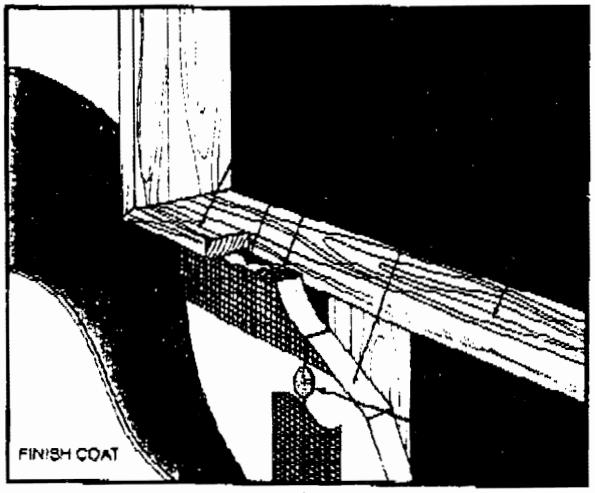
STARTER TRACK

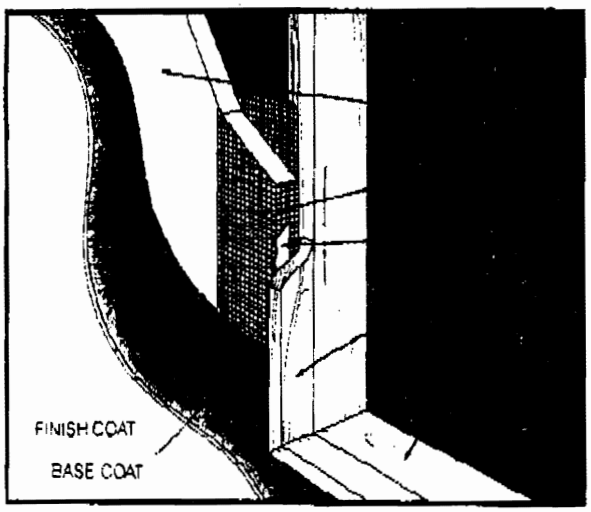


BACK WRAP

Window/Door Details

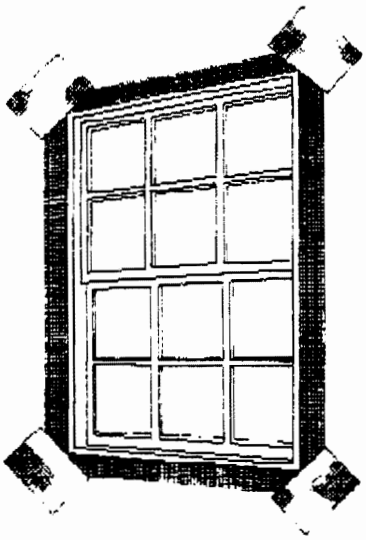
Thermax® Quik-R™ Wall Insulation can be easily installed around windows and doors. It can be trimmed with a sharp knife and straight edge. All cut edges shall be wrapped with reinforcement mesh.

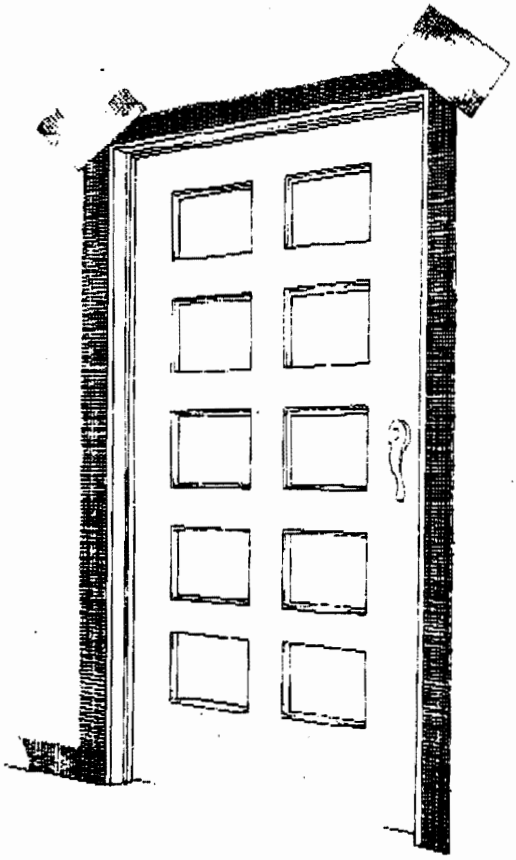




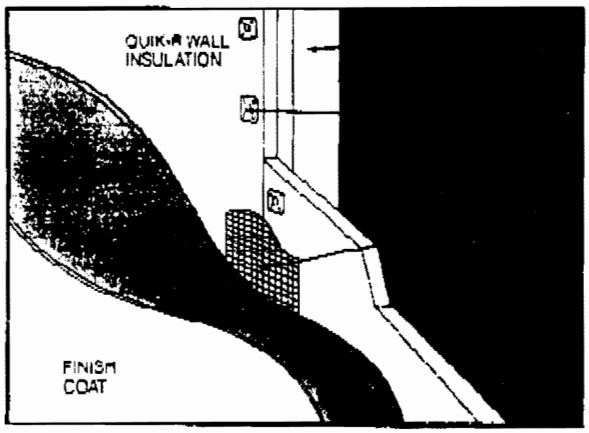
Band Aid Details

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	⅝"	¾"	1"	1½"	2"
System R-Value	15.8	16.5	17.9	20.7	23.5
System U-Value	.063	.061	.056	.048	.042

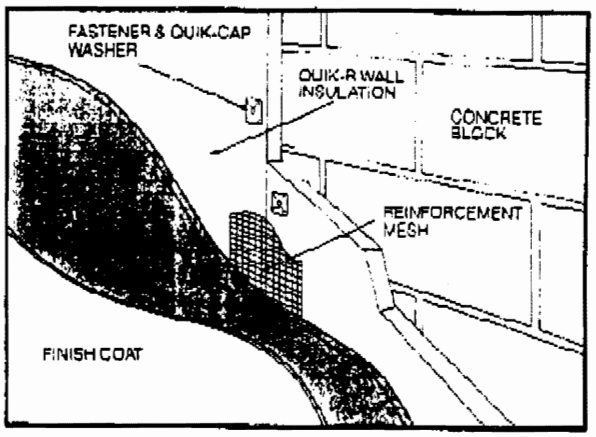
System calculations are through cavity and in accordance with ASHRAE Handbook Fundamentals and stabilized R-values at 75°F mean temperature.

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.

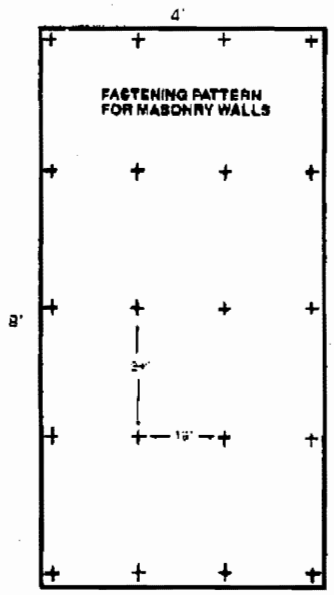
Mechanical Fasteners

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 (ERICO) 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

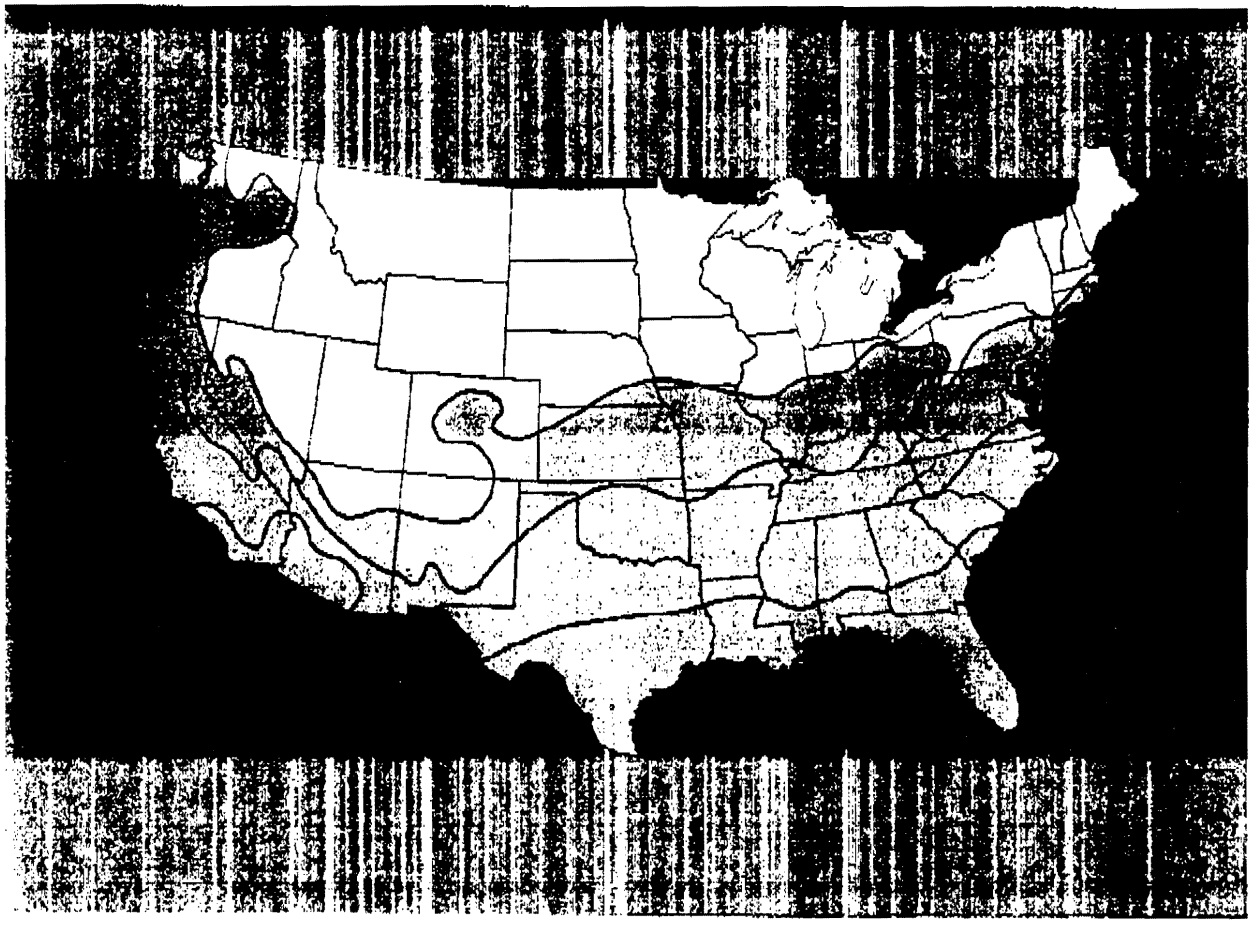
In the Sunbelt, exterior humidity is often higher than interior humidity, and while moisture condensation within the wall may be minimal and not sufficient to affect its insulation value, the use of a vapor retarder rated at 1 perm or less such as a 2 to 6 mil polyethylene film, installed between Thermax 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 6000 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.



ENERGY AUDIT
CITY OF EKATERINBURG
DISTRICT HEATING SYSTEM
RUSSIA

APPENDIX 6
RECOMMENDED TOOL KIT FOR HOSPITAL HEATING SYSTEM MAINTENANCE
BY UNIVERSITY OF PITTSBURGH

APPENDIX 6

HOSPITAL MAINTENANCE TOOLS

A list of tools which are required by a hospital for minimum heating system maintenance has been developed and is attached below.

TOOL LIST

RECOMMENDED BY
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FOR
RCG/HAGLER, BAILLY, INC.
ENERGY EFFICIENCY AND MARKET REFORM PROJECT
FOR RUSSIA
HEATING SYSTEM ENERGY EFFICIENCY IMPROVEMENT

The following is a list of tools and accessories which are necessary to accomplish essential maintenance tasks on mechanical, electrical and architectural features of a hospital. Performance of these tasks will increase the efficiency of energy utilization by preserving the existing facility.

Model numbers shown below are those of the Stanley Works, Snap On, Hobart, United Abrasives, Metabo, amprobe, and Milwaukee. Products of equal quality such as Bosch, Wiss, DML, Lenox, Delta or Porter Cable are acceptable. All power tools must operate at their rated performance on European power of 220 volts 50 Hertz and be provided with a dual pin central European plug. Also, all power tools must be provided with all specialty items such as chuck keys, spanner wrenches, etc, required for their operation.

BORING TOOLS

Mfgr.	Model No.	Qty.	Description
Stanley	03-624	1	Heavy duty hand drill
Stanley	04-201	4	Spade bit set
Stanley	04-312	2	12" power drill extension
Stanley	06-450 thru 06-473	4	Metric drill bit set (24 pieces) 1.5mm thru 13.0mm at o.5mm increments.

CUTTING TOOLS

Mfgr.	Model No.	Qty.	Description
Stanley	12-004	2	Wood Plane, 50mm cutter width
Stanley	12-220	2	Block plane, 40mm cutter width
Stanley	14-542	2	Aviation snips
Stanley	14-543	2	Aviation snips

Stanley	14-544	2	Aviation snips
Stanley	15-111	2	Wood hand saw, 660 mm, crosscut
Stanley	15-408	2	Hack saw, 305mm
Stanley	15-510	2	Mini hack saw
Stanley	15-412	4	Carbide hacksaw blade, 305mm
Stanley	15-822	100	Molybdenum 305mm blades, 32 teeth
Stanley	15-824	100	Molybdenum 305mm blades, 24 teeth
Stanley	15-828	100	Molybdenum 305mm blades, 18 teeth
Stanley	15-899	100	Molybdenum 305mm blades, 14 teeth
Stanley	84-151	3	8" lineman pliers
Stanley	84-133	3	7" diagonal pliers
Stanley	84-140	4	12" groove joint pliers

MEASURING AND LAYOUT TOOLS

Mfgr.	Model No.	Qty.	Description
Stanley	34-330	2	30 m long metric tape measure
Stanley	33-156	5	5 m metric tape measure
Stanley	42-264	2	torpedo levels

STRIKING AND STRUCK TOOLS

Mfgr.	Model No.	Qty.	Description
Stanley	51-041	2	Curved claw hammer, 16 oz
Stanley	51-050	2	Rip claw hammer, 16 oz.
Stanley	18-395	2	Seven piece cold chisel set to 3/4"
Stanley	18-396	2	Six piece pin punch set

FASTENING TOOLS

Mfgr.	Model No.	Qty.	Description
Stanley	66-789 thru 66-792	4	Set of four screwdrivers (16 pieces total)
Snap-On	TDM99117	2	Metric tap and die set, 3 mm to 24 mm

SOCKETS AND WRENCHES

Mfgr.	Model No.	Qty.	Description
Stanley	86-852 thru 86-867	2	Combination metric wrenches, 7 mm thru 22 mm, 15 pieces total
Stanley	86-927	2	14 piece 6 point metric socket set, 1/2" drive, 7 mm thru 19 mm
Stanley	86-925	2	9 piece 6 point deep metric socket set, 1/2" drive, 10 mm thru 19 mm
Stanley	86-400	2	Ratchet, 10", 1/2 " drive
Stanley	86-406	2	1/2" drive 2 1/2" extension
Stanley	86-407	2	1/2" drive 5" extension
Stanley	86-408	2	1/2" drive 10" extension

Stanley	86-413	2	Flex 1/2" drive handle, 17" long

POWER TOOLS

Mfgr.	Model No.	Qty.	Description
Milwaukee	5051-2	1	8" bench grinder, 2875 RPM, 2.2 amps, with one 36 grit and one 60 grit wheel, and with lighted eye shields
United Abrasives	28023	4	8"x1" A36 Al Oxide grinding wheel
United Abrasives	28024	4	8"x1" A60 Al Oxide grinding wheel
Milwaukee	0567-4	2	Variable speed 0-450 RPM) heavy duty drain cleaner including 1/4"x 7.6 m steel cable, repair hook, toilet trap holder, toilet trap guide, and steel carrying case.
Milwaukee		2	Additional 48-53-0015 5/16" x 9 m steel cable including repair hook.
Milwaukee		2	Additional 48-53-0025 5/16" x 9 m inner core drop head cables including 3/4 and 1' cutter, socket head screw and wrench for changing heads.
Milwaukee	5389-2	1	Heavy duty 3.1 amp rotary hammer drill with steel carrying case, 680 watts, 0 - 19,000 blows per minute.
Milwaukee		2	Carbide tip masonry bit sets: 48-87-(0120, 0150, 0170, 0180, 0210, 0250, 0251, 0280, 0310, 0370, 0430, 0500, 0502, 0560, 0620, 0680, 0750, 0870, 1000, 1120, 1250,and 1500). This includes 23 bits from 1/8" thru 1 1/2" bore and 1/8" thru 1/2" shank diameter
Milwaukee	6140-2	1	Hand grinder, 10,000 RPM, 2.75 amps with standard accessories.
Metabo	16.307	3	Box of 25 each A24R 4 1/2 x 1/4 grinding wheels for steel (total 50 pieces)
Metabo	16.729	1	Box of 25 each C24N 4 1/2 x 1/4 grinding wheels for stone (total 50 pieces)
United Abrasives	03426	2	Knot wire wheels, 5/6 x 11 for hand grinder
Milwaukee	6377-2	1	Worm drive 4400 RPM 8.2 amp saw. Include one pint oil 49-32-0060.
Milwaukee		10	Carbide tipped saw blades, 7 1/4", 20 teeth, 48-40-3915.
Milwaukee		10	Carbide tipped saw blades, 7 1/4", 40 teeth, 48-40-3920

Miller		1	Thunderbolt AC/DC arc welder, 230 amps AC, 150 amps DC.
Hobart			AWS/E7018 welding electrodes as follows: 2.4 mm 20 lb 3.2 mm 40 lb 4.0 mm 20 lb
Hobart			AWS/E6010 welding electrodes as follows: 2.4 mm 20 lb 3.2 mm 40 lb 4.0 mm 20 lb
(various)		2	Leather welding gloves
(various)		2	Welding helmet with front lift glass holder
(various)		2	Weld cleaning tomahawks
(various)		4	Wire brush

MISCELLANEOUS

Mfgr.	Model No.	Qty.	Description
Milwaukee	9546	1	Steel body lever hoist for welding and rigging, 16,345 kg at 3 m
(various)		1	Heavy duty 300 lb rated 8 foot aluminum ladder
Milwaukee	8925-2	1	Wet-dry vacuum cleaner, stainless steel 16" diameter tank, 5.0 amps, 1100 watts, 110 CFM, 105" H2O suction.
Milwaukee		1	49-90-1670 wet and dry cleaning kit (8 pieces)
(various)		1	Heavy duty tool chest with 18 gage steel construction on entire exterior and drawers, double side walls, 5" diameter locking wheels rated at 280 lb each, (two casters shall be double ball bearing swivel with side brake and two shall be rigid). Approximately 8 drawers. Over all dimensions approximately 26 1/2" wide X 42 1/2" high X 18" deep.
Amprobe	RS-1000	1	Analog clamp-on amp and volt meter, accuracy +/-3% FS. Amps capacity 15/40/100/300/1000. Voltage 150/300/600.
Amprobe	RS-1	1	Analog clamp-on amp and volt meter, accuracy +/-3% FS. Amps capacity 16/415/40/100. Voltage 150/600.
Rigid		1	12 inch pipe wrench
Rigid		1	14 inch pipe wrench
Rigid		1	24 inch pipe wrench

END OF TOOL LIST