PN-ACD-546
99362

Order #30
Industrial Energy Efficiency - Ukraine
November, 1997

REPORT
ON ENERGY AUDIT
AT *KHARKIV TILE FACTORY*
Kharkiv City, UKRAINE

Prepared by Mr George Keller, P E
Mrs Nelly Smirnova
Mr Mikhail Tarnovsky
Mr Yury Bykov

Prepared for United States Agency for International Development
Washington, D C 20523-1415

Burns and Roe Enterprises, Inc
1400 K Street NW Suite 1050 Washington D C 20005
Telephone 202 408 6831 Facsimile 202 408 6835

TABLE OF CONTENTS

	PAGE
1 EXECUTIVE SUMMARY	**3**
1 1 INTRODUCTION	3
1 2 PRINCIPAL FINDINGS	3
1 3 RECOMMENDATIONS	4
2 FACILITY BACKGROUND	**9**
2 1 HISTORY OF THE PLANT	9
2 2 TYPES OF PRODUCTS	10
2 3 NUMBER OF EMPLOYEES	10
2 4 NUMBER OF SIMILAR ENTERPRISES IN THE UKRAINE	12
2 5 SIGNIFICANCE OF SECTOR TO ECONOMY	12
3 CURRENT STATUS OF PRODUCTION	**13**
3 1 TOTAL CAPACITY OF THE PLANT	13
3 2 RECENT PRODUCTIVITY 1997 VS 1995 & 1996	13
3 3 CURRENT TREND	13
3 4 EXPORTS VS DOMESTIC CONSUMPTION	13
4 FINANCIAL STATUS OF THE PLANT	**14**
4 1 CURRENCY VS BARTER	14
4 2 VIABILITY OF THE PLANT	14
5 ANNUAL ENERGY CONSUMPTION, 1995 - 1997	**15**
5 1 ANNUAL CONSUMPTION, 1995 - 1997	15
5 2 CURRENT ENERGY AND FUEL PRICES	19
5 2 1 Electricity	*19*
5 2 2 Fuel	*19*
5 3 ENERGY USE PROFILE	19
6 PREVIOUS ENERGY IMPROVEMENTS	**22**
7 ENERGY AUDIT	**23**
7 1 SHORT TERM ENERGY SAVING RECOMMENDATIONS	23
7 2 LONG TERM RECOMMENDATIONS	26
8 ENVIRONMENTAL IMPACT OF RECOMMENDATIONS	**27**

APPENDICES

A ENERGY CONSERVATION OPORTUNITIES (ECOs)
B SPECIFICATIONS FOR THE REQUIRED EQUIPMENT
C AUDIT RECORDS AND PLANT DATA
D PLANT PHOTOGRAPHS
E CONVERSION FACTORS
F ABBREVIATIONS

1 EXECUTIVE SUMMARY

1 1 Introduction

This energy audit has been conducted under a program sponsored by the US Agency for International Development This project, referred to as Delivery Order #30, consisted of performing twenty four audits throughout Ukraine The purpose of the project was to develop Ukrainian energy service company (ESCO) capabilities To accomplish this task, ***Burns and Roe Enterprises, Inc*** (the primary contractor) hired Ukrainian engineers These engineers were trained in U S techniques of conducting energy audits and in ESCO concepts The industrial energy audits were conducted to facilitate the ESCO training

The energy audit fulfillment included visiting the plant by a group usually consisting of two-three engineers As the plants were very large, a one week site visit was not enough to adequately audit the entire facility The visit was limited to one week for other principal grounds But the engineers were prepared to develop measures that would be implemented for the whole plant This audit is based on what was managed to be done within the one week available Though this audit contains numerous recommendations for the plant management, the plant management is encouraged to perform a complete audit of the entire facility We hope that the plant management will consider the issue of hiring the engineers trained under this project to continue this work This will result in a complete understanding of the energy usage within the plant, as well as it make it possible to prepare a complete list of all the measures aimed at energy utilization

The current report describes the findings of the energy efficiency audit performed by *Burns and Roe* at the *Closed Joint-Stock Company "Kharkiv Tile Factory" Kharkiv Tile Plant* is specializing in production of facade smooth and relief tiles, faced tiles for finishing works, including here the ornamented and marblelike smooth tiles and relief large-size tiles for floors The products of the factory are on demand both on the domestic market of the country, and on the markets in the CIS-countries The products meet the high requirements to the quality In 1996 the production output was 4,000,000 m^2 The export in 1997 was 82,377 m^2 per year

The barter operations versus the currency ones were 30 per cent

The tasks of the energy audit were as follows

- to conduct informal training in the energy management practices
- to create an institutional awareness of energy management
- to produce recommend certain aimed at improvement of energy efficiency, including the measures of the management, low-cost and medium-cost measures and equipment that could be purchased for the money from the USAID
- to produce recommendations concerning possible capital investments and implementation of middle-cost measures enabling to gain a large-scale energy saving

A group of energy auditors consisting of one specialist from the USA and three Ukrainian engineers carried out an energy audit during November 17 -21, 1997 In accordance with the objectives of the Project the energy auditors group has prepared the following report

1 2 Principal Findings

Closed Joint-Stock Company *Kharkiv Tile Factory* is quite a large energy consuming

enterprise In 1996 there was consumed as follows

- electric power - 15,382 MW h
- natural gas - 21,358,000 m^3

As expected, the audit team found many attractive opportunities for energy efficiency improvements at current energy prices When energy prices were 20-30 times lower, energy efficiency improvements were uneconomical Today energy efficiency improvements make sense but difficult to accomplish due to exorbitant interest rates and distortions in economic incentives caused by the bartering system and mutual non-payments

- The tile plant is reasonably successful by Ukrainian standards but still has to rely on the bartering system for its supply of gas and electric power

- The plant personnel was against receiving expensive portable analyzers as part of this program They are concerned that the analyzers will be expropriated by the inspecting authorities as was the case in the past We were told to use only stationary combustion analyzers

- All control systems on the plant are morally and technically obsolete

- rally and technically outdated

- The energy inefficiency is exacerbated via oversizing and overbuilding of all heat and electric supply systems Heat generation is oversized by 150%, heat distribution by 300%, electric distribution by 700%

- One of the energy audit participants, Mr Tarnovsky, saw possibilities for some private development beyond the AID program in the area of heat distribution system

- The most important factor in developing private sector ESCO is an availability of long term (2-3 years) financing Ukrainian banks demand exorbitant interest rates for a loan of 6 months duration This makes developing private sector ESCO in Ukraine almost impossible

- Schedule of this project will make the monitoring phase impossible for ECOs that require heating season for their implementation

1 3 Recommendations

Below a list of the energy conservation opportunities for the plant is given in a table These measures are recommended to be implemented as soon as possible The management of the factory is proposed to consider to issue of implementation of other measures while financial opportunities appear with the factory

To contribute to improvements of the energy efficiency at the plant and to decrease the energy costs, USAID will provide the plant equipment for performing energy audits This equipment will include portable devices and measuring instruments for energy audits The given energy saving opportunity is shown in the table as energy conservation opportunity #1 (ECO #1) The point of the recommendation is to organize energy management departments that are to be responsible for the control, analysis of energy consumption at the enterprise and to bear responsibility for development recommendations aimed at redesigning or upgrading any systems if that can lead to energy saving

As a rule, an energy management service should consist of three persons a techniCal manager, electric engineer and thermal engineer The manager should be included into the plant management and report directly to the director of the plant It is very important, as the energy use issues become especially important, and the plant manager should be aware of all the potential opportunities capable of giving energy saving

The majority of the measures recommended by the auditors can be implemented with insignificant changes at other industries, that is it can serve as a standard remedy in settling standard problems

Providing realization of the measures proposed by the auditors, a decrease in the yearly energy saving is possible

- electric energy saving - 17,726 MW h,
- natural gas saving - 3,272,000 m^3, and as the result of these,
- a decrease in the amount of the harmful emissions into the environment, in particular
  - hard particles - 7 t/yr,
  - sulfur dioxide - 16 t/yr,
  - carbon oxide - 20 t/yr
  - nitrogen oxide - 11 5 t/yr

The proposals enlisted in Table 1 will allow to improve the energy efficiency at the enterprise, decrease losses and retain the competitiveness of the enterprise In the table there are given several energy conservation opportunities (ECOs) with a short-term payback period

Investment of US $175,600 to improve the energy efficiency with a short-term payback period (ECO #1 to ECO #7) will result in the annual savings of US $328,520, which is equivalent to 2,956 8 thousand m^3 of natural gas savings and to 1,726 5 MW h of electric power savings An additional investment of US 2,750,000 into the energy saving program (ECO #8) will result in the annual savings of up to US $666,000, which is equivalent to 315,000 m^3 of natural gas savings and to 16,000 MW of electric power savings

List of Energy Conservation Opportunities (ECOs)

ECO	Description	Saving					Yearly saving, USD	Project costs, USD	Payback period, year
		Electric power, MW h	Natural gas, 1,000 m^3	Steam, GCal	Hot water, 1,000 m^3	Water, 1,000 m^3			
1	**Introduction of an energy management program** The measure provides controlling of the energy resources consumption and improves the energy utilization efficiency at industrial facilities	1,600	2 200				260,000	130,000	0 5
2	**Optimization of the scheme for controlling the combustion in*KVG-7,56 Boilers*** Installation of an auxiliary equipment while implementing the measure will provide operation of the boiler with an excess of air after the boiler and before the exhaust fan with automatic controlling of the fuel-to-air ratio according to the load of the boiler		241				20,000	15,000	0 8
3	**Changing the scheme of the hot water supply for the plant in the summer period** Implementation of the proposal will provide gas consumption for the hot water supply needs, for that it is proposed to install a 100-kW boiler and a plate-type heat exchanger with a corresponding heat production capacity		198,650				16,500	14,300	0 9
4	**Optimization of the hydraulic regime of the heat supply system**	90,720	100,750				12,000	11,700	1,0

ECO	Description	Saving					Yearly saving, USD	Project costs, USD	Payback period, year
		Electric power, MW h	Natural gas, 1,000 m^3	Steam, GCal	Hot water, 1,000 m^3	Water, 1,000 m^3			
	The measure will make it possible to eliminate the overconsumption of the delivery water, for that it is proposed to refuse from the collector system inside thje boiler-house and to provide one outlet pair of pipelines with the nominal bore D=200 mm								
5	**Opportunity to save natural gas during the operation process** The measure will provide identification, liquidation of leaks, saving of gas by providing a thorough control of the maintenance of the transportation systems, for that a detector of the gas-and-air mixtures is recommended		160				13,300	1,000	0 1
6	**Replacement of the lamps in the factory lighting system** The measure will provide a decrease in electric power consumption for the external lighting of the territory of the factory resulting from replacement of the mercury lamps with high-pressure sodium lamps while using the currently existing illuminants and start-up accessories	37,750					1,720	2,300	1 3
7	**Control of the operation temperature mode of the equipment and the delivery water supply system** This measure will provide identification in due time and elimination of heat losses, it will enable to decrease the fuel		567,400				5,000	1,300	0 3

ECO	Description	Saving					Yearly saving, USD	Project costs, USD	Payback period, year
		Electric power, MW h	Natural gas, 1,000 m^3	Steam, GCal	Hot water, 1,000 m^3	Water, 1,000 m^3			
	consumption								
8	**Operation of a gas turbine plant for drying the raw materials** Installation of the proposed improved integral unit for drying raw materials will allow to produce up to 21,000 MW h of electric power per year and to decrease gas consumption by the drying tower by 10 per cent	16,000	315				666,000	2,750,000	4 1
	Total	**17,726,640**	**3,271 8**				**994,520**	**2,925,600**	**2 9**

2 FACILITY BACKGROUND

Director Alexander Z Ivashchenko
Chief Energy Engineer Valeriy M Korolik
Tel (0572) 99-11-55
Fax (0572) 99-86-55
Address 297 Moskovsky Prospect
Kharkiv 310106
Ukraine

2 1 History of the Plant

Kharkiv Tile Plant was designed by Ukrainian Scientific Research Institute and put in operation in 1946 At that time the facility produced ceramic tiles for floors, sanitary faience, insulation materials, paintwork materials

In 1949 production of facing tile for Moscow sky-scrapers was started

In 1951-56 new lines were launched for producing decorative clay finish tile and flooring tile

In 1962-66 all of the technology lines were changed considerably, after designing and implementing new conveyor drying ovens Besides these radiation dryers, the plant in collaboration with Institute of Gas introduced first samples of roller oven, high-temperature ovens, etc

Implementation of new up-to date technologies, evenness of load distribution between main and auxiliary workshops, regulatory control of production and coordination of functioning of all sectors resulted in product quality improvements

From 1976 to 1981 six flow conveyor lines were installed with an annual output of 800,000 m^3 of flooring tile and another line producing 160,000 m^3 of large-size ornamented tile Labor productivity increased by 42%, product quality also increased considerably

During the period from 1983 to 1986 the whole technology of finish tile production was retrofitted and the old technology lines became obsolete Retrofitting included implementation of 4 conveyor lines designed by Stroykeramika Research Institute with designed overall output of 1,000,000 m^3 per year

More than 15 production units were transferred from manual to automated control, production output of the plant increased by 46%, and labor productivity by 48 9% Product quality improved and cost of production decreased by 15 5%

The facility consists of 4 production workshops

In January 1991 the enterprise staff leased the facility from the State

Since September 1994 the facility became a limited liability closed joint-stock company Kharkiv Piston Plant

2 2 Types of Products

Currently the facility produces smooth and crinkle facing tile, finish tile including ornamented and marble-like smooth tile, and large-size flooring tile

Artistic Ceramics Workshop produces household utensils (ceramic dishware and majolica dishware)

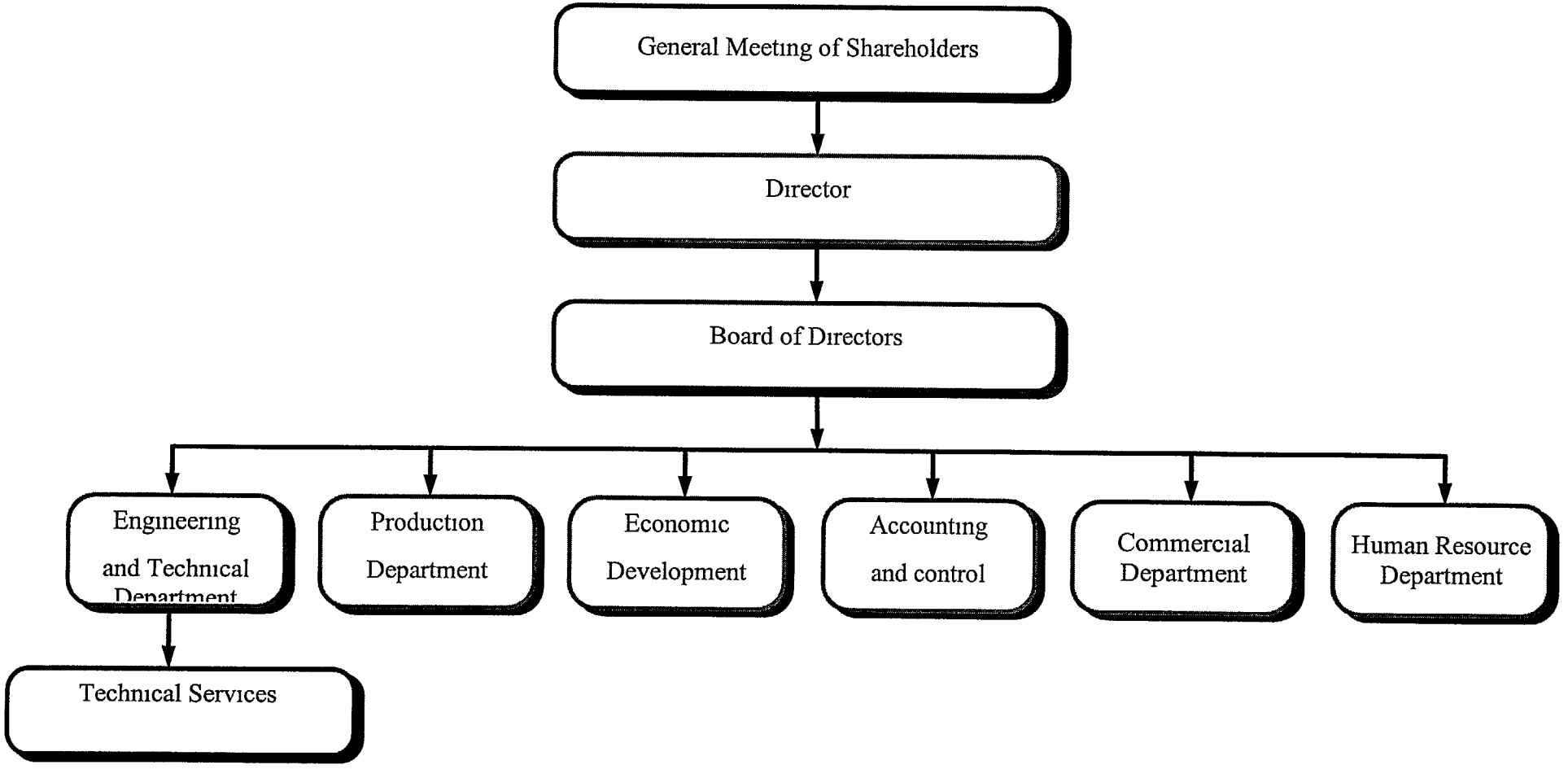
Polymer Concrete Workshop has started production of polymer tanks, lavatory and closet basins and large finish tile sized 1,900x500 mm

2 3 Number of Employees

The facility uses continuos technological process of tile production, therefore the lines operate 24 hours a day The enterprise staff consists of 1610 people, including

engineers	199 people
production lines workers	699 people
auxiliary workers	713 people

Organizational management structure of JSC "Kharkiv Tile Plant"



2 4 Number of Similar Enterprises in the Ukraine

For the time being Ukraine has on its territory three enterprises producing facing clay tile, these are

1 Kharkiv Tile Plant

2 Slavyansk Ceramics Factory

3 Lviv Ceramics Plant

2 5 Significance of Sector to Economy

The Product of the facility has a good demand in the country's internal market and has 70% market share The quality of the product is better than that of ceramic tile produced by two other enterprises Its market price is also 2 - 2 5 times lower than the price of imported tile

Considering the great demand for finish tile for both residential and facility buildings, this sector in the country's economy seems to have a good future

3 CURRENT STATUS OF PRODUCTION

3 1 Total Capacity of the Plant

Table 1 represents history of capacity utilization at the facility in 1995 - 1997

TABLE 1

		units	1995	1996	1997 (9 months)
1	Planned output	1,000 m²	4,935	4,526	2,872
2	Actual output	1,000 m²	4,429	4,000	2,790
3	Percent of equipment utilization	%	89 75	88 38	97 14

3 2 Recent Productivity 1997 vs 1995 & 1996

TABLE 2

№	Year	Units	Labor Productivity per Worker
1	1995	m²	2,500
2	1996	m²	2,306 5
3	1997 (9 months)	m²	1,718 7

3 3 Current Trend

At the moment the facility has almost completed creating a commercial network of shops inside the country to sell their product In nearest future the following shops will be opened

- two shops in Kharkiv
- a shop in Donetsk
- a shop in Zhitomir

The Marketing Department of the enterprise will keep promoting the product and expand its market presence in the future

3 4 Exports vs Domestic Consumption

In 1997 exports amounted to 82,377 m²/yr

4 FINANCIAL STATUS OF THE PLANT

4 1 Currency vs Barter

The facility has established a system of barter payments with Kharkiv Carbon Paper Factory, which supplies packaging material for the enterprise, and with Pravex company, broker between the enterprise and the electricity provider

The barter to currency payments ratio is 30%

4 2 Viability of the Plant

Table 3 represents profitability of the facility during the past 3 years (in percent)

TABLE 3

Year	Overall Output	Facing Tile	Flooring Tile
1995	12 0	15 0	3 4
1996	11 3	13 9	2 8
1997 (9months)	8 4	10 3	5 8

Overdue accounts payable for 1997 - $400,000

Overdue accounts receivable - $158,000

Accounts payable and receivable are balanced annually

5 ANNUAL ENERGY CONSUMPTION, 1995 - 1997

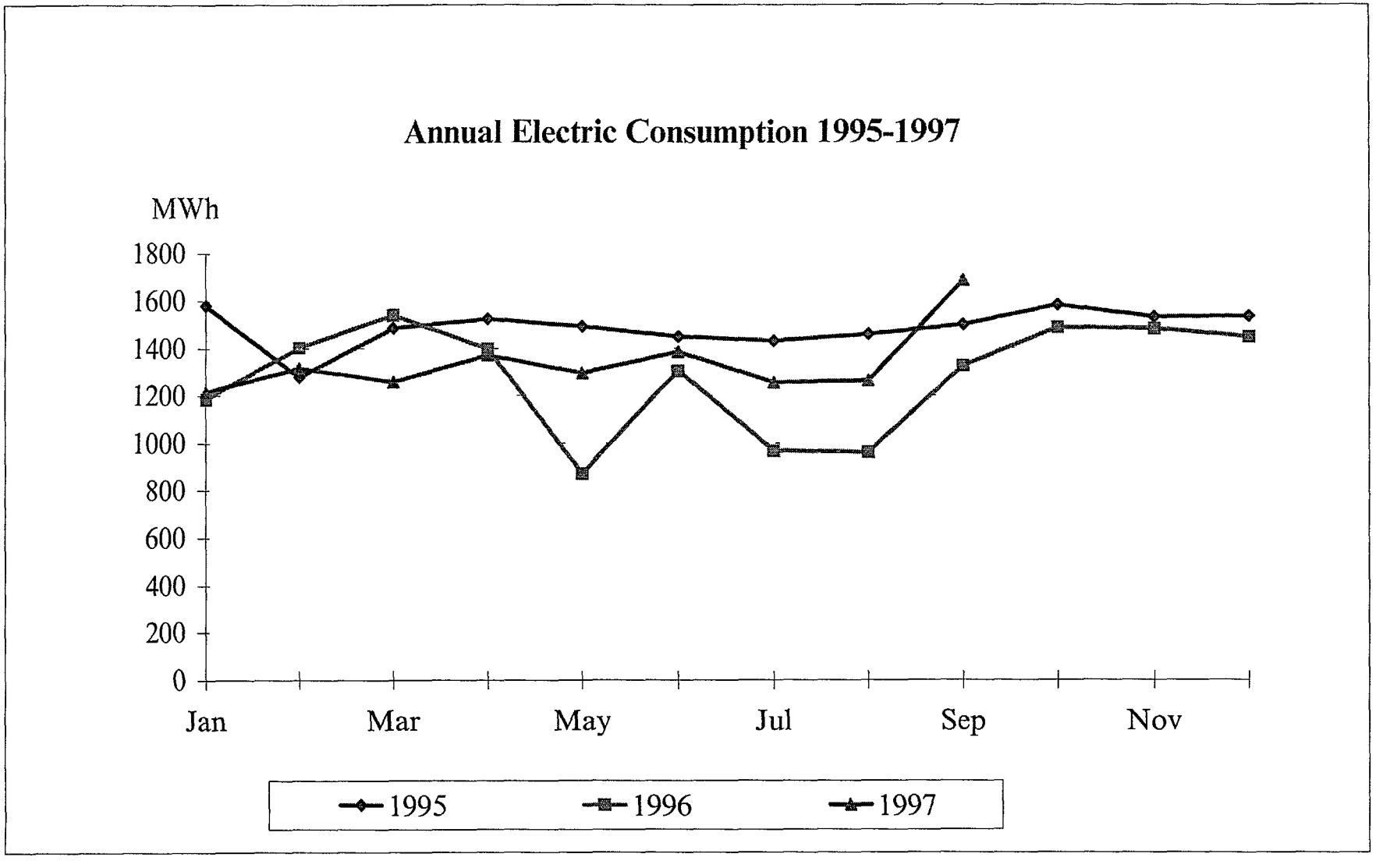
5 1 Annual Consumption, 1995 - 1997

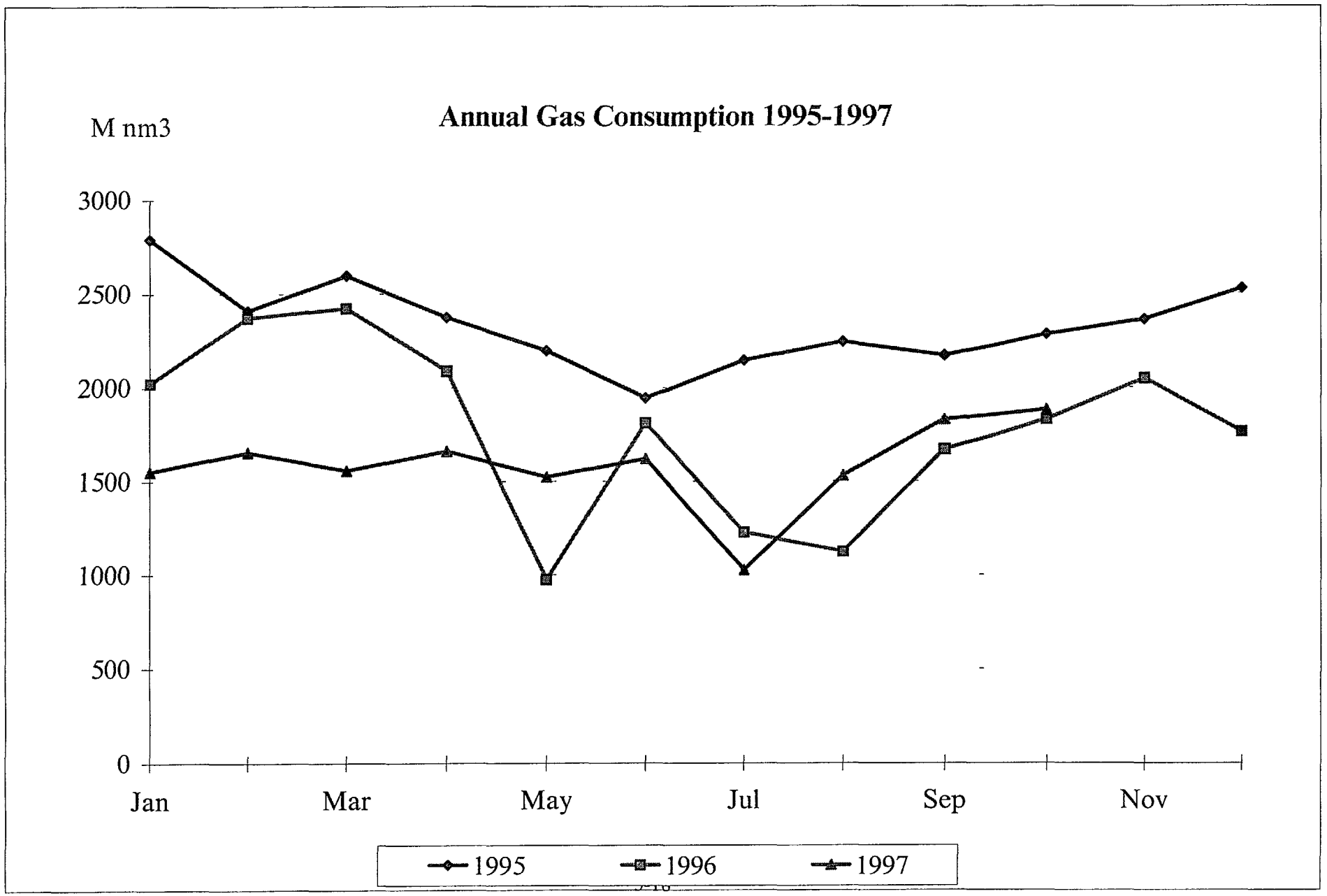
ELECTRIC CONSUMPTION

Months	1995 MW h	1996 MW h	1997 (9months) MW h
January	1,581	1,185	1,215 1
February	1,278	1,404 4	1,316 82
March	1,487	1,542 23	1,258 24
April	1,525	1,399 06	1,371 46
May	1,493	871 48	1,295 03
June	1,450	1,305 26	1,385 39
July	1,432	968	1,255 27
August	1,459	962 39	1,262 25
September	1,500	1,325 9	1,684 5
October	1,582	1,487 91	
November	1,531	1,482 03	
December	1,535	1,448 88	
TOTAL	**17,853**	**15,382 54**	**12,044 06**

GAS CONSUMPTION

Months	1995 1,000 m³	1996 1,000 m³	1997 (10months) 1,000 m³
January	2,788	2,023	1,552
February	2,409	2,371	1,654
March	2,597	2,424	1,558
April	2,373	2,089	1,660
May	2,195	976	1,523
June	1,945	1812	1,620
July	2,144	1,228	1,025
August	2,243	1,124	1,530
September	2,168,4	1,669	1,828
October	2,281,4	1,831	1,882
November	2,362	2,048	
December	2,527	1,763	
TOTAL	**28,032 8**	**21,358**	**15,832**


Annual Electric Consumption 1995-1997
MWh
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Mar
May
Jul
Sep
Nov
1995
1996
1997


Annual Gas Consumption 1995-1997
M nm3
3000
2500
2000
1500
1000
500
0
Jan
Mar
May
Jul
Sep
Nov
1995
1996
1997

5 2 Current Energy and Fuel Prices

5 2 1 Electricity

The facility pays for electricity according to the tariff based on the stated capacity and the actual consumption

1 Stated capacity
2 Actual electric consumption according to the kW meters

Contract for electricity supply with Pravex company is based on following costs

- kWh of stated power $4
- kWh of consumed power $0 04

Electricity is mostly imported from Russia

Stated capacity	3,000 kW
Payments for stated capacity	3,000 * 4 = $12,000
Average monthly electric consumption	1,512,000 kWh
Payments for consumed power	1,512,000 * 0 04 = $60,480
Total payments	12,000 + 60,480 = $72,480
Actual cost per kWh	72,480 / 1,512,000 = $0 048

5 2 2 Fuel

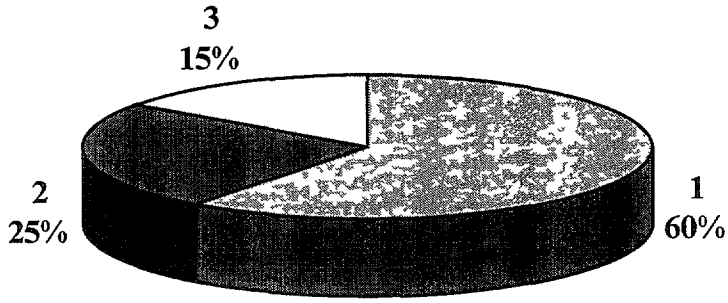
The only fuel used on the facility is natural gas

Cost for 1000 M^3 is $83

5 3 Energy Use Profile

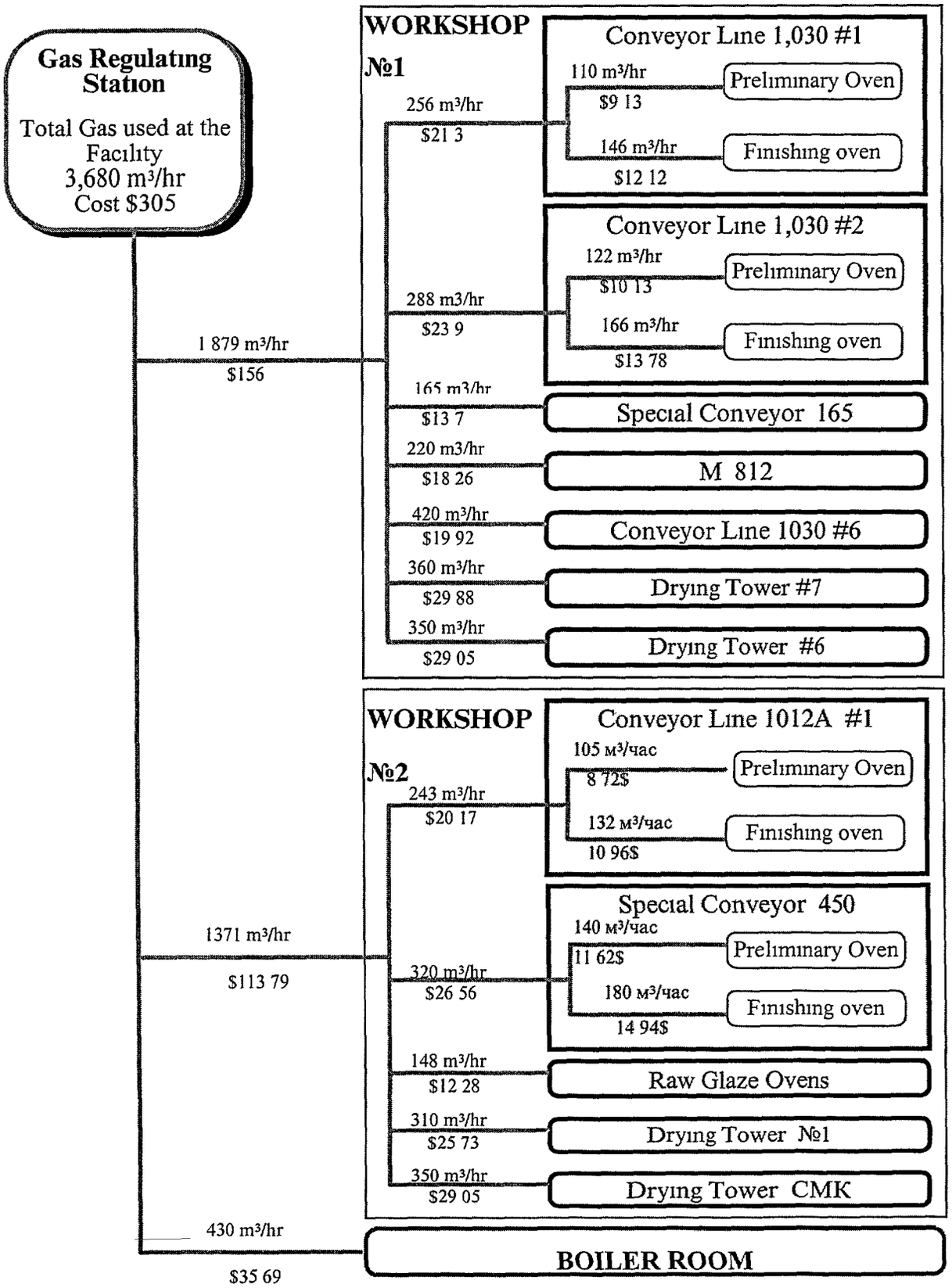
Average electricity consumption per hour is 2,100 Kw

Distribution of Power Consumption



#	Consumers	%	Load, kW	Cost, $
1	Main Production	60	1,268 4	60 88
2	Auxiliary Services	25	516 6	24 8
3	Misc consumers	15	315	15 12
	TOTAL	**100**	**2,100**	**100 8**

Hourly Distribution of Gas Consumption



6 PREVIOUS ENERGY IMPROVEMENTS

Measures to improve energy use implemented by the facility in 1997

1 Implementation of mass preparation technology using a new type of grinders in the preliminary workshop is expected to result in reduction in energy consumption of about 2,468,000 kWh per year

   At current cost of $0 04per kWh, annual cost savings will be

   0 04 * 2,468,000 = $98,720

2 Implementation of automatic control system for preliminary and finishing ovens will result in reduction of gas consumption by some 53,000 m^3 per year

   At current cost of $0 083 per 1$m^3$ of gas, annual cost savings will be

   0 083 * 53,000 = $4,399

3 Improvements in the boiler house equipment will allow to reduce gas consumption by some 12,000 m^3 per year

   At current cost of $0 083 per 1$m^3$ of gas, annual cost savings will be

   0 083 * 12,000 = $996

Total expected energy cost savings

98,720 + 4 399 + 996 = $104,085

7. ENERGY AUDIT

7 1 Short Term Energy Saving Recommendations

In the result of the energy audit at *Kharkiv Tile Factory* the group of energy auditors has recommended several proposals aimed at improvement of the energy efficiency at the combine facility The majority of the given problems are typiCal for the Ukrainian facilities, and settlement of these problems can be disseminated at other industries of the similar profile

Implementation of the measures recommended by the auditors will make it possible to decrease consumption of energy resources in the following rates

- electric power consumption - by 17,726 MW
- natural gas consumption - by 3,272,000 m^3

Below the results of the technical and economic estimations for the energy conservation opportunities are given

ECO #1 Introduction of energy management

The basic instrument in decreasing energy consumption by using it more effectively is energy management Energy management is a management system based on fulfilling typical measurements and checkings providing such an operation of the plant when there is consumed only the amount of energy required for the processing needs By introduction of energy management it is possible to gain a more detailed picture of energy consumption at the plant, which males it possible to compare the energy consumption levels at a given plant with those at other industries to estimate more precisely the energy projects aimed at saving energy that are planned to be introduced at the given factory

We propose to introduce at the factory a system of energy management in its full scope Implementation of this measure will result in a possibility to decrease the energy resources saving by 10 per cent

Implementation of this projects will enable to decrease the costs of the energy resources by USD 260,000 per year The payback period will be 0 5 year More detailed commentaries in regard of this proposal are given in Appendix A1, ECO #1

ECO #2 - Excess Air Control for Boiler KBG-7 56

The plant had three boilers KVG-7 56 made by Ukrainian plant TEKOM There are thousands of such boilers operating in Ukraine While this recommendation does not have the best payback of all recommendations for this plant, the audit team decided to assign first priority to this ECO due to vast possibilities for replication

The existing combustion control strategy used for this boiler relies on the boiler operator to make an air flow set point adjustment after each load change, i e manual excess air correction We are proposing to add equipment to enable an automatic excess air vs load correction on one of three boilers

Our Calculations indicate that such operation will result in 5% savings in consumption of natural gas Given $400,000 as an annual fuel expenses per boiler and total

implementation cost of $15,000, The payback period is 0 8 year See Appendix A 1, ECO #2 for more details on this proposal

ECO #3 - Improvement in Hot Water Supply System during the Summer Season

Currently the hot water supply during the summer is provided by means of a shell-type boiler "Lancashire' operated on a gas fuel in the water-boiling mode The boiler is used as a voluminous heater and it is operated continuously 24 hours The specific gas consumption for production of 1 GCal of the thermal energy for the hot water supply is 960 m^3/GCal The efficiency of "Lancashire" boiler in this operation mode is only 12 5 per cent It is an indicator of the very poor boiler operation

Instead of the hot water production there, it is proposed to install a boiler with the capacity of 100 kW and a plate-type heat exchanger with a corresponding thermal productivity The new system will produce 2 1 tons of hot water per hour with the temperature of 60°C The hot water will be supplied into the "Lancashire" boiler redesigned as accumulating tank From the accumulating tank the hot water will be pumped to the end users

Implementation of this proposal should result in decrease in 1998 consumption of natural gas by 198,650 m^3/yr

The cost saving will be US $16,500 per year

The payback period is 0 95 year

See Appendix A 1, ECO #3 for more details on this proposal

ECO #4 - Optimization of the Hot Water Supply System

Currently heat supply is not provided from the boiler-house where there are three water-heating boilers KVG-7 56 having the total heat capacity 19 5 Cal/hour In the boiler-house there is a system of headers for the supply and return water Seven pairs of different diameters pipe lines are going in the same direction The acceptable temperature range for the thermal lines is 130 to 70°C The heat supply system is hydraulically unbalanced The hydraulical unbalance results in hot water overconsumption by some 150 85 tons/hour It is necessary to simplify the header system inside the boiler-house and to use only one pair of pipes with D_y = 200 mm

This will result, after the hydraulic adjustment of the heat supply system, in the power consumption decrease of 90,720 kW and the gas consumption decrease of 100,750 m³/year The minimum total economic effect will be US $12,000 per year

The payback period is 1 year

See Appendix A 1, ECO #4 for more details on this proposal

ECO #5 - Reduction in Leakage of Natural Gas via Purchase of Modern Leak Detector

Natural gas is widely used in the processing lines at Kharkiv Tile Plant The TACIS experts from the European Commission that visited Open Joint-Stock Company "Kharkiv Tile Plant" in 1996, determined via testing with sensitive electronic instrumentation that leaks of gas from valves, various cranes and joints amount to 10 per cent

Therefore the most important function is to identify and eliminate leaks of gas used for industrial processing A gas and air mixture detector is recommended The saving results from setting a thorough control and maintenance of the gas transporting system This is the gas saving method requiring the lowest expenses

The Calculation gives the payback period of 0 1 year and a significant gas saving of 160,000 m³/year, which is equivalent to USD 13,300 per year

See Appendix A 1, ECO #5 for more details on this proposal

ECO #6 - Replacement of lamps in the exterior lighting system of the factory

We propose to replace 59 mercury light bulbs DRL-250 in the exterior lighting system of the plant area with high-pressure sodium light bulbs DNaT-100-3 while using the existing lighting fixtures and replacing only the starters with the corresponding power consumption capacity

Implementation of the project will allow *a)* to decrease the costs of replacing DRL-250 light bulbs as their life time is 2 5 times shorter than that of DNaT-100-3 electric bulbs, and *b)* to decrease the electric power consumption by the exterior lighting system by 2 2 times The payback period will be 0 5 year

See Appendix A 1, ECO #6 for more details on this proposal

ECO #7 - Portable High Range Infrared Thermometer (heat spy)

During the audit check the audit team made surface temperature measurements using non-contact thermometer (heat spy) to locate heat losses and evaluate their amount The measurements indicated that considerable losses occur in heat network, district heat systems, in operation processes, etc

A non-contact thermometer is necessary to implement the facility energy management program, which, according to expert evaluation, may save up to 10% of energy used Spotting and fixing heat losses promptly will result in gas savings of 56,400 m^3 and cost savings of $5,000 annually Payback period is 0 3 year

See Appendix A 1, ECO#7 for more details on this proposal

7 2 Long Term Recommendations

ECO#8 - Installation of Gas Turbine for Process Drying and Cogeneration

The current technology provides drying raw materials in drying towers with 6 GGV-100 burners each Drying towers operate in continuous year-round mode and use 50% of gas consumed in the facility The drying technology requires temperature control in different zones of the towers The existing heat system with three burners is roughly tuned and allows disturbances in zones temperature conditions, which results in decrease in process quality and additional consumption of at least 10% of gas (this is according to expert evaluation)

We propose to improve existing drying equipment using gas-turbine unit GT 2500 or GT 3000 as heat source The unit produces 2,500 - 3,000 kW of power needed by the plant Exhaust gases from the unit at 450 - 500°C are supplied to the drying tower and used for the drying process Implementation of this system will allow to produce up to 21,000 MW h per year and reduce amount of gas used by the drying tower by 10% Annual energy cost savings will be $666,000 Payback period is 4 1 year

See Appendix A 1, ECO#8 for more details on this proposal

8 ENVIRONMENTAL IMPACT OF RECOMMENDATIONS

The proposed project contains energy conservation measures aimed at saving fuel and electric power The main fuel used at Kharkiv Piston Plant is natural gas The harmful substance that forms in significant quantity during combustion of natural gas are nitrogen oxides (NO_x) The nitrogen oxides are harmful to the human health and can cause severe respiratory problems

Since combustion of natural gas results in the least emissions of the carbon dioxide CO_2 (that is the main gas responsible for setting "the green house effect"), saving natural gas will contribute to weakening of "the green house effect" This happens because less coal will be burnt if natural is available for combustion

Carbon monoxide (CO) is another harmful substance that forms after an incomplete combustion of natural gas Reduction in natural gas combustion will contribute to reduction in carbon monoxide emissions

Annual natural gas savings due to implementation of energy saving measures at Kharkiv Tile Plant will be as shown in Appendix A 8 Calculations

electricity saving -	1,600,000 kWh
natural gas saving -	2,200,000 m^3

According to the data from the Ministry of Energy, in 1996 1 kW h of the electric power meant emitting into the atmosphere of 17 g of contaminating substances, including the following

sulfur dioxide SO_2	9 9 g
carbon oxide CO	0 5 g
nitrogen oxides NO_x	2 2 g
hard particles	4 4 g

Reducing electric consumption results in decreasing the amount of the emitted harmful substances that can be determined by the formula

$$h = h_n \quad E_{ps},$$

where

h_n - the specific content of emissions, g/kW h

E_{ps} - electric power saving, kW h

Calculation of the carbon dioxide that forms at burning natural gas is made by the formula

$$M_{CO} = 0\ 001 \quad B \quad K_{CO} \quad Q_r\ (1 - q/100),$$

where

B - consumption of natural gas, m^3/yr

K_{CO} = 0 25 kg/GJ - the quantity of carbon dioxide that is produced per heat unit releasing at burning of natural gas

Q_r = 35MJ/m^3 - the lowest Calorific value of natural gas

q = 0 5 % - heat losses resulting from an incomplete gas combustion

M_{CO} = 0 001 2,200,000 0 25 35 (1 - 0 5/100) = 19,150 (kg/yr),

or M_{CO} = 19 t/yr

Calculation of the nitrogen oxides per time unit (t/yr) shall be done by the formula

$M_{NOx} = 0\ 001\ \ B\ \ K_{NOx}\ \ Q_r\ \ (1 - b)$,

where

K_{NOx} = 0 12 kg/GJ - a parameter characterizing the amount of the nitrogen oxides forming per 1 GJ of heat, kg/GJ,

b = 0 15 - a coefficient for taking into account the degree of decreasing the level of emissions of nitrogen oxides resulting from implementation of some technical measures

$M_{NOx} = 0\ 001\ \ 2{,}200{,}000\ \ 0\ 12\ \ 35\ \ (1 - 0\ 15) = 7{,}850$ (kg/yr),

or M_{NOx} = 8 t/yr

Implementation at the Tile Plant of energy conservation measures allows to decrease the energy sources consumption, and that in its turn, to decrease the quantity of harmful emissions into the atmosphere The data showing decreasing emissions of contaminating substances are given in the following table

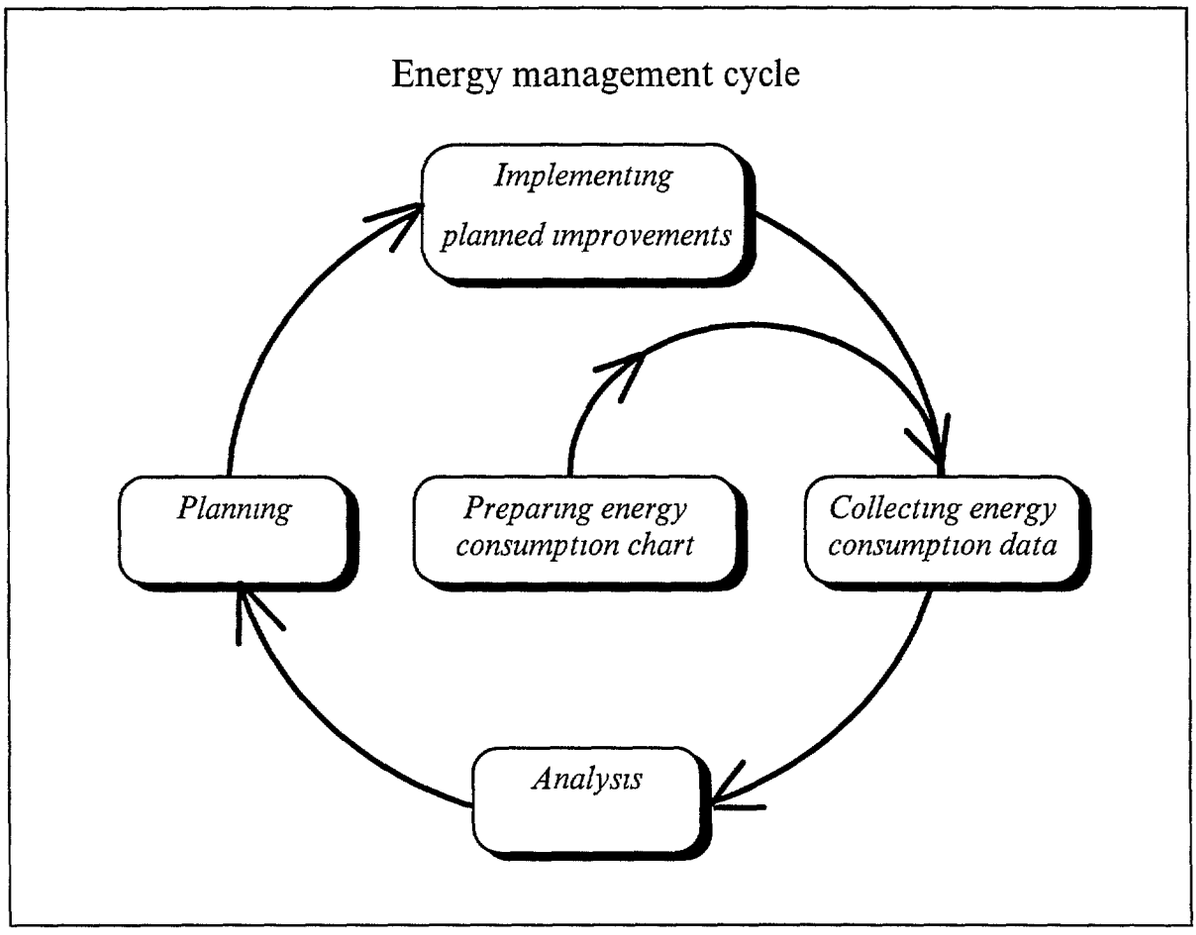
	Reduction in emissions as result of the energy savings, t/yr		
Emissions	**Electric power**	**Natural gas**	**TOTAL**
Hard particles	7	-	7
Sulphur dioxide	16	-	16
Carbon oxide	0 8	19 2	20
Nitrogen oxide	3 5	8	11 5

Appendix A ENERGY CONSERVASTION OPPORTUITIES (ECOs)

ECO #1 - Introduction of energy management

ECO description

Energy management is the main avenue by which energy usage reduction and increase in consumption efficiency can be achieved This management strategy is based on conventional measurements and documentation and provides operating conditions that facilitate minimal energy consumption needed for the technology This is also a management tool which comprises a continuous research allowing precise knowledge on facility's energy distribution and consumption, as well as on best energy utilization for production, district heat and other non-productive purposes



Implementation of energy management program will result in having more detailed energy consumption records Such system will allow comparison of the energy usage to that of other enterprises for precise evaluation of energy saving projects that are considered by the facility

Implementing an energy management activity typically would involve establishing a separate section of employees to deal only with energy efficiency At a minimum an energy management section should consist of three people technical supervise, an electric engineer and a thermal engineer

The main duties of an energy management section include

- Preparing facility's energy consumption chart (probably in collaboration with an outside consultant, energy auditor),
- Collecting fuel and energy consumption data using measuring and testing equipment,
- Preparing a plan for implementing additional measuring and testing equipment,
- Collecting data on raw materials and energy consumption and on production output,
- Making key Calculations on improving energy efficiency - for overall facility as well as specific production lines,
- Implementing new technologies on existing and new energy systems to improve energy efficiency of operation,
- Encouraging the personnel to indicate potential energy conservation opportunities
- Keeping informed on current energy policy trends and neighboring issues, (e g , such as new tax legislation, existing consumption restrictions, subsidies, environmental protection aspects etc)

In order to implement permanent energy consumption monitoring and analysis we recommend to institute energy management system at the plant and to provide required measuring equipment The set of equipment that will be useful for the plant should include

- three phase energy analyzer,
- tachometer,
- hot-wire anemometer,
- combustion analyzer,
- non-contact thermometer,
- ultrasonic leak detector,
- digital contact thermometer,
- light meter,
- power factor meter,
- portable temperature/humidity/ dew point meter,
- computer with printer

Annual energy savings

Currently the works use annually on average 16,000,000 kWh of electric power and 22,000,000 m^3 of natural gas

Typically, combustion efficiency improves by 2 5% from utilizing the combustion analyzer Electric power use efficiency can be linked to a wide range of factors i e power factor correction, improvement of equipment load control (shutting off idling equipment), optimization of motor loads, optimization of pump operation, improvement of compressor load control On average improvement of electric power use can ensure from 3 to 10% savings of total electric power consumption

The global experience and practice show that in case of institution of full-time energy management ensures 10% of fuel and energy consumption savings Energy savings will amount to

1) Electric power - 16,000,000 x 0 1 = 1,600,000 (kWh)

2) Natural gas - 22,000,000 x 0 1 = 2,200,000 (m^3)

Annual cost saving estimate

1 At the price of $0 048 per 1 kWh of electric power the cost savings will be

1,600,000 x 0 048 ≈ $76,800

2 At the price of $0 083 per 1 m^3 of natural gas the cost savings will be

2,200,000 x 0 083 ≈ $182,600

Total energy cost savings will be

76,800 + 182,600 ≈ $260,000

Commissioning Costs

According to the world practice, the commissioning costs are of about 50% of the expected energy savings, i e

260,000 x 0 5 ≈ $130,000

Simple payback

Implementation costs - $130,000

Annual cost savings - $260,000

Simple payback period will be

130,000 / 260,000 ≈ 0 5 (year)

ECO#2 - Excess Air Control for Boiler KBG-7 56

Description of Opportunity

The Plant had three boilers made by Ukrainian plant TECOM There are thousands of such boilers operating in Ukraine While this recommendation doesn't have the best payback of all recommendations for this plant, the audit team decided to assign first priority to this ECO due to vast possibilities for replication

The combustion control strategy used for this boiler is standard for all small boilers in the N I S This strategy cannot be Called anything but primitive The design dates back to approximately the year of 1965, and it meets the requirements of the standard in the former Soviet Union The combustion control strategy used in the USA by the Bailey Co in 1920 was better As result, the excess air ranges from 31% to 100% at the boiler exit and from 82% to 175% at the ID fan suction

There are three major problems with the existing control system

- Instead of air flow, FD fan discharge pressure signal is used This makes air flow control very erratic at low loads and makes automatic excess air correction impossible to achieve

- There is no automatic excess air correction vs load, i e , no oxygen program The system relies on the boiler operator to make an air flow set point adjustment after each load change Of course this doesn't happen and the boiler always operates with too much excess air

- There is no automatic excess oxygen correction

We are proposing to resolve all three problems The tile plant will fabricate a piezometer ring and install it on the FD fan suction The piezometer ring will serve as an air flow element Additional equipment includes two differential pressure transmitters, an oxygen analyzer, a microprocessor based controller and a variable frequency drive The resultant system will provide true air flow control and an automatic excess air vs load correction, i e an oxygen program according to the boiler load

After implementation of this proposal it will become possible to operate KBG-7 56 boiler at 5% excess air at the boiler exit and 15% excess air at the ID fan suction under an automatic excess air vs load correction Such operation will result in 5 to 6% savings on fuel (natural gas)

Annual Fuel Cost Savings

The factory Chief Engineer showed us the expenses on the fuel for the boiler-house, the total sum was US $400,000 This corresponds to gas consumption by the factory boiler-house of 4,820,000 m^3 Assuming 5% savings in natural gas consumption, the annual fuel cost savings will come to

$$4{,}820{,}000 \quad 0\ 05 - 241{,}000\ m^3$$

Implementation Costs

Cost of Equipment

Two differential pressure transmitters	$2,500
One local compressor based controller	$2,500
One oxygen analyzer	$4,000
One variable frequency drive, 15 kW	$2,500
Shipping and handling	$2,000
Subtotal	**$13,500**

Cost of Installation and Commissioning

Installation labor and materials will be provided by the plant These expenses are negligible

Registration and certification by GOSNADSOR will cost	$500
Technical supervision and commissioning will cost	$1,000
Subtotal	$1,500
Total Commissioning Costs	**$15,000**

Simple Payback

Commissioning costs	- US $15,000
Yearly savings	- US $20,000

Simple payback is $15,000/$20,000 = 0 75 year or 4 5 months of the heating season

ECO #3 - Improvement in Hot Water Supply System during the Summer Season

Description of Opportunity

Currently at Kharkiv tile works on coming the heating season to the end the hot water supply is provided with the help of a shell-type boiler "Lancashire" in the water heating mode on a gas fuel The boiler is used as a voluminous capacity heater and it operates twenty-four hours a day The volume of the boiler is V=27 m^3 without the flue tube The flow rate of water is cyclical, so the speed of the water in the boiler is below 0 01 m/s, and, consequently, the boiler scale quick deposits on the surfaces of heating "Lancashire" boiler has two installed burners of GTV-100 type The gas flow rate according to the data from the works is 60 m^3/h, or B= 1440 m^3/day With that the flow rate of hot water amounts to about 30 m^3/day The heat required for heating the water is

$$Q = G_w \ (t^0_{hw} - t^0_{cw})/1000$$

where

Q - amount of the thermal energy, GCal
G_w - amount of the heated water, ton
t^0_{hw} - temperature of the hot water, ^0C
t^0_{cw} - temperature of the cold water, ^0C

When water is heated from 10^0C to 60^0C the heat flow rate during 24 hours is

$$Q = 30 \ (60 - 10)/1000 = 1\ 5 \text{ (GCal)}$$

The specific gas flow rate for generating 1 GCal of thermal energy for the hot water supply is

$$b_{act} = B/Q = 1440/1\ 5 = 960 \text{ } (m^3/GCal)$$

If the Calorific power of gas Q_l = 8320 $kCal/m^3$ per 1 GCal of heat, supposing that the boiler efficiency

$\eta_{ideal} = 1$, there is required

$$b_{ideal} = (1/8320) \ 10^6 = 120 \text{ } (m^3/GCal)$$

The efficiency of "Lancashire"boiler in such an operation mode is

$$\eta_b = b_{ideal} \ 100/b_{act} = 120 \ 100/960 = 12\ 5 \text{ } (\%)$$

It is a very low indicator of the boiler operation Practically in the volume of the boiler there is no a convective constituent to the thermal exchange process The water is moving in the boiler laminary, the heating is performed at the cost of the heat conductivity On the external surface of the flue tubes there is taking place a near-wall boiling of the water that did not passed the chemical treatment and having an increased contents of Calcium and magnesium salts, which results in an intensive deposition of scale That decreases the heat conductivity coefficient and, eventually, we have a low boiler efficiency

According to the data from "Hydro-X" Danish Company 1 mm of scale brings to decreasing the boiler efficiency by 8 to 9 per cent It is the scale deposition that lead to an abrupt dropping of the efficiency of "Lancashire" boiler that has got obsolete morally

Instead of an imperfect processing of the hot water preparation there is suggested to install a 100-kW boiler and a plate-type he t exchanger with a corresponding heat production capacity The given complex (a boiler-water heater) will produce 2 1 tons of hot water per hour with the temperature of 60°C The hot water will go into an accumulating tank that should be made of "Lancashire" boiler This is not difficult to do by covering the flue tubes with a metal sheet (10-mm thickness) Inside the tubes openings with a 100-mm diameter must be done in the lower and upper points to use effectively the internal volume of the flue tubes with the volume of V = 5 6 m^3 and to make the total volume of the accumulating tank equal to the volume of V= 32 m^3, which corresponds to a daily need of the works in hot water The hot water flow rate according to the data from the works is 30 m^3/day The hot water from the accumulating tank is supplied by the existing pumps to the users

In the result of implementing the given suggestion there is an opportunity to decrease the gas flow rate for the hot water supply needs, as the efficiency of the suggested plant η_{sugg} = 90 per sent, and not 12 5 per cent

Annual Energy Savings

Let us suppose the following data for the Calculation

n_s = 365 - n_s = 365 - 167 =178 (days/year),

where

n_h - the number of days when the summer hot water supply mode is used

n_s - duration of the heating season

The flow rate of gas for the needs of the hot water supply in the non-heated period is

B_s = B n_h= 1440 178 = 256,320 (m^3)

If to install the proposed complex of a boiler with a water heater having efficiency η_{prop} = 90%, the fuel efficiency will rise by

$\eta = \eta_{pr}$ η_b = 90 - 12 5 = 77 5 (%)

Gas saving in the natural units is

B_s η/100 = 256,320 77 5/100 = 198,650 (m^3/year)

Annual Fuel Cost Savings

At current cist of $83 per 1000 m^3 of gas, annual cost savings will be

$Saving_{mon}$ = $Saving_{gas}$ 0 083 = 198,650 0 083 = $16,500

Implementation Costs

Cost of the plant boiler-water heater US $6,000

Cost of materials	US $1,000
Cost of the project designing, registration, agreeing	US $1,000
Cost of the installation works by a specializing company	US $1,000
Cost of turning "Lancashire" boiler into an accumulating tank with the thermal insulating works	US $2,000
Overhead costs	US $3,300
TOTAL COSTS	**US$14,300**

Simple Payback

Annual cost savings	US $16,500
Implementation costs	US $14,300

Simple payback

14,300/16,500 = 0 9 year

As the equipment is in operation 6 months a year, the actual payback period will be

6 0 9 = 5 4 months

ECO #4 - Optimization of the Hot Water Supply System

Description of Opportunity

Currently the heat supply of the works is provided from a boiler-house, where 3 water heating boilers of KVG-7 56 type are installed with the total heat production capacity of Q = 19 5 GCal/hour The boiler-house has a system of headers of the supply and return water In the result the boiler-house has seven pairs pipelines of different diameters outgoing in the same direction The temperature mode of the thermal networks is 130 to 70 ^{0}C

When the boiler-house was visited, the following operation mode was

- the external temperature t^0_{ext} = 0°C
- the temperature at the supplying header t_{suppl} = 67^{0}C
- the temperature at the reverse header $t_{reverse}$ = 55^{0}C
- the temperature in the pipelines incoming and outcoming into the joint header of the reverse line water

1) Workshop #1	- 55°C
2) Workshop #2	- 58°C
3) inhabited settlement	- 49°C
4) "Polymer-Cement" Workshop	- 60°C
5) artistic ceramics workshop	- 55°C
6) garage	- 58°C
7) MechaniCally & Preparatory Area + Workshop #1	- 51^{0}C

The design temperature of the return line water at t^0_{ext} = 0°C for the city of Kharkiv

$t^0_{return\ wat}$ = 45 9°C (the minimum design temperature t_{min} = -23°C), while the temperature of the supply water $t^0_{suppl\ wat}$ = 72 3°C The differential temperature of the coolant between the supply and return headers of the pipelines in the boiler-house is practiCally $\Delta t^{act} = t^{act}_{suppl\ wat} - t^{act}_{return\ wat}$ = 67 - 55 =12 (°C), while for the temperature schedule of the heat supply there must be the design temperature of $\Delta t^d = t^d_{supply\ wat} - t^d_{return\ wat}$ =72 3 - 45 9 = 26 4 (°C)

Supposing the water flow rate through the boiler G = 79 ton/hour the heat production capacity of the boiler is

$$Q^b = G\ \ (t_{out} - t_{in})/1000 = 79\ \ (97 - 55)/1000 = 3\ 32\ (\text{GCal/hour})$$

Gas flow rate according to an instrument is G_{gas} = 430 m^3/hour

The specific gas flow rate is

$$b = G_{gas}/Q^b = 430/3\ 32 = 129\ 5\ (\text{m}^3/\text{hour})$$

If the gas Calorific value is Q_{gas} = 8320 kCal/m^3 per 1GCal of heat and if the boiler efficiency η_{ideal} = 1, there is required

$$b_{ideal} = (1\ /8320)\ \ 10^6 = 120\ (\text{m}^3/\text{GCal})$$

In our case the efficiency

$\eta_b = b_{ideal}/b \quad 100 = 120/129\ 5 \quad 100 = 92\ 66\%$ which is a real efficiency for KVG-7 56 boilers

The instrument for metering the flow rate of water into the thermal network with the measurement range of 0 to 250 m^3/hour was not sufficient, so we can Calculate the actual water flow rate as

$$G_w^{act} = Q^b/\Delta t^{act} \quad 1000 = 3\ 32/12 \quad 1000 = 276\ 6 \text{ (ton/hour)}$$

If to suppose that the maximum continuous rate of the boiler Q^b = 3 32 GCal/hour corresponds to the heat load that is available with a user, so the line water flow rate according to a standard must be

$$G^d = Q^b/\ \Delta t^d \quad 1000 = 3\ 32/26\ 4 \quad 1000 = 125\ 75 \text{ (ton/hour)}$$

Absence of a hydraulic balancing of the objects results in an overcomsumption of the line water by

$$\Delta G = G_w^{act} - G^d = 276\ 6 - 125\ 75 = 150\ 85 \text{ (ton/hour)}$$

We suppose that the optimal speed of the water in the thermal is ω = 1 m/s, the head losses in the tubes is $\Delta h \leq 10$ mm/m Under these conditions to transport a standardized quantity of the coolant G^d = 125 75 ton/hour there is enough to have tubes with D = 200 mm

This brings to the conclusion that one can refuse a collector system inside the boiler-house, if to output from the boiler-house one pair of pipe lines with D_y = 200 mm The following measures must be implemented for that

- to determine using the installed instruments the actually connected heat load,
- to choose using the currently put pipe lines the optimal diameters of the tubes that must remain in operation We can exclude by this from operation the auxiliary pairs of pipe lines, put in parallel in the same direction,
- using the chosen schemes of the thermal lines to make the required switchings,
- after the hydraulic Calculation one has to set the controlling diaphragms directly near each user before the heating system After that all the heat supply system will be hydraulically stable It is necessary that the resistance of the internal systems in front of which the controlling diaphragms must be placed should be not higher than $h \leq 1$ mm water column Otherwise, the internal systems will have the coolant flow rate 1 5 to 2 times higher than the designed one,
- after installation of the controlling draining diaphragms there are required a thermal testing of the system and checking of correspondence of the actual flow rates to the designed ones In case of any variations in any direction, one shall correct the diameters of the controlling draining diaphragms

The above mentioned measures after their implementation shall give the following results

- decrease of the volume of the external heat supply lines by V = 100 m^3,
- decrease of the electric power consumption for the coolant transportation,
- decreased heat losses into the environment at the cost of decreased external surface of the heat lines

Annual Energy Savings

Electric power consumption of the line pump D-320-50 with a motor of N = 90 kW, according to the made measurements, is N_{act} = 60 kW

Electric power consumption during a heating season is

$$E_{act} = N_{act} \quad 24 \quad n_{heating} = 60 \quad 24 \quad 189 = 272{,}160 \text{ (kW)},$$

where

$n_{heating}$ - duration of the heating period

In case of decreasing the flow rate of the line water there must go down electric energy consumption up to N_{pr} = 40 kW

Correspondingly, the expected electric power consumption shall be

$$E_{pr} = N_{pr} \quad 24 \quad n_{heating} = 40 \quad 24 \quad 189 = 181{,}440 \text{ (kW)}$$

The expected electric power saving on transporting the coolant per year is

$$E_{act} - E_{pr} = 272{,}160 - 181{,}440 = 90{,}720 \text{ (kW)}$$

On the boiler-house there is no registration of the heat production To determine the minimum heat production level during the heating period we shall make Calculations

The temperature of the external air on the day of the measurements was $t_{ext\ air} = 0^0C$

Heat production at $t_{ext} = 0^oC$ Q_{hr} = 3 32 GCal/hour

If the average temperature during 24 hours is $t_{ext\ air} = 0^0C$, heat production during 24 hours is

$$Q_{daily} = Q_{hr} \quad 24 = 3\ 32 \quad 24 = 79\ 68 \text{ (GCal/day)}$$

Number of degree-days is $n = 18 - t_{ext} = 18 - 0 = 18$

Heat flow rate per one degree-day is

$$q = Q_{daily} / n = 79\ 68/18 = 4\ 43 \text{ (GCal/degree-day)}$$

Number of degree-days according to the regulations for Kharkiv city $n_{d\ d}$ = 3,500

Total heat level production for the whole tile works must be

$$Q_{annual} = q \quad n_{annual} = 4\ 43 \quad 3{,}500 - 15{,}505 \text{)GCal/yr)}$$

Supposing that the standard thermal losses by the external lines are 10%, which corresponds to

$$Q_{losses} = Q_{annual} \quad 0\ 1 = 15{,}505 \quad 0\ 1 = 1{,}550 \text{ (GCal/yr)}$$

Providing expected decreasing of the external surface of the pipe lines by 50 per cent, the heat losses shall be decreased by

$$Q_{losses} \quad 0\ 5 = 1{,}550 \quad 0\ 5 = 775 \text{ (GCal/yr)}$$

In case of the ideal gas consumption b = 130 m^3/GCal, the gas saving per year must be

$$775 \quad 130 = 100{,}750 \text{ } (m^3/yr)$$

Annual Fuel Cost Savings

Cost saving resulting from decreasing the electric power consumption at the price of $0 04 per 1 kWh is

$$90{,}720 \quad 0\ 04 = 3{,}630 \text{ (\$)}$$

Cost saving resulting of decreasing gas consumption at the price of $ 0 083 per 1 m^3 is

$$100{,}750 \quad 0\ 083 = 8{,}370 \text{ (\$)}$$

Total saving from implementation of the ECO

$$3{,}630 + 8{,}360 \cong 12{,}000 \text{ (\$)}$$

Implementation Costs

The design works

- determination of the actual heat loads,
- development of a new thermal lines system,
- hydraulic Calculation of the thermal lines

The approximate cost is $5,000

Fulfillment of the installation works to connect the heat lines and the equipment on the blocking fixture maintenance area

- cost of materials - $2,000
- labour cost - from the resources of the works (from the salary and wages fund for the energy department of the works

Installation of the controlling draining diaphragms shall be done by the energy department of the works according to the schedule at the cost of its own salary fund on the basis of payment per each worked hour

The thermal tests, correcting the hydrauliCal design and diameters of the draining diaphragms C_3 = $2,000

Overhead costs $2,700

ECO #5 - Reduction in Leakage of Natural Gas via Purchase of Modern Leak Detector

Description of Opportunity

Natural gas id widely used in the industrial process at Kharkiv Tile Plant From the gas distributing station gas is supplied through a metal pipeline supported over the land The gas pipeline has branches to Workshop #1 and Workshop #2 where the pressure of the gas is decreased to the level required for operating the burners used in the industrial processing at the plant The pipelines for supplying gas to the burners have threaded joints with seals of oakum

European Commission TACIS experts that visited Open Joint-Stock Company "Kharkiv Tile Plant" in 1996 determined, with the help of different tests using electronic and measuring instrumentation, that leaks of gas from valves, various cranes and joints are 10 per cent

One of the important functions is identification and elimination of leaks of the gas used in the industrial process It is recommended for that to use a detector of gas and air mixtures Elimination of leaks shall be done by a team of repairing metal workers Saving is received by organizing a thorough control and maintenance of the gas transportation system It is the cheapest way to decrease gas consumption The calculation given below shows the efficiency of using the given detector even if the gas leaks are minimal (2 to 5 per cent)

Annual Gas Savings

The input data for the calculation

- four conveyer lines including a utilizing and glost firing furnaces,
- Conveyor line annual time providing a continuous production - F = 7,200 hours,
- flow rate at each production line
  - 1 Conveyor Line 1030 #1 256 m^3/h
  - 2 Conveyor Line 1030 #2 288 m^3/h
  - 3 Conveyor Line 1012 #1 243 m^3/h
  - 4 Special Conveyor Line 450 320 m^3/h
- gas losses K = 2%

The annual gas saving if the leaks are eliminated

7,200 (256 +288 + 243 + 320) 2 /100 = 160,000 (m^3/yr)

Annual Fuel Cost Savings

Saving in money units if 1000 m^3 of gas cost US $83

160,000 0 083 = 13,300 ($/yr)

Implementation Costs

Cost of the detector of gas and air mixtures	US $0 6 to 1,000

Simple Payback

Annual cost saving	US $13,300
Commissioning costs	US $ 1,000

Simple payback period 1,000/13,300 = 0 1 (yr)

Total costs are 5,000 + 2,000 + 2,000 + 2,700 = 11,700 ($)

Simple Payback

Annual cost saving	$ 12,000/yr
Costs of commissioning works	$11,700
Simple payback period	11,700/12,000 = 1 (yr)

As the duration of the heating season is 6 1 months per year, actually the payback is

1 6 = 6 (months)

Annual Fuel Cost Savings

Saving in money units if 1000 m^3 of gas cost US $83

160,000 0 083 = 13,300 ($/yr)

Implementation Costs

Cost of the detector of gas and air mixtures	US $0 6 to 1,000

Simple Payback

Annual cost saving	US $13,300
Commissioning costs	US $ 1,000

Simple payback period 1,000/13,300 = 0 1 (yr)

ECO #5 - Reduction in Leakage of Natural Gas via Purchase of Modern Leak Detector

Description of Opportunity

Natural gas id widely used in the industrial process at Kharkiv Tile Plant From the gas distributing station gas is supplied through a metal pipeline supported over the land The gas pipeline has branches to Workshop #1 and Workshop #2 where the pressure of the gas is decreased to the level required for operating the burners used in the industrial processing at the plant The pipelines for supplying gas to the burners have threaded joints with seals of oakum

European Commission TACIS experts that visited Open Joint-Stock Company "Kharkiv Tile Plant" in 1996 determined, with the help of different tests using electronic and measuring instrumentation, that leaks of gas from valves, various cranes and joints are 10 per cent

One of the important functions is identification and elimination of leaks of the gas used in the industrial process It is recommended for that to use a detector of gas and air mixtures Elimination of leaks shall be done by a team of repairing metal workers Saving is received by organizing a thorough control and maintenance of the gas transportation system It is the cheapest way to decrease gas consumption The Calculation given below shows the efficiency of using the given detector even if the gas leaks are minimal (2 to 5 per cent)

Annual Gas Savings

The input data for the Calculation

- four conveyer lines including a utilizing and gas-firing furnaces,
- Conveyor line annual time providing a continuous production - F = 7,200 hours,
- flow rate at each production line

  1 Conveyor Line 1030 #1 256 m^3/h

  2 Conveyor Line 1030 #2 288 m^3/h

  3 Conveyor Line 1012 #1 243 m^3/h

  4 Special Conveyor Line 450 320 m^3/h

- gas losses K = 2%

The annual gas saving if the leaks are eliminated

$$7{,}200 \quad (256 + 288 + 243 + 320) \quad 2/100 = 160{,}000 \ (m^3/yr)$$

ECO #6 - Installation of More Efficient Lighting

Description of Opportunity

The exterior lighting system at the plant includes 59 lighting fixtures of SZPR-250 type with DRL-250 mercury high-pressure lighting fixtures and they are installed on reinforced supports of 10-m height Part of the area of the plant is lit with ordinary 100- and 150-W incandescent lamps The luminous flux from DRL-250 lighting is 10,000 lm, while the nominal life time is 2,400 hours

There is proposed for consideration a project of replacing DRL-250 mercury lighting fixtures in the exterior system for lighting the area of the plant with DNaT-100-3 sodium high-pressure lighting fixtures while using the existing lighting fixtures and replacing starters of the corresponding power capacity DNaT-100-3 sodium high-pressure lighting fixtures are produced in Poltava, Ukraine, and have a larger life time of 6,000 hours when the luminous flux is 9,000 lm

Annual Electricity Savings

SZPR-250 type lighting with a DRL-250 mercury lamp consumed

$P_{\Sigma l} = (P_{Ll} + P_{start\ l})\ \cos\varphi$

where

$P_{Ll} = 250$ W - power of DRKL-250 lamp

$P_{start\ l} = 54\ 1$ W - power of the starters

$\cos\varphi = 0\ 98$

$P_{\Sigma} = (250 + 54\ 1)\ \ 0\ 98 = 298$ W or 0 298 kW

The amount of the electric power consumed by 59 lighting fixtures during a year on condition of an average switching for about 10 hours a day is

$P_l = P_{ll}\ \ n\ \ F,$

where

$n = 59$ - the number of lighting fixtures

$F = 10\ \ 365 = 3\ 650$ (hours) - the annual operation time for a lighting

$P_l = 0\ 298\ \ 59\ \ 3{,}650 = 64{,}173\ 3$ (kWh)

The electric power consumption of a SZPR-250 lighting with a DNaT-100-3 sodium lamp is

$P_{\Sigma 2} = (P_{L2} + P_{start\ 2})\ \cos\varphi$

where

$P_{L2} = 100$ W - power of DRKL-250 lamp

$P_{start\ 2} = 34\ 7$ W - power of the starters

$\cos\varphi = 0\ 98$

$P_{\Sigma 2} = (100 + 34\ 7)\ \ 0\ 98 = 132$ W or 0 132 kW

The amount of the electric power consumed by 59 lighting fixtures during a year on condition of an average switching for about 10 hours a day is

$P_2 = P_{\Sigma 2}\ \ n\ \ F = 0\ 132\ \ 59\ \ 3{,}650 = 28{,}426\ 2$ (kWh)

The annual electric power saving in the natural units when using DNaT-100-3 lamps is

$P_1 - P_2 = 64{,}173\ 3 - 28{,}426\ 2 = 3{,}574\ 1$ (kW)

Annual Cost Savings

Saving of means in the pecuniary form, if 1 kWh of power costs for the plant US $ 0 048

35,747 1 0 048 ≅ 1,720 ($/yr)

Implementation Costs

Cost of DNaT-100-3 with its starters - 59 lamp × $30	US $ 1,770
Overhead costs	US $ 530
Total costs	US $ 2,300

Cost of the installation works is not taken into account, as these sort of works will be fulfilled by the plant staff

Simple Payback

Annual saving of losses	US $1,720
Commissioning costs	US $ 2,300

Simple payback is

2,300/1,720 = 1 3 (year)

ECO #7 - Portable High Range Infrared Thermometer (Heat Spy)

Description of Opportunity

During audit check the audit team based on equipment and heat systems surface temperature measurements made using non-contact heat spy to locate heat losses and evaluate their amount The heat spy's function us based on objects' infrared radiation measuring and converting at 0°C - 1000°C temperature range Measurement indicated that considerable losses occur

- in heat networks due to insufficient pipeline and stop valves,
- in district heat systems due to hydraulic and, consequently, thermal unbalance of heating equipment,
- in operation processes due to faulty insulation of technology ovens and other equipment

Non-contact thermometer is necessary to implement on the Facility energy management program, which, according to expert evaluation, may save up to 10% of energy used Spotting and fixing heat losses promptly will result in gas savings of 56,400 m^3 and cost savings of $5,000 annually Payback period is 0 3 year

Annual Energy Savings

Assuming conservatively that proposed equipment will allow to locate just 10% of heat losses, fixing the imperfections found will result in 0 5 - 1% gas savings Basing on annual gas consumption for district heat needs at 5,640,000 m^3 (according to the plant's data), annual gas savings may come to

$5{,}640{,}000 \times 0{,}01 = 56{,}400\ m^3$

Annual Cost Savings

At current price of $ 0 083 per 1 m^3, annual cost savings will be

$56{,}400 \times 0\ 083 \cong \$5{,}000$

Implementation Costs

non-contact remote-sensing thermometer (heat spy)	$1,000
Overhead expenses @ 30%	$300
TOTAL COSTS	**$1,300**

Simple Payback

Annual cost savings	$5,000
Implementation costs	$1,300

Simple payback is 1,300 /5,000 = 0 3 year

ECO#8 - Installation of Gas Turbine for Process Drying and Co-generation

Description of Opportunity

Current technology provides drying raw materials in drying towers with 6 GGV-100 burners each At the time of our visit four out of ten towers were functioning, two towers at each workshop Drying towers operate in continuous year-round mode and use 50% of gas consumed on the facility Minimum gas consumption per tower is 310 m^3/hr, maximum is up to 450 m^3/hr At 8,300 kCal/m^3 heat content of gas, heat amount required for drying process is minimum 2 6 GCal/hr, maximum 3 7 GCal/hr

The drying technology requires temperature condition control in different zones of the towers

Zone 1 - 320 - 360°C, Zone 2 - 200 - 220°C, Zone 3 - 100 - 110°C

Currently existing heat system with three burners is roughly tuned and allows disturbances in zones temperature conditions, which results in decrease in process quality and additional consumption of at least 10% of gas according to expert evaluation

We propose to improve existing drying equipment using gas-turbine unit GT 2500 or GT 3000 as heat source Specific equipment is to be determined after a comprehensive energy audit check and preliminary study of technology process in all details It would be most efficient to retrofit the whole drying complex and not it's separate parts We recommend the following technological sequence

1 Gas-turbine unit produces 2,500 - 3,000 kW of power needed by the plant

2 Exhaust gases from the unit at 450 - 500°C are supplied to the drying tower via a distribution device The distributor should provide uniform temperature condition for specific zones in order to make the performance controllable and optimum

The raw material should be supplied to the drying tower with uniform pressure and flow rate to provide quality spraying inside the tower Equipment currently in use does not always allow to keep these conditions It is necessary to change pumps and retrofit the drying tower

Implementation of this system will allow to produce up to 21 M kW h per year and reduce amount of gas used by the drying tower by 10%

Annual Energy Savings

As the gas-turbine unit will cover all of the plant's electricity needs, annual savings on purchased electricity will come to approximately 16,000,000 kWh Gas consumption per drying tower averages 360 m^3/hr or 3,150,000 m^3/yr Annual 10% gas savings will constitute

$3150000 \times 0{,}1 = 315000\ m^3$

Annual Cost Savings

At current electricity price of $0 04 per 1 kW h, annual electricity cost savings will be

16,000,000 × 0 04 = $640,000

At gas price of $0 083 per 1 m^3, annual gas cost savings will be

315,000 × 0 083 = $26,000

Total energy cost savings

640,000 + 26,000 = $666,000

Implementation Costs

Gas-turbine unit	$1,300,000
Tower and raw materials pumps	$400,000
Design works	$300,000
Commissioning and turnkey installation	$500,000
Overhead expenses and unforeseen costs @10%	$250,000
TOTAL COSTS	**$2,750,000**

Simple Payback

Implementation costs	$2,750,000
Annual cost savings	$666,000

Simple payback is

2,750,000 / 666,000 = 4 1 year

Appendix B. SPECIFICATIONS FOR THE REQUIRED EQUIPMENT

51

B 1 Equipment and Works Specification, ECO#1 - Implementation of Energy Management Program

#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Implementation of an Energy Management program and introduction of an energy consumption record keeping system							"Elta" Consulting Kharkiv, Ukraine	130,000	130,000	Financing from the funds of the Tile Plant
	TOTAL									**130,000**	

B 2 Equipment and Works Specification, ECO#2 - Excess Air Control for *KVG 7,56* Boiler

#	Equipment/ Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Controller	348 FILDPAC™	*Moore Products,* USA	Pressure 0 to 5 mm H_2O	1	2,500	750		3,250		
2	Differential Pressure Transmitters	I 340D XTC ™ II 341D XTC™	*Moore Products,* USA		1 1	3,544	1,063		795	5,402	
3	Flue Gas Oxigen Analyzer with a mounting kit and 600 mm insertion sensor	Termos Series 210	PRO-TECH SOLUTIONS, USA	Power 220 VAC/50 Hz Output 4 - 20 mA DC	1	2,900	870			3,770	
4	Induction motor rotation speed converters and installation	AT 01	*Triol Corporation,* Kharkiv, Ukraine	Motor capacity 15 kW	1	2,330		***Triol***		2,330	Installation costs including
		REN-15	*International Consortium for Energy Conservation,*	Motor capacity 15 kW	1	2,800	-	*International Consortium for Energy*		2,800	Installation costs including

B 2 Equipment and Works Specification, ECO#2 - Excess Air Control for *KVG 7,56* Boiler

#	Equipment/ Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
			Kharkiv					*Conservation*, Kharkiv			
		ACF601-0016-3	*ABB Ukraine* "*Elmash* Research & Production Company	Motor capacity 15 kW	1	2,458	737			3,195	Installation costs to be included
		CXOq110 V 34A2NO	*Honneywell* Kyiv, Ukraine	Motor capacity 15 kW	1	2,695	810	***Ecoterm***	660	4,165	
		TTE(P)1	***Preobrazovatel*** Research Institute, Zaporizhzhia, Ukraine	Motor capacity 14 kW	1	2,973	892			3,865	Installation costs to be not included
5	Registration, certification, implementation works							*Elta Consulting* Company, Kharkiv, Ukraine	2,400	2,400	

B.3 Equipment and Works Specification, ECO#3 - Changing summer season hot water supply scheme

#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Water boiler	BGV-50T	Closed JSC *Termo*, Lugansk, Ukraine	N = 50 kW	2	870	360			2,100	
2	Water heating unit with a plate-type heat exchanger, temperature control, circulating pump	N0 1-(1,5 + 1,5)-KY	*Ancor-Teploenergo Ltd* Kharkiv, Ukraine	N = 100 kW	1	2,000	200			2 200	Shipment costs to be included in the installation cots
3	Design, registration, approval, shipment, installation, commissioning works							*Elta Consulting*, Kharkiv, Ukraine		10,000	
	TOTAL									**14 300**	

B.4 Equipment and Works Specification, ECO#4 - Optimization of thermal networks hydrolic mode

#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Material for installing stop valve servicing platforms	due to the project	due to the project	due to the project						2,000	
2	Design, registration, approval, shipment, installation, testing, commissioning works							*Elta consulting,* Kharkiv, Ukraine	9,700	9,700	
3	Portable one-channel flow meter	TransPort™ PT868	I I *PANAMETRICS* Inc JSC *Pergam* II *PEEK Measurements*	I = 4 to 20 mA	1	9,500	480			9,980	
	TOTAL									**21,680**	

B.5 Equipment and Works Specification, ECO#5 - Saving natural gas in flow process

#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Ultrasound Listening Device for Leak Detection	EPD-500S kit	*EPD* 14, Hayes Street, Elmsford,New York, 10523, USA		1	1,700				1,700	
2	Combustion analyzerl	ENERAC-2000	*Energy Efficiency Systems, Inc* Drive, Westbury, NX 11590, USA	Analyzed gases O_2, CO, SO_2, NO_x	1	5,000				6,500	
	TOTAL									**8,200**	

B 6 Equipment and Works Specification, ECO#6 - Replacing exterior lighting fixtures

#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	High pressure sodium lamp with controls	DNaT-100-3 EIPRA	OJSC *Poltava Gas-Discharge Lamp Plant*, Poltava, Ukraine, *Interface Company*, Vynnytsia, Ukraine	U= 220 V P=100 W	59	39		JSC *Kharkiv Tile Factory*, Kharkiv, Ukraine		2,301	Shipment costs including
	TOTAL									**2,301**	

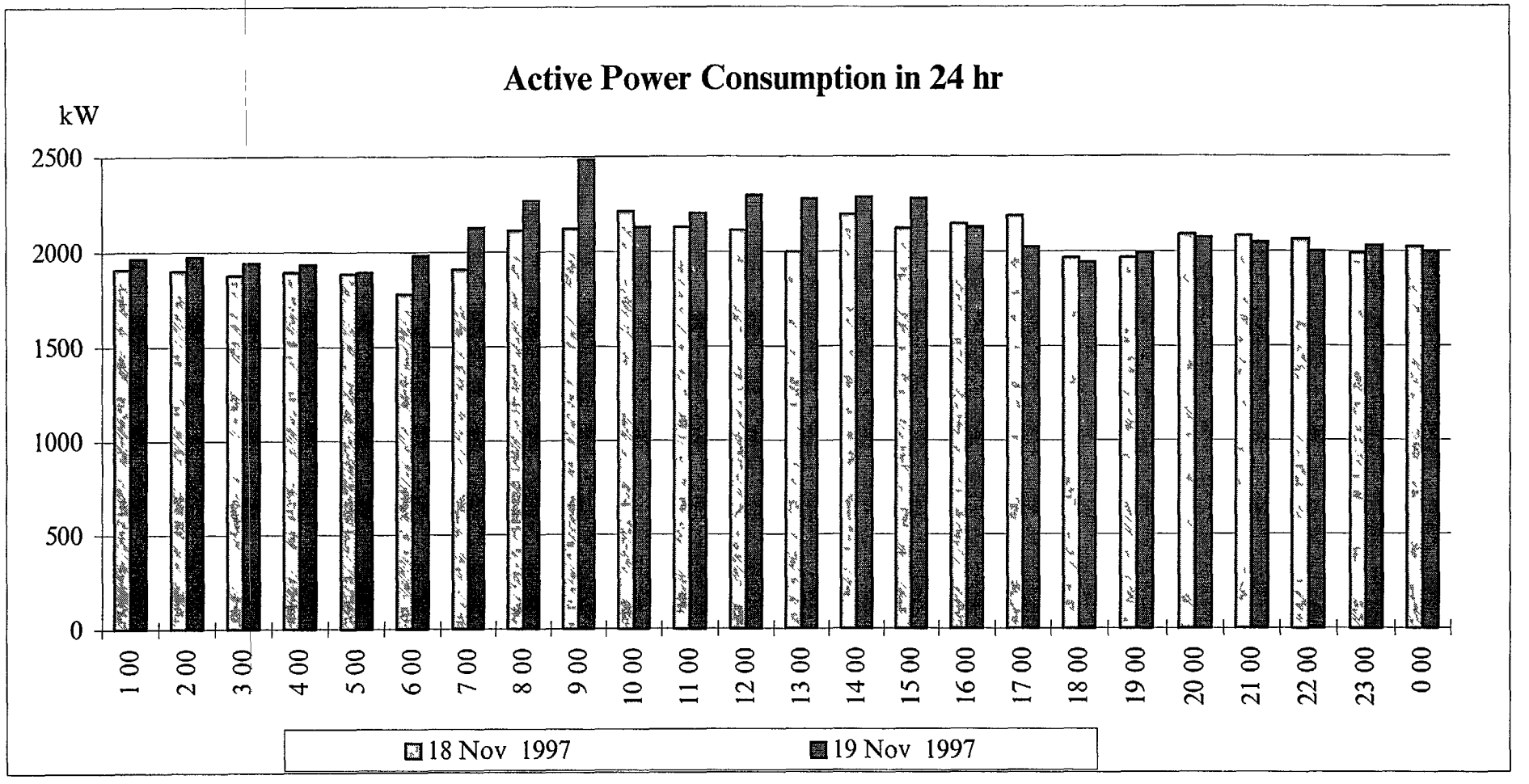
B.7-Equipment and Works Specification, ECO#7 - Controlling equipment and heat networks temperature condition

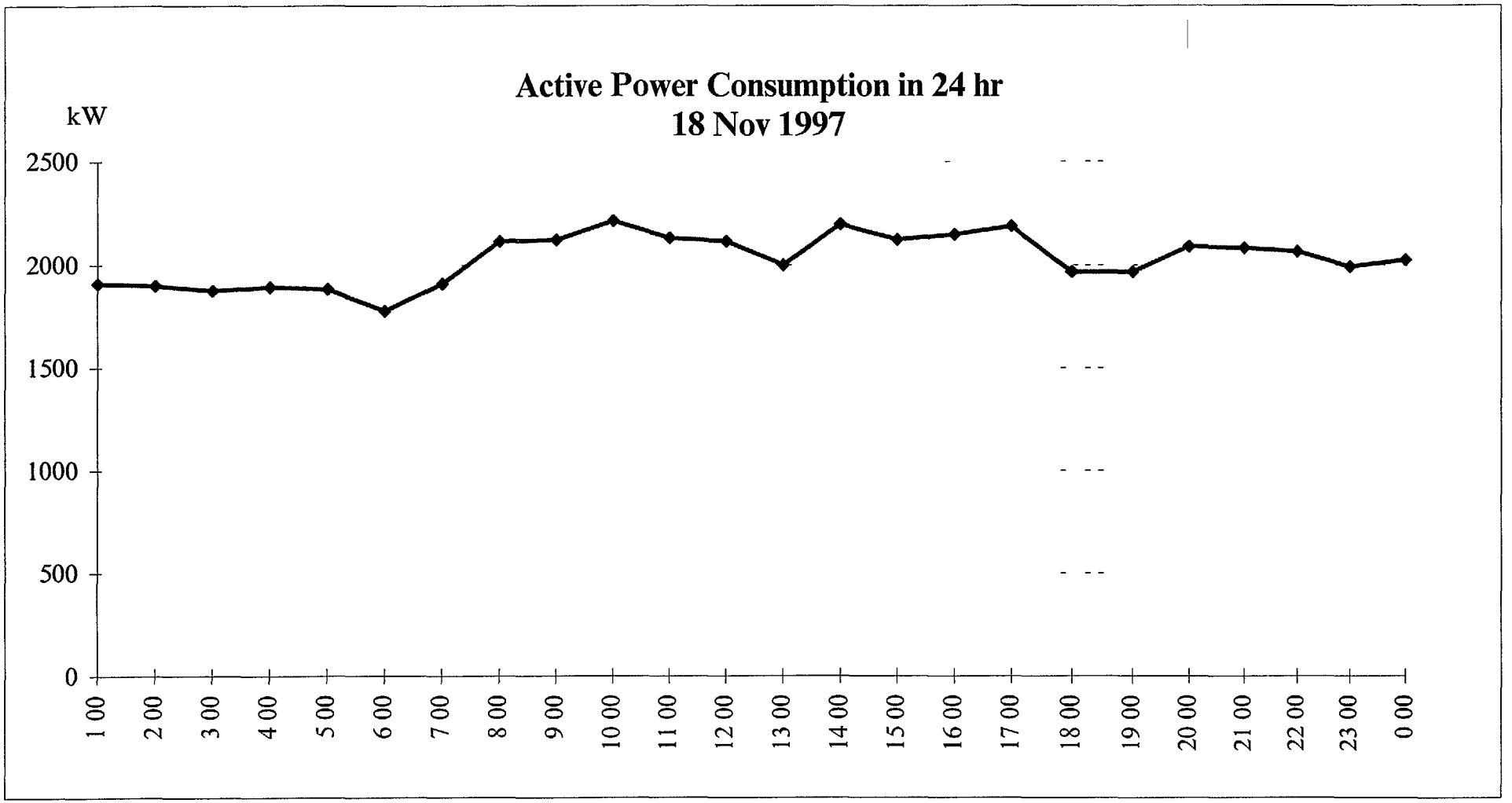
#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Infra-red Non-contact Thermometer	ST6 LS	*Davis Instruments* 4701 Mount Hope Drive Baltimor, MD21215, USA	t° = -20 to 500°C	1	499				499	
	TOTAL									**499**	

B.8 Equipment and Works Specification, ECO#8 - Using gas-turbine unit got driving raw materialsion

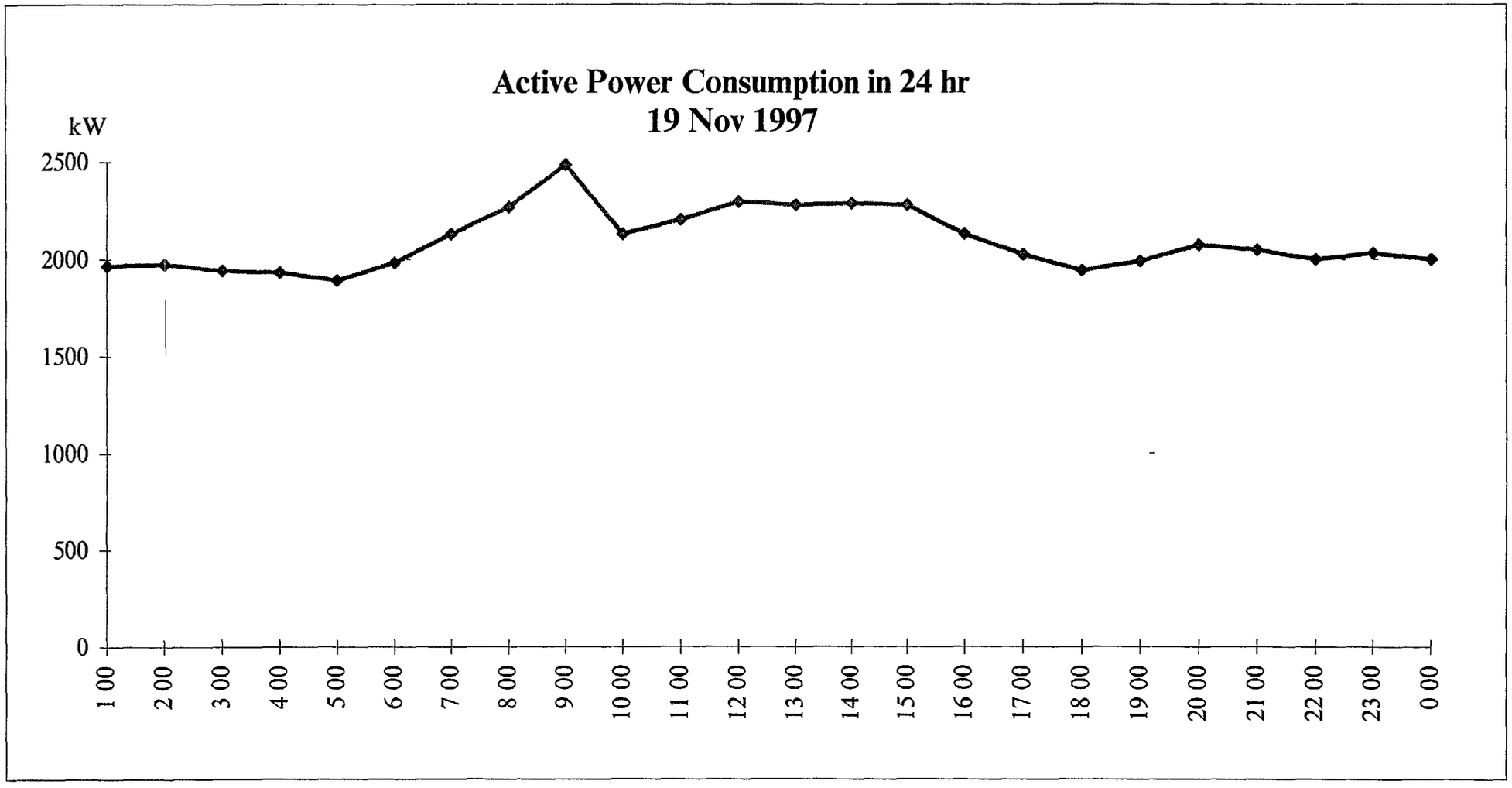
#	Equipment/Works Description	Model or Type	Manufacturer, Country of Origin	Basic Parameters	Quantity, unit	Cost per Item US$	Shipping Costs US$	Contractor	Cost of Works US$	Total Costs US$	Notes
1	Gas-turbine unit	GT-2500	*Mashproekt* Research & Production Enterprise, Mykolayiv, Ukraine	P = 19 kg/cm^2 G_r = 4 GCal/hr	1			*Elta Consulting*, Kharkiv, Ukraine		1,300,000	
2	Design, production of non-standard equipment, ordering the processing equipment, "turn-key" installation and commissioning works by the subcontractors							*Eltao Consulting* Kharkiv, Ukraine		1,450,000	
	TOTAL									**2,750,000**	

Appendix C AUDIT RECORDS AND PLANT DATA


Active Power Consumption in 24 hr
kW
2500
2000
1500
1000
500
0
1 00
2 00
3 00
4 00
5 00
6 00
7 00
8 00
9 00
10 00
11 00
12 00
13 00
14 00
15 00
16 00
17 00
18 00
19 00
20 00
21 00
22 00
23 00
0 00
18 Nov 1997
19 Nov 1997


Active Power Consumption in 24 hr
18 Nov 1997
kW
2500
2000
1500
1000
500
0
1 00
2 00
3 00
4 00
5 00
6 00
7 00
8 00
9 00
10 00
11 00
12 00
13 00
14 00
15 00
16 00
17 00
18 00
19 00
20 00
21 00
22 00
23 00
0 00

62


Active Power Consumption in 24 hr
19 Nov 1997
kW
2500
2000
1500
1000
500
0
1 00
2 00
3 00
4 00
5 00
6 00
7 00
8 00
9 00
10 00
11 00
12 00
13 00
14 00
15 00
16 00
17 00
18 00
19 00
20 00
21 00
22 00
23 00
0 00

Analysis of the exhaust combustion gases after KVG-7,56,
by ENERAC - 2000 combustion analyzer

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 30 53
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	84 9	%
AMBIENT TEMPERATURE	69	°F
STACK TEMPERATURE	225	°F
OXYGEN	09 1	%
CARBON MONOXIDE	36	PPM
CARBON DIOXIDE	06 8	PPM
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	1 6	
EXCESS AIR	68	%
OXIDES of NITROGEN	49	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 34 32
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	85 0	%
AMBIENT TEMPERATURE	69	°F
STACK TEMPERATURE	253	°F
OXYGEN	06 3	%
CARBON MONOXIDE	36	PPM
CARBON DIOXIDE	08 4	PPM
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	0 8	
EXCESS AIR	38	%
OXIDES of NITROGEN	61	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

Analysis of the exhaust combustion gases after KVG-7,56,
by ENERAC - 2000 combustion analyzer

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 37 53
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	84 4	%
AMBIENT TEMPERATURE	70	°F
STACK TEMPERATURE	273	°F
OXYGEN	06 1	%
CARBON MONOXIDE	32	PPM
CARBON DIOXIDE	08 5	PPM
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	0 7	
EXCESS AIR	37	%
OXIDES of NITROGEN	64	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 39 40
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	84 4	%
AMBIENT TEMPERATURE	70	°F
STACK TEMPERATURE	273	°F
OXYGEN	06 3	%
CARBON MONOXIDE	35	PPM
CARBON DIOXIDE	08 4	PPM
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	0 7	
EXCESS AIR	39	%
OXIDES of NITROGEN	64	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

Analysis of the exhaust combustion gases after KVG-7,56, by ENERAC - 2000 combustion analyzer

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 45 24
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	84 2	%
AMBIENT TEMPERATURE	70	°F
STACK TEMPERATURE	270	°F
OXYGEN	05 1	%
CARBON MONOXIDE	142	PPM
CARBON DIOXIDE	09 1	PPM
COMBUSTIBLE GASES	0 06	%
STACK DRAFT (INCHES H20)	0 4	
EXCESS AIR	29	%
OXIDES of NITROGEN	66	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 51 16
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	82 9	%
AMBIENT TEMPERATURE	70	°F
STACK TEMPERATURE	269	°F
OXYGEN	04 8	%
CARBON MONOXIDE	374	PPM
CARBON DIOXIDE	09 3	PPM
COMBUSTIBLE GASES	0 20	%
STACK DRAFT (INCHES H20)	0 4	
EXCESS AIR	27	%
OXIDES of NITROGEN	67	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

MODE PPM OXY_REF=TRUE%

Analysis of the exhaust combustion gases after KVG-7,56,
by ENERAC - 2000 combustion analyzer

SERIAL # 11003501

ENERAC MODEL 2000

COMBUSTION TEST RECORD

TIME 11 57 28
DATE 11/18/97
FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	83 7	%
AMBIENT TEMPERATURE	70	°F
STACK TEMPERATURE	270	°F
OXYGEN	05 1	%
CARBON MONOXIDE	192	PPM
CARBON DIOXIDE	09 1	PPM
COMBUSTIBLE GASES	0 11	%
STACK DRAFT (INCHES H20)	0 5	
EXCESS AIR	29	%
OXIDES of NITROGEN	67	PPM
SULFUR DIOXIDE	0	PPM
CARBON MONOXIDE ALARM	50	PPM

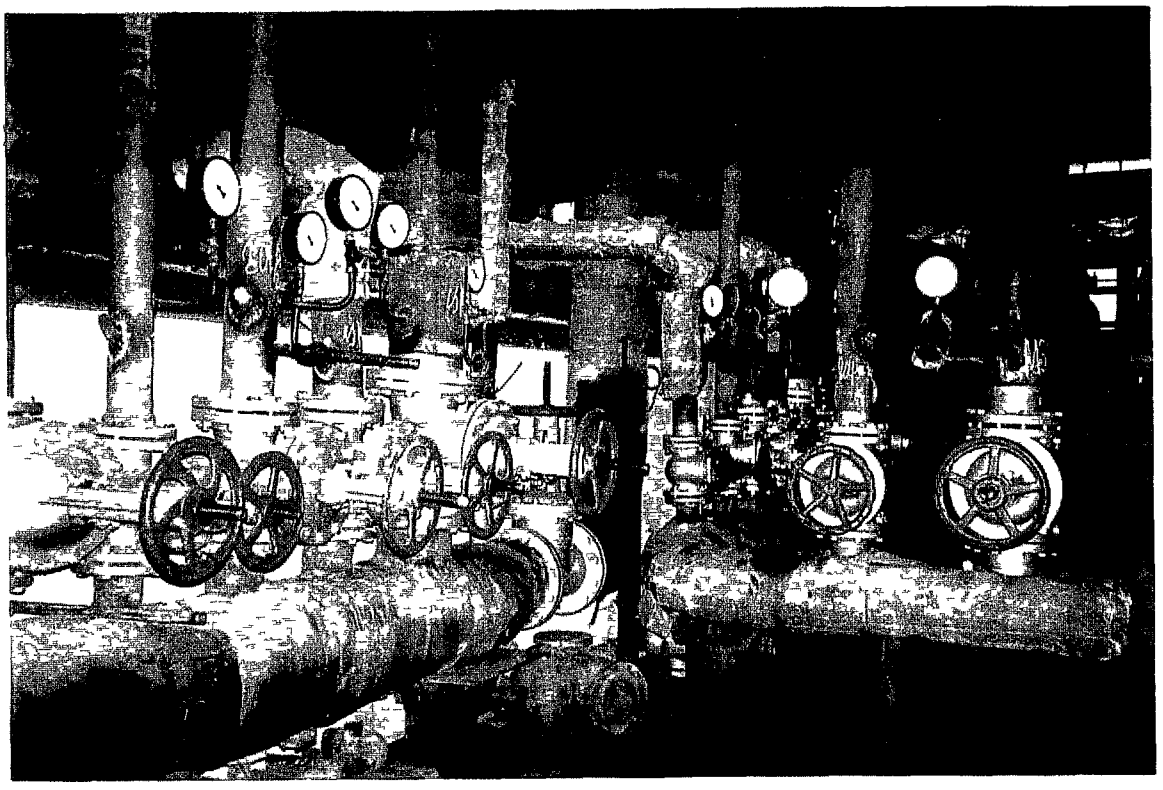
MODE PPM OXY_REF=TRUE%

Appendix D. PLANT PHOTOGRAPHS

69

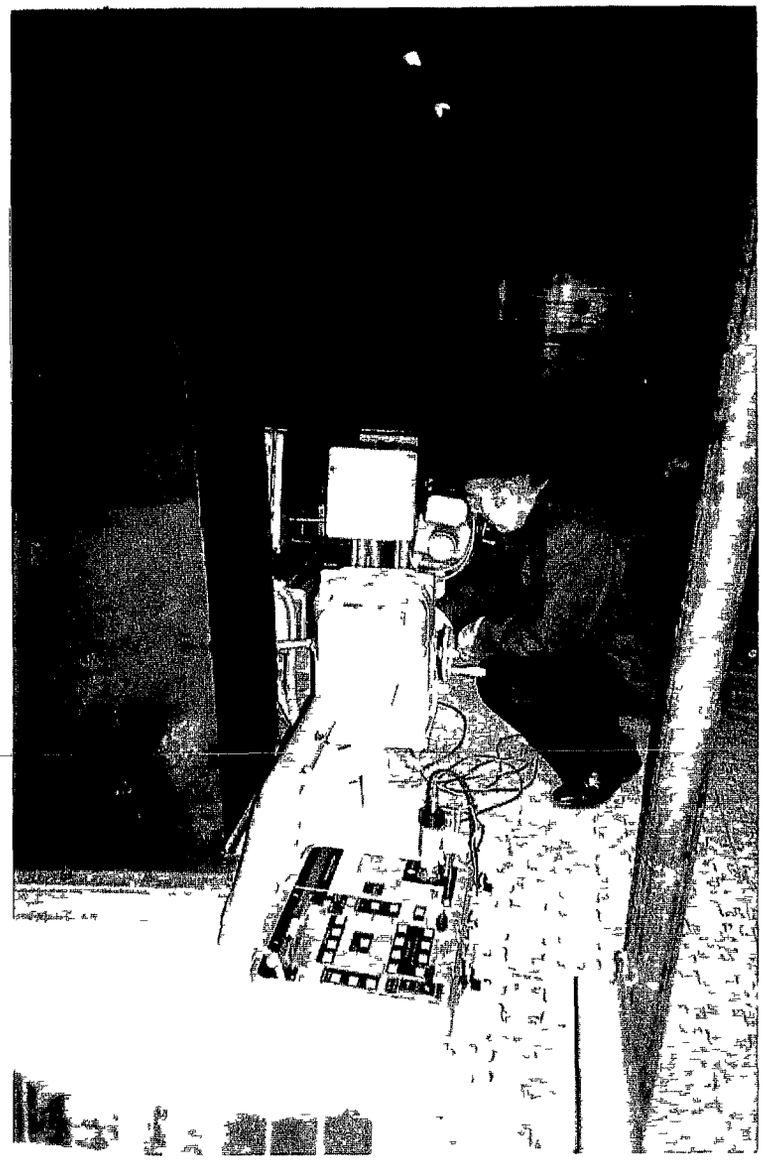
Харьковский плиточный завод
Kharkiv Tile Plant

Облицовочная керамическая плитка
Finishing ceramic tile



Существующая схема распределения теплоносителя
внутри котельной коллекторного типа
The heat-carrier distributing system existing currently at the collector-type

характеризуется наличием излишних трубопроводов
идущих в одном направлении (Приложение А 3)
is characterized by presence of too meny pipelines going
in the same direction Appendix A 3

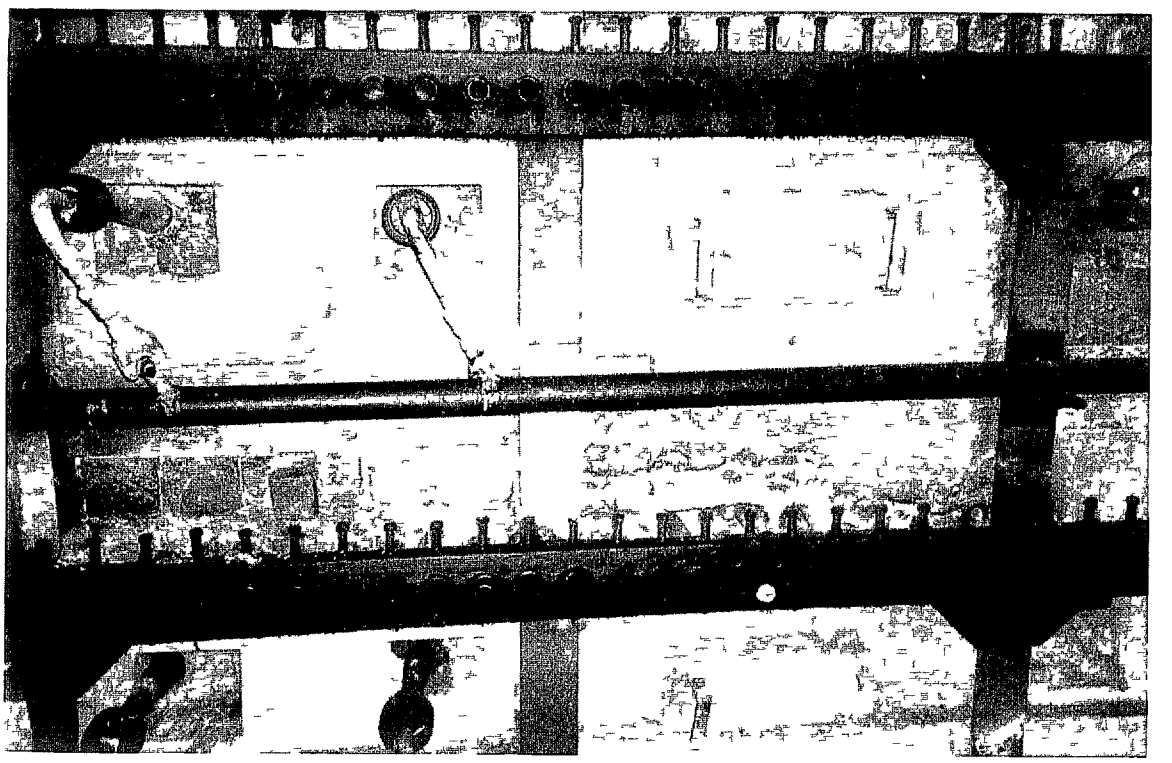


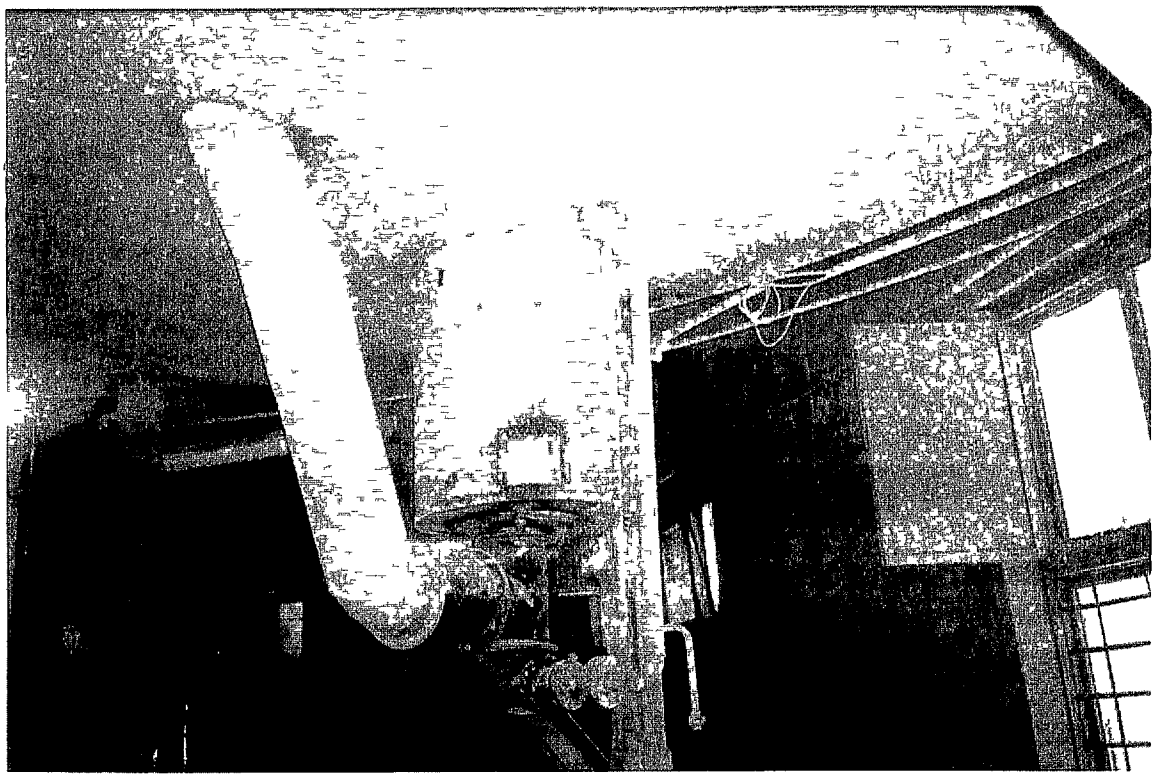
Производство измерений
технико-экономических показателей КВГ-7,56 энергоаудиторами
Measuring the technical and economic characteristics of KVG-7,56
by the energy auditors

Цех ' Полимер бетон
"Polymer concrete" workshop

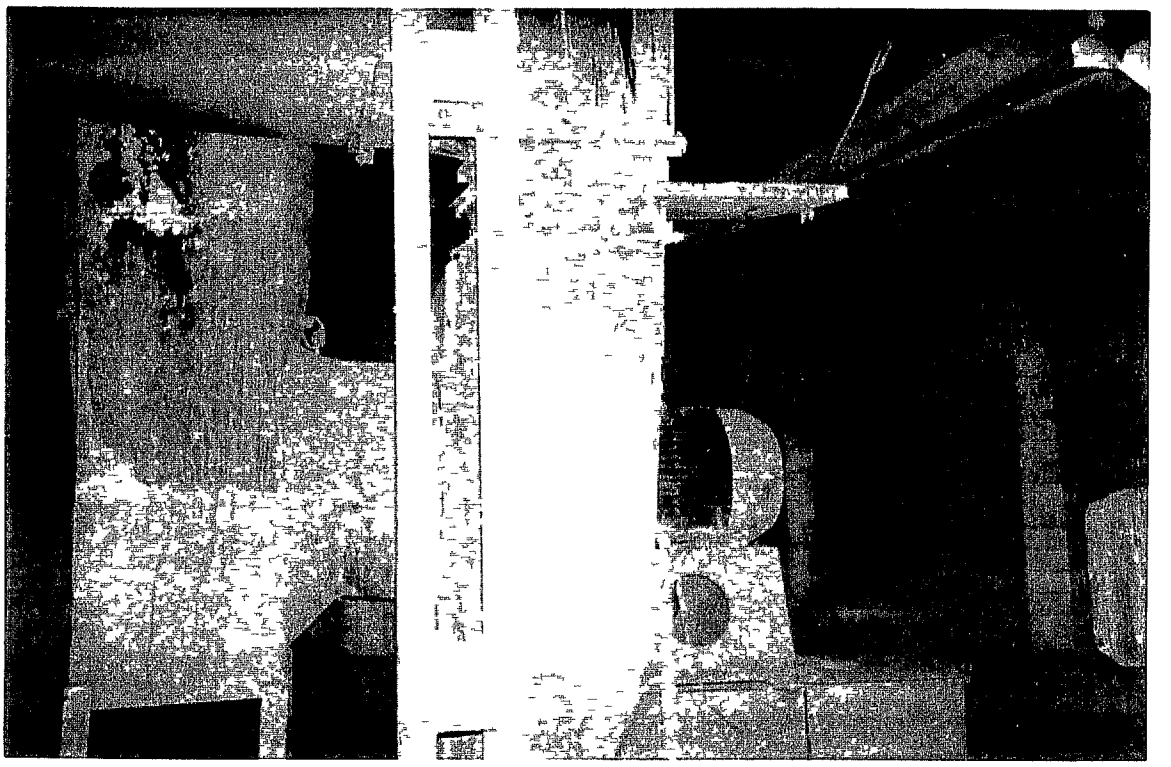
Производство полимерных плит ванн компактов раковин
Production of polymer slaas, tubs baths hoppers and sinks

Поточно-конвейерные линии
Conveying lines

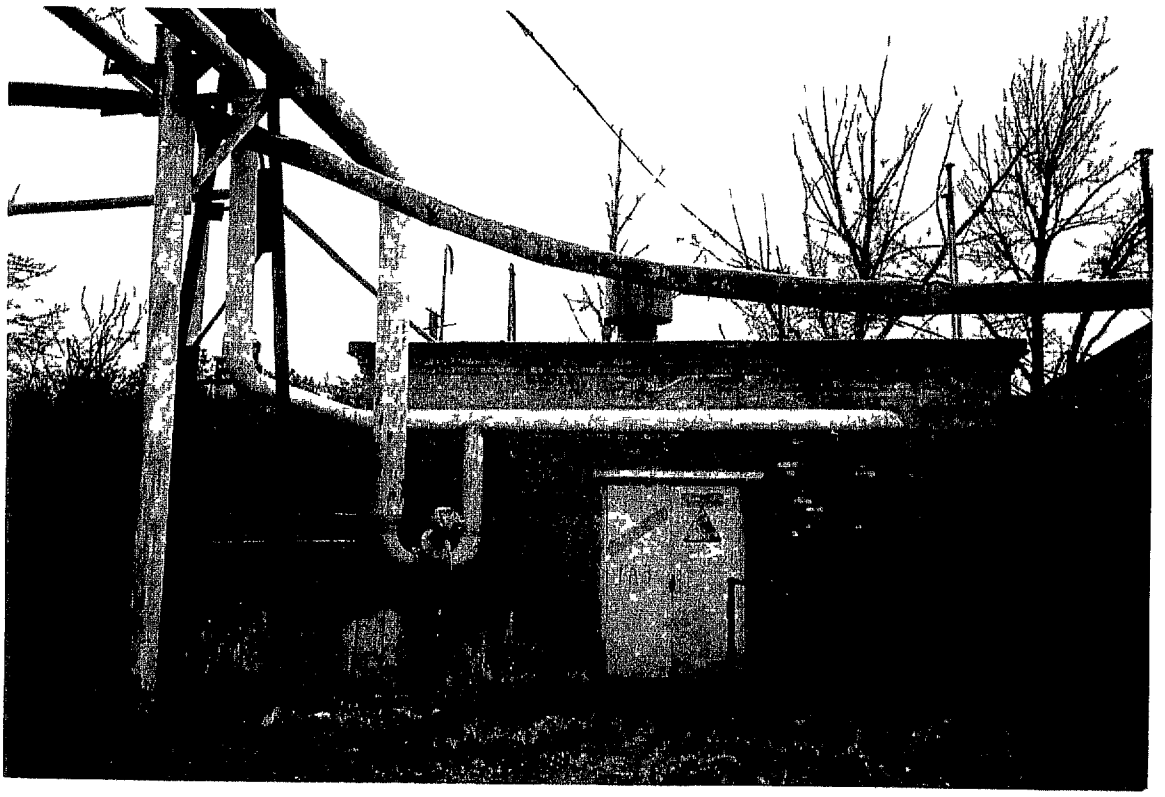




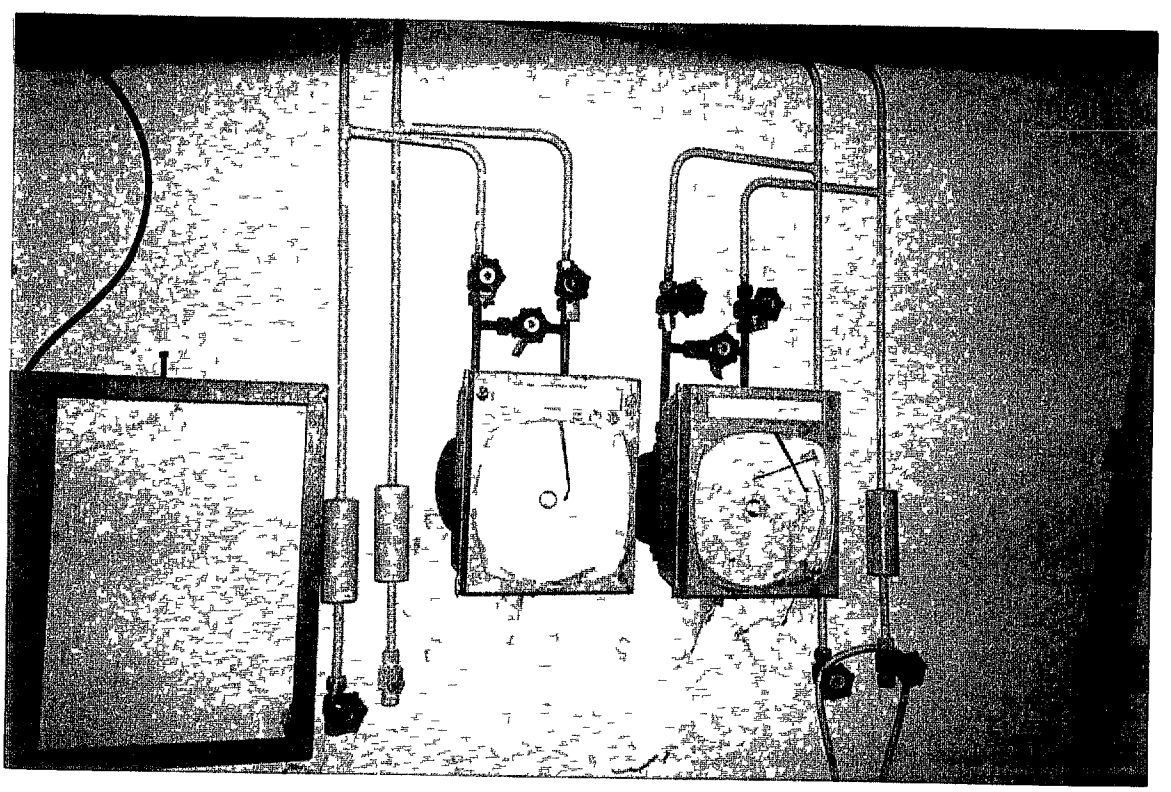
Сушильные башни сырья плиточного производства
Towers for drying the raw materials for tile production

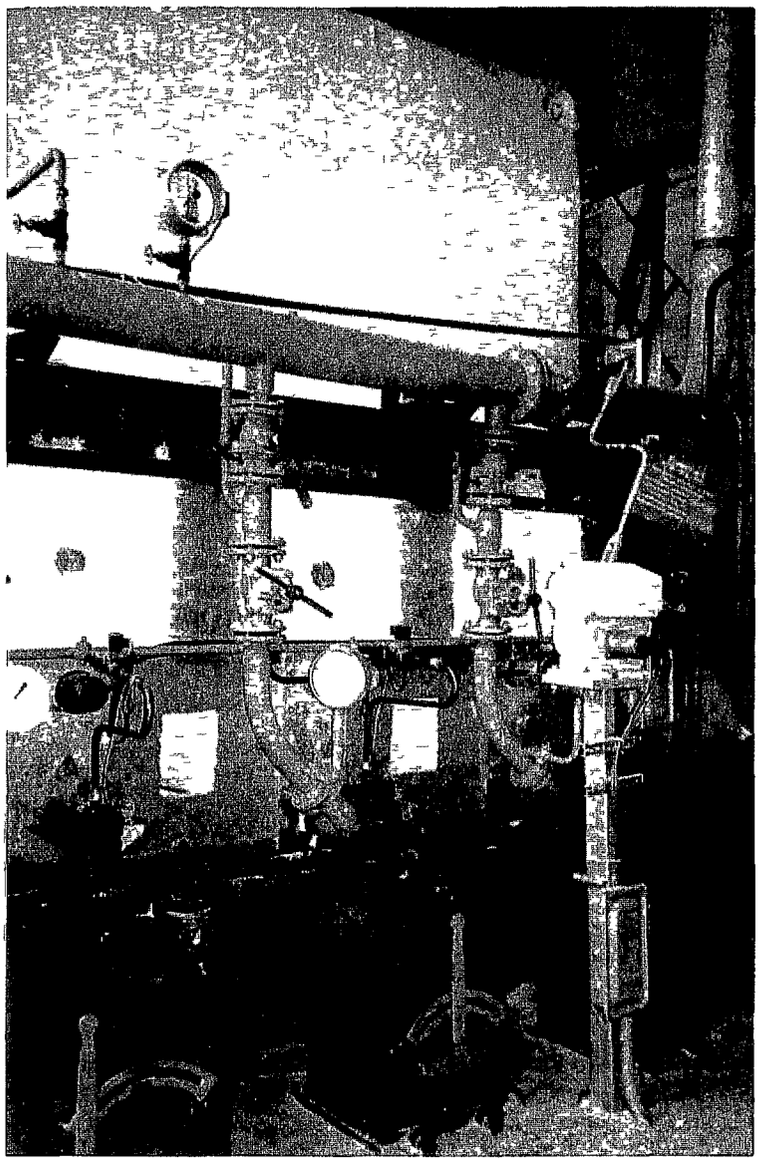


Дымосос сушильной башни ДН-12 5
The output fan at DN-12,5 drying tower



Газораспределительный пункт завода
Gas distributing station at the plant





Фронт котла КВГ-7,56
The front view of KVG-7,56 Boiler

Appendix E. CONVERSION FACTORS

Currency rates of exchange

1 hrivnia - local currency unit

1hrivnia = US $0 54 as of December 1997

Conversion factors

Heat

1 Cal = 4 187 J

1 kCal = 4 187 kJ = 3 968 BTU

1 GCal = 4 187 x 10^3 = 4 187 GJ

1 BTU = 1055 J = 1 055 kJ = 1 055 x 10^3 MJ

Power

1 W = 3 6 x 10^3 J = 3 6 kJ

1 kW = 3 6 x 10^3 kJ = 3 6 MJ = 860 kCal

1 MW = 3 6 x 10^3 MJ = 860 kCal

1 kCal = 1 163 x 10^3

1 GCal = 1163 kW = 1 163 MW

1 kW = 1 36 HP

1 kW = 1 34 hp

Pressure

1 kg/cm^2 = 1 atm

1 atm = 101 325 kPa = 0 1 MPa

1 bar = 10^5 Pa = 100kPa = 0 1 MPa

Length

1 mm =0 03937 in = 0 00328 ft

1 cm = 0 3937 in = 0 0328 ft

1 m = 3 937 in = 3 281 ft

Weight

1 gram = 2 2046 x 10^{3} lb

1 kg = 2,2046 lb

1 t = 1000kg = 2 2046 x 10^{3} ft

Area

1 cm^2 = 0 155 square in = 1 076 x 10^{3} square ft

1 m^2 = 1 55 x 10^3 square in= 10 76 square ft

Volume

1 m^3 = 35 31 cu ft = 1000 l

1l = 35 31 x 10^3 cu ft

1l = 0 264 US gal

Heat content

1 kJ/kg = 0 43 BTU/lb

1 kJ/m^3 = 26 84 x 10^{3} BTU/cu ft

1 MJ/m^3 = 26 84 BTU/cu ft

1 $KCal/m^3$ = 4,187 kJ/m^3 = 0 112 BTU/cu ft

Temperature

^0C = 0 56 (^0F-32)

Appendix F ABBREVIATIONS

82

ABBREVIATIONS

CIS - Commonwealth of Independent States

ECO - energy conservation opportunity

ESCO - energy service company

etc - et cetera

Hr - hrivnia

i d - id est

JSC - joint-stock company

mln - million

TACIS - TechniCal Assistance to CIS countries

tel - telephone

thou - thousand

US - United States

USAID - United States Agency of International Development

BTU - British thermal unit

^{0}C - degrees Celcium

cm^2 - centimeter squares

^{0}F - degrees Faranheit

g - gram

GCal - gigaCalorie

GJ - gigajoule

h - hour

kCal - kiloCalorie

kg - kilogram

kgf - kilogram-force

kV - kilovolt

kV-A - kilovolt-amper

kW - kilowatt

kW h - kilowatt hour

Lm - lumen

m - meter

m^2 - meter squared

m^3 - meter cubed

min - minute

MJ - megajoule

mm H_2O - millimeters of the water column

MW - megawatt

t - tonne

t/h - tonnes per hour

W - watt