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Delivery Order #30
Energy Efficiency in the Industry of Ukraine
November, 1997

REPORT

ON ENERGY AUDIT

AT JOINT-STOCK COMPANY "*LAMP PLANT*"
Lviv City, UKRAINE

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1 EXECUTIVE SUMMARY

1 1 Introduction

As part of Delivery Order #30, Industrial Energy Efficiency – Ukraine, the U S Agency for International Development (***USAID***) sponsored energy efficiency audits at 8 industrial plants that met the criteria and were approved by ***USAID*** The purpose of this project was to develop Ukrainian energy service company (ESCO) capabilities To accomplish this task, *Burn and Roe Enterprises, Inc*, (the primer 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

This report details the findings of ***BURNS & ROE ENTERPRISES***, Inc energy report performed at ***LVIV Lamp PLANT (ISKRA)***

In accordance with the sub-task of this Contract, 24 enterprises out of 90 potential ones have been selected for audit Each enterprise has been considered from the point of view of project participants selection criteria (approved by ***USAID***) Such selection criteria included the following long-term economic development forecast, financial status of an enterprise, export revenue share, relation of the present product output to the maximum possible one, energy saving potential, the possibility to extrapolate the project on similar enterprises and enterprise's availability as demonstration site for other enterprises

The majority of the energy efficiency problems of the plant are typical for the most of Ukrainian industrial plants, and solutions to these problems can be replicated in diverse industries

The objectives of the energy efficiency audits were as follows

- to conduct informal training in the energy management practices
- to create an institutional awareness of energy management
- to recommend specific steps for improvement of energy efficiency, including management actions, low-cost energy saving measures and selection of equipment to be used for their implementation
- to recommend medium cost and capital investments actions reflecting large energy conservation opportunities

A project team consisting of

- Mr William Dries as the team leader from ***USAID***,
- Mr Volodymyr Mamalyga as an expert in the fields of electric engineering, electric mechanics and economy,
- Mr Dmitry Kramarenko as an expert in the field of thermal engineering and in the processing issues

performed an energy audit during November 25 to 29, 1997 Due to the objectives of the audit, the energy auditing team prepared the following draft report

In performing the audit Mr Gassan Mustafayev – Expert, Mr Volodymyr Shestopal – Civil Construction Engineer and Driver, Miss Anastasia Leonova – Interpreter also took direct

participation The audit report was translated by Mr Valery Gool Mr Mikhailo Tarnovsky and Mr Yury Bykov participated in development of recommendations aimed at introduction of the energy management service (Item 7 1)

1 2 Principal findings

- *LVIV LAMP PLANT ISKRA* is considered to be quite successful by the Ukrainian standards, but it also has to rely on the bartering system when paying for the electric power supply
- The energy audit group have identified several quite attractive opportunities for improvement of energy efficiency in the plant operation
- Despite a repeated rising of energy prices, currently their proportion in the structure of the operation costs does not exceed ***12 1*** per cent However, inspite of that the top plant management pays a serious attention to the issues related to energy saving
- Availability at the enterprise of an internal economic self-supporting system should be considered as a fact advantageous to stimulation of energy saving Under the conditions each self-supporting structure unit shall pay only for the resources that were consumed by it itself
- As the plant management did not provide the team with required financial data, the auditors failed to have an opportunity to analyze the financial and economic activities of the plant in detail Therefore, the auditors failed to analyze and develop recommendations concerning how effective it would be to produce some sorts of products on the basis of analysis of their production profitability The auditors also failed to check how there was reasonable the method of making budgets of separate plant departments
- Out of the total cost of the energy resources consumed by the enterprise ***49,6*** per cent are related to gas the major part of which (***33,97*** per cent) is consumed by *RIBBON* glassmaking furnace The total costs of the potable water and the sewage system are ***26,4*** per cent, while the electric power costs are ***24*** per cent The main consumer of electric power is the compressor station (***29,53*** per cent of the total consumption at the enterprise) The balance diagrams for electric power consumption made during the energy audit identified possible areas to save energy
- Significant decrease in the electric power consumption would enable introduction at the enterprise would result from introduction of an energy monitoring and management system

1 3 Recommendations

Table 1 1 belowshows a list of possible energy conservation opportunities (ESMs) They are arranged according to their importance for the enterprise The recommendations will improve the efficiency of energy utilization at the enterprise and make it more competitive The issues of implementation of the energy saving measures that cannot be financed within the frames of the given project should be settled on the basis of the priorities of the plant and its financial opportunities

Table 1 1

List of Energy Conservation opportunities

#	Measure	Electric power saving, kW h x 1,000	Saving of natural gas, m^3 x 1,000	Yearly saving, USD	Measure costs, USD	Simple payback period, yr	Item in the given report
1	Implementation of energy management	631	875	114,587	110,032	0 96	7 1
2	Improvement of the schedule for the compressor station operation	1,435	0	64,464	10,000	0 155	7 2 2
3	Transfer of operation of the processing equipment on the air from the local compressor plants	1,693	0	76,063	86,500	1 14	7 3
4	Controlling the compressor station production capacity by means of a speed-variable electric driver	1,731	0	77,780	126,000	1 62	7 2 3
5	Replacement of the current compressors with new ones, economically more efficient	1,065	0	47,886	252,252	5 27	7 2 4
6	Improvement of the opreation efficiency of *DE-6 5* Boilers in the steam boiler-house	0	80	6,640	5,000	0 75	7 5
7	Introduction into practice of infra-red gas-fired heating systems in the electroplating workshop	0	96	8,000	6,000	0 75	7 6
8	Utilization of the heat from the combustion products leaving *RIBBON* furnace	0	2,000	166,000	200,000	1 2	7 4 5
9	Improvement of the operation efficiency of *RIBBON* glass-making furnace by controlling the air supply for burning	0	50	4,150	5,000	1 2	7 4 6
10	Provision of temporary insulation on the furnace unit	0	190	75,000	5,200	0 07	7 4 3
11	Thermal insulation of the furnace with the materials bought by the plant	0	1,765	145,000	70,000	0 48	7 4 4
12	Provision of thermal insulation on the basis of light materials on the glass-making furnace *RIBBON*	0	2,036	170,000	350,000	2 06	7 4 1
13	Provision of efficienct thermal insulation on the basis of ceramic fibers on the glass-makingh furnace *RIBBON*	0	2,036	170,000	560,000	3 3	7 4 2

1 4 Operation and energy management

It is typical for industrial plant management to mainly think in terms of production, and to want to increase its output Therefore it is sometimes difficult to think of the importance of energy and energy costs on the operation of the plant

For JSC *"Lviv Lamp Plant"*, as with most industries in Ukraine, in the past the energy costs were significantly subsidized, therefore energy saving was not a major consideration in the plant operations

With the rising energy costs during the past few years, the energy costs have now become very influential part of the expenses The energy costs at JSC *"Lviv Lamp Plant"* are about *3 4* per cent of the total cost of the products produced

Currently, at the JSC *"Lviv Lamp Plant"*, like at other Ukrainian enterprises too, though the problems in relation of the energy resources and energy costs are now well understood by the staff, there is a tendency to think of implementing large projects with the intent of saving large amounts of energy And at the same time at the facilities a large number of small energy saving projects exist that have short payback periods

Most industries in Ukraine have a person or persons who are referred to as energy engineers These people are typically responsible for ensuring that there is an adequate supply of energy to the plant, not to improve the energy efficiency of the plant But with the rise in energy prices and the uncertainty of availability of all fuels, an energy manager to conserve energy becomes important Each plant should seriously consider establishing an energy manager position as a minimum, and for large industries, possibly even an energy management section

These people should be regularly monitoring all operations, and especially reviewing monthly energy consumption These monthly data should be graphed and compared to previous months and years to determine any variations in consumption Where variations do occur, they should then determine the cause of the variation and if remedial action is required For instance, if monthly consumption increases, the reasons why should be determined and if appropriate, steps taken to correct any problem

In addition, the energy management staff should also review each process, and look for energy saving opportunities They should see that all cost effective energy improvements are implemented, beginning with items identified in this energy audit They should then also have responsibility to review all proposed changes to the facility to ensure that each process is as energy efficient as possible

A plant the size of JSC *"Lviv Lamp Plant'* should have several people working in an energy management group As a minimum, it would be good to have a thermal specialist (someone who is knowledgeable about steam and gas supply systems) and a specialist in the electrical power engineering There should be a third person to manage all of the activities of this group, and to report directly to the top plant management

At many facilities the energy management section is assigned an energy goal, such as "reducing the overall energy usage by *5* per cent year" While the percentage goal can vary, this type of challenge gives a benchmark by which the section can be evaluated And in industries in Ukraine, where energy efficiency is just at its infancy, the percentage goal could even be higher Some industries also have an incentive program, in which employees are encouraged to submit energy efficiency improvement ideas These ideas, if accepted and implemented, would result in a small reward being given to the employee

2 0 GENERAL BACKGROUND

Name of the enterprise – Open Joint-Stock Company "LVIV LAMP PLANT ISKRA"
Chairman of the Board – Mr Pavlo Prystavsky
Tel (38 - 0322) – 21-91-66
42-40-96
Deputy Director General – Mr Mykhailo Vlokh
Tel (38-0322) – 42-81-13
21-91-08
Chief Engineer Mr Ihor DRIBNYUK
Address 14, Vuletska Str , Lviv, 290066, Ukraine

2 1 History of Plant

Designing of the Plant was started in 1965, its construction was started in 1967 The first phase of the construction works was completed in 1972 Production of miniature electron tubes was started in that year

2 2 Types of products

Currently *LVIV LAMP PLANT ISKRA* produces the following assortment of products

- general-purposed incandescent lamps for a voltage from ***230*** to ***240*** V, the output power is ***25*** to ***100*** W The designed production capacity of the plant in relation of the incandescent lamps is ***220*** million units per year Currently the plant produces ***180*** ml general-purposed incandescent lamps per year,
- miniature incandescent lamps for a voltage of ***1 5*** V, ***2 5*** V and ***6 3*** V The designed production capacity of the plant of the miniature electric lamps is ***150*** million units per year In the recent years these lamps have been produced in lots of small number of units due to small demands,
- flasks for incandescent lamps The designed production capacity is ***400*** ml units per year Now ***180*** ml units are being produced for the own production facilities and ***100*** ml units per year are being produced for sales to others (mainly to be exported),
- automobile lamps for lighting the driver's cab,
- automobile head-lamps,
- household lighting fixtures

2 3 Number of employees

Currently at *Lviv Lamp Plant ("ISKRA")* about 4,000 workers and officers are employed

2 4 Number of manufacturers of incandescent lamps

Lviv Lamp Plant is the largest in Europe in regard of its production capacity, and at the same time it is the only in Ukraine enterprise for production of general-purposed incandescent lamps

3 0 CURRENT STATE OF THE PLANT

3 1 Export possibilities of enterprise

The plant exports general-purposed incandescent lamps The largest source of incomes in hard currency is sale of ***100*** ml flasks for general-purposed incandescent lamps per year The products of the plant are sold to Poland, Yugoslavia, Chechia, Romania, Bulgaria, Germany, Italy, Iran, United Arabic Emirates

3 2 Significance of enterprise for Ukrainian economy

The importance of the plant for the Ukrainian economy is determined by the fact that the enterprise is practically a monopolic manufacturer of general-purposed incandescent lamps in the country This is proved by the fact that, in comparison with 1991, the enterprise, as a matter of fact, has not decreased the production level It can be accounted for very easily the price on the general-purposed incandescent lamps produced at the plant is UAH ***0 28*** (USD ***0 15***) per unit The price on the similar lamps imported from other countries is ***10*** to ***30*** times higher Even if the life-time of the imported lamps is ***10*** times longer (which is quite doubtful for the Ukrainian electric power supply systems with unstable parameters) and the discount ratio is ***15*** per cent, the price on the lamps produced abroad cannot exceed that on the national ones more than ***4*** to ***5*** times Only on this condition use of foreign lamps will be economically reasonable Despite that the enterprise should pay more attention to mastering production of new types of products, to carry out regularly marketing surveys (and not only within the Ukrainian market!)

3 3 General outlay of plant

Lviv Lamp Plant "ISKRA" includes the following buildings and structures

1 Main Building, the area is 36,288 m^2
2 Engineering and household building
3 Glass Building, the area is 12,096 m^2
4 Combined Building, the area is 2,304 m^2
5 Building with Mechanical Workshops, the area is 7,128 m^2
6 Electric Plating Workshop, the area is 5,184 m^2
7 Canteen (530 seats)
8 ITM-GO
9 Storage #1
10 Storage Building #2
11 Oxygen Discharging

The arrangement of these buildings is shown in the general outlay of the plant (see Fig 3 1)

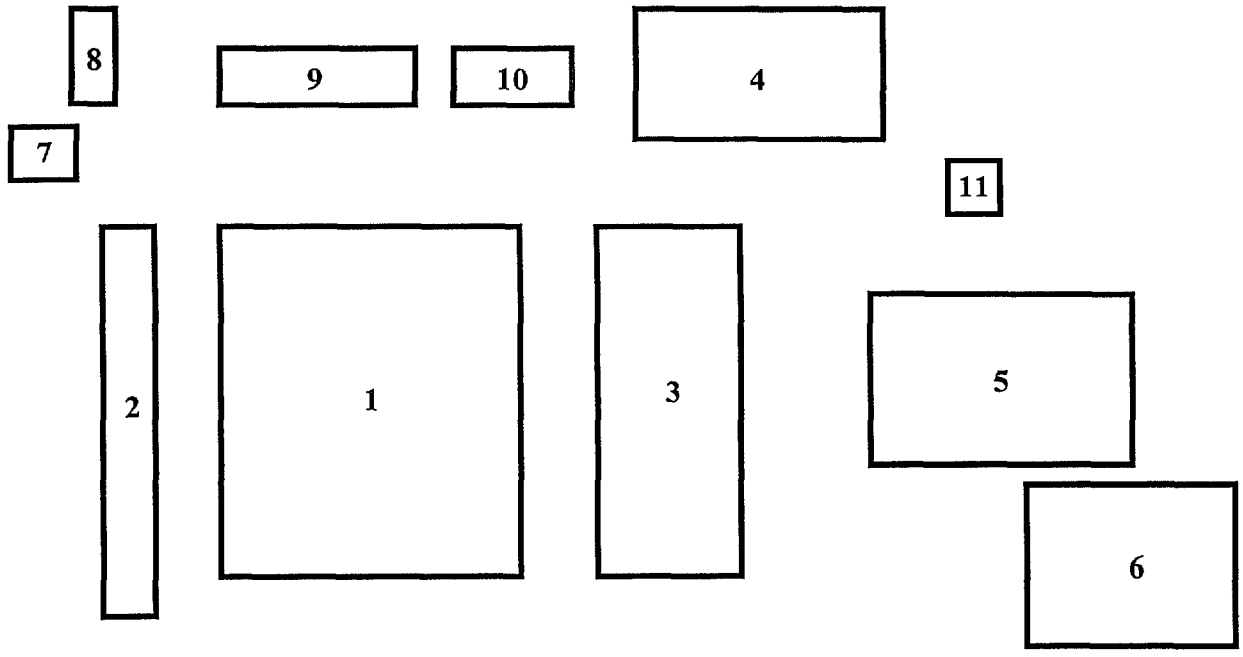


Fig 3 1 General outlay of *Lviv Lamp Plant "ISKRA"*

4 0 FINANCIAL STATUS OF PLANT

Lviv Lamp Plant ISKRA failed to avoid the crisis of non-payments that occurred in Ukraine, and the enterprise is facing lack of the working capital, the wages have not been paid for *3* to *4* months The top management of the plant tries to overcome the financial problems by using barter-based operations, clearing and other financial instruments

Financial problems of the plant will improve in the near future, as its products are in continuous demand

The enterprise has good prospects That is why solving the energy saving problems are very important, and that can only improve the viability of the plant under the market economy conditions

The structure of the costs on the production of *Lviv Lamp Plant ISKRA* products is given below

Expenditure items	*%*
1 Raw and other materials,	**34 1**
including also	
• tungsten wire	5 6
• molybdenum wire	3 9
• tape (steel, molybdenum)	6 3
• soda ash	2 6
• paper, cardboard	7 7
• other materials	8
2 Accessory materials	**3 6**
3 Energy resources,	**12 1**
including here	
• electricity	2 9
• gas	6
• chemical gases	2
• water	1 2
4 Payroll Fund	**14 1**
5 Charge on payroll	**7 1**
6 Depreciation	**2 4**
7 Other costs,	**3 6**
including the payment to the railroad	1
Total net cost	**77**
8 Income (profit),	**11**
including the income tax	3 3
9 VAT	**12**
The total income after sale	**100**

Fig 4 1 shows a diagram of the production costs for separate items The analysis showed that the main expenditures are for the raw and other materials (*34 1* per cent), as well as on paying wages with charges on them (*14 1%* + *7 1%* = *21 2%*) The energy costs are *12 1* per cent Saving energy resources is considered at the plant as a serious problem For example, a *10* per cent saving of the

energy costs will enable the of increase the wages by *5 7* per cent, or that of the incomes – by *11* per cent Despite the fact that analysis of the economic indicators of production is not the main task of energy auditors, one cannot fail outstressing that the costs of paper and cardboard (that is of the packing materials) seem to be unjustly high in the total production cost These costs exceed the cost of purchasing any other materials and raw materials directly used in lamp production Therefore, the plant management should pay attention on possibilities of decreasing the costs on paper and cardboard

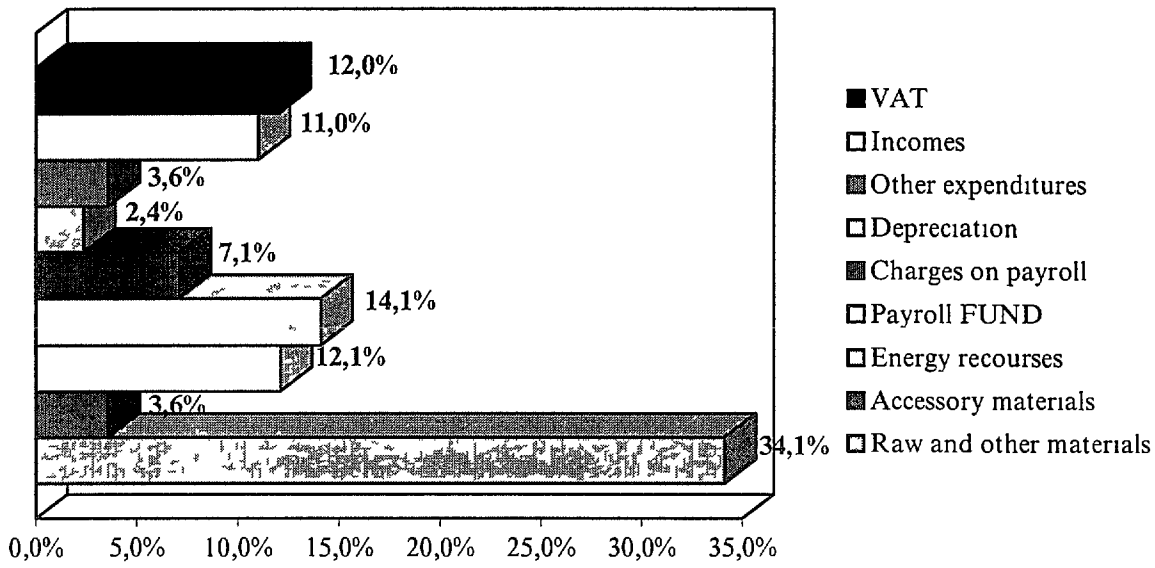


Fig 4 1 Structure of production cost

5 0 ENERGY CONSUMPTION AND ITS COSTS

5 1 Energy consumption data

Tables 5 1, 5 2 and 5 3 respectively show the data concerning consumption of electric power, gas and domestic water

Table 5 1a

Electric power consumption

1995

Reported period		Electric power consumption, kW h *×10³*	Cost, USD
Quarter I	January	2,118 3	88,197 16
	February	2,007 84	83,598 06
	March	2,012 76	83,802 91
Total		**6,138 9**	**255,598 13**
Quarter II	April	2 220 24	92,441 52
	May	1,848 8	76,976 3
	June	1,855 8	77,267 75
Total		**5,924 84**	**246,685,57**
Quarter III	July	1,530 6	63,727 78
	August	1,348 8	56,158 39
	September	2,030 4	84,537 38
Total		**4,909 8**	**204,423 55**
Quarter IV	October	2,063 52	85,916 34
	November	2,356 2	98,102 32
	December	2,525 4	105,147 09
Total		**6,945 12**	**289,165 75**
Total in 1995		**23,918 66**	**995,873**

1996

Table 5 1b

Reported period		Electric power consumption, kW h *×1,000*	Cost, USD
Quarter I	January	2,205 6	99,114 62
	February	2,593 2	116,532 48
	March	2,521 2	113,296 96
Total		**7,320**	**328,944 08**
Quarter II	April	2,454 24	110,287 94
	May	1,691 4	76,007 65
	June	1,807 2	81,211 44
Total		**5,952 84**	**267, 507 04**
Quarter III	July	1,587	71,316 15
	August	964 2	43,328 95
	September	626 4	28,148 99
Total		**3,177 6**	**142,794 09**
Quarter IV	October	351	15,773 14
	November	1,780 2	79,998,12
	December	2,448	110,007 53
Total		**4,579 2**	**205,778 79**
Total for 1996		**21,029 64**	**945,024**

Table 5 2a

Gas consumption data

1995

Reported period		Natural gas consumption, m^3 *×1,000*	Cost, USD
Quarter 1	January	5,283	408,044 74
	February	4,605	355,677 84
	March	4,878 22	376,780 63
Total		**14,766 22**	**1,140,503 21**
Quarter II	April	3,753 32	289,896 36
	May	3,098	239,281 21
	June	2,954 79	228,220 05
Total		**9,806 11**	**757,397 62**
Quarter III	July	2,409 75	186,122 62
	August	2,223 37	171,727 13
	September	2,672 0	206,378 11
Total		**7,305 12**	**564,227 86**
Quarter IV	October	3,451	266,545 98
	November	4,725	364,946 32
	December	5,149	397,694 91
Total		**13,325**	**1,029,187 21**
Total for 1995		**45,202 45**	**3,491,316**

1996

Table 5 2b

Reported period		Natural gas consumption, m^3 *×1,000*	Cost, USD
Quarter I	January	3,637	301,871
	February	4,879 97	405,037 52
	March	4,174 2	346,458 51
Total		**12,691 17**	**1,053,367 03**
Quarter II	April	3,353 92	278,313,21
	May	2,227 17	184,855,31
	June	2,092 05	173,640 2
Total		**7,673 14**	**636,870 72**
Quarter III	July	1,925 28	159,798 24
	August	872 3	72,400 9
	September	912 29	75,720 07
Total		**3,709 87**	**307,919 21**
Quarter IV	October	666 3	55,302 47
	November	1,603 645	133,102 53
	December	2,817 37	233,837 14
Total		**5,087 315**	**422,247 14**
Total for 1996		**29,161,50**	**2,420,404**

Table 5 3a

Domestic water consumption

1996

Reported period		Water consumption, m^3	Cost, USD
Quarter I	January	25,227	48,135 57
	February	23,658	45,186 78
	March	23,391	44,676 81
Total		**72,276**	**138,047 16**
Quarter II	April	19,773	37,766 43
	May	23,009	43,947 19
	June	29,768	56,856 88
Total		**72,550**	**138,570 5**
Quarter III	July	27,036	51,638 76
	August	22,212	42,424 92
	September	7,496	14,317 36
Total		**56,744**	**108,381 04**
Quarter IV	October	8,587	16,401 17
	November	10,027	19,151 57
	December	16,019	30,596 29
Total		**34,633**	**66,149 03**
Total in 1996		**236,203**	**451,147 73**

1997

Table 5 3b

Reported period		Water consumption, m^3	Cost, USD
Quarter I	January	27,129	5,1816 39
	February	27,009	51,587 19
	March	24,865	47,492 15
Total		**79,003**	**150,895 73**
Quarter II	April	22,969	43,870 79
	May	22,357	42,701 87
	June	23,744	45,351 04
Total		**69,070**	**131,923 7**
Quarter III	July	23,462	44,812 42
	August	25,658	49,006 78
	September	20 446	39,051 86
Total		**69,566**	**132,871 06**
Total for 3 quarters in 1997		**218,639**	**414,690 49**

Fig 5 1 shows the monthly electric power consumption in 1995 and in 1996, Fig 5 2 shows the monthly gas consumption, while Fig 5 3 shows the monthly domestic water consumption

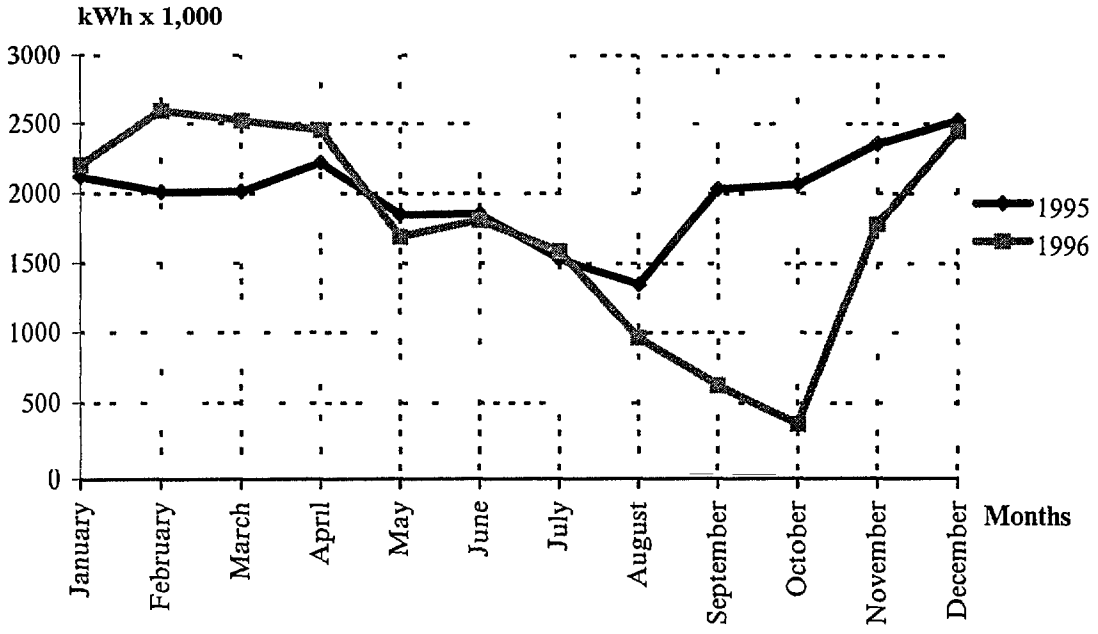


Fig 5 1 Dynamics of the monthly electric power consumption

Fig 5 2 Dynamics of the monthly gas consumption

Fig 5 3 Dynamics of the monthly domestic water consumption

5 2 Tariffs on gas, electric power and water

Lviv Lamp Plant Iskra buys gas, electric power and water and it pays for the sewage system according to the following

- electric power (a two-rate tariff)

  - for 1 kW of the installed power – UD $3 6 per month,
  - for 1 kW h of the consumed electric power – US $0 034,

- natural gas
  - US $83 for 1,000 m^3,

- domestic water (supplied from the city water supply system – UAH 2,750 for 1,000 m^3, the sewage system – UAH 850 for 1,000 m^3) Total UAH 3,600 (USD 1,945 9) for 1,000 m^3

Fig 5 4 below shows the structure of the expenditures on energy resources

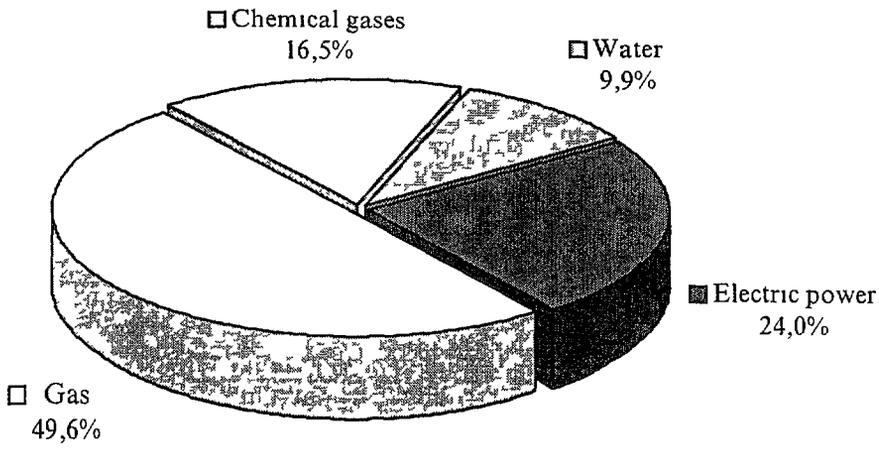


Fig 5 4 Structure of the expenditures on energy resources

5 3 Balance of energy resources consumption

5 3 1 Balance of electric power consumption

Balance of electric power consumption versus the main sorts of the equipment and workshops is shown in Fig 5 5

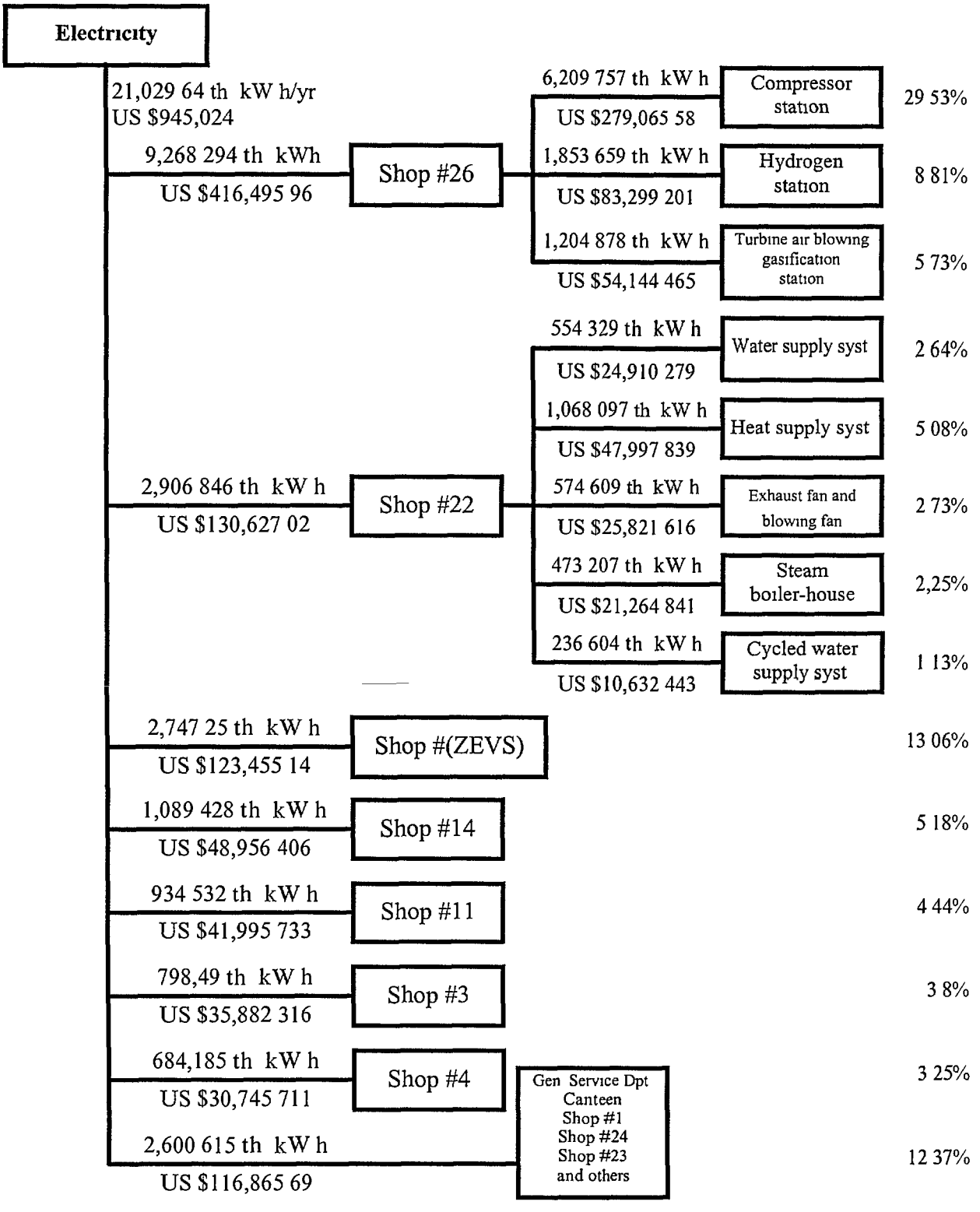


Fig 5 5 Balance of electric power consumption for 1996

5 3 2 *Balance of gas consumption*

Balance of gas consumption for the workshops and equipment is shown in Fig 5 6 below

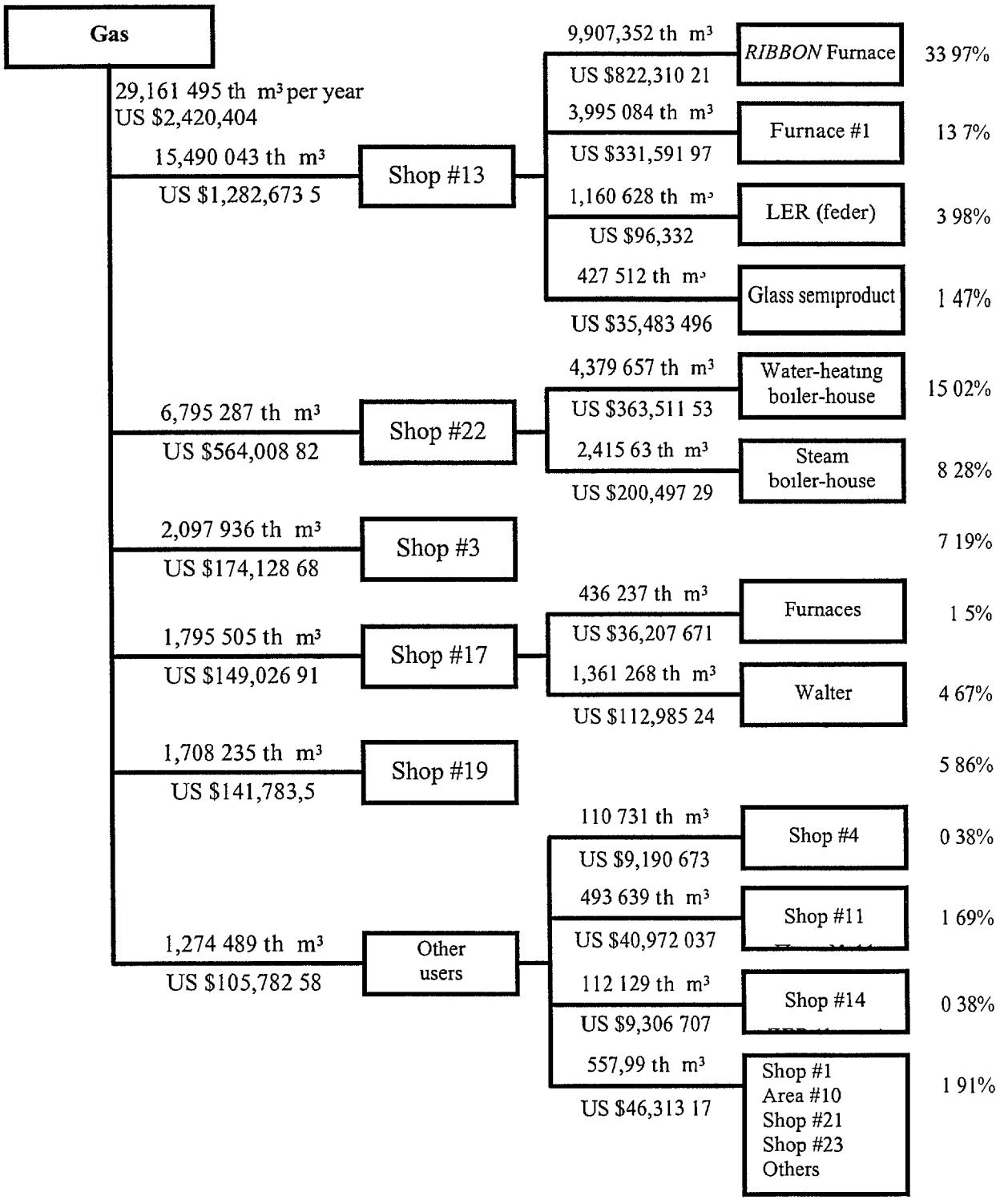


Fig 5 6 Balance of gas consumption for 1996

5 3 3 *Balance of domestic water consumption*

Balance of domestic water consumption versus the basic users is shown in Fig 5 7

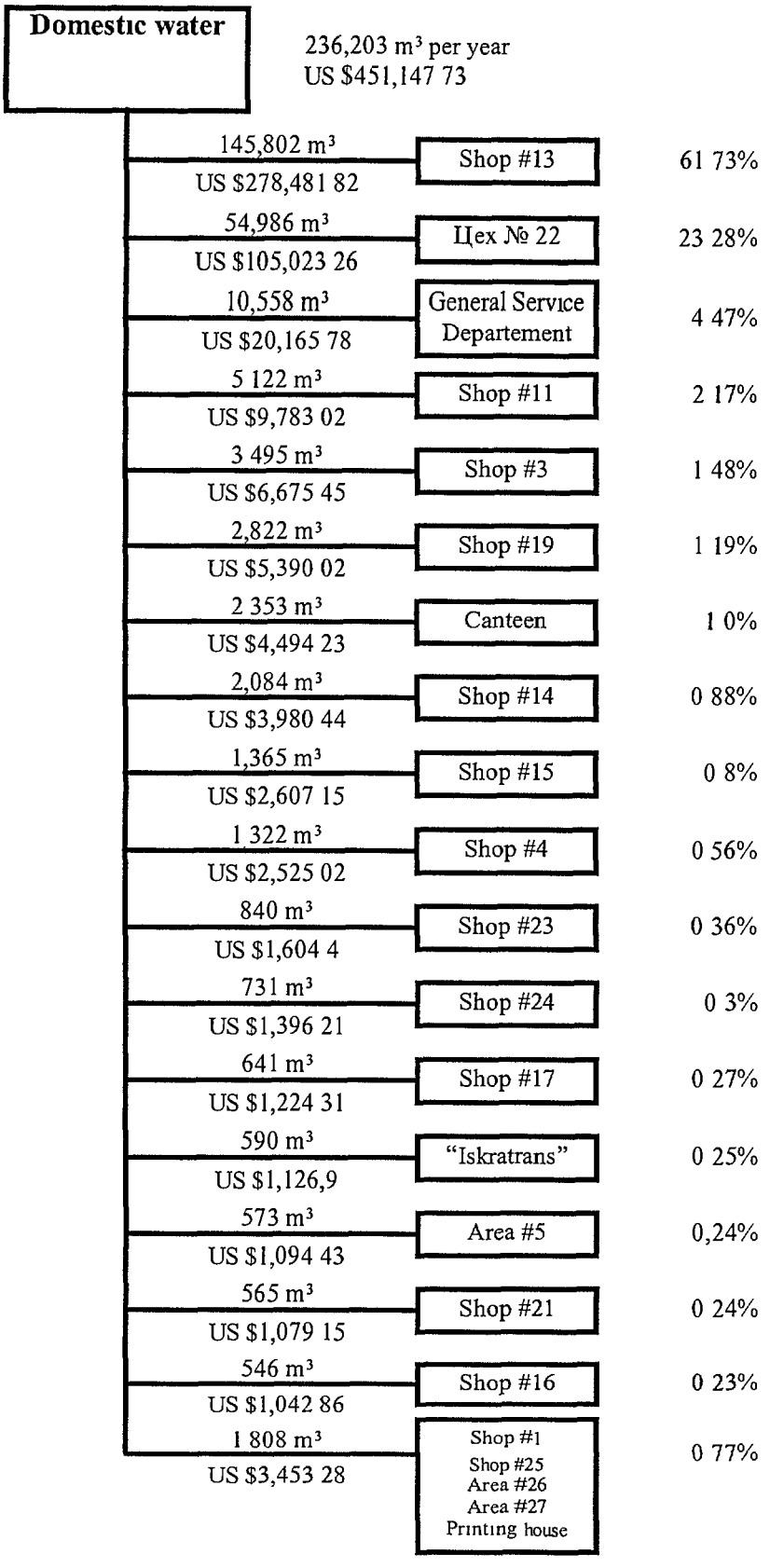


Fig 5 7 Balance of domestic water consumption for 1996

6 0 PREVIOUS ENERGY EFFICIENCY IMPROVEMENTS

Serious attention is paid at the plant to energy saving issues In particular, there was prepared preliminary study to proving the reason for switching on supplying for the processing equipment the air from turbine blowers with the pressure of *0 5* kg/cm^2 instead of supplying the air with the pressure of *4* to *6* bar that is produced by the compressor station More precise calculations in Item 7 2 in the given report showed that the payback periods for this energy saving measure was *1 5* times less than calculations made by the specialists of the plant

The Technical Department at Lviv Lamp Plant prepared a feasibility study of the works aimed at improvement of the thermal insulation of the glassmaking furnace ***RIBBON*** Currently ***RIBBON*** glass making furnace has no thermal insulation in the upper part of the furnace (the dome and the side walls) The surface temperature of the walls in these places is **330**°C The enterprise bought basalt fibers to improve the thermal insulation of furnace vault, which will decrease the gas consumption significantly (in Item 7 4, C, calculations are given concerning decreasing the heat losses if basalt thermal fiber is used) According to the calculations done a the plant, saving of natural gas will be *502,320* m^3 per year, while the payback period will be *0 9* of a year The results of out calculations are different so we present them with detailed explanations

7 0 ENERGY AUDIT

While performing the audit, the audit team and plant experts made a list of possible energy saving measures The items were selected for study by the team

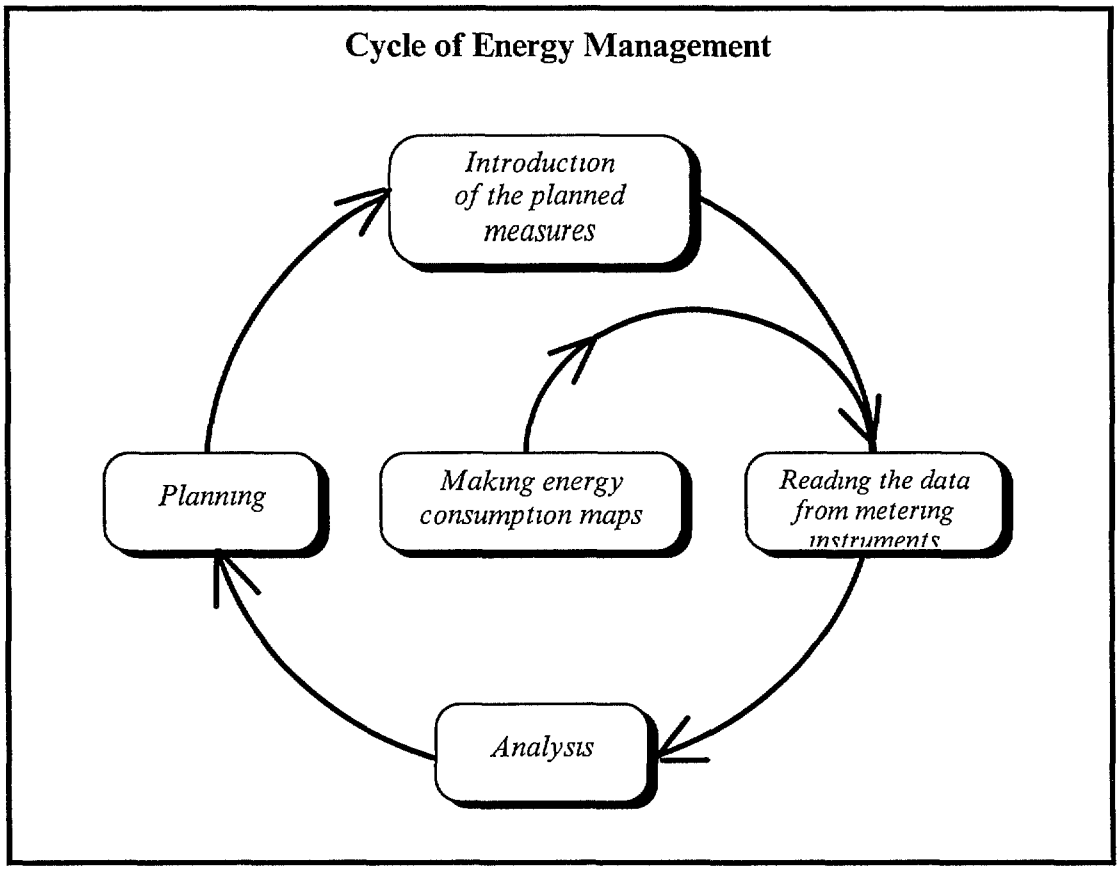
1 Controlling the production capacity of the compressor station
2 Installation of local compressor stations of low production capacity
3 Metering the high-pressure air consumption by the shops
4 Improvement the insulation of the glassmaking furnace
5 Utilization of the heat from the glassmaking furnace for heating the rooms
6 Make warmer the Building where the glassmaking furnaces are
7 Install a station for separating the air to produce oxygen, nitrogen and argon required in the processing line
8 Decreasing the capacity of the motors used for the processing equipment
9 Adjustment of the gas combustion conditions in the furnaces and boilers
10 Automatic system for metering the energy resources flow to make urgent operation decisions
11 Replacement of the obsolete furnaces for burning the wires with new ones, more effective
12 Replace the burners in the automatic machines for filling the bases of the electric bulbs in the electric bulb workshop
13 Replacement of the obsolete electrolysis units with new ones, more effective
14 Possibility to use infra-red heating systems in workshops and rooms
15 Install an automatic system for the internal and external lighting
16 Replace the steel window frames with ones of aluminum and double-glazed
17 Introduction of equipment for knurling the thread on electric bulb bases without using compressed air
18 Introduction of oxygen cutting of the wire supports on an automatic machine for cutting the wire supports produced by the glass plant
19 Introduction of a system for checking the thickness of the glass tubes in the glassmaking workshop
20 Replacement of burners on the stream water boilers
21 Installment a decentralized heating system
22 Transfer the compressor station on a two-shift operation schedule, and install at the same time local compressors
23 Replace the plants for cleaning the high-pressure air and inert gases with new ones
24 Utilize the heat from the water cooling the compressors for heating water and for preparation of gaseous oxygen, argon and nitrogen
25 Install measuring instruments for determination of the quality of inert gases and of air
26 Install a system for controlling the air temperatures in the rooms

7 1 Inroduction of energy management

The proposal

Implementation at *Lviv Lamp Plant "Iskra"* of an energy management system

The main instrument in reduction of energy consumption and improvement of the efficiency of energy utilization at industrial enterprises is energy management Energy management is a method of managing the enterprise providing continuous study and, consequently, knowledge of the distribution and conditions for energy consumption at the enterprise, as well as determining the optimal utilization of energy resources for both the production needs, and for the non-production needs



By implementation of energy management one can have a detailed picture concerning consumption of energy, which enables him to compare the energy consumption levels at other enterprises in order to determine exactly the energy saving projects that are planned for implementation at the given enterprise

Energy management starts with appointment by the top management of the plant of an executive to be responsible for introduction energy management at the enterprise – he is called the energy manager The main functions of the energy manager are as follows

- participation in making maps of energy consumption at the enterprise (probably in cooperation with an outside consultant - an energy auditor),
- collection of data concerning consumption of the fuel and energy resources using meters and measuring instruments and devices,
- making a plan of installing auxiliary meters and measuring instruments and equipment,
- collection of data concerning the flow of raw materials, fuel and energy and finished products,
- calculation of the key data in relation of improvement of the efficiency of energy utilization - on the whole and in regard of separate production lines or areas,
- introduction of new technologies for the existing and new energy systems to increase the energy efficiency of the production,

- the energy manager shall be aware of the current policy in the energy field (for example, the new legislation on taxation, the existing limitations in regard of the energy consumption levels, subsidies, issues relating to the environmental protection, etc)

We propose to introduce at the enterprise an energy management system in full scope Implementation of the given proposal is connected with a possibility of decreasing the energy consumption rate at least 3 per cent

Implementation of energy management at the plant requires performing a modernization of the existing system of metering the electric consumption rate with electric consumption meters at all the transformer substations

There is necessary to modernize the system of metering gas consumption at the gas controlling station with providing the readings of the flow meter to a computer, with installation of auxiliary gas meters in each department, which will enable to determine the dynamics of the gas consumption when producing products

Calculation of yearly energy saving

Currently the plant consumes in average during a year ***21,029 64*** thousand kW h of electric power, ***29,161 495*** thousand m^3 of natural gas and ***236 203*** thousand of all-purpose water, the total sum of those is US $***3,819,576*** The world experience and practice prove that in case of implementation of energy management guarantees a 3 per cent decrease in energy consumption

So, the cost of the saved energy resources will be as follows
- for electric power
  21,029 64 thousand kW h ***x 0 03 = 631*** thousand kW h,
- for natural gas
  29,161 495 thousand m^3 ***x 0 03 = 875*** thousand m^3,
- for domestic water
  236 203 thousand m^3 ***x 0 03 = 7 1*** thousand m^3

Calculation of a yearly saving of costs

The yearly saving of energy costs, and, consequently, the permitted value of the cost of implementation of an energy management system, will be

US $***3,819,576 x 0 03*** = US $***114,587***

Costs of implementation of the energy management service

With taking into consideration the fact that the energy users are different, we can recommend to introduce at *"Iskra" Plant* an energy management unit that would be in direct subordination to only the Technical Director or to the Director General (in the foreign practice the energy manager is subordinated to only the enterprise manager)

Taking into account the wages level at the enterprises in Ukraine, the following salaries for the energy management service could be set

- the Chief Energy Manager of the plant – US $***300*** per month,
- a specialist in data bases and economic analysis – US $***250*** per month

Total US $***550*** per month

Then the annual payroll fund with taking into account the taxation will be as follows

(US $*550* /mon) × (*12* mon./yr) × *1 52* = US $*10,032* per year

Implementation of a monitoring and control system (including the auditing automatic controlling equipment) costs USD *100,000*

Total costs on impelmentation of an energy management service is ***USD 110,032***

Simple payback of the energy conservation measure

The simple payback for this energy conservation opportunity is

USD 110,032 / USD 114,587 = 0 96 year

Conclusions An energy monitoring and control system represented by two employees should be introduced with the yearly payroll fund of US $*10,032*

7 2 Improvement of operation schedule and modernization of the compressor station

7 2 1 General description of the compressor station

At the present time the compressor station is one of the main users of electric power at *JSC "Iskra"* Its share is *29 53%* of the total electric power consumption at the enterprise, or *6,210,000* kW h per year or *$279,066* per year There are *6* compressors installed in the compressor station, they are of three size-types, their production capacity is *52, 100* and *120* m^3 per hour (two units of each size-type)

The compressors were equipped with the following electric motors

1 3-Phase synchronous electric motor of *SDK-16-24-12K*-type, the frequency of the supplied voltage is *50* Hz, the output capacity is *320 kW*, S1 operation mode, $cos\varphi_n$ = *0 9*, the stator voltage is *6,000* V, the nominal stator current is *37* A, Y-connection of the stator winding, the nominal rotational speed is *500* rot/min, the excitation winding voltage is *25* V, the nominal rotor current is *270* A, the efficiency is *92 3* per cent, the weight is *2,460* kg

2 3-Phase synchronous electric motor of *SDK2-17-26KU4*-type the frequency of the supplied voltage is *50* Hz, the output capacity is *630* kW, S1 operation mode, $cos\varphi$ = *0 9*, Y-connection of the stator winding, the stator voltage is *6,000* V, the nominal stator current is *71* A, the rotattional speed is *8 33* s^{-1}, the excitation winding voltage is *36* V, the nominal rotor current is *255* A, the efficiency is *94 1* per cent, the weight is *3,815* kg

3 3-Phase syncronous electric motor of DS-16-44-10KUHL4-type the frequency of the supplied voltage is *50* Hz, the output capacity is *800* kW, S1 operation mode, $cos\varphi$ = *1 0*, Y-connection of the stator winding, the stator voltage is *6,000* V, the nominal stator current is *81* A, the rotattional speed is *10* s^{-1}, the excitation winding voltage is *35* V, the nominal rotor current is *250* A, the efficiency is *96* per cent, the weight is *3,770* kg

The following energy conservation opportunities out of the possible ones were chosen for their further study

- improvement of the operation schedule of the compressor station,

- replacement of the current compressors with new ones, more economically efficienct

Let us consider these in more details

7 2 2 Improvement of the schedule for operating the compressor station

The proposal

To develop and introduce into practice the operation schedule of the compressor station on the base of actual needs of the processing equipment in compressed air

Study results

Table 7 1 shows the data concerning the production level of compressed air by the compressor station in October 1997 The actual specific energy consumption for production of compressed air in October 1997 were *0 0786837* kW h/m^3 The fact that the actual specific energy consumption was significantly lower than those due to the data from the manufacturer's certificate testifies to an underloading of the compressor motors

Due to the manufacturer's certificate the average value of the specific energy consumption is as follows

$$\frac{0\ 1067\ \ 39\ 852 + 0\ 105\ \ (247\ 464 + 130\ 914) + 0\ 111\ \ (207\ 27 + 13\ 806)}{39\ 852 + 247\ 464 + 130\ 914 + 13\ 806 + 207\ 270} = 0\ 107718 \text{ kW h/m}^3$$

For production of *8,125* th m^3 of compressed air practically produced in October 1997, providing the averaged data from the manufacturer's certificate concerning the energy consumption rates (*0 10718* kW h/m^3), it would have required

$$8,125,000 \text{ m}^3 \quad 0,10718 \text{ kW h/m}^3 = 870\ 83831 \text{ th kW h}$$

As in the load range between (*0 4* to *0 45*) and *1 0* of the nominal efficiency of the motor does not change significantly (in the range between *1* per cent and *2* to *3* per cent), an approximate averaged monthly value for the capacity factor of the electric motors at the compressor station will be

$$639\ 306 \text{ th kW h} / 870\ 83831 \text{ th kW h} = 0\ 734127 = 73\ 4\%$$

Therefore, the averaged loading of the motors at the compressor station is within the permitted limits (between *0 7* to *0 75* and *0 9*)

The actual consumption of compressed air by the workshops of the enterprise in October 1997 was *7,354,200* m^3 Then the losses of the compressed air in the air ducts between the compressor station and the plant workshops were *8,125,000* m^3 - *7,354,200 m*^{3} = *770,800* m^3 or *9 5* per cent of the amount produced by the compressor station This is a good indicator, and it testifies to a satisfactory conditions of the lines for supplying compressed air, as usually up between 20 and 30 per cent of compressed air are lost in the lines

The studied have shown that at the enterprise there are not available any sufficienctly well grounded recommendations concerning determination of the required capacity of the compressor station due to the needs for compressed air

Table 7 1

Production of compressed air by the compressor station in October 1997

Day of the month (October)	The number of the working hours of the compressor during 24 hours, h					Amount of compressed air produced for 24 hours, m^3
	Compressor #2	Compressor #3	Compressor #4	Compressor #5	Compressor #6	
1		24	14		18	325,000
2		24	16		11	326,000
3		15	24		18	326,000
4		14	24			224,000
5			24			144,000
6		15	24		181	224,000
7			24		18	327,000
8		24	7		15	294,000
9	10	24			15	294,000
10	10	24			18	282,000
11	10	19	15			222,000
12			24			144,000
13		14	10		18	279,000
14	9	24	4		12	294,000
15	13	24			18	327,000
16	15	24			18	324,000
17	13	24			19	313,000
18		24			18	264,000
19	3	24	3		10	14,400
20		8		16	18	230,000
21		11		14	24	360,000
22	8	24			18	306,000
23		24	14		18	276,000
24		24			18	325,000
25	6	24	18			144,000
26		24				264,000
27		24		18		282,000
28	14	24		6		282,000
29	13	16		18		270,000
30	6		3	14	14	266,000
Total for the month	139 hours	544 hours	228 hours	86 hours	344 hours	8 125,000
Electric power consumption during the month, th KW h	39 852	247 464	130 914	13 806	207 270	639,306 th kW h/month
Specific energy consumption, kW h/m^3	Due to Manuf Cert 0 1067	Due to Manuf Cert 0 105	Due to Manuf Cert 0 105	Due to Manuf Cert 0 111	Due to Manuf Cert 0 111	Practical specific losses of the compressor station during the month are 0 0786838
Motor capacity	320	630	630	800	800	

Table 7 2 represents possible combinations of the compressor plants operation in regard of the installed capacity (see also Table 7 1)

Table 7 2

##	**Installed capacity of the motors if the compressors are operated at the same time, kW**	**Total installed capacity of the motors if the compressors are operated at the same time, kW**	**Difference of the installed capacity from its closest lower value, kW**
1	320	320	–
2	630	630	310
3	800	800	170
4	320 + 630	950	150
5	800 + 320	1120	170
6	2×630	1260	140
7	800 + 630	1430	170
8	2×630 + 320	1580	150
9	2×800	1600	20
10	800 + 630 + 320	1750	150
11	2×800 + 320	1920	170
12	800 + 2×630	2060	140
13	2×800 + 630	2230	170
14	2×800 + 630 + 320	2250	320
Average value		$\frac{1278,6}{1372,7}$ kW	$\frac{171,5}{143}$ kW

The average electric power consumption by the compressor station in October 1997 was as follows

$$(639,300 \text{ kW h/mon})/[(24 \text{ h/day}) (30 \text{ days/mon})] = 887\ 9 \text{ kW h}$$

Therefore, the average value of the power consumed by the motors at the compressor station in October 1997 amounted to *887 9* kW Then the average value of the descrete increment of the consumed power was as follows

$$(171\ 5 \text{ kW}/887\ 9 \text{ kW}) = 0\ 1932 = 19\ 32\%$$

Taking into consideration the actually operated equipment, the number of combinations of the compressor station operations will be somewhat lower (see the marked out part in Table 7 3)

In this case the average value of the difference between the installed capacity of the motors (the discrete increment of the power consumed by the motors) is *143* kW or *16 11* per cent

If there are no exact data concerning the operation schedule for separate compressor plants, the actual descrete increment of the power consumed by the motors can be determined in the following way

The ratio of operation combinations of the compressors with the motors of ***320, 630*** and ***800*** kW that corresponds to the marked out area in Table 7 2, is respectively as follows

320 kW	630 kW	800 kW
1	2	1 8

In accordance with the data in Table 7 1, the ratio of the time of the actual operation of compressors with the motors of capacities of ***320***, ***630*** and ***800*** kW, is respectively as follows

320 kW	630 kW	800 kW
1 (139 hours)	5 554 (544 hours + 228 hours)	3 0935 (86 hours + 344 hours)

The average value of compressor station capacity equal in the marked out area in Table 7 2 to ***1,372 7*** kW, but actually (see above) that value amounted to ***887 9*** kW

The calculated descrete increment of the power consumed by the motors will be equal then to

$$\left(\frac{(2-1)\ (630\,kW-320kW)+(2-1\,8)\ (800\,kW-630kW)}{(5\,554\text{-}1)\ (630\,kW-320kW)+(5\,554-3\,0935)\ (800\,kW-630kW)}\right)^{-1}\times 143\,kW\ \frac{887\,9\,kW}{1372\,7\,kW}=450\,kW$$

Therefore, from here in average for overcoming the resistance of the damper there is used

(***450*** kW - ***143*** kW) = ***307*** kW or ***23 1***% (***307*** kW/***1,372 7*** kW = ***0 231*** = ***23 1***%) of the electric power consumed by the compressor station

So, the annual saving of electric power in case of implementation of a reasonable operation schedule for the compressor station will be as follows

6,210 0 231 = ***1,435*** kW h per year

or

US $***279,066 0 231*** =US $***64,464***

Implementation of the given ECO requires a two-week work of two energy auditors at the plant with the following processing of the collected data and producing their conslusions The average cost of fulfillment of such a work without the VAT is in Ukraine US $***10,000*** The payback period of the energy saving measure is equal to

US $***10,000/US $64,464 = 0 155*** yr

Conclusions Development and implementation of more reasonable operation schedule for the compressor station is one of the most quickly repaid energy saving measures at *Lviv Lamp Plant "Iskra"*

7 2 3 Controlling of the production capacity of the compressor station by means of a controllable electric drive

The proposal

Controlling of the production capacity of the compressor station versus the needs in compressed air of the processing equipment by using systems for controllable electric driving

Study results

It was found above (see Item 7 2 2) that the calculated discrete increment of the power consumed by the motors is *450* kW or *32 79%* (*450* kW/*1,372 7* kW = *0,3279* = *32 79%*)

Using gradually controllable electric driving systems will enable to utilize the electric power, with the efficiency of *0 85* to *0 9*, that earlier was used to overcome the resistance of the damper (throttle)

So, the electric power saving after implementation of this ECO (providing using a compressor station of *6,209,757,000* kW h per year that costs USD *279,066*) will be equal to

6,210 0 3279 0 85 - 1,731,000 kW h per year,

or

US $*279,066 0 3279 0 85* = US $*77,780* per year

An approximate cost of the transducer for controlling the rotational frequency of the synchronous electric motor is US $*126,000* (for more details see Appendix A)

The payback period for this energy saving measure is

US $*126,000* / US $*77,780* = *1 62* years

Conclusions Controlling the production capacity of the compressor station by using a controllable electric drive is an energy saving measure with the payback period of *1 62* years, and it can be implemented providing a the plant its own or involved funds

7 2 4 Replacement of the existing compressors with new ones, more economically effective

The proposal

Replacement of the existing compressors with the production capacity of *100* m^3/min each with three new compressors with the production capacity of *66* m^3/min each The installed capacity of the driving motors will change after that from *2 × 630* kW to *3 × 370* kW

Study results

The proposed ECO enables to decrease the descrete increment of the compressor production capacity However it does not allow to change significantly the difference between the installed capacity and the closest lower value (see Table 7 2)

It is easy to prove that if the average loading of the compressor drive is not lower than *1,260* kW, the compressors are operated only on week-days and on Saturday On week-ends and on holidays only one compressor works, and the capacity of its driving motor is *630* kW

Hence, when calculating the electric power saving resulting from implementation of the given ECO, one should be based on the following working schedule simultaneously for the three new

compressors with the motors having the capacity of *370* kW *296* days (with taking into account the days off and well-days), which corresponds to *7,104* hours per year

Then, a yearly electric power saving after implementation of the given energy saving measure will be as follows

$$(2 \times 630 \text{ kW} - 3 \times 370 \text{ kW}) \quad 7{,}104 \text{ hours} = 1{,}066{,}000 \text{ kW h}$$

The cost of the electric power saved in the result of implementation of the given ECO is

$$(1{,}066{,}000 \text{ kW h}) \quad (\text{US } \$945{,}024 / 21{,}029{,}640 \text{ kW h}) = \text{US } \$47{,}886,$$

where US $*945,024* is the cost of the electric power consumed in 1996,

21,029,640 kW h is the value of the electric power consumption in 1996

The three compressors of the production capacity of *66* m^3/min each cost (for more details see Appendix A)

$$3 \left(\frac{\text{US } \$175}{1kW} \right) 370kW = US\$194{,}250$$

Taking into considerations the customs and transportation expenditures, the total cost for purchasing the equipment will be equal to the following

$$\text{US } \$194{,}250 \quad 1\,3 = \text{US } \$252{,}252$$

Then the payback period for the given energy saving measure will be

$$\text{US } \$252{,}252 / \text{US } \$47{,}886 = 5\,27 \text{ years}$$

Conclusions Implementation of the given energy saving measure should be considered reasonable only in case of the life-time of the compressors that are installed now to have been over Otherwise, this ECO may be referred to the long-term ones

7 3 Transfer on starting operation of the processing equipment using the air from the local compressor plants

The proposal

Currently the compressor station of the enterprise works round the clock This can be accounted for by the requirements of the processing technology Transfer of the procesing equipment operated round the clock on air from the local compressor stations will enable to disconnect the compressor station from the network on days-off, week-ends and at night Besides decreasing thr energy consumption, it will allow to decrease the air leaks in the pipe lines from the compressor station to the processing equipment

To decrease the losses of heat through the external fences (the walls and the roof) of *RIBBON* furnace anf to decrease the temperature of their surfaces to the standardized one by providing an efficient thermal insulation on the basis of light materials

Study results

The analysis carried out jointly with representatives of "Iskra" Plant showed that the local compressors can be installed in the following

- in the chambers of GVT-type glassmaking furnace – *3* turbine blowers of *35*-kW power consumption capacity, the output capacity is *8* m^3/min and the pressure is *1* bar,

- on the area of shaping the wire supports – *3* turbine blowers of *40*-HP capacity (*29,84* kW = *40* HP *0 746*), the output capacity is *14 7* m³/min and the pressure is *0 5* bar,
- the sewage structures on the area "Burden" and for operating the "***Ribbon***" furnace equipment for production of flasks – *4* compressors of *50*-HP capacity (*37 3* kW = *50* HP× *0 746*), the pressure is *6 9* bar and the output capacity is *6 1* m/min

The initial data for the calculation are as follows

- the number of the working days per year – *113* days,
- the number o the days in a year *365 - 113 = 252* days,
- the operation time of the processing equipment on week-days – *16* hours/day,
- losses of compresed air in the pipe lines from the compressor station to the workshop – *9 5*% (see Item 7 1, A),
- losses of compressed air in the internal workshop lines *20*% - *9 5*% = *10 5*% (*20*% is the average value for the facilities in the machine building industry,
- withdrawal from operation of the compressor with a *630*-kW drive, the actual capacity factor is *0 95*,
- the toal capacity of the electric motors of the new local comprssors is

35 kW *3* units + *29 8* kW *3* units + *37 3* kW *4* units = *343 6* kW,

the calculated capacity factor is *0 70*

The decrease of the compressor plants capacity resulting from implementation of the given ECO is

630 kW *0 95* - *343 6* kW *0 7* = *358* kW

A yearly saving of electric power resulting from introduction of the local compressors will be as follows

(*113* days *24* hours + *252* days *8* hours) *358* kW= *4,728* hours *358* kW =

= *1,693,000* kW h/yr

So, the cost of the electric power saved yearly providing implementation of the proposed ESM is (see Fig 5 5)

(*1,693,000* kW h / *6,210,000* kW h) US $*279,066* /yr = US $*76,063* per year

The costs of the local compressors see below (Appendix A), it is US *86,500*

There should be taken into account that compressors in the compressor station have worn out physically and they are subject to replacement Approximate cost of one new compressor with taking into account the cost of the electric motor with the capacity of *630* kW is US *126,000* So, introduction of local compressors will allow to save on the cost of the equipment in addition

USD *126,000* - USD *86,500* = USD *39,500*

The payback period for the given energy saving measure is

US $*39,500* / (US $*76,063* yr ^{1}) = *0 52* year

Conclusions Implementation of this measure will allow to save electric power (*1,693,000* kW h per year), due to its simple payback period this measure can be recommended as one of the most prospective measures

Conclusions Implementation of this measure will allow to save electric power (***1,693,000*** kW h per year), due to its simple payback period this measure can be recommended as one of the most prospective measures

7 4 Improvement of the operation efficiency of RIBBON glass-making furnace

7 4 1 Provision of effective thermal insulation of "RIBBON" glassmaking furnace on the basis of light-weight materials

The proposal

Decreasing the heat losses through external guardings obstacles (the walls and the vault) of *"RIBBON"* furnace and decreasing the temperatures of their surfaces to the rated one by providing effective thermal insulation on the basis of light-weight materials

Calculations were made with the aim to estimate the amount of the saved energy resources and the costs on the implementation After fulfilling more detailed calculations some design changes are possible in the proposed measures There is also possible, and in some places it is just required, to use (after an additional development) an evapation or water cooling followed by utilization of the removed heat The cost of an area unit of the cooling surface does not significantly from that of an efficient thermal insulation, so its use will not influence the costs and the payback period for the given measures

Study results

Aiming at finding how reasonable is provision of effective thermal insulation on *"RIBBON"* furnace measurements of temperatures of the walls and vault of the aggregate were made Infra-red Thermometer "Heat Spy" was used (*DHS-26X* Model) for measurements The measurements showed that the average surface temperature $t_{ext.}$ is as follows

for the walls	-	310 °C,
for the furnace vault	-	330 °C,
for the walls of the regenerator	-	250 °C,
for the vaults of the regenerator	-	300 °C

Calculation of thermal losses from the furnace aggregate

Thermal losses through the external guarding obstacles are

$$Q = q \quad S, \text{ (kcal/h)},$$

where $q = \alpha \quad (t_{ext.} - t_{int})$ kcal/m^2 h – the specific thermal flux through the guarding,

S – the area of the guarding surface, m^2,

α – the heat transfer coefficient, kcal/m^2 h °C,

t_N – the average temperature of the surface of a guarding obstacle, °C,

t_V – the average temperature of the air in the workshop, $t_V = 30$ °C

Let us consider each guarding obstacle

- The furnace vault (the feeder including)

$$q = 15 \quad (330 - 30) = 4,500 \text{ kcal/m}^2 \text{ h},$$

$S = 8\ 0\ \ (11\ 0 + 3\ 0) + 25 = 137\ 0$ m^2,

$Q = q\ \ S = 4{,}500\ \ 137\ 0 = 616\ 500$ kcal/h

- The furnace bottom (without the feeder)

$q = 15\ \ (300 - 30) = 4{,}050$ kcal/m^2 h,

$S = 8\ 0\ \ 11\ 0 = 88\ 0$ m^2,

$Q = q\ \ S = 4{,}050\ \ 88\ 0 = 356\ 400$ kcal/h

- The furnace walls (including the feeder)

$q = 15\ \ (310 - 30) = 4{,}200$ kcal/m^2 h,

$S = 1\ 5\ \ 11\ 0\ \ 2 + 8\ 0\ \ 3\ 0 + 21\ 0\ \ 2\ 0 = 99\ 0$ m^2,

$Q = q\ \ S = 4{,}200\ \ 99\ 0 = 415\ 800$ kcal/h

- The regenerator vaults

$q = 15\ \ (300 - 30) = 4{,}050$ kcal/m^2 h,

$S = 3\ 0\ \ 10\ 0\ \ 2 = 60\ 0$ m^2,

$Q = q\ \ S = 4{,}050\ \ 60\ 0 = 243\ 000$ kcal/h,

- The regenerator walls

$q = 15\ \ (250 - 30) = 3{,}300$ kcal/m^2 h,

$S = ((5\ 0 + 3\ 0)\ \ 10\ 0 + 5\ 0\ \ 3\ 0)\ \ 2 = 190\ 0$ m^2,

$Q = q\ \ S = 3{,}300\ \ 190\ 0 = 627{,}000$ kcal/h

- Gas and air ducts (between the furnace and the regenerators)

$q = 15\ \ (300 - 30) = 4{,}050$ kcal/m^2 h,

$S = 80\ 0$ m^2,

$Q = q\ \ S = 4{,}050\ \ 80\ 0 = 324\ 000$ kcal/h

Common thermal losses through the external guarding obstacles of the whole aggregate are as follows

$$Q = 616\ 500 + 356\ 400 + 415\ 800 + 243\ 000 + 627\ 000 + 324\ 000 = 2{,}582{,}700 \text{ kcal/h}$$

Calculation of the thermal balance and of the real efficiency of the furnace

The coming heat

- the chemical heat of the fuel (gas - the lowest operation combustion heat is $Q^{op}_L = 8{,}100$ kcal/m^3, $G = 1{,}500$ m^3/h is the consumption of natural gas by the glassmaking furnace) is

$$Q_{Ch} = Q^{op}_L\ \ G = 8{,}100\ \ 1{,}500 = 12{,}150\ 000 \text{ kcal/h},$$

- the physical heat of the supplied air (the volume required for burning 1 m^3 of gas is $12\ 62$ m^3 of air, at the flow ratio of $1\ 4$, the heat content at the temperature of 20 °C is $6\ 3$ kcal/m^3) is as follows

$$Q_V = 6\,3 \quad 12\,62 \quad 1{,}500 = 120\,000 \text{ kcal/h},$$

$$Q_{oth} = 12{,}150{,}000 + 120{,}000 = 12{,}270{,}000 \text{ kcal/h}$$

The outgoing heat

- the useful heat for melting the furnace charge and warming the glass to *1,500* °C (the productivity of the furnace is *4,500* kg of glass per hour, at the reasonable thermal losses equal to *700* kcal/kg) is

$$Q_{useful} = 700 \quad 4{,}500 = 3{,}150{,}000 \text{ kcal/h},$$

- the heat quantity taken away with the combustion products (the amount of the combustion products is *13 65* m^3 per 1 m^3 of gas, at the air flow coefficient of *1 4,* the heat content in the combustion products at the temperature of $t_1 = 600$ °C per *1* m^3 of gas, consumed by the furnace is *2,800* kcal per 1m^3 of gas) is

$$Q_{taken} = 2{,}800 \quad 1{,}500 = 4{,}200{,}000 \text{ kcal/h}$$

- thermal losses through the external guardings of the whole aggregate are

$$Q_{Gurd} = 2{,}580{,}000 \text{ kcal/h},$$

$$Q_{\Sigma taken} = 3{,}150{,}000 + 4{,}200{,}000 + 2{,}580{,}000 = 9{,}930{,}000 \text{ kcal/h}$$

Then the losses not taken into account are

$$Q_{not\ account.} = Q_{oth} \quad Q_{\Sigma taken} = 12{,}270{,}000 - 9{,}930{,}000 = 2{,}340{,}000 \text{ kcal/h},$$

which is less 20 per cent of the coming heat

The efficiency of the furnace is

$$(3{,}150{,}000 / 12{,}270{,}000) \quad 100\% = 25\ 7\%$$

Calculation of the limiting temperature between the vault and the thermal insulation

To decrease the temperature of the external surfaces provision of effective thermal insulation is required

According to the sanitary specifications and standards the temperature of the external surfaces of high-temperature plants shall be *45* °C (*SN 245-71*)

Let us calculate the limiting temperature between the vault and effective thermal insulation after providing the latter

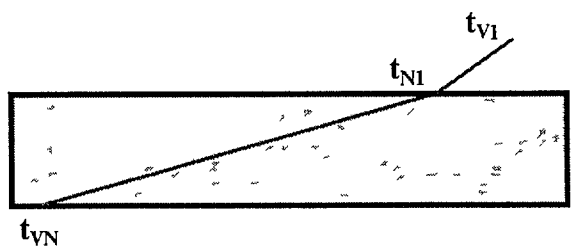


Fig 7 1 Temperature distribution in an insulated vault

The thermal flux through the non-insulated vault is (Fig 7 1)

$$q_1 = a_1 \ (t_{N1} - t_{V1}),$$

where $t_{N1} = 330$ °C – is the temperature of the external surface of the vault,

$t_{V1} = 30$ °C – is the temperature of the ambient air,

$a_1 = 15$ kcal/m^2 h °C – is the coefficient of heat transfer from the vault to the air at these temperatures

$$q_1 = 15 \ (330 - 30) = 4,500 \text{ kcal/m}^2 \text{ h}$$

The heat transfer resistance of the vault materials

$$R_{SV} = (t_{VN} - t_{N1})/q_1,$$

where $t_{VN} = 1,500$ °C – is the temperature of the internal surface of the vault,

$$R_{SV} = (1,500 - 330)/4,500 = 0\ 26 \text{ m}^2 \text{ h °C/kcal}$$

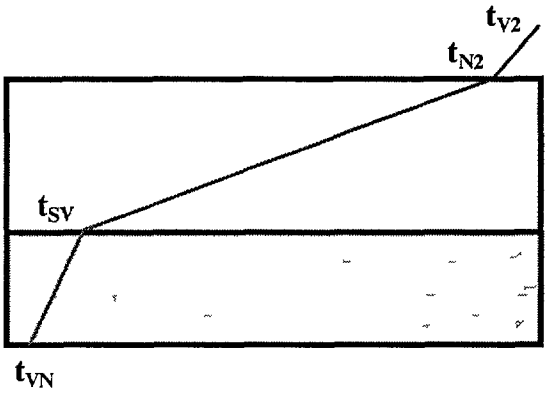


Fig 7 2 Temperature distribution in a vault thermally insulated

The heat flux through the vault after providing thermal insulation is

$$q_2 = a_2 \ (t_{N2} - t_{B2}),$$

where $t_{N2} = 45$ °C – is the temperature of the external surface of the insulation (Fig 7 2),

$t_{V2} = 25$ °C – is the temperature of the ambient air after provision of insulation for on the furnace,

$a_2 = 6$ kcal/m^2 h °C – is the coefficient of heat transfer from the insulation to the air at these temperatures

$$q_2 = 6 \ (45 - 25) = 120 \text{ kcal/m}^2 \text{ h}$$

The limiting temperature between the vault and the insulation (Fig 7 2) after its provision is determined from the formula

$$q_2 = (t_{VN} - t_{SV})/R_{SV},$$

$$t_{SV} = t_{VN} - q_2 \ R_{SV} = 1,500 - 120 \ 0\ 26 = 1,470 \text{ °C}$$

Taking into account the value of the received temperature the conclusion about need of a multilayer insulation is made

Method of calculating the thermal insulation of a furnace

The value of the required heat transfer resistance R_{MS} of a multilayer insulation provided on the furnace is determined from the formula

$$q_2 = (t_{VN} - t_{N2})/(R_{SV} + R_{MS})$$

$$R_{MS} = (t_{VN} - t_{N2})/q_2 - R_{SV} = (1,500 - 45)/120 - 0\ 26 = 11\ 865 \text{ m}^2 \text{ h °C/kcal}$$

Knowing the heat transfer resistance and the limiting temperatures of the multilayer insulation, one can choose thermal insulating materials and make calculations of the thickness of the layers in accordance with their effective temperature range, taking into account that

$$R_{MS} = R_1 + R_2 + \ + R_n \text{ (m}^2 \text{ h °C/kcal)},$$

where $R_1, R_2, \ , R_n$ – are heat transfer resistances of each layer respectively, $R_i = d_i/k_i$ (m^2 h °C/kcal),

d_i – is the thickness of the i-th layer of the thermal insulation, m,

k_i – is the heat conductivity coefficient of the material of the i-th layer in the thermal insulation, kcal/m h °C

Calculation of effective thermal insulation on the basis of light-weight materials

We shall make the first layer of the thermal insulation with *DL-1,2 Dinas* light-weight material (up to *1,550* °C) We shall determine its thickness from the formula

$$q = (t_{SV} - t_1)\ \ k_1/d_1$$

$$d_1 = (t_{SV} - t_1)\ \ k_1/q,$$

where $t_1 = 1,300$ °C – is a preliminary chosen temperature between the first and the second thermal insulations,

$$k_1 = 0\ 47 + 0\ 000257\ \ (t_{SV} + t_1)/2 = 0\ 47 + 0\ 000257\ \ (1,470 + 1,300)/2 = 0,83 \text{ kcal/m h °C},$$

$$d_1 = (1,470 - 1,300)\ \ 0,83/120 = 1\ 17 \text{ m}$$

We shall make the second layer of the thermal insulation with ShLA-1,3 chamotte light-weight material (up to *1,400* °C) We shall determine its thickness from the formula

$$q = (t_1 - t_2)\ \ k_2/d_2$$

$$d_2 = (t_1 - t_2)\ k_2/q,$$

where $t_2 = 1,200$ °C – is a preliminary chosen temperature between the second and third layers of the thermal insulation,

$$k_2 = 0\ 4 + 0\ 00033\ \ (t_1 + t_2)/2 = 0\ 4 + 0\ 00033\ \ (1,300 + 1,200)/2 = 0\ 81 \text{ kcal/m h °C}$$

$$d_2 = (1,300 - 1,200)\ \ 0\ 81/120 = 0\ 68 \text{ m}$$

We shall make the third layer of the thermal insulation with *ShLB-1,0* light-weight material (up to *1,300* °C) We shall determine its thickness from the formula

$$q = (t_2 - t_3)\ \ k_3/d_3$$

$$d_3 = (t_2 - t_3)\ \ k_3/q,$$

where $t_3 = 1,170$ °C – is a preliminary chosen temperature between the third and fourth layers of the thermal insulation,

$$k_3 = 0\ 27 + 0\ 0003 \quad (t_2 + t_3)/2 = 0\ 27 + 0\ 0003 \quad (1,200 + 1,170)/2 = 0\ 63 \text{ kcal/m h °C}$$

$$d_3 = (1,200 - 1,170) \quad 0\ 63/120 = 0\ 16 \text{ m}$$

We shall make the fourth layer of the thermal insulation with *ShLB-0,9* chamotte light-weight materials (up to *1,270* °C) We shall determine its thickness from the formula

$$q = (t_3 - t_4) \quad k_4/d_4$$

$$d_3 = (t_3 - t_4) \quad k_4/q,$$

where $t_4 = 1,150$ °C – is a preliminary chosen temperature between the fourth and fifth layers of the thermal insulation,

$$k_4 = 0\ 233 + 0\ 00024 \quad (t_3 + t_4)/2 = 0\ 233 + 0\ 00024 \quad (1,170 + 1,150)/2 = 0\ 51 \text{ kcal/m h °C}$$

$$d_4 = (1,170 - 1,150) \quad 0\ 51/120 = 0\ 085 \text{ m}$$

We shall make the fifth layer of the thermal insulation with *ShLB-0,8* chamotte light-weight material (up to *1,250* °C) We shall determine its thickness from the formula

$$q = (t_4 - t_5) \quad k_5/d_5$$

$$d_5 = (t_4 - t_5) \quad k_5/q,$$

where $t_5 = 1,100$ °C – is a preliminary chosen temperature between the fifth and sixth layers of the thermal insulation,

$$k_5 = 0\ 194 + 0\ 00019 \quad (t_4 + t_5)/2 = 0\ 194 + 0\ 00019 \quad (1,150 + 1,100)/2 = 0\ 41 \text{ kcal /m h °C}$$

$$d_5 = (1,150 - 1,100) \quad 0\ 41/120 = 0\ 17 \text{ m}$$

We shall make the sixth layer of the thermal insulation with *ShLB-0,6* chamotte light-weight material (up to *1,200* °C) We shall determine its thickness from the formula

$$q = (t_5 - t_6) \quad k_6/d_6$$

$$d_6 = (t_5 - t_6) \quad k_6/q,$$

where $t_6 = 1,050$ °C – is a preliminary chosen temperature between the sixth and seventh layers of the thermal insulation,

$$k_6 = 0\ 135 + 0\ 000155 \quad (t_5 + t_6)/2 = 0\ 135 + 0\ 000155 \quad (1,100 + 1,050)/2 = 0\ 3 \text{ kcal/m h °C}$$

$$d_6 = (1,100 - 1,050) \quad 0\ 3/120 = 0\ 125 \text{ m}$$

We shall make the seventh layer of the thermal insulation with *ShLB-0,4* chamotte light-weight material (up to *1,150* °C) We shall determine its thickness from the formula

$$q = (t_6 - t_7) \quad k_7/d_7$$

$$d_7 = (t_6 - t_7) \quad k_7/q,$$

where $t_7 = 850$ °C – is a preliminary chosen temperature between the seventh and eighth layers of layers of the thermal insulation,

$$k_7 = 0\ 1 + 0\ 00014 \quad (t_6 + t_7)/2 = 0\ 1 + 0\ 00014 \quad (1,050 + 850)/2 = 0\ 23 \text{ kcal /m h °C}$$

$$d_7 = (1,050 - 850) \quad 0\ 23/120 = 0\ 38 \text{ m}$$

The eighth, external, layer of the thermal insulation is made from *TK* basalt-based thermal insulation cardboard (up to *950* °C) We shall determine its thickness from the formula

$$q = (t_7 - t_8)\ k_8/d_8$$

$$d_8 = (t_7 - t_1)\ k_8/q = (850 - 45)\ 0\ 05/120 = 0\ 35 \text{ m}$$

The calculation will give us a multi-layer thermal insulation made with the nationally produced materials (Table 3)

Table 7 3

#	Material of the thermal insulating layer	Heat transfer coefficient, kcal/h m °C	Layer thickness, m	Limiting temperature before the layer, °C
1	*DL-1 2*	0 83	1 17	1,70
2	*ShLB-1,3*	0 81	0 68	1,00
3	*ShLB-1 0*	0 63	0 16	1,00
4	*ShLB-0 9*	0 51	0 085	1,70
5	*ShLB-0,8*	0 41	0 17	1,50
6	*ShLB-0 6*	0 3	0 125	1,00
7	*ShLB-0,4*	0 23	0 38	1,50
8	*TK*	0 05	0 35	0,85

1 m² of thermal insulation for a furnace costs US $*500* (including the design and installation works) in case of overlapping of provision of the thermal insulation with a planned reconstruction of the furnace

If the total area of the thermal losses for the furnace is *700* m², the cost of providing thermal insulation for the whole furnace will be

$$500 \times 700 = \text{US } \$350{,}000$$

The thermal losses from the plant after providing thermal insulation of the plant, if the average thermal flux is $q = 120$ kcal/m² h, will amount to

$$120 \times 700 = 84{,}000 \text{ kcal/h}$$

Heat saving will be equal to

$$2{,}585{,}700 - 84{,}000 = 2{,}498{,}700 \text{ kcal/h}$$

Which is

$$(2{,}498{,}700/12{,}270{,}000)\ \ 100\% = 20\ 4\% \text{ of the total heat income}$$

For a year

$$2{,}498{,}700 \times 275 \times 24 = 16{,}491{,}420{,}000 \text{ kcal/year}$$

If to recalculate into gas volume (the heat value is $Q = 8{,}100$ kcal/m³)

$$16{,}491{,}420{,}000/8{,}100 = 2{,}035{,}978 \text{ m}^3 \text{ of gas per year}$$

The total saving will be (supposing the cost is US $83 for 1,000 m^3 of gas) US $170,000 per year

The payback period is

US $350,000/US $170,000 = 2 06 years

Conclusions The measure has a middle-term payback period There is recommended to carry out the design works, to prepare the required documentation and materials for a planned reconstruction of the furnace It seems to be reasonable before fulfilling the reconstruction to provide a temporary insulation

Due to a large thickness of the insulation, there is possible replacement of some materials with more effective ones while retaining the same value of the heat transfer resistance

7 4 2 Providing effective thermal insulation for "RIBBON" glassmaking furnace on the basis of ceramic fibers

The proposal

Decreasing heat losses through the external guardings obstacles (the walls and the vault) of *"RIBBON"* furnace, decreasing the temperature of their surfaces to the specified value by providing effective thermal insulation on the basis of ceramic fibers

Study results (See Item 7 4 1)

Calculation of thermal insulation

We shall make the first layer with *Unifrax-3000* ceramic fiber (*192* kg/m^3, *1,540* °C) We shall determine its thickness from the formula

$$q = (t_{SV} - t_1)\ k_1/d_1$$

$$d_1 = (t_{SV} - t_1)\ k_1/q,$$

where $t_{vault} = 1,470$ is the limiting temperature between the vault and the insulation (see Fig, 7 3) after its provision (for the design calculationn see Item 7 4 1),

$t_1 = 1,340$ °C – is a preliminary chosen temperature between the first and second layers of the thermal insulation (see Fig 7 3)

$$k_1 = 0\ 5 \text{ kcal/m h °C}$$

$$d_1 = (1,470 - 1,340)\ \ 0\ 5/120 = 0\ 54 \text{ m}$$

We shall make the second layer of the thermal insulation with *Unifrax-2600* ceramic fiber (*224* kg/m^3, *1,340* °C) We shall determine its thickness from the formula

$$q = (t_1 - t_2)\ k_2/d_2$$

$$d_2 = (t_1 - t_2)\ k_2/q,$$

where $t_2 = 1,190$ °C – is a preliminary chosen temperature between the second and third layers of the thermal insulation (see Fig 7 3),

$$k_2 = 0\ 3 \text{ kcal/m h °C}$$

$$d_2 = (1,340 - 1,190)\ \ 0\ 3/120 = 0\ 375 \text{ m}$$

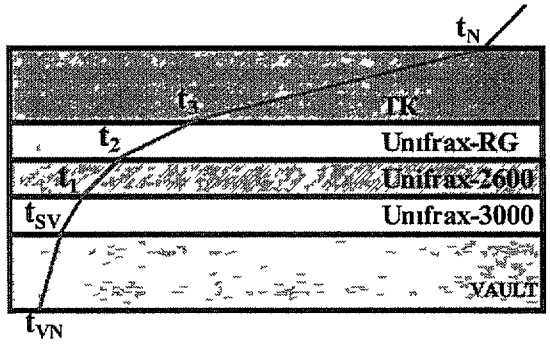


Fig 7 3 Temperature distribution in the vault
with a thermal insulation on the basis of ceramic fibers

We shall make the third layer of the thermal insulation with *Unifrax-RG* ceramic fiber (***258*** kg/m^3, ***1,190*** °C) We shall determine its thickness from the formula

$$q = (t_2 - t_3)\ k_3/d_3$$

$$d_3 = (t_2 - t_3)\ k_3/q,$$

where $t_3 = 850$ °C – is a preliminary chosen temperature between the third and fourth layers of the thermal insulation (see Fig 7 3),

$$k_3 = 0\ 25 \text{ kcal/m h °C}$$

$$d_3 = (1,190 - 850)\ \ 0\ 25/120 = 0\ 71 \text{ m}$$

The external layer of the thermal insulation is made of *TK* basalt-bases thermal insulated cardboard (up to ***950*** °C) Its thickness was determined above (see Item 7 4 1)

The calculation will give us a multi-layer insulation made of the materials on the basis of ceramic fibers (Table 7 4)

Table 7 4

#	Material of the thermal insulating layer	Heat transfer coefficient, kcal/h m °C	Layer thickness, m	Limiting temperature before the layer, °C
1	*Unifrax-3000*	0 5	0 54	1,470
2	*Unifrax-2600*	0 3	0 375	1,340
3	*Unifrax-RG*	0 25	0 71	1,190
4	*TK*	0 05	0 35	0,850

1 m^2 of thermal insulation for the furnace costs US $***800*** (including the design and installation works) in case of overlapping of provision of the thermal insulation with a planned reconstruction of the furnace

If the total area of the furnace heat losses is *700* m^2, the total cost of insulation for the whole furnace is as follows

$$800 \times 700 = \text{US } \$560{,}000$$

The thermal losses after provision of thermal insulation at the average thermal flux of $q = 120$ kcal/m^2 h will be equal to

$$120 \times 700 = 84{,}000 \text{ kcal/h}$$

Heat saving will be

$$2{,}585{,}700 - 84{,}000 = 2{,}498{,}700 \text{ kcal/h},$$

which is $(2{,}498{,}700/12{,}270{,}000) \quad 100\% = 20\ 4\%$ of the total heat income

Yearly

$$2{,}498{,}700 \times 275 \times 24 = 16{,}491{,}420{,}000 \text{ kcal/year}$$

If to recalculate that for amount of gas (the heat value is $Q = 8{,}100$ kcal/m^3)

$$16{,}491{,}420{,}000 / 8{,}100 = 2{,}035{,}978 \text{ m}^3 \text{ of gas per year}$$

Total saving (supposing that $1{,}000$ m^3 of gas cost US \$83) will be US \$170,000 per year

Payback period is

$$560{,}000 / 170{,}000 = 3\ 3 \text{ years}$$

Conclusions The measure is a middle-term one concerning its payback period There is recommended to carry out the design works, to prepare the documentation and materials required for a planned reconstruction of the furnace Providing a temporary thermal insulation before fulfilling the reconstruction seems to be reasonable

7 4 3 Providing a temporary thermal insulation on the furnace unit

The proposal

Decreasing the heat loss through the external guarding obstacles (the walls and the vault) at *"RIBBON"* furnace by providing a temporary thermal insulation on the basis of basalt cardboard

Study results (See Item 7 4 1)

Calculation of a temporary insulation of the vault by means of *TK*-basalt based cardboard

The thermal flux through the vault after making thermal insulation should provide the limiting temperature between the vault and the insulation equal to $t_{SV} = 850$ °C (See Fig 7 4) The resistance to the thermal conductivity of the material for the vault $R_{vault} = 0\ 26$ m^2 hour °C/kcal was determined above (see Item 7 4 1)

$$q_2 = (t_{VN} - t_{SV})/R_{SV} = (1,500 - 850)/0\ 26 = 2,500 \text{ kcal/m}^2 \text{ h}$$

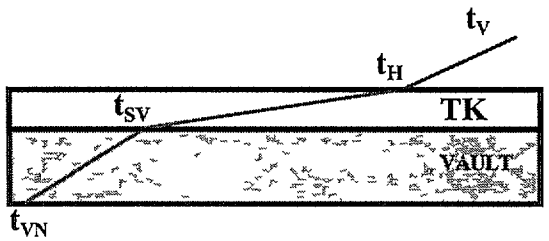


Fig 7 4 Temperature distribution in the vault with a temporary thermal insulation

Then the temperature of the external surface of the insulation will be

$$t_N = t_V + q_2/a,$$

where $t_V = 25$ °C – is the ambient air temperature,

$a = 15$ kcal/m^2 h °C – is the coefficient of the heat transfer from the thermal insulation to the air after providing the thermal insulation on the furnace

$$t_N = 25 + 2,500/15 = 190 \text{ °C}$$

The heat transfer resistance required R_{TK} for the thermal insulation to be provided on the furnace shall be determined from the formula

$$q_2 = (t_{VN} - t_N)/(R_{SV} + R_{TK})$$

$$R_{TK} = (t_{SV} - t_N)/q_2 - R_{SV} = (1,500 - 190)/2,500 - 0\ 26 = 0\ 26 \text{ m}^2 \text{ h °C/kcal}$$

The thickness of the thermal insulation to be provided on the furnace is

$$d = R_{TK}\ \ k_{TK} = 0\ 26\ \ 0\ 05 = 0\ 013 \text{ m}$$

After providing the thermal insulation the heat saving from *1* m^2 will be

$$q = q_1 - q_2 = 4,200 - 2,500 = 1,700 \text{ kcal/m}^2 \text{ h}$$

Then for the vault

$$Q = q\ \ S = 1,700\ \ 137 = 233,000 \text{ kcal/h},$$

which is *(233,000/12,270,000)* *100%* = 2% of the total heat income

The annual heat saving (taking into consideration the routine stops and temporary underloading modes, we set *275* days in a year) will amount to

$$233{,}000 \quad 275 \quad 24 = 1{,}537{,}000{,}000 \text{ kcal/yr}$$

Providing the lower heat value of gas $Q^{op}_{L} = 8{,}100$ kcal/m^3, we receive the annual saving of

$$1{,}537{,}000{,}000/8{,}100 = 190{,}000 \text{ m}^3\text{/yr}$$

If *1,000* m^3 of gas cost US $*83*, the annual saving after providing a temporary thermal insulation will be

$$190 \quad \text{US } \$83 = \text{US } \$15{,}770\text{/year}$$

The cost of the insulation (*TK 1-5* and *TK 1-10*) including the delivery cost, installation works and other expenditures is US $*8* for *1* m^2 of the insulating area

Then the cost of the insulation for the vault is US $*8* *137* = US $*1,100*

Payback period is US $*1,100*/US $*15,770* = *0 07* year (less than a month)

When installing a temporary thermal insulation on all the area of the aggregate (the bottom, walls, vault of the furnace and of the feeder, vaults and walls of the regenerators), the saving will amount to *9* per cent of the total heat income into the furnace, while the annual saving will amount to US $*75,000*

The total cost of insulating the whole furnace (*TK 1-5* and *TK 1-10*), including expenditures on delivery, installation works and other costs, is US $*8,650* = US $*5,200*

Payback period is US $*5,200*/$*75,000* = *0 07* yr (less than a month)

Conclusions The measure is economically benefitial and it has a short payback period It is recommended for implementation as a temporary measure before a planned reconstruction of the furnace

7 4 4 Thermal insulation of the furnace with using the materials having been purchased by the plant

The proposal

Decreasing thermal losses through the external guarding obstacles in regard of *"RIBBON"* furnace (the walls and the vault) by means of a thermal insulation with materials having been purchased by the plant

Study results (See Item 7 4 1)

Aiming at thermal insulation of the furnace, the plant purchased thermal insulating basalt-based mats *TM-40* (*RST of Ukraine* 1981-87, Rev -1) They are supposed to be put in the intermediate layer of a fire-resisting thermal insulator made of *DL-1,2 Dinas* light-weight material (*GOST 5040-68 TU 14-8-73*)

Let us calculate thermal insulation of the vault by these materials

Calculation of thermal insualtion

The thermal flux through the vault after providing the insulation should be a sort of for the limiting temperature between the intermediate insulation and basalt mats to be $t_M = 500$ °C

$$q = (t_M - t_V) / (R_M + R_B),$$

where $t_{BV} = 25$ °C – is the temperature of the ambient air,

$R_M = d_M / k_M$ – is the heat transfet resistance of basalt mats, m² h °C/kcal,

$R_V = 1/a$ – is the resistance of heat transfer from basalt mats to the air, m² h °C/kcal,

$d_M = 0\ 4$ m – is the thickness of insulation of basalt mats,

$k_M = 0\ 6$ kcal/m h °C – is the heat transfer coefficient of mats,

$a = 8$ kcal/m² h °C – is the coefficient of the heat transfer from the air after providing the furnace with insulation,

$R_M = 0\ 04/0/06 = 0\ 67$ m² h °C/kcal,

$R_V = 1/8 = 0\ 125$ m² h °C/kcal,

$$q = (500 - 25)/(0\ 67 + 0\ 125) = 600 \text{ kcal/m}^2 \text{ h}$$

Then the temperature of the external surface of the insulation (see Fig 7 5) is

$$t_N = t_V + q/a = 25 + 600/8 = 100 \text{ °C}$$

The temperature of the vault surface under the insulation is

$$t_{SV} = t_{VN} + q \quad R_{SV} = 1{,}500 - 600 \quad 0\ 26 = 1{,}350 \text{ °C}$$

The thickness d_L of the intermediate layer of the thermal insulation from *DL-1,2 Dinas* light-weight materials (up to *1,550* °C) can be determined from the formula

$$q = (t_{VN} - t_M)/(R_{SV}\ d_L/k_L)$$

$$d_L = ((t_{VN}\ t_M/q - R_{SV}) \quad k_L$$

where k_L – is the coefficient of heat transfer of the *Dinas* light-weight material,

$$k_L = 0\ 47 + 0\ 000257 \quad (t_{VN} + t_M)/2 = 0\ 47 + 0\ 000257 \quad (1\ 350 + 500)/2 = 0\ 71 \text{ kcal/m h °C},$$

$$d_L = ((1{,}500 - 500)/600 - 0\ 26) \quad 0\ 71 = 1\ 00 \text{ m}$$

To decrease the thickness of the intermediate layer of the insulation, this layer must be a multilayer one

The thickness d_1 of the layer of the thermal insulation from *DL-1 2 Dinas* light-weight materials (up to *1,550* °C) can be determined from the formula

$$q = (t_{SV} - t_1) \quad k_1/d_1$$

$$d_1 = (t_{SV} - t_1) \quad k_1/q,$$

where $t_1 = 1200$ °C – is a preliminary chosen temperature between the first and second layers of the thermal insulation (see Fig 7 5),

k_1 – is the coefficient of the heat transfer of the *Dinas* light-weight materials,

$$k_1 = 0\ 47 + 0\ 000257 \quad (t_{VN} + t_1)/2 = 0\ 47 + 0\ 000257 \quad (1{,}350 + 1{,}200)/2 = 0\ 8 \text{ kcal/m h °C},$$

$$d_1 = (1{,}350 - 1{,}200) \quad 0\ 8/600 = 0\ 2 \text{ m}$$

The second layer of the thermal insulation will be made with *ShLB-0 9* chamotte light-weight material (up to *1,270* °C) Its thichness will be determined from the formula

$$q = (t_1 - t_2)\ k_2/d_2$$

$$d_2 = (t_1 - t_2)\ k_2/q,$$

where $t_2 = 1{,}500$ °C – is a preliminary chosen temperature between the second and third layers of the thermal insulation (see Fig 7 5),

k_2 – is the heat transfer coefficient of the chamotte light-weight material,

$k_2 = 0\ 233 + 0\ 00024\ (t_1 + t_2)/2 = 0\ 233 + 0\ 00024\ (1{,}200 + 1{,}050)/2 = 0\ 5$ kcal/m h °C,

$$d_2 = (1{,}200 - 1{,}050)\ 0\ 5/600 = 0\ 125 \text{ m}$$

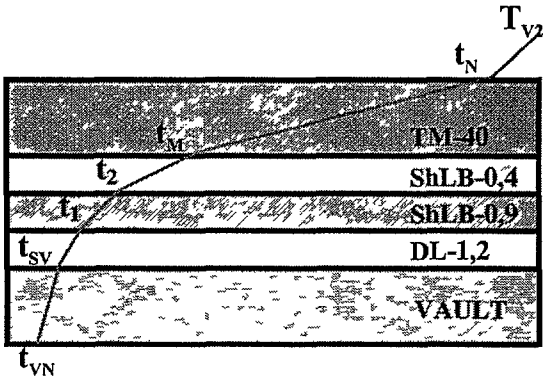


Fig 7 5 Temperature distribution in the vault with a multi-layer insulation

The third layer of the thermal insulation will be done with *ShLB-0,4* chamotte light-weight material (up to *1,150* °C) Its thickness will be determined from the formula

$$q = (t_2 - t_1)\ k_3/d_3$$

$$d_3 = (t_2 - t_1)\ k_3/q,$$

where k_3 – is the heat transfer coefficient of the chamotte light-weight material,

$k_3 = 0\ 1 + 0\ 00014\ (t_2 + t_M)/2 = 0\ 1 + 0\ 00014\ (1{,}050 + 500)/2 = 0\ 2$ kcal/m h °C,

$$d_3 = (1{,}050 - 500)\ 0\ 2/600 = 0\ 18 \text{ m}$$

The calculations give us a multi-layer thermal insulation made of the materials (*TM-40)* purchased by the plant (Table 7 5)

Table 7 5

#	Material of the thermal insulating layer	Heat transfer coefficient, kcal/h m °C	Layer thickness, m	Limiting tepterature before the layer, °C
1	DL-1,2	0 8	0 2	1,350
2	ShLB-0,9	0 5	0 125	1,200
3	ShLB-0,4	0 2	0 18	1,050
4	TM-10	0 06	0 40	0,500

To decrease the weight of theintermediate layer of the thermal insulation it is possible instead the chamotte light-weight materials (*ShLB-0,9* and *ShLB-0,4*) using fiber-based mullite-silica or chamotte-fiber-based slabs (*MKRPG-400* or *ShShGT-450*) and mullite-silica-based rolled materials (*MKRR-130*)

1 m^2 of the furnace insulation (including the design and fulfillment of the work) – US $*100*

The total area of the heat losses from the furnace is *700* m^2, so the insulation for the whole furnace is

$$100 \times 700 = \text{US } \$70,000$$

The thermal losses after providing a thermal insulation at the average thermal flux of $q = 600$ kCal/m^2 h will be

$$600 \times 700 = 420,000 \text{ kcal/h}$$

The heat saving will be

$$2,585,700 - 420,000 = 2,165,700 \text{ kcal/h},$$

which is *(2,165,700/12,270,000) 100% = 17 7%* of the total amount of the coming heat

For a year

$$2,165,700 \times 275 \times 24 = 14,293,620,000 \text{ kcal/yr}$$

If to recalculate it in gas units (the heat value is $Q = 8,100$ kcal/m^3), it gives

$$16,491,420,000/8,100 = 1,764,644 \text{ m}^3 \text{ of gas per year}$$

The total gas saving (supposing that 3a *1,000* m^3 costs US $*83*) will amount to US $*145,000* per year

The payback period

$$70,000/145,000 = 0\ 48 \text{ year}$$

Conclusions The measure is a short-term repaid one, but it requires fulfillment of some additional design works Such works are recommended to be carried out with the aim of perfect choosing the materials with the following direct providing of the insulation

7 4 5 *Utilization of heat from the combustion products in "RIBBON" gas making furnace*

The proposal

Installation of a steam generator for utilization with the following using the heat from the combustion products to produce steam for the processing needs and for heating the space in the buildings in winter

Study results

Due to the data received with the help of *ENERAC-2000* Combustion Analyzer (see Appendix B), the amount of the heat removed by the combustion products from the glassmaking furnace is currently as follows (at the temperature $t_1 = 600$ °C)

$$Q_1 = G \quad \iota$$

The heat tthat will be removed from the glassmaking furnace by the combustion products after installation of a steam generator, at the temperature of the combustion products $t_2 = 150^0$C

$$Q_2 = G \quad \iota_2,$$

where $G = 1{,}500$ m^3/h – is the amount of natural gas consumed by the glassmaking furnace (the lower operation heat value $Q^{op}_L = 8{,}100$ kcal/m^3, the volume of the combustion products is *13,65* m^3 when burning *1* m^3 of gas, at the air flow coefficient of *1 4*)

$\iota_1 = 2{,}800$ kcal/m^3 of gas and $\iota_2 = 700$ kcal/m^3 of gas are the heat content of the combustion products respectively at $t_1 = 600$ °C, $t_2 = 150$ °C per 1 m^3 of gas consumed by the furnace

Heat saving resulting from it utilization when cooling the exhaust gases from the temperature of *600* °C to *150* °C is

$$Q_E = Q_1 - Q_2 = G \quad \iota_1 - G \quad \iota_2 = G \quad (\iota_1 - \iota_2) = 1{,}500 \quad (2{,}800 - 700) = 3{,}150{,}000 \text{ kcal/h}$$

Taking into account the efficiency of the steam generator equal to *80* per cent, the gas saving will be

$$G_E = 0\ 8 \quad Q_E/Q^{op}_L = 0\ 8 \quad 3{,}150{,}000/8{,}100 = 311 \text{ m}^3\text{/h},$$

which is *(311/1,500) 100*% = *20 7*% of the total gas consumption by the furnace

The annual saving (with taking into consideration the regular repair and maintenance stops as well as the temporal underloaded operation modes which we suppose to be equal to *275* days/year)

$$(311 \text{ m}^3\text{/h}) \quad (275 \quad 24 \text{ h/year}) = 2{,}000{,}000 \text{ m}^3\text{/year}$$

The cost of the gas saved during a year is

$$(2{,}000{,}000 \text{ m}^3\text{/year}) \quad \text{US } 0\ 083 \text{ per } 1\text{m}^3 = \text{US } \$166{,}000$$

The cost of an *ESG* Steam Generator and the required equipment, with taking into account the transportation cost and the expenditures on certification as well as other costs, is US $200000

The payback period for the given measure is

$$\text{US } \$200{,}000/\text{US } \$166{,}000 = 1\ 2 \text{ years}$$

Conclusions The given measure is economically profitable and it has a middle-term payback period It is recommended to consider the opportunities for purchasing and installation of an *ESG*-type Steam Generator Plant

7 4 6 Improvement of the operation efficiency at "RIBBON" glassmaking furnace by controlling the supply of air for combustion process

The proposal

Improvement of the operation efficiency of the furnace by controlling the air supply for the combustion process by means of *ENERAC 2000* Combustion Analyzer

Study results

The results after the tests carried out with the help of the combustion analyzer (see Appendix) showed that it may be possible to increase the operation efficiency of the furnace by approximately *0 5* to *1* per cent

ENERAC 2000 Combustion Analyzer costs US $*5,000*

The consumption of natural gas by *"RIBBON"* glassmaking furnace is

$$B = 10,000,000 \text{ m}^3/\text{year}$$

Saving of *0 5* per cent of natural gas will be

$$B \frac{0\,5\%}{100\%} = 10,000,000 \frac{0\,5}{100} = 50,000 \text{ m}^3/\text{year},$$

or, if *1,000* m^3 of gas cost US $**83**, the saving will be US $*83 50*= US $*4,150*

The payback period will be

US $*5,000* / US $*4,150* = *1 2* year

Conclusions The measure is economically profitable and it has a short-term payback period There should be recommended consideration of opportunities for purchasing and installation of an *ESG*-type steam generator

Final conslusion While implementing energy saving measures aimed at improvement of efficiency of the operation of *"RIBBON"* glassmaking furnace, it is possible to increase the efficiency of the aggregate from *25* to between *45* and *50* per cent with an additional utilization still other *20* per cent of the heat of the total amount consumed by the furnace It results finally in decreasing the net cost of the products There is recommended to consider thoroughly the proposed measures and to choice those that are worth their implementing

7 5 Improvement of operating efficiency of DE-6,6 Boilers in the boiler-house

The proposal

Increasing the operation efficiency of *DE-6,5* Boilers by controlling air supply for combustion process using *ENERAC 2000* Combustion Analyzer

Study results

The data received after the tests carried out with the help of the combustion analyzer (see Appendices) showed that, maybe, there is possible to increase the operation efficiency of *DE-6,5* Boilers by approximately *2* to *3* per cent

Calculation of the proposal efficiency

The cost of *ENERAC 2000* Combustion Analyzer – US $*5,000*

The consumption of natural gas by the steam boiler-house is

$$B = 4{,}000{,}000 \text{ m}^3/\text{year}$$

A *2*-per cent saving of natural gas is equal to

$$B \frac{2\%}{100\%} = 4{,}000{,}000 \frac{2}{100} = 80{,}000 \text{ m}^3/\text{year},$$

and if US $*83* is to be paid for *1,000* m^3, the saving will amount to

US $*83* *80* = US $*6,640*

The payback period will be

US $*5,000*/US $*6,640* = *0 75* year

Conclusions The measure has a short-term payback period, it accounts for why it is reasonable to purchase a combustion analyzer to monitor constantly the fuel combustion quality

7 6 Operation of an infra-red heating system in the workshop for electric plating

The proposal

Aiming at energy saving in heating systems, installation in the workshop for electric plating an infra-red heating system

Study results

The workshop for electric plating is on two levels and it has a water heating system The heat-supply tubes are set along the whole perimeter of the building on the first and on the second floors At the present time, as a result of the reduction of production levels, in the electric plating workshop only *50* per cent of the total area of the floor are used for the production purposes, as for the second floor is concerned, only 1/3 of that is used for production purposes

Under the conditions, operation of an infra-red heating system working on natural gas would lead to a significant decrease of costs on heating of the building The saving resulting from using that sort of a heating system would be in heating only the space where equipment is installed and the zone needed for working of the operating personnel

The preliminary discussions with the top management of the enterprise showed large interest on their side in installation of an infra-red heating system

Calculations concerning using an infra-red heating system in the electric plating workshop at ISKRA Plant

Area of the building - 5,200 m^2

Quantity required for heating the building

- providing the current heating system

$$80 \text{ kCal/m}^2 \text{ h} \times 5{,}200 \text{ m}^2 = 41{,}600 \text{ kcal/h},$$

- providing use of *5* infra-red heaters *50,400* kcal/h

$$5 \times 50{,}400 = 252{,}000 \text{ kcal/h}$$

Saved heat

$$(1 - 252{,}000/416{,}000) \quad 100 = 40\%$$

or

$$(416{,}000 - 252{,}000) \quad 4{,}400 \text{ hour/h} = 721{,}600{,}000 \text{ kcal/h}$$

Suppose that production of *1* Gcal of heat requires using of *133* m^3 of gas, which, if *1,000* m^3 costs USD *83*, will ampunt to US $*11*

The gas saving is

$$133 \text{ m}^3/\text{Gcal} \quad 721\ 6 \text{ Gcal/yr} = 96{,}000 \text{ m}^3/\text{yr}$$

Saving in dollars

$$\text{USD } 11 \text{ per Gcal} \quad 721\ 6 \text{ Gcal/yr} = \text{USD } 8{,}000 \text{ per year}$$

The cost of the infra-rd heaters is

for 1 unit – US $*1,200*

for 5 units – US $*6,000*

The payback period is $6{,}000/8{,}000 = 0\ 75$ year

Conclusions Installation of infra-red hearters is a measure with a short-term payback period equal in less than 1 heating season

8 0 EFFECTS OF RECOMMENDATIONS ON THE ENVIRONMENT

Implementation of energy saving measures leads to decreasing the level of harmful emissions into the atmosphere due to decreasing the amount of the fuel and electric power IN accordance with the data received at the plant, burning of *1,000* m^3 of gas results in emitting into the atmosphere the following

CO – carbon monoxide – 0 28 kg,

NO_X – nitrogen oxides – 1,458 kg,

According to the data after measurements for the glass-making furnace (see Appendix B), when *1,000* m^3 of gas are burned, into atmosphere there are emitted as follows

CO - carbon monoxide - *0 4* kg,

NO_u - nitrogen oxide - *14* kg

In 1996 the average amount of harmful emissions per на *1,000* kW h of the produced electric power, according to the data from the Ministry of Energy of Ukraine, was as follows

CO – *0 5* kg,

NO_X – *2 2* kg,

SO_2 – *9 9* kg,

Ash – *4 4* kg

Implementation of the proposed energy saving measures will enable to decrease the electric power consumption by *6,555* thousand kW h, which is equivalent to decreasing the amount of harmful emissions into the atmosphere

CO (*6,555* thousand kW h) (*0 5* kg/th kW h) = *32,785* kg

NO_x (*6,555* thousand kW h) (*2 2* kg/th kW h) = *14,421* kg

SO_2 (*6,555* thousand kW h) (*9 9* kg/th kW h) = *64,895* kg

Ash (*6,555* thousand kW h) (*4 4* kg/th kW h) = *28,842* kg

Implementation of the proposed energy conservation measures will enable to save consumption of natural gas at the boiler-houses by *380* thousand m^3, at other areas (furnaces, feeders, etc) by *4,757* thousand m^3 which is equivalent to decreasing the amount of harmful emissions into the atmosphere as follows

- for the boiler-houses

CO *380* th. m^3 *0 28* kg/th m^3 = *106* kg

NO_x *380* th m^3 *1,458* kg/th m^3 = *554* kg,

- for the furnaces, etc

CO *4,757* th m^3 *0 4* kg/th m^3 = *1,903* kg

NO_x *4,757* th m^3 *14* kg/th m^3 = *66,598* kg

In total, implementation of the proposed energy conservation measures will allow to decrease emissions into the atmosphere by the following amount

CO - by ***34,794*** kg

NO_x - by ***81,573*** kg

SO_2 - by ***64,895*** kg

Ash - by ***28,842*** kg

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Table A 1

Energy Conservation Opportunities

#	Measure	Electric power saving, kW h x 1,000	Saving of natural gas, m^3 x 1,000	Yearly saving, USD	Measure costs, USD	Simple payback period, yr	Item in the given report
1	Implementation of energy management	631	875	114,587	110,032	0 96	7 1
2	Improvement of the schedule for the compressor station operation	1,435	0	64,464	10,000	0 155	7 2 2
3	Transfer of operation of the processing equipment on the air from the local compressor plants	1,693	0	76,063	86,500	1 14	7 3
4	Controlling the compressor station production capacity by means of a speed-variable electric driver	1,731	0	77,780	126,000	1 62	7 2 3
5	Replacement of the current compressors with new ones, economically more efficient	1,065	0	47,886	252,252	5 27	7 2 4
6	Improvement of the opreation efficiency of *DE-6 5* Boilers in the steam boiler-house	0	80	6,640	5,000	0 75	7 5
7	Introduction into practice of infra-red gas-fired heating systems in the electroplating workshop	0	96	8,000	6,000	0 75	7 6
8	Utilization of the heat from the combustion products leaving *RIBBON* furnace	0	2,000	166,000	200,000	1 2	7 4 5
9	Improvement of the operation efficiency of *RIBBON* glass-making furnace by controlling the air supply for burning	0	50	4,150	5,000	1 2	7 4 6
10	Provision of temporary insulation on the furnace unit	0	190	75,000	5,200	0 07	7 4 3
11	Thermal insulation of the furnace with the materials bought by the plant	0	1,765	145,000	70,000	0 48	7 4 4
12	Provision of thermal insulation on the basis of light materials on the glass-making furnace *RIBBON*	0	2,036	170,000	350,000	2 06	7 4 1
13	Provision of efficienct thermal insulation on the basis of ceramic fibers on the glass-makingh furnace *RIBBON*	0	2,036	170,000	560,000	3 3	7 4 2

The list of the equipment required for implementaiton of the energy conservation measure **"Transfer on operation of the processing equipment using the air from the local compressor plants"**

1)

- either a turbine blower o filter of ***Blower Frame Size 55 type*** with the production capacity f ***547*** CFM and the pressure of *7* PSI in a set with a spare

  Manufacturer's address DRESSER INDUSTRIES, INC
  ROOT DIVISION
  900 WEST MOUNT STREET,
  CONNERSVILLE, INDIANA 47331
  Fax 317/825-7669

- or a turbine blower Model DRS15BQ72 with the production capacity of 14 7 m^3/min and with the pressure of 0 5 bar in a set with a spare filter and an electric motor of 40-HP capacity, 3-phase power supply of 50 Hz, 380 V

  Manufacturer's address "PORTRON"
  EG & G PORTRON, SAU GERTIES,
  N Y 12477 USA
  Fax 914/246-38-02

The approximate cost is US $***8,000*** per unit Purchasing of *3* turbine blowers is needed, the total cost is US $***24,000***

2)

- either turbine blowers of *8*-m^3/min capacity, the pressure is *1* bar with an electric motor of **35**-kW capacity with a belt drive and a spare filter The power supply voltage is **380** V, 3 phases of 50 Hz

Manufacturer's address LAMSON CENTRIFUGAL BLOWE RS
GARDNER DENVER MACHINERY INC
P O BOX 4857
SURACUSE, N Y 13206
Fax 315/433-5451

- or turbine blowers of ***Blower Frame Size 53*** type with the capacity of ***295*** CFM and the pressure of ***15*** PSI, the rotational frequency is 2,850 RPM, with an electric motor and a spare filter

Manufacturer's address DRESSER INDUSTRIES, INC
ROOT DIVISION
900 WEST MOUNT STREET,
CONNERSVILLE, INDIANA 47331
Fax 317/825-7669

The approximate cost is US $*7,500* per unit Purchasing of *3* turbine blowers is needed, the total cost is US $*22,500*

3)

C50-type compressor with the production capacity of ***6 51*** m^3/min, pressure of ***6 9*** bars, with a spare filter and an electric motor of *50* HP, the voltage is *380* V, 3 phases of 50 Hz

Manufacturer's address ROTARY COMPRESSOR CORPORATION
329 NEWMAN DRIVE
COOCE VILLE, TENNESSEE 38501
Fax 615-528-92-77

The approximate cost is US $*10,000* per unit Purchasing of *4* compressors is needed, the total cost is US $*40,000*

The equipment required for implementation of the ECO "***Replacement of the existing compressors with new, more economic ones***"

- C500 Compressor from Rotary Air Compressor, 6 9 Bar, 70 79 m^3/min, 500HP Motor (370 kW)

The manufacturer's address ROTARY COMPRESSOR CORPORATION
329 NEWMAN DRIVE
COOCE VILLE, TENNESSEE 38501
Fax 615/528-92-77

The equipment required for implementation of the ECO "***Controlling the production capacity of the compressor station by using a variable speed drive***"

- frequency converter to control the rotational speed of the synchronous electric motor with the power capacity of ***800*** kW and the stator voltage of ***6*** kV

The manufacturers Electro-Mechanical Plant" Open Joint-Stock Company "Kharkiv
Kharkiv, Ukraine
"Alan Bredly"
"ABB"

Approximate cost – US $***80,000***

The thermal insulating materials required for implementation of the ECO **"Provision of effective thermal insulation on *"RIBBON"*glassmaking furnace on the basis of light-weighting materials"**

- *DL-1,2*, *ShLA-1,3*, *ShLA-0,4* to 1,0

Manufacturer's address 3, Schmidt Str ,
Krasnoarmeisk, Donetsk Oblast,
343100, Ukraine
Tel (06239)-2-04-10

Velikoanadolsk Combined Facility for Fire-Resisting Materils
Valdimirovka Settlement in
Donetsk Oblast,
Volnovakhsky Raion,
342331, Ukraine
Tel 33-03, 33-20

Konstiantinovka Combined Facility for Fire-Resisting Materials
2, Miroshchnichenko Str ,

Konstiantynivka Settlement,
Donetsk Oblast,
342007, Ukraine
Tel 33-03, 33-20

Chasiv-Yar Combined Facility for Fire-Resisiting Materials
1, Komsomolskaya Str ,
Chasiv Yar Town, Donetsk Oblast
343440, Ukraine
Tel 23-01, 23-02

- *TK1-5, 1-10*

Manufacturer's address Open Joint-Stock Company "Teplozvukoizoliatsiya"
7, Stroitelnaya Str ,
Kotsiubynske Settlement, Kyiv Oblast
255700, Ukraine
Tel (277)-7-23-50, 7-12-03

Closed Joint-Stock Company "Izoliatsiya"
7, Svitly Shliakh Str ,
Donetsk, 340029, Donetsk
Tel (0622) 66-61-42

The thermal insulating materials required for implementation of of the ECO **"Provision of effective thermal insulation on "*RIBBON*" glassmaking furnace on the basis of ceramic fibers"**

- *Uniofrax 3000, 2600, RG*

  Manufacturer's address Unifrax Corporation
  Corporate headquarters

- TK-5, 1-10

  Manufacturer's address Open Joint-Stock Company "Teplozvukoizoliatsiya"
  7, Stroitelnaya Str ,

Kotsiubynske Settlement, Kyiv Oblast,
255700, Ukraine
Tel (277)-77-23-50, 7-12-03

Closed Joint-Stock Company "Izoliatsiya"
7, Svitly Shliakh Str ,
Donetsk, 340029, Ukraine
Tel (0622) 66-61-42

The thermal insulating materials required for implementation of the ECO **"Thermal insulation of the furnace using materials purchased by the plant"**

- *DL-1,2, ShLA-1,3, ShLA-1,3, ShLB-0,4, ShLB-0,9*

Manufacturer's address Krasnoarmeisk Dinas Plant
3, Schmidt Str ,
Krasnoarmeisk Town,
Donetsk Oblast, 343100
Tel (06239)-2-04-10

Velikoanadolsk Combined Facility for Fire-Resisting Materials
Valdimirovka Settlement in
Donetsk Oblast,
Volnovakhsky Raion,
342331, Ukraine
Tel 33-03, 33-20

Konstiantynivka Combined Facility for Fire-Resisting Materils
2, Miroslichnichenko Str ,
Konstiantinovka Settlement,
Donetsk Oblast,
342007, Ukraine
Tel 33-03, 33-20

Chasiv-Yar Combined Facility for Fire-Resisiting Materials

1, Komsomolskaya Str ,

Chasiv Yar Town, Donetsk Oblast

343440, Ukraine

Tel 23-01, 23-02

The thermal insulating materials required for implementation of the ECO **"Utilization of the combustion products outgoing from *"RIBBON"* glassmaking furnace"**

- *"CAIN" ESG - 62 FL18CSS*

The thermal insulating materials required fior implementation of the ECO **"Improvement of the operation efficiency of *"RIBBON"* glassmaking furnace by controlling the air for burning"**

- *ENERAC-2000*

The thermal insulating materials required for implementation of the ECO **"Improvement of the operation efficiency of DE-6,5 boilers in the steam boiler-house"**

- *ENERAC-2000*

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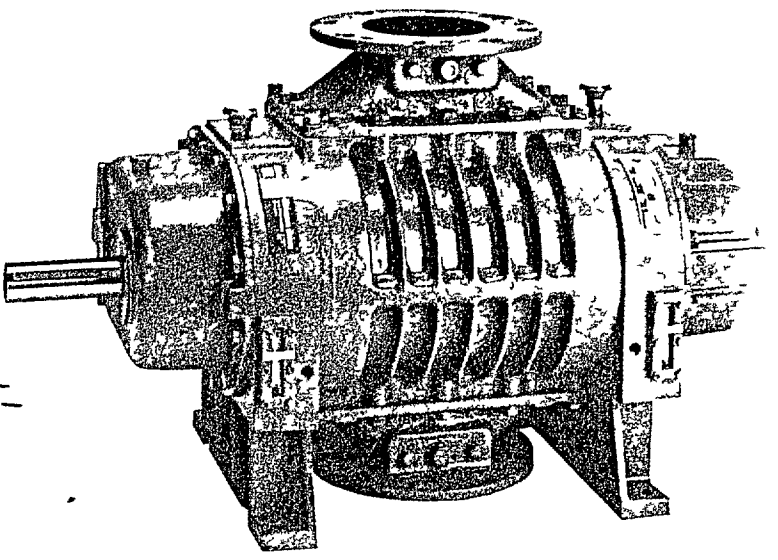
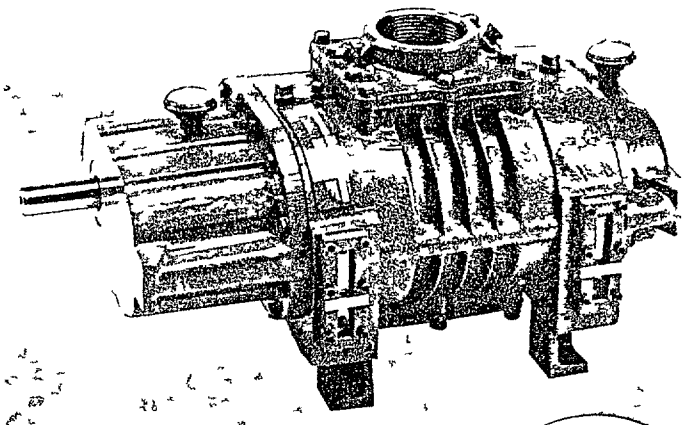
A-12 Product Brochur

Heavy Duty
Rotary Positive Blowers





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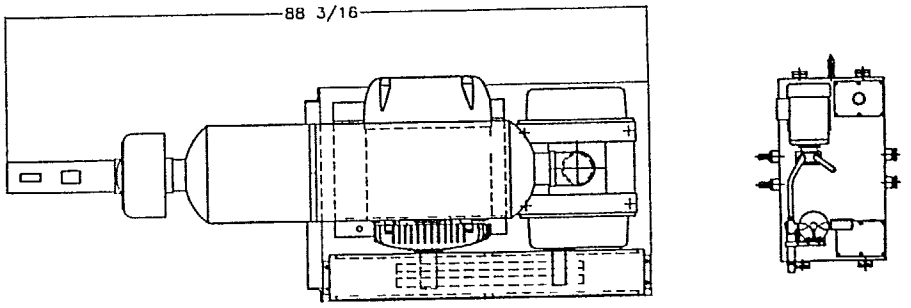
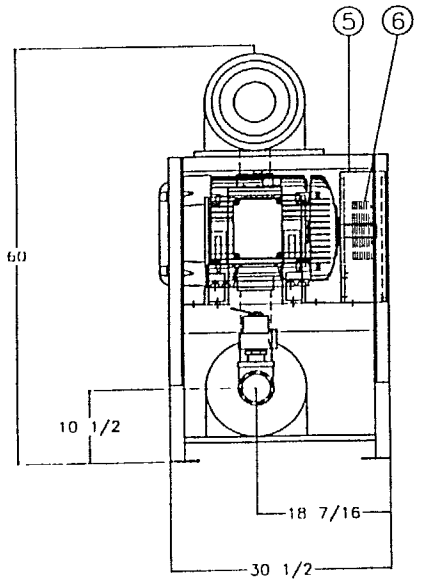
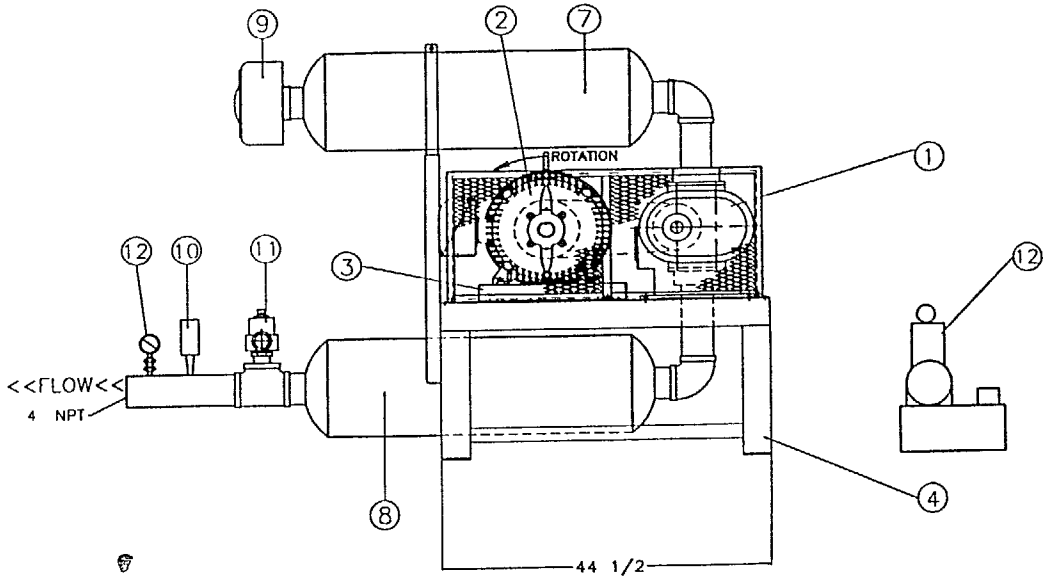
ITEM	MANUFACTURER	PART NO	DESCRIPTION
1	M-D PNEUMATICS	5607-46L3	ACOUSTICAIR BLOWER
2	BALDOR	M4110T-50	40HP,TEFC 380/3/50MOTOR
3	BALDOR	324T	SLIDE BASE
4	METAL MASTERS	B4056	BASE WELDMENT
5	METAL MASTERS	BG-4	OSHA GUARD
6	TB WOODS		V-BELT DRIVE
7	EM PRODUCTS	UE-4	INLET SILENCER
8	EM PRODUCTS	UF-4	DISCHARGE SILENCER
9	EM PRODUCTS	EMF-4	INLET FILTER
10	KOENIG-PRETEMPCO	F100-7BS	TEMPERATURE SWITCH
11	BAYCO	218011	RELIEF VALVE
12	MARSH	J7642P	PRESSURE GAGE
SUPPLIED LOOSE FOR FIELD INSTALLATION			
13	M-D PNEUMATICS	28320-C	EXTERNAL LUBE SYSTEM







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Fax (610) 692-5837
jgasho@compuserve com

Date 3/30/1998

Application Worksheet (Normal Condition)

Reference/Quot

AMBIENT CONDITIONS

Atmospheric Pressure	14 700 PSIA
Ambient Temperature	70 F

APPLICATION REQUIREMENTS

Gas	AIR	Gas Properties	
Molecular Weight	28 966		
CP	0 241 BTU/lb -F	Duty Cycle	more than 4 hours per day
K Value (Cp/Cv)	1 398	Relief Pressure	15 000 PSIG
Inlet Temperature	70 F		
Inlet Pressure	0 000 in H2O Vac (includes 0 000 in H2O Vac filter and/or silencer loss)		
Standard Volume	280 000 SCFM		
Inlet Volume	280 000 ICFM		
Mass Flow	1260 000 lbs/hr		
Discharge Pressure	14 926 PSIG (includes 0 226 PSIG silencer loss)		

MODEL SELECTED FOR THE APPLICATION

Model Number	5507-85L3 PD PLUS
Materials of Construction	Standard
Seal Type	Lip
Lubrication	External Pressure
Rotative Speed	1949 RPM
Discharge Temperature	324 F
Discharge Temperature @ Relief	325 F
Discharge Volumetric Flow	205 470 CFM
Required Input Power	32 354 BHP
Required Input Power @ Relief	32 536 BHP
Estimated Blower Noise	94 dB(A) at 1 meter open field

SELECTED BLOWER OPTIONS

NONE

TESTING

Standard Mechanical Integrity Test

64

Performance Tables

In conjunction with our program of continuous testing and design upgrading all specifications are subject to change without notice
All data are approximate Request a quotation for your specific application

Pressure (14 70 PSIA and 70° F Inlet)

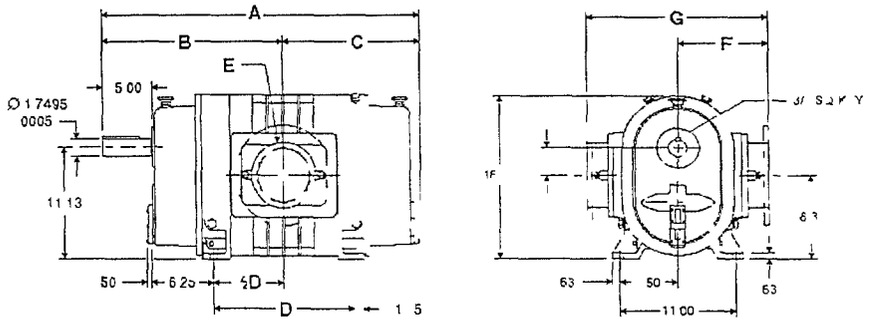
BLOWER MODEL	SPEED (RPM)	2 PSIG		5 PSIG		8 PSIG		10 PSIG		12 PSIG		15 PSIG		18 PSIG		Max Vacuum		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	Hg	CFM	BHP
5507	1150	206	3 7	167	7 2	139	11	123	15	—	—					12	124	8 3
	1750	349	5 6	310	11	282	16	266	20	252	24	232	29	—	—	15	234	15
	3600	789	11	750	23	722	34	706	41	692	49	672	60	655	71	17	648	35
5509	1150	252	4 1	207	8 4	175	13	157	16	—	—					13	146	10
	1750	424	6 3	379	13	347	19	329	24	312	28	290	35	—	—	15	292	18
	3600	953	13	908	26	876	40	858	49	841	58	819	71	799	85	17	791	44
5511	1150	311	4 8	258	10	219	15	198	19	178	22	—	—			13	185	12
	1750	521	7 3	468	15	429	23	408	29	388	34	362	42	—	—	15	364	22
	3600	1168	15	1115	31	1077	48	1055	59	1036	70	1009	86	985	103	17	975	50
5514	1150	398	5 7	333	12	285	19	258	24	234	28	—	—			13	242	16
	1750	667	8 7	600	19	552	29	525	36	501	43	469	53	—	—	15	321	27
	3600	1489	18	1423	39	1375	60	1349	74	1325	88	1292	109	—	—	15	1294	55
5516	1150	459	6 4	386	14	333	14	304	27	277	32	—	—			13	286	18
	1750	765	9 7	692	21	639	33	609	41	582	49	—	—			15	548	31
	3600	1706	20	1633	44	1580	68	1551	84	1524	100	—	—			15	1490	63
5518	1150	520	7 0	440	16	383	24	350	30	321	36	—	—			13	331	20
	1750	863	11	784	24	726	37	694	46	664	54	—	—			15	627	34
	3600	1922	22	1842	49	1784	76	1752	94	1722	112	—	—			15	1685	70
5520	1150	583	7 7	497	17	435	27	—	—							12	402	20
	1750	965	12	878	26	816	41	—	—							12	784	31
	3600	2141	24	2055	54	1993	84	—	—							12	1961	63

Shaded areas indicate operation above maximum allowable horsepower Applications in shaded areas must be factory approved

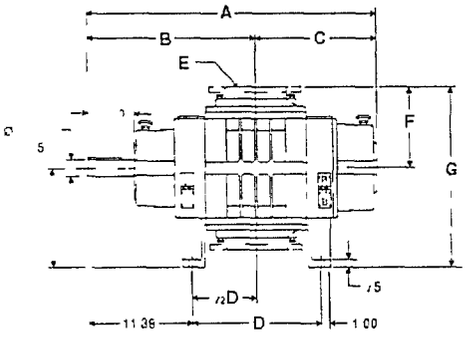
Dimensions

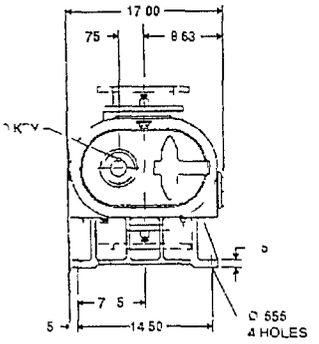
Certain dimensions for 64/67 double envelope gastight differ slightly from those shov n belov
Certified drav ings are available through your local M D representative

Series 17/57 (Horizontal Flow)



Series 46/81 (Vertical Flow)





MODEL	SERIES	A	B	C	D	E	F	G
5507	17/57	28 94	16 63	12 31	10 50	4 NPT	8 50	17 00
	46/81	28 31		11 69	10 75			19 00
5509	17/57	30 44	17 38	13 06	12 00	5 NPT	8 50	17 00
	46/81	29 81		12 44	12 25			19 00
5511	17/57	32 44	18 38	14 06	14 00	5 NPT	8 50	17 00
	46/81	31 81		13 44	14 25			19 00
5514	17/57	35 44	19 88	15 56	17 00	6 FLG	10 00	20 00
	46/81	34 81		14 94	17 25			20 50
5516	17/57	37 44	20 88	16 56	19 00	8 FLG	10 00	20 00
	46/81	36 81		15 94	19 25			20 50
5518	17/57	39 44	21 88	17 56	21 00	8 FLG	10 00	20 00
	46/81	38 81		16 94	21 25			20 50
5520	17/57	41 44	22 88	18 56	23 00	8 FLG	10 00	20 00
	46 81	40 81		17 94	23 25			20 50

Values are approximate and should not be used for construction
Certified drawings are available through your local M D representative

LEADING THE SEARCH FOR NEW SOLUTIONS

TUTHILL CORPORATION | M-D Pneumatics Division

4840 We t Kearney Street P O Box 2877
Springfie l Mi s ri USA 65801 0877
Tel +1 7 [illegible] 869 Fax 417 869 2950

ISO 9001 1994

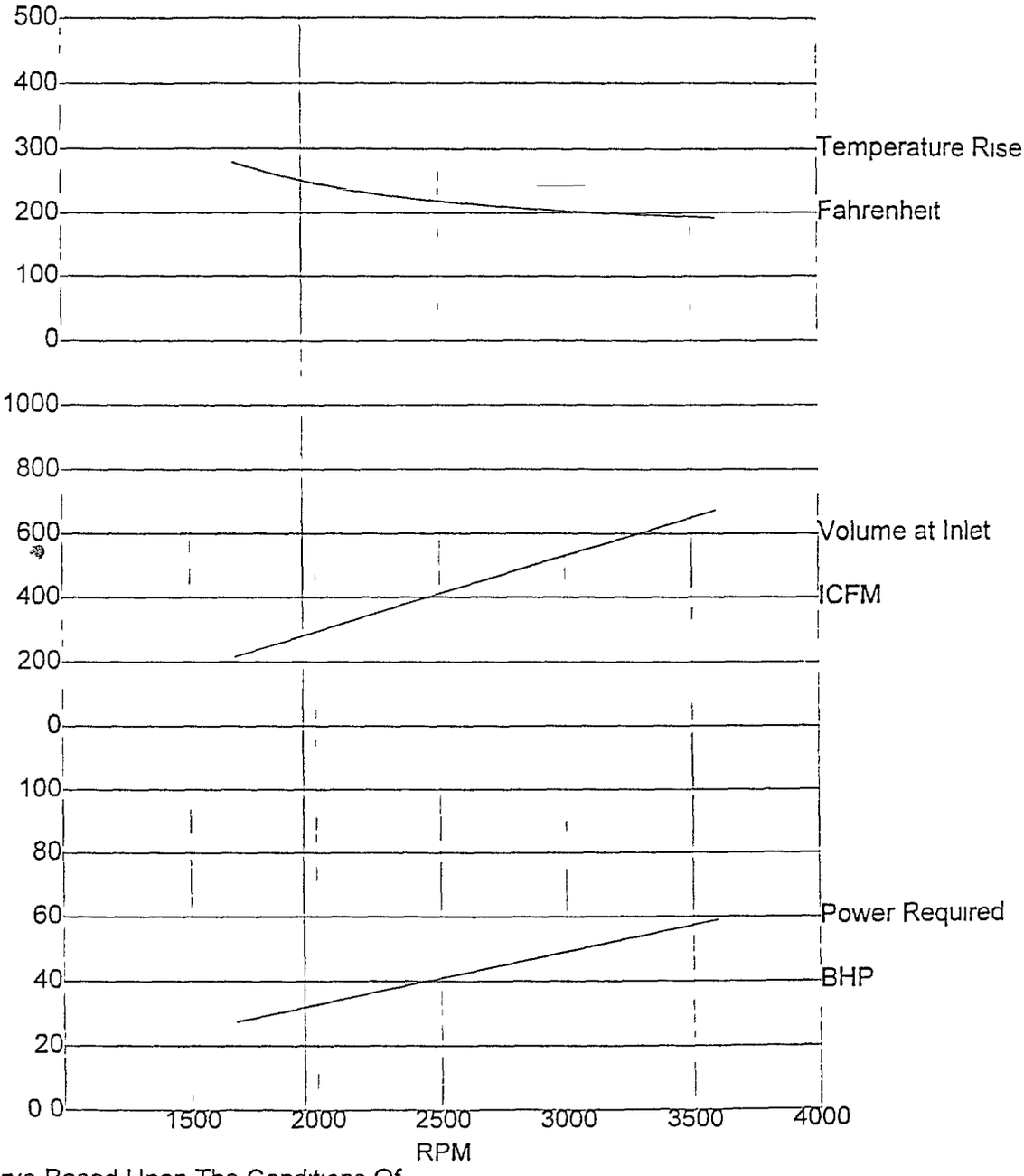
TUTHILL CORPORATION | Pneumatics Division

Date 3/30/1998

Local representative
James E Gasho & Associates
460 West Gay Street
West Chester PA 19280
Tel (610) 692-5650
Fax (610) 692-5837
jgasho@compuserve com

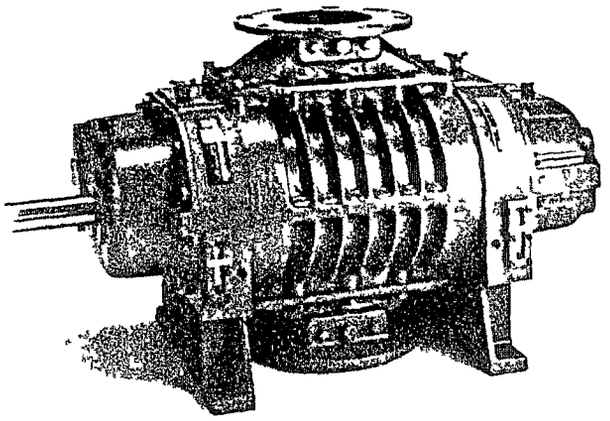
Normal Operating Point Curve for 5507-85L3

Reference/Quote



Performance Curve Based Upon The Conditions Of

Displacement	0 238 CFR
Atmospheric Pressure	14 700 PSIA
Gas	AIR
Inlet Temperature	70 F
Molecular Weight	28 966
K Value	1 398
Inlet Pressure	0 000 in H2O Vac
Discharge Pressure	14 926 PSIG



PD PLUS®

Model 5500 Heavy Duty
High Pressure Industrial Blowers

Bi-directional Rotation

17 Series - Horizontal Air Flow
46 Series - Vertical Air Flow

57 Series - Horizontal Flow Single Envelope Gastight
81 Series - Vertical Flow, Single Envelope Gastight

64 Series - Horizontal Flow Double Envelope Gastight
67 Series - Vertical Flow, Double Envelope Gastight

Model 5500 PD PLUS heavy duty industrial blowers are designed for high performance applications up to 18 PSIG pressure boost or 17 Hg dry vacuum (24 Hg water injected)

17/46 Series

This series has wide application in pneumatic conveying wastewater treatment and the general process industry where high pressure high volume air is required Seal areas are vented to atmosphere to relieve process pressure against the internal lip seals and to provide oil free air

57/81 Series (Single Envelope Gastight)

This series is utilized in such applications as closed loop pneumatic conveying fuel or process gas handling or elevated pressure applications up to 100 PSIG discharge Vent openings are tapped and plugged to prevent gas leakage or may be plumbed to the inlet port These fittings can also accept an inert gas purge for positive containment of the process gas

64/67 Series (Double Envelope Gastight)

This series is built to laboratory standards where virtually complete sealing is required In addition to the features shown on the 57/81 series the drive shaft is mechanically sealed and the oil sumps are plugged to provide an even higher degree of leakage protection

MODEL SIZE	Max Press PSI	Max Vac (in Hg)	Max Comp Ratio	Nom Min RPM @ Max Disch Press	Nom Max RPM @ Max Disch Press	Displ CFR
5507	18	17	2 31 1	2250	3600	235
5509	18	17	2 31 1	2150	3600	282
5511	18	17	2 31 1	2050	3600	345
5514	15	15	2 02 1	1450	3300	445
5516	12	15	2 02 1	1150	3600	509
5518	12	15	2 02 1	1150	3200	572
5520	8	12	1 84 1	1150	3600	636

Material Specifications

Housing Cast iron
End Plates Cast iron
End Covers Gear end Cast iron
Free end Aluminum
Rotors Ductile iron
Shafts Ductile iron cast integrally with rotor
Bearings Gear end Double row ball
Free end and drive shaft Single row ball
Drive Shaft SAE 4140 forged alloy steel
Gears Heat treated alloy steel helical cut
Seals 17 46 Lip and labyrinth type on rotor shafts lip seal on the drive shaft
57 81 Mechanical and labyrinth type on rotor shafts lip seal on the drive shaft
64 67 Same as 57 81 plus mechanical sealing on the drive shaft
Lubrication Oil splash system both ends

For elevated pressure applications 57/81 series and 64/67 series are available with high pressure sealing and testing to allow discharge pressures as high as 100 PSIG (15 PSI maximum pressure boost)

Blowers operating with a discharge pressure above 20 PSIG require mechanical rotor shaft sealing above 25 PSIG requires hydrostatic testing and special high pressure seal leakage testing

Optional Water Cooled End Plates

All vertical flow model 5500 PD PLUS® models are available with M D exclusive optional water cooled end plates to provide cooling of lubricating oil with less than 0 5 GPM cooling water for high performance applications where external lubrication is not desired or practical Specify E suffix

Optional Lubrication Systems

All model 5500 PD PLUS® models are available with external lubrication to provide positive bearing lubrication and filtration of lubricant for extreme applications When optional lubrication systems are specified the series numbers change as follows

Standard Splash Lube	Optional External Pressure Lube
17/46 series	18/85 series
57/81 series	54/84 series
64/67 series	65/68 series

65/68 series utilizes gastight external lubrication system rated to a maximum pressure of 15 PSIG Consult your local M D representative or factory if higher design pressure is required

LEADING THE SEARCH FOR NEW SOLUTIONS

TUTHILL CORPORATION | M-D Pneumatics Division

4840 West Kearney Street P O Box 2877
Springfield Missouri USA 65801 0877
Tel 417 865 8715 800 825 6937 Fax 417 865 2950

ISO 9001 199

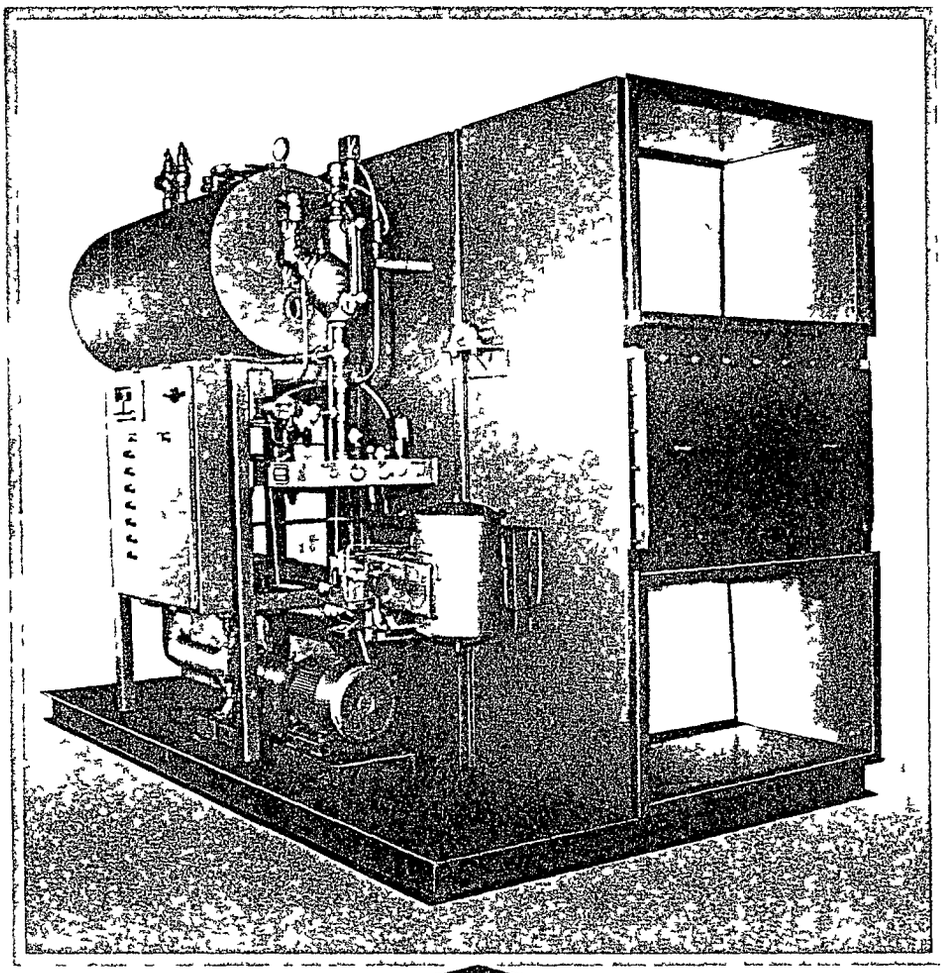
68

ESG SERIES

EXHAUST STEAM GENERATOR

FOR

FUME AND CATALYTIC INCINERATORS
GAS TURBINE AND DIESEL ENGINES



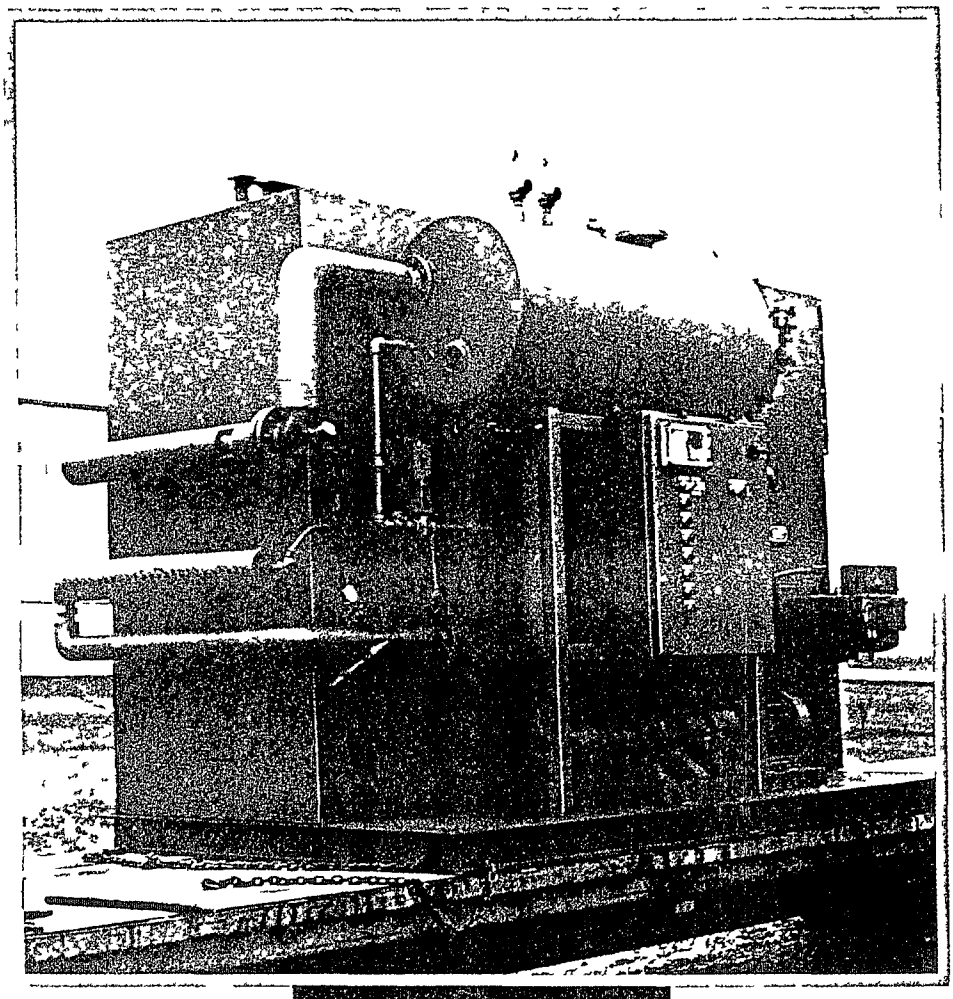
cain industries

#9007

ESG vs CONVENTIONAL FIRETUBE BOILERS

YOUR AUTHORIZED CAIN REPRESENTATIVE

- 1/3-1/2 the weight size & floor space
- 99% dry steam
- 100% turndown capacity
- 5-10 minute startup to full output
- Integrated full exhaust modulating bypass
- Explosion proof heat transfer exchanger
- Low friction loss for minimum static exhaust back pressure
- High circulating flow minimizes scale buildup
- No thermal expansion problems accepting cold water boiler feedwater
- Lowest pinch point (final leaving exhaust temperature minus—operating steam temperature) offering greater thermal efficiency



ESG DESIGN MODIFICATIONS

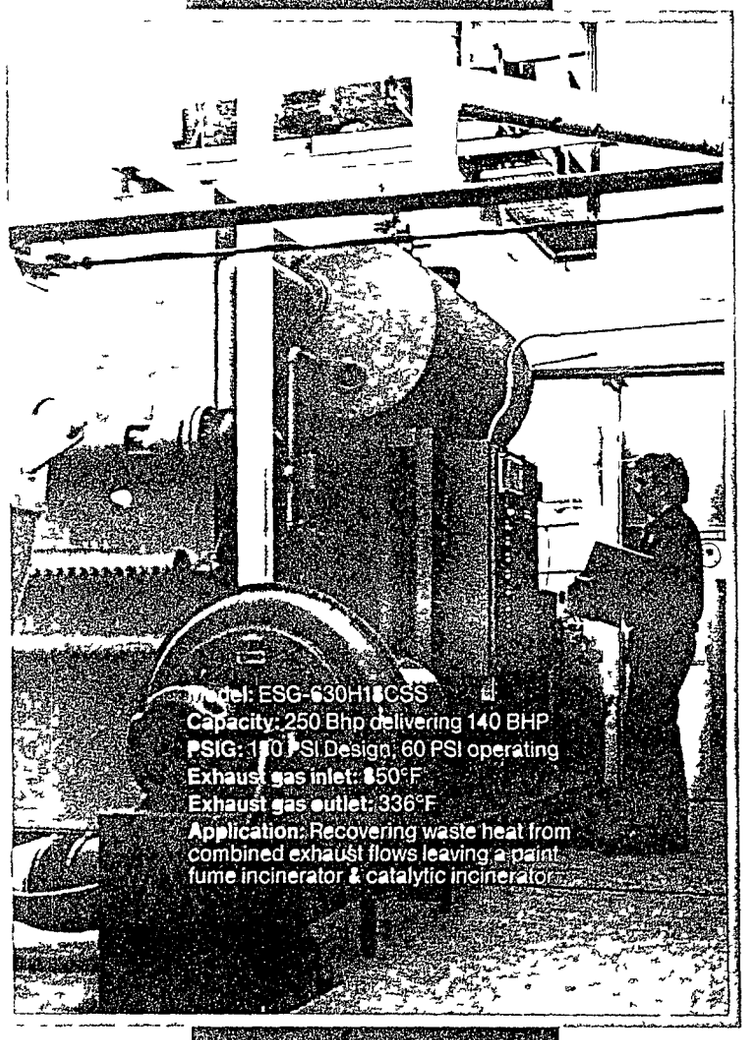
- Liquid Phase Oil Heaters
- Hot Water Boilers
- Steam Superheaters

cain industries
heat recovery systems

APPLICATION DATA

- Source of Exhaust Gas
- Temperature of Exhaust Gas
- SCFM or LBS/hr of Exhaust Gas
- Operating Steam Pressure
- Desired Performance Output either
  - —PPH Steam
  - —BTU/hr Transfer
  - —Leaving Exhaust Temperature

Mequon Rd & Kleinmann Dr, PO Box 189, Germantown, WI 53022, Tel 1-414-251-0051 WATS 1 800-558-8690 FAX 1-414-251



THE COMPLETE PACKAGE

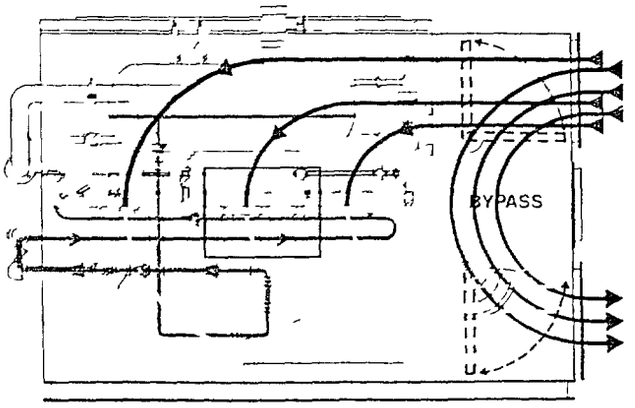
Selecting the appropriate waste heat boiler system for fume incineration or cogeneration retrofit involves considerable engineering time and money Important areas of concern have been controlling and bypassing waste heat optimum performance selection operating pressures size weight and installation The ESG is specifically designed to address these concerns and more as standard design features not found with conventional waste heat boilers The timely needs of the project engineer and customer can all be achieved accurately in a complete package

VARIETY OF MODELS

Cain Industries offers 40 standard models achieving performance outputs from 20 to 350 boiler horsepower and operating steam pressures ranging from 3 to 250 PSIG A packaged forced circulation water tube design the ESG is manufactured and tested in accordance with the requirements of the ASME Boiler and Pressure Vessel Code and National Board

FUNCTIONAL

As a fully automatic steam generator the ESG responds immediately to fluctuating exhaust flows in conjunction with steam load demand swings This allows the ESG to easily function as a supplemental or primary steam output station For the very large waste exhaust systems multiple generator arrangements can easily adapt effectively without complex central controls



DESIGN

The ESG is a compact design including three basic sections the fintube heating surface steam flash drum assembly and a modulating full port exhaust bypass prepiped and wired for ease of installation and minimal customer connections An integral circulating pump continually circulates water to the heat transfer section recovering BTUs from the exhaust and back to the steam drum assembly where superheated water flashes to steam

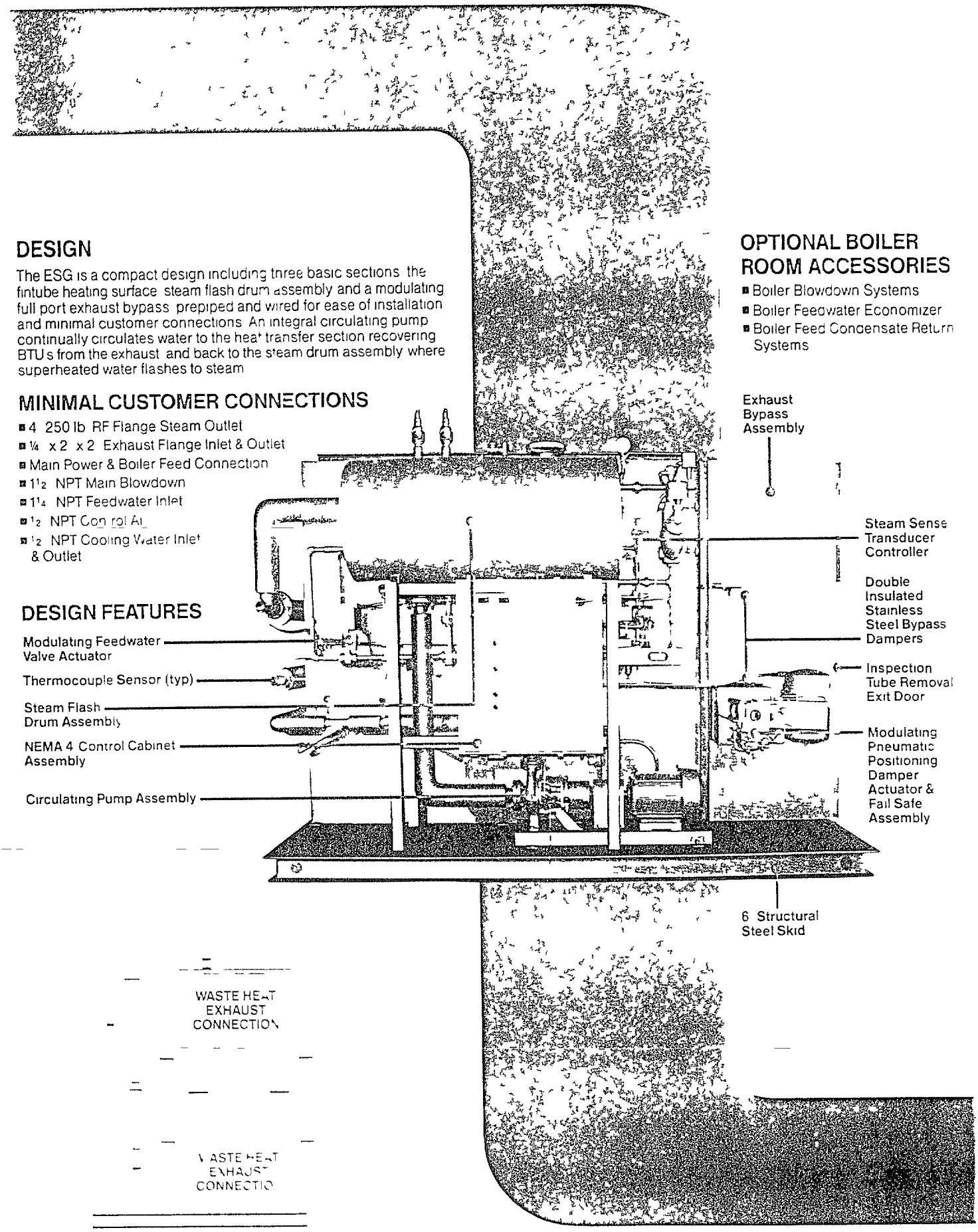
MINIMAL CUSTOMER CONNECTIONS

- 4 250 lb RF Flange Steam Outlet
- ¼ x 2 x 2 Exhaust Flange Inlet & Outlet
- Main Power & Boiler Feed Connection
- 1½ NPT Main Blowdown
- 1¼ NPT Feedwater Inlet
- ½ NPT Control Air
- ½ NPT Cooling Water Inlet & Outlet

DESIGN FEATURES

OPTIONAL BOILER ROOM ACCESSORIES

- Boiler Blowdown Systems
- Boiler Feedwater Economizer
- Boiler Feed Condensate Return Systems

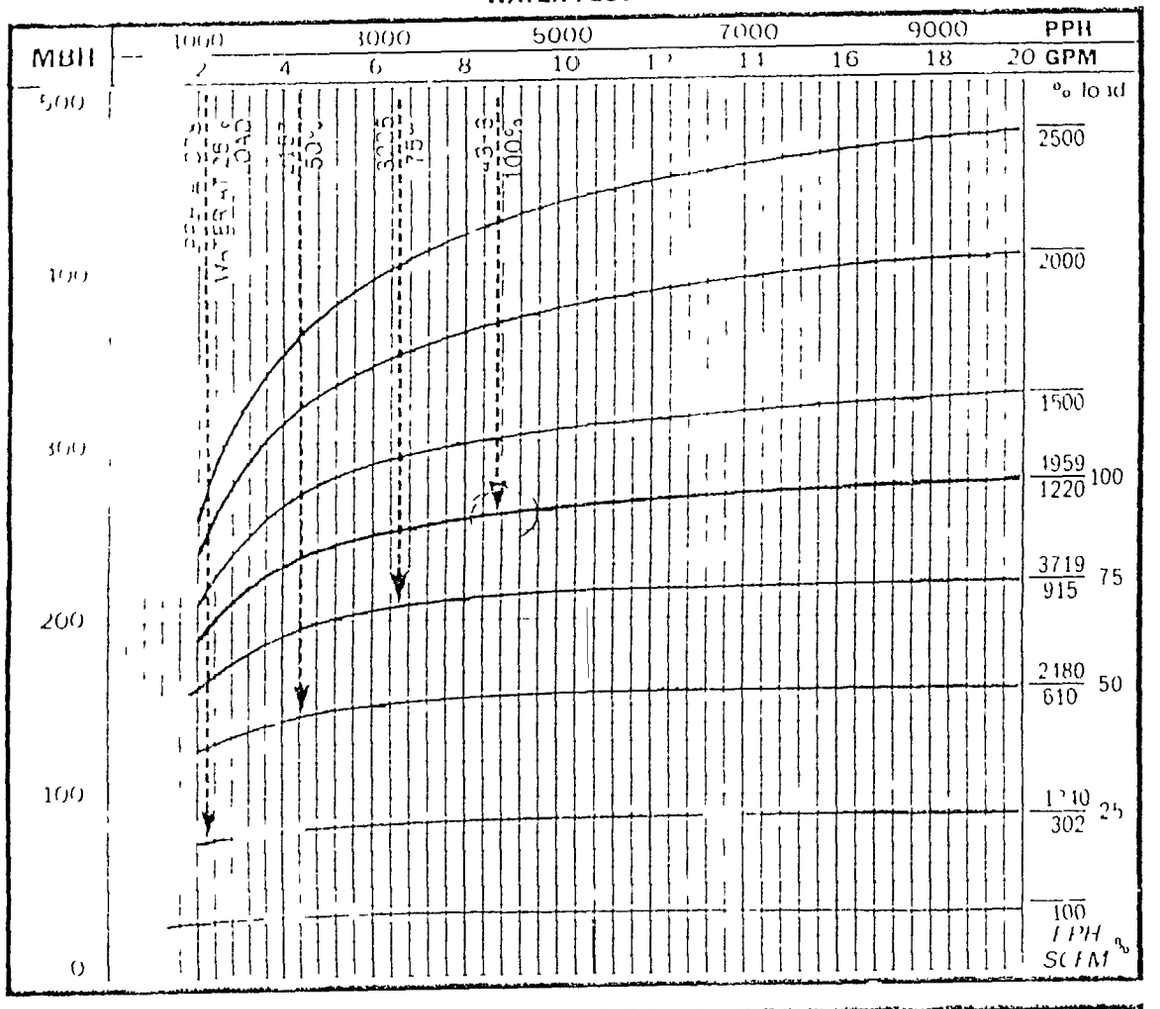


Recommended BHP 125	Model B12 6 FINS/INCH CIRCULATING OR PERFORMANCE CURVES PRLHEATING BOILER FEED

CAIN INDUSTRIES
FUEL SAVING ECONOMIZERS

BULLETIN NO. [illegible]

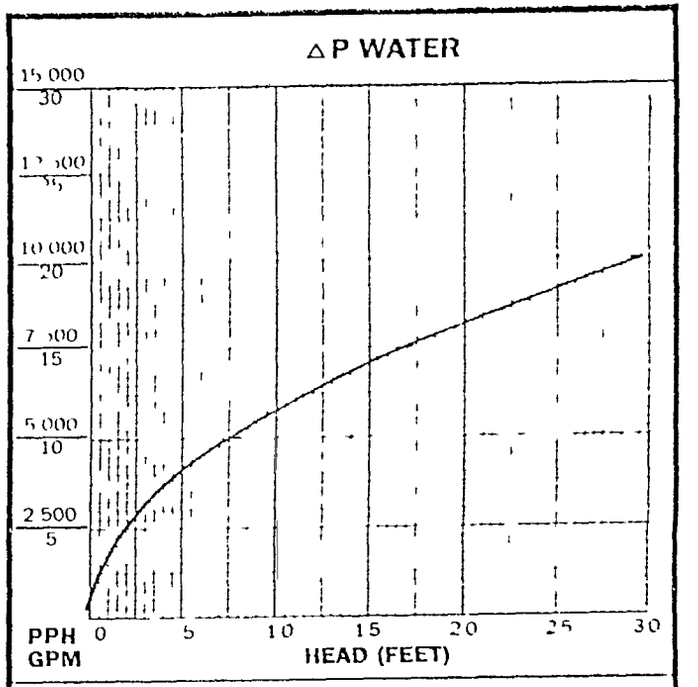
WATER FLOW

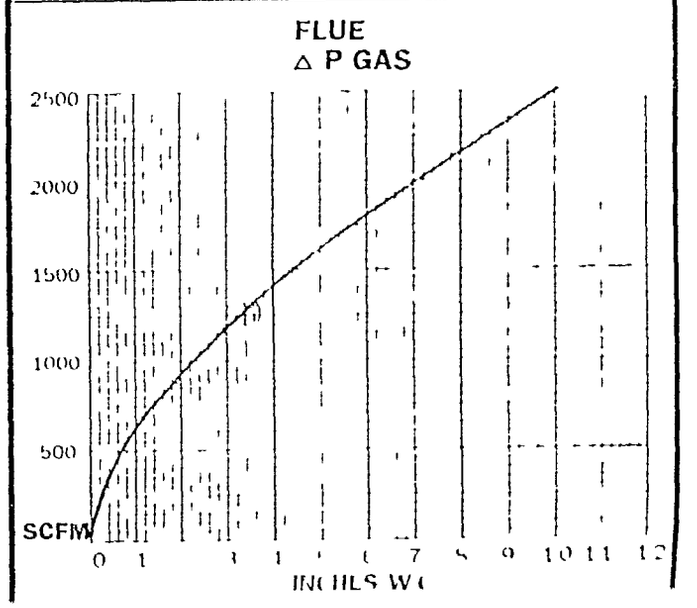


Correction Factors	(MBH							
	Multipl. by	9	60	90	10	1 17	1 55	1 83
	F T D F	100	200	300	3 0	100	500	600
	Multipl, by	78	85	95	1 0	1 05	1 11	1 21

(C r ade Fe ure Drop x

TGO Temp Gas Out TGI ((BTU/HR SCFM) 10815)
TLO Temp Water Out TLI (BTU/HR PPH Water)



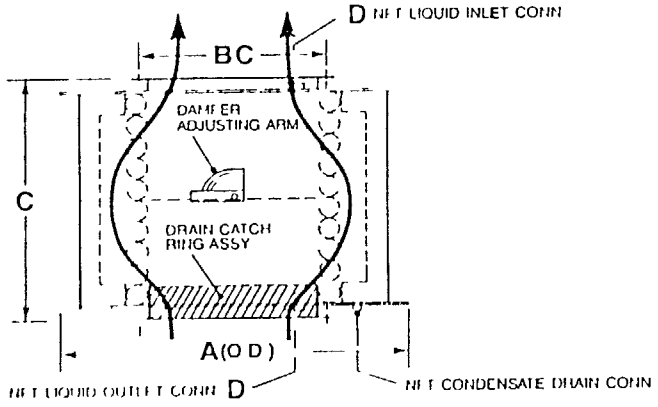


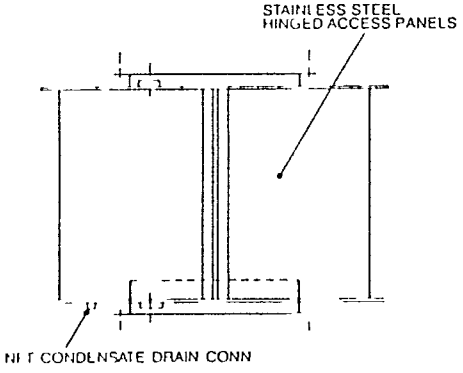
BEST AVAILABLE COPY

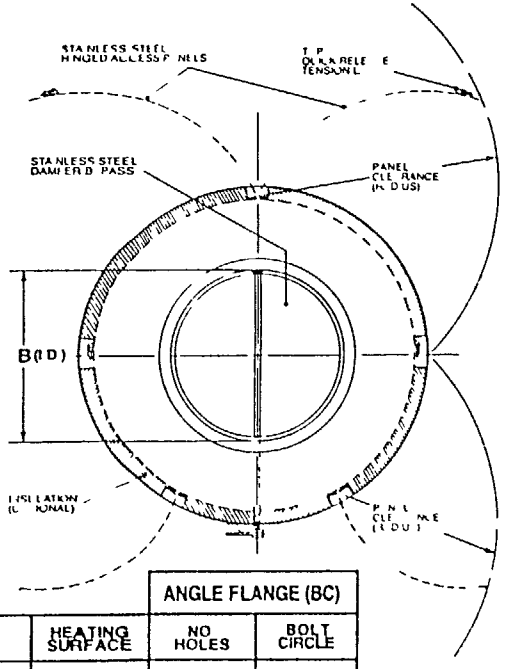
		100	4313	220	264	2 45	4959	465	323	24	190 779	239 973				
		75	3235	220	265	1 46	3719	460	315	13	146 720	184 553				
GAS		50	2157	220	265	70	2480	445	301	06	97 180	123 012				
		25	1078	220	264	20	1240	420	280	01	46,989	61 024				
	6	100	4313	220	264	2 45	5154	465	323	24	191 122	230 267	218	275"	36 '	345
		75	3235	220	266	1 46	3866	460	315	13	145 020	175 782				
NO 2		50	2157	220	265	70	2578	445	301	06	97 897	119 386				
		25	1078	220	267	20	1288	420	282	01	50 499	63 123				
		100	4313	220	253	2 45	4959	465	359	16	142 259	179 8 12				
		75	3235	220	254	1 46	3719	460	351	09	110 566	139 076				
GAS		50	2157	220	254	70	2480	445	334	04	74 345	94 108				
		25	1078	220	254	20	1240	420	310	01	36 928	47 958				
		100	4313	220	253	2 45	5154	465	360	16	142 510	171 699				
		75	3235	220	254	1 46	3866	460	351	09	111 176	134 759				
NO 2	4	50	2157	220	255	70	2578	445	335	04	74 880	91 317	151	275"	36"	330
		25	1078	220	257	20	1288	420	313	01	39 599	49 498				
		100	4313	220	253	2 45	5145	465	360	16	142 009	170 070				
		75	3235	220	254	1 46	3859	460	351	09	110 041	132 579				
NO. 6		50	2157	220	254	70	2573	445	335	04	74 167	89 899				
		25	1078	220	254	20	1286	420	310	01	36 837	45 760				

ECONOMIZER MODEL NO B12

DIMENSIONAL LAYOUT







WEIGHTS AND DIMENSIONS (INCHES)

DRY WT LBS	A	B	C	D	HEATING SURFACE	ANGLE FLANGE (BC) NO HOLES	ANGLE FLANGE (BC) BOLT CIRCLE
260	36	16	275	1	218	8	18

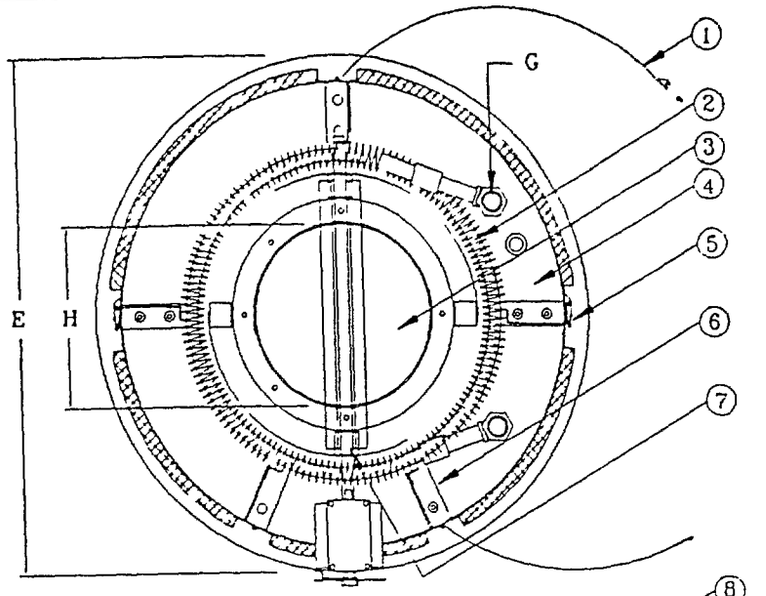
SUBMITTAL

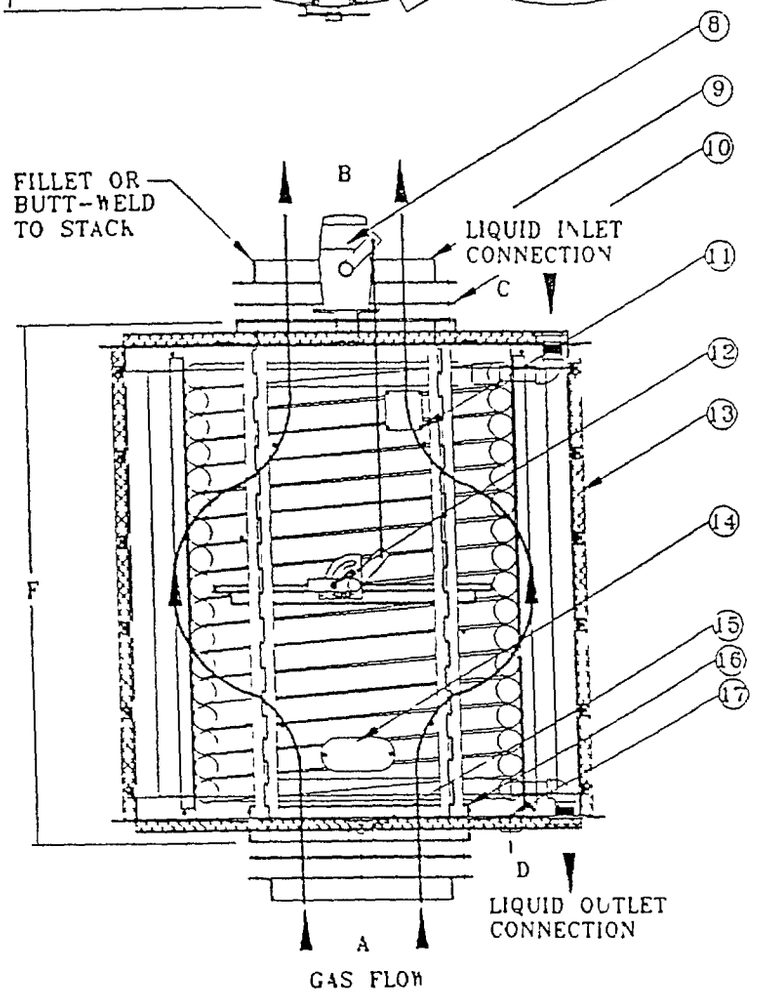
DATE _____ PEF# _____ FOR _____
B- 12 _____ C/O _____
Bul #10012

B-SERIES

PEPFORMANCE
AND
DIMENSION DATA

A	F
B	F
C	F
D	F
E	OAD
F	OAH
G	NPT
H	I D
	#WGT
	H S
	PSIG
	TEMP





PARTS LIST

(SEE DESIGN DATA FOR CONSTRUCTION

1 HINGED STAINLESS ACCESS PANEL
2 FIN-TUBE ASSEMBLY
3 STAINLESS FLUE GAS BYPASS
4 LID ASSEMBLY
5 SELF-LOCKING TENSION LATCH
6 SUPPORT BRACE ASSEMBLY
7 DAMPER SHAFT
8 MODULATING DAMPER ACTUATOR (OPTIONAL)
9 MATING FLANGE (OPTIONAL) (SEE MATING FLANGE LIST FOR DIMENSIONS)
10 GASKET (OPTIONAL)
11 ASME STAMP (OPTIONAL)
12 MANUAL BYPASS ADJUSTING ASSY
13 INSULATION (OPTIONAL)
14 CAIN INDUSTRIES LOGO
15 LIFTING LUG
16 DRAIN CATCH RING (OPTIONAL)
17 1 NPT CONDENSATE DRAIN

Cain Industries Inc PO Box 189 Germantown,WI 53022 414-251 0051 WATS1 800 558 8690 FAX1 414 251 0115

PUMP KIT ASSEMBLY

Bul #100

PUMP KIT ASSEMBLY

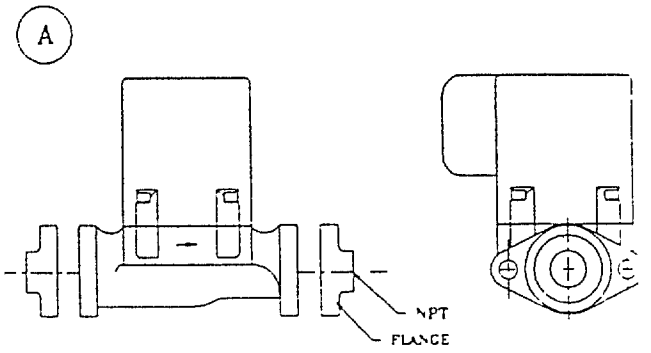
	P/N	NPT	A	B	C	D	E	F
✓	99830	1	55321	55316	55316	55308	55154	55909
	99840	1 1/2"	55330	55307	51040	55484	55154	55909
	99850	2"	55340	55309	55421	55340	55154	5 909
	99860	2"	55350	55309	55421	5 340	55154	5909
	99882	1 1/2"	5 69	55307	51040	55340	55154	55909

A CIRCULATING PUMP

SEE BUL#10020 FOR PERFORMANCE GRAPHS

	P/N	WGT	H P	VOLTS	AMPS
	55321	12	1/12	115	1 85
✓	55330	15	1/6	115	2 15
	55340	44	1/12 1/4 OR 1/3	115/220	4 6
	55350	49	1/6 1/2 OR 3/4	115/220	8 5
	55669	42	1/3	115/220	4 6

HIGH TEMP (MAX INLET TEMP 330)

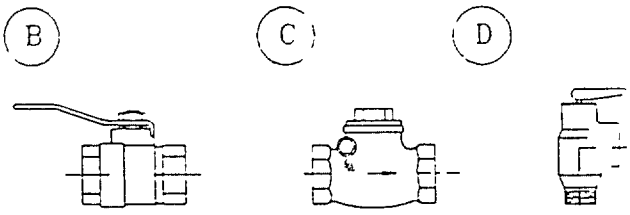


B FLOW CONTROL VALVE, Brass

	P/N	NPT
	55315	3/4
	55316	1
	55307	1 1/2"
	55309	2"

C CHECK VALVE, Brass

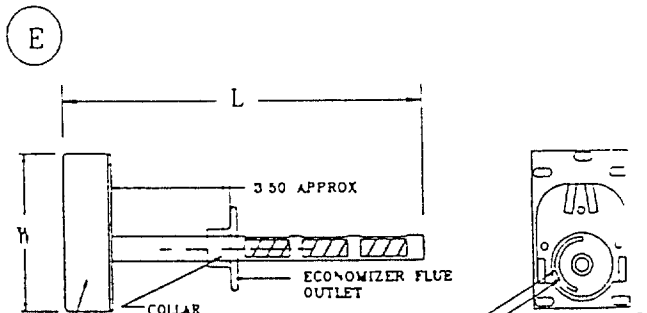
	P/N	NPT
	55315	3/4
	55316	1
	51040	1 1/2"
	55421	2"



D RELIEF VALVE, Bronze

	P/N	INLET	OUTLET	PSIG
	55308	3/4	3/4	125
	55332	1	1	125
	55484	3/4	1	125
✓	55340	1	1	150
	55348	1	1	300

TEMPERATURE 210°F @ 125 PSIG

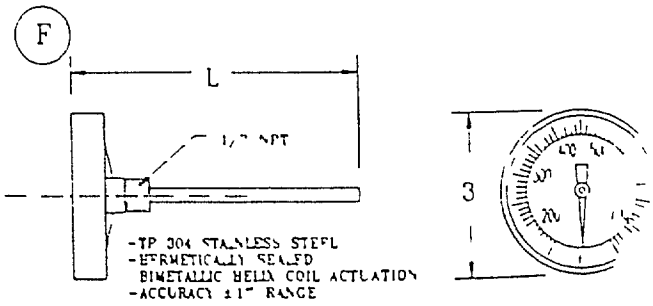


E PUMP CONTROLLER

	P/N	L	W
✓	55154	13 65	4 25

F (2) THERMOMETERS Gas F

	P/N	L	TEMP F
✓	55909	3 5	250
	55662	1"	1000
	55665	1"	1200



SUBMITTAL

VERTICAL PRESSURIZED STORAGE TANK

Bul #21832

SELECT TANK SIZE BASED ON ECONOMIZER BTU/HR RECOVERY

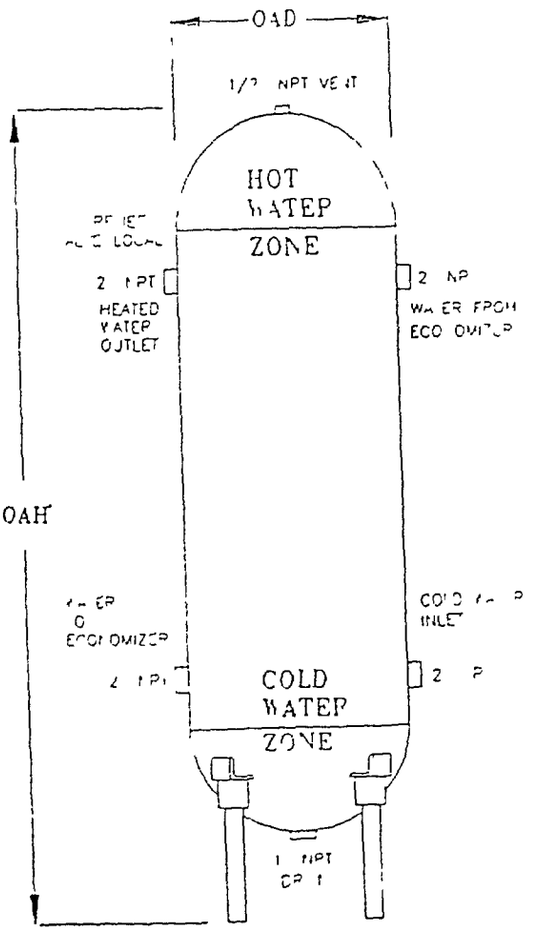
BTU/HR ECONOMIZER RECOVERY	MODEL # TANK	CAPACITY GALLONS	S T C O D	O A H	WEIGH LBS
38 000	12-1	15		31	66
63 000	12-2	24	1	51	19
75,000	14-1	30	14		121
100 000	14-2	40	14	63	159
150 000	16-1	60	16	72	210
200,000	20-1	80	20	62	233
250,000	20-2	100	20	7	283
300,000	24-1	120	24	6	33
350,000	24-2	140	24	77	343
450,000	30-1	180	30	66	388
550,000	30-2	220	30	78	449
675,000	36-1	270	36	70	489
800 000	36-2	320	36	83	569
937 000	36-3	375	36	94	671
1,062,000	36-4	425	36	118	771
1,200,000	36-5	480	36		
1,350,000	42-1	540	42	95	88
500 000	42-2	600		118	66

DESCRIPTION

THE VERTICAL PRESSURIZED STORAGE TANK IS APPLIED IN SYSTEMS WHERE STEADY WATER FLOW THROUGH THE ECONOMIZER CANNOT BE CONSTANT OR SOMETIMES DROPS DOWN TO AN UNACCEPTABLE FLOW RATE THE APPLICATION OF THIS SEPARATE SYSTEM ALLOWS ABSOLUTE CONTROL OF ECONOMIZER OUTLET FLUE GAS AND WATER TEMPERATURES WHICH CAN BE MAINTAINED IN ADDITION TO THE MAXIMUM BTU/HR RECOVERY MAXIMUM BTU/HR RECOVERY IS ALWAYS POSSIBLE BECAUSE WATER IS CIRCULATED FROM THE BOTTOM OF THE TANK OR COLD WATER ZONE (WHERE NEW WATER ENTERS) TO THE ECONOMIZER AND BACK TO THE TOP OF THE TANK OR "HOT WATER ZONE" (WHERE HEATED WATER LEAVES) THIS ALLOWS THE GREATEST ENTERING TEMPERATURE DIFFERENCE TO OCCUR FOR MAXIMUM HEAT TRANSFER EFFECTIVENESS AT ALL TIMES THE TANK BECOMES THE NEW HEAT SINK OR "BULGE IN THE WATER FLOW LINE" AND IS SPECIFICALLY USED FOR

1. PROCESS WATER CONTROL
2. PREHEATING MAKEUP WATER TO THE CONDENSATE TANK OR DEAERATOR
3. PREHEATING BOILER FEEDWATER LEAVING THE BOILER FEED PUMP TO THE BOILER

THE PRESSURIZED TANK SYSTEM WILL ELIMINATE ANY POTENTIAL FLASHING IN THE ECONOMIZER AND FOR ON/OFF BOILER FEEDWATER SYSTEMS AVOIDS MAJOR FEEDWATER PIPING AND CONTROL CHANGES THE EXISTING WATER FLOW SYSTEM WILL NOT BE AFFECTED EXCEPT FOR THE CONTROLLED INCREASE IN WATER TEMPERATURE AS A RESULT OF THE BTU RECOVERED FROM THE WASTE HEAT COMBUSTION SOURCE



NOTES

1. MANUFACTURED IN ACCORDANCE WITH SECTION VIII ASME PRESSURE VESSEL CODE
2. LEGS ARE FURNISHED WITH ALL TANKS
3. MATERIALS OF CONSTRUCTION BLACK STEEL
4. RELIEF VALVE INSTALLED IN TEE AT HEATED WATER OUTLET CONNECTION UPON INSTALLATION
5. DESIGN PRESSURE 200 PSIG

Cain Industries, Inc P O Box 189 Germantown, WI 53022 414-251-0051 WATS1 800 558 8690 FAX1 414 251 0118

"MANUFACTURING WASTE HEAT TRANSFER PRODUCTS TO SAVE ENERGY"
Boiler Exhaust Economizers-Incinerator Exhaust Economizers-Diesel & Gas Engine Heat Recovery Silencers Waste Heat Steam Generators-Finned Tubing

cain industries

TRANSMITTAL COVER SHEET

COMPANY DRIES ASSOCIATES

ATTN: MR BILL DRIES

PHONE NO: 608-231-2556

DATE: 12/15/97

FAX NO: 608-238-0495

PAGES 9 (including cover sheet)

Inquiry
[ ] Phone
[X] Fax
[ ] Mail

SUBMITTED BY JIM ROZANSKI

SUBJECT: ISKA ELECTRIC LAMP FACTORY

REFERENCE#: 00-259 (Cain computer printout)

Out
[ ] Fax ONLY
[ ] Fax, File
[X] Fax, Mail, File
[ ] Mail, File
[ ] OVERNITE, File

MESSAGE:

- AS REQUESTED, ATTACHED IS YOUR PROPOSAL
- 12-14 WEEK DELIVERY
- THE QUOTED PRICE IS F O B CAIN INDUSTRIES
- OUR TERMS OF SALE, BUL #25500, AND "BOILER TERMS" FORM PART OF THIS PROPOSAL

PO Box 189 Germantown WI 53022 PHONE 414-251-0051 WATS 1-800-558-8690 FAX 1-414 251-0118

TB

"MANUFACTURING WASTE HEAT TRANSFER PRODUCTS TO SAVE ENERGY

Boiler Exhaust Economizers-Incinerator Exhaust Economizers Diesel & Gas Engine Heat Recovery Silencers-Waste Heat Steam Generators-Finned Tubing

cain industries

FURNACE EXHAUST STEAM GENERATOR
Re-Circulation Design w/ Exhaust Bypass

Ref# 00-259
Date 12/15/97
Page 1
Rev#. 0

Engineered for:
Dries Associates, Inc
1600 N Highpoint Rd
Middleton, WI 53562

Attn Mr Bill Dries
Ph (608)231-2556
FAX. (608)238-0495

System Description.

Cain Industries is pleased to propose the following Exhaust Steam Generators (ESG) to recover exhaust heat from a natural gas fired furnace and produce 100 PSIG steam

The ESG is packaged and skid mounted It has a modulating exhaust gas bypass that controls steam production in relation to the steam demand It is compact in design, and is prepiped and wired for ease of installation

Quotation:

QTY	PART #	UofM	DESCRIPTION	PRICE
1		EACH	ESG-627L18CSS -INCLUDING Full Modulating Exhaust Bypass Skid Mounted Packaged Design Packaged Boiler Control Trim Factory Insulation Modulating Water Level Control Low Exhaust Friction Loss 10 Ga Steel Exterior Stainless Steel Inner Lining ASME & Nat'l Board Stamped 4" Thks Factory Insulation	
			TOTAL PRICE	$ 102,207 00
			ANNUAL RETURN ON INVESTMENT	% 164
			5 YEAR SAVINGS .	.$ 838,798
			10 YEAR SAVINGS	.$ 1,677,597
			PAYBACK PERIOD, MONTHS	7 3

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"MANUFACTURING WASTE HEAT TRANSFER PRODUCTS TO SAVE ENERGY

Ref# 00-259
Date 12/15/97
Page 2
Rev# 0

Terms of Sale
Delivery 12-14 weeks
Payment Schedule See Boiler Terms of Sale
See Bulletin 25500 including 'Warranty and Performance Guarantee'

Representative

Jim Rozanski
Cain Industries

P.O. Box 189 Germantown, WI 53022 PHONE 414-251-005 WATS 1-800 558-8690 FAX 1-414-251-0118

FURNACE EXHAUST STEAM GENERATOR
Re-Circulation Design w/ Exhaust Bypass

Ref#· 00-259
Date 12/15/97
Page 3
Rev# 0

Waste Heat Exhaust·

Primary Fuel Type	Natural gas
Exhaust Gas Flow Direction	Horizontal
Heat Source Description	Furnace
Heat Sink Description	Steam load

c a i n
industries
Heat Recovery Systems

Model. ESG-627L18CSS

Overall Length, inches	150
Overall Width, inches	112
Overall Height, inches	112
Dry Weight, lbs	12760
Wet Weight, lbs	13770
Surface Area, Ft2	3634
Design Pressure, PSIG	150
Operating Steam Pressure, PSIG	100
Hydrostatic Test Pressure, PSIG	225
@ Design Temperature, 'F	650
Maximum Entering Temperature, 'F	1250

Customer Connections	
Exhausts, 2x2 Angle	67x30
Steam, RF Flange	4
Boiler Feedwater, NPT	1
Blowdown Manifold	2
Steam Safety Valve, NPT	2
Pump Cooling Water, NPT	1/2
Control Air, NPT	3/8
Circulator Motor HP	10
Voltage	230/460
Phase 3 Hertz	60

Performance

Exhaust Flow Rate, SCFM	10075
Exhaust Entering Temp 'F	1080'F
Exhaust Gas Leaving Temp 'F	417'F
Pressure Drop " W C Max	1 07
*Equivalent Evaporation, lb/hr	8581
*Boiler Horsepower, BHP	249
Boiler Feedwater Flow, GPM	17 2
Heat Recovered, MBtu/hr	8326

(*Steam Capacity from and at 212'F)

Savings

Heat Saved, (x 100,000 BTU/hr)	83 264
Fuel Cost per 100,000 BTU	0 23
Annual Hours of Operation	8760
Savings per Load	$ 167760
ANNUAL SAVINGS	$167,760

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SUBMITTAL

DATE. 12/15/97 REF# 259 FOR· Dries Associates, Inc
MODEL· ESG-627L18CSS C/O. Cain Industries
Bul #88235

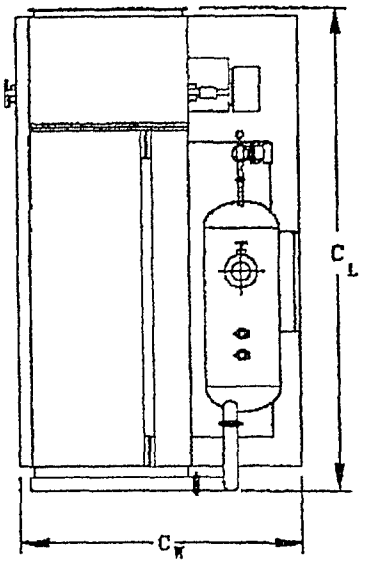
ESG

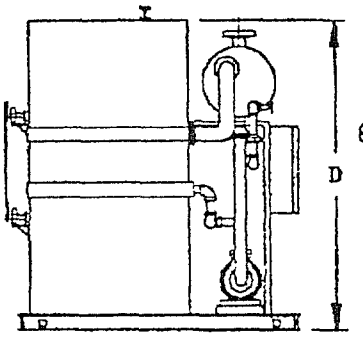
PERFORMANCE
AND
DIMENSION DATA

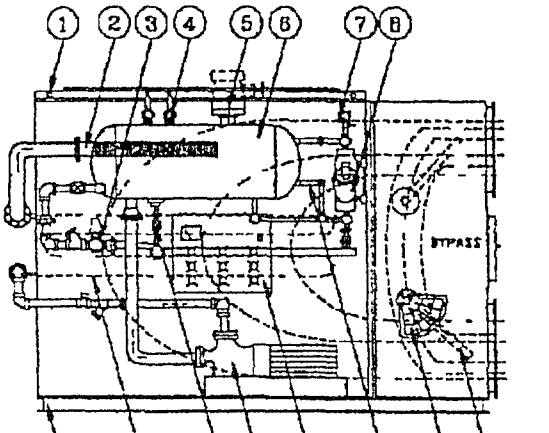
A	1080'F
B	417'F
	100 PSI
	249 BHP
C	112x150" W x L"
D.	112" OAH"
E	4" CONN
F	67x30" CONN
	12760# WGT
	3634 H S
	150 PSIG
	1250 TEMP

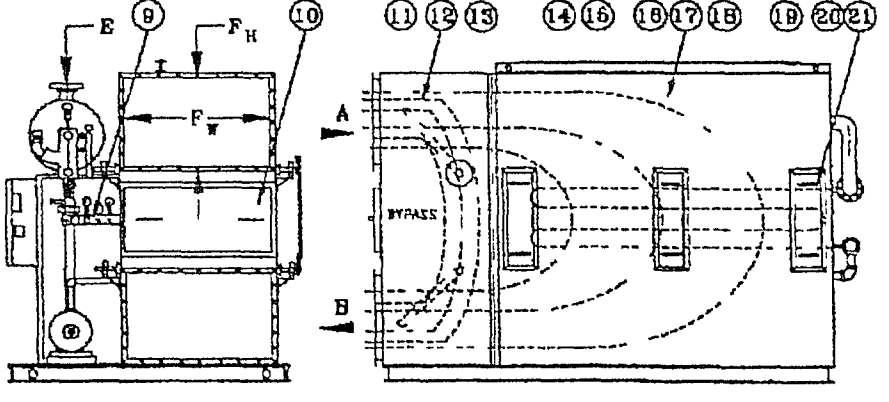
PARTS LIST
(SEE DESIGN DATA FOR CONSTRUCTION)

1 LIFTING EYE
2 STEAM MANIFOLD
3 MODULATING FEEDWATER VALVE
4 ASME STEAM SAFETY VALVE
5 STEAM OUTLET FLANGE
(STEAM STOP AND CHECK VALVE SUPPLIED BY OTHERS)
6 STEAM FLASH DRUM/DRY PIPE
7 EXCESS STEAM PRESSURE SWITCH
8 WATER LEVEL CONTROL
W/ LOW & HIGH WATER CUTOUT
9 LOCALIZED PIPING CONNECTIONS
FEEDWATER, BLOWDOWN MANIFOLD,
100 PSIG CONTROL AIR &
CIRCULATING PUMP COOLING WATER
10 TUBE REMOVAL ACCESS DOOR
11 6" STRUCTURAL STEEL BASE









12 EXHAUST BYPASS
13 FIN.UBE HEAT
TRANSFER SECTION
14 MAIN BLOW DOWN VALVE
16 CIRCULATING PUMP
18 CONTROL PANEL ASSY
FUSE DISCONNECT
MAGNETIC STARTER
STEPDOWN TRANSFORMER
ALARM LIGHTS
STEAM CONTROLLER
17 10GA CARBON STEEL
EXTERIOR
18 CONTINUOUS SURFACE
BLOWDOWN
19 PNEUMATIC MODULATING
DAMPER ACTUATOR
20 STAINLESS STEEL
INSULATED DOUBLE
DAMPER ASSY
21 INSPECTION DOORS

NOTES

A 3" THKS INSULATION
4' ☑ (OPTIONAL)
6" ☐ (OPTIONAL)
B EXHAUST FLANGE CONN S
2 x 2' ANGLE (STANDARD)
3 x 3" " ☐ (OPTIONAL)
C ASME & NAT'L BOARD
STAMPED - SEC 1, DIV I

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Ref 00-259

EXHAUST STEAM GENERATOR (ESG)

1.0 GENERAL DESIGN

manufactured and tested in accordance with the requirements of Section I, Division 1 of the ASME Boiler and Pressure Vessel Code, and stamped to the appropriate Section.

1.2 The ESG shall have the capacity to operate as a supplemental or primary steam generator The ESG shall be designed to produce full output steam in approximately 15 minutes from a cold start and to operate fully automatically under fluctuating steam loads and/or exhaust volumes

2.0 CONSTRUCTION

2 1 The design shall be made up of three basic sections mounted on a 6" structural steel skid, including all necessary integral piping and wiring for ease of installation and shall not require field assembly

2 2 The sections shall include the fintube heating surface, steam flash drum assembly, and a modulating full port exhaust bypass as standard design components

2 3 An integral circulating pump shall also serve to circulate water from the steam flash drum assembly, to the heat transfer section, and back to the steam flash drum assembly Sufficient velocity flow shall serve to reduce sediment buildup in the tubes.

2 4 All water and air connections shall be localized within a common manifold assembly for ease of piping installation.

2 5 Exhaust volume connections shall be interchangeable to serve the ease of installation

2 6 Heat Exchanger Section The explosion proof heating surface shall be standard brazed/welded fin to tube, for high heat transfer (SA178 grA 109" wall thickness x carbon steel 030" minimum fin thickness)

2 7 The fin tubing section shall be designed in multiple sections for ease of tube replacement

2 8 The heat exchanger section shall contain a main inspection door for tube removal and (3) inspection access ports for cleaning and/or inspection.

2 9 The reinforced enclosure of the heat exchanger section shall be lined with 4" thickness high density fiberwall insulation, designed to operate with exhaust temperatures entering @ 1250°F maximum and shall be clad with a 10ga carbon steel exterior, primed and painted with high temperature metallic blue

2 10 Modulating Bypass Assembly The modulating bypass assembly shall also be constructed with 4" thickness high density fiberwall insulation, 10ga exterior, and bolted to the heat exchanger section

2 11 The section shall contain a double damper bypass assembly, controlled by a modulating pneumatic positioning actuator & steam pressure dial controller, for controlling the volume of waste heat exhaust as required

2 12 The dampers shall be insulated and constructed of reinforcing stainless

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steel for maximum service conditions

2 13 In addition the damper assembly shall be designed for tight seal during the full bypass or full operating position

2 14 The damper shafts shall contain high temperature bearings and packing glands to seal exhaust leakage

2 15 In the event of

steel for maximum service conditions

2 13 In addition the damper assembly shall be designed for tight seal during the full bypass or full operating position

2 14 The damper shafts shall contain high temperature bearings and packing glands to seal exhaust leakage

2 15 In the event of an air pressure or electrical failure, the modulating bypass assembly shall contain a fail safe operating mode, whereby the damper assembly shall automatically move to the full exhaust bypass position

2 16 Steam Flash Drum & Control Assembly. The steam flash drum assembly shall include as standard components circulating pump and motor, drum blowdown valve, surface blowdown valve, and water level control blowdown valve manifolded for a single connection; low and high water cutouts, Modulating boiler feedwater pump level control and valve assembly, red line water level sight glass with drain cock, all required oil filled gauges for steam, feedwater, pump cooling water, and air indication, (1) ASME code steam safety relief valve

2 17 The steam flash drum shall contain internal baffles and dry pipes for 99% dry steam output and shall be insulated with 1" thickness insulation with 16ga carbon steel shell

2 18 The control panel shall be designed to accept a single main power connection with main fused disconnect and starter, fused stepdown transformers, power on indicating light, run indicating light, fill indicating light, low & high water alarm indicating lights

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"MANUFACTURING WASTE HEAT TRANSFER PRODUCTS TO SAVE ENERGY"
Boiler Exhaust Economizers-Engine Exhaust Economizers-Diesel & Gas Engine Heat Recovery Silencers Waste Heat Steam Generators-Finned Tubing
cain industries

STANDARD ESG BOILER TERMS OF SALE

1 The 'Terms of Sale' #25500 form a part of this proposal.
2 Purchase order shall be issued directly to Cain Industries
3. Payment Schedule:
   a 10% w/written order
   b 10% w/receipt of approved drawings
   c 30% 6 wks after receipt of approved drawings
   d 30% prior to shipment
   e Balance due 30 days from date of invoice or US Dock which ever occurs first.
4. Approval drawings are submitted 10 working days after receipt of written purchase order.
5 Startup $600 per day, per man, plus expenses upon receipt of completed Pre-Startup form
6. Delivery 12-14 weeks upon receipt of approved P O
7. This quotation is valid for 60 days from the date of this proposal
8. 1 year warranty from date of shipment shall form part of this quotation (See "Terms of Sale" bul 25500 for warranty information)

P.O. Box 89 Germantown W 53022 PHONE 414-251-0051 WATS 1-800-558-8690 FAX 1-414-251-0118

TERMS OF SALE

Bul 25500

OFFER EXPIRATION
All offers expire thirty days from the quotation date unless otherwise stated and are subject to cancellation by Cain Industries, Inc. at any time prior to the formal acceptance of our offer to furnish equipment as quoted

TAXES OR SURCHARGES:
Quoted prices do not include sales, use, excise, occupation processing transportation or other similar taxes which Cain Industries, Inc. may be required to pay or collect with respect to any of the quoted materials. Such taxes which are or may be incurred shall be paid by the purchaser.

MINIMUM BILLING:
Orders for $25.00 Net or less will be invoiced at $25.00 plus transportation.

CANCELLATION AND CHANGES
As many Cain Industries, Inc. products are manufactured or adjusted "to order" orders accepted and acknowledged by Cain Industries, Inc. are not subject to change or cancellation without prior consent of Cain Industries Inc. Order quantity reductions or cancellations, if granted, will be subject to Cancellation Charges consistent with components "restockability versus made to order specifications" percent of production completion, etc.

QUOTED DELIVERY TIME.
Delivery times quoted are approximate, and based on conditions at the time of quotation. Cain Industries, Inc. will, in good faith, attempt to effect delivery within the time quoted. In no case shall Cain Industries, Inc. be liable for incidental or consequential damages resulting from failure to meet requested or quoted delivery schedules. Delivery is based upon receipt of written purchase order or upon receipt of special approved drawings marked approved for production when required.

SHIPMENT OF GOODS.
Unless otherwise specifically agreed all shipments are made F.O.B. Factory Via "best way" Cain Industries, Inc. responsibility ceases upon acceptance by the carrier SHOULD GOODS BECOME LOST OR DAMAGED IN SHIPMENT THE PURCHASER OR RECIPIENT OF THE GOODS MUST IMMEDIATELY NOTIFY AND PLACE CLAIM WITH THE CARRIER. ADVISE CAIN INDUSTRIES, INC. OF ANY DAMAGE OR DISCREPANCY AND OBTAIN AUTHORIZATION FOR RETURN OR REPLACEMENT As a courtesy Cain Industries, Inc. will assist in tracing and recovering lost goods and the collection of just claims, but cannot guarantee safe delivery Loss or damage in shipment does not release the purchase from payment of the total invoice.

RETURN OF GOODS FOR WARRANTY REPAIR, REPLACEMENT OR CREDIT·
Authorization to return goods for any reason must be obtained from Cain Industries, Inc. prior to the return shipment being made. All items returned for repair, replacement or credit shall be returned freight prepaid. Freight collect shipments will not be accepted. A restocking charge of 30% minimum" will be made on all items returned for credit.

PROPRIETARY DATA.
All manufacturing drawings, specifications and technical material submitted by Cain Industries, Inc. are the property of Cain Industries, Inc. are proprietary and are to be considered as confidential.

TERMS-ESTABLISHED ACCOUNTS
Net 30 days from date of invoice.

TERMS-NEW ACCOUNTS
Initial Order-Cash with purchase order and completed credit application for immediate processing; or 50% with purchase order and completed credit application (order will be held until credit limit has been established)

TERMS-ORDERS OUTSIDE THE UNITED STATES
Initial Order-Letter of Credit with purchase order All Orders-Payment in full prior to shipment outside the United States.

PROGRESS PAYMENT SCHEDULE FOR ORDERS EXCEEDING ESTABLISHED CREDIT LIMIT·
From $20,000 to $50,000: 30% with purchase order, 30% with return of approved submittal drawings or prior to shipment, Balance 2% discount within 10 days of invoice date or NET 30 days.
Over $50,000: 30% with purchase order, 30% due within the first 45 days of production beginning with return of approved submittal drawings 30% due prior to shipment, Balance 2% discount within 10 days of invoice date or NET 30 days.

CREDIT LIMIT·
Accounts over credit limit will be on a "Cash with Order" basis until account is brought back to below "Credit Limit" status. Special instances may occur wherein credit limits may be adjusted for companies with past credit history satisfactory to Cain Industries Inc.

SERVICE CHARGES.
A 2% per month service charge will be assessed on all past due amounts.

OEM QUANTITY DISCOUNTS.

A	(1-4)	Total Discount Each	0%
B	(5-9)	Total Discount Each	8%
C	(10-19)	Total Discount Each	13%
D	(20-49)	Total Discount Each	17%
E	(50-99)	Total Discount Each	20%
F	(100-249)	Total Discount Each	22%
G	(250-499)	Total Discount Each	25%
H	(500-999)	Total Discount Each	28%
I	(1000+)	Total Discount Each	35%

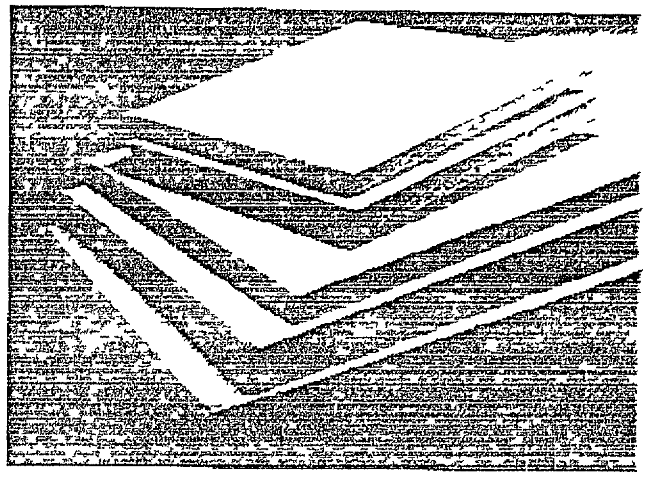
OEM DISCOUNT PROVISIONS
OEM pricing is effective for quantities per written purchase order A shipping release schedule must also be included as required. Release dates for multiple unit order must fall within 1 year from date of purchase order to hold curre OEM pricing. Individual invoicing for multiple unit releases begin at "item A of the quantity discount schedule and prorate through" to the total quantity ordered as noted on the Sales Order acknowledgement. Cancellation charges will apply to the balance of the order pending with a minimum of 30% to a maximum of 80% as determined at the point of cancellation dependent on the work in process. Quantities already shipped to the point of cancellation shall be issued an additional invoice for the difference in price breaks between the original quantity ordered and the total shipped up to the point of cancellation Minimum release per shipment is (10) units. Special prototype order delivery requirements available upon request.

WARRANTY AND PERFORMANCE GUARANTEE

Cain Industries Inc. warrants all products manufactured to be free from defects in material or workmanship under normal use and conditions for a period of one year from the date of shipment from our factory. Cain Industries liability under this warranty to the buyer shall be limited to Cain's decision to repair or replace at its factory Items deemed defective after inspection at the factory Buyer agrees that in no event will Cain be liable for cost of processing, loss of profits, injury to goodwill, or any other consequential or incidental damages or costs of any kind resulting from the orde and/or use of the product, whether arising from breach of warranty non-conformity to order specifications, delay in delivery or any loss sustained by the buyer No agent or employee of Cain Industries, Inc. has any authority to make verbal representation or warranty of any goods manufactured and sold by Cain Industries, Inc. without written authorization signed by an executive officer of Cain Industries, Inc. Cain Industries, Inc. warrants the equipment designed and fabricated to perform in accordance with the specifications as stated in this particular proposal and while the equipment is in a new and clean condition and properly operated within the specific design limits for that equipment. Should any piece of equipment designed by Cain Industries, Inc. not meet performance requirements when determined by standard test procedures. Cain will make corrections it deems necessary at its option under the limitations of this warranty Any alterations or repair of Cain equipment by personnel other than those directly employed by Cain shall void the warranty This warranty does not cover corrosion resulting from the effects of physical or chemical properties of water steam or the liquids or gases used in the equipment Cain makes no other warranties of performance or product either express or implied which extends beyond the limits contained within this instrument. All acceptance tests shall be conducted at the buyers expense Any such tests shall be made when the equipment is new clean and before being placed into service and shall be made within 90 days of delivery. The buyer must furnish at their expense, a copy of such report stating the test used. All workmanship, material and performance requirements shall be deemed to have been met if a contrary report has not been furnished within 90 days of delivery Where field tests are desired, the following procedures are to be used The equipment shall be in clean and unused condition and all testing shall begin immediately after installation of the unit but within 90 days of the shipping date. The exhaust gas and liquid inlet and outlet temperatures shall be recorded simultaneously, Gas volume shall be determined by actual measurement, if practical, or by calculations if necessary All factors of CO_2, excess air fuel input, altitude and the operating efficiency of the primary direct fired unit, shall be incorporated in the fina. determination and calculation of the volume of the flue gas. Payment for such test shall be the responsibility of the purchaser and a copy of the test procedures conducted, data accumulated and calculations used to arrive at the final results shall be submitted to Cain Industries, Inc. at the buyers expense

Cain Industries, Inc P O.Box 189 Germantown,WI 53022 414-251-0051 WATS1-800-558-8690 FAX1-414-251-0118

Fiberfrax Duraboard® Products



Introduction

Fiberfrax Duraboard [illegible] rigid high temperature ceramic [illegible] manufactured [illegible] wet forming process using Fiberfrax alumina-silica fiber [illegible] binders. All Duraboard products offer [illegible] thermal conductivity, high temperature stability, [illegible] density, and excellent resistance to thermal shock and [illegible].

The [illegible] vibration, mechanical [illegible]. The excellent rigidity and [illegible] boards make [illegible] light weight and eas[illegible].

[illegible] due to their high [illegible] protective refractory [illegible].

Product Range

Temperature	Density	Board	Description
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Formed from alumina-silica Fiberfrax [illegible] fibers. These boards [illegible] temperature [illegible]
[illegible]	10-12 [illegible]	[illegible]	[illegible] Fiberfrax [illegible]

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Applications

Board						
RG	LD*	HD	GH	2600	3000	Application
•		•		•	•	Full thickness refractory lining
•	•	•		•	•	Insulating backup to dense refractories
•				•	•	Insulating backup to brick & castable
•				•	•	Furnace hot face lining in ceramic kiln box furnace & petrochemical furnace
•	•	•		•	•	Board over blanket hot face lining
•						Alternative to lower temperature mineral wool block
•	•					Use in industrial heat processing equipment
•	•	•				Rigid high temperature gaskets & seals
•	•	•	•	•		High temperature baffles & muffles
	•	•	•	•	•	Flue & chimney linings in furnaces & kilns
	•	•		•	•	Infrared element supports
			•			Heating element support brackets
•	•	•		•	•	Glass tank side & end wall & port neck insulation
•	•	•		•	•	Trough & insulation linings for conveying molten metals
			•			Molten metal trough covers
•	•	•		•	•	Thermal insulation where high velocities are encountered
	•	•		•	•	Heat shields for personnel protection
•	•	•		•	•	Hot gas duct linings
	•	•		•	•	Low & high temperature dryers
	•	•				Pouring forms for castable
	•	•				Expansion joint material
			•			Wind tunnel insulation
	•		•			Industrial heat shields & thermal barriers
	•			•	•	Industrial combustion chamber construction
	•					Domestic appliance & light duty industrial combustion chamber construction
	•		•			Wood burning stove backup insulation

Duraboard LD has been evaluated under certain categories at Underwriters Laboratories Inc

Duraboard® Products

Duraboard RG

DuraBoard RG (Refractory Grade) insulation is a cost-effective insulating board manufactured with the specific requirements of the refractory industry in mind. It has a rolled rigidized surface which gives it a high modulus of rupture and compressive strength as well as high abrasion and hot gas erosion resistance.

These properties make Duraboard RG insulation ideally suited for use both as a backup to dense refractories such as those used in the glass industry and as a hot face protective layer over blanket linings where the rigidized surface aids in dust suppression during both installation and operation.

Duraboard LD

This product possesses the same density and temperature rating as Duraboard RG insulation but is manufactured to tighter dimensional tolerances and has an excellent finished surface. These characteristics make it ideally suited for use as a sandwich or cover material or for use in the manufacture of components where aesthetic quality as well as uniformity and performance is important.

It is available in a variety of standard thicknesses ranging from ½" to 2".

Duraboard HD

Duraboard HD insulation is a high density board product that offers the same high level of dimensional and surface uniformity as Duraboard LD insulation but provides enhanced compressive strength and a higher modulus of rupture. This higher density is achieved through the inclusion of clay additives during the manufacturing process.

Its higher strength makes Duraboard HD insulation particularly well suited to weight load support applications such as refractory brick backup or for covering larger unsupported spans.

GH Board

GH Board insulation possesses the highest density and modulus of rupture of the board product family. This rigid board is manufactured using inorganic binding agents and is post soaked to impart its high density.

Due to its high modulus of rupture it is ideal for use in areas experiencing vibration, mechanical stress and strong erosive forces.

Duraboard 2600

Duraboard 2600 insulation is a high temperature insulating board designed to promote high stability at elevated temperatures. This capability is achieved by manufacturing a board formulated with a blend of Fibertrax® alumina silica fibers and Fibermax® (Unifrax Corporation's patented polycrystalline mullite fibers.

This unique formulation controls shrinkage to a level of only 5% after 168 hours at 2600°F/1427°C.

Duraboard 3000

Duraboard 3000 insulation is the highest temperature rated board manufactured by Unifrax Corporation. It provides maximum high temperature stability and shrinkage resistance. Also formulated from a blend of Fibertrax alumina-silica fibers and Fibermax (Unifrax Corporation's patented polycrystalline mullite fibers), Duraboard 3000 insulation derives its exceptional high temperature capability from an increased Fibermax fiber concentration in the blend.

This unique formulation controls shrinkage to a level of only 1.2% after 168 hours at 2700°F/1482°C.

Typical Chemical Properties

The Fibertrax Duraboard family exhibits excellent chemical stability, resisting attack by most corrosive agents. Exceptions are hydrofluoric, phosphoric, hydrochloric and sulfuric acids as well as concentrated alkalies. Fibertrax Duraboard products also resist oxidation and reduction. If wet by water, steam or oil, thermal and physical properties are completely restored upon drying.

In order to provide handling strength during the manufacturing process, small quantities of organic and inorganic binders are typically added to the board formulation. Where present, the organic binding agents burn out at temperatures between 450°F/232°C to 600°F/316°C during initial heat up by the end user. Following burnout of the organic binder, the boards are white in color.

Inorganic Boards

Duraboard products are manufactured using a combination of both organic and inorganic binding agents. In certain applications, the presence of organic binders and the low temperature burnout that is associated with them may be unacceptable. These products may be pre-treated with the organic binding agent already removed by heat treating following the manufacturing process. Heat treated boards display a reduced modulus of rupture and an increase in dustiness.

Availability

Sheet Size	Thickness ⅛ 3 mm	¼ 6 mm	½ 13 mm	1 25 mm	1½ 38 mm	2 51 mm
12 x 36 305 x 914 mm		GH		HD	HD	HD
18 x 18 457 x 457 mm				2600 3000	2600 3000	2600 3000
24 x 24 610 x 610 mm				2600 3000	2600 3000	2600 3000
24 x 36 610 x 914 mm		LD	LD	LD HD	LD HD	LD HD
24 x 48 610 x 1120 mm		LD	LD	RG LD HD 2600 3000	LD HD 2600 3000	RG LD HD 2600 3000
42 x 48	LD	LD	LD			

Duraboard® HD & Duraboard LD are available in 3" & 4" thick by special order. Other sizes by special request.

Product Properties

Properties		Board RG		LD		HD		GH		2600		3000	
Nominal Density	lb/ft³ kg/m³	16	258	16	258	26	419	35	560	14	221	12	19
Continuous Use Limit	°F °C	2300	1260	2300	1260	2300	1260	2300	1260	2600	1427	3000	1649
Product Melting Point	°F °C	3200	1760	3200	1760	3200	1760	3200	1760	3300	1816	3300	1816
MOR PSI	Green (typ.) Fired (24 hrs @ cont. use)	250 10		200 60		500 125		300 25		150 65		150 55	
LOI (% by Wt)		57%		57%		57%		0		46%		46%	
Dielectric Strength		—		27 volts/mil		27 volts/mil		27 volts/mil		—		—	
Color		Cream to tan		Cream white		Cream		White		Cream		Cream	
Shrinkage	(%)												
24 Hrs @ Cont. Use Limit		5%		4.5%		4.5%		5%		1.5 (168 hrs 1.5)		—	
24 Hrs @ 1600 F/871 C		—		—		—		0%		—			
24 Hrs @ 1800°F 982 C		—		1.8		2.3		—		—		—	
24 Hrs @ 2540 F 1393 C		—		—		—		—		1.4 %		1.0%	
24 Hrs @ 2600 F 1427 C		—		—		—		—		—		1.0 %	
24 Hrs @ 2700 F 1482 C		—		—		—		—		—		1.2	
168 Hrs @ 2450 F 1343 C						—		—		1		1.2%	
Compressive Strength	lb/in²	Green	Fired	Green	Fired	Green	Fired	Green	Fired	Green	Fired	Green	Fired
Deformation @	5%	16	25	22	20	29	26	—	—	22	19	47	—
	10%	61	25	50	22	70	33	—	—	25	18	44	—
	50%	71	25	57	23	81	32	—	—	27	18	47	—
Fiber Content													
Fiberfrax®		100%		100%		100%		100%		75%		50%	
Fibermax®										25%		50%	
Thermal Conductivity	Temperature					Btu in/ft² °F							
	600°F 316°C	0.62		0.62		0.62		0.74		0.50		0.47	
	1000°F 538 C	0.85		0.85		0.85		1.07		0.71		0.73	
	1400 F 760 C	1.14		1.4		1.44		1.44		1.02		1.16	
	1600 F 982 C	.53		1.53		1.55		.83		1.36		1.70	
	2200°F 1093 C	—		—		—		—		.85		2.40	

Fiberfrax is Unifrax's patented 2300 F (1260 C) amorphous aluminosilicate fiber.
Fibermax is Unifrax's patented 2600 F (1649 C) polycrystalline mullite fiber.
As per ASTM C 892.

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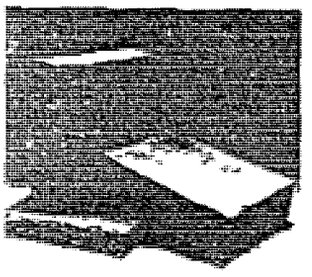
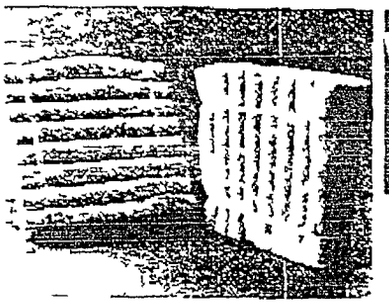
Product Specifications

Fiberwall™ Bonded Module Systems





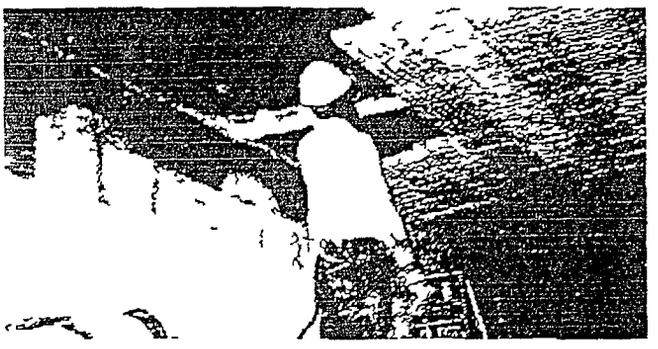
Introduction

Fiberwall™ Bonded module systems provide fast and simple techniques for effective insulating all types of heat processing equipment. Bonded modules can be installed with Hemy Lock™ hardware as a full thickness mechanical anchored lining over all or face veneer over existing refractory surfaces in suitable condition.

Fiberwall Bonded modules are constructed with folded and tightly compressed Durablanket® S, Durablanket HP S or Durablanket 2600 ceramic fiber blanket. They are available in a range of densities and thicknesses to match a wide variety of the ma requirements in applications up to 2300°F. At high temperatures this folded construction takes advantage of the inherent shrinkage present in all ceramic fiber blanket products by causing the layers at the hot face folds to seal against one another, thereby preventing heat flow to the shell.

Fiberwall Bonded 30 modules are designed for hot face veneering over existing refractory linings at temperatures up to 1182°C (2700°F). The felt used in Bonded 30 modules is made from a 50/50 blend of Fiberfrax® high purity bulk fibers and Fibermax®. Unifrax's patented polycrystalline mullite fibers. The use of Fibermax in the felt formula for produces a product which exhibits extremely low shrinkage at elevated temperatures.

Bonded Module Installation
Ceramic Fiber Module Veneer



Bonded modules are typically mechanically anchored into place over existing refractory lining. 938 kg/m³ to 1.36 kg/m³ (12 to 5 lbs/ft³) of Fiberstick® board module. This lining over refractory (veneering) approach not only increases the insulation value of the refractory lining but helps to protect it from further degradation.

For recommendations on veneering installation procedures refer to the Fiberwall installation manual (Form C 724).

Many furnace operators have chosen this method for upgrading the performance of existing linings because of the ease, speed and simplicity of installation. And a ceramic fiber veneer is often a more attractive alternative than completely relining a unit due to the lower cost and shorter downtime.

Advantages of Fiberfrax Ceramic Fiber Veneer

Lower heat losses
Reduction in overall heat storage
- Easier heat up and cool down cycles
- Low installed cost
- Easy repairs
- Thermal shock resistance
- High heat reflectance
- Good sound absorption
- Excellent corrosion resistance

Typical Veneering Applications

- Soaking pit covers
- Forge furnaces
- Refractory kilns
- Linings over fiber
- Reheat furnaces
- Pyrolysis furnaces
- Ceramic kilns
- Boiler fire boxes
- Brick kilns
- Heat treating furnaces

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Hefty-Loc™ Module System

Fiberfrax® Bonded modules and Hefty Loc alloy steel hardware comprise the Hefty Loc modular system which provides lining insulation for a variety of heat processing equipment.

The Hefty Loc system consists of two components a base which is welded directly to the furnace casing and a pin which passes through the Bonded module and locks into the base.

Hefty-Loc fasteners are stocked in two alloy grades both SS 304 and SS 310 with Inconel 601 available on request.

For recommended installation procedures refer to the Fiberwall installation manual Unifrax Form C 729.

The Fiberwall Hefty Loc modular system provides many installation and design advantages.

High strength as well as resistance to corrosive atmospheres. Unidirectional pattern of installed modules allows for maximum compression and results in tight uniform linings which give unsurpassed thermal performance.

- The design provides a tight seal between the fiber and shell. This insures no heat channeling or convection currents will develop.
- A layered backup lining of Durablanket S or Duraback insulation is easily installed behind the modular hot face. This practice is an economical method of increasing the thermal performance of the lining. As an additional advantage the layered backup lining acts as a safety lining which will protect the casing if mechanical damage occurs on the modular hot face.

  Field cutting of modules for special shapes is simplified. Just trim the Bonded module to the desired contour. Hefty Loc fasteners are laid out to accommodate the hot face module design. This practice completely eliminates the need to cut the attachment hardware.
- When lining process equipment fired by high sulfur fuels a stainless steel layer of foil is easily installed over the backup blanket insulation. This layer acts as a vapor barrier eliminating corrosion to the casing and weld base of the anchors.

  Quickly installed. Simply slip the Bonded module into position then lock the pin to the repositioned base pin by impaling the module.

  In applications where high velocities are present the folded module is installed with the edge grain blanket on the hot face. This edge grained fiber is punctured with a nail board then coated with TopCoat® M or TopCoat® 3000 to provide a surface coating resistant to velocity attack.

  Installation equipment is readily available.

Bonded modules used in the Hefty Loc system offer the same advantages as Fiberwall Anchor Loc® module linings and layered Fiberwall construction when compared to refractory construction.

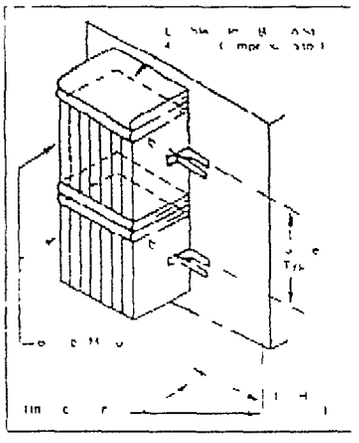
These advantages are:

- Faster temperature cycling
  Lower heat storage
  Lower fuel costs
- Increased productivity
  Resistance to thermal shock and spalling
- Lower installed cost
  Easier repairs
  Reduced maintenance

The Hefty Loc system is used for a wide range of thermal requirements in applications up to 2100 F. Typical applications for the Hefty Loc system are as follows:

- Stress relieving furnaces
  Annealing furnaces
- Car bottom heat treating furnaces
- Process heaters
- Furnace kiln and boiler linings
- Incineration equipment and stack linings
- Field steam generators
- Aluminum soaking pits and reheating furnaces

Hefty Loc Modular System
Typical Installation



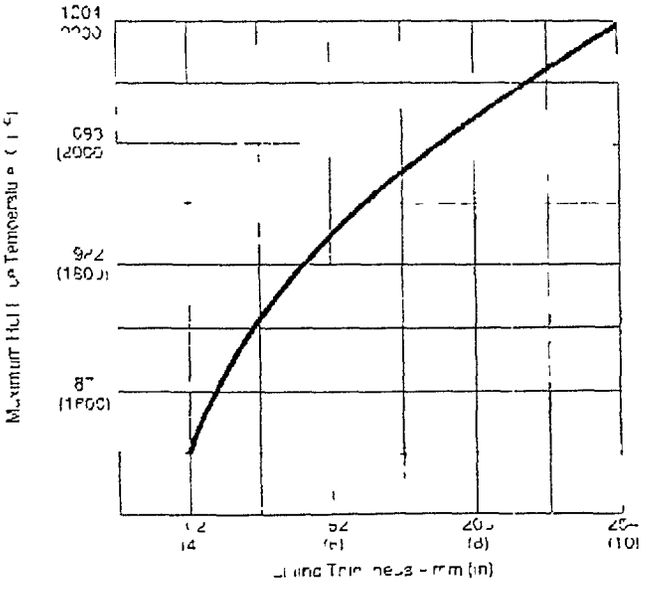
Installation Note

Bases of Hefty Loc anchors are welded to the steel casing by manual electric arc welding or by arc stud welding.

For arc stud welding the accessories listed below are required.

Description	KSM Part No
Female Chuck	000 300
Shield Grip	000 185

Hefty Loc Hardware
Recommended Use Temperature



Note: The data presented above is for general guidelines only. Please check with Application Engineering regarding particular applications.

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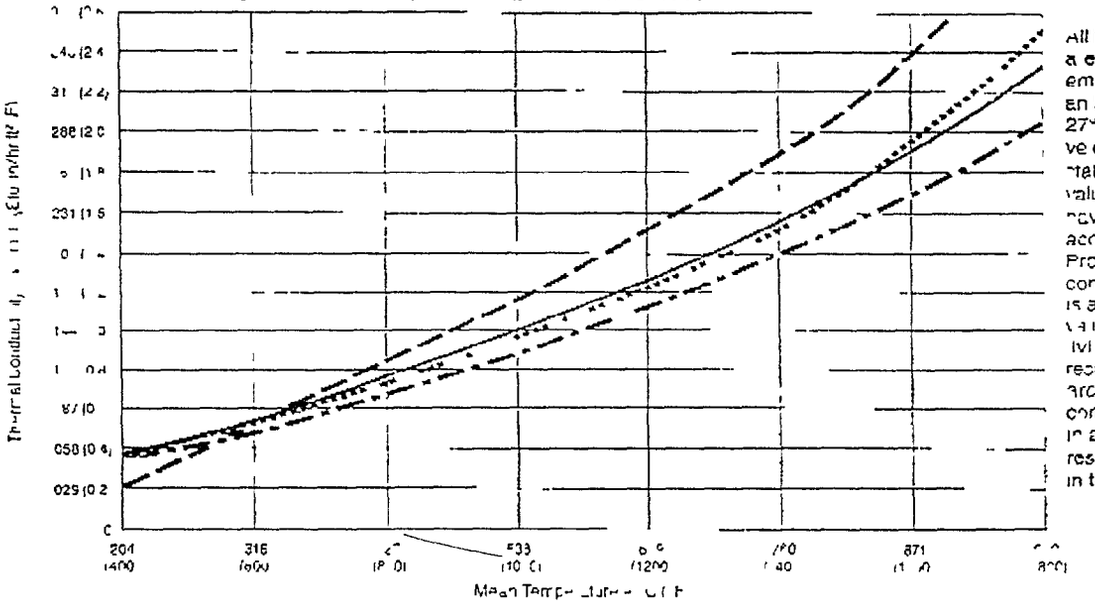
Available Bonded Modules – 305 mm x 305 mm (12 x 12)

Module Type	Design Temperature Limit	Recommended Operating Temperature	Construction	Module Density
Bonded 22	1204 C (2200 F)	1093 C (2000 F)	Folded Durablanket S	112 kg/m³ (7 lb ft³) 149 kg m³ (9 3 lb/ft³)
Bonded 24	1316 C (2400°F)	1232°C (2250 F)	Folded Durablanket HP S	149 kg/m³ (9 3 lb ft³) 171 kg m³ (10 7 lb ft⁴)
Bonded 2600	1427°C (2600°F)	1343 C (2450 F)	Folded Durablanket 2600	149 kg m (9 3 lb ft³) 171 kg m (10 7 lb/ft³)
Bonded 30	16–9°C (3000 F)	1538°C (2800 F)	Edge Grained Bonded 30 Felt	1 2 1 kg m³ (7 lb ft³)

Fiberwall® Bonded Modules
Thermal Conductivity vs Mean Temperature (per ASTM C-177)



All heat flow calculations are based on a surface emissivity factor of .90 an ambient temperature of 27°C (80 F) and zero wind velocity unless otherwise stated. All thermal conductivity values for Fiberfrax materials have been measured in accordance with ASTM Test Procedure C 177. When comparing similar data it is advisable to check the validity of all the thermal conductivity values and ensure the resulting heat flow calculations are based on the same condition factors. Variations in any of these factors will result in significant differences in the calculated data.

Fiberwall Bonded Modules – Ceramic Fiber Veneer

Fiberwall Bonded 22/Fireclay Brick — **Folded Modules 112 kg/m³ (7 lb/ft³)**

Hot Face	Insulation Thickness – mm (in)	Cold Face Temperature °C (F)			
C (°F)	Refractory Thickness – mm (in)	0 (0) 228 (9)	51 (2) 228 (9)	76 (3) 228 (9)	102 (4) 228 (9)
649 (1200)		187 (369)	97 (207)	81 (177)	70 (158)
871 (1600)		236 (456)	142 (288)	119 (247)	104 (219)
1093 (2000)		282 (539)	183 (372)	162 (324)	143 (289)

Fiberwall Bonded 24/Superduty Castable — **Folded Modules 149 kg/m³ (9 3 lb/ft³)**

Hot Face	Insulation Thickness – mm (in)	Cold Face Temperature °C (F)			
°C (F)	Refractory Thickness – mm (in)	0 (0) 228 (9)	51 (2) 228 (9)	76 (3) 228 (9)	102 (4) 228 (9)
1093 (2000)		203 (398)	156 (313)	137 (279)	123 (253)
1149 (2100)		210 (410)	164 (328)	146 (294)	131 (267)
1232 (2250)		219 (426)	177 (350)	158 (317)	143 (289)

Fiberwall® Bonded Modules – Ceramic Fiber Veneer (Cont'd)

Fiberwall Bonded 2600/Superduty Plastic		Folded Modules 149 kg/m³ (9.3 lb/ft³)			
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in) / Refractory Thickness – mm (in)	0 (0) / 228 (9)	51 (2) / 228 (9)	76 (3) / 228 (9)	102 (4) / 228 (9)
1232 (2250)		226 (438)	179 (354)	159 (319)	144 (291)
1288 (2350)		232 (450)	187 (369)	168 (334)	152 (306)
1343 (2450)		238 (461)	195 (383)	177 (350)	161 (321)

Fiberwall Bonded 30/Superduty Plastic					
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in) / Refractory Thickness – mm (in)	0 (0) / 228 (9)	51 (2) / 228 (9)	76 (3) / 228 (9)	102 (4) / 228 (9)
1343 (2450)		238 (461)	194 (381)	175 (347)	159 (318)
1427 (2600)		247 (477)	205 (401)	187 (368)	171 (340)
1538 (2800)		259 (498)	220 (428)	202 (396)	186 (367)

Fiberwall Bonded Modules – Hefty-Loc™ Lining

Fiberwall Bonded 22		Folded Modules 112 kg/m³ (7 lb/ft³)			
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in)	102 (4)	152 (6)	203 (8)	254 (10)
649 (1200)		64 (148)	53 (128)	48 (118)	44 (111)
982 (1800)		104 (220)	83 (182)	72 (161)	64 (147)
1093 (2000)		126 (259)	101 (213)	86 (187)	76 (169)

Fiberwall Bonded 22		Folded Modules 149 kg/m³ (9.3 lb/ft³)			
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in)	102 (4)	152 (6)	203 (8)	254 (10)
649 (1200)		61 (142)	51 (124)	46 (114)	40 (104)
982 (1800)		96 (205)	77 (171)	67 (152)	56 (133)
1093 (2000)		110 (230)	84 (183)	72 (162)	64 (148)

Fiberwall Bonded 24		Folded Modules 149 kg/m (9.3 lb/ft³)			
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in)	152 (6)	203 (8)	254 (10)	305 (12)
871 (1600)		67 (153)	59 (138)	50 (122)	49 (121)
1038 (1900)		82 (180)	71 (160)	59 (139)	58 (137)
1204 (2200)		94 (202)	81 (177)	72 (161)	66 (150)

Fiberwall Bonded 24		Folded Modules 171 kg/m³ (10.7 lb/ft³)			
		Cold Face Temperature °C (°F)			
Hot Face °C (°F)	Insulation Thickness – mm (in)	152 (6)	203 (8)	254 (10)	305 (12)
871 (1600)		59 (138)	52 (125)	47 (117)	44 (112)
1038 (1900)		71 (160)	62 (143)	56 (132)	52 (125)
1204 (2200)		85 (185)	73 (163)	65 (149)	59 (139)

UNIFRAX

Form C 1429
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Предприятия-изготовители теплоизоляционных материалов

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Семилукский огнеупорный завод	396810, г Семилуки Воронежской обл тел 55-5479 9-3237	Изделия высокоглиноземистые, легковесные теплоизоляционные огнеупорные ВГЛ-1 0 ВГЛ-1 ВГЛ-1 4 Изделия корундовые легковесные, теплоизоляционные, огнеупорные КЛ-1 1 КЛ-1 3 КЛ-1 8
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Часов-Ярский огнеупорный комбинат	343440 Украина г Часов-Яр Донецкой обл ул Комсомольская 1 тел 23-01 23-02	ШЛ-1-0 4
Великоанадольский огнеупорный комбинат	342331, Украина, пос Владимировка Волновахского района Донецкой обл , тел 33-03 33-20	ШЛА-1,3
Восточно-Сибирский огнеупорный комбинат	665448, пос Михайловка Иркутской обл , тел 1-10 1-123, 1-16, 1-40	ШЛ-1 3
Внуковский огнеупорный комбинат	143000, г Одинцово Московской обл , ул Верхне-Пролетарская, 25, тел (095) 593-0821, 593-2162 593-4645	ШЛ-1,0 ШКЛ-1,3
Подольский огнеупорный комбинат	142101, г Подольск Московской обл , ул Плешевская, 15, тел (09675) 137-9497, 137-9584	ШЛ-1-0,4
Северский доломитный комбинат	343350, Украина, г Северск Донецкой обл , пр Ленина, 6, тел 5-2713, 5-2235	Плиты шамотно-волокнистые, теплоизоляционные ШВП-1150, ШВП-1350
ОАО «Теплозвукоизоляция»	255700, Украина, пос Коцюбинское Киевской обл , ул Строительная, 7, тел (277) 7-2350, 7-1203	Картон теплоизоляционный ТК-4-6 ТК-1-5 ТК-1-10
ЗАО «Изоляция»	340029, Украина, г Донецк, ул Светлого пути, 3, тел (0622) 66-6142	ТК-1-5

343350 Украина г Северск Донецкой обл
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Уважаемые господа !

ОАО "Северский комбинат" предлагает Вам высокоэффективные теплоизоляционные огнеупорные волокнистые мультикремнеземистые материалы и изделия из них

Они устойчивы к высокой температуре имеют низкую удельную теплопроводность низкое аккумулирование тепла, легкий вес, превосходную коррозиеустойчивость устойчивы к термоударам прекрасное звукопоглощение

Температура применения рулонных материалов войлока фетра до 1150°С шамотно-волокнистых плит ШПГТ-450, плит МКРПГ-400 - до 1250°С

Применяются во всех отраслях промышленности от бытовых газовых и электропечей, холодильников до мощных тепловых агрегатов в металлургии и машиностроении Материалы экологически чистые, прекрасно заменяющие вредный для здоровья асбест, стекловату и минеральную вату

ТЕХНИЧЕСКАЯ ХАРАКТЕРИСТИКА ВОЛОКНИСТЫХ МАТЕРИАЛОВ И ИЗДЕЛИЙ

Наименование параметра	Норма для марок			
	МКРР-130	МКРП-340	МКРПГ-400	ШПГТ-450
ГОСТ или ТУ	23619 79	23619 79	ТУ\ 322 7 00 19053 065 96	ТУ\ 322 7 00 19053 065 96
Массовая доля на прокаленное вещество % Al_2O_3, не менее	51	50	40	40
Массовая доля $Al_2O_3+SiO_2$ % не менее	97	97	90	85
Изменение массы при прокаливании % не более	0,25	6	8	0 3
Кажущаяся плотность кг/м³,не более	130	340	400	450
Температура применения,°С	1150	1150	1250	1250
Теплопроводность при средней температуре 600°С,Вт/(м К) не более	—	0 23	0,28	0 28
Предел прочности при изгибе, Н/мм2, не менее	—	—	0,25	0,4
Средний диаметр волокна, мкм,не более	4	—	—	—
Содержание неволокнистых включений,% размером 0,5 мм и выше	3	—	—	—
Цена за тонну без НДС USD*	1170	1790	1550	1600

*) Цена франко склад ОАО «Северский комбинат» (без транспортных расходов) ориентировочные могут быть изменены в зависимости от объема заказа

Размеры (мм) для рулонного материала МКРР-130,
Длина - 5000-15000, ширина - 600-1400, толщина - 20,30,40 Вес рулона от 10 до 14 кг

Размеры (мм) для плит МКРП-340 МКРПГ-400
Длина - 530-730, ширина - 400, толщина - 40

Размеры (мм) для термообработанных (обожженных) плит ШПГТ 450
Длина 500, ширина - 500, 250, толщина - 100

Размеры могут быть изменены по согласованию с потребителем

Отгрузка любым видом транспорта по согласованию с потребителем

В грузовике объемом 65 м3 можно транспортировать
рулонные материалы - 6-7 тонн,
плиты - 8-12 тонн
В ж д вагоне - 10-13 тонн

Упаковка рулонов в полиэтиленовые пакеты по 8-16 кг Плиты и вставки - в деревянной обрешетке либо в контейнерах

По вопросам приобретения продукции обращаться

Генеральный директор	Чурилов Владимир Васильевич	(06274) 5-26 61
Главный инженер	Северин Владимир Александрович	(06274)5-27-13
Зам ген директора	Миронов Владимир Иванович	(06274)5 41-63
Начальник отдела маркетинга и сбыта	Крапивин Иван Михайлович	(06274)5-22-35

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N	Предприятие	Продукция	Ед. изм.	Цена	Примечания
1	2	3	4	5	6
	Алчевский завод стоительных конструкции	БСТВ сп	кг	3 50	
		Маты мин ват прош стеклохолст	м3	72 00	
		Плита пов жесткости из мин ваты	м3	162 00	фен льное связующее толщ 60мм
4	Белицкий завод Теплозвукоизоляция	БСТВ сп	кг	4 44	
		БСТВ стр	кг	3 24	
		БСТВ с п	кг	3 24	
		Картон ТК 1 10	м2	5 52	
		Картон ТК 1 5	м2	3 12	
		Картон ТК – 6	м2	2 76	
		маты БЗ 1 1000 1000 100	шт	25 80	
		маты БЗМ 1000 1000 50	шт	18 72	
		маты БЗМ 1000 500 50	шт	12 60	
		Маты Т 1 0 15	шт	10 68	
		Маты ТМ 10 20	шт	11 04	
		Плита ПЖТС 14 гидрофоб	м2	16 06	
		Плита ПЖТС 19 гидрофоб	м2	19 08	
5	Донецкий завод изоляционных мат лов	Маты минераловатные прош	м3	50 4 52 3	рулон в оберточной бумаге
		Картон ТК 1 5	м2	4 17	
		Ватин базальтовый	м2	6 85	рулон в оберточной бумаге
		Маты прош теплоиз баз МТПБ	м3	125 00	без обкладки
		Маты прош теплоиз баз МТПБ	м3	289 20	в обкладке
		Полотно иглопроб стекловолокн	м2	5 60	
		Холст стекловолокнистый	м2	0 36	
		Плиты пенополистирольные 25	м3	125 0 140	
		ИБПа 2500 000 65	м3	204 00	
6	Житомирский з д мин ват изделии	Плита Мин ват ПГ 125	м3	50 00	Шлак + базальт
		Вата	м3	12 50	Отходы плиты ПГ
6	Запорожский к т теплоизоляционных м лов	Плиты мин ватные на бит связ	м3	70 50	Отработка из дом печеи нагрев раздув
		Маты мин ватные прошивные	м3	65 13	толщ 50мм
		Маты мин ватные на провол сетке	м3	435 91	
		Плиты пенополистирольные 25	м3	160 50	
7	К т Победа	БСТВ сп	кг	4 50	
		БСТВ стр	кг	3 70	
		маты БЗ М 1000 1000 100	шт	23 00	
		маты БЗМ 1000 1000 50	шт	21 00	
		маты БЗМ 1000 500 50	шт	10 32	
		Плита ПМТБ	м3	498 00	водоотталкивающая
		МБВП	м2	7 08	
		МБПа	м3	216 00	
8	Костопольский з д базальтовых теплоиз м лов	БСТВ супер	м3	40 00	?
		маты баз прошивные в с/ткани	м3	60 00	
		маты баз прошивные			
		маты строительные	м3	70 00	плотность 70кг/м3 2000 1000 50
		маты стр гофриров структ	м3	0 81	плотность 90кг/м3 2000 1000 50
9	Мариупольский з д изоляционных м лов	Маты мин ватные прош	м3	53 52	1000 х 2000 х 65
		Маты мин ватные прош в с/ткани	м3	275 00	1000 х 2000 х 65
		Плиты пенополистирольные 25	м3	184 00	
10	Мерефянский стеклозавод				
11	Новомосковский з д Прогресс				
12	Самаровский з д ЖБИ и фильтровальных изд	Базальтовые маты	м3	60 00	БСТВ т 7см прошит бровингом в ПВХ
13	Павлоградский з д стеновых м лов	БСТВ-сп	кг	5 57	
		БСТВ (тонкие 15 мкм)	кг	2 78	
		Картон ТК 1 10	м2	6,50	
14	Черновицкий з д теплоизоляционных изделии	БСТВ сп	кг	3,40	
		БСТВ стр	кг	2 48	
		Маты ТМ 10 20	шт	7 20	
		Картон ТК 4 5	м2	3,48	
		МБПа	м3	142 00	толщ 40мм 1м3=25м2
	Светловодский завод изоляционных изделии				
18	Кемеровское ПО Прогресс РОССИЯ	БСТВ сп	кг		5 5 грн/кг
19	Ивотский стеклозавод				

АКЦІОНЕРНЕ ТОВАРИСТВО

Білицький завод
ТЕПЛОЗВУКОІЗОЛЯЦІЯ

255700 смт Коцюбинське Київська обл вул Будівельна 7
Тел/факс (04497) 72-306 72-647 - комерційний відділ

№ п/п	ПЕРЕЛІК ПРОДУКЦІЇ	МАРКА ВИРОБУ (розміри)	ОД ВИМ	ЦІНА (гривн з ур ПДВ)
1	ХОЛСТ БАЗАЛЬТОВИЙ	СУПЕРТОНКЕ	кг	4 44
		БУДІВЕЛЬНЕ	кг	3 24
2	КАРТОН ТЕПЛОЗВУКОІЗОЛЯЦІЙНИЙ	Тк 1-5 1180 х 850 х 5	м	3 12
		Тк 1 10 1180 х 850 х 10	м²	5 52
		Тк-4-6 1000 х 1000 х 6	м²	2 75
3	МАТИ ЗВУКОПОГЛИНАЧІ БЗМ	1 100 1000 х1000х100	шт	25 80
		1-50 1000 х1000х50	шт	18 72
		1-50 бк 1000 х 1000 х 50	шт	15 72
		1-30 1000 х 1000 х 30	шт	19,80
		1-30 бк 1000 х 1000 х 30	шт	11 64
		2 100 1000 х 500 х 100	шт	18 12
		2 50 1000 х 500 х 50	шт	12 60
		2-50 бк 1000 х 500 х 50	шт	10 80
		2 30 1000 х 500 х 30	шт	13 92
		2-30 бк 1000 х 500 х 30	шт	9 72
		4-30 1000 х 1000 х 30	шт	18 42
		4-50 1000 х 1000 х 50	шт	19 86
		4-50 бк 1000 х 1000 х 50	шт	15 00
		5-50 1000 х 500 х 50	шт	12 12
		5-50 бк 1000 х 500 х 50	шт	10 32
		6-50 500 х 500 х 50	шт	8 46
		6-50 бк 500 х 500 х 50	шт	6 84
		7-50 600 х 600 х 50	шт	12 24
		7-50 бк 600 х 600 х 50	шт	9 00
		8-50 1000 х 600 х 50	шт	13,92
4	МАТИ ТЕПЛОЗВУКОІЗОЛЯЦІЙНІ	ТМ 10-15 1100 х 600 х 15	шт	10 68
		ТМ 10-20 1100 х 600 х 20	шт	11 04
5	ПЛИТА ЖОРСТКА ТЕПЛОЗВУКОІЗОЛЯЦІЙНА ГІДРОФОБИЗОВАНА	ПЖТЗ 14 1115 х 850 х 14	м²	16 08
		ПЖТЗ 19 1115 х 850 х 19	м²	19 08
6	СМУГА ТЕПЛОІЗОЛЯЦІЙНА ПДТС	5000 х 100 х 20	м/п	2 28
		5000 х 100 х 30	м/п	2 64
		5000 х 200 х 20	м/п	3 84
		5000 х 300 х 20	м/п	4 92
		5000 х 300 х 30	м/п	6 12
		5000 х 400 х 20	м/п	7 68
		5000 х 400 х 30	м/п	8 64
		5000 х 400 х 40	м/п	9 72
		5000 х 500 х 20	м/п	8 40
		5000 х 500 х 30	м/п	9 36
		5000 х 500 х 40	м/п	9 84
		5000 х 500 х 50	м/п	10 92
		5000 х 500 х 60	м/п	12,96
7	РУЛОННИЙ МАТЕРІАЛ БАЗАЛЬТОВИЙ 5000 х 1000 х	РОМБ С-30	м²	11 76
		РОМБ - С-50	м²	13 80
		РОМБ С 70	м²	19 68
		РОМБ С 100	м²	22 20
8	ШНУР ТЕПЛОІЗОЛЯЦІЙНИЙ	БТШ 10	м/п	0 48
		БТШ 20	м/п	0 60
		БТШ 30	м/п	0 84
9	ШНУР ТЕПЛОІЗОЛЯЦІЙНИЙ НАБИВНИЙ	ШБТН 50	м/п	0 90
10	НИТКА КОМПЛЕКСНА	КНБ 9-50	кг	9 72
11	ЖГУТ БАЗАЛЬТОВИЙ	ЖБТН 0-100	кг	8 52
		ЖБТН 0-150	кг	7 32
		ЖБТН 0-300	кг	6 36
		ЖБТН 14-2640	кг	6,96

Банківські реквізити підприємства Р/рахунок № 26003313492 в Бучанському АК УСБ пос Буча Київської обл , МФО 321165, код підприємства 00292729, ІПН 002927210283

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Білицький завод
ТЕПЛОЗВ[illegible]

25[illegible] смт Оболонське
Київської обл вул Б[illegible]вельна
Тел (0[illegible]) 72 050
~~Телетайп 32026 Зенит~~
Факс (0[illegible]) ~~22023~~ 92 5-00

Код підприємства 00292720
Код ст Білич 322303
Р рахунок № 2[illegible]565 в Ірпінському
відділенні АК УСБ МФО 32[illegible]65
смт Бича Київської обл

Від _____ № _____
На _____ від _____

АО Белицкий завод " Т Е П Л О З В У К О И З О Л Я Ц И Я "
предлагает
высокоэффективные, экологически безвредные изоляционные материалы на основе базальтовых волокон, обладающие малой объемной массой, обеспечивающие полную пожарную безопасность, надежную изоляцию от вулканического жара и космического холода, не выделяют в воздушную и водную среды вредных для здоровья соединений
Область применения изоляция стен, полов, потолков, металлических и других поверхностей различной конфигурации, тепловых агрегатов, труб и трубопроводов, а также в качестве звукопоглощающего слоя (или наполнения в конструкциях с двойной стенкой) в строительстве авиа- и судостроении , автомобилестроении электротехнической и химической промышленности

КРАТКИЕ ТЕХНИЧЕСКИЕ ДАННЫЕ НА [illegible]

*** БАЗАЛЬТОВОЕ СУПЕРТОНКОЕ ВОЛОКНО БСТВ ***

Соответствует РСТ УССР 1970-86 изм 1

Средний диаметр волокна, мкм, не более	2,0 - 3,0
Плотность, кг/м куб	20,0 - 25,0
Влажность, % ,не более	2
Теплопроводность при 25 град С, Вт/(м К), не более	0,038 - 0,040
Температура применения ,град С	от -260 до +700

* Применяется в качестве тепло- и звукоизоляции, для изготовления теплозвукоизоляционных, звукопоглощающих и фильтрующих материалов и изделий, которые эффективно используются в автомобилестроении, авиастроении , гражданском и промышленном строительстве , теплоэнергетике , а также для грубой очистки воздуха
Базальтовое волокно применяется и как армирующий материал

*** КАРТОН ЖЕСТКИЙ ТЕПЛОИЗОЛЯЦИОННЫЙ ТК-1-5 , ТК-1-10 ***

Соответствует ТУ Украины 023 018-95

Формат,мм	длина	1150
	ширина	850
	толщина	5 0
Плотность,кг/м куб,не более		150
Гигроскопичность за 24 часа, не более %		0,35
Теплопроводность при 25 град С, Вт/(м К),не более		0,045
Предел прочности при растяжении,МПа, (кгс/см Кв) не менее		0,32(3,2
Температура применения,град С		от -260 до+700

* Является эффективным заменителем асбокартона

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*** [illegible] ТЕПЛОИЗОЛЯЦИОННЫЕ МАТЫ ***

Соответствует ТУ-88 Украины 023 015 93

Размеры мм	длина	1115
	ширина	850
	толщина	14, 19
Плотность, кг/м куб, не более		280
Сорбционное увлажнение, %, не более		5,0
Теплопроводность при температуре 25град С, Вт/(м К) не более		0,046
Предел прочности при изгибе, МПа, не менее		0,5
Предел прочности при растяжении, МПа, не менее		0,005
Температура применения, град С		от -260 до +700

* Предназначены для изоляции холодных и горячих поверхностей в строительстве, судостроении (для изготовления панелей отделки судовых помещений в качестве тепловой и звуковой изоляции) машиностроении, при производстве электробытовых приборов, машин и в других областях, где требуется [illegible] Заменитель асбестовых плит

*** МАТЫ ЗВУКОПОГЛОЩАЮЩИЕ ТЕПЛОИЗОЛЯЦИОННЫЕ БЗМ ***

Соответствует РСТ Украины 1977-87 изм-1

Размеры мм	длина	500, 600, 1000
	ширина	500, 600, 1000
	толщина	30, 50, 100, 200
Плотность, кг/м куб		от 34 до 264
Теплопроводность Вт/(м К), не более при 25 град С		0,037
	при 125град С	0,068

Нормальный коэффициент звукопоглощения матов при толщине 15 мм и при частоте 500-2000 Гц 0,35-0,78

Среднеарифметический реверберационный коэффициент звукопоглощения мата толщиной 15 мм, не менее, в диапазоне частот

среднечастотный	0,6
высокочастотный	0,8

* Применяются в качестве звукошумопоглощающего покрытия (наполнения)

*** МАТЫ ТЕПЛОИЗОЛЯЦИОННЫЕ БАЗАЛЬТОВЫЕ ТМ-[illegible] ***

Соответствует РСТ Украины 1981-87 изм-1

Размеры мм	длина	1100
	ширина	600, 700, 800
	толщина	5, 10, 15, 20
Плотность, кг/м куб		от 41 до 66
Теплопроводность при температуре 25 град С, Вт/(м К), не более		0,057
Предельная температура применения, град С		+ 450

* Причисляются для изоляции холодных и горячих поверхностей в строительных объектах, авиастроении, судостроении и машиностроении

*** ПОЛОСЫ ДЛИННОМЕРНЫЕ ТЕПЛОИЗОЛЯЦИОННЫЕ МАТЫ ***

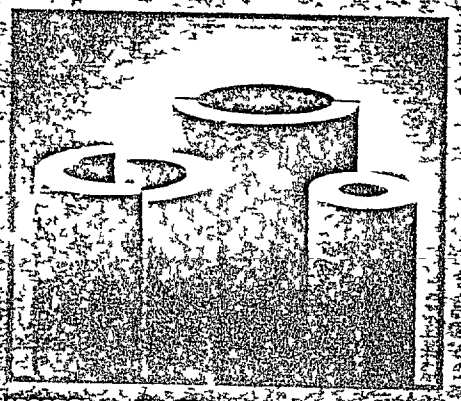
Соответствует ТУ-88 Украины 023 015 94

Размеры, мм	длина	не менее 5000
	ширина	100, 200, 300, 400, 500
	толщина	20, 30, 40, 50, 60
Теплопроводность, Вт/(м К)		0,040
Предельная температура применения, град С		+ 450

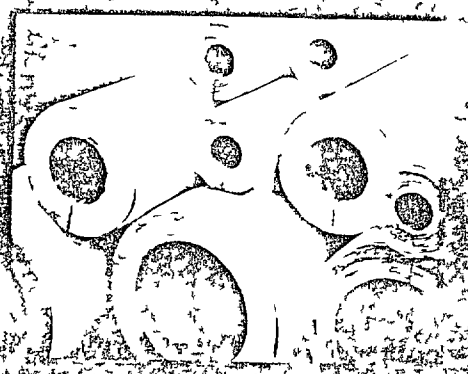
* Полосы применяются для изоляции труб, тепловых агрегатов, систем общего и специального назначения в различных отраслях народного хозяйства

COMPANION CERTAINTEED INSULATIONS

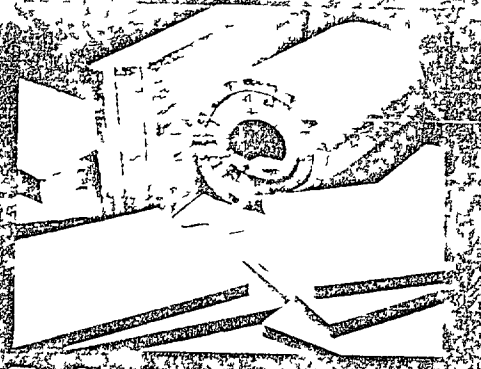
CertainTeed



1200 Snap-On Pipe Insulation — One-piece mineral fiber pipe insulation for hot and cold pipe, up to 1200°F.



500 Snap-On Pipe Insulation — One-piece fiber glass insulation for hot and cold pipe, up to 500°F.



Fiber Glass Board — Full line of semi-rigid to rigid board insulations for sub-zero to 850°F. Flexible board with facing for temperatures up to 250°F. Boards without facing up to 450°F. 850°F fiber glass board for hot metal surfaces up to 850°F. Snap-N-Wrap semi-rigid wrap type all-purpose insulation for large piping, tanks and other curved surfaces. Up to 450°F.

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Chowchilla, CA 93610
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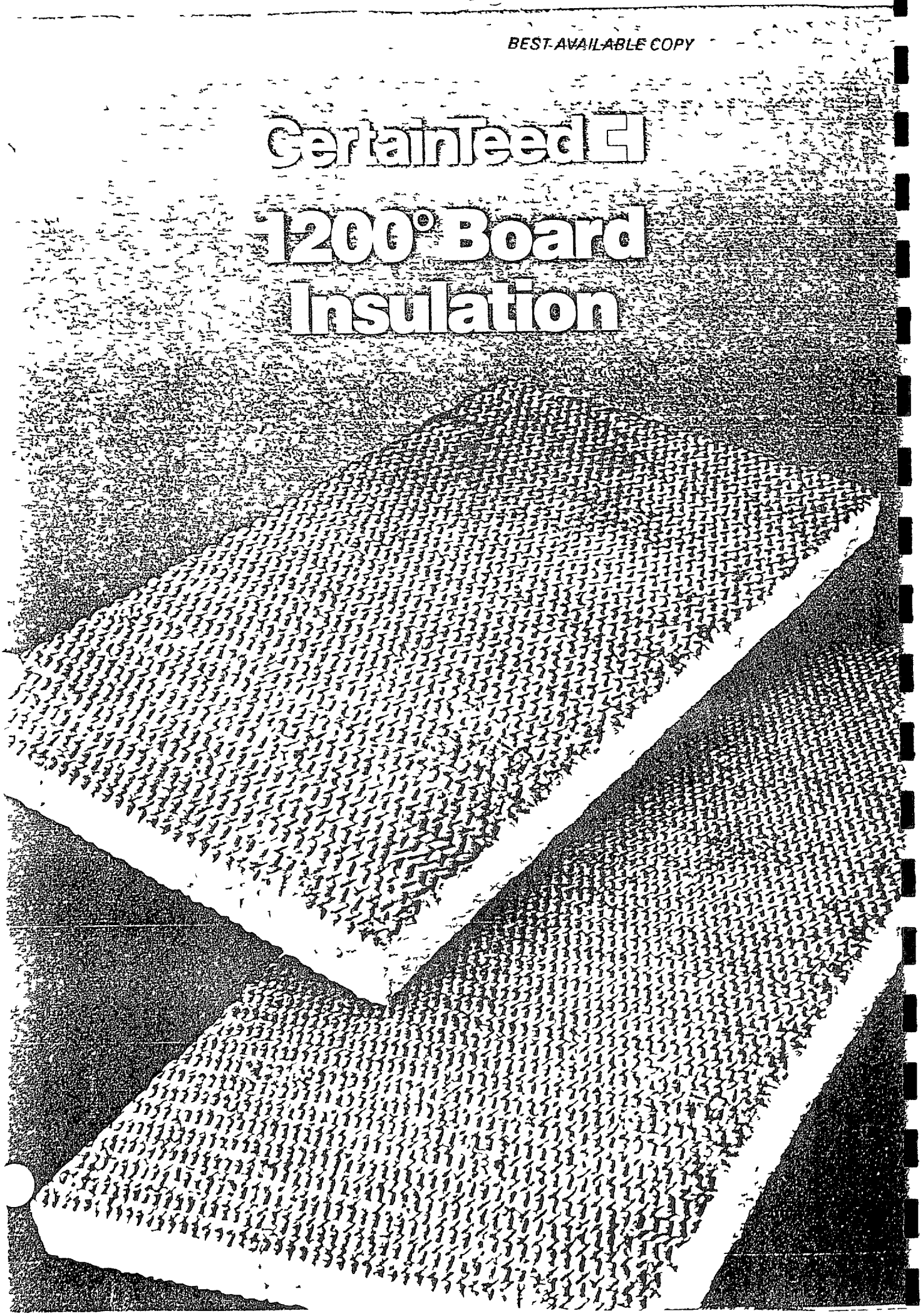
Inasmuch as CertainTeed has no control over installation, design, installation workmanship, accessory materials, or conditions of applications, CertainTeed does not warrant the performance or results of any installation containing 1200 Board Insulation. This warranty disclaimer includes all implied warranties, including the warranties of merchantability and fitness for a particular purpose.

CertainTeed

1200° Board Insulation



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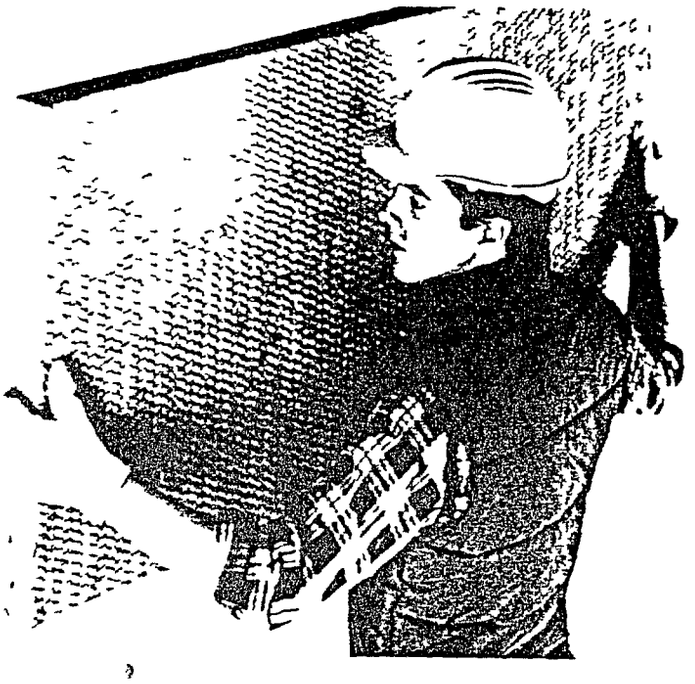
1200° Mineral Fiber Board Insulation



Description

1200 Board is a high quality board type insulation manufactured from long rugged mineral fibers tightly bonded together with a thermosetting resin The result is a product of exceptional uniformity and density not found in other mineral fiber board insulations State of the art fiber forming processes have contributed to this new age quality The boards are lighter in weight and have excellent thermal and acoustical properties

Available in various densities from semi rigid to rigid in thicknesses from 1 to 7 in ½ increments Board lengths are 36 and 48 widths are 24" and 48

Uses

1200 Board has an extended temperature range up to 1200 F This extended range coupled with rugged strength corrosion and fire resistance properties makes 1200 Board an extremely versatile all purpose insulation for many industrial uses Typical are

Storage tanks columns towers
Cat crackers and cokers
Chemical vessels
Ducting breeching chimneys precipitators
Turbines boiler walls
Exhaust stacks and headers

Benefits

Lower fuel bills — excellent thermal efficiency and no shrinkage heat loss due to open insulation joints

Lower installed costs — boards fabricate easily with only a knife No saws are required The insulation fits snugly around obstacles

Low fire hazard classification — non combustible characteristics make 1200 Board a particularly suitable insulation to use as added protection against fire damage to contents

No heat up requirements — unlike some other insulations that require a heat up schedule 1200 Board can be applied directly to hot surfaces or brought up directly to maximum operating temperatures

Performance Characteristics

Thermal Performance (ASTM C 177 ASTM C 158)

Thermal Conductivity (k) — Btu • in / (hr SF F)

Type	Specified Density lbs per cubic ft	50	150	300	500	700
1240	4	4		4		
1260	6		6	7		
1 80		8	8			
1210			9	9		
12 2		4				

The above densities are as specified by ASTM C 612 Delivered densities may vary For more information contact your CertainTeed representative

Service Temperature (ASTM C 411) 1200 continuous temperature

Moisture Adsorption (ASTM C 553) Less than 2%

Corrosion Resistance (HH I 558B 4 4 3 ASTM C 665) Does not accelerate corrosion of steel copper or aluminum Non corrosive to austenitic stainless steel

Shrinkage (ASTM C 356) 0% at 1200 F

Combustibility (ASTM E 136) Non combustible

Specification Compliance

1200 Board insulation has physical properties that regularly meet the requirements of the following specifications

ASTM C 612, Class 4 — Mineral fiber board spec, including density and shot determination

ASTM C 795 — Stress corrosion and chemical analysis

NRC 1 36 — Stress corrosion and chemical analysis

When certificates of compliance are required this must be stated on the purchase order

Recommended Minimum Thickness (inches)

Operating Temp F	150	250	350	450	550	650	750	850	950	1050	1150
Flat Surface Insulation Thickness	2	3½	4	4½	5½	8½	9½	10	10	10	10

The Thermal Insulation Manufacturers Association (TIMA) compiled these tables based on the application of the TIMA Economic Thickness of Insulation (ETI) computer program to obtain economic thicknesses of the insulation types over a wide range of operating temperatures and an average set of general economic and ambient design criteria The economic thickness is defined as that insulation thickness which yields the lowest annual cost of ownership and operation This Energy Saving Guide does not replace ETI it reflects the results of multiple applications of ETI based on current economic and typical design conditions

CertainTeed also manufactures fiber glass insulation for Mechanical Systems and Commercial and Industrial Buildings including

Ultralite Duct Liner — used as an acoustical liner in sheet metal ducts

Standard Duct Wrap — blanket type vapor retarder faced insulation used for wrapping heating ventilating and cooling ductwork

Ultra•Duct Board — rigid board faced with foil laminate air barrier and molded male and female shiplap joints for fabrication into duct sections

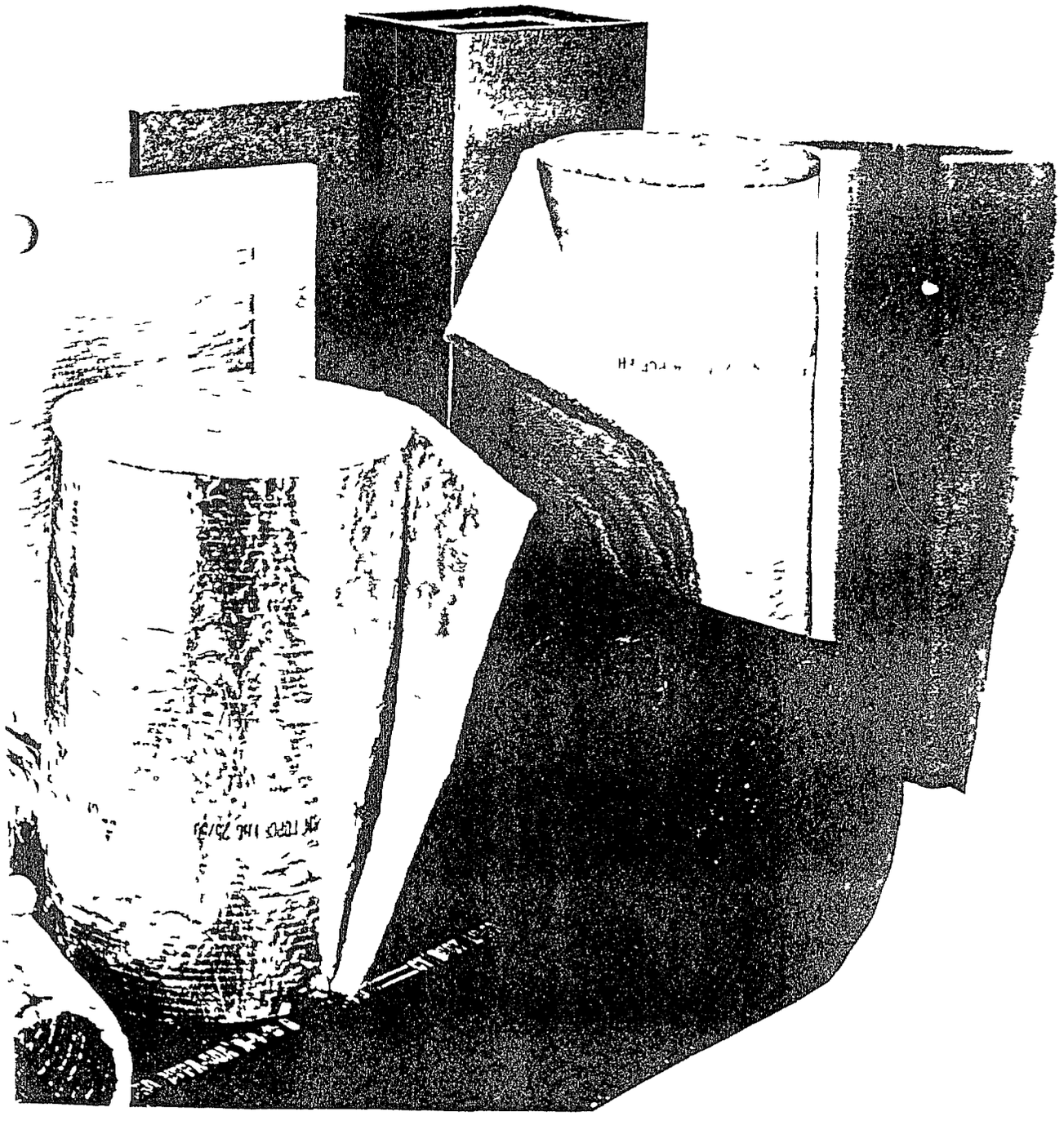
Certaflex — flexible insulated reinforced air duct with choice of two outer jackets used for HVAC runouts

Metal Building Insulation — MBI 202 is a fiber glass insulation with laminator applied vapor retarder that meets TIMA specifications MBPI unfaced fiber glass insulation is used as a filler insulation and applied as a second layer over MBI 202

Wall and Panel Insulation — semi rigid fiber glass boards plain or with an FSK 25 vapor retarder facing used in wall construction

In addition CertainTeed also offers a wide range of thermal and acoustical insulations for Light Commercial and Residential applications including

Unfaced Building Insulation
Kraft Faced Building Insulation
Foil Faced Building Insulation
Sound Control Batts
Insulation with Flame Resistant Foil Facing
Insul Safe III®
Masonry Wall Batts
Sill Sealer
Ultratherm Suspended Ceiling Batts

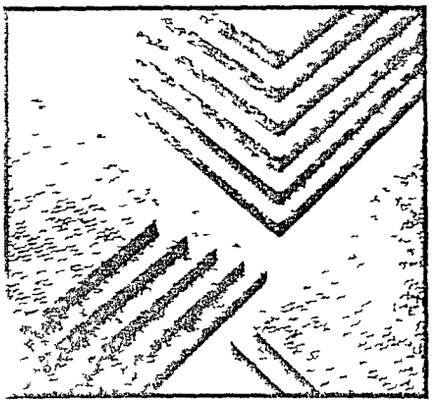


CertainTeed

1200° BOARD INSULATION

Description:

1200 Board is a high quality board type insulation manufactured from high temperature resistant mineral fibers tightly bonded together with a thermosetting resin. The result is a product of exceptional uniformity and density not found in other mineral wool board insulations. State of the art fiber forming processes have contributed to this new age quality. The boards are lighter in weight and have excellent thermal and acoustical properties. Available in various densities from semi rigid to rigid in thicknesses from 0.7 in. increments. Board lengths are 36 and 48, widths are 24 and 48.



Uses:

1200 Board has an extended temperature range from ambient to 1200 F. This extended range coupled with rugged strength, corrosion and fire resistance properties makes 1200 Board an extremely versatile thermal insulation for energy conservation, process control and personnel protection. Typical uses are:

- Storage tanks, columns, towers
- Cat crackers and cokers
- Chemical vessels
- Ducting, breeching, chimneys, precipitators
- Turbines, boiler walls
- Exhaust stacks and headers

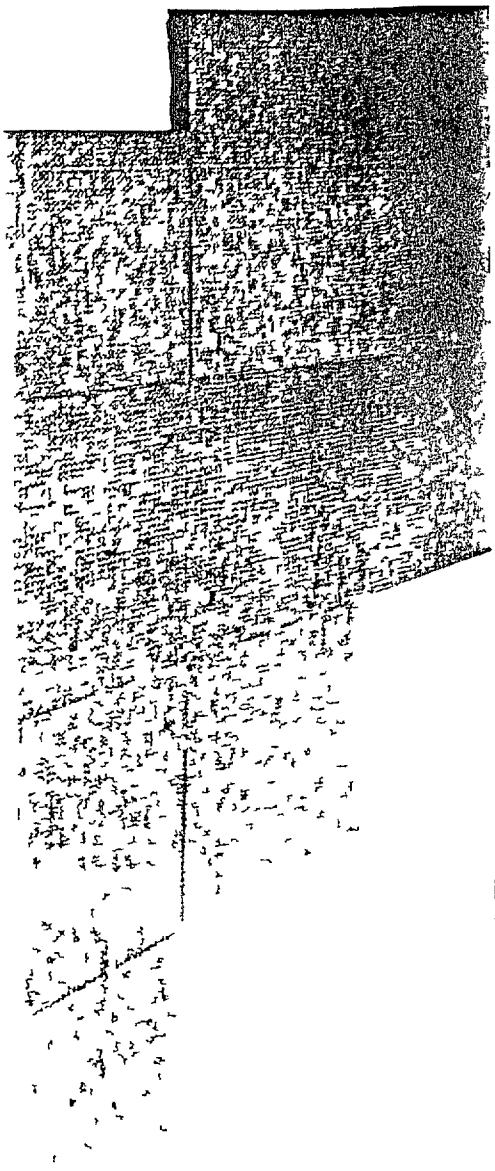
Benefits

Lower Energy Costs—Excellent thermal conductance.

Lower Installed Costs—Boards fabricate easily providing easy installation. In addition there is less waste due to breakage. The insulation fits snugly around obstacles.

Low Fire Hazard Classification—Non combustible characteristics make 1200 Board a particularly suitable insulation to use as added protection against fire damage to contents.

No Heat Up Requirements—Unlike some other insulations that require a heat up schedule, 1200 Board can be applied directly to hot surfaces or brought up directly to maximum operating temperatures.



Performance Characteristics

Thermal Performance (ASTM C177) (ASTM C158)

Thermal Conductivity (k) — B

Type	Specific Density lbs per cubic ft	50	150	300	500	700
1240	4.0	224	272	40	6.6	9.5
1260	6.0	7	26	38	5.1	7.2
1280	8.0	228	260	35F	4	1
1210	1.0	226	26	34	47	F
1212		2.4			4.4	5

The above densities are as specified by ASTM Co 2 Delivered densities may vary For more information contact your Ch anTeed representative

Service Temperature (ASTM C411) 1200 continuous temperature

Moisture Absorption (ASTM C553) Less than 2 %

Corrosivity (HH I 558B 4 4 3) (ASTM C665)

Does not accelerate corrosion of steel copper or aluminum Non corrosive to austenitic stainless steel

Fire Hazard Classification UL 723 (ASTM E 84)

Flame spread rating not exceeding 25 and smoke developed rating not exceeding 50

Specification Compliance

1200 Board insulation has physical properties that regularly meet the requirements of the following specifications

ASTM C612, Class 4—Mineral fiber board spec including density and shot determination

ASTM C795—Stress corrosion and chemical analysis

NRC 1 36 –Stress corrosion and chemical analysis

Spe equirements apply V e lo tes ng u a/ / he follow ng kind e ed ind ate

1 a he y e and m e s ted nd

2 l e a cop of the custom- on raul and the spe fica o to the o pe t RC 1 Cb Chemica ana s S ess Co s on Cracking ST C79 Chemica A e S ess Co os n C acki o F e epo dure co e e Fo pe to e c a c pe

Recommended Thickness—CT1260 Mineral Fiber Board Insulation

65 amb en a 7 5 mph wind

Ful Se ce—8760 h s pe yea

T—Ba n e ange T) F

ST—S e Tempera u e

OPERATING TEMPERATURE																	
150			250			350			450			550			650		
T	HL	ST	T	HL	ST	T	HL	ST	T	HL	ST	T	HL	ST	T	HL	ST
1	20		1	48	88	2		86	2	52		3	52		5	50	89
	750			850			950			1050							

GLASS FURNACE

CertainTeed

EQUIPMENT, TANK INSULATION

850° Fiber Glass Board Insulation

description

CertainTeed 850 Fiber Glass Insulation Board is a semi rigid board insulation composed of glass fibers bonded together with a special binder This highly efficient insulation is usually applied in 2 x 4 sizes but larger sizes up to 4 x 10 are available for large surfaces The product is available in thicknesses from 1 to 4

The glass fiber is not affected by moisture will not corrode metals and is permanent 850 Board will permit expansion and contraction of the heated surface without cracking or shrinking The insulation will not slump or disintegrate under normal vibration conditions

uses

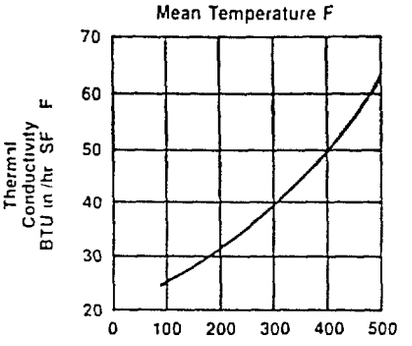
850 Board is saving energy and installation cost in power process and commercial buildings for such uses as breeching boilers ducts precipitators chimney liners and other heated equipment The lightweight boards are usually installed directly to heated surfaces and finished with insulating cement or metal jacketing It can also be used in metal panel systems

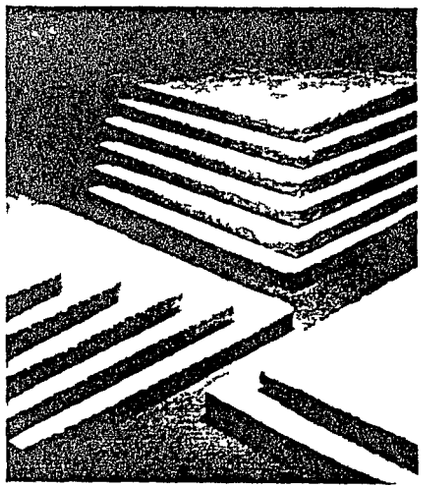
benefits

- No heat up schedule required can be applied on hot surfaces up to 850°F
- Lower energy cost
  Efficient larger size boards up to 4 x 10 mean less joints to leak heat Dimensionally stable boards will not slump or disintegrate in the presence of vibration Thickness remains constant because of board compression recovery
- More comfortable working conditions
  Efficiency of CertainTeed 850° Board keeps areas around heated equipment cooler
- Installation cost savings
  Larger sized boards cover area faster Lighter weight and structural integrity permits handling of larger boards with no breakage loss Boards may be cut with an ordinary knife to fit tightly around appurtenances
- Reduced maintenance cost
  A properly installed CertainTeed 850° Board insulation job requires little or no maintenance The strong dimensionally stable boards are permanent They will not slump or crack The only maintenance required is to keep the surface covering in good condition for appearance or weather protection reasons

thermal performance

(ASTM C 177) after exposure to 850° F





performance characteristics

Fire Safety
Meets requirements of (ASTM E 136 73) flame spread not exceeding 25 and smoke developed not exceeding 50 (UL 723 or ASTM E 84)

Service Temperature
Recommended for temperatures up to 850 F (ASTM C 411)

Thermal and Vibration Shock Resistance
Will not crack split shrink or crumble

Moisture Adsorption
Less than 1% by volume (ASTM C 553)

Corrosion Resistance
Will not cause corrosion of aluminum steel or copper or stress corrosion cracking of stainless steel (HH 1 558 and MIL 1 24244B)

Resistance to Fungi & Bacteria
Does not breed or promote growth (ASTM C 665 86)

Alkalinity
Less than 0 6% sodium oxide pH of 9 1 (MIL 1 22344B)

specification compliance

850 Board has physical properties that regularly meet the requirements of MIL I 15475C (Ships) (except for vibration) HH I 558B Insulation Blocks Boards Blankets Felts Sleeving (Pipe and Tube Covering) and Pipe Fitting Covering Thermal (Mineral Fiber Industrial Type) Form A Class 3 (waiver needed on compressions strength) ASTM C 612 70 Class 3 (to 850 F) For compliance with MIL I 24244 contact Customer Service in Valley Forge

Note 850 Board is designed to comply with any one of the above specifications should indicate that requirement on the purchase order

installation

CertainTeed 850° Board is usually applied directly to metal surfaces by impaling over welded pins or studs secured with washers or clips The insulation surface is then covered with metal mesh insulating cement and canvas or finished with a metal covering sheet

Pins or studs should be spaced on center not exceeding 16 Pins at the insulation edges should not be more than 4 from the edge

Multiple layer installation with broken joint construction should be used for service temperatures above 600° F

Designers are cautioned to consider thermal bridging when using pins studs framing and supports made of metal Limit maximum insulation surface temperature to 150 F

CertainTeed

FIBER GLASS EQUIPMENT, TANK INSULATION

Industrial Insulation Board

description

CertainTeed Industrial Insulation Board (IB Board) is composed of glass fibers bonded together with a thermosetting resin It is available in 2 x 4 standard sizes either faced with a vapor barrier facing or plain in thicknesses of 1 to 4 depending on density Special sizes up to 48 x 120 are available with Foil Scrim Kraft or All Service Jacket The Foil Scrim Kraft (FSK) is a glass scrim reinforced laminate of aluminum foil and kraft bonded together with a fire retardant adhesive The foil side is out to present a neat metallic surface finish All Service Jacket (ASJ) is composed of a reinforced white kraft and aluminum foil laminate with the white kraft facing out

uses

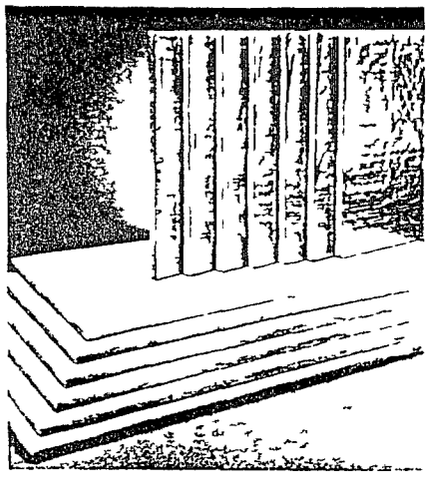
IB Board is a general purpose insulation used to insulate hot or cold tanks vessels equipment ductwork plenums as a lining for equipment rooms or wherever a neat finished insulation job is desired IB Board is made in varying densities imparting rigidity characteristics from flexible (IB 150) to rigid (IB 600) There is a degree of rigidity for nearly any application requiring conformance to curved surfaces or resistance to compression or where sharp square edges are required

IB Board plain (unfaced) is used primarily for heated application (up to 450F) and for acoustical treatment It may be subsequently finished Faced IB board in either FSK (metallic foil appearance) or ASJ (clean white kraft appearance) is used where a neat appearance is desired and/or a vapor barrier is required on cold surfaces Matching foil or ASJ tapes are available to finish off

When IB Board is faced the insulation must be of sufficient thickness to maintain a surface temperature not exceeding 150 F

benefits

- Lower fuel bills
  Exceptional thermal efficiency of IB Board helps save more energy than many board or block type insulations used in industrial or commercial applications
- Conforms to irregular surfaces
  Fiber glass composition permits conformance to curved surfaces or where surface irregularities exist
- Dimensionally stable
  Strong fiber glass resin bonded boards retain thickness and structural integrity under severe service conditions that will cause other insulations to compress compact crack or crumble Recovers thickness after being compressed
- Lower installed cost
  It is easier to cut and fit and is less weight than other insulations No breakage under ordinary conditions means less waste
- Neat finished appearance
  Board type insulation cuts cleanly with neat square corners Available in a choice of factory applied vapor barrier facings for metallic or crisp white surface appearance



performance characteristics

thermal conductivity (ASTM C 177)

Board Type	Density lbs cu ft.	K Factor at Mean Temperatures 75	100	200	300
IB150	1 ½	25	.26	33	43
IB200	2	23	25	32	40
IB250	2 ½	.23	24	30	38
IB300	3	23	23	28	36
IB420	4 ½	23	23	28	35
IB600	6	22	23	27	33

BTU in HR SF F

sound absorption (ASTM C 423 unfaced board)

Type	Thickness	Coefficients at Frequencies 12	250	500	1000	2000	4000	NRC
IB150	1	19	62	72	82	88	89	75
IB200	1	15	55	73	86	92	94	75
IB250	1	.25	52	71	83	89	95	75
IB300	1	19	49	69	87	92	94	75
IB420	1	33	40	70	94	1 00	98	75
IB600	1	12	52	68	87	93	99	75

No se Reduct on Coefficient
F25 Mounting (formerly No 6)

Fire Safety (ASTM E 84 or UL 723) Flame Spread rating not exceeding 25 and a Smoke Developed rating not exceeding 50

Service Temperature (ASTM C 411) Recommended for use from -20F to 450F

Thermal Shock Resistance Will not crack split shrink or crumble

Moisture Adsorption (ASTM C 553) Not exceeding 1 0% by volume

Corrosion Resistance Will not cause corrosion of aluminum steel or copper as tested in accordance with the Method in HH I 558

Resistance to Fungi & Bacteria (ASTM D 2020 Method A) Does not breed or promote

Vapor Transmission (Facings) (HH B 100B) 02 perm rating puncture resistance (beach units) 50 ASJ 25 FSK

specification compliances

	IB 150	IB 200	IB 250	IB 300	IB 420	IB 600
HH B 100B Type 1 (Facing)	x	x	x	x	x	x
HH I 558 B						
Form A						
Class 1 & 2				x	x	x
Form B Type 1						
Class 6						
B-4	x					
B 5		x				
B 6				x		
Form B Type I						
Class 7	x	x	x	x		
Class 8						
MIL I 22023C						
Type I & II						
Class 4	x					
Class 5		x				
Class 6				x		
ASTM C 553 70						
Type I B4	x					
B5		x				
ASTM C 612 70						
Class 1			x	x	x	x
Class 2				x	x	x

NOTE
All products ordered to comply with any one of the above specifications should indicate that requirement on the purchase order The product has physical properties that meet the physical requirements section of the referenced specification

installation

CertainTeed IB Board Insulation is usually applied directly to metal surfaces by impaling over welded pins or studs secured with washers or clips The insulation surface is then covered with metal mesh insulating cement and canvas or finished with a metal covering sheet or faced boards are neatly taped at the joints For cold applications a vapor barrier facing is required with all joints taped to assure a continuous vapor barrier Rub pressure sensitive tapes with a nylon sealing tool to assure positive bond Apply only if temperature is between 35 and 110 F Outdoor applications require addition of weather protection Facings may be painted with a water based paint Consult your CertainTeed representative for special conditions

Pins or studs should be spaced on center not exceeding 16 ' Pins at the insulation edges should not be more than 4" from the edge Cover all pins and washers with a matching vapor barrier patch

Designers are cautioned to consider thermal bridging when using pins studs framing and supports made of metal Limit maximum insulation surface temperature to 150 F

CertainTeed

CertainTeed Corporation
P O Box 860 Valley Forge PA 19482

qualifications for use

The maximum use temperature of an insulating material is that temperature above which it no longer provides satisfactory or efficient service as a thermal insulation when applied under conditions of normal usage A normal condition implies low applied loads limited vibration moderate thermal stresses and a nondestructive atmosphere

There is no single test for determining the maximum use temperature applicable to all types of insulation or even to one type of insulation under all possible conditions of use The maximum use temperature of 850°F for 850° Board has been estimated from product performances in the following test procedures

1 ASTM C 356 Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat 850° Board has negligible linear shrinkage and or warpage after 96 hours exposure and the loss in weight does not exceed 4% by weight
2 ASTM C 411 Hot Surface Performances of High Temperature Thermal Insulation 850° Board does not flame glow smolder crack warp or delaminate when applied to the hot surface and exposed for 96 hours During initial heat up the controlled decomposition of the bonding material may result in smoke having an acrid odor If natural convection is not adequate in confined areas forced ventilation should be provided
3 ASTM C 177 Thermal Conductivity of Materials by Means of the Guarded Hot Plate The thermal conductivity (k) of 850° Board exposed for 96 hours per ASTM C 411 shows no appreciable deterioration from the thermal conductivity of the specimen measured before the exposure
4 ASTM E 84 Surface Burning Characteristics of Building Materials 850° Board has a maximum flame spread classification of 25 and a maximum smoke developed classification of 50
5 850° Board does not smolder when a steel rod ¾ x 2 at 1450°F is placed between two specimens (12 x 12 x nominal thickness) mounted on a flat surface under a load of 2 pounds for a period of one hour

The information herein is accurate (subject to normal production and testing variations) and reliable to the best of CertainTeed Corporation s knowledge However since CertainTeed has no control over installation design installation workmanship accessory materials or conditions of application no express or implied warranty is made as to the performance or results of an installation containing 850° Board

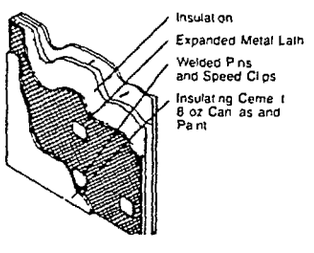
recommended thickness

	Service Temperature															
	500				600				700				800			
	Indoor		Outdoor		Indoor		Outdoor		Indoor		Outdoor		Indoor		Outdoor	
Thickness	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
bare	1567	500	4185	500	2299	600	5519	600	3231	700	7068	700	4400	800	8865	800
50																
10																
15																
20																
25	58	115	65	21												
30	49	110	54	18	67	120	73	23								
35	42	106	47	16	58	115	63	20								
40	3	103	41	14	51	111	55	18	68	120						
45	33	101	36	13	45	108	49	17	61	116	64	21				
50	30	99	33	12	41	106	44	15	55	113	58	19	71	121	74	23
55	27	98	30	11	3	104	40	14	50	110	52	18	65	118	67	21
60	25	96	27	10	34	102	37	13	46	108	48	16	59	116	61	20
65	23	95	25	10	32	100	34	12	42	106	44	15	55	113	57	19
70	21	94	23	9	30	99	31	12	39	105	41	15	51	111	53	18

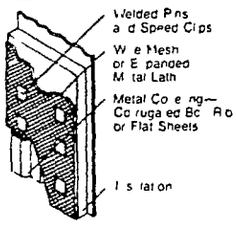
legend & inputs
HL—Heat Loss Btu ft hr
ST—Surface Temperature F
outdoor—0 F ambient air 20 mph 4 emissivity
indoor—80 ambient air 0 mph 9 emissivity
No parallel heat flow paths considered

application details

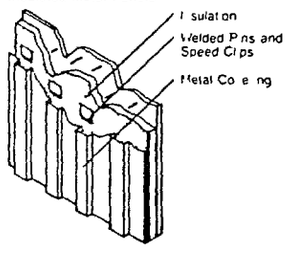
Canvas Finish



Metal Finish



Insulated Metal Panels



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713 988 4411

Inasmuch as CertainTeed has no control over installation design installation workmanship accessory materials or conditions of application CertainTeed does not warrant the performance or results of any installation containing their products This warranty disclaimer includes all implied warranties including the warranties of merchantability and fitness for a particular purpose

Code No 30 31 50 10M 7/88

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P O Box 860 Valley Forge PA 19482

recommended thickness

Hot Surfaces—Indoor Conditions—80 F ambient still air (No parallel heat flow paths considered)

Service Temp	200			300			400		
Thickness (in)	Energy Loss Bare (btu/sq ft)	Energy Loss Insul (btu/sq ft)	Surface Temp (F)	Energy Loss Bare (btu/sq ft)	Energy Loss Insul (btu/sq ft)	Surface Temp (F)	Energy Loss Bare (btu/sq ft)	Energy Loss Insul (btu/sq ft)	Surface Temp (F)
1	282	26	97	641	52	112	1126	85	127
2	282	14	90	641	28	99	1126	45	108
3	282	9	87	641	19	94	1126	31	99
4	282	7	86	641	15	91	1126	24	96
5	282	6	85	641	12	89	1126	19	93
6	282	5	84	641	10	88	1126	16	91
7	—	—	—	—	9	86	1126	14	90
8	—	—	—	—	—	—	1126	12	89
9	—	—	—	—	—	—	—	—	—

Hot Surfaces—Outdoor Conditions—0 F ambient 20 mph wind

Service Temp	200			300			400		
Thickness (in)	Energy Loss Bare (btu/sq ft)	Energy Loss Insul (btu/sq ft)	Surface Temp (F)	Energy Loss Bare (btu/sq ft)	Energy Loss Insul (btu/sq ft)	Surface Temp (F)	Energy Loss Bare (btu sq ft.)	Energy Loss Insul (btu/sq ft.)	Surface Temp (F)
1	1375	43	15	2358	72	20	3517	105	31
2	1375	22	9	2358	37	13	3517	54	18
3	1375	15	7	2358	25	10	3517	37	14
4	1375	19	8	2358	28	10	3517	39	13
5	1375	9	5	2358	15	7	3517	22	9
6	1375	8	4	2358	13	6	3517	19	8
7	—	—	—	2358	11	5	3517	16	7
8	—	—	—	—	—	—	3517	14	6
9	—	—	—	—	—	—	—	—	—

cold surfaces

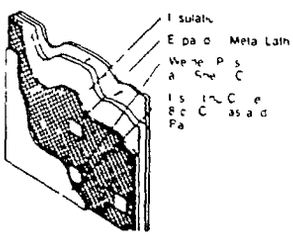
Thickness options based on permissible relative humidity (RH) and heat gain (HG)—90 ambient (3 300 hrs /yr operation)

Operating Temperature	60 F		50 F		40 F		30 F		0 F	
Insulation Thickness	HG	RH	HG	RH	HG	RH	HG	RH	HG	RH
1	20	89	26	86	33	82	39	79	58	72
1½	14	91	18	90	23	87	27	85	40	79
2	11	92	14	91	18	90	21	88	31	82
2½	9	93	12	92	14	91	17	90	25	86
3	7	94	10	93	12	92	14	91	21	89

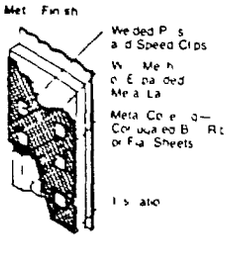
RH figures shown are maximum permissible humidity (%) to prevent condensation on the insulation surface
HG Heat Gain = MM BTU gained 1000 sq ft during operating year For information on sub-zero applications contact CertainTeed representative

application details

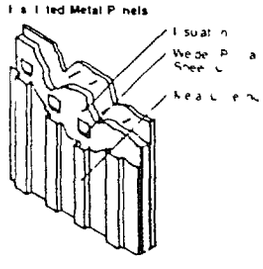
Cast Finish



Metal Finish



Installed Metal Panels



Sales Regions & Offices

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Kansas City KS 66115
913 [illegible] 0094

Western Region Office
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Chatsworth CA 91311
213 [illegible] 1318

Southern Region Office
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Atlanta District Sales Office
4360 Chamblee Dunwoody Road
Suite 230
Atlanta GA 30341
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Houston District Sales Office
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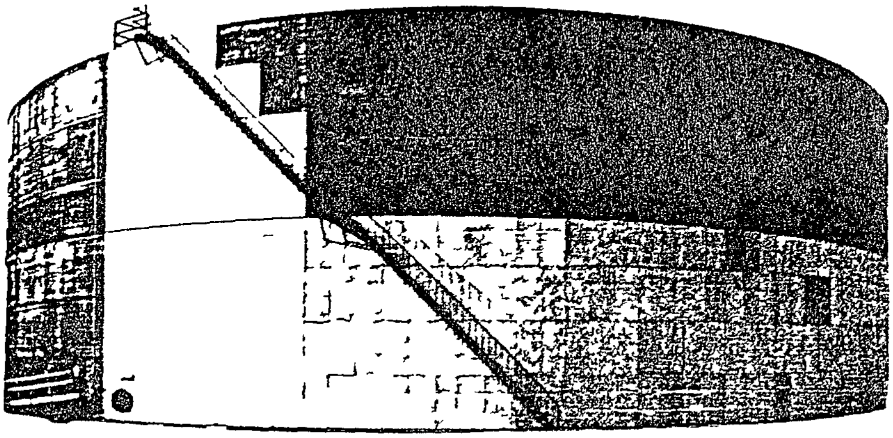
Houston TX 77036
713 995-4411

CertainTeed

IB Fiber Glass Equipment, and Tank Insulation Board



Description

CertainTeed Industrial Insulation Board (IB Board) is composed of glass fibers bonded together with a thermo setting resin It is available in 2 x 4 standard sizes either faced with a vapor retarder facing or plain in thicknesses of 1" to 4" depending on density Special sizes up to 48 x 120" are available with Foil Scrim Kraft or All Service Jacket The Foil Scrim Kraft (FSK) is a glass scrim reinforced laminate of aluminum foil and kraft bonded together with a fire retardant adhesive The foil side is out to present a neat metallic surface finish All Service Jacket (ASJ) is composed of a reinforced white kraft and aluminum foil laminate with the white kraft facing out

Uses

IB Board is a general purpose insulation used to insulate hot or cold tanks vessels equipment ductwork plenums and as a lining for equipment rooms or wherever a neat finished insulation job is required IB Board is made in varying densities imparting rigidity characteristics from flexible (IB 150) to rigid (IB 600) There is a degree of rigidity for nearly any application requiring conformance to curved sur faces or resistance to compression or where sharp square edges are required

IB Board plain (unfaced) is used primarily for heated applications (up to 450 F) and for acoustical treatment It may be subsequently finished Faced IB Board with either FSK (metallic foil appearance) or ASJ (clean white kraft appearance) is used where a neat appearance is desired and/or a vapor retarder is required on cold surfaces Matching foil or ASJ tapes are avail able to finish off and seal joints

When IB Board is faced the insula tion must be of sufficient thickness to maintain a surface temperature not exceeding 150 F

Benefits

Lower fuel bills — exceptional thermal efficiency of IB Board helps save more energy than other board or block type insulations

Conforms to irregular surfaces — fiber glass composition permits con formance to curved surfaces or where surface irregularities exist

Dimensionally stable — strong fiber glass resin bonded boards retain thick ness and structural integrity under severe service conditions that will cause other insulations to compress compact crack or crumble Recovers thickness after being compressed

Lower installed cost — it is easier to cut and fit and weighs less than many other insulations No breakage under ordinary conditions means less waste

Neat finished appearance — board type insulation cuts cleanly with neat square corners Available in a choice of factory applied vapor retarder facings for metallic or crisp white surface appearance

Performance Characteristics

Thermal Performance (ASTM C 177)

Board Type	Density lbs cu ft	k factor at Mean Temperatures			
		5	100	[illegible]	300
[illegible]	[illegible]		[illegible]		[illegible]
[illegible]					[illegible]
[illegible]	[illegible]				[illegible]
[illegible]	[illegible]				[illegible]
[illegible]	[illegible]				[illegible]
	[illegible]				

Sound Absorption (ASTM C 423 unfaced board)

Board Type	Thickness	coefficients at frequencies						
		125	250	500	1000	2000	4000	NRC
IB150	1	19	62	72	82	88	89	
IB200	1	15	55	73	86	92	94	7
IB250	1	25	52	71	83	89	95	7
IB300	1	19	49	69	87	92	94	7
IB420	1	33	40	70	94	1 00	98	7
IB600	1	12	52	68	87	93	99	

Noise Reduction Coefficient F2 Mounting (formerly No [illegible]

Fire Safety (ASTM E 84 or UL 723) Flame Spread rating not exceeding 25 and a Smoke Developed rating not exceeding 50

Service Temperature (ASTM C 411) Recommended for use from −20 F to 450 F

Thermal Shock Resistance Will not crack split shrink or crumble

Moisture Adsorption (ASTM C553) Not exceeding 1 0% by volume

Corrosion Resistance (ASTM C 655) Will not cause corrosion of aluminum steel or copper as tested in accordance with the method in HH 1 558

Resistance to Fungi & Bacteria (ASTM D 2020 Method A) Does not breed or promote

Vapor Transmission (Facings) (HH B 100B) 02 perm rating puncture resistance (beach units) 50 ASJ 25 FSK

Specification Compliances*

	IB150	IB200	IB250	IB300	IB420	IB6[illegible]
HH B 100B Type 1 (Facing)	x	x	x	x	x	
HH I 558 B Form A Class 1 & 2				x	x	
Form B Type [illegible] Class 6 [illegible]	x					
Form B Type [illegible] Class [illegible] 8	x			x		
[illegible]						
[illegible]						
[illegible]						

NOTE All products ordered to comply with any one of the above specifications should indicate that requirement on the purchase order The product has physical [illegible] that meet the physical requirements [illegible] the reference specification

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Installation

CertainTeed IB Board insulation is usually applied directly to metal surfaces by impaling over welded pins or studs secured with washers or clips The insulation surface is then covered with metal mesh insulating cement and canvas or finished with a metal covering sheet or faced boards are neatly taped at the joints For cold applications a vapor retarder facing is required with all joints taped to assure a continuous vapor retarder Rub pressure sensitive tapes with a nylon sealing tool to assure positive bond Apply only if temperature is between 35 F and 110 F Outdoor applications require addition of weather protection Facings may be painted with a water based paint Consult your CertainTeed representative for special conditions

Pins or studs should be spaced on center not exceeding 16" Pins at insulation edges should not be more than 4 from the edge Cover all pins and washers with matching vapor retarder patch

Designers are cautioned to consider thermal bridging when using pins studs framing and supports made of metal Limit maximum insulation surface temperature to 150°F

Recommended Thickness

Hot Surfaces—Indoor Conditions—80 F ambient still air (No parallel heat flow paths considered)

Service Temp	200			300			400		
Thickness (in)	Energy Loss Bare (Btu/sq ft)	Energy Loss Insul (Btu sq ft)	Surface Temp (F)	Energy Loss Bare (Btu sq ft)	Energy Loss Insul (Btu sq ft)	Surface Temp (F)	Energy Loss Bare (Btu/sq ft)	Energy Loss Insul (Btu/sq ft)	Surface Temp (F)
	282	[illegible]	9	[illegible]			1126	85	
	282	[illegible]	90	[illegible]	78	[illegible]	1 6	4	[illegible]
3	282	[illegible]	8	[illegible]		[illegible]	11 [illegible]	31	[illegible]
4	28		85		[illegible]	[illegible]	11 [illegible]	[illegible]	[illegible]
[illegible]	282	[illegible]	85	[illegible]41	2	84	1126	19	[illegible]
[illegible]	282	[illegible]	84	641	10	88	1126	16	[illegible]
	—	—	—	—	9	86	1126	14	[illegible]0
[illegible]	—	—	—	—	—		1126	12	[illegible]
	—	—	—		—				

Hot Surfaces—Outdoor Conditions—0 F ambient 20 mph wind

Service Temp	200			300			400		
Thickness (in)	Energy Loss Bare (Btu/sq ft)	Energy Loss Insul (Btu/sq ft)	Surface Temp (F)	Energy Loss Bare (Btu/sq ft)	Energy Loss Insul (Btu/sq ft)	Surface Temp (F)	Energy Loss Bare (Btu/sq ft)	Energy Loss Insul (Btu/sq ft)	Surface Temp (F)
	1	3	15	23 8	2	[illegible]	3	105	[illegible]
[illegible]	13	[illegible]2	9	23[illegible]8	3	13	3 17	54	18
	13 5	15	7	23 8	25	10	3[illegible]17	37	14
	13 5	19	8	23 8	28	10	3[illegible]17	39	13
	13 5	9	5	23 8	1	[illegible]	3[illegible]17	22	9
	13 5	[illegible]	4	23 8	[illegible]	6	1	13	[illegible]
	—	—		23 [illegible]	1		17	16	
	—	—	—	—	—	—	3[illegible]17	14	[illegible]
	—	—	—	—	—	—	—	—	—

Cold Surfaces

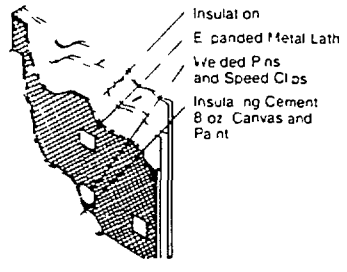
Thickness options based on permissible relative humidity (RH) and heat gain (HG)—90 F ambient (3 300 hrs /yr operation)

Operating Temperature	60 F		50 F		40 F		30 F		0 F	
Insulation Thickness	HG	RH	HG	RH	HG	RH	HG	RH	HG	RH
1	20	89	26	86	33	82	39	79	58	72
1 ½	14	91	18	90	23	87	27	85	40	79
2	11	92	14	91	18	90	21	88	31	82
2 ½	9	93	12	92	14	91	17	90	25	86
3	7	94	10	93	12	92	14	91	21	89

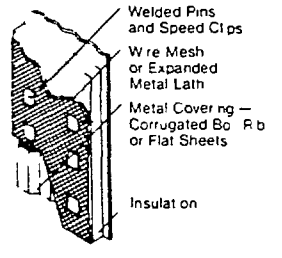
RH figures shown are maximum permissible humidity (%) to prevent condensation on the insulation surface
HG Heat Gain = MM Btu gained/1000 sq ft /3 300 hr operating year For information on sub-zero applications contact CertainTeed representative

Application Details

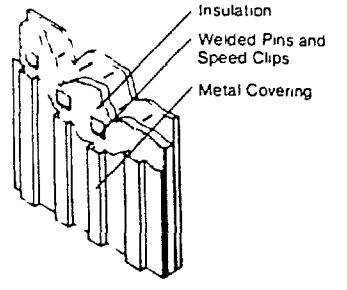
Canvas Finish



Metal Finish

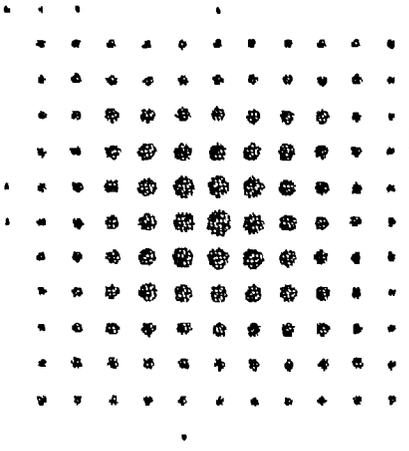


Insulated Metal Panels



EC-1

Submittal Sheet



INNOVA®

Temperlite® 1200°

Number ITI-IC-SS-1c

Effective June 30, 1994

Supersedes ITI-IC-SS-1b, August 1992

Submittal Date

Description Temperlite® 1200° is a rigid, high temperature, water resistant molded perlite thermal insulation available in either block, pipe or molded fitting form. The product is a light gray material with dark heat stabilized flecks throughout the product for easy identification as an insulation which does not contain asbestos.

Uses. The product has an application temperature range up to 1200°F, even under cyclic conditions. Its unique water resistant formulation makes it especially suitable for those applications where water incursion is a consideration and where cellular glass or other foam insulations have previously been the only viable option. The product is naturally high in silicates, making it the preferred choice for those applications where stress corrosion is a consideration. Because the material will not retain moisture, it does not contribute to premature corrosion of protective jacketing systems.

Features and Benefits

Moisture Resistance Temperlite 1200° is extremely resistant to water absorption. Mechanical strength and thermal performance are preserved and the insulation will not act as a reservoir for jacket corrosion as is common with many other rigid insulations.

Corrosion Resistance Because Temperlite 1200° is non wicking and high in silicates, it will not cause or promote stress corrosion cracking of austenitic stainless steel.

Thermal Efficiency Temperlite 1200° provides excellent thermal insulating properties throughout its full range of use. This thermal efficiency results in reliable temperature control for critical process operations.

Fire Resistance Temperlite 1200° will not burn or carry flame. It has a Flame Spread of zero and a Smoke Developed of zero when tested per ASTM E 84.

Heat Stability Unlike some other rigid insulations, Temperlite 1200° will maintain its integrity and insulating efficiency even under conditions of soaking heat up to its full 1200°F recommended operating range.

Rigidity Temperlite 1200° is designed and manufactured to provide the strength required to withstand personnel traffic and other common installation and application abuses.

[illegible]

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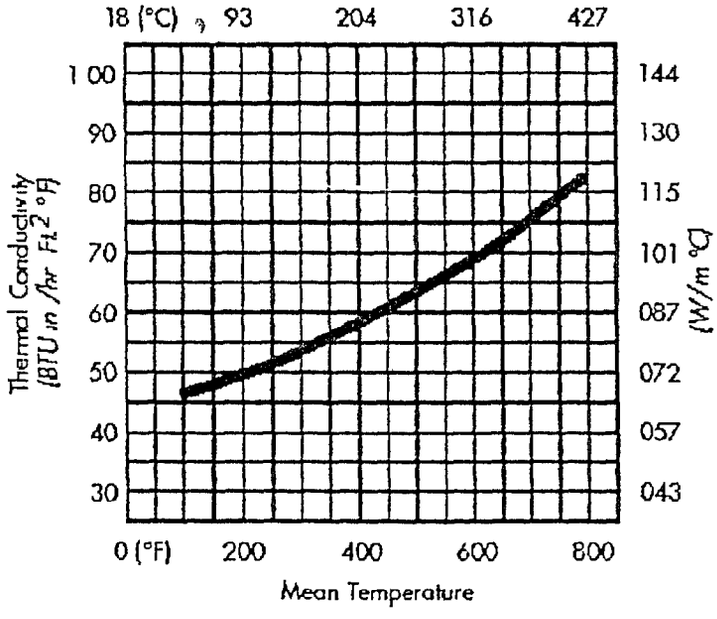
Specification Compliance

ASTM C 610 Type II "Standard Specification for Expanded Perlite Block and Pipe Thermal Insulation"*
ASTM C 795 "Standard Specification for Wicking Type Thermal Insulation for Use Over Austenitic Stainless Steel"
MIL I 24244C (SH) "Insulation Material with Special Corrosion Chloride, and Fluoride Requirements"
NRC Reg Guide 1 36 "Nonmetallic Thermal Insulation for Austenitic Stainless Steel"
DuPont "Dana" Accelerated Stress Corrosion Test after 700°F Soaking Heat
USCG 164 009/308/0 "Noncombustible Material"
*Waiver required on tumbling friability

Physical Properties.

Property	*Test Method*	*Value*	
Density	ASTM C 303	12 0 1 4 pcf	
Water Absorption	ASTM C 209	2 hrs 1 2% max	24 hrs 3 8% max
Flexural Strength	ASTM C 203	48 56 psi	
Compressive Strength	ASTM C 165	60 70 psi	(5% deformation)
Linear Shrinkage	ASTM C 356	2% max	(1200°F for 24 hrs)
Surface Burning Characteristics	ASTM E 84	Flame Spread 0	
	Maximum	Smoke Developed 0	
Acid Resistance	7 days – 10% HCl	No visible change	
	7 days – 10% H_2SO_4	No visible change	
	24 hrs – 25% HCl	No visible change	
	24 hrs – 25% H_2SO_4	No visible change	
pH	MIL-I 24244C (SH)	10 4 10 7	
Thermal Conductivity	ASTM C 177		
	100°F Mean Temp	0 44 BTU in/hr Ft²F	
	200°F Mean Temp	0 48 BTU in/hr Ft²F	
	400°F Mean Temp	0 57 BTU in/hr Ft²F	
	600°F Mean Temp	0 68 BTU in/hr Ft²F	

K vs Mean Temperature



Notes

The chemical and physical properties of Temperlite® 1200° Insulation represent typical average values determined in accordance with accepted test methods The data is subject to normal manufacturing variations The data is supplied as a technical service and is subject to change without notice References to numerical flame spread ratings are not intended to reflect hazards presented by these or any other materials under actual fire conditions Check with your Knauf regional office to assure information is current

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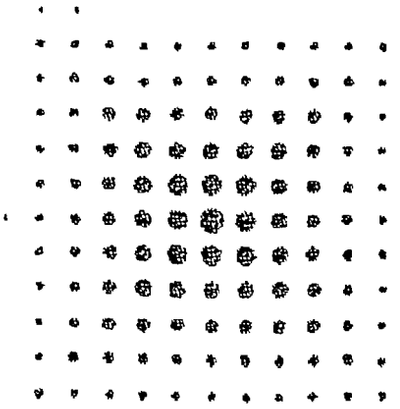
Southern 1170 Corporate Drive West Suite 203 Arlington, Texas 76006 (817) 640 8986
Canada 88 University Avenue Suite 800 Toronto, Ontario M5J 1T6 (416) 593 4322

Innova Technologies, Inc is wholly-owned by Knauf Fiber Glass Knauf has founded Innova Technologies in order to pursue the development and manufacturing of non fibrous insulation materials Innova products are available exclusively through Knauf Fiber Glass

E.U.F-1

Submittal Sheet



INNOVA®

Temperlite® PC

Number ITI-IC-SS-3

Effective June 30, 1994

Submittal Date

Description

Temperlite® PC is a precision cut, v-grooved pipe and vessel insulation manufactured from Temperlite® 1200°, a rigid, high temperature, water resistant, molded perlite thermal insulation. It is produced to fit precise pipe and vessel sizes for industrial applications from 80°F to 1200°F. Temperlite PC is supplied with a glass mat adhered to the precision cut segments for ease of handling and installation. When compared against more time consuming alternatives such as molded curve segments or scored block, Temperlite PC can represent a significant field labor savings.

Uses.

The product has an application temperature range up to 1200°F, even under cyclic conditions. Its unique water resistant formulation makes it especially suitable for those applications where water incursion is a consideration due to either loss of thermal efficiency or corrosion. The product is naturally high in silicates, making it the preferred choice for those applications where stress corrosion is a consideration. Because the material will not retain moisture, it does not contribute to premature corrosion of protective jacketing systems.

Features and Benefits

Moisture Resistance

At temperatures up to 700°F, Temperlite PC is extremely resistant to water absorption. Mechanical strength and thermal performance are preserved and the insulation will not act as a reservoir for jacket corrosion as is common with many other rigid insulations.

Corrosion Resistance

Because Temperlite PC is high in silicates and non wicking, it will not cause or promote stress corrosion cracking of austenitic stainless steel.

Thermal Efficiency

Temperlite PC provides excellent thermal insulating properties throughout its full range of use. This thermal efficiency results in reliable temperature control for critical process operations. Because it is precision v grooved to exact sizes, it closes tightly around its intended vessel, eliminating unclosed spaces or cracks which are common with field installations of other scored products.

Fire Resistance

Temperlite PC will not burn or carry flame. Temperlite PC has a maximum flame spread of 10 and a maximum smoke developed of 10 when tested per ASTM E 84.

Rigidity

Temperlite PC is designed and manufactured to provide the strength required to withstand personnel traffic and other common installation and application abuses.

Ease of Installation

Temperlite PC installs quickly and easily, minimizing field labor and breakage. It also stores compactly at the jobsite due to its "in the flat" shipping configuration.

Nationally distributed by
Knauf Fiber Glass

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PRODUCT DATA SHEET

KNAUF ELEVATED TEMPERATURE BLANKET 1000°F

Form No IC DS 8G Effective 4/95
Supersedes IC DS 8F Dated 8/93

DESCRIPTION

Knauf Elevated Temperature Blanket Insulation is a lightweight thermal insulation blanket made from highly resilient, inorganic glass fibers bonded by a high-temperature thermosetting resin

APPLICATION

Knauf Elevated Temperature Blanket Insulation is used for industrial heating equipment to 1000°F (537°C) Applications include industrial furnaces panel systems marine applications and irregular surfaces

COMPLIANCE

- *SPECIFICATION COMPLIANCE*
  HH-I 558C Form B Class 7 8
  MIL I-24244C
  ASTM C 795
  NRC 1 36 Reg Guide
  USCG 164 009/259/0
  MIL I 22023D
  Type I, Class 3
  Type II, Class 3
  IN CANADA
  CGSB 51 GP 11M
  DND 15280 02 E-2
  CCG 100/FT-172

FEATURES & BENEFITS

- *EXCELLENT THERMAL PROPERTIES*
  Knauf Elevated Temperature Blanket Insulation has low thermal conductivity It provides for increased system efficiency as it decreases fuel usage
- *LOW COST INSTALLATION*
  Knauf Elevated Temperature Blanket Insulation is lightweight and easy to handle and fabricate Its flexible characteristics make it ideal for flat or irregular surfaces
- *DAMAGE RESISTANT*
  Knauf Elevated Temperature Blanket Insulation is tough and resilient It resists damage in shipment as well as during and after installation
- *RESISTS MOLD GROWTH (ASTM C 665)*
  Knauf Elevated Temperature Blanket Insulation does not promote the growth of fungi or bacteria It will not rot or sustain vermin
- *NON-CORROSIVE (ASTM C 665)*
  Knauf Elevated Temperatu e Blanket Insulation will not accelerate corrosion of steel It complies to stress corrosion requirements of MIL-I-24244C

NOTES

The chemical and physical properties of Knauf Elevated Temperature Blanket Insulation represent typical average values determined in accordance with accepted test methods The data is subject to normal manufacturing and testing variations The data is supplied as a technical service and is subject to change without notice References to numerical flame spread ratings are not intended to reflect hazards presented by these or any other materials under actual fire conditions Check with your Knauf regional office to assure information is current

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Toronto Ontario M5J 1T6
(416) 593 4322

KNAUF

PRODUCT DATA SHEET

KNAUF ELEVATED TEMPERATURE BOARD TO +850°F

ECR-2

Form No IC-DS-4H Effective 4/95
Supersedes IC DS-4G Dated 1/92

DESCRIPTION

Knauf Elevated Temperatu e Board is a lightweight insulation made from inor ganic fibers bonded with a h gh tem perature thermosetting resin The insu- lation is in a semi rigid board-like form with superior handling properties and insulating effectiveness at minimum cost

APPLICATIONS

Knauf Elevated Temperature Board is designed to be utilized as an elevated temperature light density insulation for boiler walls hot precipitatore hot durt work cylindrical tanks towers stacks industrial ovens, and manne applica- tions The product is designed for appli- cations to maximum operational tem- perature of 850°F (454°C) and thick- nesses not to exceed 6 (152 mm)

FEATURES & BENEFITS

- *ENERGY CONSERVATION*
  Knauf Elevated Tempe ature Board offers excellent resistance to heat loss which saves ene gy and lowers operating costs
- *LARGE SIZES*
  Sizes up to 4' x 10' (1219 mm x 3048 mm) reduce the number of joints reduce installation time and eliminate potential sources of heat leakage

SPECIFICATION COMPLIANCE

Knauf Elevated Temperature Board complies to the property require- ments of the following specifica- tions

USCG 164 009/214/0
Canadian Coast Guard 100/FT-109
MIL-I 24244C
ASTM C 795
NRC 1 36 Reg Guide
MIL I 15475C (SHIPS)
ASTM C 612 Type IA IB II
HH I 558C (Amend 3)
Form A Class 1 2 3
M L I 22023D Type II
IN CANADA
CGSB 51 GP 10M
DND 15280 02 E 2
CCG 100/FI-170

FORMS AVAILABLE

Knauf Elevated Temperature Board is produced in lengths of 24 through 120 (610 mm through 3048 mm) in 1 (25 mm) increments widths of 24 and 48 (610 mm and 1220 mm) and thicknesses from 1 to 4 (25 mm to 102 mm) in ½ (13 mm) increments

REGIONAL OFFICES

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NOTES

The chemical and physical properties of Knauf Elevated Temperature Board represen typical average values de er mined in accordance with accepted test methods The data is subject to no mal variations The data is supplied as a technical service and is subject to change without notice References to numerical flame spread ratings are not intended to reflect hazards presented by these or any other material under actual fi e conditions Check w th your Knauf regional office to assure informa- tion is current

KNAUF

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PLATE NO 20

ECR 1 & 2

DUCTS, PLENUMS, AND HOUSINGS

Fibrous Board Duct Insulation Rectangular/Exposed

Fibrous board duct insulation may be specified for exposed rectangular ducts plenums and housings Outdoor installations require a weather-barrier finish in addition to the factory-applied jacketing used on indoor exposed applications Finishes other than the reinforced weather-barrier mastic include (1 an outer jacket of metal, plastic or laminate overlapped and secured (See **Plate No 22A)** and (2 One coat finishing cement reinforced with wire mesh and corner bead (See **Plate No 22B**) Choice of finish is dependent upon the mechanical abuse, weather exposure and appearance requirements of the installation

Materials Fibrous board duct insulation (shown with factory-applied vapor-retarder jacket), vapor-retarder tape, staples adhesive, mechanical fasteners, weather-barrier mastic and reinforcing mesh

1 Rectangular duct
2 Fibrous board insulation (corners may be straight or kerfed)
3 Adhesive spotted to assist the installation (optional)
4 Mechanical fasteners as required to secure insulation (starting 3" [maximum] from the butt joint)
5 Vapor-retarder tape over joints, breaks and penetrations of the vapor-retarder jacket
6 Weather-barrier mastic reinforced with fabric or mesh (for outdoors applications)
7 Jacketing applied for mechanical abuse protection, appearance requirements or weather protection (shown as metal secured with screws)
8 Standing seam (optional)

3/93

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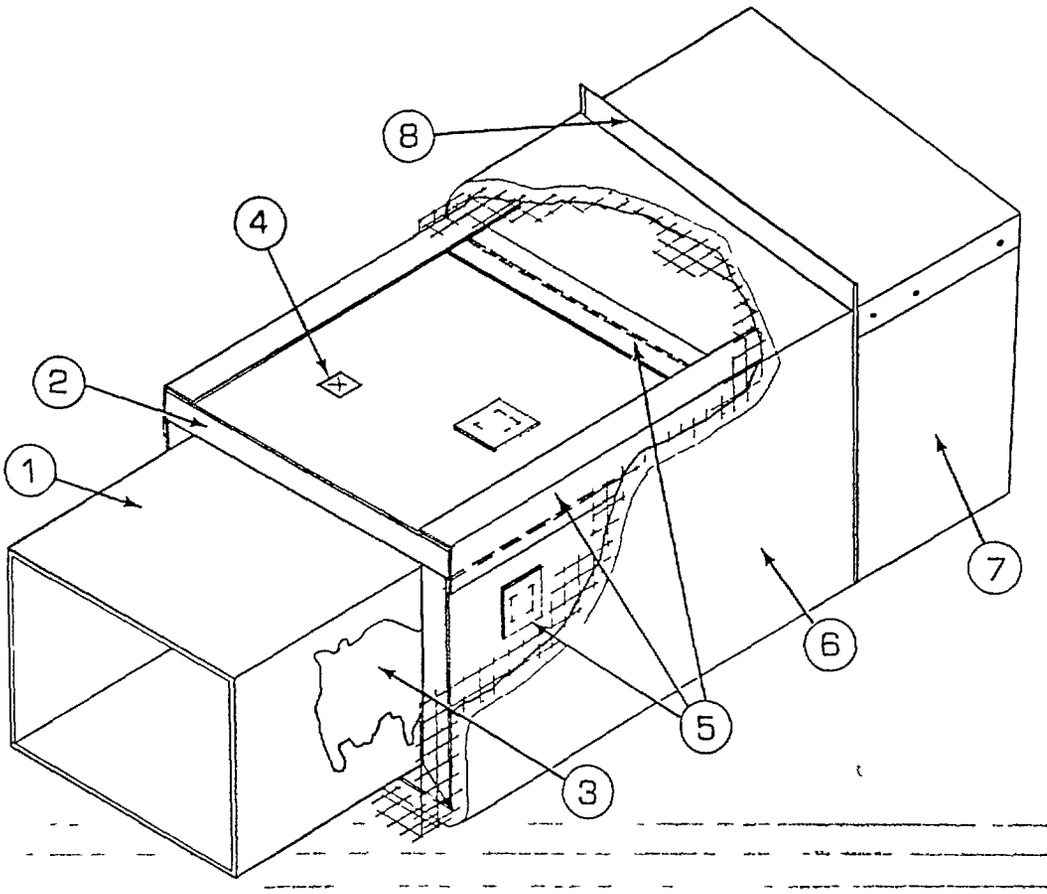
FIBROUS BOARD DUCT INSULATION
RECTANGULAR/EXPOSED



SUBMITTAL DATA

MATERIALS

(1) SYSTEM _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

( ) _____

( ) _____

( ) _____

3/93

PLATE NO 26

VESSELS, TANKS AND EQUIPMENT

Curved Surfaces
Rigid Board Insulation

Boards of cellular glass mineral fiber or glass fiber are used primarily on flat surfaces such as breeching and flues However if scored or beveled, rigid boards can be made to conform to the surface curvature of vessels, support legs, skirts and other irregular surfaces

Materials Rigid boards, corrugated or smooth sheeting sheet metal screws or pop rivets and bands and mechanical fasteners

1 Vessel wall

2 Insulation board scored or beveled to fit the curvature of the vessel surface

3 A method of securement is impalement of insulation on mechanical fasteners (Optional)

4 Bands (specify type, size & centers) and S' clips as required (**See Plate No 25** for detail) Provide for expansion if necessary

5 Bottom tier of insulation is cellular glass in potential splash, wash-down or flood areas where water absorption and wicking may occur (Optional)

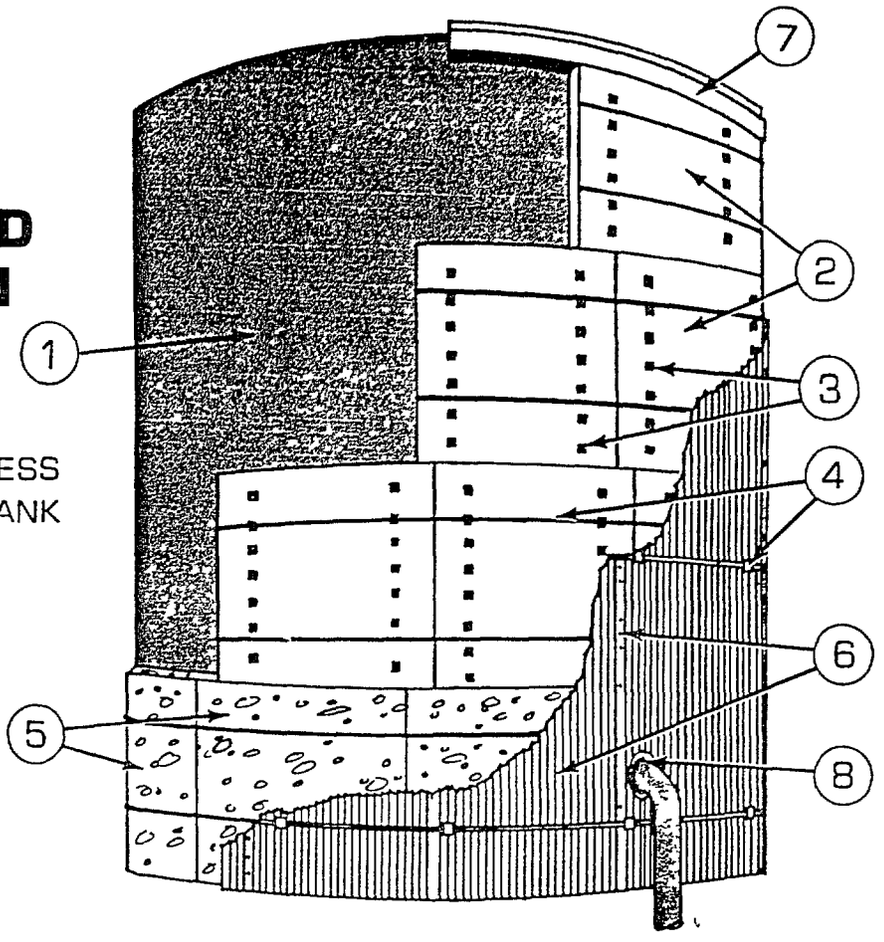
6 Corrugated or smooth sheeting secured with sheet metal screws, pop rivets or adhesive

7 Head flashing

8 Caulking/flashing at fittings (Optional)

CURVED SURFACES RIGID BOARD INSULATION

PROCESS
STORAGE TANK



SUBMITTAL DATA

MATERIALS

(1) **SYSTEM** _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

(7) _____

(8) _____

( ) _____

PLATE NO 29

VESSELS, TANKS AND EQUIPMENT

Extreme Temperature Vessels Block Insulation

High temperature (above 600°F) and/or refrigerated (below 32°F) installations such as boilers, refrigerant tanks and power/process equipment may require double layer block construction, securement of the insulation with bands and the design of expansion/contraction joints. High temperature insulation is illustrated. Similar methods are employed on extreme low temperature surfaces as noted.

Detail A — Expansion/contraction joint (typical)

Detail B — Double layer staggered joint construction

Materials Rigid block insulation, fiber blanket insulation, metal jacketing bands, stranded cable and vapor-retarder mastic

1 Vessel surface

2 Expansion joint filled with blanket insulation to absorb linear expansion of vessel when at operating temperatures. (Material is compressed tightly into joint when used for expansion or contraction on hot vessels.)

3 Contraction/expansion slip joint. (See **detail A,** also **Plate No 35, detail D-6**.)

4 Direction of linear expansion contraction. (Opposite for cold surfaces.)

5 Double layer blocks — staggered joint construction. (See detail .)

6 Jacketing banded in place. (metal shown.)

7 Bands. (Provide for expansion if necessary.) Specify type, size & centers.

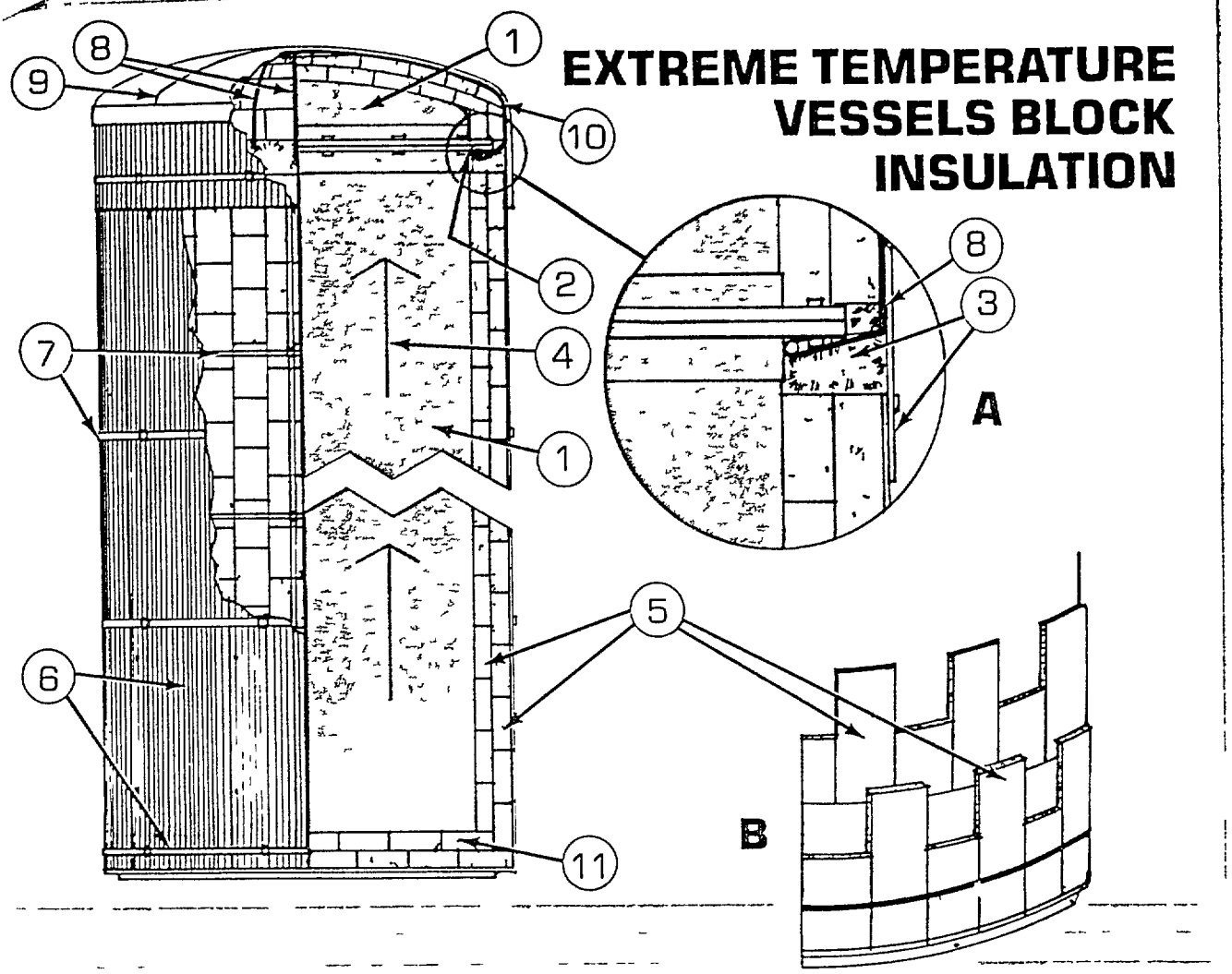
8 Head insulation secured with a floating ring of cable fastened to another ring of cable under head flange. (See **detail A,** also **Plate No 35 — detail A & D**.)

9 Pre-fabricated metal tank head cover. (**See Plate No 35 — detail B**.)

10 Weather/vapor-retarder if required.

11 Bottom insulation. (High compressive strength required.)

EXTREME TEMPERATURE VESSELS BLOCK INSULATION



SUBMITTAL DATA

MATERIALS

1	SYSTEM _____	10	_____
2	_____	11	_____
3	_____	○	_____
4	_____	○	_____
5	_____	○	_____
6	_____	○	_____
7	_____	○	_____
8	_____	○	_____
9	_____	○	_____

155 600 | Heating System Access.

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1993 BARE COSTS MAT	LABOR	EQUIP	TOTAL	TOTAL INCL O&P
640	0620	90 lb per hour	Q-5	3	5.333	Ea	3 300	132		3 432	3 850
	0640	120 lb per hour		2 50	6 400		4 325	158		4 483	5 025
	0660	180 lb per hour		2	8		5 125	198		5 323	5 950
	0700	With blower									
	0720	10 lb per hour	Q-5	5 50	2 909	Ea	2 500	72		2 572	2 850
	0740	17 lb per hour		4 75	3.368		2 575	83		2 658	2 950
	0760	30 lb per hour		3 75	4.267		2 625	105		2 730	3 050
	0780	60 lb per hour		3 50	4 571		3 225	113		3 338	3 725
	0800	90 lb per hour		2 75	5 818		4 575	144		4 719	5 250
	0820	120 lb per hour		2	8		5 950	198		6 148	6 850
	0840	180 lb per hour		1 50	10 667		6 375	263		6 638	7 425
651	0010	INSULATION									
	0100	Rule of thumb as a percentage of total mechanical costs				Job				10%	
	1000	Boiler 1 1/2" calcium silicate 1/2 cement finish	Q-14	50	.320	S F	3 43	7 55		10 98	15 75
	1020	2" fiberglass		80	.200		2.17	4 70		6 87	9 50
	2000	Breeching 2 calcium silicate with 1/2 cement finish, no lath									
	2020	Rectangular	Q-14	50	.320	S F	4 79	7 55		12 34	17 25
	2040	Round		40	400		5.30	9 40		14 70	21
	2300	Calcium silicate block, + 200° to + 1200 F									
	2340	1 thick	Q-14	30	533	S F	2 71	12 55		15 26	23
	2360	1 1/2 thick		25	640		2 95	15 05		18	27 50
	2380	2 thick		22	727		3 74	17 10		20 84	31 50
	2400	3" thick		18	889		5 95	21		26 95	40
	2900	Domestic water heater wrap kit									
	2920	1 1/2 with vinyl jacket 20-60 gal	1 Plum	8	1	Ea	25 50	27 50		53	69 50
	3000	Ductwork									
	3020	Blanket type fiberglass flexible									
	3030	Fire resistant liner black coating one side									
	3050	1/2 thick 2 lb density	Q-14	380	.042	S F	38	99		1.37	2
	3060	1" thick 1 1/2 lb density		350	.046		50	1 08		1 58	2.27
	3070	1 1/2 thick 1 1/2 lb density		320	.050		62	1 18		1 80	2 60
	3080	2 thick, 1 1/2 lb density		300	.053		86	1 25		2 11	2 9
	3140	FRK vapor barrier wrap 75 lb density									
	3160	1 thick	Q-14	350	.046	S F	25	1 08		1.33	2
	3170	1 1/2 thick		320	.050		34	1 18		1 52	2.25
	3180	2 thick		300	.053		41	1 25		1 66	2 45
	3190	3 thick		260	.062		62	1 45		2 07	2 99
	3210	Vinyl jacket, same as FRK									
	3280	Unfaced 1 lb density									
	3310	1 thick	Q-14	360	.044	S F	.24	1 05		1.29	1 93
	3320	1 1/2 thick		330	.048		36	1 14		1 50	2.22
	3330	2 thick		310	.052		48	1.21		1 69	2 47
	3490	Board type fiberglass, 3 lb density									
	3500	Fire resistant black pigmented 1 side									
	3520	1 thick	Q-14	150	.107	S F	1 44	2 51		3 95	5 60
	3540	1 1/2 thick		130	.123		1 78	2 89		4 67	6 60
	3560	2" thick		120	.133		2 15	3 14		5.29	7 35
	3600	FRK vapor barrier									
	3620	1 thick	Q-14	150	.107	S F	1.25	2 51		3 76	5 40
	3630	1 1/2" thick		130	.123		1 54	2 89		4 43	6.30
	3640	2 thick		120	.133		1 80	3 14		4 94	7
	3680	No finish									
	3700	1 thick	Q-14	170	.094	S F	79	2.21		3	4 40
	3710	1 1/2" thick		140	.114		98	2 69		3 67	5.35
	3720	2" thick		130	.123		1 62	2 89		4 51	6 40

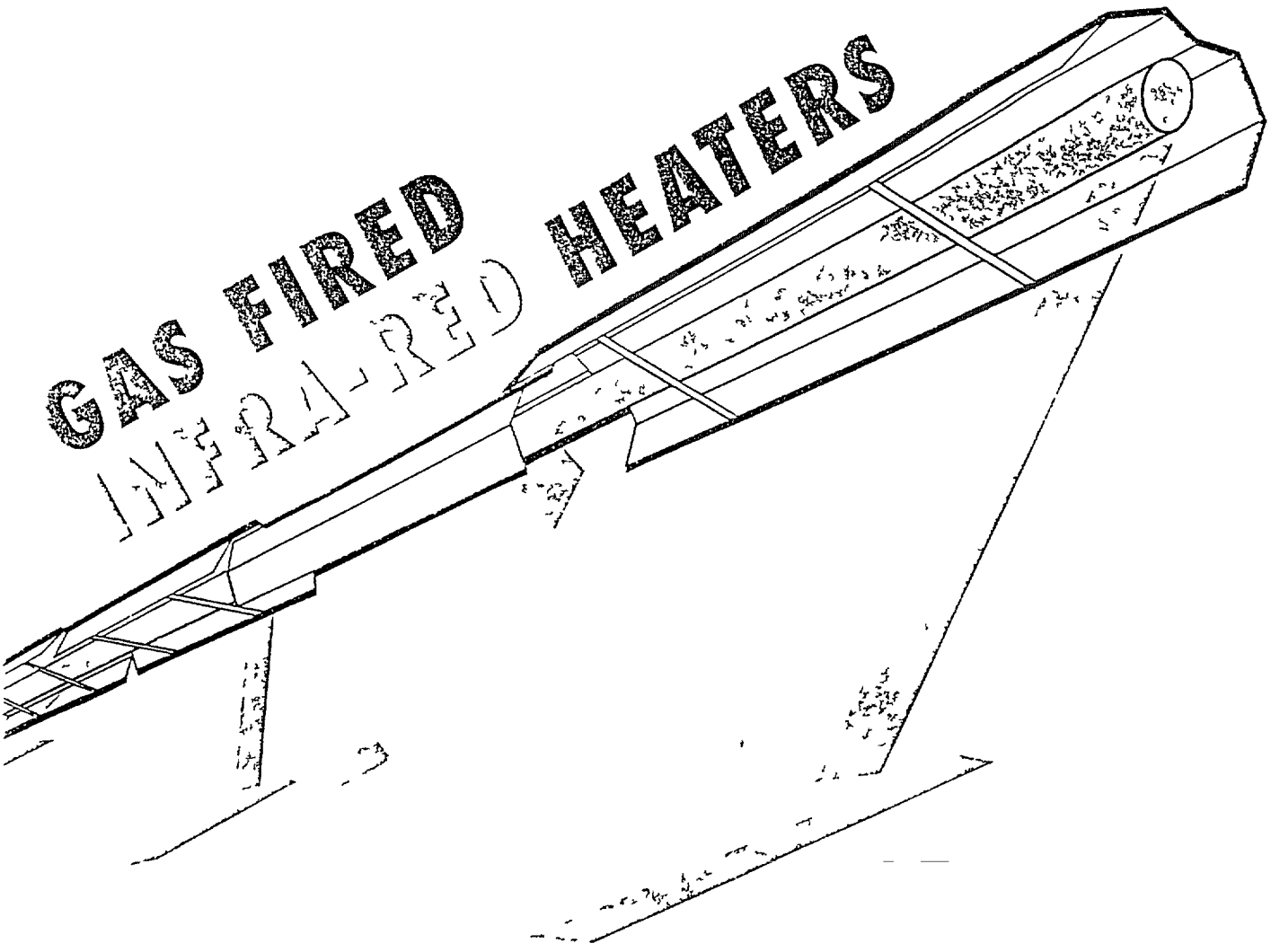
See the Reference Section for reference number information Crew Listings and City Cost Indexes

155 400 | Warm Air Systems

	CREW	DAILY OUTPUT	MAN HOURS	UNIT	1993 BARE COSTS MAT	LABOR	EQUIP	TOTAL	TOTAL INCL O&P	
For no cooling deduct				Ea	25%	10%				440
INFRA RED UNIT										451
Gas fired unvented electric ignition 100% shutoff Piping and wiring not included										
Input 15 MBH	Q-5	7	2.286	Ea	310	55.50		365.50	425	
30 MBH		6	2.667		330	66		396	465	
45 MBH		5	3.200		350	79		429	505	
50 MBH		4.50	3.556		380	88		468	555	
60 MBH		4	4		410	99		509	600	
75 MBH		3	5.333		445	132		577	690	
90 MBH		2.50	6.400		495	158		653	785	
105 MBH		2	8		700	198		898	1.075	
120 MBH		2	8		740	198		938	1.125	
Electric single or three phase										
6 KW 20.478 BTU	1 Elec	3	2.667	Ea	310	71		381	445	
13.5 KW 40.956 BTU		2.50	3.200		485	80.50		570.50	665	
24 KW 81.912 BTU		2	4		985	107		1.092	1,225	
Gas fired two stage pump controls solenoid valve venter										
117.000 BTU one burner	Q-5	2.50	6.400	Ea	2,375	158		2.533	2.875	
234.000 BTU two burner		2.25	7.111		4.400	176		4.576	5.100	
351.000 BTU three burner		2	8		6.600	198		6.798	7.550	
468.000 BTU four burner		1.50	10.667		8.800	264		9.064	10.100	
Free air inlet per burner add					135			135	149	
Prepurger per unit add					56.50			56.50	62	
MAKE UP AIR UNIT										461
Indoor suspension natural/LP gas direct fired										
Standard controls For flue pressure loss 680 CFM temperature rise MBH is										
2000 CFM 168 MBH	Q-6	3	8	Ea	4.575	475		5.050	5.350	
3000 CFM 252 MBH		2	12		4.575	713		5.288	5.925	
4000 CFM 336 MBH		1.60	15		4.775	950		5.725	6.800	
6000 CFM 502 MBH		1	16		5.775	950		6.725	7.975	
8000 CFM 670 MBH		1.40	17.143		6.525	1.050		7.575	8.975	
10.000 CFM 838 MBH		1.20	20		7.125	1.250		8.375	9.900	
12.000 CFM 1005 MBH		1	24		7.175	1.500		8.675	10.300	
14.000 CFM 1180 MBH		.94	25.532		7.275	1.575		8.850	10.500	
18.000 CFM 1340 MBH		.80	27.907		7.350	1.725		9.075	10.800	
20.000 CFM 1675 MBH		.76	31.579		9.050	1.975		11.025	13.100	
24.000 CFM 2010 MBH	Q-7	1	32		9.350	2.000		11.350	13.500	
30.000 CFM 2510 MBH		.96	33.333		9.500	2.075		11.575	13.800	
36.000 CFM 3015 MBH		.92	34.783		12.100	2.175		14.275	16.900	
40.000 CFM 3350 MBH		.88	36.364		12.400	2.275		14.675	17.400	
45.000 CFM 3770 MBH		.84	38.095		12.700	2.375		15.075	17.900	
50.000 CFM 4185 MBH		.80	40		12.900	2.475		15.375	18.300	
55.000 CFM 4605 MBH		.76	42.105		16.400	2.625		19.025	22.500	
60.000 CFM 5020 MBH		.70	45.714		17.100	2.850		19.950	23.600	
65.000 CFM 5440 MBH		.60	53.333		17.200	3.325		20.525	24.400	
75.000 CFM 6275 MBH		.50	64		18.100	3.975		22.075	26.300	
Oversize base unit					10%					
For options add					20					
For flush top damper add					10%					
For vertical unit add					10%					
For explosion proof motor add										

Solaronics

Suntube IV



SAVE UP TO 75%... AND DIRECT THE HEAT WHERE YOU WANT IT.

Suntube IV

GAS FIRED INFRA-RED HEATERS

BEFORE YOU BUY

Our computer aided design service offers a multitude of impor- tant facts comparative fuel costs life cycle costs accurate heat loss data etc providing you with the most economical heating system available We will also provide you customized equipment plans and layouts AT NO EXTRA COST when you invest your heating dollars in a SUNTUBE Infra Red system Our factory engineering experts are ready to offer their help in evaluating your designs or plans and offer any assistance you may require SOLARONICS is ready to help you start saving heating dollars now!

WHAT IS INFRA RED HEAT?

SUNTUBE heat is produced by Infra Red rays an energy form similar to visible light This energy travels at 186 000 miles per second in a straight line without loss of heat to the air It can be turned reflected or focused by materials that have a highly reflective surface such as Bright aluminum for example When infrared strikes an absorptive object such as concrete wood tile paint skin or clothing it is converted into heat at the surface Surrounding air is then warmed by conduction and convection The best example of this transfer of heat is from the sun to the earth without loss of heat to outer space

STANDARD FEATURES

SYSTEMS

Available 10 15 20 25 30 35 40 45 50 55 60 65 or 70 feet long straight design with 20 30 40 50 60 or 70 feet long compact U tube design Easily adaptable to perimeter area span or spot heating arrangements

✓ Inputs of MBTUH 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 165 190 195 and 200 Available in either Natural (NAT) or Propane (LP)

✓ Preassembled in 10 and 5 sections just hang and connect

✓ Customizing for most any layout is achievable with the use of 45° and 90° elbows

✓ Integral turnbuckles and a sliding hanger for ease of leveling and to help in compensating for expansion

BENEFITS

✓ Since infra red heaters warm objects and people directly and do not require air movement as a means of heat transfer several benefits are provided in comparison with conventional forced air heaters **fuel savings of 30% to 50% payback periods of one to three years** equal or greater employee comfort at 5° to 10° lower thermostat settings reduced heat losses lower ceiling air temperatures quicker recovery a cleaner and quieter working environment zone control without partitions and warmer floors and surroundings

BURNER AND OPERATION

✓ SUNTUBE has been field proven for over 25 years This has resulted in exceptional quality reliability and service free maintenance

✓ Certified by International Approval Services (IAS) for the American and the Canadian Gas Associations

✓ Dry no condensation of flue products during steady state operations

✓ Direct spark ignition 100% safe shut off

✓ Positive pressure blower with pre purge cycle

✓ Simple chain hanging arrangement

✓ 120 VAC 1 Phase 60 Hz

✓ A max of 1 47 full load amps

✓ 1 25 HP blower motor with a max of 148 CFM free air

✓ 1 2 FPT gas inlet

✓ Three prong grounded power cord 36 long

✓ Electronic flame monitoring for safety

✓ Air pressure switch for air flow safety

✓ Three system validation lights for safety

✓ Spark and flame observation window

✓ Fixed combustion air orifice for sea level or high altitude

COMBUSTION CHAMBER

✓ Heavy duty 14 ga (083) Aluma Therm (Aluminized Titanium steel) 4 O D tubing 10 long finished with a high emissivity rated corrosion resistant black coating

HEAT EXCHANGER(s)

✓ Rugged and durable 12 ga (109) black steel 4 O D tubing 5 or 10 long

✓ The last or marked heat exchanger has a factory installed [illegible] for increased efficiency

REFLECTORS

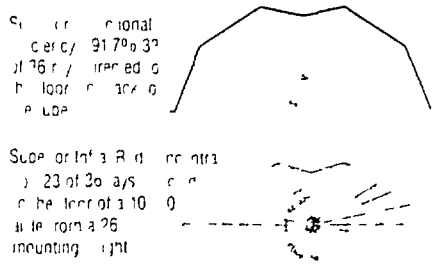
✓ 91 7% Reflectional Efficiency (std reflector design)

✓ Mirror Brite Aluminum finish (highly polished)

✓ 5 or 10 long and free to expand Scientifically designed for optimum infra red dispersion Patented adjustable reflectors each section adjusts individually for any angle or horizontal mounting Allows lower mounting heights and perimeter location without the use of reflector side extensions

✓ Removable without tools (Snap in Snap out)

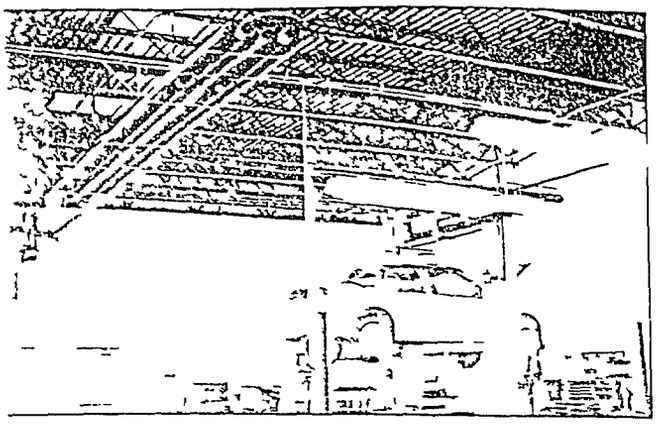
STANDARD REFLECTOR CROSS SECTION

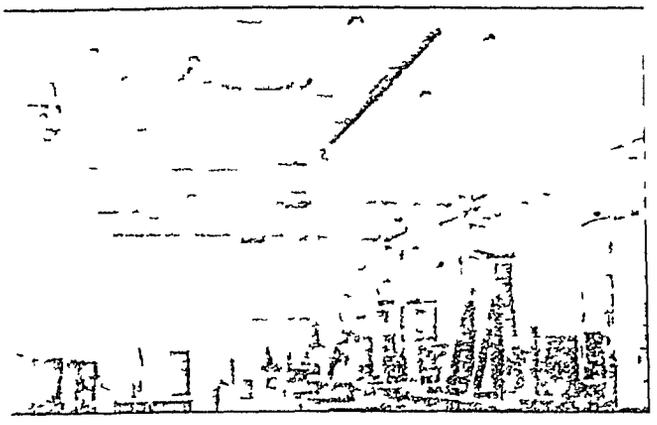


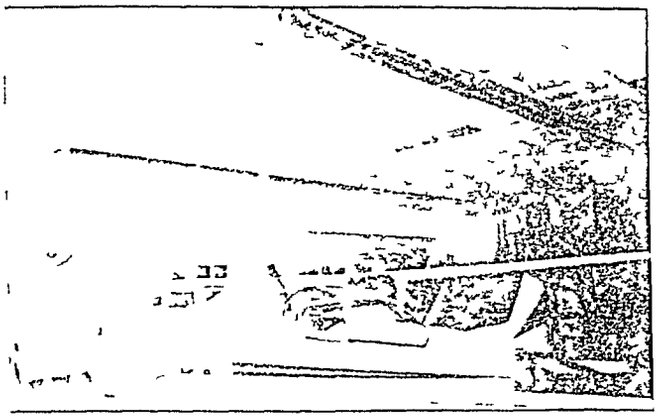
SIMULATED PARABOLIC REFLECTOR CROSS SECTION

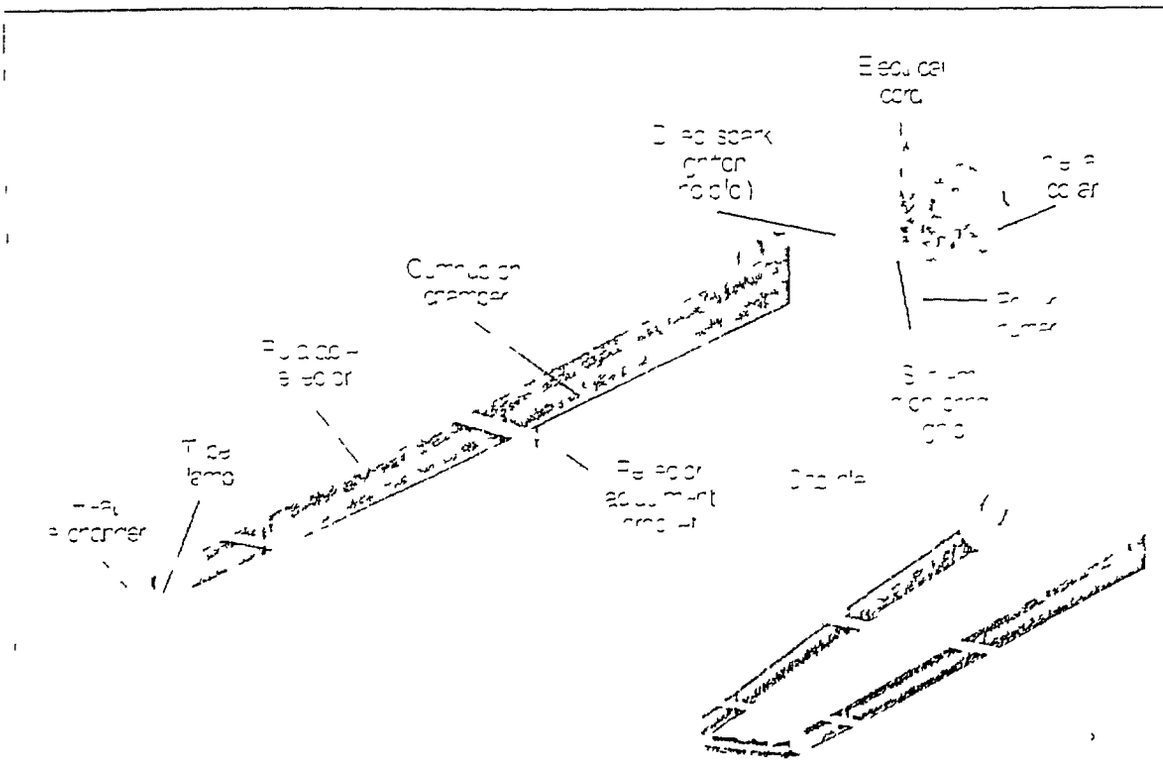
WARRANTY

ACCESSORIES



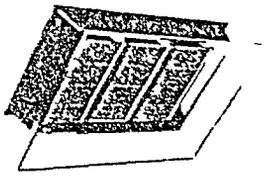






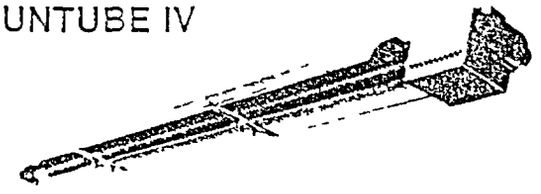
CUT HEATING COSTS UP TO 75% OR MORE WITH SOLARONICS GAS INFRA-RED HEATERS

K-SERIES



- 30 000 to 200 000 BTU
- 120 Volt • 24 Volt • Millivolt
- Spot or Area Heating
- Direct Spark 100% Safe Shutoff
- Natural or Propane Gas
- 0° to 30° Angle Mounting
- Simple Chain Mounting

SUNTUBE IV

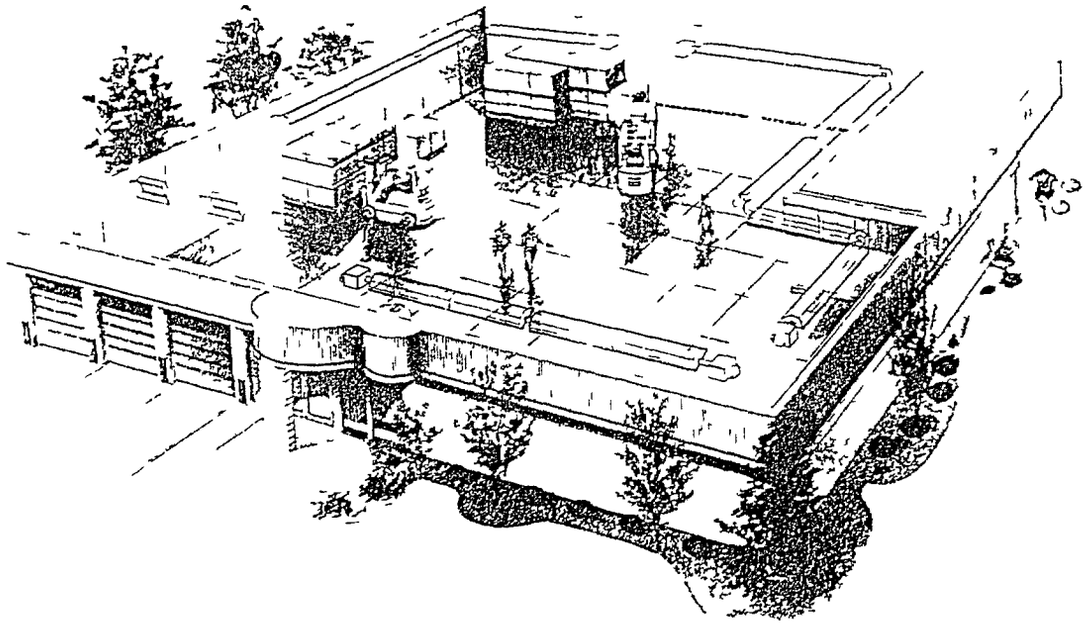


- 30 000 to 200 000 BTU
- Over 500 Different Models
- 10 to 70 Long Systems
- Independent Rotating Reflectors
- Mirror Bright Reflectors
- Natural or Propane Gas
- Pre Assembled in 5 and 10 Sections

TYPICAL BUILDING LAYOUT

Below is a typical perimeter layout of a warehouse or small manufacturing building with a Solaronics gas infra red heating system installed. This system uses both our SunTube (low intensity) and our K Series (high intensity) heaters.

We will be pleased to offer our heating expertise to help you layout your building heating requirements. Please call us toll free, fax your specifications or contact us on the internet as indicated below.



See us on the Internet

Thomas Register url http://www.thomasregister.com/solaronicsusa Sweet's Catalog http://www.sweets.com

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Form DIRECT 2
690090

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Solaronics®

introduction to infra-red heating

INTRODUCTION TO INFRA-RED HEATING

ed infra red hea ers are highly effic ent produce s e red ene gy that can be used in numerous ng applications Their greatest uses o date have in the heating of industrial and commercial ings spot and area heating commerc al food ng and cooking and in process heat ng ovens

Solaronics installation at GM s Inland Divis on plant Euclid Ohio slashed energy costs 75% during a e heating season Prior energy costs in the house were running around $106 000 per year er installing Solaronics gas infra red heaters, ergy costs plummeted to $27,000 *

Equally important was employee com ort Under the old forced air s stem complaints e e numerous After installat on morale improved greatly So the combination of Solaronics and ef cient gas not only delivered energy savings but emp'oyee comfort as well And with a payback period of less than 15 months

GM s Inland Division is just one o many installat ons realizing incredible savings by s ching to Solaron cs gas infra red heaters Most infra red users can expect to realize 30 50% average fuel reduct ons when compared with conventional heating systems

Case History #19 available upon request

HEATING PRINCIPLES

ansfer of heat from a warm object to a cooler - akes place b / one of three me hods or a combi on thereof Tnese methods are conduct'on ection or radiation

CONDUCTION

nduction of heat occurs when faster moving lecules pass on some of their energy to adjacent ecules which are slower moving i e at a lo /er perature Tnis may occur within a solid or be en a solid and an adjacent fluid such as air In / heated building or enclosure heat is conducted ransmitted from the warm inside air to the inside aces, then through the wall or roof, to the cooler de surface and on to the outside air

CONVECTION

nvection transfer of heat involves the mixing of m and cool particles of fluid The mixing may me as a result of density differences due to perature differences which is natural convection, or e mixing is produced by mechanical means forced nvection

a heated building convection losses occur when cold side air enters a building mixes with the warmer de air, and then exits through an exhauster or ough doors, cracks etc

RADIATION

at transfer by radiation differs from the transfer of at by conduction or convection in that it does not ed matter to accomplish the transfer Radiated heat usually termed infra red This is just one of the eral forms of radiation (see the electromagnetic ectrum, Figure #1) Infra red is transmitted at the eed of light, 186 000 miles per second in a straight ine with minimal loss to the air It can be aimed reflected or focused by materials that have a highly reflective surface Bright aluminum for example When infra red strikes an abso ptive object such as conc e e,

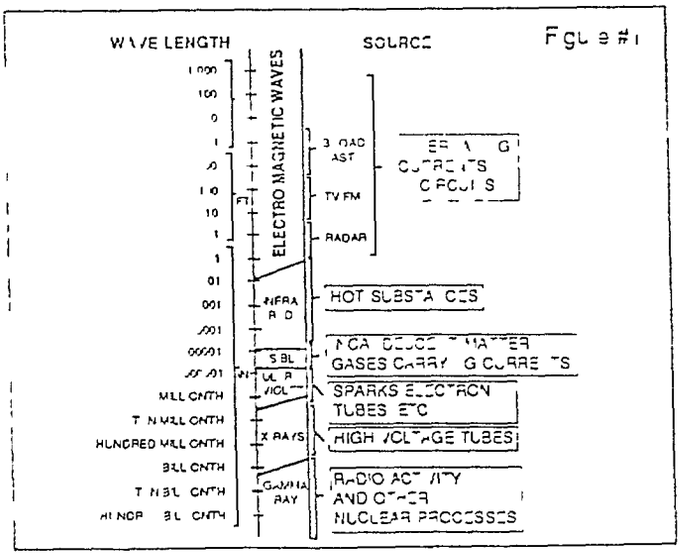

Figure #1

wood water paint skin or clothing it is converted into heat at the surface Surrounding air is then warmed by conduction and convection The best example of this transfer of heat is from the sun to the earth without loss of heat to outer space

Radiation or infra red energy is emitted by all matter that is above absolute zero (460 F) Tne net transfer of heat is from one object to a cooler object

Warm objects including people inside a heated building lose or radiate heat to the cooler inside surfaces of the walls The walls conduct heat to the outside surface and then lose heat by radiation conduction and convection to the outside

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HOW INFRA RED WORKS

The amount of radiation produced by a perfect radiator is expressed by the Stephan Boltzman Law where

$Q = \sigma T^4$

Q = Quantity of heat radiated per ft²
σ = Stephan Boltzman constant
T = Absolute temperature (F − 460)

For ordinary objects (non perfect radiators) Q is reduced by multiplication of the object's emissive power (always less than one) Thus at normal temperatures the amount of infra red radiation produced by an object is relatively low but as the temperature is increased radiation increases significantly

For example An object at 300 F (760 absolute temperature) with an emissive power of 0 85 will produce 94 BTUH ft² When its absolute temperature is doubled to 1080 its output is increased sixteen fold to 1,984 BTUH ft² If its absolute temperature is quadrupled to 2160 its output increases two hundred and fifty six fold to 31 744 BTUH ft²

HEATING WITH INFRA-RED

Solaronics gas infra red heaters, high and low intensity convert a high rate of their input to infra red output Input energy not converted into infra red is released as convected heat and water vapor Unvented units high & low intensity return a total of 92% of input to the space they occupy Vented units only low intensity may be vented return up to 90% of input to the space they occupy The longer the unit the higher the percentage

The most frequent use of Solaronics infra red heaters is for comfortable heating in buildings This may entail heating of the entire space or just spot or area heating Although it may be tempting to use rule of thumb methods to determine requirements it is strongly recommended that standard ASHRAE heat loss calculation methods be used These methods are outlined in the Total Building Heating Design Guide (Form # DG 1) Spot and Area Heating Design Guide (Form # DG SPOT) and Protection of Stored Material Heating Design Guide (Form # DG PSM 1)

For heating entire spaces a Solaronics infra red system really provides several systems in one One of these is very similar to a floor radiant system The infra red emitted by the system is absorbed by the floor, material and equipment These objects become warmer than the surrounding air and act as low level heat exchangers heating the air They also re radiate their energy and provide a higher Mean Radiant Temperature (MRT)

The products of combustion released by indirectly vented units rise and help offset the upper wall and roof area losses and also help to temperature isolate a In this respect the system acts as a warm air system

While the heaters operate they deliver infra red energy directly to people s body surfaces This substantially increases the mean radiant temperature and provides comfort yet air temperture can be lower than that needed with conventional heating

A well designed infra red heating system will cycle on and off most of the time as will any other system When the temperture outside falls to design levels all heaters will operate and at this time the system will act as a large area heating system

These advantages and many others are illustrated and described in the How to Cut Heating Costs brochure (Form # 25K) for additional information phone Solaronics TOLL FREE at 1 800 223 5335

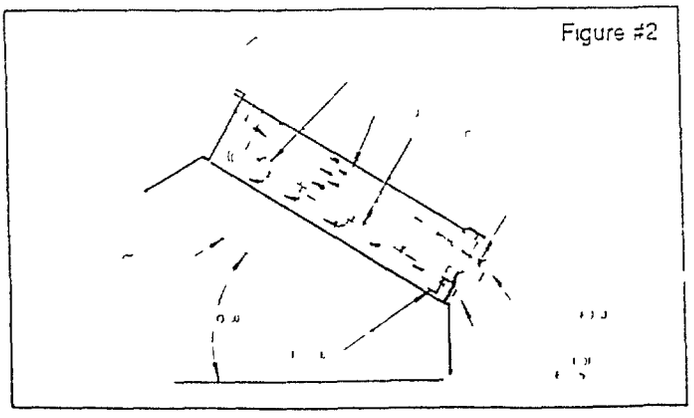
SOLARONICS HI-INTENSITY HEATERS

At the heart of Solaronics hi intensity heaters is an atmospheric type 100% primary air burner utilizing a perforated ceramic combustion surface The burner, along with a heater frame, reflector means of ignition and controls comprise the entire heater These heaters are certified by the American Gas Association Canadian Gas Association and are described by separate literature

HI INTENSITY BURNER

The burner is made of a 1/2' thick ceramic tile surface with 235 perforations per square inch, minimum of 0 045' diameter, a one piece aluminized steel plenum a spun metal venturi pan diffuser and stainless steel retainer clips

Figure #2



enters the burner through the orifice part of the manifold assembly which is centered at the ring of the venturi (See Figure #2) Primary bustion air is aspirated by the flow of gas from the e through the converging section of the venturi e the design of the burner components secondary not required The gas is thoroughly mixed with bustion air in the venturi and mixing tube and the e is distributed by the plenum chamber to the of the ceramic tiles The mixture then enters the holes in the tile and as it exits from the holes it s on the surface of the ceramic As a result the e causes the ceramic surface to reach temperature pproximately 1700 to 1850°F (an incandesent) with ving and a high rate of infra red energy is ated

CERAMIC INFRA RED GENERATOR

ceramic infra red generator used in the Solaronics ensity heater is cordierite based grooved ceramic atures an exclusive design whereby alternate of holes terminate at the bottom of slots ore one half of the flame is well below the c surface (See Figure #3) This feature provides er ceramic surface temperature with a low gas esulting in more heat transfer surface and more e contact between flame and the ceramic This

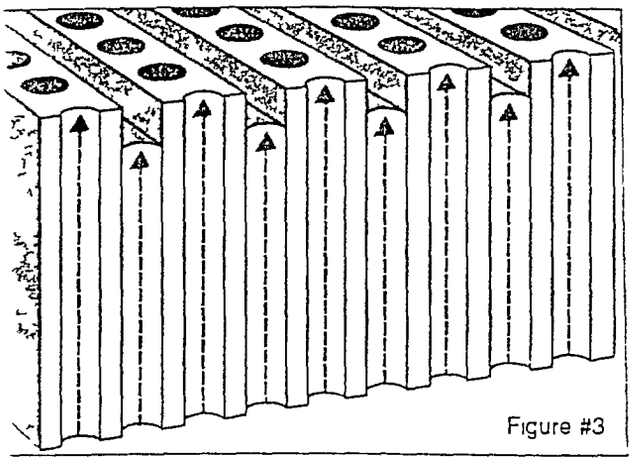


Figure #3

is in higher radiant outputs than any other similar petitive burner

OPTIONAL WIRE GRID

urner radiation may be increased by the addition optional wire grid A wire grid can be installed ly in front of the ceramic combustion surface ce temperatures are enhanced by hindering the e of products of combustion and preventing any ng or secondary air to come in contact with the mic infra red generator

combustion products (primarily hot nitrogen and on dioxide) leaving the ceramic surface must pass gh and heat the wire grid The grid increases its tion substantially and its area can replace much of w radiation areas of the ceramic holes Heat also tes back to the ceramic surface thereby increasing eramic temperature

REFLECTORS

Infra red heat that is produced by the burner must be directed into the space to be heated High intensity

Figure #4

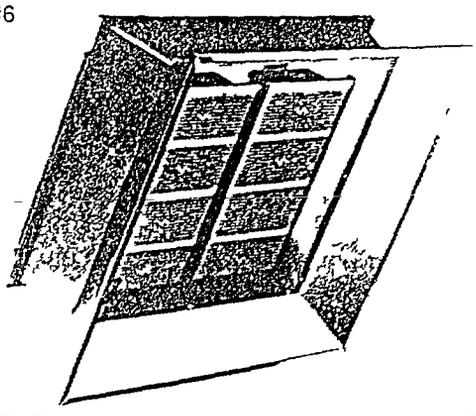
Figure #5

units are AGA and CGA design certified to be mounted horizontally or at an angle up to 30° These attitudes plus a standard shallow straight sided reflector insures that infra red output is not directed to the walls The standard reflector reduces dispersion to the sides and produces a conical spread of approximately 90° A parabolic reflector extension may be added to the standard reflector to produce a deep (concentrating) reflector The extension is used for concentrating infra red energy usually for spot heating or higher mounting height applications (see Figure #5)

SOLARONICS K-SERIES

Solaronics gas fired infra red K Series heaters are designed to save fuel in manufacturing facilities ware houses airports hangars and other buildings They are especially suited in spaces with high negative or positive pressures A wide range of BTUH inputs enables the specifier to select the best heater for a particular application whether a modern low ceilinged, well insulated building or an older poorly insulated one with high bays

Figure #6



Solaronics gas fired infra red K Series heaters are available in many different input capacities American Gas Association and Canadian Gas Association certified heater capacities range from 30 000 to 200 000 BTUH and are certified for operation on Natural or Propane gas Sixteen different control arrangements feature 100% safety shut off, 120V, 25V or Millivolt operation, direct spark spark to pilot, glow coil or manual burner ignition, concealed pilot that is protected from drafts and 1/2 FPT gas inlet

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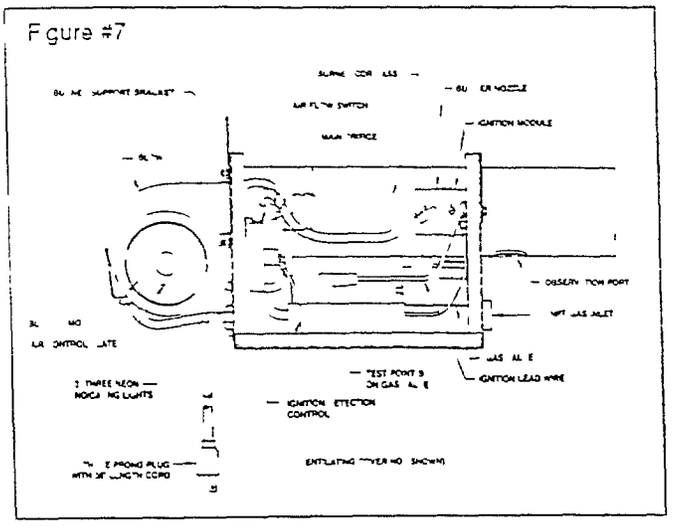
Solaronics Suntube low intensity heaters are powered by a positive pressure burner which fires into 4 diameter by 5 or 10 long steel tubes Burner ignition is accomplished by pilotless direct spark Combustion air is supplied to the system by a centrifugal blower and fixed inlet orifice A standard 4 diameter inlet air collar allows for connection to outside air without the use of supply fans The system is approved for either directly vented or indirectly vented operation without the use of a vacuum pump The power burner along with combustion chamber, heat exchangers and reflectors comprise the entire heater These heaters are design certified by the American Gas Association, Canadian Gas Association and are described by separate literature

LOW INTENSITY BURNER

The low intensity burner utilizes a 1/25th HP 120V AC single phase 60Hz motor and centrifugal blower which provides 148 CFH free air with a 1 47 full load AMP draw on A & B Series and 138 CFH free air with a 1 33 full load AMP draw on C Series A fixed air orifice plate regulates the appropriate air required for combustion Gas is introduced to the burner by a two stage redundant gas valve Gas is then regulated by two orifices, an easily accessible subsidiary orifice sized for the appropriate length and BTUH rating of the burner and a fixed main orifice Air and gas are thoroughly mixed in spiral motion by the burner core assembly and are then ignited by direct spark at the ignition module (see Figure #7)

Burner operation is monitored and controlled by an ignition detection control When the thermostat calls for heat power is applied to the blower motor A dual air flow switch continuously monitors the air supply When adequate inlet air and flue back pressure are present the ignition detection control is energized and institutes a 15 second pre purge cycle This is followed by a 35 second trial for ignition during which a spark is developed at the ignition module and the gas valve is opened to the first step of its two stage operation Gas is then ignited and approximately 5 seconds later the gas valve stages to its second and final operation position A flame rod part of the ignition module senses flame presence and the ignition detection control shuts off the spark current and monitors continued flame presence Should flame failure blocked flue or blocked inlet air occur during ignition or normal operation the ignition detection control will close the gas valve and lock out the system The system will remain locked out until the thermostat is cycled to off position

Figure #7



Three system monitoring lights indicate normal burner operation When lit these monitoring lights indicate normal conditions for power on inlet air and flue back pressures and gas valve on A burner inspection sight glass also allows for visual inspection of the flame and ignition module

COMBUSTION CHAMBER AND HEAT EXCHANGER(S)

The flame produced by the burner heats the combustion chamber and heat exchanger(s) and causes them to reach temperatures in the range of 200° to 1000°F Infra red generated is in the range of 300 to 6500 BTUH/ft² thus the term low intensity

The combustion chamber is made of 14 gauge (0 083) aluminized steel or 12 gauge (0 109) black steel The heat exchanger(s) is made of 12 gauge black steel or 14 gauge aluminized steel Both provide 1 052 per square feet of radiant surface per linear foot The last heat exchanger in each system incorporates a spiral turbulator for increased efficiencies

The 10 and 5 sections are joined by standard compression coupling tube clamps These clamps are made of two layers of 18 gauge (0 052) aluminized steel The inner sleeve has precision meshing teeth for even draw and pressure Each tube clamp is closed with three 5/8 , 65lb torque zinc plated carriage bolts A #5 malleable iron turnbuckle-5/8 eye to eye is also standard

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REFLECTORS

c oduced infra red heat must be directed into ace to be heated Since heat is generated he entire circumference of each steel tube s e eflector design is extremely c itical n accom g his goal A standa d (discers ng) e lector is FE (Reflec oral E c ent) Th rty three out cr s a e directed into he heated space rct back he ube (see Figure #8) A simulated parabolic at ng) reflector usually used for higher g neight applica ors, directs 23 or 26 rays into s e from a 26 mount ng heigh (see F gure #9)

portant in directing heat into the space is c otation Sola onics utilizes a patented 25) design to direct the heat in any direction t einstalling the system Each 5' or 10 long adjusts individually for any angle or horizontal ng (see Figure #10) which allows for lower ng neights and per meter loca ion without side ors This design also makes reflectors able without tools for easy cleaning ance or serv ce

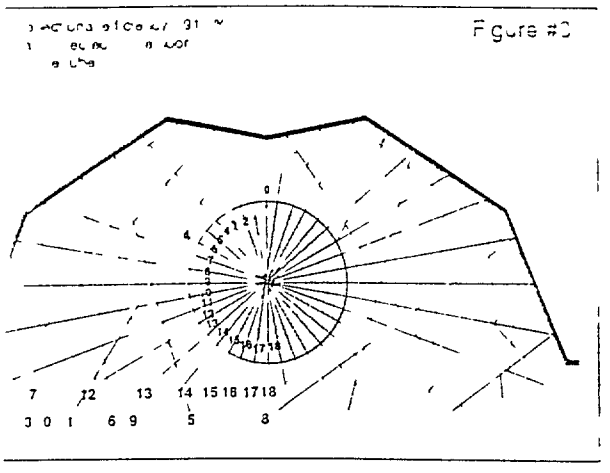


Figure #8

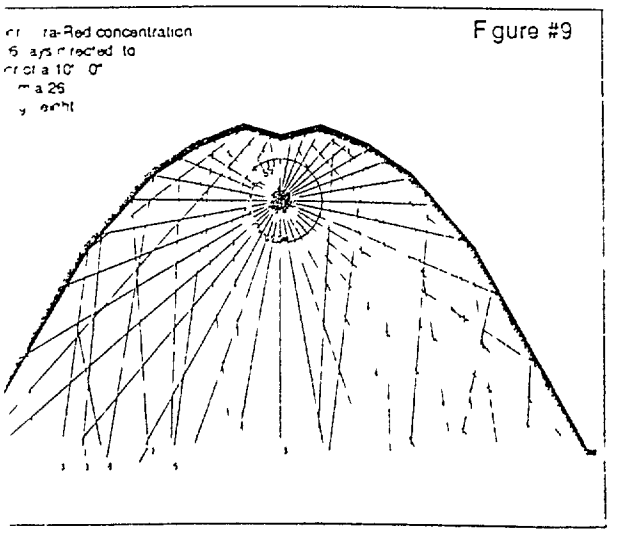


Figure #9

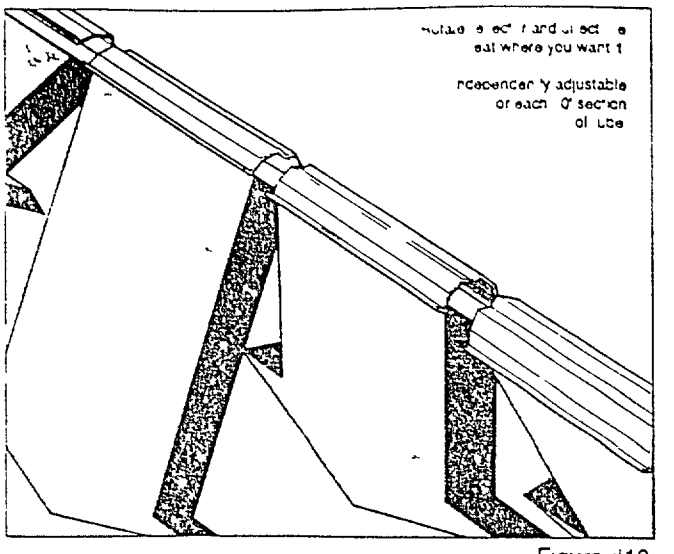


Figure #10

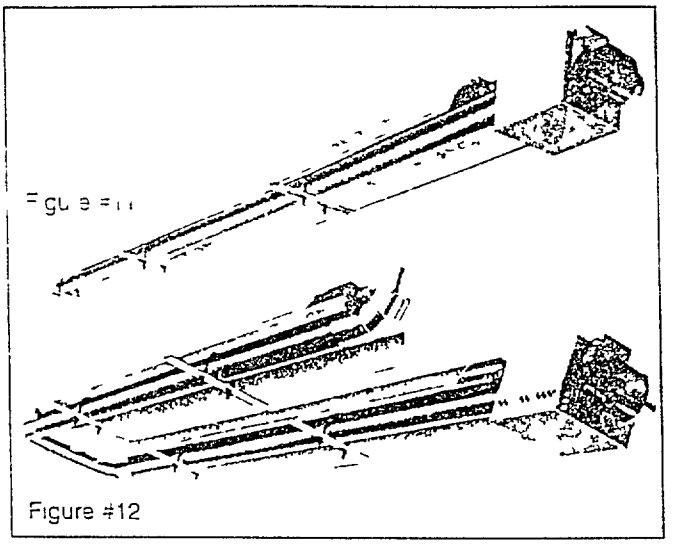


Figure #12

SOLARONICS SUNTUBE

Solaronics gas fired infra-red Suntube systems are ideal for any commerc al or industrial building Inlet air capa bilities make nem particularly well adapted for buildings with high negative pressure or airborne contaminants such as dust over spray and degreasing fumes Directly vented units are an ideal choice for buildings with low infiltration or where condensation is a problem Although not explosion proof Suntube has no open flame

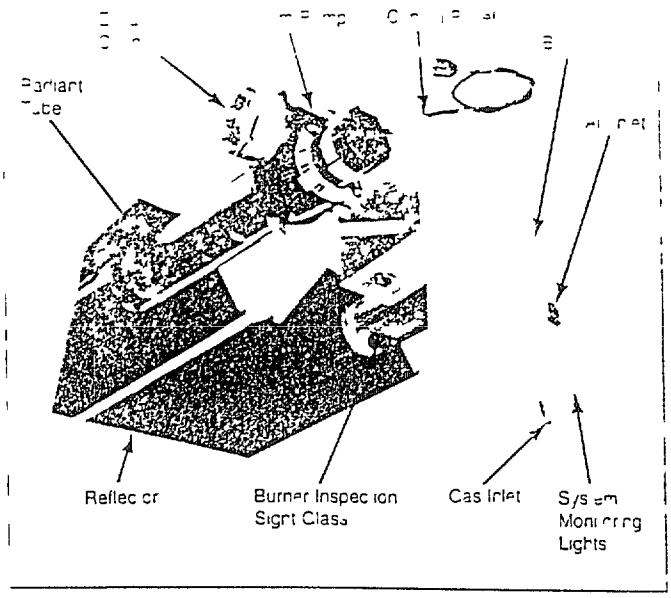
Solaronics gas fired infra red Suntube systems are avail able in many different input capac ties system lengths and configurations AGA and CGA design certified heater capacities are 40,000 thru 200,000 BTUH every 5,000 BTUH Tney are available in 10 , 20 25 , 30 , 35', 40', 45 50 55 , 60 , 65 , and 70 system lengths in both straight and compact U tube configurations Each system comes factory preassembled in 5 or 10' long sections to eliminate loose hardware and for ease of field installation Suntube is design certified for either directly or indirectly vented operation and for use with inside or outside combustion air

SOLARONICS SOLARVAC LOW INTENSITY HEATERS

Solaronics Solarvac low intensity heaters are of the negative pressure type (vacuum) dry non condensing design and utilize either a single burner or multiple burners on a vacuum pump Ignition is accomplished by a silicon carbide hot surface igniter

The burner(s) shall have two system monitoring lights and a burner inspection sight glass through which both the flame and the spark may be observed Burner operation includes pre purge cycles and can be controlled by a 24 volt thermostat The burner housing is a Nema 1 enclosure 16 gauge steel with polyester coating and a totally sealed hinged cover

SVS AND SVU SERIES GAS INFRA RED HEATERS



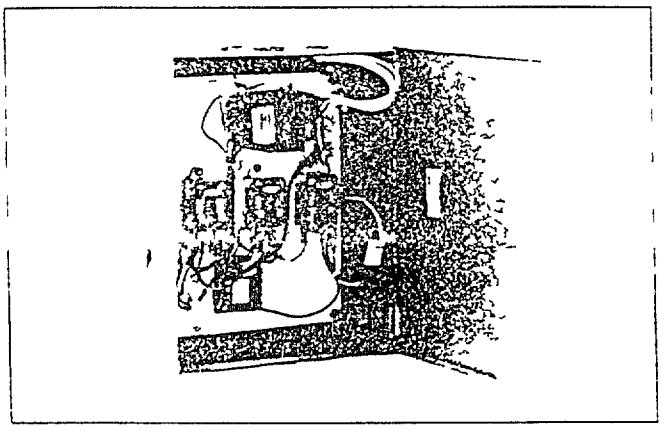
The vacuum pump for a SVS and SVU series single burner system is air cooled with sealed bearings a thermal overload switch and 1/20 horsepower motor

The vacuum pump for an SV series multiple burner system is totally enclosed externally fan cooled with double shielded prelubricated ball bearings externally located capacitor factory balanced 18 gauge stainless steel wheel 16 gauge aluminized steel housing and 1/3 horsepower reversible motor capable of operating at 3450 R P M

The control panel shall be factory wired complete with multiple thermostats when required for zone control and include 115 24 VAC transformer and three pronged power cord The control panel housing is a Nema 1 enclosure 16 gauge aluminized steel with polyester coating and a totally sealed hinged cover

The combustion chamber heat exchanger(s) are constructed of 16 gauge aluminized steel utilizing a swedged tube design 4 OD by 5 or 10 long and have 1 052 square feet of radiant surface per linear foot

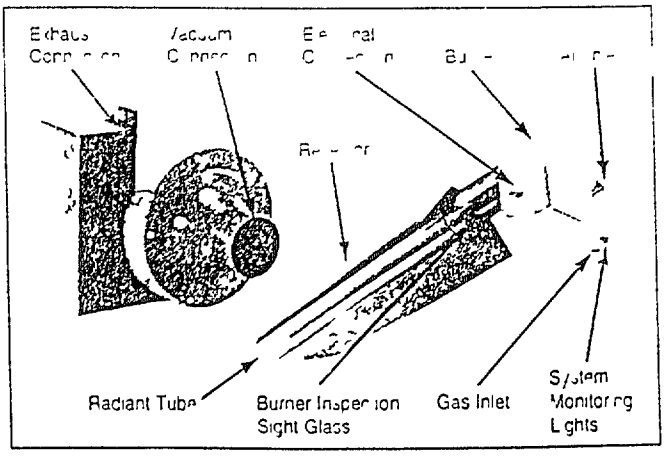
CONTROL PANEL



Reflectors are constructed of 0 025 gauge bright polished aluminum certified for 0 to 45 deg angle mounting

Heaters are design certified by the American Gas Association and by the Canadian Gas Association

SV SERIES GAS INFRA RED HEATERS



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THE LEADER IN QUALITY INFRA-RED PRODUCTS

SOLARONICS DESIGN SERVICE

~ our custom computer backed design service you a multitude of important facts such as comparative costs life cycle costs, accurate heat loss data to ' ou the most economical heating system available ~ s plus customized equipment plans and layouts be yours at NO EXTRA EXPENSE when you s your dollars in a Solaronics infra red heating em Factory engineering experts are ready and ng to evaluate designs or plans and offer any stance you require So let Solaronics show you facts

aronics has been a leader in quality infra red ucts since 1962 Our complete line o high and ~ ensity infra red heaters are distributed through out North America by manufacturer s representatives with integral territories These products are of the highest quality in the industry and possess many exclusive features and benefits

Solaronics world headquarters is located in Rochester, Michigan This facility in addition to our Canadian plant houses almost 70 000 square feet of production and office space In all, Solaronics employs some 100 people each with the knowledge and skill required to put them at the forefront of their respective fields In addition to space heating products, we manufacture make-up heaters gas fired door jet heaters process ovens for specialized applications and an array of gas fired infra red process and cooking burners

SOLARONICS, INC

P O Box 217
Rochester, MI 48308-0217
1 800 223-5335 FAX (810) 651-0357

In Canada 2140 Winston Pk Dr #13
Oakville, ON Canada L6H 5V5
1 800 387-0300 or (905) 829 0300

APPENDIX B MEASURED AND COLLECTED DATA

Below the results of making measurements of combustion gases

"RIBBON" Glassmaking Furnace
at ISKRA Plant
Measurements data after the regenerator

SERIAL # 11003246
ENERAC MODEL 2000
COMBUSTION TEST REKORD

FOR BURNS & ROE

TIME 11 43 25
DATE 11/27/97

FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY 51 8 %
AMBIENT TEMPERATURE 23 °C
STACK TEMPERATURE 624 °C
OXYGEN 09 7 %
CARBON MONOXIDE 54 MGM
CARBON DIOXIDE 06 3 %
COMBUSTIBLE GASES 0 00 %
STACK DRAFT (INCHES H20) –0 7
EXCESS AIR 77 %
OXIDES of NITROGEN 1396 MGM
SULFUR DIOXIDE 0 MGM
CARBON MONOXIDE ALARM 200 PPM

MODE MGM OXY_REF = 0%

"RIBBON" Glassmaking Furnace
at ISKRA Plant
Measurements data after the regenerator

SERIAL # 11003246
ENERAC MODEL 2000
COMBUSTION TEST REKORD

FOR BURNS & ROE

TIME 11 57 54
DATE 11/27/97

FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY 55 9 %
AMBIENT TEMPERATURE 23 °C
STACK TEMPERATURE 727 °C
OXYGEN 05 4 %
CARBON MONOXIDE 36 MGM
CARBON DIOXIDE 08 8 %
COMBUSTIBLE GASES 0 00 %
STACK DRAFT (INCHES H20) –0 7
EXCESS AIR 31 %
OXIDES of NITROGEN 1172 MGM
SULFUR DIOXIDE 0 MGM
CARBON MONOXIDE ALARM 200 PPM

MODE MGM OXY_REF = 0%

"RIBBON" Glassmaking Furnace
at ISKRA Plant
Measurements data after the regenerator

SERIAL # 11003246
ENERAC MODEL 2000
COMBUSTION TEST REKORD

FOR BURNS & ROE

TIME 12 18 35
DATE 11/27/97

FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	53 7	%
AMBIENT TEMPERATURE	21	°C
STACK TEMPERATURE	604	°C
OXYGEN	09 5	%
CARBON MONOXIDE	0	MGM
CARBON DIOXIDE	06 5	%
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	–0 7	
EXCESS AIR	74	%
OXIDES of NITROGEN	1579	MGM
SULFUR DIOXIDE	0	MGM
CARBON MONOXIDE ALARM	200	PPM

MODE MGM OXY_REF = 0%

'RIBBON Glassmaking Furnace
at ISKRA Plant
Measurements data after the regenerator

SERIAL # 11003246
ENERAC MODEL 2000
COMBUSTION TEST REKORD

FOR BURNS & ROE

TIME 12 24 59
DATE 11/27/97

FUEL NATURAL GAS 21870 BTU/LB

COMBUSTION EFFICIENCY	58 0	%
AMBIENT TEMPERATURE	21	°C
STACK TEMPERATURE	637	°C
OXYGEN	06 7	%
CARBON MONOXIDE	0	MGM
CARBON DIOXIDE	08 0	%
COMBUSTIBLE GASES	0 00	%
STACK DRAFT (INCHES H20)	–0 5	
EXCESS AIR	42	%
OXIDES of NITROGEN	1183	MGM
SULFUR DIOXIDE	6	MGM
CARBON MONOXIDE ALARM	200	PPM

MODE MGM OXY_REF = 0%

APPENDIX C MEASUREMENTS UNITS

CURRENCY EQUIVALENTS

1 hrn - a Ukrainian money unit
1 hrn = 0,5 x US $1 (the state on April 1998)

CONVERSION FACTORS

HEAT

1 cal = 4 187 J
1 kcal = 4 187 kJ = 3 968 Btu
1 Gcal = 4 187 10^3 MJ = 4 187 GCal
1 Btu = 1,055 J = 1 055 kJ = 1 055 10^{-3} MJ

POWER

1 W = 3 6 10^3 J = 3 6 kJ
1 kW = 3 6 10^3 kJ = 3 6 MJ = 860 kCal
1 MW = 3 6 10^3 MJ = 0 86 GCal
1 kcal = 1 163 10^{-3} kW
1 Gcal = 1163 kW = 1 163 MW
1 kW = 1 36 HP
1 kW = 1 34 hp

PRESSURE

1 kgf/cm^2 = 1 barg
1 barg = 101 325 kPa = 0 1 MPa
1 bar = 10^5 Pa = 100 kPa = 0 1 MPa

LENGTH UNITS

1 mm = 0 0394 in = 0 00328 ft
1 cm = 0 3937 in = 0 0328 ft
1 m = 39 37 in = 3 281 ft

WEIGHT UNITS

1 g = 2 2046 10^{-3} lb
1 kg = 2 2046 lb
1 t = 1000 kg = 2 2046 10^3 lb

AREA UNITS

1 cm^2 = 0 155 in^2 = 1 076 10^{-3} ft^2
1 m^2 = 1 55 10^3 in^2 = 10 76 ft^2

VOLUME UNITS

1 m^3 = 35 31 ft^3 = 1000 l
1 l = 35 31 10^{-3} ft^3
1 l = 0 264 gal (US)

HEAT CONTENT

1 kJ/kg = 0 43 Btu/lb
1 kJ/m^3 = 26 84 10^{-3} Btu/ft^3
1 MJ/m^3 = 26 84 Btu/ft^3
1 kcal/m^3 = 4 187 kJ/m^3 = 0 112 Btu/ft^3

TEMPERATURE

°C = 0 56 (°F – 32)

APPENDIX D ABBREVIATIONS

ABBREVIATIONS

ESCO	- energy servicing company
ECO	- energy conservation opportunity,
Fig	- figure,
hrn	- hryvnia,
tel	- telephone,
USAID	- United States Agency for International Development,
VAT	- value-added tax,

barg - atmosphere gauge
BTU - British thermal unit
°C - degrees Celcius
cm^2 - centimeter squares
°F - degrees Fahrenheit
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 H2O - millimeters of the water column
MW - megawatt
t - tonne
t/h - tonnes per hour
W - watt