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ENERGY EFFICIENCY AUDIT REPORT
PUSSI FIBREBOARD PLANT
PUSSI, ESTONIA

JULY 1992

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QUALITY ASSURANCE STATEMENTS

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

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FINAL ENERGY AUDIT
PUSSI FIBREBOARD PLANT
PUSSI, ESTONIA

I. ACKNOWLEDGEMENTS:

USAID, TERMOX and RCG/Hagler, Bailly, Inc. gratefully acknowledge the assistance, and cooperation shown by USAID, Tallinn, Tallinn Technological University's (TTU) Messrs. Vladimir Marchenkov, Heinrich Suik and Prof.Dr.Sc. Arvo Ots. We also gratefully acknowledge the personalized assistance and cooperation of the following PUSSI FIBREBOARD PLANT individuals:

Mr. Nicolai Neshumayev
Chief Engineer

Mr. Alexander Ladnov
Chief Energy Mgr.

II. EXECUTIVE SUMMARY

A team of engineers from RCG/Hagler, Bailly, Inc. made up of Messrs. Barry G. Tunnah and Eduardo S. Maal, Messrs. Vladimir Marchenkov, Heinrich Suik and Prof.Dr.Sc. Arvo Ots from Tallinn Technical University (TTU) and TERMOX's Messrs. Aare Kivilo, Mr. K Jugesman and translator, carried out Preliminary Energy Auditing site activities at PUSSI FIBREBOARD PLANT (PFP) from Dec 7-10, 1991 to work together with (PFP) staff to identify and implement improvements to energy efficiency.

PFP is a solidly based company, currently exporting products to the "free" western economies on a competitive basis. PFP still has some problems to resolve, such as stopping the use of formaldehyde (not permitted in most industrialized countries) as a fibreboard bonding agent. This is the one industry of the four visited that will adapt the quickest to Estonia's entry into a "free economy" system. PFP is currently undertaking a self financed, extensive equipment improvement program, which is being implemented by Finnish companies.

RCG/HB has based it's work on consumption in 1989 and 1990 and energy prices in US $. This has been done due to the severe devaluation of the Estonian/Russian RUBLE at the time of the visit and the fact that Estonia will have to pay "world, free economy" prices for fuels.

Based on 1989 and 1990 figures, RCG/HB estimates total yearly energy costs for 1992 at PUSSI FIBREBOARD PLANT as:

PUSSI FIBREBOARD		
Yearly Electricity use in Mwh	73,369	
Yearly TOTAL Fuel use in Tons of Mazout	39,509	
Yearly BOILERS Mazout use in Tons	29,691	
Yearly value of Elect. at US$ 50.00/Mwh	$3,668,438	57%
Yearly value of TOTAL Mzt at US$ 70.00/Tn	$2,765,646	43%
Yearly value of BLRS Mzt at US$ 70.00/Tn	$2,078,380	32%
Yearly value of TOTAL Energy in US $	$6,434,084	

The bases for the Energy savings identified in this report, which cannot always be considered additive, have been broken down as follows:

GENERAL AND ENERGY MANAGEMENT IMPROVEMENTS. IMPROVEMENT FROM USAID FINANCED EQUIPMENT PURCHASES

RCG/Hagler, Bailly conservatively estimates that the potential for energy efficiency improvement without major process changes, at PUSSI FIBREBOARD PLANT (PFP),is substantial. PFP can and should start to implement these measures immediately.

As a result of the survey performed, the RCG/Hagler, Bailly team recommends purchase of the equipment required to implement the energy efficiency projects listed below. PUSSI FIBREBOARD PLANT has agreed to pay for installation and other costs necessary to implement the recommended projects and to make full use of any equipment to be supplied by USAID. The details for the recommended USAID financed equipment purchases are:

ECO P-1:

TOTAL COST	YEARLY SAVINGS	SIMPLE PAYBACK
$4,500	$64,341	0.1

Portable Computer
LOTUS 123, software with ALLWAYS

ECO P-2:

TOTAL COST	YEARLY SAVINGS	SIMPLE PAYBACK
$9.000	$128,682	0.1

Electronic Combustion Gas Analyzer
FLUKE Temperature Indicator & probes
Electronic, Total Dissolved Solids meter
Infra-red pyrometer
Ultrasonic Steam Trap Tester
Electric Survey Meter

ECO P-3:

TOTAL COST	YEARLY SAVINGS	SIMPLE PAYBACK
$16,500	$35,313	0.5

Fuel Oil Meters for Boilerhouse (4)
Fuel Oil Meters for Process Areas (2)

The total cost for the recommended USAID financed equipment purchases is $32,000 and the expected yearly savings are $240,000 with a simple payback of approximately 0.1 years.

III. INTRODUCTION

3.1. Background

PFP is a company with a solid "economic" base (unlike other Estonian companies which had no "economic" reason for existing and whose reason for existing was "political", ie. to provide work for people in a given geographic area). PFP is currently exporting wood based products to the "free" western economies on a competitive basis. PFP still has some problems to resolve, such as the use of formaldehyde (not permitted in most industrialized countries) as a fibreboard bonding agent. This is the one industry of the four visited that will adapt the quickest to Estonia's entry into a "free economy" system. PFP is currently undertaking a self financed, equipment improvement program, which is being implemented by Finnish companies.

3.2. Plant Description

The PUSSI FIBREBOARD PLANT (PFP) consists of a number of production lines and workshops. The main processes are set up in three lines: for making chipboard, laminates and fiberboard (or hardboard). The basic steps are the receipt of raw wood and its breakdown into wood chips. The chips are then sent either to the chipboard line (from which about one third of the chipboard product passes to the laminates section) or to the fibreboard line. The various processes are described further in subsequent sections of this report. The relationship of the production quantities of the various products, Chipboard, Laminated Chipboard and Fibreboard is seen on Appendix E.

3.3. Process Description

The processing operations may be divided into three main activities, the manufacture of chipboard, the production of laminates using a part of the chipboard, and an entirely separate facility for the manufacture of hardboard (fiberboard).

The basic raw material for the plant is wood which is brought by trucks or by rail in the form of 1-6 meter logs. Some wood is local and some is imported from Russia. The logs are stored outside and transferred with bulldozers, dump trucks and conveyor belts to the chipping machines (two units, one with a 1000 Kw motor, the other 500 Kw). The coarse chips and wood pieces are transferred pneumatically to a storage area, which is also outside, before passing to the grinding section of the chipboard line. Part of the production of wood pieces is also used for the fiberboard production line. In the grinding section, the wood is reduced to chips of the correct size: there are 8 machines with 160 Kw motors. The final chips are again transferred pneumatically to outside storage bunkers.

In the bunkers, the chips are exposed to the prevailing weather conditions. Their moisture content fluctuates from over 90 percent in the winter to around 40 percent in the summer. The wet chips are passed from the storage area to the drying section, in which four mazout fired rotary dryers take the moisture content down to 2-5 percent. Approximately 700 tonnes of mazout are consumed monthly. The dryers also fire wood dust which is blown into the mazout combustion chamber.

The dried chips and accompanying wood dust are transferred pneumatically (four 160 kW air blowers) to the separation section where vibrating screens are used to divide the material into two main fractions of chips and the waste wood dust.The separated chips are stored in bunkers before passing to the mixing section which consists of two units. Here the chips are mixed with glue, the proportions of glue and chips being automatically controlled by weight. The chips/glue mix is transferred to the forming machines by a mechanical scraper-type conveyor: in the forming machines, the chipboard is prepared with a layer of larger chips in the middle of two outer layers of finer chips. The chipboard is laid on a travelling horizontal belt and this passes into the cold press, which squeezes the chips together to make a firm flat board. Sections of the board are cut into standard lengths and these pass into a special machine for storage as stacks of 19 boards.

The stacks of chipboard are then passed into the hot press in which heated plates compress the chipboard firmly at about 180 deg C. The press is heated by circulating hot oil. The boards are sent to a cooling chamber where air is blown over the boards (warm air is vented to atmosphere). A heat recovery system is being installed in which hot dusty air from above the hot press is ducted to the combustion air intakes of the rotary chip dryers. The system is expected to be operational within a month or so.

Cooled chipboard sheets are finally cut and polished to the required thickness: two grades are currently made, 16 and 18 mm, and consideration is being given to making 22 mm chipboard. The finished product, typically 140,000 M^3 per year, is then ready for shipment, but about one third of the production is processed further in the plant to make laminates. Energy consumed specifically for making the chipboard is not known, as there are insufficient separate meters. Energy is consumed in the form of electricity for motor drives and as hot oil (generated in mazout-fired heaters) for the hot press.

Approximately 2 million M^2 of chipboard are sent to the two lines of the laminate workshop. Here, plastic and paper films are joined to both sides of the boards in hot presses. Edging strips are added. Some of the purchased films are put through a wet coating process before being bonded to the board. Finished laminates are cut to size for orders and shipped. A small amount of production is made into furniture for special orders in a small workshop at the Pussi plant.

The other major product of the plant is hardboard (also called fiberboard). Raw material comes from the chipboard section: wood pieces are washed to remove sand and dirt and then pass to disc-type "defibrator" machines heated with direct injection 10 bar steam. The wood pieces pass into grinding machines (five, with 7000 volt/180 kW motors) where the fibers are broken down. Steam condensate and the fibers are mixed with additional water to form a pulp which is stored in stirred basins.

The pulp passes through a vacuum device to remove water and then passes into the forming machines. Sets of rollers squeeze water out and the wet fiberboard is cut into 5.5 meter pieces. These are automatically stacked and transferred to the hot press. Here the board is pressed by heated plates, alternating between smooth surfaces and those with a ribbed finish. The plates are heated to 220 deg C by a circulating pressurized hot water system at 20 bars, energy for which is provided by high pressure steam. Hot gases from the press contain steam, fibers and resins, and pass through the roof to atmosphere. A heat recovery system was installed at one time but this became heavily fouled and did not work. The system was therefore dismantled. The roof area is cleaned once per month and the press itself is cleaned once per week.

Hot water also drains from the press. The water has a pH of 3-5 and contains fibers and waxes. About 80 M^3 of hot water are discharged each shift but heat recovery is not thought to be practical.

After the hot press, the sheets of hardboard are sent to a tempering stage at about 170 deg C, followed by cooling and then cutting for shipment of orders.

IV. ENERGY USE ANALYSIS

4.1. Energy Use

Utilities are consumed in the form of electricity, hot water and steam. Electricity is of course consumed in the large number of motor drives, as much of the process involves chipping, grinding and cutting of wood, pressing of wood particle boards and fiberboard, and the transport of raw materials, intermediates and products. Transport is both "direct" on conveyor belts and in mechanical stacking equipment, and "indirect" in pneumatic transfer systems.

In this plant, the fuel used is mazout (residual fuel oil). Energy systems in the process areas are users of steam, hot water, electricity, and mazout is also fired directly in wood chip dryers. Some waste wood sawdust is burned in the dryers also. The boilerhouse generates steam and hot water both for process uses and for space heating.

Although electricity prices are likely to rise in the short term, electricity is generated using Estonian resources, i.e. shale oil. By contrast, fuel oils and natural gas are imported and their prices are expected to rise even faster and the fuels themselves are likely to become in very short supply. For this reason, this project concentrated on the efficiency of use of thermal energy: the boilerhouse and thermal energy users were studied during our visit.

For a plant/process with good energy management potential, graphs of PRODUCTION versus ENERGY USE yield points which are usually near a straight line, with more energy used for a higher level of production. An excellent example of this is observed in Appendix C, the Boilerhouse's HEAT production vs. Mazout Graph. On the other hand, on a plantwide, TOTAL production basis this relationship is considerably less linear and more scattered, as seen on Appendix A, graph of Total (Chipboard plus Laminated Chipboard plus Fibreboard) Production vs. Total Mazout use. When comparing Appendix D, graph of Total Production vs. Electricity use, and Appendix A, graph of Total (Chipboard plus Laminated Chipboard plus Fibreboard) Production vs. Total Mazout use, we can see clearly see that there are better Energy Management opportunities in Electricity use than in Mazout use. Appendix B, graph of Chipboard Production vs. Mazout use shows that there is a fairly good opportunity for effective Energy Management.

4.2. Boilerhouse

There are two hot water boilers and two steam boilers in normal use, with one old Babcock steam boiler available for emergency use. The steam boilers have superheaters, economizers and two stage air preheaters. The hot water boilers were originally steam boilers. They were converted for hot water duty and have no economizers or combustion air preheaters.

V. RECOMMENDATIONS FOR ENERGY EFFICIENCY IMPROVEMENTS

Recommendations have been divided into two areas:

GENERAL AND ENERGY MANAGEMENT IMPROVEMENTS.
IMPROVEMENT FROM USAID FINANCED EQUIPMENT PURCHASES

RCG/HB suggests that improvements in the first category should be undertaken as quickly as possible, concurrent with or before, those financed by USAID. RCG/HB didn't, at this time, consider IMPROVEMENTS REQUIRING MAJOR CAPITAL INVESTMENTS due to the current economic situation in Estonia and at PUSSI FIBREBOARD PLANT.

5.1. GENERAL AND ENERGY MANAGEMENT IMPROVEMENTS

5.1.1. Boiler House Operation Control Improvement

Current Conditions:

Superheated steam is generated at the plant boilerhouse at up to 39 bars and is used in a number of process steps. The steam is reduced to 20 bars (with desuperheating) for the fibreboard (hardboard) process section. Hot water is also generated in the plant boilerhouse and a circulating system provides space heating in the plant workshops, nearby residential areas and an oil shale quarry.

All the boilers are well insulated and no major heat loss was observed.

Some minor steam leaks were observed at valves. Insulation generally looked adequate but some sections of insulation were clearly damaged.

It was noted that all boiler combustion air intakes are inside the boilerhouse at a level of about 3-5 meters above the floor. This is good practice, as the combustion air temperature was measured at 15 deg C compared with the outside air temperature of -4 deg C. In warmer weather, e.g. in the summer, the air intakes can be switched to take outside air if outside temperatures are higher.

Readings were taken around one hot water boiler which was firing mazout. The boiler has no economizer or air preheat sections. The water inlet temperature was 60 deg C and outlet 101 deg C. Stack gas temperature was 178 deg C. Stack gas carbon dioxide content was 7 percent, corresponding to an excess air rate of nearly 130 percent.

Although this is very high, the operators said that it was not possible to reduce the air rate without causing black smoke. This suggests that the burners are in poor condition and should be replaced. Combustion gas analyses are not done by the plant but the operations are checked following start up after a major maintenance shut down:this is done by a specialist group from Tallinn, usually once per year.

The heat loss from the boiler outside surface is low, the typical temperature being about 30 deg C. Taking this and the other readings into account, it is estimated that the hot water boiler was operating at 83 percent efficiency (based on gross CV). Reduction of the excess air to a more reasonable level, say 30 percent, could improve efficiency by 4-5 percentage points, equivalent to fuel savings of around 5 percent. A new burner may be required to achieve this.

Readings were taken around the one operating steam boiler, also firing mazout. Superheated steam production was 37.5 t/h at 29.5 bars. close to maximum capacity. Stack gas temperature was 201 deg C and carbon dioxide content 6 percent. This corresponds to an excess air rate of 165 percent, a very high level. It is possible that this result is distorted by air leakage from air preheater system: samples of combustion gases could not be taken before the economizer or air preheater equipment to check. However, the burner equipment appears very old and the louvers around each of the 6 burners did not seem able to control the ingress of air, making it probable that the boiler does indeed run with too much air.

The Total Dissolved Solids level in the boiler water seems high at 4300 ppm (and 9000 from an external cyclone) for a 30 bar system. A level of 2000 ppm would normally be recommended. The actual blowdown is said to be 5 percent (based on water sample TDS levels, the rate is indeed 2 tonnes/hour or 5 percent). The blowdown is partly continuous, supplemented by intermittent blowdown twice per shift (about 10 seconds each time). The quantity of blowdown is based on phosphate and alkalinity figures determined by the boilerhouse chemist who takes samples every two hours. TDS figures are not determined. In fact, the rate should be nearer double, say 10 percent or 4 tonnes/hour, to maintain the lower recommended TDS level. At such a high blowdown rate, a heat recovery system might be economically justified.

The condensate return was checked and the TDS found to be about 30 ppm. This is not excessive but may indicate minor carryover of solids from the boiler drum into the steam system. There is, however, no indication of excessive maintenance on the steam distribution system caused by corrosive materials, and the boiler tubes are understood to have lasted from 1978 on one boiler (which is currently undergoing maintenance). Tubes in the operating boiler have lasted equally long, suggesting that water quality is adequate.

The estimated boiler efficiency is 76 percent, based on gross CV. In theory, reducing the excess air rate from 165 to say 30 percent could improve the efficiency by 6-7 percentage points. However, the condition of the equipment is such that this is very unlikely to be possible, even with comprehensive maintenance. A major rebuilding or replacement of the boiler appears necessary to achieve high efficiency.

Recommended Actions:

It is unlikely that the full benefits of lower excess air operation are achievable with the existing old equipment. Nevertheless, regular use of the portable analyzer recommended as **ECO P-1** should allow the plant to make the best use of the boilers, pending renovation or boiler replacement.

Proper use of the USAID supplied TDS meter will help the operators to maintain the correct blowdown rate and thus minimize the risk of carryover of salts into the steam (avoiding corrosion).

It is also recommended that all burner tips be repaired/maintained to improve atomizing performance. With properly operating burner tips, it should be possible to operate with lower excess air.

Expected Results:

A Boilerhouse Energy efficiency improvement of 1-4 % as well as longer intervals between programmed maintenance should easily be achieved.

5.1.2. Hot Oil Heater

Current Conditions:

The plant claimed that one of the hot oil heaters, used to provide circulating hot oil for the chipboard hot press, was running with an excessively high stack temperature. There was no opportunity to check this as the unit was shut down at the time.

Recommended Action:

Since the unit is relatively new (about two years old), the performance should be checked by the plant against design parameters. If indeed the stack temperature is too high, the manufacturer should be consulted and asked to suggest remedies, and could also be asked

to consider the cost and benefits of a heat recovery system (e.g. for combustion air preheating).

5.2. USAID FINANCED EQUIPMENT PURCHASES

Taking into account the findings of the brief audit made at PUSSI FIBREBOARD PLANT and the needs expressed by plant management, it is recommended that the following equipment be supplied to the plant to assist in making energy efficiency improvements in the short term:

5.2.1. ECO P-1, Energy and production management computers

Existing conditions:

PFP collects a vast amount of information every day, but has no way of organizing this data and using it for production and energy management control.

Recommended action:

Provide one IBM-PC 386 equivalent computer with printer and Lotus 1-2-3 software, together with the spreadsheets of production and energy developed by RCG/Hagler, Bailly, Inc. PFP will obtain training in Lotus locally.

Estimated cost of equipment:

$4,500

Estimated cost of installation and training:

$1,000

Estimated benefits, energy savings (and economic savings):

The equipment, with the proper software, can serve as the basis of an energy management information and control system. The introduction of a management information system, with control actions taken in response to conditions identified in the plant, can achieve energy savings of 5-10%. Based on savings of at least 1% of energy costs, benefits are estimated as $64,341 per year, not including productivity or quality benefits.

Estimated payback period: 0.1 year

5.2.2. ECO P-2, Portable efficiency monitoring instruments

Existing conditions:

The Total Dissolved Solids level in the boiler water seems high at 4300 ppm (and 9000 from an external cyclone) for a 30 bar system. A level of 2000 ppm would normally be recommended. The actual blowdown is said to be 5 percent (based on water sample TDS levels, the rate is indeed 2 tonnes/hour or 5 percent). The blowdown is partly continuous, supplemented by intermittent blowdown twice per shift (about 10 seconds each time). The quantity of blowdown is based on phosphate and alkalinity figures determined by the boilerhouse chemist who takes samples every two hours. TDS figures are not determined. In fact, the rate should be nearer double, say 10 percent or 4 tonnes/hour, to maintain the lower recommended TDS level.

The condensate return was checked and the TDS found to be about 30 ppm. This is not excessive but may indicate minor carryover of solids from the boiler drum into the steam system. There is however no indication of excessive maintenance on the steam distribution system caused by corrosive materials, and the boiler tubes are understood to have lasted from 1978 on one boiler (which is currently undergoing maintenance). Tubes in the operating boiler have lasted equally long, suggesting that water quality is adequate.

Some areas of inadequate insulation were observed, and heat loss from steam and hot water distribution systems is substantial. Further optimization would be possible with advanced instrumentation and efficiency teams.

Recommended action:

It is recommended that some basic instruments be provided to the boilerhouse to assist them in checking performance regularly:

Electronic Combustion Gas Analyzer
FLUKE Temperature Indicator & probes
Electronic, Total Dissolved Solids meter
Infra-red pyrometer
Ultrasonic Steam Trap Tester
Electric Survey Meter

These instruments can be used to check combustion conditions and ensure excess air is kept to a minimum.

The TDS meter will help the operators to maintain the correct blowdown rate and thus minimize the risk of carryover of salts into the steam (avoiding corrosion).

Estimated cost of equipment: $9,000 consisting of:

combustion kit	4,000
TDS meter:	500
thermocouple:	1,000
infrared:	1,000
ultrasonic (air/solid)	1,500
electric survey meter	1,000

Estimated cost of installation:

none

Estimated benefits, energy savings (and economic savings):

Based on boiler efficiency at time of audit, combustion efficiency improvements of 3-5% are possible. Avoidable losses in the distribution system are estimated as 1-3%. The estimated annual saving are 2% of total energy use, or $128,000 per year.

Estimated payback period:

Less than 0.1 year.

5.2.3. ECO P 3, Fuel Oil Meters for Boilerhouse and Process Areas

Existing Conditions:

Instrumentation and controls are not very good: much of the equipment looks old and some is in poor condition (e.g. the damper controls around the steam boiler burners, with many gaps around the burners allowing excessive air entry).

There are no separate meters for the fuel to each boiler or to the dryer department. Total mazout use is not metered either. A quick check of boiler efficiency cannot be made easily.

Recommended Action:

The purchase and installation of oil meters on boilers is recommended (2 steam boilers, 2 hot water boilers, total of 4 meters). Although metering cannot save energy directly, a better knowledge of fuel consumption should lead to closer monitoring of equipment performance and, in the long term, an improvement in efficiency.

At least two mazout meters should be installed, 1 meter for fuel to hot oil heaters and 1 meter for fuel to chip dryers.

Estimated Cost of Equipment: $16,500

Estimated Cost of Installation: $5, 000

Estimated Savings:

Accurate fuel measurements and accounting can easily yield a savings equivalent to 2% of Process Plants Energy use, plus 1% of Boilerhouse fuel use or $35,000 per year.

Estimated payback Period:

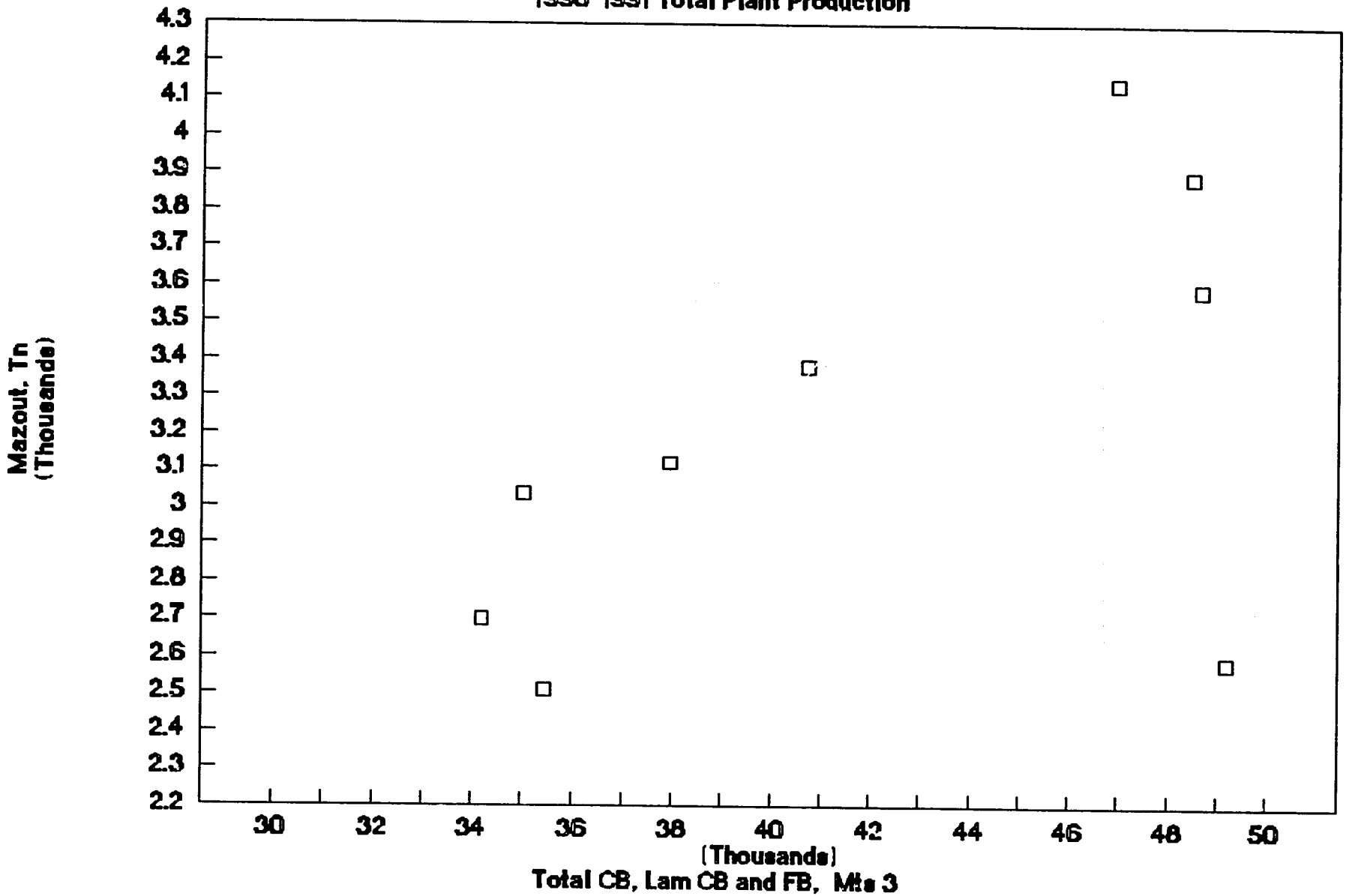
Less than 0.5 years.

APPENDICES
GRAPHICAL PRESENTATION OF HISTORICAL ENERGY, AND PRODUCTION DATA

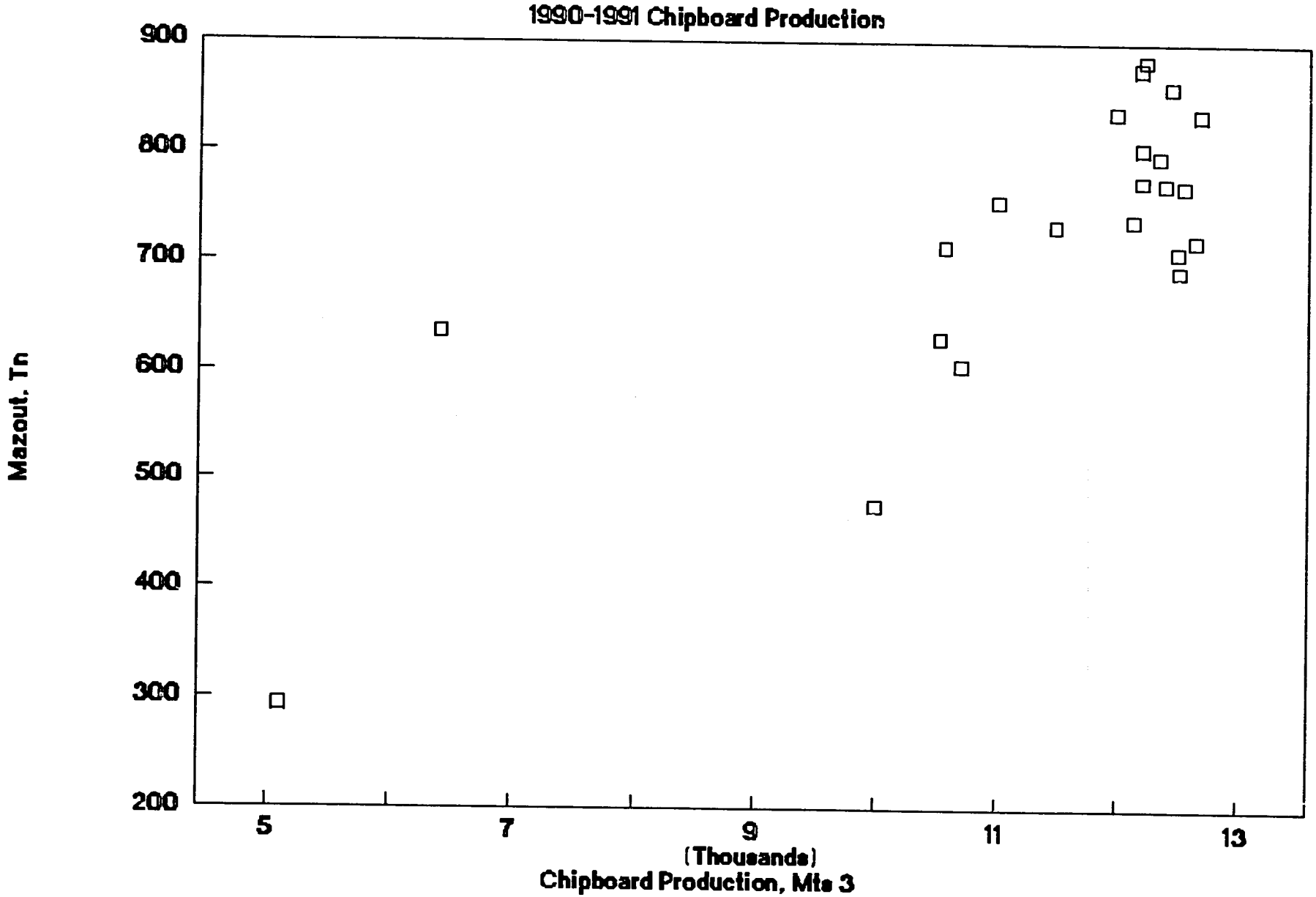
PUSSI FIBREBOARD PLANT

PUSSI FIBREBOARD PLANT – PRDCTN vs MZT

1990-1991 Total Plant Production



PUSSI FIBREBOARD PLANT–CHIPBOARD vs MZT



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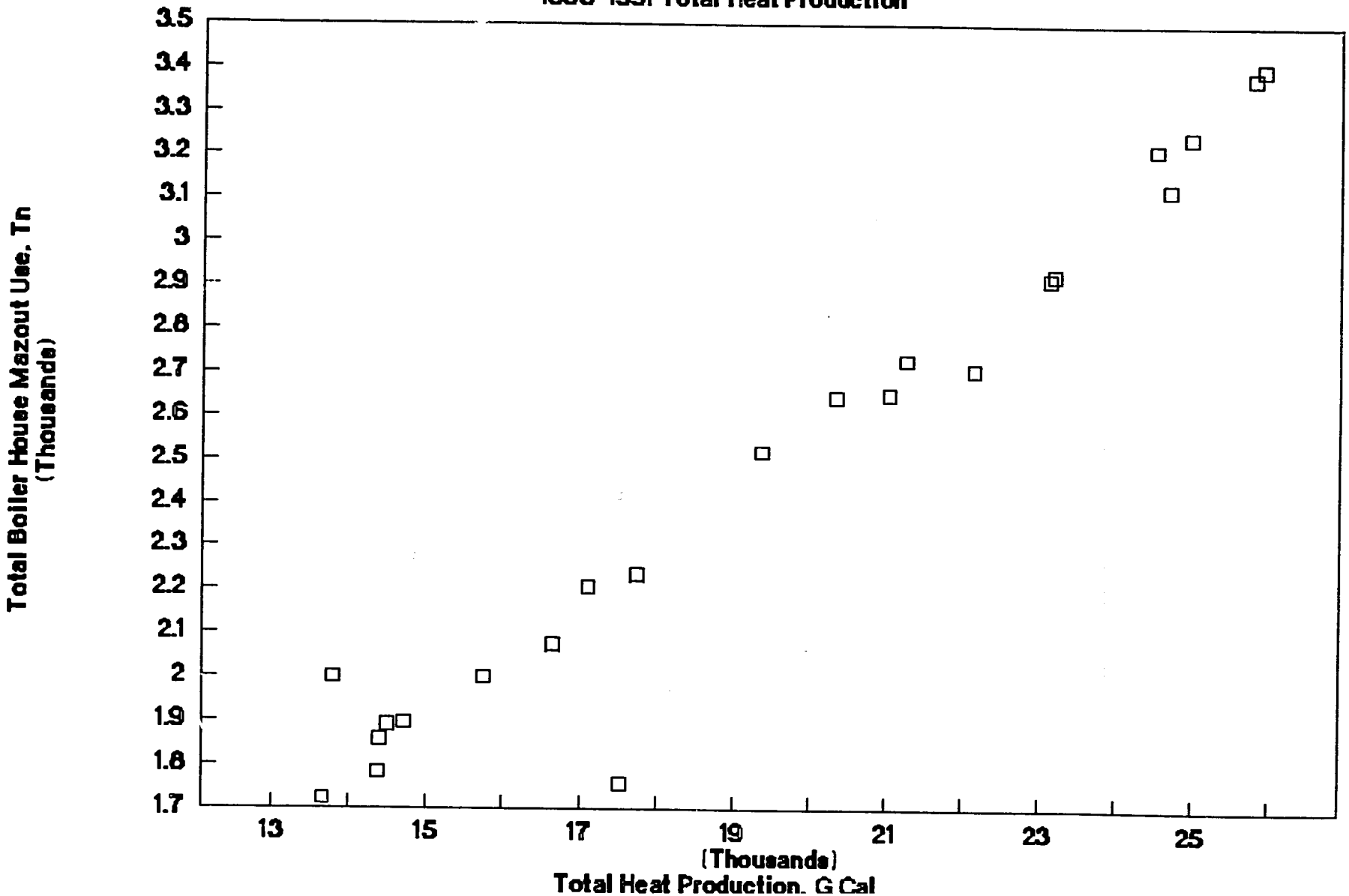
PUSSI CHIPBOARD PLANT – HEAT vs MAZOUT

1990-1991 Total Heat Production



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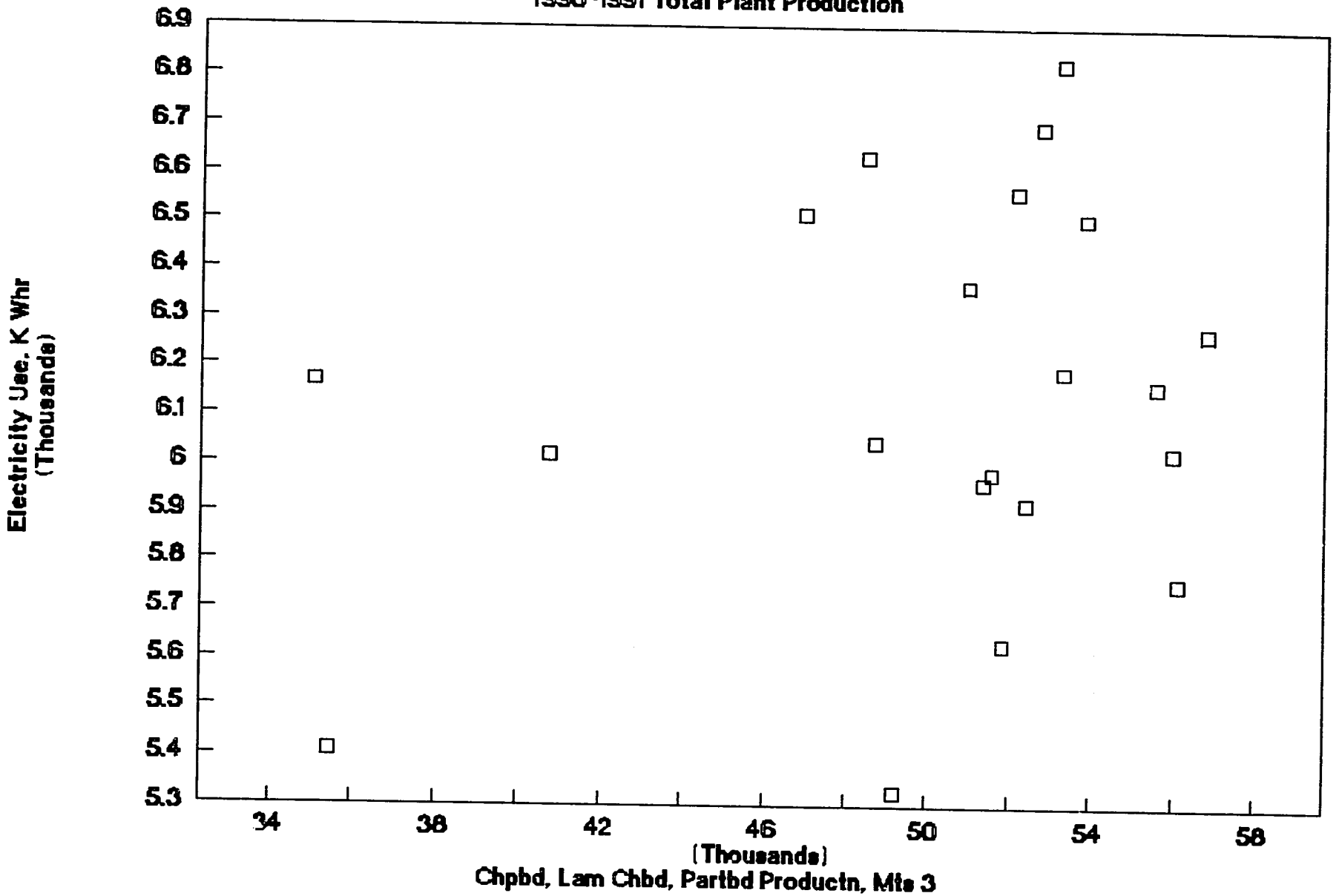
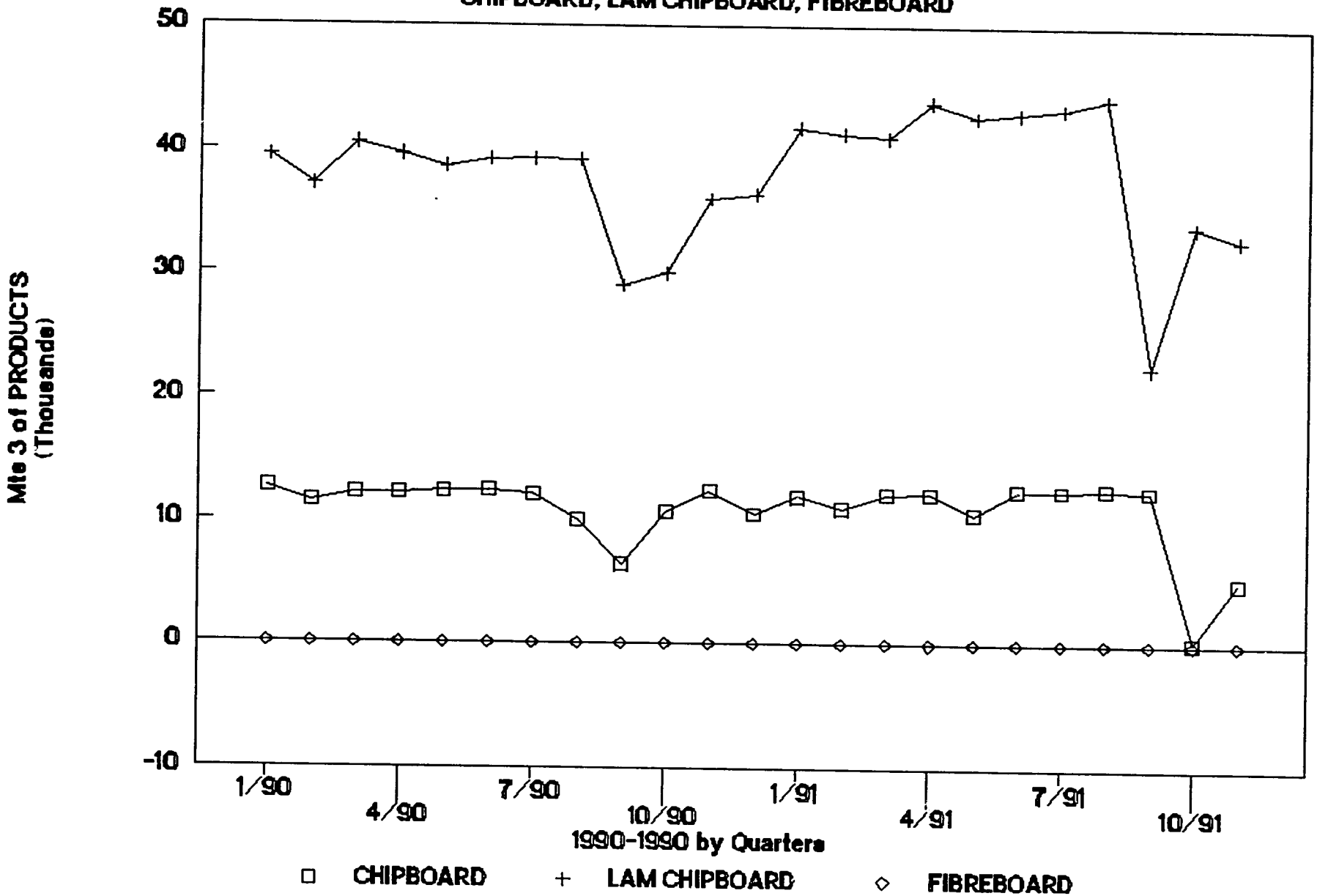
PUSSI FIBREBOARD PLANT – PRD vs ELEC

1990-1991 Total Plant Production



PUSSI FIBREBOARD PLANT - PRODUCTS

CHIPBOARD, LAM CHIPBOARD, FIBREBOARD