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ENERGY EFFICIENCY AUDIT REPORT

MATADOR PLANT
Bratislava, Czechoslovakia

JANUARY 1992

PREPARED BY: RESOURCE MANAGEMENT ASSOCIATES OF MADISON, INC.
Madison, WI

and

ELEKTROPROJEKT
Banska Bystrica, Czechoslovakia

U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
WASHINGTON, D.C. 20523

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U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
OFFICE OF DEVELOPMENT RESOURCES
ENERGY & INFRASTRUCTURE DIVISION
WASHINGTON, D.C. 20523

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i. Executive Summary

Czechoslovakia faces severe energy problems including uncertain oil supplies, pollution from coal, and questions about the future of nuclear energy. The Czechoslovakian industrial sector has experienced large increases in energy prices, the latest in January 1991. At the same time, the country has embarked upon a fundamental economic structural reform. The U.S. Agency for International Development established the Industrial Energy Efficiency Program to help mitigate the impacts of increased energy costs on the industrial sector by providing technical support through energy audits and economic support through purchase and installation of energy conservation equipment in selected representative industrial plants. Resource Management Associates of Madison, Inc. (RMA) is the technical assistance contractor for this component of the program in Czechoslovakia. RMA was provided with valuable assistance by two in-country subcontractors: 1) Stredisko pro Efektivni Vyuzivani Energie (SEVEn), in the plant selection and in-country logistics; and 2) Elektroprojekt in the audit and equipment installation work.

As part of this program, an energy audit was conducted at the Matador factory in Bratislava, Czechoslovakia. The factory produces rubber products such as conveyer belts, hoses, floorings, roof membranes, and molded products.

Energy Audit

Results of the Matador energy audit showed that there are many no/low-cost Energy Conservation Opportunities (ECO's) available in the facility. The two areas selected for demonstration are: 1) reduction of steam leaks/repair of steam traps; and 2) improvement of boiler combustion efficiency by controlling excess combustion air. Both offer large savings and rapid paybacks. The facility's annual energy consumption includes 760,833 GJ of steam generated by heavy fuel oil and 124,121 GJ (34,478 MWh) of electricity.

The following specifications were prepared for three ECO demonstration projects.

1. Replace steam traps in the Flooring Department. The estimated annual saving is 16,600 GJ and the payback is 0.2 years. This ECO has replicability potential for the whole plant, as well as for many other industrial plants.

2. Purchase test instruments for use in all of the production areas. The estimated annual savings is 21,925 GJ and the estimated payback is 2 months.

3. Purchase a combustion efficiency analyzer for the steam boilers. The estimated annual savings is 16,603 GJ and the estimated payback is 2 months.

The total estimated savings from implementation of the above ECOs is 55,128 GJ, or 6.2% of the total annual energy consumption. Additional ECO's were identified for Matador as part of their own energy conservation program. Recommendations were also made for changes in the company's organizational structure to better facilitate energy management.

Implementation Phase

A follow-up visit to Matador took place July 29 and 30, 1991. The purpose of the visit was to determine the status of installation of the energy conservation equipment, and to assist in preparation of a case study for the industrial efficiency seminar. Training was provided to the plant staff in the use of the portable equipment.

ii. Description of Energy Efficiency Program

Czechoslovakia's industrial sector is well developed and contains many large and heavy industries. However, there are many medium size industries within the country that consume a large percentage of the industrial energy used. Many of these industries are made up of multiple companies and plants within the country, making them ideal targets for industrial energy audit work because of high potential replication. Many of these medium-size plants are quite viable, but have not yet implemented energy conservation activities.

Increases in energy prices to equivalent world prices have put additional pressures on industrial firms to conserve energy. Changes within the economic system (increasing energy prices, privatization, etc.) will necessitate increased energy efficiency and reduced energy intensity of production. The Industrial Energy Efficiency Program will train Czech managers and engineers in energy efficiency measures and practices, as well as in energy management. This training will demonstrate the benefits of energy conservation and illustrate the advantages of making all employees aware of energy waste.

The Industrial Energy Efficiency Program is based on four distinct tasks:

1. Industrial plant screening
2. Industrial plant energy audit
3. Policy analysis
4. Implementation.

Fifteen industrial plants were screened and eight were selected to be audited. Criteria used in this selection included:

- opportunity for energy savings (with a focus on oil savings)
- potential replicability of energy saving options in similar plants or systems
- future viability of the plant in the changing economy
- size of the plant
- other activities such as joint ventures or other bi-lateral aid projects.

The energy audit activity, described in detail in this report, determined the overall energy efficiency of the plant, which was used to identify no/low-cost equipment opportunities with short-term payback. An assessment was made of the technical and management capabilities and capital investment decision-making processes regarding energy conservation applications. Preparation of equipment specifications and other documents required for procurement of U.S. equipment or materials completed the audit.

In the implementation phase, equipment specified in the energy audit was procured, cleared through customs, and delivered to the plant. Also, requirements for installation of the material were identified. Where possible, this was done by plant personnel, or alternatively, by CSFR contractors. Following installation, the effectiveness of the energy conservation application was evaluated.

1.0 Plant Description

Following are the key data for the Matador plant.

Name: Matador

Address: 852 01 Bratislava, Kopcianska 2c

Contact: Mr. Frantisek Dudas, Manager, Energetics

Phone: 07-352 189

Products: Variety of rubber products, including conveyer belts, hoses, molded products, roof membranes, flooring, etc.

Plant size: 2,300 employees

Electric Energy:

Maximum demand	9,240 kW
Annual consumption	34,478 MWh
No refrigeration load	

Steam Requirements:

Method of supply:	Boiler steam system
Average demand:	40 metric ton/hr
	Temperature 445 °C (833 °F)
Pressure 3.8 MPa (567 psig)	

2.0 Plant Energy Profile

Matador fabricates a wide range of rubber products. Fabrication processes include formulation of different rubber compounds; shaping or molding the rubber into sheet, belts or other shapes; vulcanizing, finishing, and finally shipping to both domestic and international markets.

The plant used a total of 19,979 metric tons of heavy oil and 34,478 MWh of electricity (see *Figure 1*). Peak electric demand was 9,240 kW. *Figure 2*, Energy Costs, shows the relative costs: 45 million Kcs for electricity and 41 million Kcs for heavy oil.

All steam used in the facility is generated on-site by four boilers: three 20 metric ton/hr oil fired boilers and one 50 metric ton/hr oil or gas fired boiler. The latter boiler has just been reconstructed for either oil or gas firing. At present it is the only boiler being fired; the others are under modification for natural gas which is expected to be used beginning in May.

Steam is used for most processes including formulation, roll pressing, molding and vulcanizing. Steam is also used for space heating in the processing areas and in the administration buildings. Steam consumption for processes is about 33% of the total steam produced, as shown in *Figure 3*, Annual Steam Use. Steam is normally produced at 3.8 MPa (567 psig), and 445 °C (833 °F). Steam pressure is normally reduced to .8 MPa (116 psig) by extraction from a 6 MW extraction turbine generator. The turbine has been inoperative for about 18 months and steam is reduced in pressure through pressure reduction valves. There is an additional extraction stage at 0.15 MPa (22 psig) used for heating water for space heating and for sale to steam customers. A third extraction stage provides steam for feedwater heating.

Electricity is used for generation of compressed air, pressurized water and production processes. The 6 MW extraction steam turbine was inoperative throughout 1990 but is expected to operate this summer. Normally over 60% of electrical use is self generated. There is a proposal to modify the turbine to eliminate the condensing stage and normally the plant attempts to operate with only minimum condensing flow.

Major electrical loads include several 750 kW 6,000 volt motors for rubber formulation, 300 kW motors on four air compressors and 250 kW motors on pressure water pumps producing 150 bar water for vulcanizing presses. There are many lesser motor loads ranging from less than 16 kW to 100 kW on various production equipment.

Electricity is purchased from the utility at 115 kV and reduced to 6 kV by a 15 MVA transformer for in-plant distribution. In each building, voltage is then reduced to 220/380 volts for distribution within the building.

Overall energy use is depicted in *Figure 4*, Energy Use. About 18% of the total energy used in the plant is exported (sold) to other steam users, principally for space heating. *Table 1* shows the plant's annual energy use and cost.

Figure 1. Energy Sources

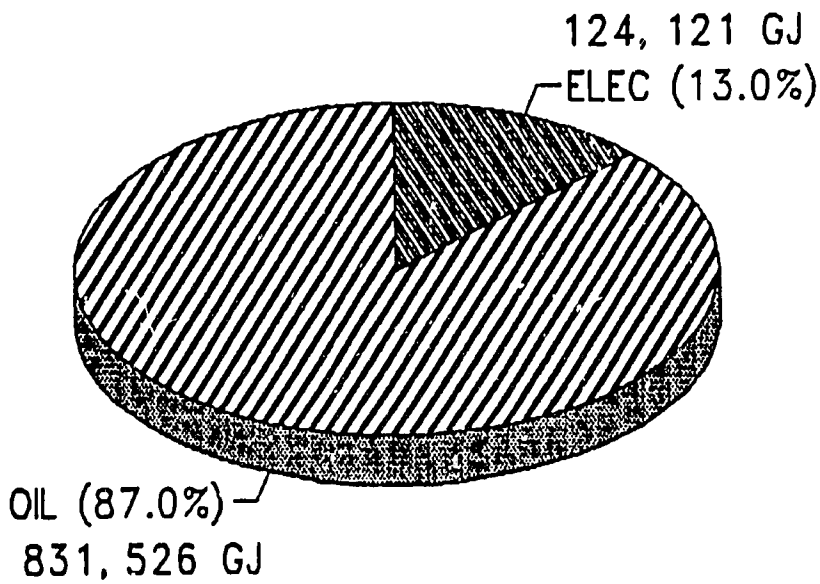


Figure 2. Energy Costs

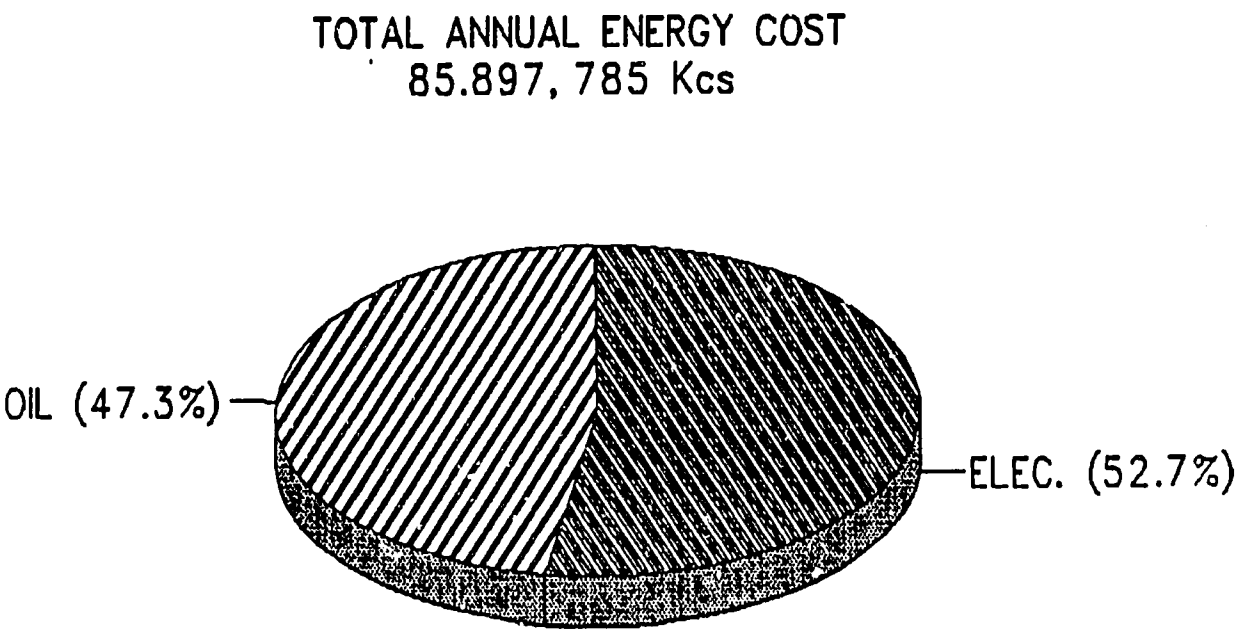


Figure 3. Annual Steam Use

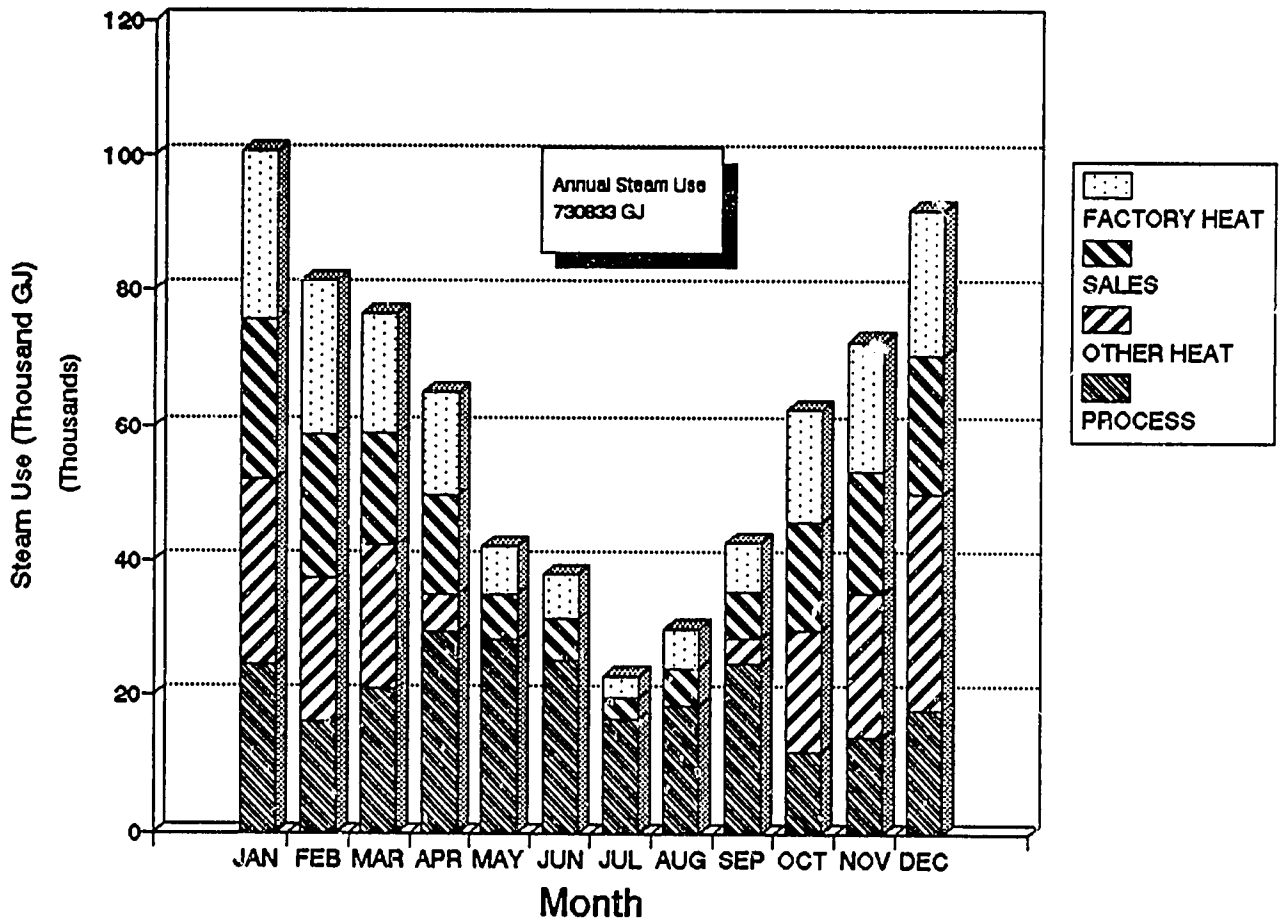


Figure 4. Energy Use

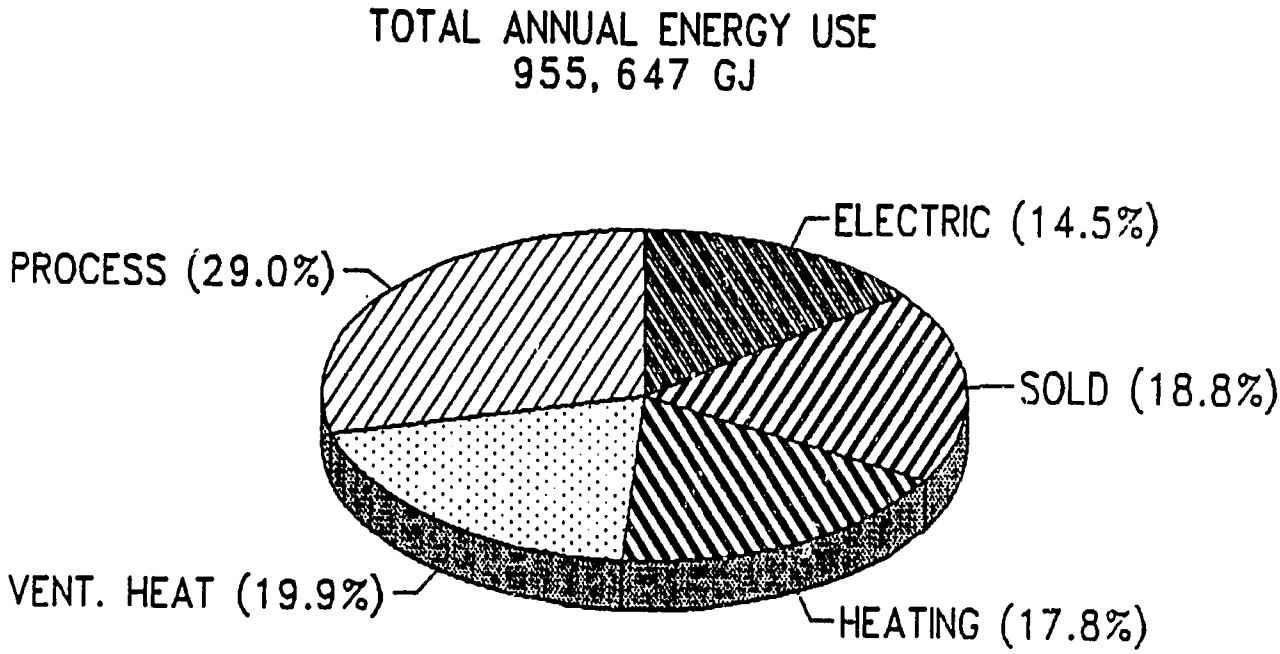


Table 1. Annual Energy Use

	ELECTRICITY		HEAVY	COSTS (Kcs)	
MONTH	KW	MWH	OIL (METRIC TONS)	ELEC.	OIL
JAN	9,240	3,377	2,715	4,353,631	5,522,310
FEB	8,520	3,377	2,172	4,014,511	4,417,848
MAR	8,600	2,997	2,037	4,052,012	4,143,258
APR	8,400	3,109	1,813	3,957,864	3,687,642
MAY	7,480	2,787	1,169	3,524,393	2,377,746
JUN	7,720	2,643	1,048	3,637,365	2,131,632
JUL	7,600	2,569	660	3,580,810	1,342,440
AUG	7,520	2,579	851	3,543,135	1,730,934
SEP	7,720	2,679	1,212	3,637,382	2,465,208
OCT	7,920	2,968	1,748	3,731,718	3,555,432
NOV	7,720	2,785	2,039	3,637,432	4,147,326
DEC	7,620	2,608	2,515	3,590,248	5,115,510
TOTAL		34,478	19,979	45,260,499	40,637,286
				$1,616,446	$1,451,332

3.0 Audit Description

The audit team was at the Matador plant April 2-5, 1991. The team focused on detailed discussions with plant management on the current and projected uses of energy, the energy management organizational structure and perceived energy problem areas. On the first day the audit team toured the plant to learn the process and observe overall conditions. On the second day the team identified potential ECO areas characterized by: 1) high energy consumption; 2) potential for no/low-cost conservation opportunities; and 3) replicability within the plant and other industrial facilities. Selected plant areas were revisited for additional information and confirmation of initial impressions. The third day involved testing boiler combustion efficiency, obtaining specific operational data and formulating recommendation projects. The team developed the recommendations with the plant management to properly address the plants needs and ensure that management would agree with the final recommendations. On the final day the team finalized the recommendations and presented them. At a meeting attended by three senior plant managers and representatives from Elektroprojekt, management enthusiastically gave a verbal expression of interest and agreed to provide a written expression of interest for participation in the ECO demonstrations.

4.0 Summary of Results

A large number of process equipment steam leaks and steam plumes originating from steam condensate collection points were the most striking examples of energy loss. Company personnel were not aware of the impact of escaping steam on energy consumption and costs. The following low-cost ECO's are recommended for equipment procurement:

1. Replacement of steam traps, requires the concurrent implementation of the second ECO.
2. Purchase of Energy Conservation Test Equipment.
3. Increase boiler combustion efficiency with a combustion test analyzer.

All three ECO's have a high degree of replicability in the Matador plant as well as plants throughout Czechoslovakia. Subsection 4.1 defines the ECO's recommended for demonstration, and subsection 4.2 identifies additional ECO's that Matador should consider implementing internally.

4.1 Short-Term Recommendations

1. Replacement of Steam Traps in the Flooring Department.

Current Condition: The Flooring Department vulcanizes rubber sheet material with steam heated rotary presses. The 32 rotary presses use fifteen metric tons/hr of steam at 0.8 MPa. Generally the steam traps were 10-20 years old and poorly maintained; most of the flange bolts had thick layers of rust that had not been disturbed for long periods. Several traps were blowing steam. In addition, numerous valves and flanges had steam leaks. Temperatures of the three condensate return lines were 100, 110 and 130 °C respectively. Normally, since the condensate was vented to the atmosphere, a temperature of 100 °C or less would be expected. These temperature observations were confirmation that steam was blowing through some of the traps.

Based on the above information and the simplified layout of the steam system, the Flooring Department (building 29) was identified as the ideal location for demonstrating the energy saved by properly maintained steam traps. A conservative estimate of potential energy savings is 10%; a more probable level of savings is 15% to 25%.

Recommended ECO: Install new steam traps on the 32 vulcanizing machines along with the installation of a steam flow meter to measure steam consumption in the Department. The recommended steps for implementation of this ECO are:

1. Install the steam flow meter in the 100 mm steam supply line to the Flooring Department.
2. Measure the steam demand and consumption for a minimum of one week during normal production periods. Also, monitor and record the condensate return temperatures from each bank of presses.

3. Test the operation of each existing steam trap, for both blockage and blowing.
4. Install the new steam traps on each of the 32 presses.
5. Check the new steam traps for proper operation.
6. Measure the steam demand and consumption for a minimum of one week during normal production periods and monitor and record the condensate return temperatures from each bank of presses.
7. Determine the resulting energy savings.
8. Extend the testing and maintenance of steam traps the plant (not part of the ECO demonstration).

Specifications for the steam traps are given in Appendix A.

Estimated Energy Savings: Estimated annual energy savings for installation of steam traps in the flooring department is as follows:

Estimated annual steam consumption: two shifts per day, five days per week, 50 weeks per year: 166,400 GJ

Estimated savings at 10% of consumption: 16,600 GJ

Cost savings: (132 Kcs per GJ steam) 2.2 million Kcs or $74,500.

Estimated cost for steam traps - based on 36 new traps and 36 new trap strainers (extra traps are included for spare parts or use in other areas): $16,200

Estimated payback: 0.2 years

Note: If the steam flow meter identified in ECO 2 were included in the costs, the estimated payback would be increased to 0.3 years.

2. Energy Conservation Test Equipment

Current Condition: Plant personnel do not have crucial test equipment needed to detect malfunctioning steam traps or monitor steam flow in supply lines to determine when excessive steam leaks are occurring, or to measure the results of improved maintenance of the steam system. The proposed test equipment is needed initially for implementation of Demonstration ECO 1 above, and upon completion of the Demonstration, for replication of the ECO (improved steam trap maintenance) to all steam systems in the plant.

Recommended ECO: Purchase the following test equipment to measure steam trap performance and monitor steam consumption patterns:

- 1 portable steam flow meter, complete with totalizer readout.
- 1 hand held infrared thermometer.
- 1 hand held ultrasonic sensor, "electronic-stethoscope", for detecting steam flow through steam traps.

Specifications for the listed test equipment are given in Appendix B.

Estimated Energy Savings: Estimated energy savings based on a savings of 3% of all steam used in the plant for improved performance of maintained steam traps:

Energy savings: 21,925 GJ, at 132 Kcs per GJ steam = 2,894,098 Kcs or $103,361.

Estimated cost for test equipment: $10,000

Estimated payback: 2 months

3. Combustion Test Analyzer

Current Condition: Combustion settings on the steam boilers are set manually with the aid of permanently mounted oxygen sensors in the stack area. The boiler operators set excess air on the high side to assure a low smoke density level, and reduce the risk of complaints from adjacent neighborhoods. The audit team demonstrated, with the use of the portable combustion analyzer, that oxygen levels could be reduced without noticeable increases in smoke density, while reducing the NO_X levels. The resulting improvement in combustion efficiency was about 3%.

The other boilers do not have oxygen sensors, and the operators set the combustion control through experience. Without a full capability combustion analyzer, boiler plant personnel cannot set the combustion settings at optimal levels for any of the boilers.

Recommended ECO: Purchase a portable combustion analyzer for increasing the operating efficiencies of the steam boilers.

Estimated Energy Savings: Energy savings are based on an estimated increase in combustion efficiency of about 2% for all boilers annually.

Energy savings: 16,603 GJ, at an average fuel cost of 54.23 Kcs/GJ - 901,955 Kcs or $32,213.

Estimated cost for the test equipment: $10,000

Estimated payback: 2 months

4.2 Long-Term Recommendations

The following ECO's were examined only briefly by the audit team, primarily due to time constraints. However, in many facilities, these ECO's have proven to be effective and have short payback periods.

1. Steam Distribution Systems/Equipment Insulation: Many steam lines feeding process equipment are either uninsulated or poorly insulated with asbestos rope material. The rope insulation was fully exposed and subject to water wetting and physical damage by workers operating the machines. The rope insulation has minimal value for reducing heat losses. In addition, the continual exposure to asbestos is a health hazard to the workers. It is recommended that the steam pipes be reinsulated with "rockwool" type insulation to economic thickness levels, and jacketed with a protective layer.

2. Repair of Steam Leaks: Many steam leaks are present throughout the plant. It is estimated that the total leakage through valves, flanges and other connectors accounts for at least 3-5% of all steam generated by the boilers. Two maintenance personnel should be assigned to repair steam leaks on a continuing basis; steam leaks continue to happen, thus no repairs are final. The labor costs for the repair program could be easily repaid by savings in steam costs.

3. Lighting: Lighting represents only about 5% of the total electrical consumption. However, the cost of lighting should not be overlooked because lighting ECO's have rapid paybacks. Much of the fluorescent lighting in the plant areas was ineffective due to dirt accumulation or burnt-out tubes. During daylight hours, much of the lighting system did not contribute to the overall illumination of the work areas. The following actions should be taken to reduce energy expended for unnecessary lighting and to gain greater benefit from the lighting when it is needed.

   - Clean reflectors and tubes on a regular schedule.
   - Replace tubes that have lost more than 80% of their lighting power.
   - Turn off lights that are not needed.
   - Disconnect lights that are not used. Simply "delamping" still allows the ballast (the high voltage control transformer) to consume 10-20 watts per fixture.
   - Consider replacement of fluorescent and mercury vapor lamps with high efficiency sodium vapor lamps. Savings in lighting energy would be about 20-50% for comparable lighting levels.

4. Space Heating Control Systems: Space heating represents about 25% of the steam load in the Matador facility. Space heating in office and other non-production areas is not thermostatically controlled. Installation of thermostatic control elements at heat sources, e.g. radiators, would prevent overheating and save energy. As a longer range approach, programmable control systems would allow temperature control of whole buildings or groups of buildings, including temperature setbacks during evening and weekend periods. Energy savings from these control systems could be as much as 15-25%.

5. Boiler Opacity Meter: A stack opacity measuring device will allow the boiler operators to maintain excess oxygen levels at 3% to 5% rather than the current 7% to 8% by monitoring stack smoke levels. Current levels, maintained to avoid smoke complaints, are wasteful. Combustion analysis testing showed that efficiency could be improved by 3% without any visible smoke by reducing stack oxygen (as indicated by the boiler room readout) from 7.2% to 4.8%.

5.0 Plant Energy Management/Organization

The Department of Energetics reports to the Manager of the Maintenance and Energetics Division and is on the same organizational level as the Maintenance Department. The Department of Energetics is responsible for supplying energy (steam, electrical power, pressurized water and compressed air) to the whole facility and to external customers. Its responsibility starts with the purchase and generation of electric power and the generation of steam, and ends with the delivery of the energy to the outside of the buildings, e.g. the production and administrative buildings. The Department of Maintenance is responsible for the distribution of energy within the buildings and for the maintenance of all energy distribution and energy consuming equipment. The Production Division has no responsibility for the generation of supplied energy sources, energy distribution, or the maintenance of energy consuming equipment.

Due to the lack of capability for measuring energy flows to the respective production units, energy costs are prorated among production and other users by a preset formula involving connected loads and number of shifts. Hence, the production units are charged for certain amounts of energy regardless of the actual usage, and there is little incentive to improve energy efficiency. Although the Department of Energetics has a program in progress to develop a method for allocating energy costs based on actual consumption, e.g. submetering, the efforts have been thwarted by the lack of allocated funds for measuring devices and control systems. Likewise, the Maintenance Department is not charged with any energy costs for production operations or other buildings, and therefore has no incentive for assuring that energy distribution systems and equipment are operating efficiently. Their prime responsibility is to assure operation of production equipment.

As indicated above, Matador has several organizational problems regarding energy management and the implementation of energy conservation measures on a continuing basis:

1. The organizational structure has no clear vertical line of responsibility for energy management or energy conservation.
2. Management has no method for controlling energy costs within operating units.
3. Operating units have no incentive for increasing energy efficiency, and conversely, are not penalized for wasting energy.
4. Operating units have no direct supervision or budget control over the maintenance of their energy distribution system or their operating equipment.
5. No assignment has been given for the development of a comprehensive, company wide energy management program.

To remedy the existing situation, three suggested organizational approaches are outlined below.

Approach 1: Assign responsibility and authority for development and implementation of energy management/energy conservation to the Manager, Department of Energetics. In this role, the Manager would have responsibility for both energy supplies and the efficient use of energy within operating units.

Approach 2: Create a new high level staff position reporting to the Managing Director with the authority and responsibility for developing and implementing energy management/energy conservation. The position would primarily involve planning and monitoring energy programs and coordinating efforts between and within the operating divisions.

Approach 3: Another organizational approach that may be considered is the assignment of the Maintenance Department to the Production Division. This change would allow for the direct vertical line responsibility for maintaining equipment in good, energy efficient condition, and the budgets for energy and maintenance would be tied together.

6.0 Implementation Evaluation

Dates visited: July 29 and 30, 1991

Contacts: Ing. Frantisk Dudas and staff of the Energetics Department.

Objectives of the visit:

1. Determine the delivery status of equipment provided to Matador.
2. Evaluate the status of the demonstration project.
3. Assist in the preparation of the Matador presentation at the August 13 and 15, 1991 seminars.
4. Assess the status of other energy conservation measures undertaken by Matador.

6.1 Status of Equipment Delivered to Matador

The test instruments and steam traps for the demonstration project were received at Matador coincident with the visit. Photograph #1 in Appendix D shows some of the test equipment; the air velocity meter and an Enerac unit. All items were unpacked and were found to be complete and in good working order. The operation of each instrument was reviewed with plant personnel. To facilitate use and care of the instruments, Matador will have the instruction manuals translated into Slovok; it was agreed that additional copies of the translated manuals would be made available to other plants receiving similar instruments.

6.2 Status of the Demonstration Projects

The objectives of the two demonstration projects to be conducted at the Matador plant are:

1. To improve the combustion efficiencies of the steam boilers.
2. To reduce steam losses in the Flooring Department by replacement of steam traps on the vulcanizing presses.

Due to the delivery date of the combustion analysis instrument and the overall maintenance shut-down of the boilers during the week of the visit, monitoring and adjustment of boiler combustion efficiencies were begun during the week of August 5, 1991. Plant personnel have agreed to provide data to RMA, upon request, regarding improvements in combustion efficiencies as they become available.

Guidelines for implementation of the steam trap demonstration were prepared and submitted to Matador. During the visit, the installation of the steam flow measurement instrument ("Annubar Flow Meter") was initiated. It is planned to start the testing project the week of August 5, 1991. It is anticipated that the demonstration project will require approximately 4-6 weeks for completion. As above, plant personnel agreed to provide test data to RMA upon request.

Photograph #2 in Appendix D shows a steam trap prior to replacement.

6.3 Preparation for the Seminars

Assistance was provided to the speaker in outlining the presentation and drafting of the graphics to be used for the presentation. Draft copies of the graphics were sent to SEVEn for final preparation.

6.4 Status of Energy Conservation Projects Undertaken by Matador

Based on the results of the audit team report, the Matador management is planning to expand their energy conservation efforts in the following areas:

- extension of steam trap repair and elimination of steam leaks to all operating departments;
- monitoring of energy use by department and applying energy costs to the individual departments accordingly;
- thermostatic control of space heating in administrative areas; and
- modify the organizational structure to strengthen energy management.

Due to the time required to evaluate the above measures and the uncertainties in the financial and corporate structures of the company, it is unclear when actions will take place on the above measures.

APPENDIX A
Specification for Steam Traps for Flooring Department

Point of contact:

Ing. Frantisek Dudas, Manager, Energetics Department Matador
852 01 Bratislava, 1 Kopcianska 2c
Telephone: 07-352 189

Equipment Specification:

36 each FLOAT and THERMOSTATIC (F&T) steam traps and 36 each compatible strainers ("Y-type") complete with blow-down cocks. The operating conditions for the traps and strainers are:

- differential pressure - 0.8 MPa (0.8 MPa to atmosphere)
- condensate flow - 0.5 metric tons per hour, for use in press rollers for vulcanizing rubber
- pipe size - 25 mm, steel
- flange - standard DIN flange
- material, trap interior - stainless steel

APPENDIX B
Specification for Steam System Test Equipment

Point of contact:

Ing. Frantisek Dudas, Manager, Energetics Department Matador
852 01 Bratislava, 1 Kopcianska 2c
Telephone: 07-352 189

Equipment specifications:

All items should have, where applicable:

- two copies of full operating instructions.
- battery chargers or other electrical connections set for 220 volts, 50 hertz.
- maximum reliability under industrial plant conditions.
- spare parts or extra expendable materials, especially those that may break easily, e.g. glass parts.
- warranties extendable to Matador, and instructions for obtaining servicing.
- support technical literature that describes the uses and limitations of the equipment.

Item 1. Steam Heat Flow Meter

Complete "Annubar FLO-TAP" or similar model DHF-flanged for HF-15, with digital read out, flow computer with associated transmitter (differential pressure transmitter) and water fill tees as required. Approximate flow rate - 15 metric tons per hour. Steam pipe size - 100 mm inside diameter; 108 mm outside diameter, DIN flanges.

Head: HA1
Valve: SA1, for steam
Gland: GV4SA
Insert retractor: IHRS, stainless steel
Mounting hardware: FA4C

Item 2. Hand held infrared thermometer, range to 2000 °F
Same as supplied to audit teams, "Heat Spy"

Item 3. Hand held ultrasonic sensor, "electronic stethoscope",for detecting steam flow through steam traps, having audible and meter display.

Suggested vendor - open

Appendix C
Portable Combustion Analyzer

Point of contact:

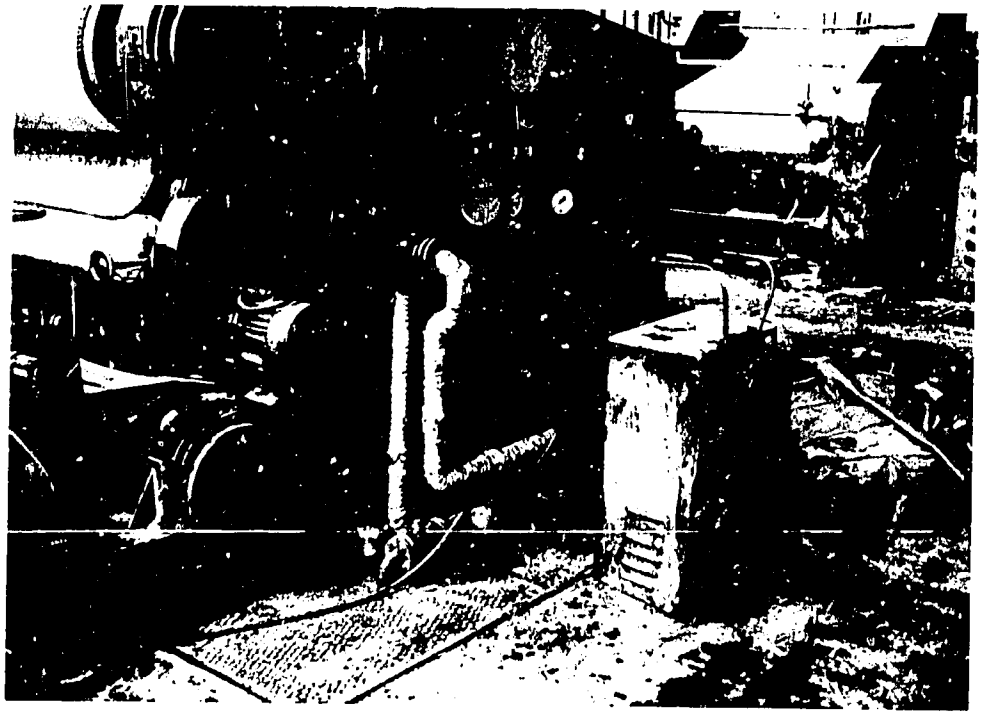
Ing. Frantisek Dudas, Manager, Energetics Department Matador
852 01 Bratislava, 1 Kopcianska 2c
Telephone: 07-352 189

Equipment specification:

Similar combustion analyzer to that supplied to audit teams. The length of the combustion gas probe should be specified to be one meter, or a longer accessory probe should be supplied. The probe on the audit team analyzer was too short to sample gases in the central portions of larger diameter stacks.

APPENDIX D
Photographs

1. An air velocity meter, sitting on an Enerac unit. From left to right: Robert Erickson (RMA), Robert Anderson (RMA), Frantisek Dudas (Manager of the Department of Energetics at Matador) and Milos Revallo (Electroprojekt).



2. A steam trap prior to replacement.

APPENDIX E
List of Abbreviations

AC	= alternating current
amps	= amperes
atm	= atmosphere = 14.696 pounds per square inch
bar	= 100,000 pascals = 14.504 pounds per square inch
BTU	= British thermal unit
cfm	= cubic feet per minute
cm	= centimeter = 0.3937 inches
cm^2	= square centimeter = 0.155 square inches
CO	= carbon monoxide
CO_2	= carbon dioxide
DC	= direct current
°C	= degree Celsius T[°C] = 5/9*(T[°F] - 32
°F	= degree Fahrenheit
°R	= degrees Rankine T[°R] = T[°F] + 460
eff	= efficiency
ex air	= excess air
Gcal	= gigacalorie = 1 billion calories = 3.968 million BTU
GJ	= gigajoules = 1 billion joules
gph	= U.S. gallons per hour
gpm	= U.S. gallons per minute
GWh	= gigawatt hours = 1 billion watt hours
H_2	= hydrogen
H_2O	= water
H_2SO_4	= sulfuric acid
hectare	= 10,000 square meters = 2.471 acres
hectoliter	= 100 liters = 26.42 U.S. gallons
Hg	= mercury
hr	= hour
Hz	= hertz = cycles per second
J	= joules
kcal	= kilocalories = 1 thousand calories = 3.968 BTU
Kcs	= 29.77/$1 US
kg	= kilogram = 2.2046 pounds
Kgcc	= 7,000 Kcal = 27,776 BTU
kJ	= kilojoules = 1 thousand joules = 0.947813 BTU
km	= kilometer = 0.621 miles
kN	= kilonewton = 1 thousand newtons
kPa	= kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	= kilovolts = 1 thousand volts
kVA	= kilovolt-amperes
kVAr	= kilovars = 1 thousand volt-amperes (reactive)
kW	= kilowatt = 1 thousand watts
kWh	= kilowatt hour = 1 thousand watt hours
lbs	= pounds
liter	= 0.2642 U.S. gallons = 0.03531 cubic feet
m	= meter = 39.37 inches
m^2	= square meter = 10.76 square feet

m^3	= cubic meter = 35.31 cubic feet
mA	= milliampere = 0.001 amperes
MCal	= megacalorie = 1 million calories
metric ton	= 1 thousand kilograms = 1.1023 U.S. tons
mg	= milligrams
min	= minute
MJ	= megajoules
mm	= millimeter = 0.03937 inches
MPa	= 1 million pascals = 145.04 pounds per square inch
MVA	= megavolt-amperes
MW	= megawatt = 1 million watts
MWh	= megawatt hours = 1 million watt hours
NG	= natural gas
nm	= nanometer
Nm^3	= cubic meters at standard conditions of temperature and pressure (20°C and 1 atmosphere)
NO_X	= nitrogen oxide
O_2	= oxygen
P	= pressure
PC	= personal computer
ppm	= parts per million
psi	= pounds per square inch
psig	= pounds per square inch (gauge)
R	= thermal resistance
s	= second
SO_2	= sulfur dioxide
sq ft	= square feet
Tcal	= teracalorie = 1 trillion calories = 3.968 billion BTU
T	= temperature
V	= volts
VArs	= volt-amps (reactive)
VSD	= variable speed drive
yr	= year