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TRIP REPORT #1

TO

SODI LTD.
DEVNYA, BULGARIA

WASTE MINIMIZATION DEMONSTRATION PROJECT #1

WORLD ENVIRONMENT CENTER
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TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Executive Summary	2
III.	Itinerary	3
IV.	Appendix	
	1. Environmetrics Systems, Inc. - Interim Report #1 on Waste Minimization Demonstration Project at Sodi Ltd.	4 - 21
	2. Business Cards	22

I. INTRODUCTION

Pursuant to the Technical Assistance Program for Central and Eastern European countries funded by U.S. Agency for International Development, the World Environment Center (WEC) has organized a reconnaissance trip to a soda ash manufacturing plant - Sodi Ltd. in Bulgaria. A team consisting of Dr. Bohdan Aftanas of WEC's staff, Mr. Raghu Raghavan, President of Envirometrics Systems, Inc. and Mr. Daniel Chellaraj, pro bono specialist, paid a visit to Sodi Ltd. to determine if the Waste Minimization Demonstration Project (WMDP) is feasible at that plant. During this visit an effort was also made to select the process line and to determine the anticipated degree of pollution reduction with associated cost benefits.

II. EXECUTIVE SUMMARY

WEC was a participant in the USAID Environmental Team which visited Bulgaria October 2 - 16, 1992. During this trip the WEC staff visited, among others, a number of industrial enterprises and selected Sodi Ltd. as a candidate for the first WMDP in Bulgaria. As a follow-up, during February 1 through 5, 1993, a team from WEC paid a reconnaissance visit to Sodi Ltd. with the purpose of getting acquainted with the plant processes, production facilities, operational procedures, environmental problems and to select the most promising subject for the WMDP.

WEC's team included Dr. Bohdan Aftanas, Project Manager with WEC, Mr. Daniel Chellaraj, pro bono specialist, and Mr. Raghu Raghavan, consultant from Envirometrics Systems, Inc. In addition, the team was accompanied by Mr. Kliment Dilianov, Chief Expert from the International Relations Department at the Ministry for Environment and Dr. Vaselin Zlatev, Chief Expert from the Ministry of Industry. A number of meetings were held with the plant management represented by Mr. Nedialko Petkov, Development Management Department, Ms. Neli Dimitrova, Head of the Environmental Department and Mr. Dimo Krosnev, Head of the Coordination Department.

Following presentation of the waste minimization program and its benefit for the plant, the anticipated project procedure and steps, including Memorandum of Understanding, was outlined and discussed. The plant management expressed great interest in the project and assured their fullest support and cooperation. A number of discussions and field visits led to the conclusion that the relatively high losses of ammonia occurring during the production of soda ash will be a subject of the WMDP. Specifically, the project will focus on possibilities of improving operation of the distillation facilities to reduce ammonia loss. A raw estimate indicates that by implementing "Best Management Practice", the ammonia loss can be reduced by about 1,600 tons / year, yielding approximately $200,00.00 in cost savings. In addition, due to the relatively high toxicity of ammonia, even the small reduction in the concentration of this air pollutant will diminish the incidence of respiratory diseases among plant workers and neighboring residents. For more information on this reconnaissance trip to Sodi Ltd. and results, refer to the enclosed report of Envirometrics Systems, Inc.

I met with Dr. Valentin Bossevsky, the Minister for Environment, to brief him on the current WEC programs for Bulgaria and on the results of our reconnaissance visit at Sodi Ltd. The Minister has expressed strong interest in the Waste Minimization Program and gave his endorsement to WEC's decision on the selection of Sodi Ltd. for the first WMDP. He would like to be kept informed on the progress of our technical assistance program for this country.

III. ITINERARY

January 31, 1993 - Sofia

- Arrival in Sofia

February 1, 1993

- Departure from Sofia to Varna
- Visit to "Sodi" Ltd. Plant in Devnya

February 2, 1993

- Meeting and plant visit at "Sodi" Ltd.

February 3, 1993

- "Sodi" Ltd. plant visit
- Visit to Ministry of Environment, Regional Inspectorate in Varna

February 4, 1993

- "Sodi" Ltd. plant visit
- Departure from Varna to Sofia

February 5, 1993

- Meeting with the Minister of Environment

February 6, 1993

- Return to U.S.

IV. APPENDIX

1. ENVIROMETRICS SYSTEMS,INC.
INTERIM REPORT #1

ON

WASTE MINIMIZATION DEMONSTRATION PROJECT AT SODI LTD.

Interim Report # 1
Waste Minimization Demonstration Project
at
SODI Ltd., Devnya, Bulgaria

Table of Contents

	Page No.
Executive Sumary	4-6
Section 1 : Introduction • World Environment Center • Project Team • Reconnaissance Visit • Dates and Description of Activities	7-10
Section 2 : Background Information • History of Plant and Process • Existing Problems in Operation • Waste Generation and Management • Need to Improve Operations • Need to Reduce Pollution	11-15
Section 3 : Waste Minimization Opportunity Assessment • Waste Minimization Options • Technical Assessment • Financial Assessment	16-17
Section 4 : Waste Minimization Demonstration Project • Project Description • Additional Information Needs • Required Monitoring Equipment • Project Implementation • Project Schedule • Estimated Benefits of WMDP	18-21

30

EXECUTIVE SUMMARY

INTRODUCTION

Under a cooperative agreement made with the United States Agency for International Development (USAID), the World Environment Center (WEC) will develop and implement several projects to demonstrate the economic benefits of waste minimization at suitable industrial plants in the countries of Central and Eastern Europe. In the current project, WEC paid a reconnaissance visit to a soda ash manufacturing plant in Devnya, Bulgaria (SODI Ltd.) during February 1993 to determine if a waste minimization demonstration project (WMDP) at this plant will meet with the objectives of the cooperative agreement. The WEC team visiting SODI Ltd. consisted of 3 personnel : Dr. Bohdan T. Aftanas, Project Manager, Technical Programs in WEC; Mr. Daniel J. Chellaraj, a specialist in chemical manufacturing processes; and Mr. Raghu K. Raghavan, President, Envirometrics Systems, Inc. (ESI). ESI has been hired as an environmental consultant to assist in the International Environment and Development Service (IEDS) Program of WEC. The project team conducted several meetings with Dipl. Ing. Nedialko Petkov, Deputy Director responsible for technical development and investments at SODI. The team also met with Dipl. Eng. Zlati Kolarov, Director of the Regional Inspectorate of the Ministry of Environment located in the city of Varna, as well as with senior representatives of the Ministries of Environment and Industry. The following interim report is based mainly upon the background information obtained during the reconnaissance visit. This report also provides details of a proposed WMDP which was discussed in concept with SODI Ltd. for implementation.

BACKGROUND INFORMATION

SODI Ltd. includes two plants for manufacturing light soda ash by using the Solvay Process. These plants were installed in the highly industrialized valley of Devnya in 1954 and 1974 respectively. An additional process line for manufacturing dense soda ash was also started at the newer plant in 1987. The total capacity for manufacturing soda ash at these two plants is estimated to be 1.5 million metric tons per year. It is also possible to manufacture additional products at SODI Ltd., such as calcium chloride and sodium bicarbonate. The major raw materials required for manufacturing soda ash - common salt and limestone - are readily available in the area. Ammonia is also used in manufacturing soda ash and is supplied by pipe from a fertilizer plant located in Devnya.

Although SODI Ltd. is claimed to be one of the world's largest manufacturers of soda ash by using the Solvay Process, a major replacement of process equipment is

necessary to modernize both plants. The signs of heavy deterioration can also be seen in the plant and office buildings. The older plant has now been shut down completely while the current utilization of capacity at the newer plant is less than 50% at present. This decrease in size of operations is due to a fall in global demand, an international merger of competitors, and the termination of arrangements with the former Soviet Union to import soda ash in return for supply of other raw materials and fuel to Bulgaria at subsidized rates. Despite these conditions, it appears that the continuation of operations at SODI Ltd. is assured as it can potentially earn large exports for Bulgaria, and because it is a major employer and a major user of the natural and industrial resources being developed in the valley of Devnya.

Major problems in operations at SODI Ltd. include the non-removal of sulfate during brine purification, distillation of the intermediate products of reaction from excess raw materials, and the filtration of sodium bicarbonate prior to calcining it as soda ash. These problems are resulting in high losses of ammonia, brine, energy and process water. Most of these losses occur in the distillation step of operations. There is also a high down-time on the distillation equipment in order to remove precipitates of calcium sulfate which reduce heat and mass transfer during operations. High losses of materials in the process are shown as air emission of ammonia, discharge of highly alkaline wastewaters with high ammonia content, and generation of large quantities of solid waste during distillation. Loss of ammonia at 30 kilograms per metric ton of soda ash may cost up to $ 4 million per year if operations are conducted at full capacity at SODI Ltd.

The wastewaters generated at SODI Ltd. are mixed without any segregation of waste streams and are pumped off-site to a lagoon which receives wastewaters from other plants in the region as well. The untreated effluent from the lagoon is discharged first into the Provadiyska River and then the Beloslavsko Lake which feeds to the Black Sea. Under newly promulgated regulations, SODI Ltd. paid approximately $2,500 last year for discharging about 20 million cubic meters of wastewater to the local surface water streams. In addition to this fee on wastewater discharges, SODI Ltd. paid about $750 last year for exceeding the limits on air emission of ammonia. It is expected that these fines will be increased by about 10 times in the near future as more stringent regulations are promulgated in Bulgaria. SODI Ltd. recognizes that its operations have adversely impacted on air and water quality in the region and that it is necessary to improve their operations from both the economic as well as the environmental considerations.

WASTE MINIMIZATION OPPORTUNITY ASSESSMENT

Several options exist at SODI Ltd. to achieve waste minimization and benefit economically from the improved operations. These options range from substitution of raw materials and/or process changes related with brine purification to

modernization of equipment and controls for better distillation and/ or filtration of reaction products. These options will however require substantial investment in process research and replacement of equipment at SODI Ltd. It is however feasible to consider the implementation of best management practices (BMPs) which can contribute towards pollution prevention and reduction of operating costs at SODI Ltd. Some examples of BMPs are : the segregation and reuse of wastewaters, better repair and preventative maintenance of plant equipment, standardization and better monitoring of operating conditions, and better housekeeping. An implementation of alternative BMPs was therefore considered to select and propose a waste minimization demonstration project at SODI Ltd.

PROPOSED WASTE MINIMIZATION DEMONSTRATION PROJECT

The proposed waste minimization demonstration project will focus on BMPs associated with more efficient operation of a selected distillation column and its auxiliary equipment. First, details of the design, operation and performance analysis for these equipment will be reviewed to determine the monitoring equipment required for improved control of operations during the project. These monitoring equipment necessary are expected to include the instruments for measuring the concentration of ammonia (in air emission or wastewater discharge) and/or the flow rates of different process streams. Then, a set of BMPs will be proposed for implementation in the project including inspection of equipment, measurement of air and water emissions of ammonia, adjustments of process controls, record-keeping and information management. After obtaining an endorsement of these BMPs by SODI Ltd., the operations will be tracked for about one to two month to establish the reduction in loss of ammonia. Based upon the findings of this study, the BMPs will be finalized for implementation by plant personnel over a period of two or three months. The proposed waste minimization demonstration project can be developed and implemented by the end of September 1993 leaving at least three months for final project implementation and review by an Coordination Committee of the project. It is expected that this project will result in a reduction of ammonia loss by at least 2-3% (estimated to be a saving of $25,000 per year per column) with a potential for additional savings when fully implemented at SODI Ltd.

Section 1

INTRODUCTION

WORLD ENVIRONMENT CENTER

The World Environment Center (WEC), an independent, not-for-profit and non-advocacy environmental organization in the United States, has a cooperative agreement with the United States Agency for International Development (USAID) to provide U.S. private sector expertise to transfer technology and skills to the representatives of industry and government in the countries of Central and Eastern Europe so that they can:

- reduce industrial and urban pollution,
- improve solid, hazardous, and toxic waste management,
- improve industrial health and safety practices,
- improve energy conservation and management, and
- increase community awareness in environmental and energy related areas.

One of WEC's major efforts to achieve these objectives has been to identify industrial plants and processes that are suitable for waste minimization, and then work with U.S. consultants to develop and implement waste minimization demonstration projects at these plants.

In the current project, WEC has selected SODI Ltd. in Devnya, Bulgaria, a major producer of soda ash, as a potential candidate for demonstration of the waste minimization concept. This interim report describes the findings of a reconnaissance visit which was made during February 1993 to the plant by a team consisting of WEC staff, a process specialist and an environmental consultant. This report will be reviewed by WEC to determine if the objectives of their cooperative agreement with USAID will be met by demonstrating waste minimization at one or more process lines in operation at SODI Ltd. A Memorandum of Understanding (MOU) will then be prepared between WEC and SODI Ltd. to design and implement the demonstration project, develop and conduct personnel training at the plant, as well as to assure the commitment of plant management to continue with a specific program of waste minimization at SODI Ltd.. The MOU will also identify the plant personnel or departments that will comprise a Waste Minimization Committee and a Coordination Committee in implementing the project over a longer period of time and reviewing the benefits of waste minimization and disseminating this information to other nearby companies.

PROJECT TEAM

Under its International Environment and Development Services (IEDS) Program, WEC has successfully exchanged technical expertise and information to the benefits of both the private and public sectors worldwide. WEC representatives have also visited and performed environmental reviews in factories throughout Central and Eastern Europe. As a part of the USAID/World Bank/USEPA team working with Bulgarian counterparts to prepare a national environmental strategy plan, WEC staff have visited numerous plants in the metallurgical, chemical, fertilizer and pharmaceutical manufacturing industries. WEC has also successfully developed and implemented a waste minimization demonstration project (WMDP) for fugitive emissions of volatile organic compounds (VOCs) at a large oil refinery in the Czech Republic. Other WMDPs are also being developed and implemented by WEC in Bulgaria, Czech and Slovak Republics, Hungary, Poland. Rumania, Lithuania, Latvia and Estonia Dr. Bohdan T. Aftanas, Project Manager, Technical Programs in WEC was in charge of the reconnaissance team visiting SODI Ltd. He is qualified in Sanitary Engineering and has over 35 years of work experience as an environmental consultant in the United States and abroad. He is also involved in the development of other WMDPs under the same program of WEC.

Mr. Daniel J. Chellaraj was the pro-bono process specialist in the reconnaissance team which visited SODI Ltd. He is qualified in Chemistry and Chemical Engineering, and has over 40 years of work experience in manufacture of chemicals and environmental quality management. He has also assessed and advised steps to abate pollution from chemical manufacturing operations in the countries of Latin American.

Enviromettrics Systems, Inc. (ESI), an environmental consulting firm with which WEC has contracted to assist in the IEDS Program, was represented in the reconnaissance team visiting SODI Ltd. by Mr. Raghu K. Raghavan. He is qualified in Chemical and Mechanical Engineering and has over 20 years of experience in industrial manufacturing and environmental consulting. He has completed several projects in the areas of pollution control and waste minimization both in the United States and abroad. His work in the United States has included the tracking of waste minimization progress being achieved in specific industrial facilities in New Jersey, New York and Pennsylvania. His work abroad has involved the assessment of environmental projects to control industrial and urban pollution as well as the potential for trade development in implementation of these projects.

RECONNAISSANCE VISIT

The reconnaissance visit to SODI Ltd. took place from February 1 through 5, 1993. The first meeting of the visit was attended by :

- Dipl. Ing. Nedialko Petkov, Deputy Director, Investment and Development, (SODI Ltd.)
- Mr. Dimo Krosnev - Head, Department of Regional Cooperation (SODI Ltd.)
- Ms. Nedka Dinitrova - Head, Department of Ecology (SODI Ltd.)
- Dipl. Eng. Kliment Dilianov - International Relations Dept. (Ministry of Environment)
- Dr. Veselin B. Zlatev - Chief Expert (Ministry of Industries)
- WEC's Project Team - (Dr. Aftanas, Mr. Chellaraj, and Mr. Raghavan)

This group met at least once on each day of the visit with the objectives of the WEC Team developing a better understanding of the plant operations, reviewing the observations made during tours of the plant, and discussing the additional information needed to identify the process lines at SODI Ltd. which are suitable for a WMDP. The background information obtained during these meetings is summarized in the following section of this report. A final review of waste minimization options and a tentative selection of WMDP were made during the last meeting of this group.

In addition to the daily meetings with this group, the reconnaissance team of WEC also met with the plant personnel responsible for different operations at SODI Ltd.. These operations included brine purification, lime kilns and slakers, absorption, carbonization, distillation, calcination and filtration. A trip was also made to the offsite lagoon to which wastewaters of SODI Ltd. are discharged. Plant tours were completed during the second and third day of the visit. A visit was also made on the third day of the visit to the City of Varna to meet with Mr. Zlati Kolarov, Director, Inspectorate of the Ministry of Environment and his personnel responsible for enforcement of environmental regulations at SODI Ltd. A complete itinerary for the reconnaissance visit as well as identification of the plant personnel are given in Table 1 of the report.

Waste Minimization Demonstration Project
at
SODI Ltd., Devnya, Bulgaria

Dates and Description of Activities

February 1, 1993	Meeting with Dipl. Ing. Nedialko Petkov, Deputy Director, Investment and Development, and other senior personnel to discuss current status of business and operations at SODI Ltd.
February 2, 1993	Meeting to discuss waste generation and management. Plant visits to the departments of lime kilns, lime slakers, absorption / distillation, calcination and filtration. Plant personnel met included : Dimitar Stancher , Head of Department Distillation / Adsorption. Ivo Bojidarov, Head of Department Carbonization. Angel Trislov, Head of Department Calcination. Lubomir Petrov, Head of Department Implementation of Projects.
February 3, 1993	Meetings to discuss brine purification and filtration Plant visits to the wastewater lagoon and waste management offsite. Visit to the Inspectorate for Ministry of Environment City of Varna to meet with the Director Mr. Zlati Kolarov and other personnel in the Ministry of Environment.
February 4, 1993	Meeting to discuss ammonia loss in distillation and feasibility of a WMDP on this subject. Meeting to discuss environmental monitoring needs of SODI Ltd.
February 5, 1993	Review of meeting notes and discussions with personnel in the Ministries of Environment and Industries at Sofia, Bulgaria.

Section 2

BACKGROUND INFORMATION

HISTORY OF PLANT AND PROCESS

SODI Ltd. uses the Solvay Process for manufacturing light soda ash at two plants in the highly industrialized valley of Devnya. The first plant was installed in 1954 with a capacity for manufacturing 150,000 metric tons per year of light soda ash along with other intermediate products or by-products such as sodium bicarbonate, calcium chloride and borax. The second plant was installed in 1974 with a capacity for manufacturing 1,200,000 metric tons per year of light soda ash . An additional process line for manufacturing dense soda ash, at a capacity of 400,000 metric tons per year, was also started at the newer plant in 1987. The total capacity for manufacturing soda ash at these two plants is estimated to be 1.5 million metric tons per year. Both plants together employ over 2,000 personnel.

The raw materials used in the Solvay Process for manufacturing soda ash - calcium carbonate and sodium chloride - are readily available in the valley of Devnya. SODI Ltd. operates a limestone quarry to supply calcium carbonate which is reduced in lime kilns to form calcium oxide and carbon dioxide. The calcium oxide is then slaked with excess water to form a thick 'milk of lime' or calcium hydroxide. The second major raw material used in the Solvay Process - sodium chloride - is obtained as saturated brine from mines of rock salt nearby. After further purification at the plants, the brine is ammoniated to form an alkaline solution. Ammonia for this step is supplied to the plants by pipe from a fertilizer plant in Devnya. When reacted with carbon dioxide, the ammoniated brine forms ammonium chloride and sodium bicarbonate. Sodium bicarbonate is then filtered from the solution of ammonium chloride which is then stripped of ammonia and carbon dioxide in a distillation tower. This solution is also reacted with the "milk of lime" to form calcium chloride as a by-product and release additional ammonia which is recycled into the process. Unreacted brine, calcium chloride and the non-recycled ammonia are the main constituents of the hot and alkaline "distillery liquid" which is discharged as a wastewater by SODI Ltd.. Filtered precipitates of sodium bicarbonate are calcined to form the soda ash. A simplified flow diagram and list of reactions of the Solvay Process are given in Figure 1.

EXISTING PROBLEMS IN OPERATIONS

Based upon the information provided by SODI Ltd., the actual production reported for 1991 was only 782,432 metric tons of soda ash. At present, the older plant has been shut down completely while the production from the newer plant was reported

to be ranging from only 30,000 to 40,000 metric tons per month. It was also observed by the WEC team during plant visits that equipment and buildings were in need of major replacement in order to be operated as a modern facility. This situation has been reportedly due to the following reasons.

First, the global demand for soda ash has been decreasing during the recent past with more production capacity being diverted away from the Solvay Process towards the use of natural ore rich in soda ash as the raw material. Second, there has recently been an increased competition for supplying soda ash to the global market by international firms which are merging in an effort to control the price of this product. Three large European firms manufacturing soda ash by using the Solvay Process - Solvay, Rhone-Pholenc and ICI - have bought into production capacity of U.S. firms - FMC and Tenneco - which process natural soda ash found in Wyoming and California. The firms in Europe are also showing interest in buying large plants manufacturing soda ash in Poland. SODI Ltd. has reported that a similar interest has not yet been shown by the European firms in Bulgaria capacity to manufacture soda ash. Third, the old market for SODI Ltd., which included the now independent republics in the former Soviet Union, has declined substantially during recent years. It was reported by SODI Ltd. that soda ash was supplied in the past to these customers at much lower prices than those in the free market and in return for similar transactions in import of fuel and other essential commodities.

Although the current status of business raises some concern about the future of SODI Ltd., a growth in demand is expected with new applications being developed for soda ash, for example, in the production of caustic soda. A major user of soda ash, the glass manufacturing industry, is also expected to grow in the countries of Central and Eastern Europe. SODI Ltd. is currently involved in developing these new markets for soda ash. If it is successful in these efforts, SODI Ltd. can achieve large exports for Bulgaria. A large population of employees, as well as the financial health of other industries in Devnya, are also depending upon continued operation of SODI Ltd.

The specific problems in operating the plants of SODI Ltd. were identified by Mr. Petkov during detailed discussions with the WEC team. A major problem is related with brine purification which was designed for efficient removal of calcium and magnesium but could not remove sulfate ions present in the crude brine. These sulfates precipitate as a salt of calcium in the step of distillation in the Solvay Process. Although this problem has been reported at other plants using the same process, very large quantities of calcium sulfate are formed as hard scales of material during distillation at SODI Ltd. (approximately 10 metric tons of calcium sulfate per month are formed in each distillation tower).

The design of distillation towers could also play an important factor in the reported magnitude of scaling of the tower internals encountered at SODI Ltd., where a distillation tower could be run at a time for only 2 to 3 weeks without substantial

reduction in heat and mass transfer. The equipment is then shutdown to allow for manual removal of the scales. Calcium sulfate precipitation has also been a major problem in the pipes used for pumping the wastewater from distillation towers to a lagoon, despite mixing the distillery waste with other plant wastewaters to cool it and reduce precipitation during its transfer.

Another major problem in the operations reported by SODI Ltd. involves the filtration of sodium bicarbonate prior to calcining it as soda ash. The rotary vacuum filters used for this unit operation are not very efficient in dewatering which required additional water washes of the filtered salts to control the maximum concentration of ammonia and chlorine in the final product. A close supervision of the process as well as special operating skills are also needed to avoid product loss with the wash water. Wash waters from filtration are then mixed with the distillery wastewaters and pumped to the lagoon.

While these operating problems have resulted in high losses of energy, brine and process waters, the most expensive loss of material from a malfunctioning of the equipment is associated with loss of ammonia which is used at 25% concentration in water. While the stochiometry of the Solvay Process indicates that ammonia can be totally recycled, a minimal loss of ammonia (approximately 4 to 8 kilograms per metric ton of soda ash produced) has been reported in other plants using this process. However, SODI Ltd. appears to be losing about five times more quantities of ammonia (approximately 30 kilograms per metric ton of soda ash produced). Most of this loss occurs in the distillation towers with either the wastewaters or stack gas emissions. The rotary vacuum filters also release ammonia as air emissions. SODI Ltd. has reported that fugitive air emissions of ammonia at the plant are minimal however.

WASTE GENERATION AND MANAGEMENT

The wastewaters generated at SODI Ltd. are pumped out (without any attempt at segregation, recycling or treatment of wastes on-site) to a lagoon located 10 kilometers from the plant. Approximately 20 million cubic meters of wastewaters were discharged to the lagoon by SODI Ltd. in 1991. This wastewater is highly alkaline (pH of 11) and has high concentrations of solids (both dissolved and suspended solids) and ammonia (260 milligrams per liter). The lagoon also receives untreated wastewaters from other plants in the valley of Devnya, such as the fertilizer plants and a thermal power station supplying electricity to industries in the area. The lagoon is nearly 15,000 acres in area and is capable of only settling the suspended solids in the wastewaters. The effluent from the lagoon is highly alkaline however, and is discharged into the Provadiyska River and then into the Berloslav Lake. The Provadisyska River does not meet the quality standards for even the third category of surface water streams in Bulgaria while the Berloslav Lake receives large quantities of industrial wastewaters which ultimately feed to the Black Sea. A facility is being

built at the mouth of the lake now to prevent silting of the waterway to the Black Sea through formation of carbonate sediments. Frequent dredging of bottom sediments in the Provdiyska River is also carried out to maintain the necessary depth of water flow in the river. Several foreign firms have proposed treatment of industrial wastewaters in Devnya.

In addition to generation of large quantities of wastewaters which have an adverse effect on water quality in the region, the operations at SODI Ltd. release air pollutants such as ammonia, carbon dioxide and particulates. Nearly 2,000 metric tons of ammonia were released in 1991 from the condensers on distillation towers and the vacuum pumps on the filters. The flow rate of non-condensed gases from the distillation towers was 1208 cubic meters per minute with an ammonia content of 0.335%. The flow rate of vacuumed air from filters was 500 cubic meters per minute with an ammonia content of 0.233%. Air quality standards require that ammonia content from both sources be reduced to 0.013%. SODI Ltd. has reportedly contacted a firm in Germany for supply of demisters to be used with existing processes for controlling the air emission of ammonia. Releases of carbon dioxide and particulates are largely associated with performance of the lime kilns.

In addition to the sedimentation from wastewaters discharged by SODI Ltd., other solid wastes are generated in brine purification, slaking of lime and the distillation step. The most significant quantities of solid waste generated are associated with the calcium sulfates removed periodically as scaled material from the distillation towers and disposed on-site.

NEED TO IMPORVE OPERATIONS

SODI Ltd. recognizes that a major improvement in their operations is required to make them competitive in the global market for supplying soda ash. Better process control to reduce the loss of ammonia during distillation and vacuum filtration should probably be given the highest priority in an effort to modernize operations. At the same time, it is recognized that more permanent improvement in operations can be achieved only by replacing the existing design of plant equipment for these operations by more advanced technologies. SODI Ltd. believes that although the Solvay Process has been discontinued in the United States, appropriate technologies for the distillation towers and filters for use in the process can be supplied by this country.

Better design of distillation towers can also assist SODI Ltd. to overcome the problem of scaling of calcium sulfate. Besides reducing down time on these equipment, a decrease in capacity of the distillation towers due to loss of heat and mass transfer coefficients resulting from scaling of the interior of the towers can also be alleriated. Another need for modernization of operations is associated with the removal of sulfates during brine purification. SODI Ltd. is looking for a cost-effective technology

for achieving this goal and believes that the appropriate technology can be developed in the United States. With improved operations of the distillation towers, an increase in utilization of brine in production of soda ash would also become feasible. This improvement will in turn enable SODI Ltd. reduce the excess ammonia used in the process and create an opportunity for controlling better the loss of ammonia during filtration by replacing the existing design of vacuum filters with better rotary vacuum filter designs or other filtration technologies.

NEED TO REDUCE POLLUTION

SODI Ltd. recognizes that the current inefficiency in operations is closely related with the current release of environmental pollutants. In particular, the loss of ammonia in the process directly has an adverse impact on water and air quality. Last year, SODI paid approximately 2,500 dollars for wastewater discharges and an additional 750 dollars for air emissions of ammonia. At this time, however, the cost of treatment of wastewaters at the lagoon or other environmental pollution control has been prohibitively high. With a significant improvement of operations, more cost-effective solutions can be found to control the pollutants being released to the air, water or as solids from the process.

Section 3

WASTE MINIMIZATION OPPORTUNITY ASSESSMENT

WASTE MINIMIZATION OPTIONS

There are several potentially feasible options for improving operations and reducing pollution at SODI Ltd., which are briefly described below.

1. The brine purification can be improved to reduce the generation of solid wastes during distillation of process residues and transfer of distillery wastes. For this purpose, it is possible to consider a change in source of salt, a change in source of water used to form the crude brine or changes in the process for purifying the crude brine to include the removal of sulfate ions. The change in process for purifying brine may include additional chemical treatment or new physical separation techniques applicable for liquids with dissolved solids.

2. The distillation of process residues can be improved to reduce the loss of ammonia. For this purpose, it is possible to consider a change in operating procedures and / or a change in the equipment and controls used for distillation. The change in operating procedures will probably be based upon continuous monitoring of ammonia in the wastewater and stack gas emissions from the distillation towers. Some of the desired changes in operating procedures for distillation may have to be assisted by changing the equipment design for better heat and mass transfer or by installing better process control.

3. The filtration of sodium bicarbonate can be improved to reduce the need for additional washing of filtered solids during product recovery. For this purpose, it is possible to consider a change in the process equipment being used for filtration. The change in equipment may involve installation of more efficient vacuum filtrate systems or other filtration technologies suitable for this process.

4. The carbonization of ammoniated brine can be improved to reduced the excess of brine or ammonia used in the step. For this purpose, too, it may be necessary to change the equipment for better heat and mass transfer.

5. Waste management can be improved to reduce the quantities of wastewater and the pollutants being discharged to the lagoon. For this purpose, the

practice of mixing all wastewaters generated in the plant must be changed to segregate, treat and recycle some of the wastewater streams.

6. The distillery waste itself can be treated on-site to reduce the pH and dissolved solids in the final wastewaters being discharged to the lagoon. For this purpose, installation of new equipment will be required with major additional capital and operating costs. On-site treatment can also be used to produce additional by-products such as calcium chloride.

TECHNICAL ASSESSMENT

An implementation of these waste minimization options will require different levels of effort. For example, improvement of brine purification will require additional research and capital investment in process changes. Although a final improvement in distillation will also require substantial investment in equipment changes or instrumentation, some of the changes in operating procedures can be achieved through little or no investment. Other improvements in operation designed to minimize the waste generation also appear to require major investment in equipment changes. Even the option to segregate and recycle some of the wastewater streams on-site will require investment in changing the routes of pipes and installation of new treatment capacity. It may be possible to introduce on-site treatment of some distillery waste liquids however by using unused absorption towers in the older plant of SODI Ltd. to achieve partial neutralization of the wastewaters and for evaporating the residues if necessary to recover calcium chloride as a by-product.

FINANCIAL ASSESSMENT

The highest cost benefits from implementing these waste minimization options appear to be from reducing the loss of ammonia which is supplied to SODI Ltd. at slightly more than $100 per metric ton. At a rate of losing 30 kilograms of this material per metric ton of soda ash, SODI Ltd. can be losing approximately $4 million at full operating capacity. As an effort to modernize distillation equipment and controls can be a major capital investment, only the use of best management practices (BMPs) in the existing plant may be considered for achieving a modest loss reduction of ammonia.

Section 4

WASTE MINIMIZATION DEMONSTRATION PROJECT

DESCRIPTION OF PROJECT

Envirometrics Systems, Inc. (ESI) has proposed that the Waste Minimization Demonstration Project (WMDP) at SODI Ltd. focus on the development and implementation of a few Best Management Practices (BMPs) associated with more efficient operation of a selected distillation tower and its auxiliary equipment. These BMPs will be developed with the close cooperation of a Waste Minimization Committee consisting of senior technical personnel who are very familiar with the Solvay Process and plant operations at SODI Ltd.. These personnel must select the distillation column for demonstrating the project and provide adequate details of the design, operations and performance for the selected equipment as required to define the existing procedures in distillation. ESI will identify additional information needs and obtain the required monitoring equipment before initiating the BMPs. SODI Ltd. must then accept the BMPs and identify plant personnel who will be responsible for implementing the demonstration project. ESI will assist in training plant personnel in project implementation at the stage of finalizing the BMPs as well during the final demonstration of the project. After assuring the benefits of the project, SODI Ltd. must identify an Coordination Committee including personnel outside the company to review and comment upon the project over a longer period of time. ESI will assist in formalizing the review process to be performed by the oversight committee.

ADDITIONAL INFORMATION NEEDS

A good design of a multi-component distillation process requires the following information to be developed : material and energy balances; vapor-liquid equilibrium data (alternatively bench scale test results); limitations of the distillation tower and auxiliary equipment for heating and cooling the process liquids; and other estimation methods used in the past to determine operating procedures. Some of these additional information needs can be met by SODI Ltd. even after starting the first demonstration of the BMPs. However, procurement of adequate details of the existing operations is required tc identify these additional information needs as well as to start developing the BMPs.

ADDITIONAL MONITORING EQUIPMENT

The distillation unit at SODI Ltd. is provided with a comprehensive set of temperature and pressure monitoring equipment. However, additional monitoring equipment are

needed to readily measure the concentration of ammonia in different process streams in this unit. As the ultimate goal to be achieved in the WMDP is to reduce the loss of ammonia, it is reasonable to expect that these additional monitoring equipment must be installed during the project. Other equipment for monitoring the flows of liquid may also be required to monitor a particular process stream or to check performance of a selected portion of distillation column or auxiliary equipment.

IMPLEMENTATION PROCEDURES

ESI recommends the following procedure for implementing the WMDP:

Step 1 : SODI Ltd. provides details of the design, operations and performance history for a selected unit of distillation column and auxiliary equipment. Design details may include as-built drawings, conceptual process flow diagrams, design calculations and pipe and instrumentation diagrams (P & IDs). Operating details may include a set of instructions for starting and controlling the process, a set of guidelines for troubleshooting the operations and shutdown of operations due to formation of material deposits, and a set of operating conditions as monitored by existing instruments or through periodic sampling and analysis. Details of the performance history may include the information on unique characteristics of the selected equipment and actual results of operations in the recent past.

Step 2 : ESI will review the details provided by SODI Ltd. to identify any additional information needs to be obtained during the following steps, identify the required monitoring equipment, and propose a set of BMPs to be applied during the starting phase of the WMDP. The BMPs to be addressed are expected to include the inspection of equipment, measurement of air and water emission of ammonia, adjustment of process controls, maintenance, record-keeping and information management. ESI's proposal of BMPs will be reviewed by SODI Ltd. which will then identify plant personnel responsible for implementation of WMDP.

Step 3 : After SODI Ltd. reviews ESI's proposal, discusses it with plant personnel and approves the proposed waste minimization concept, the BMPs will be implemented by the Waste Minimization Committee for at least one complete cycle of plant operations on the selected distillation column. Additional information needs which were not met in the past will also be obtained during this step. ESI's personnel will visit SODI Ltd. during this step of the project in order to assist plant personnel in implementation of BMPs as required. ESI will also recommend any changes in BMPs to achieve better waste minimization.

Step 4 : Based upon the findings of this study, the BMPs will be finalized for another implementation by the Waste Minimization Committee for two consecutive cycles of operation or two months, whichever is longer. Assuming that the finalized BMPs are implemented with improved results, ESI personnel will visit SODI Ltd. again during this step of the project in order to assist in the formation of a Coordination Committee and develop guidelines for assessing the waste minimization demonstrated by the project.

Step 5 : The project will then be continued for three months and the results will be monitored by the Coordination Committee responsible for reviewing the project. More changes in the new operating procedures will be made as found necessary to improve upon reduction of loss of ammonia or to meet with new operating needs. A final report will be issued at the end of the project after completion of this project review.

PPRJECT SCHEDULE

The project will be started after WEC reviews and approves the implementation procedure for WMDP, and has developed a memorandum of understanding (MOU). SODI Ltd. then reviews and signs the MOU and compiles details of design, operation and performance of a distillation column for the WMDP. Two weeks are adequate for ESI to propose the BMP's to be implemented during the first stage of project demonstration. ESI will also recommend the additional monitoring equipment at the same time. In additional four weeks, it is possible to test the approved BMPs and finalize the new operating procedures. The new procedures can then be tested for an extended period of time to make the project ready for review by the Coordination Committee. The waste minimization demonstration project can be developed and finally implemented before the end of September 1993.

The following schedule highlights milestones of the proposed WMDP :

Start Project	• WEC and SODI sign a MOU April 30, 1993
Step 1	• SODI provides information needed May 15, 1993
Step 2	• ESI proposes BMPs to be implemented June 1, 1993
Step 3	• First Demonstration of Project June 30, 1993
Step 4	• Finalize BMPs and Second Demonstration of Project August 30, 1993
Step 5	• Commence Review by Coordination Committee Sept. 30, 1993

End Project • Complete WMDP Dec. 31, 1993

ESTIMATED BENEFITS OF WMDP

It is estimated that at least 25 % of the ammonia loss (totalling $ 4 million per year at full operating capacity) can be reduced by improving the distillation operations at SODI Ltd. Although the maximum potential for saving operating costs through this option is estimated to be at least $1 million at full operating capacity of SODI Ltd., an effort to modernize distillation equipment and controls can be a major capital investment. Therefore, the "low or no cost" BMPs to be proposed for the WMDP are estimated to achieve only another 25 % of the total savings potential ($250,000 per year at full operating capacity). As the WMDP is going to be conducted in only one out of nine distillation columns at SODI Ltd., the benefit from this project is estimated to be a cost savings of approximately $25,000 per distillation column per year. If successful, however, the results of WMDP can also be potentially achieved in the operation of other distillation equipment at SODI Ltd.

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