TRIP REPORT #2 CHEMKO

STRAZSKE, SLOVAK REPUBLIC

WASTE MINIMIZATION PROJECT

FEBRUARY 28 - MARCH 6, 1993

WORLD ENVIRONMENT CENTER
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File (2)
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I. ITINERARY

February 28, 1993 - Michalovce
○ Arrive in Michalovce, Slovak Republic

March 1, 1993 - Strazske
○ Met with Department Managers at Chemko

March 2, 1993 - Strazske
○ Met with Process Technicians & Engineers
○ Tour the Production Facilities

March 3, 1993 - Strazske
○ Met with Repair and Maintenance Engineers

March 4, 1993 - Strazske
○ Met with the Manager of the Environmental Department
○ Tour the Environmental Laboratory and the R & D Laboratory

March 5, 1993 - Strazske/Bratislava
○ Met with the CEO and Managers
○ Travel to Bratislava
○ Meeting at the Ministry of Economy of the Slovak Republic

March 6, 1993 - Vienna, Austria
○ Return trip to United States
II. EXECUTIVE SUMMARY

Pursuant to the Technical Assistance Program for Central and East European countries funded by U.S. Agency for International Development, the World Environment Center (WEC) has organized a reconnaissance trip to Chemko, a manufacturer of organic and inorganic chemistry, located in the eastern most part of Slovak Republic.

A team consisting of WEC staff, Mr. Thomas McGrath and Ms. Dorothy Chuckro, Mr. Sharad Gandbhir from Advanced Engineering Associates, Inc., and Mr. Paul Cheremisinoff from the New Jersey Institute of Technology, visited the Chemko complex in Strazske from March 1 to 5, 1993. The objective of their reconnaissance visit was to assess and identify the waste source point and/or process segments for the waste minimization demonstration project (WMDP).

During the visit, the WEC team reviewed process flow diagrams and data; tour of manufacturing facility and environmental research laboratories. Discussions were held with managers from the following departments: technical process support, engineering, product development, maintenance and repair, environmental protection and health and safety.

The WEC team and Chemko management, selected the cyclohexanone process for the waste minimization demonstration project. The project will involve the measurement of fugitive volatile organic compounds (VOC) at the Cyclohexanone Plant. Based on the information supplied by Chemko, it is estimated that 1,068 metric tons of benzene are lost yearly.

Messrs. Gandbhir and Cheremisinoff estimated that the waste minimization demonstration project may result in a reduction of benzene between 50% and 70% with a resultant cost savings of 78,500 to 314,000 per year, depending on the factory’s operating capacity. Currently, Chemko’s cyclohexanone production is operating at 50% capacity. Since benzene is a known carcinogen and poses serious health risks, a possible reduction of this amount is significant.

WEC and Chemko are preparing a Memorandum of Understanding for the project. Chemko agrees to commit the enterprise to future waste minimization projects to be performed by Chemko employees.

The start-up phase of waste minimization demonstration project is scheduled for the end of July. WEC will have supplied monitoring equipment for detecting fugitive benzene and on-site training of plant personnel in performing field measurements and in the techniques of waste minimization will be started.
Please refer to Mr. Sharad Gandbhir’s report, Attachment I.
IV. ATTACHMENTS
WASTE MINIMIZATION PROJECT
at
CHEMKO STRAZSKE

Report 1
by
Sharad S. Gandbhir, Project Manager

May 1993
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</table>
BACKGROUND

Chemko Strazske was established in 1952 and presently produces 49 different products in 14 organic and 8 inorganic production plants. Chemko is strategically located in the eastern most part of Slovakia in Strazske, about 60 kilometers of the Hungarian, Polish and Ukrainian borders. It currently employs 3,200 people. Chemko's major products are cyclohexanone (an intermediate for caprolactum), urea formaldehyde glues and liquid nitrogen fertilizers. Of the total 10 million square meters occupied by Chemko about 3.8 million square meters are improved and built-upon.

Chemko complex consists of many different manufacturing and support facilities which were developed in three stages. During stage one from 1957 to 1963, facilities for the manufacturing of urea-formaldehyde glues, phenol-formaldehyde glues, and pentaerythritol were built. Nitrogen chemistry complex was built as stage two from 1964 to 1969 to produce ammonia, nitric acids, and NPK fertilizers. The cyclohexane, cyclohexanone, and cyclohexanol facility was built in the third stage between 1976 and 1983. Other auxiliary facilities like power plant, water reservoirs, waste water treatment, machinery shops, and so on, were established.

Chemko's primary products are:

- Chempors
- Nitric Acids
- Formaldehyde
- Hexmethyltetramine
- "Diakol 31" - Urea Formaldehyde Glue
- "Fenokol 43" Phenol Formaldehyde Glue
- Pentaerythritol
- Cyclohexanone

The most important raw materials used are benzene, methanol, urea, sulphur and potash.

Chemko's PCB production was stopped in 1984.

Like many other locations throughout Slovak Republic, one of the main sources of pollution at Chemko is the power plant, generating 100,000 mt of ash and 8,500 mt of SO2 on annual basis.

Chemko also identified pentaerythritol and cyclohexanone production facilities to be large sources of pollution. Estimates of air emission levels from cyclohexanone are 2,500 mt CO and 400 mt organic compound mixtures. Chemko has until 1998 to comply with air regulations legislated in 1991.
OBJECTIVE

Sharad S. Gandbhir (the consultant) had previously (in 1991) visited Czech and Slovak Republics to assist a joint mission of the U.S. A.I.D., World Bank, and U.S. E.P.A. in evaluation of the state of chemical and petrochemical industries and their impact on local, national, and international environment. The consultant visited over 15 different facilities, local, national and Federal regulatory authorities, NGOs, and teaching and research institutes to observe the operations and gather necessary data. In the report to the mission, the consultant made practical recommendations for waste minimization projects which are being vigorously followed by WEC under U.S. A.I.D. grants. Naturally, when WEC approached for an assistance to evaluate and if possible, implement a waste minimization project at Chemko Starzke, the consultant accepted the challenge.

A team consisting of the representatives from World Environmental Center (WEC), the consultant and Professor Paul N. Cheremisinoff visited Chemko facilities at Strazske from March 1, 1993 to March 5, 1993. The objective of this visit was to jointly identify waste minimization project(s) that would show significant economic and health benefits with minimum investment at Chemko Starzke chemical complex.
SUMMARY OF OBSERVATIONS AND FINDINGS

During one week visit, discussions were held with various personnel at Chemko Strazke and with Slovak Government officials in Bratislava. A list of names in alphabetical order of the persons visited along with their official titles, where possible, is presented in Appendix I.

On the first day of meetings, WEC team discussed the purpose of their visit with Chemko management and reviewed overall setup of the complex. Next day followed with technical presentations and discussions on two manufacturing processes that showed significant potential for waste minimization projects. These processes were:

A) Cylohexanone manufacturing process, and
B) Pentaerythritol process.

The following tasks were conducted during the next two days:

- Visits to above mentioned plant facilities,
- Walk-through tours of environmental and central laboratory facilities,
- Discussions with operating, maintenance, and environmental control personnel within Chemko,
- Further discussions regarding pros and cons of various options in the two processes, and
- Review of the economic data.

Chemko expressed interest in projects to improve Pentaerythritol process. WEC team explained that such projects are considered as major capital improvement projects requiring large investments and were beyond the scope of our mission. Based on the data presented by Chemko, WEC team evaluated the economic and health benefits and concluded that waste minimization project in Cyclohexanone manufacturing process had a potential to achieve the set objectives. Backup data are presented in Appendix II and computations of economic benefits are presented in Appendix III.

Total benzene losses in cyclohexanone process are 10,680 metric tons (MT) per year for the plant operating at full capacity. Chemko contribute ninety per cent of these losses to poor efficiency of the process and ten per cent to fugitive losses, which correspond to 1,068 MT/year. Currently, the plant is operating at 50% capacity due to market conditions. Setting a realistic goal of achieving 50% reduction in fugitive
emissions and assuming that plant would continue operating at such 50% capacity for the near future, reduction in hydrocarbon emissions equivalent to 267 MT of benzene per year would be realized. These reduced benzene losses correspond to operating cost savings of $78,500/year would be realized. At 100 per cent reduction of fugitive losses of benzene savings would amount to $314,000/year. At present, penalties for polluting are small, and are not included in the economic benefits.

Benzene is a known carcinogen and any reduction in fugitive emission of benzene always offers significant health benefits.
RECOMMENDATIONS

1. Chemko management and WEC team agreed upon implementation of a waste minimization project in Cyclohexanone process. WEC will prepare a draft of Memorandum of Understanding between the two parties and send it to Chemko management for their approval.

2. An Oversight Committee consisting of Chemko managers and representatives from WEC Ministry of Industry, Slovak Government Environmental Authorities, and other chemical companies within the region and consultants should be established to develop comprehensive goals and guidelines for implementation.

3. A waste Minimization Committee should be formed consisting of personnel from management, operations, maintenance, and environment control departments at Chemko.

4. The consultant recommends that the focus for the Waste Minimization project be Cyclohexanone Manufacturing Plant for the reasons stated above. Chemko should assign personnel as follows:

   Full Time - One from operations and one from maintenance
   Part Time - One from management, one from environmental, and one from laboratory. These should be on as needed basis with a priority to this project.

5. The consultant will develop specification, obtain quotes for proper Organic Vapor Detector/Analyzer and make recommendations to WEC for purchase of a selected equipment.

6. The consultant will conduct an orientation meeting for the Oversight and Waste Minimization Committees at Chemko and give demonstration of the equipment for use of equipment and discuss the objectives.

7. The consultant will develop and conduct an initial weeklong "hands on" training session for Chemko staff assigned to the project. The consultant will monitor the Chemko emission survey staff, review with them interpretation and use of the gathered information.

8. The consultant and Chemko assigned personnel will prepare Fugitive VOC Emission Survey and Leak Report for the sections of the Cyclohexanone plants.
9. Consultant will be available for consultations by telephone or fax to review through the initial survey of the cyclohexanone plant.

10. The consultant will plan for three (or four maximum) additional trips to Chemko during the course of the project. Two trips will serve as on call visits to resolve any problem that may arise during the course of the project and one final trip to measure the overall success prior to close out the project.

11. Two interim field reports and final summary report will be submitted by February 28, 1994.
Appendix I
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Head of surroundings protection Department

Ing. Štefan DUPAL
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Plant of Benzene Chemistry

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Appendix II
EXHIBIT I
Material Balance of cyclohexanone Production Plant for the 1990 year.

<table>
<thead>
<tr>
<th>a/ Inlet streams in metric tons/year</th>
<th>104 849</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>104 849</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>10 163</td>
</tr>
<tr>
<td>NaOH 42% weight</td>
<td>4 267</td>
</tr>
<tr>
<td>Air for the oxidation</td>
<td>179 165</td>
</tr>
<tr>
<td>Cobaltous nitrate</td>
<td>31</td>
</tr>
<tr>
<td>Mesoionic acids</td>
<td>54</td>
</tr>
<tr>
<td>Steam condensate</td>
<td>103</td>
</tr>
<tr>
<td>Steam</td>
<td>177 284</td>
</tr>
<tr>
<td>Earth gas</td>
<td>2 106</td>
</tr>
<tr>
<td>Air for dehydrogenization process</td>
<td>40 522</td>
</tr>
<tr>
<td>Cyclohexanone from import</td>
<td>20</td>
</tr>
<tr>
<td>Total:</td>
<td>518 564</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b/ Outlet streams in metric tons/year</th>
<th>85 428</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclohexanone</td>
<td>85 428</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>9 968</td>
</tr>
<tr>
<td>Cyclohexanol</td>
<td>91</td>
</tr>
<tr>
<td>Organic wastes</td>
<td>23 642</td>
</tr>
<tr>
<td>Alkaline waste waters</td>
<td>25 803</td>
</tr>
<tr>
<td>Effluent from hydrogenation to power station</td>
<td>3 170</td>
</tr>
<tr>
<td>Effluents from oxidation</td>
<td>147 137</td>
</tr>
<tr>
<td>Waste gases from dehydrogenation</td>
<td>42 628</td>
</tr>
<tr>
<td>Acid waste waters form oxidation</td>
<td>36 103</td>
</tr>
<tr>
<td>Neutral waste waters</td>
<td>132 068</td>
</tr>
<tr>
<td>Waste waters from DW 124 or DZ 115 reso.</td>
<td>12 436</td>
</tr>
<tr>
<td>Total outlet streams:</td>
<td>518 564</td>
</tr>
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</table>

2. Organic material balance:

<table>
<thead>
<tr>
<th>a/ Inlet streams in metric tons/year</th>
<th>151 545</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>104 849</td>
</tr>
<tr>
<td>Cyclohexanone imported</td>
<td>20</td>
</tr>
<tr>
<td>Reacted Hydrogen</td>
<td>7 003</td>
</tr>
<tr>
<td>Reacted oxygen</td>
<td>39 673</td>
</tr>
<tr>
<td>Total inlet streams:</td>
<td>151 545</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b/ Outlet streams in metric tons/year</th>
<th>85 428</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclohexanone</td>
<td>85 428</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>9 968</td>
</tr>
<tr>
<td>Cyclohexanol</td>
<td>91</td>
</tr>
<tr>
<td>Effluent from hydrogenation - cyclohexane</td>
<td>10</td>
</tr>
<tr>
<td>&quot; methane</td>
<td>193</td>
</tr>
<tr>
<td>Effluent from oxidation</td>
<td>720</td>
</tr>
<tr>
<td>&quot; hydrocarbons</td>
<td>6 262</td>
</tr>
<tr>
<td>&quot; CO</td>
<td>2 308</td>
</tr>
<tr>
<td>&quot; CO₂</td>
<td></td>
</tr>
<tr>
<td>Organic wastes</td>
<td>22 058</td>
</tr>
<tr>
<td>Alkaline waste waters</td>
<td>8 382</td>
</tr>
<tr>
<td>Reaction water</td>
<td>13 533</td>
</tr>
<tr>
<td>Hydrocarbons in waste waters</td>
<td>2 572</td>
</tr>
<tr>
<td>Total outlet streams:</td>
<td>151 545</td>
</tr>
</tbody>
</table>
1. Water balance:
   a/Inlet streams:
   Reaction water  13 553
   Water from the NaOH solution  4 215
   Steam  177 284
   Steam condensate  103
   Total:  195 155

   b/Outlet streams:
   Acid waste waters from oxidation  34 407
   Water in organic waste  1 584
   " in Alkali waste water  15 536
   " in Neutral waste waters  131 920
   Waste waters from DW-124 (or DZ-115 resp.)  11 708
   Total:  195 155

To that balance is necessary to add 2 572 metric tons of organic materials which are present in waste waters and the consumption of water for rinsing which was 181 844 metric tons.

Total amts of waste waters is then 379 571 t/year. it is average 43.3 t/hour, from technological process 22.6 tons/hour and from rinsing 20.7 t/hour.

4. Effluents Balance:
   Effluent which are de-areated to atmosphere:
   - effluents from process  147 137
   - waste gases  42 628
   Total  189 765

   In effluents from process are:
   720 t/year hydrocarbons
   6 262 t/year CO

   Actual Prices (Valid till the end of February 1993):

<table>
<thead>
<tr>
<th>Material</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>8 375 Ks/t</td>
</tr>
<tr>
<td>NaOH 40% sol.</td>
<td>6 100</td>
</tr>
<tr>
<td>Cobaltous Nitrate</td>
<td>311 500</td>
</tr>
<tr>
<td>Naphthenic Acids</td>
<td>44 000</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>11 500</td>
</tr>
<tr>
<td>Cyclohexanone</td>
<td>18 315</td>
</tr>
<tr>
<td>Pentaerythritole</td>
<td>33 235</td>
</tr>
<tr>
<td>Formic Acid</td>
<td>19 800</td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>18 850</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>15 200</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1 885</td>
</tr>
</tbody>
</table>
Within the scope and budget of WEC waste minimization project, we see two possibilities in cyclohexanone production plant.

1. Hydrocarbons Recovery from liquid wastes
2. Reduction of Benzene consumption

I. Hydrocarbons Recovery From Liquid Wastes

Substantial number of manhours would be required to carry out detailed and meaningful cost and benefit analyses of various process options. We also believe that a large capital expenditure would be required.

II. Reduction Benzene Consumption

According to Chemko data, weight ratio of benzene/cyclohexanone at Strazke plant is 1.125, compared to 1 at other production facilities.

Cyclohexanone production capacity at Strazke plant is 85,428 metric tons/year. At this capacity loss (or excess consumption) of Benzene is

\[
= (85,428) \times (0.125) \\
= 10,680 \text{ Metric Tons/Year}
\]

Ten per cent of Benzene loss is considered (by Chemko) as fugitive loss

\[
= 1,068 \text{ Metric Tons/Year}
\]

Excess operating cost due to fugitive losses of Benzene

\[
= 1,068 \text{ mt/year} \times 8,375 \text{ kcs/mt} \\
\times 0.035 \text{ $/kcs} \\
= \$314,000/\text{Year} \quad \text{(Max)}
\]

If one 25% reduction in fugitive losses, operating cost savings will be

\[
= \$78,500/\text{Year} \quad \text{(Min)}
\]
If the savings in penalties is accounted for, benefit would increase.

Health benefits by reducing the emission of benzene, a known carcinogen, would be significant.
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