The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

PN-ABY-040

Report 3114-95-26-30

un 98424

Water Quality Improvement and Conservation Project

Industrial Audit:

Jordan Iron & Steel Industries Co., Ltd.

Science Applications International Corp.

Development Alternatives, Inc.

The Technical Assistance Team Includes:

Development Alternatives, Inc.
Science Applications International Corp.
Harza Environmental Services, Inc.
Development Associates, Inc.

USAID

United States Agency for International Development
Contract No. 278-0288-00-C-4026-00

April 1995

PN-ABY-040

IRON AND STEEL INDUSTRY AUDIT REPORT JORDAN

Submitted to:

United States Agency
for International Development

Submitted by:

Development Alternatives, Inc.

Prepared for:

Amman Chamber of Industry, Jordan
Ministry of Water and Irrigation, Jordan

Prepared by:

Science Applications International Corp. (SAIC)
Falls Church, VA, USA
and
Harza Consulting Engineers and Scientists
Chicago, IL, USA

in association with:

Royal Scientific Society (RSS)
Amman, Jordan

2

PREFACE/ACKNOWLEDGMENTS

This report is the result of a 4-week study/audit/evaluation of the Jordan Iron & Steel Industries Co., LTD. The purpose of the study was to evaluate and identify potential pollution prevention/waste minimization and water conservation techniques which are appropriate. The executive summary on the following pages outlines the consultants findings and actions during the study/audit/evaluation.

Several individuals on the Water Quality Improvement and Conservation Project contributed to this report. Dr. Usama Mudallal of the Amman Chamber of Industry (Chamber); Engineer Rania Abdul Khaleq of the Ministry of Water and Irrigation (MWI); Eng. Waleed Hussein, of the Water Authority of Jordan (WAJ); and Dr. Riyad Musa and Dr. Omar Jabay of the Royal Scientific Society of Amman; plant managerial and technical staff including Mr. Mohmoud Al Edwan, Inspector General, Mr. Ahmad Pervaiz, Meltshop Manager, Mr. Jameel Halaseh, Administrative Assistanct, Mr. Suheil Awaad, Maintenance Manager, and Mr. Youse Ashkar, Treatment Plant Supervisor, shared their knowledge with Mrs. Mary Veal Walron., of Science Applications International Corporation (SAIC), Falls Church, Virginia, USA. These technical staff worked under the direction of Dr. Shawn R. Niaki, P.E., Pollution Prevention Program Director, of Harza, who heads the WQIC component under which the study/audit/evaluation was housed. It is from their combined expertise that this report was possible.

Special appreciation is given to Dr. Mohammed Bani Hani, Secretary General of MWI; Eng. Koussai Quteishat, Secretary General of WAJ; Mr. Khaldun Abuhassan, Chairman of the Chamber; Mr. Walid Al-Khathib, Director General of the Chamber; Dr. Muwaffaq Saqqar, Project Coordinator; Dr. Raja Gadoun, Director of the WAJ Laboratories; Eng. Randa Dufaha of the WAJ Laboratories; the members of the PP/WM working group from WAJ including Eng. Abdul Wahab Matar, Eng. Marwan Al-Tal, Eng. Nabeel Hejazeen, Eng. Mohamad Lafi; and to Development Alternatives, Inc., as represented by Edwin D. Stains, Chief of Party; for their cooperation and confidence.

TABLE OF CONTENTS

PAGE

PREFACE/ACKNOWLEDGEMENTS i

EXECUTIVE SUMMARY E1

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Objectives .....
1.3 Report Contents .....

2.0 PROCESS OVERVIEW .....
2.1 Iron and Steel Industry in Jordan .....
2.2 Process Operations at the Jordan Iron & Steel Industries Co., Ltd. Facility
2.2.1 Meltshop Process .....
2.2.2 Rolling Mill Process .....
2.2.3 Power Station .....
2.2.4 Oxygen Plant .....

3.0 AUDIT PROCESS .....
3.1 Audit Coordination .....
3.2 PP/WM Background Material Preparation .....
3.3 Pre-Inspection Meeting .....
3.4 Audit .....
3.5 Post-Inspection Meeting .....

4.0 AUDIT FINDINGS .....
4.1 Water Usage and Balance .....
4.1.1 Meltshop Water Use .....
4.1.2 Rolling Mill Water Use .....
4.1.3 Power Station Water Use .....
4.1.4 Oxygen Plant Water Use .....
4.1.5 Other Water Uses .....
4.2 Wastewater Discharges .....
4.2.1 Meltshop Wastewater .....
4.2.2 Rolling Mill Wastewater .....
4.2.3 Other Wastewater .....
4.3 Wastewater Treatment System Processes .....
4.3.1 Meltshop Cooling Water Pretreatment System Processes .....
4.3.2 Rolling Mill Wastewater Treatment System Processes .....
4.4 Air Emissions .....
4.4.1 Meltshop Air Emissions .....
4.4.2 Power Station Air Emissions .....

4

4.5 Solid Wastes . . . . . .
4.6 Storm Water Management . . . . . .
4.7 Data Gaps . . . . . .
4.7.1 Water Quality . . . . . .
4.7.2 Water Quantity . . . . . .

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION OPPORTUNITIES
5.1 Meltshop . . . . . .
5.2 Rolling Mill . . . . . .
5.3 Control of Other Waste Generating Activities . . . . . .
5.3.1 Wastewater Treatment System . . . . . .
5.3.2 Storm Water, Sanitary Wastes, Solid Wastes, and Air Emissions . . .

6.0 WATER CONSERVATION OPPORTUNITIES . . . . . .
6.1 Meltshop . . . . . .
6.2 Rolling Mill . . . . . .
6.3 Miscellaneous Water Conservation Techniques . . . . . .

7.0 CONCLUSIONS AND RECOMMENDATIONS . . . . . .
7.1 Success Stories . . . . . .
7.2 Conclusions . . . . . .
7.3 Recommendations . . . . . .
7.3.1 PP/WM Policy and Monitoring . . . . . .
7.3.2 Operational Modifications . . . . . .
7.3.3 Process Modifications . . . . . .
7.3.4 New Process Additions . . . . . .
7.3.5 Control of Other Waste Generating Activities . . . . . .

8.0 FOLLOW-UP ACTIONS . . . . . .

APPENDICES

Appendix A Audit Questionnaire
Appendix B Information Provided by the JISICO Facility
Appendix C Overview of the Regulations Applicable to the JISICO Discharge
Appendix D Site Visit Photographs
Appendix E References
Appendix F PP/WM Background Report

5

TABLES

Table 1 Water Balance
Table 2 WAJ Wastewater Discharge Monitoring Analytical Results
Table 3 Sampling Analytical Results
Table 4 Cooling Water Analytical Results
Table 5 Potential Water Savings

FIGURES

Figure 1 Meltshop Process and Water Balance Flow Diagram
Figure 2 Rolling Mill Process and Water Balance Flow Diagram
Figure 3 Meltshop Water Conservation Techniques Flow Diagram
Figure 4 Rolling Mill Conservation Techniques Flow Diagram

EXECUTIVE SUMMARY

Under Contract No. 278-0288-00-C-4026-00 with the United States Agency for International Development (USAID), Development Alternatives, Inc. (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber). Harza Consulting Engineers and Scientists (Harza), Chicago, Illinois, USA, and Science Applications International Corporation (SAIC), Falls Church, Virginia, USA, have been retained as the subcontractors to lead the audits. The Royal Scientific Society (RSS) of Jordan was selected as the local consultant to assist the lead consultants in the audit site visits and report preparation.

This program includes conducting the Pollution Prevention/Wast Minimization (PP/WM) audits, Feasibility Studies (FS), and design demonstration units at selected industrial facilities. Based on a ranking methodology, the PP/WM Committee selected ten industries with potential needs for PP/WM audits. One of these industries is the iron and steel industry. The SAIC/RSS team conducted an audit of the Jordan Iron and Steel Industries Company, Limited (JISICO), representing the iron and steel industry, as the first step of the IWDP Program. This report summarizes the results of the audit.

AUDIT

The facility audit was conducted on January 10, 1995. The JISICO staff and the audit team toured and inspected the facility. A follow-up visit was conducted on January 16, 1995 to collect additional information and to collect wastewater samples.

AUDIT FINDINGS

The findings presented below on water use and waste disposal practices at the JISICO facility are based on information collected during the facility audit through interviews and discussions with JISICO employees, observations made during the site visit, and data provided by JISICO both before and after the site visit.

Steelmaking Processes at JISICO

The JISICO facility produces 42,000 tons per year (T/yr) of steel billets from scrap steel and produces 34,000 T/yr of reinforcement bars. Manufacturing processes consists of:

- Production of steel billets from steel scrap in the meltshop - Two electric arc furnaces produce molten steel that is molded into steel billets by a continuous casting operation. Power for the furnaces is supplied by a power station equipped with 4 generators; two are always in operation. Oxygen for the furnaces is produced by an oxygen plant.

- Production of steel reinforcement bars from steel billets in the rolling mill - There are two rolling mill lines each with a reheating furnace; roughing, prefinishing, and finishing roll stands; and shearing machines.

Water Usage and Balance

The JISICO facility uses approximately 260 cubic meters per day (m^3/d) of groundwater. Approximately 50 percent of this water is softened using a zeolite softener unit. Water is used primarily for cooling purposes. The majority is used in the meltshop cooling system and the rolling mill cooling system. Three other cooling systems are the reheating furnace non-contact cooling water tank, the oxygen plant's cooling water system with one cooling tower, and the power station's closed-loop cooling water radiator system for one generator. The other water usages are softener regeneration and sanitary. These quantities of water use for individual operations are estimates as there are no internal water or wastewater measuring devices. The JISICO facility's daily water consumption is due to evaporative losses or discharges from the cooling towers and wastewater treatment system.

In general, water use at the facility is not excessive (2 m^3/T steel); however, opportunities for conservation do exist. The percentage of total daily water consumption by the different operations are as follows:

- Contact cooling water in the rolling mill, 38 percent;
- Cooling in the power plant, 23 percent;
- Cooling in the meltshop furnaces and continuous casting, 23 percent;
- Softener regeneration, 8 percent;
- Oxygen plant, 4 percent; and
- Sanitary, 4 percent.

Wastewater Discharges

The following wastewater discharges exist at the JISICO facility:

- Softener regeneration;
- Sand filter backwash;
- Oxygen plant blowdown;
- Power plant blowdown;
- Reheating furnace cooling tank blowdown;
- Rolling mill wastewater treatment system; and
- Flying shear pipe cooling.

Major contaminants in the wastewater are: oil and grease, metals, total suspended solids (TSS), and total dissolved solids (TDS).

Treatment

The facility operates two treatment systems: one for the meltshop's contact cooling water and one for the rolling mill's contact cooling water. The meltshop's cooling water

8

pretreatment system consists of a hydrocyclone and two sand filters. The sand filter backwash water is discharged to the rolling mill's treatment system. The rolling mill's wastewater treatment system consists of scale pits, a four-chamber sedimentation tank, oil skimmer, two circular metal screens for filtration, and a wastewater collection tank.

Air Emissions

Approximately 3 tons (T) of furnace dust (metal oxides) as well as carbon monoxide, carbon dioxide, nitrogen oxide, sulfur trioxide, and ozone are generated by the facility. There are no air pollution control devices. These fumes and dust pose a health hazard to the employees and contribute to atmospheric deposition of metals to the surrounding soils and water.

Solid Wastes

Scrap steel for the furnaces and solid wastes generated by the facility operations are stored outdoors. A four-month inventory of steel scrap (approximately 1,400 T) is stockpiled. An estimated 6,700 T of slag and 550 T of iron oxide are generated per year. Very little of this waste is recycled. Approximately 1,200 T of iron oxide was sold to a cement factory in 1994 and the meltshop reuses some of the iron oxide in the furnaces. There could be as much as 100,800 T of slag and 8,200 T of iron oxide buried or stockpiled. These wastes contributes to storm water contamination.

Storm Water Management

Except for the fuel storage tanks, none of the raw materials and wastes stockpiled outdoors are stored in areas with containment structures. There are no practices to prevent storm water run-on or run-off. Storm water is not collected for treatment.

Data Gaps

Data gaps exist in water quality and water quantity measurements. No water or wastewater metering devices exist to provide accurate measurements of the quantity of water consumed or the wastewater generated by the individual process operations. The facility's total water consumption is measured by a main water meter. The quantity of wastewater generated is unknown. This wastewater has been sampled in the past by WAJ for BOD_5, TSS, TDS, and metals. Though oil and grease is generally a contaminant found in rolling mill cooling water, no oil and grease analyses have been conducted.

PP/WM AND WATER CONSERVATION OPPORTUNITIES

The JISICO facility already practices some PP/WM and water conservation practices such as recirculating the cooling water. Additional opportunities identified during the audit are summarized below. Some actions that the facility should initiate immediately are:

- PP/WM and Water Conservation Policy - Establish a PP/WM and water conservation policy as part of JISICO management operating philosophy and distribute it to all

9

employees. Implement the policy through specific goals and targets. Make it each person's responsibility to identify PP/WM and water conservation opportunities and implement any established PP/WM and water conservation measures.

- Monitoring Program - Develop and implement a plan to monitor all water uses and wastewater flows by installing flow measuring devices. All flows should be recorded daily for a period of 12 months. Develop and implement a plan to sample wastewaters at least once a month for a period of 12 months. Establish sample collection procedures.

- Employee Training - Develop and implement an employee training program that includes periodic refresher courses regarding the JISICO facility's PP/WM and water conservation policies and procedures and proper training in the use of new equipment or practices. Staff should also have the opportunity to provide input regarding additional PP/WM or water conservation activities and should be provided with incentives for program successes.

- Water Balance and Reduction Goals - Create an overall plant water balance that identifies all uses and routes of disposal and then establish a plan to reduce water use by specific amounts in each segment of production.

- Preventative and Corrective Maintenance Program - Develop and implement a preventative and corrective maintenance program for equipment, pipes, and structures.

PP/WM Opportunities

The PP/WM techniques that the facility could implement immediately are listed below.

- Optimize Treatment Operations - The rolling mill wastewater treatment system operated by JISICO should be fully evaluated to assess influent and effluent flows and treatment efficiency. In particular, monitoring of the hydraulic and suspended solids loadings to the individual treatment units should be conducted to evaluate the performance of each unit. Additionally, the JISICO facility should follow-up this evaluation with an assessment of the need for modifications to the operation of the treatment system. These modifications should include increasing the percentage of treated wastewater reused in the rolling mill. This assessment should also evaluate the need to segregate and separately treat the softener regeneration and sand filter backwash wastewaters. Short-term operational modifications that would improve the current removal efficiencies of the system are:

    - Adding coagulant aids or flocculants such as cationic polymers to increase the removal of the fine iron oxide particles;

    - Using pumps for removing the iron oxide in the scale pits, sedimentation tanks, and collection tank to eliminate draining of the wastewater onto the ground; and

10

- Increasing the frequency of iron oxide removal in the scale pits within the rolling mill.

- Hydraulic Fluid Leak Reduction - Reduce the quantity of hydraulic oil in the cooling water with improved maintenance (both preventive and corrective programs) of the equipment to prevent or correct hydraulic fluid leaks.

- Good Housekeeping - Emphasize practices that maintain a clean work place without the use of water for cleaning. Preventing spills and leaks reduces clean-up. When spills or leaks occur, clean-up should be conducted using dry methods such as absorbents or a mobile vacuum cleaner that captures the spill rather than diluting the spill with washwater.

Other PP/WM techniques that should be investigated for feasibility studies and possible short- and long-term implementation are listed below:

- Rolling Mill Wastewater Treatment Design Modifications - Design modifications to the wastewater treatment system to achieve the water quality necessary to enable complete recycle (or 95 percent recycle) of the cooling water. An engineering analysis of the following modifications should be conducted:

  - Leveling the weirs in the sedimentation tanks to prevent short-circuiting;

  - Installing automatic oil skimming devices and/or oil/water gravity separator;

  - Replacing the 4-chamber sedimentation tank with a high efficiency clarifier design, such as tube settlers, inclined plate clarifiers, or clarifiers with continuous sludge removal; and

  - Installing sand filters or other suspended solids treatment such as microfiltration.

- Softener Regeneration - Use a regeneration chemical that is less harmful to the environment, such as acetic acid and ammonium hydroxide to reduce the high concentrations of sodium and chloride salts in the wastewater.

- Softener Upgrading - Use a newer state-of-the-art ion-exchange resin system that is regenerated with less solution and therefore generates a smaller volume, more concentrated wastewater.

- Cooling Water Treatment - Use ozone rather than biocide chemicals to control fouling in the cooling towers.

- Cooling Water Segregation - Segregate the contact cooling water for the continuous casting operation from the softened non-contact cooling water for the furnace. Reuse rolling mill cooling water or treated blowdown water. Treat the cooling water through the hydrocyclone and sand filters and recycle directly back to continuous

casting or to the rolling mill. Some of the treated wastewater from the sand filters could be used as backwash water for the filters and this backwash wastewater would serve as the blowdown. The blowdown could be reused in the rolling mill, or further treated using reverse osmosis and reused to cool the steel.

- Production Schedule Synchronation - Eliminate the reheating furnace and its cooling water by transporting the hot billets from the continuous casting operation immediately to the rolling mill operation.

Water Conservation Opportunities

The water conservation opportunities are summarized below. Table EX-1 provides potential techniques and the estimated savings for water conservation. As much as 190 m^3/day water savings could result from the implementation of these techniques.

Those techniques which the facility could implement immediately are:

- Flying Shear Cooling Water Elimination - Eliminate the once-through cooling of the pipe prior to the flying shears or capture and return it to the rolling mill wastewater treatment system.

- Reheating Furnace Cooling Water Evaporation Reduction - Eliminate the spray pipe located over the cooling water tank for the reheating furnace to reduce evaporation and drift losses.

- Sanitary and Other Miscellaneous Water Use Reduction - Modify the water faucets throughout the facility, and specifically the faucet beneath the elevated water tower, with flow regulation devices such as flow restrictors, flow shut-off devices, and low volume spray hoses. Provide water conservation awareness training to employees on a periodic basis.

The following techniques require further investigation for feasibility studies and possible short- and long-term implementation:

- Cooling Tower Blowdown Reuse - Eliminate the wastewater discharges due to cooling water blowdown from the oxygen plant's cooling tower, the power station's closed-loop radiator system, and the reheating furnace cooling water tank by treating the blowdown, using reverse osmosis, and reusing this discharge. The treated wastewater could be reused as cooling water for the rolling mill or contact cooling water for the continuous casting operation. The treated wastewater quality may even enable reuse in the cooling towers.

- Softener Regeneration Wastewater Reuse - Treat the regeneration wastewater and reuse as regeneration water or backwash water for the sand filters.

- Sand Filter Backwash Reuse - Reuse all or part of the backwash wastewater as backwash water for two or more sand filter backwash cycles.

12

- Non-Contact Cooling Water Elimination - Investigate the feasibility of a non-water cooling system for the oxygen plant and the power station.

  - Replacing the water-cooled compressor in the oxygen plant with an air-cooled compressor;

  - Installing a heat exchanger that uses the cold oxygen and nitrogen generated by the oxygen plant; and

  - Installing the closed-loop "radiator" cooling system for all the generators.

- Cooling Water Optimization - Investigate ways to reduce the quantity of water needed for cooling and lost to evaporation and blowdown. Some options to explore are:

  - Replacing the 0.5-inch diameter pipe that delivers the cooling water to the rolls with smaller orifices or spray devices with self-cleaning nozzles;

  - Increasing the concentration cycle of the cooling towers; and

  - Decreasing blowdown quantity.

Storm Water, Solid Waste, and Air Emissions

Develop and implement the following practices to minimize storm water run-on and run-off and maximize collecting and treating storm water runoff for reuse, recycling solid wastes, and air pollution control.

- Storm Water Management - Minimizing the contamination of storm water and reducing the quantity of contaminated storm water leaving the facility's site by:

  - Collecting, treating, and reusing the storm water;

  - Grading and contouring the site to minimize storm water run-on and run-off;

  - Constructing covered storage areas with concrete pads and containment dikes for the iron oxide scale to prevent storm water contamination and reduce dust pollution; and

  - Improving storage and handling procedures to reduce fuel oil spills.

- Solid Waste Reduction - Reducing the quantity of solid waste stockpiled by:

  - Reusing the iron oxide in the furnaces or recycling slag and iron oxide by selling to cement plants or marketing the slag as road material and the iron oxide as soil fertilizer;

- Purchasing bulk containers of hydraulic fluid and other oils used in large quantities to reduce the number of empty drums; and

- Returning drums or other containers to suppliers, or if the containers are steel or iron, use as steel scrap for the furnace.

- Air Pollution Control - Installing air pollution control measures to contain and concentrate the emissions and reduce worker exposure to toxic fumes. The facility should consider air pollution control devices that do not use water, such as baghouses or wet air pollution control devices, such as electrostatic precipitators, that are designed with a closed-loop water system.

14

Table EX-1 - Potential Water Savings

JISICO

MELTSHOP

Water Conservation Technique	Current Water Consumption (m^3/d)	Projected Water Consumption (m^3/d)	Projected Water Savings (m^3/d)	Percent Decrease in Total Water Consumption
1. Radiator closed-loop cooling system for all generators	60	8	52	20
2. Treat and reuse all blowdowns: oxygen plant, power station, and meltshop	30	3	27	10
3. Sand filter backwash reuse	28	8	20	8
4. Softener regeneration wastewater reuse	20	2	18	7
5. Cooling water segregation for continuous casting with reuse of rolling mill cooling water or treated blowdown	20	2	18	7
6. Eliminate water cooling in the oxygen plant	10	0	10	4
7. Water conservation ion-exchange resin system	20	10	10	4
8. Closed-loop cooling system for power station	1-2	1	1	negligible
9. Eliminate discharges from wastewater treatment system	84	7	77	30.0
10. Install water conservation devices to deliver cooling water to roll stands	100	85	15	6.0
11.a. Eliminate once-through cooling of flying shears	10	0	10	4.0
11.b. Recycle cooling water of flying shears	10	1	9	3.5
12. Reuse reheating furnace cooling water blowdown	2.5	0	2.5	1.0
13. Install water conservation devices for sanitary water	10	8.5	1.5	0.6
Total Savings	260	22 - 120	64 - 190	25 - 73

15

1.0

INTRODUCTION

1.0 INTRODUCTION

This report presents the findings of an audit conducted to evaluate the Pollution Prevention and Waste Minimization (PP/WM) and water conservation opportunities for the Jordan Iron & Steel Industries Company, Limited (JISICO) facility located in the Zarqa Basin near Amman, Jordan. The report includes a project background and objectives, provides documentation of the on-site evaluation of the facility's current operations, discusses water use and disposal practices, and provides recommendations for PP/WM opportunities. Additional information including industry background, audit procedures, and an overview of the facility's operations, are provided to support the audit findings and recommendations.

1.1 Background

Under Contract No. 278-0288-00-C-4026-00 with the United States Agency for International Development (USAID), Development Alternatives, Inc. (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber).

The IWDP will be performed in three phases. The first phase requires completion of ten PP/WM audits by DAI and its sub-contractors. The second phase requires completion of Feasibility Studies (FS) for four of the audited facilities. Finally, demonstration projects will be completed for two selected FS facilities. Based on a ranking methodology, the PP/WM Committee selected ten industries with potential needs for PP/WM audits. One of these industries is the iron and steel industry.

Harza Consulting Engineers and Scientists (Harza), Chicago, Illinois, USA, and Science Applications International Corporation (SAIC), Falls Church, Virginia, USA, have been retained as the sub-contractors to lead the audits. The Royal Scientific Society (RSS) of Jordan was selected as the local consultant to assist the lead consultants in the audit site visits and report development. The SAIC/RSS team conducted an audit of JISICO as the first step of the IWDP. This report summarizes the results of the audit.

Due to the scarcity of water in the Zarqa Basin, as well as the need to minimize the release of pollutants into waters of the basin, it is in the best interest of industries to conserve water and implement effective PP/WM practices. Companies practicing PP/WM and water conservation programs will more efficiently utilize scarce resources and minimize their impact on these resources. The hierarchy of PP/WM and water conservation practices includes:

1. Reduce waste generation

   - Substitution of less polluting raw materials in product manufacture;
   - Alteration of products manufactured to eliminate need for use of polluting materials;
   - Replacement or upgrading of outdated or inefficient process equipment; and
   - Development of employee training programs to ensure employees can efficiently manage raw materials and resources.

2. Reuse waste materials prior to disposal

- Reuse of uncontaminated raw materials and resources (including water);
- Reprocessing of previously discarded materials (e.g., off-spec materials, used materials); and
- On-site recovery of reusable materials (e.g., used solvents, waste heat, scrap).

3. Recycle waste materials.

4. Treat wastes and dispose of residues.

The PP/WM audits performed during this program will identify and evaluate available PP/WM and water conservation opportunities and will provide site specific recommendations to assist the study industry in developing a comprehensive water conservation and PP/WM strategy.

1.2 Objectives

The facility PP/WM audits are designed to assess potential opportunities for PP/WM and water conservation that may exist at the study facilities. The goal of each audit is to identify and evaluate all possible PP/WM, wastewater clean-up, and water conservation techniques that are appropriate for the study facility.

The specific objectives of this audit are as follow:

1. Review general industry background data and identify "state-of-the-art" wastewater management and processing practices.

2. Work on site with industry representatives, the MWI and the Chamber officials, and other interested parties, to review current processing procedures and identify possible options for PP/WM and water conservation.

3. Prepare a report that evaluates possible PP/WM and water conservation alternatives and provides recommendations and follow-up actions to the industry.

In order to complete the first objective, a comprehensive literature review was performed by the lead consultant. Following completion of the literature review, an on-site audit of the JISICO facility was performed. The audit was performed with close consultation of industry representatives to ensure that they were aware of and supported proposed actions. Audit activities included the careful gathering of baseline water use and waste generation data, identification and assessment of potential PP/WM and water conservation options, and solicitation of ideas and proposals from management and production line staff.

1.3 Report Contents

This report provides the findings of the audit conducted at the JISICO facility on January 10 and 16, 1995. The report provides recommendations for the development of a site-specific program that meets the specific needs and goals of the JISICO facility. Audit recommendations include both PP/WM techniques (e.g., water conservation techniques, housekeeping practices, alternate waste disposal practices, etc.) and suggestions for PP/WM training for facility staff and studies to assess program successes.

18

The report is organized into eight sections that provide a brief description of JISICO's steelmaking operations, (Section 2.0), a description of the audit procedures (Section 3.0), a description of the water use practices and waste generation activities at the facility (Section 4.0), a discussion of possible PP/WM opportunities (Section 5.0), a discussion of the water conservation opportunities at the facility (Section 6.0), the audit conclusions and recommendations (Section 7.0), and the suggested follow-up actions (Section 8.0).

Several appendices are also included in the report to provide supporting documentation and reference materials. The appendices include a copy of the audit questionnaire (Appendix A), information provided by the JISICO facility (Appendix B), an overview of regulations applicable to the discharge from JISICO (Appendix C), site visit photographs (Appendix D), references used to prepare the audit report (Appendix E), and the PP/WM Background Report (Appendix F).

19

2.0

PROCESS OVERVIEW

2.0 PROCESS OVERVIEW

Steel, an iron-carbon alloy, is made from iron in a process that reduces the elements in iron such as carbon, manganese, phosphorus, sulfur, and silicon so that the composition contains approximately 96 percent or greater iron and less than 1 percent carbon. Different grades of steel, established by national or international standards, can be produced depending on the exact composition.

2.1 Typical Steelmaking Processes

The principal steelmaking processes in use today are: basic oxygen process, open-hearth process, and electric arc process. These steelmaking processes all use oxygen to reduce by oxidation the content of carbon and other elements in the iron. The basic oxygen and open-hearth processes are principally used to convert iron into steel, while the electric arc process is used to refine steel scrap.

The basic raw materials used in the electric arc furnace are steel scrap; slag producing material such as limestone, calcium fluorspar (to control viscosity), iron oxide scale, and coke breeze; and oxygen. An electric arc is used to melt the steel scrap and other components. Oxygen is injected into the molten bath. The oxygen combines with the carbon in the molten steel to produce carbon dioxide and carbon monoxide which are released as exhaust gases from the furnace. The silicon, manganese, phosphorous, and other impurities oxidize into the slag.

The steel is cast into billets. A hot rolling mill reheats the billets and shapes them into products such as reinforcement bars. In the mill, the billet is heated to rolling temperature in a reheat furnace. The heated billet is then moved through the various mill stands each decreasing and lengthening the billet to the final finished reinforcement bar size. The mill is either arranged in a cross-country design or a continuous design. In the cross-country design, the various size roll stands (roughing, intermediate and finishing) are arranged side by side. The billet is rolled through one stand then transferred to the next, where it is rolled in the reverse direction. The continuous mill consists of a series of roll stands arranged one after the other so that the piece (billet) enters the first stand and takes one pass in each stand of rolls to merge from the last as the finished product (reinforcement bar). A detailed description of each of these processes is provided in Appendix F.

2.2 Steelmaking Process Operations at Jordan Iron and Steel Industry Company (JISICO) in Jordan

The JISICO facility manufactures two products: steel billets and steel reinforcement bars. The facility has two distinct manufacturing processes: the manufacture of steel billets from steel scrap in the meltshop and the manufacture of reinforcement bars from steel billets in the rolling mill. The rolling mill at JISICO was established in 1965 and began operation in 1966. The meltshop began operation in 1979. The company has 255 employees. Descriptions of these two processes are provided below.

2.2.1 Meltshop Process

The meltshop consists of two basic electric arc furnaces with graphite electrodes and a continuous casting operation. One furnace has a capacity of 10 ton per hour (T/hr), the other has a capacity of 12 T/hr. Both furnaces are operated 24 hours per day (hrs/d). JISICO generates its own electrical power for the furnaces. In addition, the pure oxygen used by the furnaces is also generated by JISICO.

JISICO reported an average production rate of 40,000 to 45,000 T/yr. Based on an average production of 42,000 T/yr and an average working year of 280 days, the average daily production is 150 T.

Figure 1, Meltshop Process and Water Balance Flow Diagram, provides a block flow diagram of the meltshop process operations. The steps taken to produce steel billets from steel scrap are described below.

Steel Scrap Processing - The JISICO facility purchases steel scrap from the local market and also imports steel scrap. This scrap is stored outdoors in piles all around the buildings. Bulky and light scrap are processed in an automatic baler that bundles the scrap before piling it in the scrap yard. Scrap pieces that are too large for the furnace are cut by a hydraulic shear machine. Heavy loading machines are used to move the scrap into the meltshop building. Limestone is loaded into a basket and weighed. Then the scrap steel is added to the basket by an overhead crane equipped with an electromagnet. The basket is again weighed. A basket press machine can crush and compact the scrap in the basket to increase the bulk density.

Charging - The furnace roof is swivelled open by a hydraulic cylinder, the basket is lowered into the furnace, and the limestone and scrap steel are unloaded. The roof door is closed and three graphite electrodes arranged in a triangle are inserted vertically through the furnace roof. The raising and lowering of the electrodes is automatically controlled by an electro-hydraulic servo-mechanism. When electric power (30,000 amperes and 250 volts) is supplied to these electrodes, they create an electric arc with a temperature of 4,000 degrees Celsius (°C). This high temperature melts the steel. The electrodes are turned off, the roof door opened, fluorspar is added and a second basket of scrap steel is lowered into the molten steel in the furnace. The electrodes are again activated. This process is repeated until 3 or 4 baskets have been added to the furnace. To reduce the time necessary to melt the steel and reduce the carbon content in the steel, pure oxygen is blown across the molten steel from a lance inserted into the furnace.

Testing - After all the steel is melted, molten steel is withdrawn from a small tapping hole into a sampling mold for analysis. Using a spectrometer, the composition of the steel is determined for such elements as carbon, sulfur, phosphorous, chromium, nickel, silicon, manganese, aluminum, molybdenum, copper, and tin. The analytical result is compared to the national and international steel standard specifications. If the carbon content is too high, oxygen is lanced into the molten steel to oxidize the carbon. If sulfur is too high, the slag is removed, coke breeze added, and another slag is formed that reduces the sulfur.

Tapping - When the molten steel temperature has reached 1,685°C and the steel composition meets the desired steel standard, the furnace is tilted and the molten steel is poured into a steel ladle. Ferrosilicon is added manually by shovel into the ladle. The ferrosilicon is added to scavenge the oxygen to reduce formation of gas bubbles in the steel as it cools.

Continuous Casting - The ladle is lifted by overhead crane to the continuous casting operation. A slide gate at the bottom of the ladle is manually opened and the steel flows into the tundish. In the tundish, a molten steel stream is poured through an open-ended square chromium-lined copper tube mold.

The mold is cooled by softened water that is continuously recirculated through a jacket surrounding

22

the mold. As the molten steel cools it solidifies; water is sprayed onto the steel billet as it leaves the mold to further cool and solidify the steel.

Shearing - The steel billet is continuously drawn by pincher rolls towards a hydraulic shear which cuts the billet into preset lengths of 2 meters (m). These billets are transferred to a cooling bed and then to the stockyard.

2.2.2 Rolling Mill Process

The rolling mill consists of two reheating furnaces and two separate rolling mill lines, one with a 10 T/hr capacity and one with a 12 T/hr. Reinforcement bars of different dimensional sizes, ranging in Ø8 to Ø32, can be produced depending on the rollers used. Figure 2, Rolling Mill Process and Water Balance Flow Diagram, provides a block flow diagram of the process operations. The individual operations involved in this process are described below.

The rolling mill has a production capacity of 90,000 T/yr. The production rate will vary based on the orders received and the hours of operation; the 1994 production was 34,000 T. When the rolling mill is operating both lines for 16 hrs/d, production is approximately 80,000 T/yr. Currently, the rolling mill is operated for 8 hrs/d. The rolling mill can use all of the billets produced by the meltshop plus additional imported billets.

Reheating - Cold billets are loaded into the two fuel (oil) fired reheating furnaces where the billets are heated to 1,200°C. In one reheating furnace as the cold billets enter one side, the hot billets are removed from the other side. This furnace requires no cooling water. In the other reheating furnace, a pusher rod ejects the heated billets, one at a time, from the side of the furnace onto a conveyor. The pusher rod and gear box are cooled by a recirculating water bath.

Roughing - The conveyor carries the billets to the first rolling stand, the 3-high mill roughing stand. Water is used to cool the neck of the cylinder, the plastic bearing, and the roll where the hot steel is in contact with the roll.

Prefinishing - The billets then successively pass to the 2-high mill pre-finishing stand. Water is used to cool the roll stands as described above.

Finishing - The finishing stand produces the final reinforcement bars. Water is used to cool the roll stands as described above.

Cutting, Cooling, and Packaging - The bars are cut by a hydraulic shear. The shear can be preset to automatically cut to the desired length. Different lengths can be produced. Once-through cooling water is used to cool a pipe that directs the bar to the cutting shear. The bars are conveyed to a cooling bed and then bundled.

2.2.3 Power Station

The power station generates electricity for use by the electric arc furnaces. The power station has 4 diesel generators, each 4,600 horsepower. Two generators are in operation 24 hrs/d. Noncontact recirculating cooling water is used to cool the generators.

23

2.2.4 Oxygen Plant

The oxygen plant produces pure oxygen and nitrogen from the air. Outdoor air is drawn by large fan, filtered, and compressed in a 4-stage compressor. The compression generates heat so the compressor is cooled using noncontact recirculating cooling water. The oxygen is used in the electric arc furnaces to increase the efficiency of reducing the carbon content of the steel by oxidation. The oxygen plant produces more oxygen than used by the furnaces. The excess oxygen is sold as liquid oxygen in cylinders for medical and industrial purposes. Liquid nitrogen is also produced and marketed.

24

3.0

AUDIT PROCESS

3.0 AUDIT PROCESS

The objective of the audit was to identify the potential for PP/WM, water conservation, and wastewater cleanup for the iron and steel industry. The following subtasks were undertaken to complete the audit:

- Audit Coordination;
- PP/WM Background Material Preparation;
- Pre-Inspection Meeting;
- Audit;
- Post-Inspection Meeting; and
- Audit Evaluation Report.

This section briefly describes the activities conducted under each of these subtasks.

3.1 Audit Coordination

The audit was coordinated through the Chamber and the MWI. The Chamber informed the JISICO facility about the intent and schedule of the audit prior to the site visit. An audit questionnaire, specifically developed for this PP/WM project (Appendix A), was included with the request. The JISICO staff were requested to complete the questionnaire prior to the audit. The JISICO staff were also requested to furnish an overall water flow balance, process flow diagram and description, and facility layout. This information, where available, was furnished to the audit team prior to the site visit to the facility. Copies of these materials are included in the Appendix B of this report.

3.2 PP/WM Background Material Preparation

In order to review general industry background data and identify " state-of-the-art " processing and waste management practices pertinent to PP/WM, a comprehensive literature review was performed. The review included searches of the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC) repository, on-line library catalogue databases, review of PP/WM bibliographical references, and personal contacts with pollution prevention specialists. A copy of the background report is provided in Appendix F.

3.3 Pre-Inspection Meeting

The JISICO facility audit including the pre-inspection meeting, was conducted on January 10, 1995. The initial audit team consisted of the following personnel:

Dr. Usama Mudallal	Amman Chamber of Industry
Ms. Rania Abdel Khaleq	Ministry of Water & Irrigation
Mr. Waleed Hussein	Water Authority of Jordan
Dr. Shawn Niaki	Program Director, DAI (Harza)
Mrs. Mary Waldron	Lead American Consultant (SAIC)
Dr. Riyad Musa	Local Consultant (RSS)
Dr. Omar Jabay	Local Consultant (RSS)

26

The representatives for the JISICO facility included:

Mr. Mahmond Al Edwan	Inspector General of the Plant
Mr. Ahmad Pervaiz	Meltshop Manager
Mr. Jameel Salim Halaseh	Administrative Assistant
Mr. Suheil Awaad	Maintenance Department Manager
Mr. Youse Abd Al Ashkar	Treatment Plant Supervisor

The intent of this meeting was to inform the JISICO facility staff about the conduct and the objective of the audit, and to familiarize the audit team with JISICO's process as it related to the fresh water utilization, wastewater generation, treatment and disposal, water recycle and reuse and the overall water management at the facility. The audit team explained the purpose of the audit to the JISICO facility staff.

3.4 Audit

The facility audit was conducted on January 10 and 16, 1995. The JISICO staff and the audit team toured and inspected the facility. Upon completion of the facility tour, the audit team and facility representatives continued discussions regarding overall water usage and wastewater management practices currently employed. Additional questions regarding process operations, water use and wastewater generation and disposal were presented to the JISICO staff and a second visit arranged.

Mrs. Mary Waldron, Eng. Rania Abdel Khaleq, and Dr. Riyad Musa visited the facility again on January 16, 1995 to collect additional follow-up information and to collect wastewater samples. During this second visit, additional information was provided by the JISICO staff.

3.5 Post-Inspection Meeting

Post-inspection meetings between the audit team and the JISICO representatives were held on both audit days. Data gaps and the preliminary impressions regarding PP/WM and water conservation opportunities were discussed. The facility staff were responsive to the team's suggestions and agreed to help with any additional data gathering requests.

27

4.0

AUDIT FINDINGS

4.0 AUDIT FINDINGS

The findings presented below on water use and waste disposal practices at the JISICO facility are based on information collected during the facility audit through interviews and discussions with JISICO employees, observations made during the site visit, and data provided by JISICO both before and after the site visit.

4.1 Water Usage and Balance

There is a water meter that records the amount of water used from a groundwater well. The water well serves the JISICO facility and two other industries, the National Chemical Industries (NCI), that manufactures sodium hypochlorite and other liquid bleaching detergents, and the National Steel Factory (NSF), a rolling mill.

Also, there are three water meters, one each for the meltshop, NCI and NSF. Each of these three water meters is installed on the main service water line feeding each of these facilities so there are records of the amount of water used by each facility. However, until recently, there was no water meter on the main water pipe that supplied water to the JISICO rolling mill.

In the past, the amount of water used by the JISICO rolling mill was estimated as the difference between the water well meter and the 3 water meters for the three facilities. Recently, a meter has been installed that measures the water used by the JISICO rolling mill. Table 1, Water Balance, presents a water balance of the facility. Figure 1, Meltshop Process and Water Balance Flow Diagram, and Figure 2, Rolling Mill Process and Water Balance Flow Diagram, depict the process operations that use water.

4.1.1 Meltshop Water Use

Water is used in the meltshop operations in the following areas:

- Noncontact Cooling of the Furnace - Water is continuously recirculated from the cooling towers to the furnace roof ring, slag doors, and transformers.
- Noncontact Cooling of the Copper Tube Mold - In the continuous casting operation, noncontact cooling water is continuously recirculated from the cold water pool of the cooling towers to the copper mold, then back to the hot well and the cooling towers.
- Contact Cooling of the Steel Billet in Continuous Casting - Contact cooling water is sprayed, using high pressure nozzles, onto the solidified steel as it exits the copper tube mold. As the steel cools, the surface of the steel is oxidized by contact with the air and a skin of iron oxide forms on the surface. The force of the water spray removes this iron oxide; thus this contact cooling water contains iron oxide particles referred to as scale.

  This contact cooling water contaminated with iron oxide is collected in a scale pit next to the casting operation. This wastewater is pumped to the meltshop's cooling water pretreatment system. The treated wastewater is returned to the cooling towers for reuse.

- Noncontact Cooling of the Hydraulic Shears - The hydraulic shearing machines are water

29

cooled. This cooling water is recirculated to the cooling towers.

The cooling water system for the meltshop, with two counterflow cooling towers, has a recirculation rate of 8,000 m^3/d and a concentration cycle of 3.

4.1.2 Rolling Mill Water Use

Water for cooling purposes is used in the following places in the rolling mill:

- Reheating Furnace - To cool the pusher rod that loads and ejects the heated billets from one of the reheating furnaces;
- Roughing Mill - To cool the rolling bar stand and die where the steel billet makes contact with the die;
- Prefinishing Mill - To cool the rolling bar stand and die where the steel billet makes contact with the die;
- Finishing Mill - To cool the rolling bar stand and die where the steel billet makes contact with the die; and
- Cutting Shear - To cool a pipe that directs the bar to the shearing machine. Water from a hose flows over the pipe, cools it, and falls onto the floor.

4.1.3 Power Station Water Use

The largest consumer of cooling water is the power station. For three of the generators, softened water is pumped from the main storage basin to the diesel generators. The hot water from the generators is returned to the hot water tank and then to the cooling towers. For one of the generators, the cooling water is circulated through a closed-loop cooling system. Air is used to cool the water in the pipes. The air is blown onto the cooling water pipes from large downdraft fans. Softened water is added to this closed-loop cooling system once a year and continuously recirculated within the system. Then the system is drained and new softened water is added and continuously used for another year. When draining the system, the water is allowed to drain onto the ground.

4.1.4 Oxygen Plant Water Use

Noncontact recirculating cooling water is used to cool the air compressors. The water is pumped from the wet well of a small cooling tower, next to the oxygen plant, through the water jacket that surrounds the compressors, and is returned to the top of the cooling tower. Two side draft fans draw air through the tower to cool the water as it falls through the tower. Approximately 10 m^3/d of softened water from the meltshop's cooling water supply is added, as makeup water, to the oxygen plant's cooling tower well.

4.1.5 Other Water Uses

Other activities at the facility that use water are described below.

- Water Softener Regeneration - Softened water is used for all noncontact cooling purposes in the meltshop. The softener is a zeolite process. The softened water is stored in the main water storage basin. This basin has a capacity of 500 m^3. The softener is regenerated when the softened water exiting the softener exceeds 15 milligrams per liter (mg/L) total hardness. The softened water, at less than 15 mg/L, is added to the cold water pool of the cooling tower to maintain the cooling water at 30 mg/L total hardness. Generally, the softener can treat 500 m^3 before it needs to be regenerated. A brine solution of sodium chloride is used to regenerate the softener. Approximately 3 tons of sodium chloride is consumed per month. The regeneration water, approximately 20 m^3/d, is discharged to the rolling mill's wastewater treatment system.

- Sanitary Water - The facility personnel reported that the facility has 30 toilets and estimated the sanitary water use at 10 m^3/d. However, based on an estimated 0.1 m^3/employee and 255 employees, the estimated amount of sanitary water could be approximately 25 m^3/d.

4.2 Wastewater Discharges

Most of the water used in the facility is for cooling purposes. The water used by the meltshop is recirculated through the cooling towers. The water used by the rolling mill is recirculated through the wastewater treatment system. Figure 1, Meltshop Process and Water Balance Flow Diagram, and Figure 2, Rolling Mill Process and Water Balance Flow Diagram, illustrate the process operations generating wastewater and where the wastewaters are discharged. The wastewater generated by the meltshop and the rolling mill are described below.

4.2.1 Meltshop Wastewater

The meltshop has two wastewater discharges: the brine regeneration wastewater from the softener and the backwash wastewater from the sand filters. The sand filter backwash wastewater serves as the blowdown from the cooling towers. These wastewaters are described below.

- Regeneration Wastewater - This wastewater is discharged to the rolling mill wastewater treatment system. This wastewater contains salts and total dissolved solids (TDS). The quantity of regeneration wastewater is estimated to be 20 m^3/d.

- Sand Filter Backwash Wastewater - This wastewater is discharged to the rolling mill wastewater treatment system. This wastewater contains iron oxides so it will have a high total suspended solids (TSS) concentration. An estimated 28 m^3/d of backwash wastewater is generated.

- Cooling Water Blowdown - All of the process cooling and noncontact cooling water used in the meltshop is recirculated in two counterflow cooling towers. A cooling water system usually has blowdown to control TDS buildup. However, at the JISICO facility, the water from the cooling towers is used to backwash the sand filters. As previously described, the sand filter backwash wastewater is then discharged to the rolling mill wastewater treatment system. Thus, this discharge serves as the blowdown for the cooling towers.

4.2.2 Rolling Mill Wastewater

The rolling mill generates two wastewaters:

- Reheating Furnace and Rheostat Noncontact Cooling Water Blowdown - Well water is pumped to an open above-ground concrete tank with a capacity of 30 m^3. From this tank, water is continuously circulated to the reheating furnace pusher rod and the rheostat. Every 3 to 4 weeks, the cooling water in the tank is discharged to the wastewater treatment system and the cooling water tank is refilled with well water.

- Rolling Mill Contact Cooling Water Discharge - The contact cooling water from the rolling mill stands is collected in scale pits underneath the roll stands and pumped through pipes to an outside open concrete trench. Most of the wastewater in the trench flows by gravity to the rolling mill's wastewater treatment system and returned to the rolling mill for reuse as contact cooling water. However, at the end of the trench, there is a small settling pit. A weir has been cut into a side wall of this pit. An unkown quantity of wastewater constantly overflows this weir onto the ground. Once a week, approximately 52 m^3 of wastewater is discharged from the wastewater treatment system (from one of the four chambers of the sedimentation tank) onto the ground and approximately once a month 210 m^3 of wastewater (from all of the chambers of the sedimentation tank) is discharged onto the ground.

  This wastewater contains TSS, primarily iron oxide scale, and hydraulic oil from the rolling mill machinery.

4.2.3 Other Wastewater

Other wastewater generated at the facility are as follows:

- Generator Closed-Loop Cooling Water System Blowdown - Once a year the cooling water in this system is drained onto the ground.

- Sanitary Wastewater - The sanitary wastewater is discharged to four septic tanks. The tanks are pumped once or twice per year into septic hauling trucks that deliver this sanitary wastewater to the Ain Ghazal pumping station where it is pumed to the As Samra wastewater treatment plant. Facility personnel report that these septic tanks are not maintained and may be leaking.

4.3 Wastewater Treatment System Processes

Approximately 77 percent of the daily water consumption is for cooling purposes. The contact cooling water becomes contaminated with iron oxide and machinery oils and must be treated to enable the facility to continuously recycle the cooling water. The treatment systems installed for the meltshop cooling water and the rolling mill cooling water are described below. Figure 1, Meltshop Process and Water Balance Flow Diagram, and Figure 2, Rolling Mill Process and Water Balance Flow Diagram, provide block flow diagrams of these treatment systems.

4.3.1 Meltshop Cooling Water Pretreatment System Processes

The contact cooling water for the continuous casting operation is being pretreated and reused. For pretreatment, the cooling water is collected in a scale pit next to the continuous casting equipment.

- 32

This hot scale-containing water is pumped to a hydrocyclone that separates the water from the scale. The scale slurry exits the cyclone through a pipe into a scale collection tank located below the cyclone. The water exits the cyclone through a pipe to one of two sand filters.

The sand filters are operated on an alternate basis. While water goes to one filter, the other filter is being backwashed. The filtered water is pumped to the hot water well and then to the cooling towers. The backwash water is discharged to the rolling mill wastewater treatment system.

4.3.2 Rolling Mill Wastewater Treatment System Processes

The contact cooling water becomes contaminated with iron oxide scale. This scale must be removed before the cooling water can be reused. The components of the rolling mill wastewater treatment system are described below.

Scale Pits - The rolling mill contact cooling water is collected in a series of scale pits located underneath or next to the roll stands. These scale pits act as initial settling basins where large heavy particles are deposited in the bottoms. This scale in the smaller pits is removed weekly; the scale in the two main scale pits is removed monthly. The scale is removed manually by shovels and dumped in outdoor piles. The cooling water in these pits is continuously recirculated back to the roll stands and to the outdoor open trench.

Open Trench and Basin - The hot scale-containing water is pumped to an outdoor open trench, then flows by gravity down the trench. At the end of the trench is a small shallow concrete basin. Most of the wastewater flows by gravity through a pipe in a side wall of the basin into the concrete sedimentation tank. However, some of the wastewater in this basin flows over a narrow weir that is cut into the side wall of the basin onto the ground. When a large volume of wastewater is pumped down the trench, the wastewater will overflow the entire side wall of this basin onto the ground.

Sedimentation Tank - The wastewater enters the sedimentation tank near the corner of two side walls. The tank is divided into 4 chambers, each with a capacity of approximately 52.5 m^3. The common side walls between the first and second chambers, the second and third chambers, and the third and fourth chambers are weirs. The wastewater flows over these weirs successively from the first chamber to the fourth chamber. From the fourth chamber, the wastewater can be pumped back to the roll stands.

Each of the four chambers is cleaned once every four weeks. Thus, once a week the iron oxide that settles to the bottom is removed from one of the four chambers by the following procedure. A gate is placed in the trench to divert the wastewater through a pipe to the metal circular screens and wastewater collection tank (described below), effectively by-passing the sedimentation tank. Each chamber has a flanged opening near the bottom of a side wall. The wastewater is discharged through this flanged opening onto the ground. The iron oxide remaining in the bottom of the chamber is manually shovelled out and dumped in piles on site.

The cleaning of the chambers is synchronized with the backwashing of the sand filters. The wastewater that is discharged onto the ground is replaced by the sand filter backwash water.

Oil Removal - In the fourth tank, any oil that collects on the surface of the water is drained through a pipe near the top of the tank into a drum. Any water that also drains into the drum is discharged from the drum onto the ground. The collected oil is burned as fuel in the reheating furnace.

Metal Circular Screens - From the fourth chamber of the sedimentation tank, the wastewater flows to two metal circular screens. The scale is periodically removed from the screens by lifting the screens with an overhead crane and dumping the scale onto the ground.

Wastewater Collection Tank - The wastewater flows through the screens to the wastewater collection tank. From the wastewater collection tank, the wastewater overflows through a pipe to a concrete pit. From this concrete pit, the wastewater can be discharged to the wadi or to a pump pit. From the pump pit, two pumps recycle the wastewater to the roll stands.

The iron oxide scale is removed from the wastewater collection tank approximately every two years. Wastewater in the collection tank is discharged through a flange opening onto the ground and the scale manually removed by shovels.

4.4 Air Emissions

The major sources of air emissions are the exhaust gases from the electric arc furnaces and the generators at the power station.

4.4.1 Meltshop Air Emissions

The meltshop manager estimated that approximately 3 T of dust (fine particles of metal oxides) is generated daily. For every ton of steel produced by the furnaces, 15 kilograms (kg) of dust is generated. The fumes generated by the furnaces consist of the metal oxides (mainly iron oxide but other metal oxides such as zinc oxide), carbon monoxide, carbon dioxide, nitrogen oxide, and ozone. There are no air pollution control devices on these furnaces. The employees are exposed to these toxic fumes daily. In addition, atmospheric deposition of the metal oxides in these fumes can contaminate surrounding land.

4.4.2 Power Station Air Emissions

The power station has four stacks, one for each generator. Emissions from these stacks consist of sulfur trioxide and nitrogen oxide and other incomplete combustion products produced from the burning of the diesel fuel. There are no air pollution control devices on these stacks.

4.5 Solid Wastes

Enormous quantities of solid wastes are generated by the steel manufacturing operations. Very little of these solid wastes are reused or recycled. Most of these wastes are being stockpiles outdoors. These solid wastes consist of:

- Slag from the Furnaces - Slag is generated by the furnaces at a rate of 1.5 to 2 T per heat. Based on 12 heats per day, the daily quantity of slag generated is estimated at 24 T/d or approximately 6,700 T/yr.

- Iron Oxide Scale from the Continuous Casting Operation - The meltshop generates iron oxide at a rate of 0.005 T per ton of steel produced. Based on a production rate of 150 T/d, the quantity of iron oxide generated is 0.75 T/d or approximately 210 T/yr. Some of the iron oxide is reused as raw material for the furnace. However, the addition of iron oxide cools the temperature in the furnace requiring more electrical power to be used. Approximately 1,200 T of iron oxide scale was sent to the cement factory in 1994.

- Iron Oxide Scale from the Rolling Mill - The rolling mill generates iron oxide at a rate of 0.01 T per ton of reinforcement bar produced. Based on a production rate of 122 T/d, the quantity of iron oxide generated is 1.21 T/d or approximately 340 T/yr.

- Scrap Reinforcement Bar from the Rolling Mill - Twisted and bent reinforcement bars from the rolling mill are reused in the furnace or sold to other rolling mills for reworking.

- Refractory Brick Fragments from the Furnaces - Refractory bricks that line the furnace, ladle and tundish are partially consumed during the steelmaking process and must be replaced. The furnace, ladle, and tundish are lined with new bricks and the brick fragments are removed. These fragments are shipped to a facility that crush and reuse the refractory brick. Some of the alumina brick fragments from the furnace roof are reused in the tundish.

- Spent Copper Tube Molds - Approximately 50 spent molds per year are generated and stockpiled outdoors.

- Empty Oil Barrels - Machinery oil (motor oil, hydraulic oil, gear oil, and grease) is consumed by the meltshop, rolling mill, power station, and oxygen plant. Each year, approximately 21 empty oil barrels are stockpiled outdoors.

The facility stores its products, the steel billets from the meltshop, and the reinforcement bars from the rolling mill, in large warehouses. However, the steel scrap and drums of oil are stored outdoors. The quantity of slag and iron oxide generated each year is 6,700 T of slag and 550 T of iron oxide (210 T from the meltshop and 340 T from the rolling mill). In the past 15 years, an accumulation of approximately 100,800 T of slag and approximately 8,200 T of iron oxide has been stored outdoor.

Although the facility does not need more than one month's supply of steel scrap stockpiled, the facility purchases from the local market whenever that supply is offered. This purchasing policy has resulted in an estimated four months inventory of steel scrap. Assuming that 14.5 T/d of steel scrap is consumed, approximately 1,400 T of steel scrap is stockpiled outdoors.

4.6 Storm Water Management

The raw materials and wastes, exposed to rainfall and wind, can create dust problems and during storm events can contaminate the storm water with TSS and metals. Fuel oil spills on the ground near the fuel oil tanks can also contribute to storm water contamination of groundwater and nearby wadis.

4.7 Data Gaps

Data gaps exist in water quality and water quantity measurements as noted below.

4.7.1 Water Quality

The facility does not conduct water quality tests on any of the wastewaters. However, WAJ is monitoring the facility's wastewater discharge. The analytical results of the WAJ monitoring from 1990 through 1994 are presented in Table 2, WAJ Wastewater Discharge Monitoring Analytical Results. The TSS concentrations have ranged from 12 mg/L to 305 mg/L. The TDS concentrations have ranged from 768 mg/L to 7,096 mg/L. Thus, this wastewater could not be discharged to wadis or reused for irrigation without further treatment. Metal concentrations are less than 1 mg/L. No monitoring for oil and grease, a typical contaminant in rolling mill wastewter, has been conducted.

Sampling of the rolling mill wastewater discharge was conducted as part of this audit on January 16, 1995. During the two site visits, no visible oil and grease was observed and no analyses conducted for oil and grease. The analytical results of this sampling are presented in Table 3, Sampling Analytical Results. The analytical results reveal that some removal of TSS and the metals is occurring across the treatment system. The treatment system is achieving a TSS removal efficiency of approximately 50 percent with a 95 percent reduction of the iron concentration. However, the treated wastewater discharge is still above the Jordanian Standard 202 for TDS, chloride, chromium, and cadmium.

The facility conducts regular testing of the water from the water softener and the water in the cooling tower. The 1994 analytical results for the cooling tower water are presented in Table 4, Cooling Water Analytical Results. The parameters analyzed include: pH, total alkalinity, total hardness, TDS, chloride, and phosphate. The total hardness is generally less than 30 mg/L and the TDS concentrations range from 1,300 mg/L to 2,600 mg/L.

4.6.2 Water Quantity

The meltshop and rolling mill have water meters that record the total quantity of water used. However, the facility does not record the meter readings on a daily basis, so there is no water use data. There are no metering devices on any internal water lines or wastewater pipes. Therefore, quantities for the following water uses within the facility are unknown:

- Contact cooling water for the continuous casting;
- Noncontact cooling water for the furnaces;
- Noncontact cooling water for the rolling mill;
- Sanitary wastewater; and
- Spills, leaks and clean-up.

36

5.0

POLLUTION PREVENTION AND WASTE MINIMIZATION OPPORTUNITIES

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION OPPORTUNITIES

During the audit of the JISICO facility, conducted on January 10 and 16, 1995, PP/WM opportunities were identified. The focus of the audit was on PP/WM techniques that would reduce the volume and pollution load of the wastewater generated at the JISICO facility and/or being discharged into the wadi and Zarqa watershed basin. Several PP/WM opportunities related to storm water, air emissions, and solid wastes were also identified. This section presents the PP/WM techniques and the water conservation techniques are presented in Section 6.0.

The JISICO facility discharges a portion of the wastewater overflowing from the rolling mill wastewater treatment system to nearby ground. The discharge from the JISICO facility is governed by Jordanian Standards 202, which limits industrial point source discharges to wadis and rivers. A comprehensive overview of the Jordanian Standards 202, and other applicable regulations, is provided in Appendix C. A comparison of these standards with 1994 discharge data is provided in Table 3.

The JISICO facility is a recycler of steel scrap. The steel wastes generated by other industries and the public are the facility's raw materials for producing the steel billets and reinforcement bars. However, the facility's activities generate wastes. For every 1 T of steel produced, 0.015 T of air emissions, 0.16 T of slag, and 0.015 T of iron oxide scale is generated. The facility consumes approximately 2 m^3 of water for every T of steel produced. Though most of this water is recycled, it becomes contaminated in the process. At the JISICO facility, the following PP/WM practices are being implemented:

- Off-Spec Material Reuse - Bent or otherwise imperfect reinforcement bars are returned to the meltshop as scrap steel.
- Recovered Oil Reuse - Oil that is collected from the rolling mill's sedimentation tank is reused as fuel.
- Spill Control and Containment - The fuel storage tanks are located on concrete pads with a containment dike.
- Refractory Brick Reuse - Alumina brick fragments are sent to a facility that crushes and reuses the brick. Some of this crushed brick is returned to the JISICO facility for lining the tundish.
- Scale Removal - JISICO does not have high pressure water sprays in the rolling mill for removing the scale; thereby reducing the quantity of scale in the cooling water.

The term PP/WM, in this report, refers to the reduction or elimination of the amount of waste before it is generated at the source. Further PP/WM opportunities exist and are identified in this report. These opportunities identified for the JISICO facility are grouped into three general categories:

- Meltshop;
- Rolling Mill; and
- Control of Other Waste Generating Activities.

The PP/WM opportunities identified for each of these categories are provided in the following sections.

While the PP/WM opportunities are intended to reduce waste generated, changes to process operations may result in unanticipated consequences. The JISICO facility should fully evaluate the options presented before modifying process operations.

5.1 Meltshop

The following PP/WM opportunities are identified for the meltshop and its associated power station and oxygen plant operations:

- Cooling Water Treatment - Use ozone rather than biocide chemicals to control fouling in the cooling towers. Metal-based or organic biocides, though effective, leave residuals that restrict reuse of the water for other than cooling purposes and become contaminants when the water is discharged to the wadi. Ozone, as a strong oxidant, reacts with compounds present in the water forming different compounds but does not add more contaminants.

- Cooling Tower Blowdown Reuse - Eliminate the wastewater generated due to the cooling tower blowdown by treating and reusing this discharge. Treating the cooling tower blowdown conserves water by recovering and reusing the blowdown. Currently, the biweekly blowdown from the oxygen plant's cooling tower and the yearly blowdown from the power plant's closed-loop "radiator" system are discharged onto the ground.

  These discharges could be treated using:

  - Reverse Osmosis - The reverse osmosis system requires regeneration. However, the quantity of regeneration wastewater is much less than the blowdown and can be evaporated using a solar evaporation system. Deep well injection is another disposal option, but such a disposal mechanism must be correctly designed, properly constructed, and carefully maintained and monitored to ensure protection of groundwater.

  - Lime-soda Treatment - Another possible treatment system for the blowdown is a lime-soda softening system. Treatment with a lime-soda softening system reduces the calcium, magnesium, bicarbonate and silica concentrations. If the blowdown is taken from the hot well, the higher temperature of this water enhances removal of hardness and silica. Combining boiler blowdown with the cooling tower blowdown would increase the temperature and thus enhance removal efficiencies.

    The blowdown could also be combined with fresh make-up water in a lime-soda softener for treatment of both. However, if the make-up water hardness is present as calcium or magnesium chloride or sulfate rather than bicarbonate, this softening system will increase the chlorides and sulfates, that, if not removed, will create corrosive water in the cooling system.

  The treated wastewater could be reused as cooling water for the rolling mill or contact cooling water for the continuous casting operation. The treated wastewater quality may even enable reuse in the cooling towers.

- Softener Regeneration - Instead of sodium chloride, use a regeneration chemical that is less harmful to the environment, such as acetic acid and ammonium hydroxide. This chemical substitution would

39

reduce the high concentrations of sodium and chloride salts in the wastewater.

- Softener Regeneration Wastewater Reuse - Treat the regeneration wastewater and reuse as regeneration water or backwash water for the sand filters. A treatment technology such as reverse osmosis separates the pollutants from the wastewater; thus producing water that can be reused and generates a smaller volume, more concentrated wastewater.

- Softener System Upgrading - Use a newer state-of-the-art ion-exchange resin system that is regenerated with less solution and, therefore, generates a smaller quantity of wastewater. This regeneration wastewater could be evaporated.

- Sand Filter Backwash Reuse - The JISICO facility could monitor the quality of the backwash wastewater and, if possible, reuse all or part of the backwash wastewater as backwash water for two or more sand filter backwash cycles.

5.2 Rolling Mill

The following PP/WM opportunities are identified for the rolling mill operations:

- Reheating Furnace Cooling Water Reuse - The JISICO can eliminate the discharge generated due to the reheating furnace cooling water periodic blowdown by treating this discharge by reverse osmosis to remove the TDS and reusing as cooling water for the reheating furnace or for the rolling mill.

- Cooling Water Reuse - The JISICO continuously recycles the contact cooling water; however, approximately 125 m^3/d of wastewater is discharged onto the ground to control the build-up of TSS (primarily iron oxide scale) and oil. Modifications to the design and operation of the rolling mill wastewater treatment system could eliminate this discharge. These modifications include using coagulants to aid in settling of the fine iron oxide particles, installing pumps to remove the iron oxide scale; dewatering the scale and reusing the water; and installing sand filters. These and other optimization measures for the wastewater treatment system are discussed in Section 5.3.1.

- Hydraulic Fluid Leak Reduction - The quantity of hydraulic oil in the cooling water could be reduced with improved maintenance (both preventive and corrective programs) of the equipment to reduce hydraulic fluid leaks.

5.3 Control of Other Waste Generating Activities

Several additional PP/WM opportunities address the operation of the wastewater treatment system, storm water, sanitary wastes, solid wastes, and air emissions. Opportunities in these specific areas are provided in the following sections.

5.3.1 Wastewater Treatment System

The proper design and operation of the wastewater treatment system is critical to the prevention and control of pollution at the JISICO facility. The following suggestions are provided to ensure proper design and operation of the wastewater treatment system:

40

- Wastewater Treatment Operations Optimization - If the quality of the effluent from the rolling mill wastewater treatment system is improved, the rolling mill could eliminate the need to discharge any wastewater from its system. Short-term modifications to the current operation of the system are:

  - Adding coagulant aids or flocculants such as cationic polymers to increase the removal of the fine iron oxide particles;

  - Increasing the frequency of iron oxide removal in the scale pits within the rolling mill; and

  - Using pumps to remove the iron oxide in the scale pits, sedimentation tank, and collection tank. This would eliminate the weekly discharge of wastewater from the sedimentation tanks so that the iron oxide scale can be manually shovelled out.

- Wastewater Treatment Design Modifications - The following modifications would result in improve removal of the iron oxides and oil.

  - Leveling the weirs in the sedimentation tanks to prevent short-circuiting;

  - Installing automatic oil skimming devices and/or oil/water gravity separator;

  - Replacing the 4-chamber sedimentation tank with a high efficiency clarifier design, such as tube settlers, inclined plate clarifiers, or clarifiers with continuous sludge removal; and

  - Installing sand filters.

Two alternative treatment technologies are electromagnetic separation and microfiltration.

5.3.2 Storm Water, Sanitary Wastes, Solid Wastes, and Air Emissions

The following suggestions for the treatment and disposal of storm water, sanitary wastes, solid wastes, and air emissions do not reduce the quantity of wastes generated by the JISICO facility, but are aimed at improving the management of these wastes to prevent their release into the environment. Containing and concentrating these wastes and reusing or recycling these wastes will prevent the broad scale pollution of the air, groundwater, and soil that current facility practices may be creating:

- Storm Water Management - The following suggestions would minimize the contamination of storm water and reduce the quantity of contaminated storm water leaving the facility's site by treating and reusing the storm water.

  - Grade and contour the site and construct trenches to collect and divert the storm water to a collection tank for settling of solids; water quality may be sufficient for use as cooling water in the rolling mill;

  - Construct storage areas with concrete pads and containment walls and roofs for the iron oxide scale. These storage areas will prevent storm water contamination and reduce dust pollution; and

41

- Improve storage and handling procedures to reduce fuel oil spills.

- Sanitary Wastewater Reuse - The JISICO facility could segregate the employee hand washing and shower wastewater from the rolling mill wastewater to prevent dirt, oil and grease, and soap from further contaminating the rolling mill cooling water. This wastewater could be combined with the toilet wastewater that is discharged to the septic tanks. The JISICO facility could construct an engineered septic tank with a suitable leachfield to treat the domestic wastes generated by the facility. The treated wastewater leaving the leachfield will support vegetation.

- Good Housekeeping - Improved housekeeping practices, such as keeping containers closed, materials segregated, and spills contained, could reduce inadvertent water contamination.

- Solid Wastes Recycling - The following suggestions could reduce the outdoor stockpile of iron oxide, slag, and empty containers:

  - Increase reuse of iron oxide in furnaces, as much as possible;

  - Sell the slag and iron oxide scale to cement factories;

  - Sell the iron oxide scale as a soil fertilizer supplement;

  - Sell the slag as road material; and

  - Purchase bulk containers of hydraulic fluid and other oils used in large quantities to reduce the number of empty drums. Return the drums to suppliers, or if the containers are steel or iron use as steel scrap for the furnace.

- Air Pollution Control - Install air pollution control devices to capture the furnace dust and fumes. Dry air pollution control devices such as baghouses will concentrate the waste. Semi-wet pollution control devices will increase water consumption but these systems can be designed to use the wastewater generated from other process operations and can be designed as closed-loop systems to eliminate any wastewater generation.

42

6.0

WATER CONSERVATION OPPORTUNITIES

6.0 WATER CONSERVATION OPPORTUNITIES

Water conservation is an extremely important concern in the Zarqa Basin and throughout Jordan. The limited water resources require that businesses and industry view water as a valuable raw material and optimize its use. In order to optimize water use, business and industry should carefully monitor flows and uses within facility operations and develop a written strategy to coordinate water conservation activities.

The JISICO facility already practices the following water conservation techniques:

- Cooling Water Reuse - Cooling water for the furnaces, power station, and oxygen plant is continuously recirculated through cooling towers. The cooling water for the rolling is also returned to the rolling mill as cooling water.

Additional opportunities exists and are presented in this section. These opportunities identified for the JISICO facility are grouped into three general categories:

- Meltshop;
- Rolling Mill; and
- Miscellaneous Water Conservation Techniques.

A summary of these water conservation opportunities, including the projected water savings, is provided in Table 5. Figure 3, Meltshop Water Conservation Techniques Flow Diagram, and Figure 4, Rolling Mill Water Conservation Techniques Flow Diagram, are block flow diagrams that illustrate some of these techniques.

6.1 Meltshop

A number of water conservation opportunities involve the water uses of the meltshop. Some of the PP/WM options identified in Section 5.0 that also result in water conservation are:

- Cooling Tower Blowdown Reuse - Treating and reusing cooling tower blowdown decreases the quantity of well water consumed.

- Softener Regeneration Wastewater Reuse - Treating the regeneration wastewater and reusing as regeneration water or backwash water for the sand filters.

- Sand Filter Backwash Reuse - Reusing all or part of the backwash wastewater as backwash water for two or more sand filter backwash cycles.

- Softener System - Using a newer state-of-the-art ion-exchange resin system that requires less water for the regeneration cycle.

Additional water conservation opportunities are described below:

- Non-Contact Cooling Water Elimination - The JISICO facility could investigate the opportunity for using a non-water cooling system for the oxygen plant and the power station. Use of a non-water

system would eliminate the cooling water makeup and blowdown (70 m^3/d). Three potential non-water cooling options are:

- Install a non-water based, such as ethylene glycol, closed-loop cooling system;

- Replace the oxygen plant's cooling tower with cooling coils that use the cold oxygen and nitrogen generated by the oxygen plant; and

- Install air cooled closed-loop cooling system for all the generators. The one generator already has this type of "radiator" closed-loop system. The water in the closed loop should be treated and reused in the system. A non-water based closed-loop cooling system could be used.

- Cooling Water Segregation - For the contact cooling in the continuous casting operation, a lower quality cooling water could be used. The JISICO facility should segregate the contact cooling water for the steel in the continuous casting operation from the softened non-contact cooling water system for the furnaces, copper tube mold, oxygen plant, and power station. Reuse the rolling mill cooling water or treated blowdown water for cooling the steel. This cooling water, after treatment through the hydrocyclone and sand filters, if cool enough, could be recycled directly back to continuous casting or to the rolling mill. Some of the treated wastewater from the sand filters could be used as backwash water for the filters and this backwash wastewater would serve as the blowdown. The blowdown could be reused in the rolling mill, or further treated using reverse osmosis and reused to cool the steel.

6.2 Rolling Mill

The PP/WM options identified in Section 5.0 that result in reductions in the quantity of fresh well water consumed by the rolling mill are:

- Wastewater Treatment System Optimization - Reusing the wastewater discharge from the sedimentation tank and wastewater collection tank by improving the current iron oxide and oil removal. A 95 percent reuse of the current wastewater discharges from the treatment system would result in a water savings of approximately 119 m^3/d.

- Reheating Furnace Cooling Water Blowdown Reuse - Reusing the reheating furnace cooling water blowdown by treating this discharge to remove the TDS and reusing as cooling water for the reheating furnace or for the rolling mill. These techniques would save approximately 2.5 m^3/d.

Additional opportunities for water conservation related to the rolling mill are:

- Production Synchronation - Transport the hot billets from the continuous casting operation immediately to the rolling mill operation. This would eliminate the need for the reheating furnace and eliminate the 2 m^3/d cooling water blowdown discharge.

- Cooling Water Optimization - Replace the 0.5-inch diameter pipe that delivers the cooling water to the rolls with smaller orifices or spray devices with self-cleaning nozzles. Less water is used to achieve the same cooling effect. The entire cooling water system capacity is then decreased.

45

- Flying Shear Cooling Water Elimination - Eliminate the once-through cooling of the pipe prior to the flying shears. This will increase the frequency of replacing the pipe, but the solid waste (old pipe) generated can be returned to the furnace as scrap. Another option is to capture and return this cooling water to the scale pits.

- Reheating Furnace Cooling Water Evaporation Reduction - Eliminate the spray pipe located over the cooling water tank for the reheating furnace. This device is not appreciably cooling the water in the tank and is contributing to evaporation and drift losses from the cooling water tank.

6.3 Miscellaneous Water Conservation Techniques

The JISICO estimated that the quantity of fresh water used for employee sanitary use to be approximately 10 m^3/d. Based on 0.1 m^3/employee and 255 employees, the quantity could be as high as 25.5 m^3/d. The sanitary water use and wastewater generation can be reduced by employee awareness and installation of water conservation equipment. Assuming that these procedures would reduce overall miscellaneous water use by 15 percent, a savings of approximately 1.5 m^3/d would be achieved. The following water conservation suggestions apply to the general water use activities of the JISICO facility:

- Water Conservation Devices - Replace the water faucets throughout the facility, and specifically the faucet beneath the elevated water tower, with flow regulation devices such as flow restrictors, flow shut-off devices, and low volume spray hoses.

- Water Conservation Training - Provide water conservation awareness training to employees on a periodic basis.

- Cooling System Operation Optimization - Investigate possible optimization of the design and operation of the cooling water systems for the furnaces, continuous casting, oxygen plant, power station, reheating furnaces, roll stands, and water-cooled machines such as the shears. Determine the lowest water quality and the highest temperature for each machine or operation. Modify cooling tower design, operation, or chemicals to increase the concentration cycle.

- Good Housekeeping - Emphasize practices that maintain a clean work place without the use of water for cleaning. Preventing spills and leaks reduces clean-up. When spills or leaks occur, clean-up should be conducted using dry methods such as absorbents or a mobile vacuum cleaner that captures the spill rather than diluting the spill with washwater.

46

7.0

CONCLUSIONS AND RECOMMENDATIONS

7.0 CONCLUSIONS AND RECOMMENDATIONS

'uring the audit conducted at the facility, JISICO staff and management were extremely helpful in -oviding access to facility operations and in providing requested information. The staff and management ' the JISICO facility also expressed a sincere interest in reducing current wastewater generation and ater consumption practices at their facility. Based on the information gathered during the audit, ›portunities for the application of PP/WM and water conservation techniques were identified. The ıdings of the audit and the PP/WM and water conservation options were presented in Sections 4.0, 5.0, ıd 6.0 of this report, respectively.

his section presents the audit conclusions and recommendations. The audit conclusions are provided in ›ction 7.2 and the recommendations for PP/WM and water conservation techniques are provided in ›ction 7.3.

1 Success Stories

1982, Dofasco in Canada incorporated a recycle system as part of its design and construction of a cond hot rolling mill. The recycle system consists of settling basins with skimmers to remove surface l, followed by dual phase media deep bed filters and then a cross flow cooling tower. The system hieves over 98 percent recycle of the cooling water with 2 percent of the wastewater discharged at a TSS ncentration less than 10 mg/L. The oil and grease loadings have been reduced by converting from ease to air-oil for work roll lubrication resulting in more than 24 times less grease being used. This nversion minimized the leaks from the hydraulic and lubrication systems. (McGuire et. al., 1991).

2 Conclusions

ısed on the findings of the audit conducted on January 10 and 16, 1995, the conclusions regarding the ›eration of the JISICO facility are as follows:

1. The JISICO facility produces 42,000 T/yr of steel billets from scrap steel and produces 34,000 T/yr of reinforcement bars. The products are purchased by customers in Jordan and are exported to other countries.

2. The JISICO facility conducts two separate manufacturing processes:

   - Production of steel billets from steel scrap in the meltshop - Two electric arc furnaces produce molten steel that is molded into steel billets by a continuous casting operation. Power for the furnaces is supplied by a power station equipped with 4 generators; two are always in operation. Oxygen for the furnaces is produced by an oxygen plant.

   - Production of steel reinforcement bars from steel billets in the rolling mill - There are two rolling mill lines each with a reheating furnace; roughing, prefinishing, and finishing roll stands; and shearing machines.

3. There are no internal water or wastewater measuring devices. The quantity of water used by the individual operations are based on the JISICO representatives' estimates. The JISICO facility's

118

daily water consumption is due to evaporative losses or discharges from the cooling towers and wastewater treatment system.

4. The JISICO facility uses approximately 260 m^3/d of groundwater. Approximately 50 percent of this water is softened using a zeolite softener unit. Regeneration of the unit consumes 8 percent of the total daily water consumption.

5. The major water use is for cooling purposes. There are five separate cooling systems, but the two systems consuming the majority of water are the meltshop cooling system and the rolling mill cooling system:

   - Meltshop Cooling System - This system, with two counterflow cooling towers, has a recirculation rate of 8,000 m^3/d and a concentration cycle of 3. This system serves the electric arc furnaces, copper tube molds, continuous casting, and power station. This system also provides make-up water to the oxygen plant's cooling tower and the power station's closed-loop water radiator system. The water in this cooling system is softened water from the zeolite softener.

   - Rolling Mill Cooling System - The cooling water for the roll stands is continuously recirculated with approximately 125 m^3/d being discharged from the wastewater treatment system onto the ground.

   Three other cooling systems are the reheating furnace non-contact cooling water tank, the oxygen plant's cooling water system with one cooling tower, and the power station's closed-loop cooling water radiator system for one generator.

6. In general, water use at the facility is not excessive (2 m^3/T steel); however, opportunities for conservation do exist. The percentage of total daily water consumption by the different operations are as follows:

   - Contact cooling water in the rolling mill, 38 percent;
   - Cooling in the power plant, 23 percent;
   - Cooling in the meltshop furnaces and continuous casting, 23 percent;
   - Softener regeneration, 8 percent;
   - Oxygen plant, 4 percent; and
   - Sanitary, 4 percent.

7. The meltshop's sand filter backwash water (approximately 11 percent of the daily water consumption) and the softener regeneration wastewater (approximately 8 percent of the daily water consumption) are discharged to the rolling mill's wastewater treatment system.

8. Wastewater is generated from the following areas:

   - Softener regeneration;
   - Sand filter backwash;
   - Oxygen plant blowdown;
   - Power plant blowdown;

49

- Reheating furnace cooling tank blowdown;
- Rolling mill wastewater treatment system; and
- Flying shear pipe cooling.

Major contaminants in the wastewater are: FOG, metals, TSS, and TDS.

9. The facility operates two treatment systems: one for the meltshop's contact cooling water and one for the rolling mill's contact cooling water. The meltshop's cooling water pretreatment system consists of a hydrocyclone and two sand filters. The sand filter backwash water is discharged to the rolling mill's treatment system. The rolling mill's wastewater treatment system consists of scale pits, a four-chamber sedimentation tank, oil skimmer, two circular metal screens for filtration, and a wastewater collection tank.

10. The rolling mill generates the largest wastewater discharge. Approximately 125 m^3/d is discharged onto the ground from the wastewater treatment system. The wastewaters from the softener regeneration, 20 m^3/d, and sand filter backwash, 28 m^3/d, may be hydraulically overloading the rolling mill wastewater treatment system. Furthermore, the four-chamber sedimentation tank was not designed based on settling tests of the wastewater and, therefore, may not be correctly engineered for maximum removal.

11. Approximately 3 T of furnace dust (metal oxides) as well as carbon monoxide, carbon dioxide, nitrogen oxide, sulfur trioxide, and ozone are generated by the facility. There are no air pollution control devices. This dust and fumes pose a health hazard to the employees and contribute to atmospheric deposition of metals to the surrounding soils and water.

12. Scrap steel for the furnaces and solid wastes generated by the facility operations are stored outdoors. A four-month inventory of steel scrap (approximately 1,400 T) is stockpiled. An estimated 6,700 T of slag and 550 T of iron oxide are generated per year. There could be as much as 100,800 T of slag and 8,200 T of iron oxide buried or stockpiled. This wastes contributes to storm water contamination.

3 Recommendations

ısed on the PP/WM and water conservation opportunities identified and discussed in Sections 5.0 and) of this report, the following recommendations are provided. These recommendations are grouped into 'e categories:

- PP/WM Policy and Monitoring;
- Operational Modifications;
- Process Modifications;
- New Process Additions; and
- Control of Other Waste Generating Activities.

ıe opportunities recommended in this section relate to both PP/WM and water conservation techniques.

7.3.1 PP/WM Policy and Monitoring

50

The following recommendations address the development and implementation of: management PP/WM policy; monitoring programs that will provide data to assist in evaluating the feasibility and success of PP/WM techniques; PP/WM and water conservation goals; employee training; and preventative and corrective maintenance program.

1. PP/WM and Water Conservation Policy - The JISICO management should establish a PP/WM and water conservation policy as part of JISICO management operating philosophy and distribute it to all employees. Implement the policy through specific goals and targets. Make it each person's responsibility to identify PP/WM and water conservation opportunities and implement any established PP/WM and water conservation measures. Show management commitment to the policy by implementing the following actions:

    - Designate a PP/WM and water conservation coordinator to effectively implement the program.
    - Publicize success stories and reward employees that identify cost effective PP/WM opportunities.
    - Implement the PP/WM and water conservation programs through employee training, awareness, and incentives.
    - Perform periodic assessment of the PP/WM and water conservation accomplishments by key management personnel, the coordinator, and independent experts.
    - Reinforce the policy and company commitment through management and employee meetings.

2. Monitoring Program - Increased monitoring of water use and wastewater disposal is particularly important for the JISICO facility due to the current lack of data in these areas. Specifically, the JISICO facility should begin routine monitoring of key water usage activities and wastewater discharges. This will assist the facility in more accurately targeting areas of concern, and will provide baseline data for overall plant performance. In addition, prior to initiating specific PP/WM activities, JISICO should evaluate the baseline characteristics of the wastewater (or water consumption activity) to be corrected. This baseline data can then be used to measure the initial success of the PP/WM or water conservation technique, and can also be used to ensure that the technique continues to perform successfully over time.

    - Develop and implement a plan to install flow measuring devices on the following water or wastewater lines:

        - Rolling mill wastewater discharges onto the ground (irrigation);
        - Cooling water make-up to power station;
        - Cooling water make-up to oxygen plant; and
        - Cooling water make-up to the reheating furnace.

    All flows from the above devices and the existing meters to the furnace and rolling mill

should be recorded daily for a period of 12 months. Record the water used for each cycle of the softener regeneration and sand filter backwash.

- Develop and implement a plan to sample the following wastewaters:

  - Softener regeneration wastewater;
  - Sand filter backwash wastewater;
  - Continuous casting cooling water entering and exiting the individual treatment units: the hydrocyclone and the sand filters; and
  - Rolling mill wastewater entering and exiting the individual treatment units: the sedimentation tank, the circular screens, and the collection tank.

  Conduct a short-term intensive sampling for TSS, TDS, hardness, and, for the rolling mill wastewater, oil and grease. This short-term sampling program should collect and analyze daily samples for one month. The results should be evaluated and the sampling program modified where necessary. Continue a long-term sampling program for monitoring the wastewaters at least once a month for a period of 12 months.

3. Employee Training - No PP/WM program will be successful if employees are not aware of the program goals and trained to effectively implement these goals. Employee training should include periodic refresher courses regarding the JISICO facility's PP/WM and water conservation policies and procedures and proper training in the use of new equipment or practices. Staff should also have the opportunity to provide input regarding additional PP/WM or water conservation activities and should be provided with incentives for program successes.

4. Water Balance and Reduction Goals - To begin a successful water conservation program, plant management should determine the minimum quantity of water needed for each specific process operation. The first step in the program requires an inventory of all water uses throughout the facility. This inventory should then be used to create an overall plant water balance that identifies all uses and routes of disposal. Management should then establish a plan to reduce water use by specific amounts in each segment of production.

5. Preventative and Corrective Maintenance Program - Where new equipment or processes are implemented to achieve a PP/WM or water conservation objective, the JISICO facility should provide ongoing maintenance and upkeep of this equipment. The success of any PP/WM project can be compromised if new equipment falls into disrepair, or if new processes are not correctly applied. Establishment of a long term maintenance schedule will help to ensure successful operation.

7.3.2 Operational Modifications

The following operational modifications should be implemented immediately:

1. Optimize Treatment Operations - Eliminate the discharge of any wastewater from the wastewater treatment system by improving treatment. Short-term operational modifications that would improve the current removal efficiencies of the system are:

- Adding coagulant aids or flocculants such as cationic polymers to increase the removal of the fine iron oxide particles;

- Using pumps for removing the iron oxide in the scale pits, sedimentation tanks, and collection tank to eliminate draining of the wastewater onto the ground; and

- Increasing the frequency of iron oxide removal in the scale pits within the rolling mill.

2. Flying Shear Cooling Water Elimination - Eliminate the once-through cooling of the pipe prior to the flying shears or capture and return it to the rolling mill wastewater treatment system.

3. Hydraulic Fluid Leak Reduction - Reduce the quantity of hydraulic oil in the cooling water with improved maintenance (both preventive and corrective programs) of the equipment to prevent or correct hydraulic fluid leaks.

4. Reheating Furnace Cooling Water Evaporation Reduction - Eliminate the spray pipe located over the cooling water tank for the reheating furnace. This device is not appreciably cooling the water in the tank and is contributing to evaporation and drift losses from the cooling water tank.

5. Sanitary and Other Miscellaneous Water Use - Modify the water faucets throughout the facility, and specifically the faucet beneath the elevated water tower, with flow regulation devices such as flow restrictors, flow shut-off devices, and low volume spray hoses. Provide water conservation awareness training to employees on a periodic basis.

6. Good Housekeeping - Emphasize practices that maintain a clean work place without the use of water for cleaning. Preventing spills and leaks reduces clean-up. When spills or leaks occur, clean-up should be conducted using dry methods such as absorbents or a mobile vacuum cleaner that captures the spill rather than diluting the spill with washwater.

7.3.3 Process Modifications

The following long-term design modifications should be investigated:

1. Rolling Mill Wastewater Treatment Design Modifications - Design modifications to the wastewater treatment system may be necessary to achieve the water quality necessary to enable complete recycle (or 95 percent recycle) of the cooling water. An engineering analysis of the following modifications should be conducted:

    - Leveling the weirs in the sedimentation tanks to prevent short-circuiting;

    - Installing automatic oil skimming devices and/or oil/water gravity separator;

    - Replacing the four-chamber sedimentation tank with a high efficiency clarifier design, such as tube settlers, inclined plate clarifiers, or clarifiers with continuous sludge removal; and

    - Installing sand filters or other suspended solids removal systems such as microfiltration

or eletromagnetic separation.

2. Cooling Tower Blowdown Reuse - Treat and reuse the cooling water blowdown from the oxygen plant's cooling tower, the power station's closed-loop radiator system, and the reheating furnace cooling water. The treated wastewater could be reused as cooling water for the rolling mill or the continuous casting operation. The treated wastewater quality may even enable reuse in the cooling towers.

3. Softener Regeneration Wastewater Reuse - Treat and reuse the regeneration wastewater as regeneration water or backwash water for the sand filters.

4. Sand Filter Backwash Reuse - Reuse all or part of the backwash wastewater as backwash water for two or more sand filter backwash cycles.

5. Softener Regeneration - Use a regeneration chemical that is less harmful to the environment, such as acetic acid and ammonium hydroxide to reduce the high concentrations of sodium and chloride salts in the wastewater.

6. Cooling Water Segregation - Segregate the contact cooling water for the continuous casting operation from the softened non-contact cooling water for the furnace. Reuse rolling mill cooling water or treated blowdown water. Treat the cooling water through the hydrocyclone and sand filters and recycle directly back to continuous casting or to the rolling mill. Some of the treated wastewater from the sand filters could be used as backwash water for the filters and this backwash wastewater would serve as the blowdown. The blowdown could be reused in the rolling mill, or further treated using reverse osmosis and reused to cool the steel.

7.3.4 New Process Additions

The following recommendations would require investigation of installation of new equipment, or reconfiguration of piping, pumps, and equipment.

1. Softener Regeneration - Use a newer state-of-the-art ion-exchange resin system that is regenerated with less solution and therefore generates a smaller volume, more concentrated wastewater.

2. Cooling Water Treatment - Use ozone rather than biocide chemicals to control fouling in the cooling towers.

3. Non-Contact Cooling Water Elimination - Investigate non-water cooling systems for the oxygen plant and the power station. Options are:

   - Replacing the water-cooled compressor in the oxygen plant with an air-cooled compressor.

   - Installing a heat exchanger that uses the cold oxygen and nitrogen generated by the oxygen plant.

- Installing the closed-loop "radiator" cooling system for all the generators.

4. Cooling Water Optimization - Investigate ways to reduce the quantity of water needed to cool roll stands. One possible option is replacing the 0.5-inch diameter pipe that delivers the cooling water to the rolls with smaller orifices or spray devices with self-cleaning nozzles.

5. Production Schedule Synchronation - Eliminate the reheating furnace and its cooling water by transporting the hot billets from the continuous casting operation immediately to the rolling mill operation.

7.3.5 Control of Other Waste Generating Activities

Several recommendations relating to the management of storm water, solid wastes, sanitary wastes, and air emissions are provided below:

1. Storm Water Management - The following recommendations would minimize the contamination of storm water and reduce the quantity of contaminated storm water leaving the facility's site by treating and reusing the storm water.

   - Grade and contour the site and construct trenches to collect and divert the storm water to a collection tank for settling of solids; water quality may be sufficient for use as cooling water in the rolling mill;

   - Construct covered storage areas with concrete pads and containment dikes for the iron oxide scale to prevent storm water contamination and reduce dust pollution; and

   - Improve storage and handling procedures to reduce fuel oil spills.

2. Solid Wastes - Decrease the quantity of solid waste buried or stockpiled on site by:

   - Increasing reuse of iron oxide in the furnaces;

   - Selling the slag to cement factories or sell as road material;

   - Selling the iron oxide scale to cement factories or sell as a soil fertilizer supplement;

   - Purchasing bulk containers of hydraulic fluid and other oils used in large quantities to reduce the number of empty drums; and

   - Returning drums or other containers to suppliers, or if the containers are steel or iron, use as steel scrap for the furnace.

3. Domestic Waste Treatment - To prevent groundwater contamination from leaking or improperly designed or installed septic tanks and reduce the quantity of domestic wastewater hauled to As Samra, construct a properly engineered septic tank with a suitable leachfield to treat the domestic wastes on site.

4. Air Pollution Control - Implement air pollution control measures to contain and concentrate the emissions and reduce worker exposure to toxic fumes.

8.0 FOLLOW-UP ACTIONS

To ensure the success of a PP/WM or water conservation project, a facility implementing specific actions must follow-up on these actions to ensure that the goals of the project are achieved. It is imperative, therefore, that the JISICO facility follow-up implementation of any of the recommendations of this report with activities such as increased monitoring of water use and disposal, ongoing maintenance and upkeep of new equipment, and conduct of periodic training and instruction for management and production line staff.

1. The first item of action is to establish a PP/WM water conservation policy as part of JISICO management operating philosophy and distribute it to all employees. Implement the policy through specific goals and targets.

2. Develop and implement a plan to install water and wastewater measuring devices on selected operations. Initiate monitoring of wastewaters for selected pollutants.

3. Develop and implement employee training.

4. Develop water balance for facility and determine water conservation goals.

5. Develop and implement a preventative and corrective maintenance program for equipment, pipes, and structures. Eliminate the cause of spillage. Do not just wash it down the drain.

With respect to the PP/WM and water conservation techniques recommended in Section 7.0, the JISICO facility should follow-up on all of the elements that it determines are productive. Implementation of these recommendations will reduce water consumption and pollutant loadings. In particular, the JISICO facility should follow-up on the following recommendations:

6. Optimize Treatment Operations - Eliminate the discharge of any wastewater from the wastewater treatment system by improving treatment. Short-term operational modifications that would improve the current removal efficiencies of the system are:

   - Adding coagulant aids or flocculants such as cationic polymers to increase the removal of the fine iron oxide particles;

   - Using pumps for removing the iron oxide in the scale pits, sedimentation tanks, and collection tank to eliminate draining of the wastewater onto the ground; and

   - Increasing the frequency of iron oxide removal in the scale pits within the rolling mill.

7. Flying Shear Cooling Water Elimination - Eliminate the once-through cooling of the pipe prior to the flying shears or capture and return it to the rolling mill wastewater treatment system.

8. Hydraulic Fluid Leak Reduction - Reduce the quantity of hydraulic oil in the cooling water with improved maintenance (both preventive and corrective programs) of the equipment to prevent or correct hydraulic fluid leaks.

9. Sanitary and Other Miscellaneous Water Use - Reduce miscellaneous water use and the associated wastewater by developing and implementing procedures that focus on water conservation.

- Provide water conservation awareness training to employees on a periodic basis.

- Utilize water conservation equipment as much as possible. Different types of water saving equipment include:

8.0

FOLLOW-UP ACTIONS

solution and therefore generates a smaller volume, more concentrated wastewater

- Non-Contact Cooling Water Elimination - Investigate non-water cooling systems for t oxygen plant and the power station.

- Cooling Water Optimization - Investigate ways to reduce the quantity of water need for cooling and lost to evaporation and blowdown. Some options to explore are:

  - Replacing the 0.5-inch diameter pipe that delivers the cooling water to the ro with smaller orifices or spray devices with self-cleaning nozzles;

  - Increasing the concentration cycle of the cooling towers; and

  - Decreasing blowdown quantity.

To ensure that JISICO management are kept updated on "state-of-the-art" technologies, the MWI a the Chamber should be consulted on a regular basis. Periodic site visits should be arranged for the M and the Chamber staff so that they might provide additional input and suggestions.

TABLES

Table 1 - Water Balance

JISICO

WATER IN		WATER OUT	
Source	Rate m^3/d	Source	Rate m^3/d
Well water	260	Rolling mills (evaporative losses and discharges)	100
		Power station (evaporative losses)	60
		Meltshop (evaporative losses)	32
		Sand filter backwash	28
		Regeneration	20
		Oxygen plant	10
		Sanitary	10
Total	260		260

Table 2 - WAJ Wastewater Discharge Monitoring Analytical Results

JISICO

Date	BOD	TDS	TSS	COD	NH_4	Fe	ABS	PO_4	pH
03/28/94	-	2,962	60	137	-	0.0	0.45	-	8.2
04/20/94	12	2,692	34	164	-	0.01	-	-	7.8
05/12/94	95	1,846	165	234	5.76	0.08	-	-	8.6
06/18/94	50	2,528	86	390	4.2	0.0	-	-	8.0
07/13/94	10	4,632	67	90	1.0	0.0	-	-	8.1
08/13/94	9	4,708	101	125	-	0.18	-	-	8.5
09/10/94	-	7,096	60	38	-	0.12	-	-	8.1
10/13/94	31	3,702	84	126	2.6	0.1	-	-	8.2
11/7/94	-	2,828	38	34	-	-	-	-	6.9
10/14/93	5	3,000	52	76	-	0.07	-	-	8.8
07/17/93	17	2,760	74	39	0.26	-	-	-	7.6
07/28/93	4	3,884	43	49		0.07	-	-	6.9
05/17/93	13	2,508	70	44	3	0.04	-	0.7	7.4
01/18/93	9	4,122	66	58	-	0.38	-	-	-
07/4/92	6	634	27	73	0.47	-	-	-	-
07/20/91	6	1,638	12	32	0.6	-	-	-	8.3
12/11/91	6	3,662	217	167	-	-	-	-	7.4
01/20/90	19	1,215	305	126	0.26	-	0.35	<0.1	8.3
03/06/90	10	-	30	51	-	1.12	-	-	-
02/24/90	-	-	29	26	-	1.36	-	-	-
04/17/90	-	-	30	72	-	0.59	-	-	-
05/23/90	4	1,670	263	126	-	1.39	-	-	8.4
01/09/90	17	1,032	218	61	0.06		0.25	0.31	8.22
02/07/90	19	850	20	43	0.26		0.15	0.0	8.23
09/05/90	18	1,248	64	66		0.88			7.6
07/15/93		3,792	64	114		0.0			
10/26/93	13	2,546	63	28		0.0			7.8

06/09/90	7	717	63	38	0.32	0.45	-	-	8.2
10/11/90	8	1,624	-	182	-	0.48	-	-	8.3
11/17/90	-	880	-	716	-	-	0.0	0.13	7.8

- Not Determined

Source: Waleed Hussein, WAJ

Table 3 - Sampling Analytical Results

JISICO

Parameter	202 Standard (mg/L)	Wastewater Discharge[a] (mg/L)	Wastewater Discharge[b] (mg/L)
pH	6.5 - 9	7.6	8.0
P		0.1	0.3
TSS	50[1] or 100[2]	132	67
TDS	3000[1] or 2000[2] [c]	4,026	4,360
Fe	1[1] or 5[2]	27.5	1.46
Mn	0.2	0.51	0.16
Cu	2[1] or 0.2[2]	0.09	0.02
Zn	15[1] or 2[2]	0.42	0.31
Cr	0.1	0.27	0.14
Cd	0.01	0.03	0.05
Cl	500[1] or 350[2]	1,724	1,847
M	-	0.16	0.1
Pb	0.1[1] or 1[2]	0.0	0.0
B	1	0.48	0.75

[a] Wastewater collected from open trench prior to four-chamber sedimentation tank.
[b] Wastewater collected from collection tank overflow pit.
[c] TDS limit is subject to the TDS concentration in the water supply and the water basin affected.
[1] Disposal to wadis or rivers.
[2] Reuse for irrigation.

\- Not regulated.

Table 4 - Cooling Water Analytical Results

JISICO

Date	pH	T. Alk.	T. Hardness	TDS	Cl	Phosphate
09/05/94	9.3	660	30	2,000	500	40
09/26/94	9.2	380	40	2,000	390	66
08/06/94	8.9	540	10	2,000	510	60
08/23/94	9.1	620	20	2,600	500	220
07/09/94	7.9	580	30	2,300	510	11
06/05/94	8.9	540	20	2,500	630	11
06/22/94	7.6	660	10	2,600	710	44
05/02/94	8.2	460	10	1,700	390	55
05/15/94	7.9	460	20	2,200	530	88
04/09/94	7.9	460	220	1,300	350	33
04/24/94	8.2	460	20	1,700	210	77
03/01/94	8.7	460	30	1,300	250	200
01/26/94	8.6	350	30	1,500	300	27
02/14/94	8.4	420	30	1,400	350	66
01/15/94	9.3	340	22	1,800	350	-

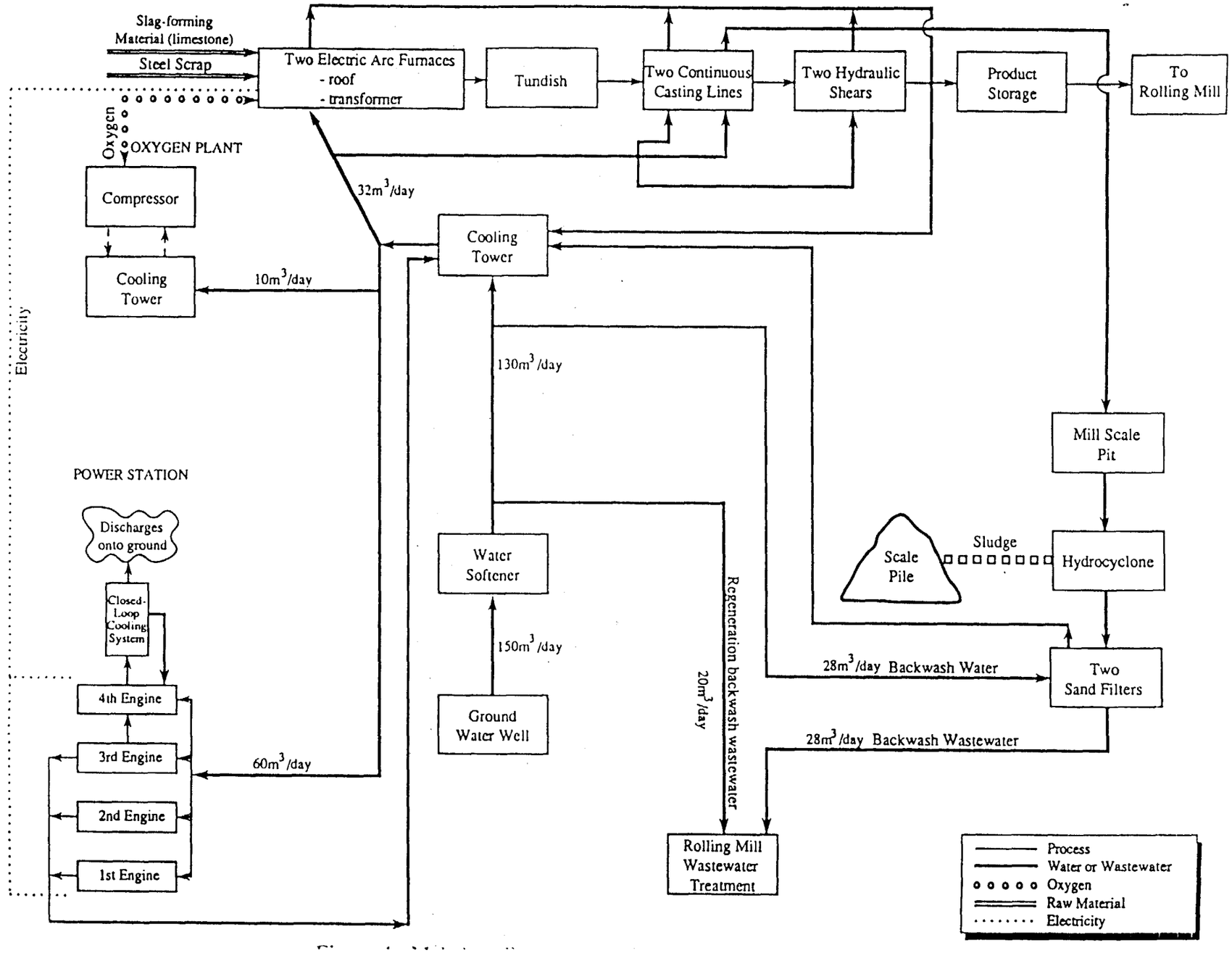
Table 5 - Potential Water Savings
JISICO

MELTSHOP

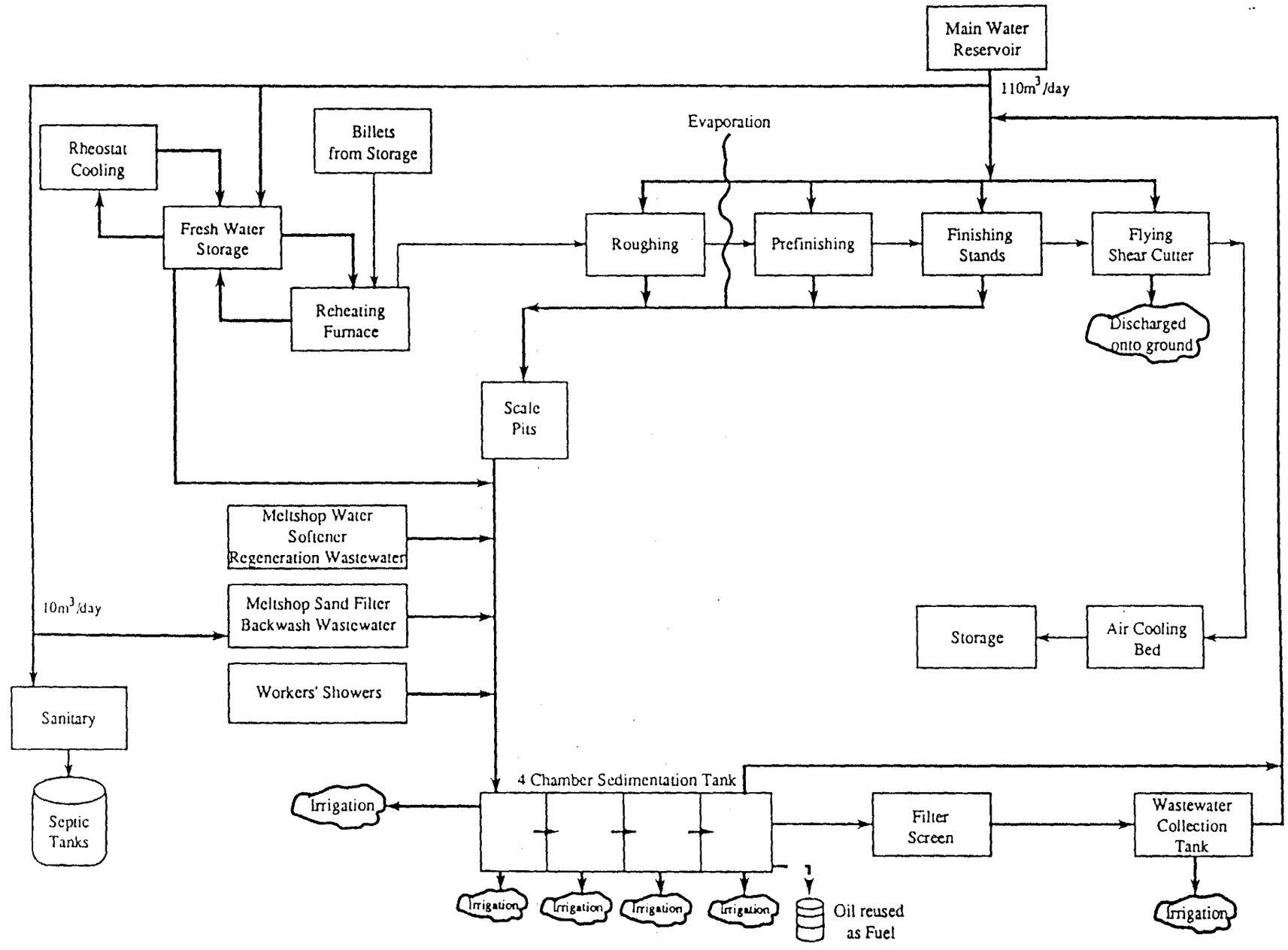
Water Conservation Technique	Current Water Consumption (m^3/d)	Projected Water Consumption (m^3/d)	Projected Water Savings (m^3/d)	Percent Decrease in Total Water Consumption
1. Radiator closed-loop cooling system for all generators	60	8	52	20
2. Treat and reuse all blowdowns: oxygen plant, power station, and meltshop	30	3	27	10
3. Sand filter backwash reuse	28	8	20	8
4. Softener regeneration wastewater reuse	20	2	18	7
5. Cooling water segregation for continuous casting with reuse of rolling mill cooling water or treated blowdown	20	2	18	7
6. Eliminate water cooling in the oxygen plant	10	0	10	4
7. Water conservation ion-exchange resin system	20	10	10	4
8. Closed-loop cooling system for power station	1-2	1	1	negligible
Total Savings	150	5 - 26	37 - 100	25 - 66

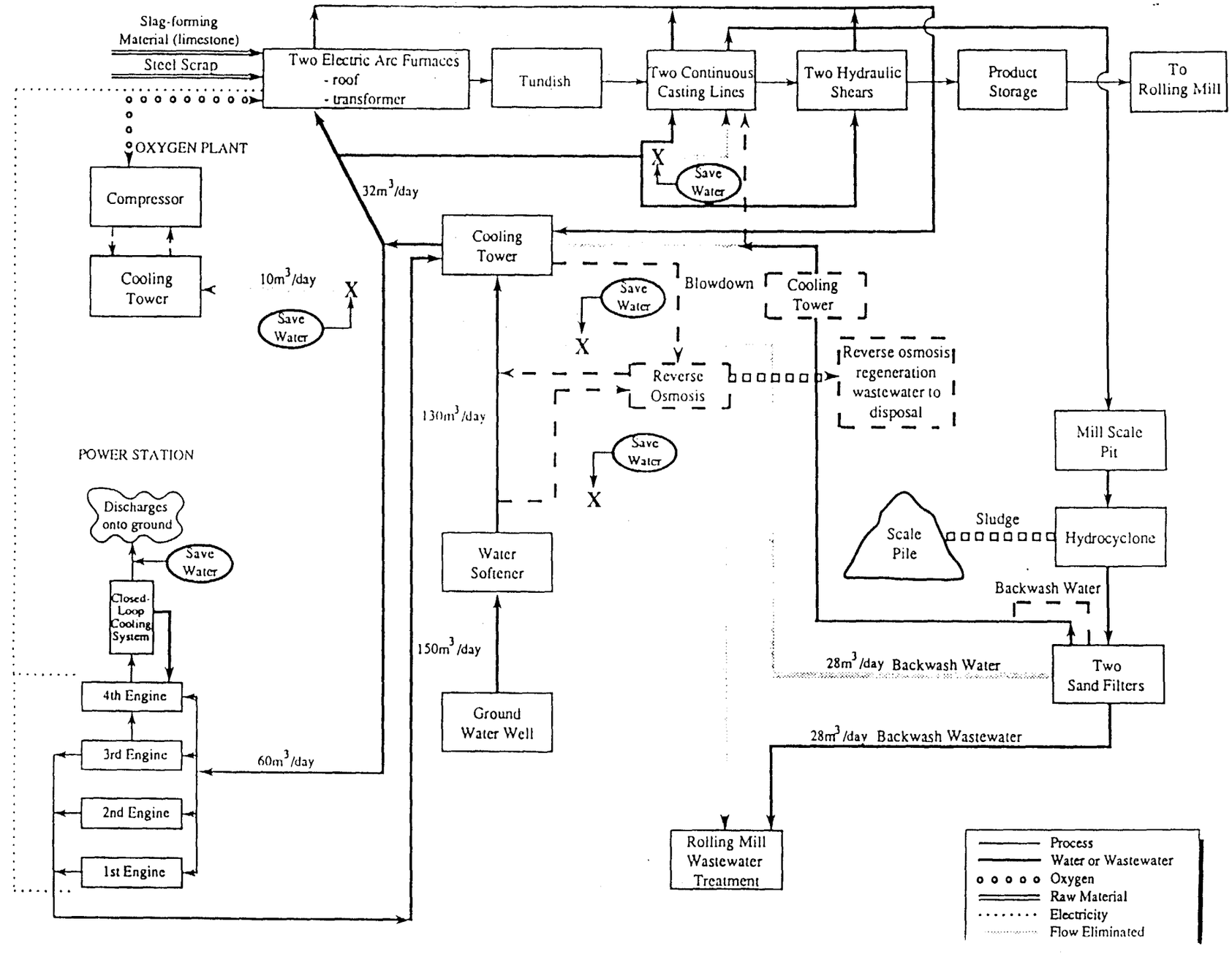
ROLLING MILL

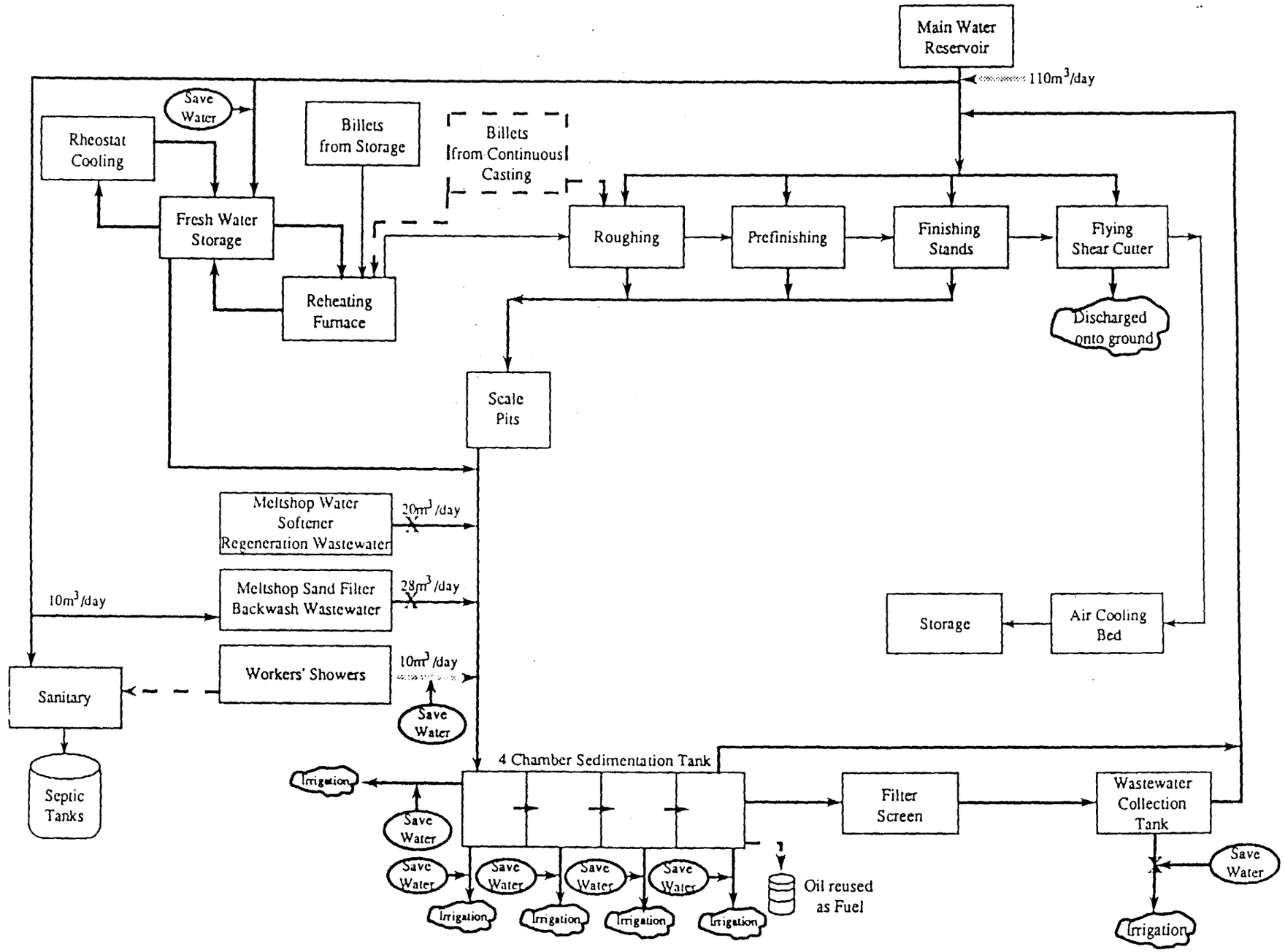
Water Conservation Technique	Current Water Consumption (m^3/d)	Projected Water Consumption (m^3/d)	Projected Water Savings (m^3/d)	Percent Decrease in Total Water Consumption
1. Eliminate discharges from wastewater treatment system	84	7	77	30.0
2. Install water conservation devices to deliver cooling water to roll stands	100	85	15	6.0
3.a. Eliminate once-through cooling of flying shears	10	0	10	4.0
3.b. Recycle cooling water of flying shears	10	1	9	3.5
4. Reuse reheating furnace cooling water blowdown	2.5	0	2.5	1.0
5. Install water conservation devices for sanitary water	10	8.5	1.5	0.6
Total Savings	110	17 - 94	27 - 90	25 - 82


Slag-forming Material (limestone)
Steel Scrap
Two Electric Arc Furnaces
- roof
- transformer
Tundish
Two Continuous Casting Lines
Two Hydraulic Shears
Product Storage
To Rolling Mill
Oxygen
OXYGEN PLANT
Compressor
Cooling Tower
32m3/day
10m3/day
Cooling Tower
Electricity
130m3/day
Mill Scale Pit
POWER STATION
Discharges onto ground
Closed-Loop Cooling System
Water Softener
Scale Pile
Sludge
Hydrocyclone
150m3/day
Regeneration backwash wastewater
20m3/day
28m3/day Backwash Water
Two Sand Filters
4th Engine
Ground Water Well
28m3/day Backwash Wastewater
3rd Engine
60m3/day
2nd Engine
1st Engine
Rolling Mill Wastewater Treatment
Process
Water or Wastewater
Oxygen
Raw Material
Electricity

FIGURES


Main Water Reservoir
110m³/day
Evaporation
Rheostat Cooling
Billets from Storage
Fresh Water Storage
Reheating Furnace
Roughing
Prefinishing
Finishing Stands
Flying Shear Cutter
Discharged onto ground
Scale Pits
Meltshop Water Softener Regeneration Wastewater
Meltshop Sand Filter Backwash Wastewater
Workers' Showers
10m³/day
Storage
Air Cooling Bed
Sanitary
Septic Tanks
4 Chamber Sedimentation Tank
Irrigation
Filter Screen
Wastewater Collection Tank
Irrigation
Irrigation
Irrigation
Irrigation
Irrigation
Oil reused as Fuel


Slag-forming Material (limestone)
Steel Scrap
Two Electric Arc Furnaces
- roof
- transformer
Tundish
Two Continuous Casting Lines
Two Hydraulic Shears
Product Storage
To Rolling Mill
OXYGEN PLANT
Compressor
Cooling Tower
32m3/day
Save Water
X
Cooling Tower
10m3/day
Save Water
X
Save Water
X
Blowdown
Cooling Tower
Reverse Osmosis
Reverse osmosis regeneration wastewater to disposal
130m3/day
Save Water
X
POWER STATION
Discharges onto ground
Save Water
Closed-Loop Cooling System
4th Engine
3rd Engine
2nd Engine
1st Engine
60m3/day
Water Softener
150m3/day
Ground Water Well
Mill Scale Pit
Scale Pile
Sludge
Hydrocyclone
Backwash Water
28m3/day Backwash Water
Two Sand Filters
28m3/day Backwash Wastewater
Rolling Mill Wastewater Treatment
Process
Water or Wastewater
Oxygen
Raw Material
Electricity
Flow Eliminated


Main Water Reservoir
110m³/day
Save Water
Rheostat Cooling
Billets from Storage
Billets from Continuous Casting
Fresh Water Storage
Roughing
Prefinishing
Finishing Stands
Flying Shear Cutter
Reheating Furnace
Discharged onto ground
Scale Pits
Meltshop Water Softener Regeneration Wastewater
20m³/day
Meltshop Sand Filter Backwash Wastewater
28m³/day
10m³/day
Storage
Air Cooling Bed
Workers' Showers
10m³/day
Sanitary
Save Water
Septic Tanks
4 Chamber Sedimentation Tank
Irrigation
Filter Screen
Wastewater Collection Tank
Save Water
Oil reused as Fuel

APPENDICES

APPENDIX A
EXAMPLE OF AUDIT QUESTIONNAIRE

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JORDAN IRON AND STEEL INDUSTRY COMPANY (JISICO)

Auditor/Firm: SAIC/RSS

Date: Jan. 10, 1995

ATTACHMENT A

AUDIT QUESTIONAIRE

SITE DESCRIPTION

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO

Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

PROCESS INFORMATION

Operation Type: -- Continuous -- Discrete

Meltshop - Batch or Semi-Batch -- Other_____

R. Mills Continuous

Document	Complete? (Y/N)	Current? (Y/N)	Document Number
Process Flow Diagram	Y	Y	
Material/Energy Balance	—		
Design	—		
Operating	—		
Flow/Amount Measurements			
Stream			
1) Meltshop	Y	Y	
2) Sister Companies	Y	Y	
Analyses/Assays			
Stream			
Cooling tower	Y	Y	
Plant Layout	Y	—	
Process Description	—	—	
Operating Manuals	—	—	
Equipment List/Age	—	—	
Equipment Specifications	—	—	
Piping & Instrument Diagrams	—	—	
Plot and Elevation Plan(s)	Y	—	
Environmental Audit Report	—	Y	
Permit/Permit applications	N.A	N.A	
Raw Material Inventory Records	Y	Y	
Product Inventory Records	Y	Y	
Management method practiced for each wastewater stream			
Wastewater treatment facilities	Y	Y	
Waste management practice	Y	Y	
Ancillary facilities	Y	Y	
Annual cost for management of the wastewater discharge	N.A	N.A	
Photographic records	N.A	N.A	

N. A : not applicable

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

INPUT MATERIALS* SUMMARY

Material	DESCRIPTION[1]		
	Stream No.	Stream No.	Stream No.
Name			
Source/Supplier SCRAP GENERATORS			
Component of Concern			
Annual Consumption Rate			
Overall			
Component(s) of Concern			
Purchase Price, $ per			
Overall Annual Cost			
Delivery Mode[2] TRUCKS			
Shipping Container Size & Type[3]			
Storage Mode[4] PILING			
Transfer Mode[5] OVER HEAD CRANES			
Empty Container Disposal/Management	N.A		
Shelf Life	N.A		
Supplier Would			
- accept expired material (Y/N)	N.A		
- accept shipping containers (Y/N)	N.A		
Acceptable Substitute(s), if any	N.A		
Alternate Supplier(s)	N.A		
Product Inventory Records	Y		

1. Stream number, if applicable, should correspond to those used on process flow diagram
2. e.g., pipeline, tank truck, etc.
3. e.g., drum, paper bag, tank, etc.
4. e.g., outdoor, warehouse, underground, aboveground, etc.
5. e.g., pump, forklift, conveyor, etc.
6. e.g., crush and dump, clean and recycle, return to supplier, etc.

* See attached sheet

Material Used In Meltshop	Quantity/year (t/yr)
Ferro-Manganese	480
Ferro-Silicon	120
Calcium Flouride	150
Coke breeze	150
High Alumina Bricks (For EAF Roof)	100
Basic Refractory Bricks (MgO > 92%)	200
High Alumina Bricks (For Tundish)	40
Guming Mix (MgO based)	300
Graphite Electrodes for EAFs	200
High Alumina Bricks for Ladle	200
Monolithicks (Basic) for EAF Bottom	100
Monolithicks for EAF Launder	50
Copper Moulds for Continous Casting Machine	50

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 1 of 4)

1. Waste Stream Name/ID: Regeneration Stream No. _____

2. Waste Characterization (attach additional sheets with composition data, as necessary)

   --- Gas --- [Liquid] --- [Solid] --- Mixed phase

   Density kg/M³ N.A High Heating Value Cal/kg _____
   pH _____ Flash Point _____ % Water _____

3. Waste Leaves Process as:

   -- air emission -- [wastewater] -- [solid waste]

4. Occurrence:
   -- continuous
   [-- discrete]
   discharge triggered by -- chemical analysis _____
   -- other (describe) _____

   Type -- periodic _____ length of period _____
   -- [sporadic]

5. Generation Rate: Regen.
   Annual _____ kg per year
   Maximum _____ kg per _____
   Average 20 ~~kg per~~ m³/d
   Frequency _____ batches per _____
   Batch Size _____ average _____ range

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 2 of 4)

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? --- [Yes] ---- No

Describe how the waste is generated.

The Regeneration Waste is generated when the Ion Exchangers are regenerated after producing 500 m³ soft water.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component, equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, venting losses, etc.

BEST AVAILABLE COPY

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 1 of 4)

1. Waste Stream Name/ID: Regeneration Stream No. _____

2. Waste Characterization (attach additional sheets with composition data, as necessary)

   --- Gas --- [Liquid] --- [Solid] --- Mixed phase

   Density kg/M³ N.A High Heating Value Cal/kg _____

   pH _____ Flash Point _____ % Water _____

3. Waste Leaves Process as:

   -- air emission -- [wastewater] -- [solid waste]

4. Occurrence:

   -- continuous

   [-- discrete]

   discharge triggered by -- chemical analysis _____

   -- other (describe) _____

   Type -- periodic _____ length of period _____

   -- [sporadic]

5. Generation Rate: Regen.

   Annual _____ kg per year

   Maximum _____ kg per _____

   Average 20 ~~kg per~~ m³/d

   Frequency _____ batches per _____

   Batch Size _____ average _____ range

BEST AVAILABLE COPY

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10, 1995

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 2 of 4)

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? --- [Yes] ---- No

Describe how the waste is generated.

The Regeneration Waste is generated when the Ion Exchangers are regenerated after producing 500 m³ soft water.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component, equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, venting losses, etc.

BEST AVAILABLE COPY

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO

Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 3 of 4)

Waste Stream Regeneration and Backwash waste streams

7. Management Method

Leaves site in
--- bulk
--- 55 gal drum
-✓ other (describe) Discharged to Treatment

Disposal Frequency interrupted

Applicable Standards/Regs N.A

Managed
-✓ onsite --- offsite
--- other (describe)

Recycling
--- direct use/re-use
--- energy recovery
--- redistilled
--✓ other (describe) recycled to the Rolling Mills

reclaimed material returned to site?

--- Yes --- [NO] --- used by others

residue yield
residue disposal

Treatment
--- biological
--- oxidation/reduction
--- pH adjustment
--- precipitation
-✓ other (describe) Sedimentation iron oxide is dumped onsite

Final Disposition
--- Dump
--- pond
-✓ other (describe) recycled, and some is used for irrigation.

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 4 of 4)

BEST AVAILABLE COPY

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

cost as of * _____ (quarter and year)

Cost Element	Unit Price JD per ____	Reference/Source
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Taxes		
Total disposal Cost		

*N.A: not Obtained

WQTCP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

WASTE STREAM INFORMATION

(one form for each stream)

Stream ID: _____

1. Streamname: Regeneration and backwash
(wastewater, waste oil, still bottoms, etc.)

2. Discharge Identification: Ion-Exchangers and Sand filters.
(Enter process or equipment from which stream is discharged)

3. Stream flow/quality:

minimum flow: _____ L/min
maximum flow: _____ L/min
Regeneration average flow: 20000 L/~~min~~ day

4. Is stream continuous orintermittent? Intermittent

5. Which of following is the cause of the waste?

a. Process chemistry = (Reaction stoichiometry, kinetic, yield).
Describe: _____

b. Engineering Design (capacity, pressure, temperature limitations, etc.). Describe: The Ion Exchangers need to be regenerated and the Sandfilters need to be backwashed.

c. Operations = (operating rates, order of addition, etc.) Describe: _____

d. Maintenance = (leaks, spills, corrosion, etc.)
Describe: _____

6. Are the components of the waste stream a raw material (RM), product (P), useful byproduct (UPB), nonuseful byproduct (NBP), solvent (S), catalyst (C), or an impurity (I) in the raw material?

(Attach analysis records if possible)

Fill out attached Figure 1 for each waste stream

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO

Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

Component Name	Conc (mg/L)	Check One						
		RM	P	UBP	NBP	S	C	I

7. Waste stream characteristics -- pH: ___ TSS: ___ TDS: ___
Color: ___ Hardness: ___ Odor: ___ TOC: ___ Other: ___

8. Current disposition of the stream: To treatment

9. Current effluent criteria and disposal limitation: JSS 202

10. Permits relevant to the waste stream disposition: N.A

11. Current cost of disposal and/or treatment for this waste stream: N.A

12. If stream is currently being treated, list:

a. Current treatment parameters (chemical consumption, treatment conditions, etc.):

b. Existing treatment equipment (identify, size and type of equipment):
Sedimentation Ponds (4)
2 Circular Screens
1 collection tank

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO

Auditor/Firm: SAIC and RSS

Date: Jan. 10, 1995

Other pertinent information: N.A

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO Auditor/Firm: SAIC and RSS

Date: JAN. 10. 1995

WASTE STREAM SUMMARY

Component of Concerns	Stream No[1]		Stream No		Stream No	
Waste ID/Name Regen. + Backwash.						
Source/Origin						
Annual Generation Rate (units_____)	13440 m³/yr					
Overall						
Component(s) of Concern						
Cost of Disposal	N.A					
Unit Cost (JD per _____)						
Overall (per Year)	N.A					
Method of Management[2]	Treated by sedimentation and					
	Ultimately discharged for irrigation					
Priority Rating Criteria[3] *	W	Rating (R)	R*W	Rating (R)	R*W	Rating (R)	R*W
Regulatory Compliance							
Treatment/Disposal Cost		Discharge to Wadi + irrigation					
Waste Quantity Generated							
Waste Hazard							
Safety Hazard							
Minimization Potential							
Potential Byproduct Recovery							
Sum of Priority Ranking Scores							
Priority Rank							

1. Stream number, if applicable, should correspond to those used on process flow diagrams.
2. For example, sanitary dump, onsite recycle, dewatering, etc.
3. Rate each stream (W) in each category on a scale from 0 to 10.

OPTION DEVELOPMENT

Meeting Format (e.g., brainstorming, nominal group technique) _____

Meeting Coordinator _____

* More information is needed.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JLSICO

Auditor/Firm: SAIC and RSS

Date: Jan. 10. 1995

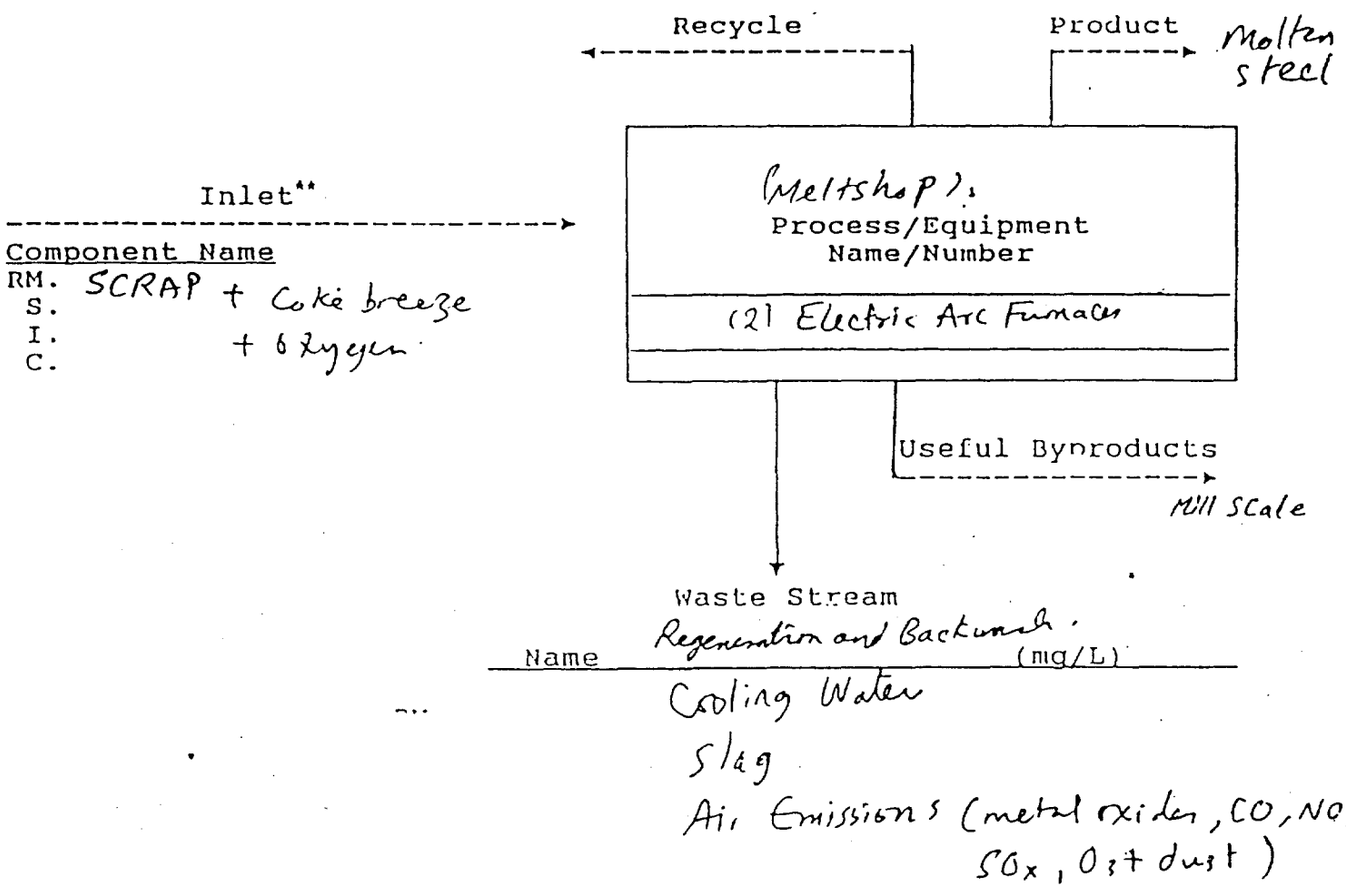
Other pertinent information: N. A

WQICP WASTE MINIMIZATION AUDIT

Facility Name: JISICO

Auditor/Firm: SAIC and RSS

Date: Jan-19-1995



WQICP WASTE MINIMIZATION AUDIT

Facility-Name: MSICO Auditor/Firm: SAIC and RSS

Date: Jan. 10, 1995

OPTION DEVELOPMENT *

Page 2 of 2

Option Name: _____

Briefly describe the option _____

Waste Stream(s) Affected; _____

Input Material(s) Affected: _____

Product(s) Affected: _____

Indicate Type;--- Source Reduction
--- Equipment-Related Change
--- Personal/Procedure-Related Change
--- Material-Related Change

--- Recycling/Reuse
--- Onsite --- Material reused for original Purpose
--- Offsite --- Material used for lower-quality Purp.
--- Material sold
--- Material burned for heat recovery

* will be developed in the report

APPENDIX B
INFORMATION PROVIDED BY THE JISICO FACILITY

STEEL MAKING DIVISION
PROCESS DESCRIPTION (IN BREIF)

IMPORTED AND STEEL SCRAP SUPPLIED BY LOCAL MARKET IS GENERALLY UNLOADED IN MELTSHOP SCRAP YARD. BULKY AND LIGHT SCRAP IS PROCESSED IN AUTOMATIC BALER BEFORE LOADING IT IN SCRAP YARD. THICK AND HEAVY SCRAP PIECES ARE CUT BY HYDRAULIC SHEAR T400 BEFORE BRINGING THEM TO SCRAP YARD. BESIDES THERE IS ALSO 500 TON BASKET PRESS INSTALLED BETWEEN THE EAFS AND SCRAP YARD IN ORDER TO INCREASE THE BULK DENSITY OF SCRAP IN THE BASKET.

STEEL SCRAP IS CHARGED BY OVER HEAD CRANE EQUIPED WITH ELECROMAGNE AND ELECTRO HYDRAULIC GRABS INTO THE CHARGING BASKETS. SCRAP BASKET FULL OF SCRAP IS WEIGHED AT WEIGHING BRIDGE AND IS CHARGED INTO THE ELECTRIC ARC FURNACE AFTER SWIVELLING ITS ROOFS BY HYDRAULIC CYLINDEF EAF ROOF IS CLOSED AND ELECTRIC POWER IS SWITCHED ON . THREE GRAPHI ELECTRODES COMES VERTICALLY DOWN AND UP AUTOMATICALLY CONTROLLED ELECTRO-HYDRAULIC SERVO-MECHANISM. ONCE ELECTRODES TOUCH STEEL SCRAP AND LIFTED BY SERVOVALVES , ELECTRIC ARC WITH ALMOST 4000 CENTIGRADE TEMPERATURE IS PRODUCED. THIS ARC LEADS TO MELTING OF STEEL SCRAP.

ONCE FIRST SCRAP CHARGE IS MELTED , SECOND AND THIRD BAKET IS CHARGE UNTIL 14.5 MT SCRAP IN ONE HEAT IS COMPLETED. DURNG MELTDOWN PERIOD OXYGEN GAS IS USED TO CUT THE HOT SCRAP IN THE EAF IN ORDER TO REDU THE MELTDOWN TIME. ABOUT 70 KGS/ MT LIMESTONE IS ADDED INTO THE FURNACE ALONGWITH CALCIUM FLOURSPAR AND MILLSCALE FOR SLAG BUILD U

AFTER CLEAR MELT MOLTED STEEL SAMPLE IS POURED INTO SAMPLING MOULD AFTER THE SAMMPLE HAS BEEN SOLIDIFIED IT IS SENT TO SPECTROMETER LABORTARY FOR THE ANALYSIS OF CARBON, SULFUR, PHOSPHOROUS, CHROMIUM,

NICKLE, SILICON, MANGANESE, ALUMINIUM, MOLBDENUM, COPPER AND TIN. ANALYSI RESULT IS COMPARED WITH THE LIMITS AND RANGES OF INTERNATIONAL STEEL STANDARD BEING PRODUCED. IF ELECMENTS PERCENTAGES ARE LESS OR MORE THAN LIMITS SET BY THE STANDARDS . THESE ARE ADJUSTED BY EAFS SUPERVISOR–SPECIALIZED IN STEEL MAKING. FOR EXAMPLE IF CARBON IS HIGHE , OXYGEN GAS IS LANCED INTO THE STEEL BATH IN ORDER TO OXIDIZE THE CARBON. IF SULFUR IS HIGHER MOLTED STEEL IS DESULFURIZED BY REDUCING SLAG. THE ELEMENTS WTH LOW NEGATIVE STANDARD FREE ENERGY OF THEIR OXIDES DELTA G'' LIKE COPPER AND TIN CANNOT BE REMOVED FROM MOLTEN STEEL BY CONVENTIONAL STEEL MAKING PRACTICE . THERFORE PERCENTAGE OF THESE DETRIMENTAL ELEMENTS IS CONTROLLED BY SCRAP INSPECTOR. HYDROGE GAS IS ALSO REDUCED DURING OXYGEN LANCING.

WHEN TEMPERATURE OF STEEL IS NEAR ABOUT 1685 CENTIGRADE , MEASURED BY THERMOCOUPLE, AND STEEL SPECIFICATIONS ARE ADJUSTED ACCORDING TO REQIURED STEEL STANDARD, HEAT IS TAPPED INTO 14 MT CAPACITY STEEL LADLE LIFTED BY 30/10 TON OVERHEAD CASTING CRANE. LADLE FULL OF MOLTEC STEEL IS FUTHER SHIFTED TO THE CONTINUOUS CASTING PLANT. SLIDE GATE FIXED AT THE BOTTOM OF LADLE IS OPENED SOTHAT MOLTEN STEEL MAY FLOW TO TUNDISH. TUNDISH HAS TWO BOTTOM ZIRCONIA NOZZLES. EACH NOZZLE DIRECT MOLTEN STEEL STREAM DOWN INTO THE SQUARE – TUBE COPPER MOLDS. BOTH THE COPPER MOLD ARE COOLED BY SOFT WATER EXTENALLY TO GET MOLTEN STEEL SOLIDIFIED. DURING SOLIDIFICATION BILLET IS DRAWN BY ROLLS DRIVEN BY MOTO–GEAR UNIT AT PRESET RATE TOWARDS HYDRAULIC SHEAR WHICH CUTS BILLETS INTO PRESET LENGTH AUTOPMATICALLY.

AFTER THE BILLETS HAS BEEN CUT BY HYDRAULIC SHEAR , THESE ARE TRANSFERRED TO THE COOLING BED AND FINALLY TO THE BILLET STOCKYARD OF

WATER SYSTEM AND DISTRIBUTION IN JISICO.LTD

ON 16/17-4-1966 JISICO'S WATER WELL STARTED TO WORK. IN BEGINNIG WATER WAS SUPPLIED TO ROLLING MILLS ONLY BECAUSE AT THAT TIME MELTSHOP AND NATIONAL STEEL COMPANY DIDNOT EXIST

STEEL MELTSHOP WAS COMMISSIONED IN SEPTEMBER 1979. PRESENTLY ABOU 350 CUBIC METER OF WATER IS USED DAILY FROM A.M WELL AND USERS OF THI QUATITY ARE ROLLING MILLS . STEEL MELTSHOP. POWER STATION AND OXYGEN PLANT OF JORDAN IRON AND STEEL COMPANY INDUSTRY LTD : AND NATIONAL STEEL ROLLING MILLS & CHEMICALS FACTORY. CONCERNING QUANTITY AND FLOW RATE OF WATER CONSUMED BY A.M SECTIONS . PLS REFER TO ENCLOSED FLOW DIAGRAM.

ALL THE A.M SECTIONS USE HARD WATER EXCEPT STEEL MELTSHOP WHICH HAVE WATER TREATMENT PLANT. A BREIF DESCRIPTION OF WTP IS AS FOLLOW.

WATER WELL: TOTAL DEPTH OF BORE: 91 METER. DEPTH OF PUMP: 81 MTR., WATER TABLE LEVEL AT THE TIME OF COMMISSIONING : 48.430 MTR. WATER HARDNESS : APPROX. 280 PPM.

WATER FROM WELL IS SUPPLIED TO THE BASE EXCHANGE ZEAOLITE PROCESS SOFTENER AND SOFT WATER IS COLLECTED IN MAIN WATER STORAGE BASIN WITH TOTAL SYSTEM VOLUME OF 500 CUBIC METER. FROM MAIN STORAGE WATER IS PUMPED TO POWER STATION WHERE TWO DIESEL ENGINES EACH 4600 HP ARE IN OPERATION ROUND THE CLOCK. HOT WATER WITH 9 DELTA T°C RETURNS TO HOT-WATER TANK OF WTP. WATER SUPPLY TO ENGINES IS CONTINUOUS. HOT WATER IS FUTHER PUMPED TO TWO CROSS FLOW COOLING TOWERS EACH WITH 680 CUBIC METER/ HR. FLOW WITH 6 DEGREE CENTIGRADE DELTA T

MELTSHOP.

FROM BILLET STOCKYARD COLD BILLETS ARE SUPPLIED TO ROLLING MILLS DEPARTMENT .

BEFORE ROLLING . COLD BILLETS ARE CHARGED INTO FUEL/AIR FIRED REHEA FURNACES. AT APPROX. 1200 CENTIGRADE BILLETS ARE DISCHARGED FROM FURNACES AND BY CONVEYOR ROLLS BILLET IS TAKEN TO ROLLING MILLS STA TURN BY TURN IN ORDER TO REDUCE THE SECTION OF BILLETS INTO BARS. REDUCTION IS COMPLETED IN MANY PASSES . DURING ROLLING ROLLS ARE CONTINUOUSLY COOLED BY WATER SPRAY.

FOR FUTHER INFORMATIONS PLS REFER TO ENCLOSED PROCESS FLOW DIAGRA

ABOUT 10 CUBIC METER OF SOFT WATER IS SUPPLIED TO OXYGEN PLANT D MAKEUP QUANTITY FOR THEIR TINY WATER COOING SYSTEM (VOLUME 50 CL

WATER IS ALSO SUPPLIED TO THE SLAG DOOR JACKETS AND TANSFORMERS BOTH ELECTRIC ARC FURNACES AND HOT WATER ENTER INTO MAIN BASIN COOLING TOWERS.

THE MAJOR USER OF SOFT WATER IN STEEL MELTSHOP IS CONINUOUS CA PLANT. THE FLOW RATE IS ESTIMATED 300 CUB.MTR / HR. HOWEVER FLOW IS CONTNUOUS AS THEIR ARE 10 TO 13 HEATS DAILY AND EACH HEAT TAKES A 40 TO 60 MINUTES. THERE ARE THREE DISTRIBUTIONS OF WATER IN CC PL BOTH COPPER MOLDS ARE COOLED BY SOFT WATER AND HOT WATER WI APPROX. 7 DEGREE DELTA T. RETURNS TO MAIN BASIN VIA COOLING TOV IN THE SECONDARY STAGE WATER IS SPRAYED DIRECT ON THE RED HOT BILLETS. THEREFORE HOT WATER CARRY SCALE (IRON OXIDE) AND IS COLLE IN SCALE PIT NEARBY THE CASTING PLANT. SCALE PIT VERTICAL PUMPS DE SCALE MIXED HOT WATER TO THE HYDROCYCLONE IN ORDER TO REMOVE MAJOR PART OF SCALE AND TO DELIVER THAT SCALE TO SCALE RECOVERY LOCATED ON THE ONE SIDE OF CYCLONE. FROM HYDROCYCLONE WATER RELATIVELY LESS SCALE ENTERS TO TWO SAND FILTERS ALTERNATELY. A FILTERATION WATER IS PUMPED FROM HOT WATER STORAGE TANK TO MAI WATER STORAGE BASIN VIA COLLING TOWERS.

AT THIRD STAGE MACHINARY PARTS OF CC. PLANT ARE COOLED AND CLEAN WATER RETURNS TO COOLING TOWERS.

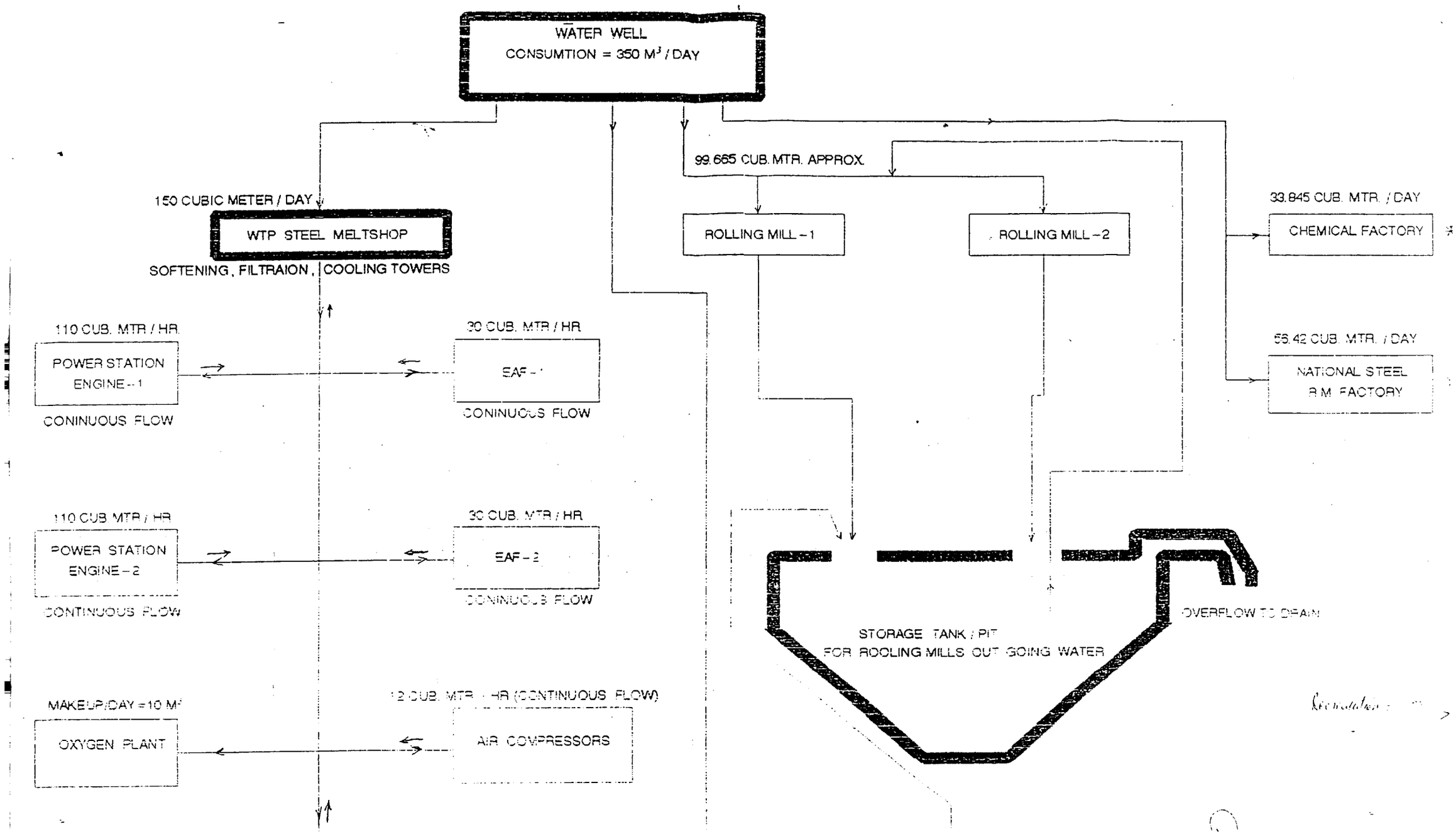
USUALLY HARDNESS OF WATER IN MAIN STORAGE IS KEPT UNDER 30 PP

AFTER THE PRODUCTION OF APPROX. 500 CUBIC METER OF SOFT WATER. R OF BASE EXCHANGE SOFTENER IS REGENERATED BY BRINE .

CONCENTRATION FACTOR OF WATER IN WTP OF MELTSHOP IS APPROX. 2.8–

BESIDES. A.M PROCESS SCALE INHIBITING AND SLUDGE CONDITIONER , AI BIOCIDES FROM HOSEMAN ENLAND AND NALCO ARE USED.
DAILY MAKEUP QUATITY FOR WTP(WATER TREATMENT PLANT) OF MELTSHOP ESTIMATED 150 CUBIC METER . IN ORDER TO BALANCE THE EVAPORATION . BLOWDOWN, DRIFT AND WATER LOSSES.

CONCERNING ROLLING MILLS. WATER IS TAKEN FROM WATER WELL AND SUPPLIED TO THE ROLLING MILLS ROLLS AND SOME OTHER PARTS FOR TH COOLING . HOT WATER MIXED WITH MILLSCALE AND SOME TIME WITH A LIT BIT FUEL OIL AND GREASE IS COLLECTED BACK IN TO PIT (SHOWN IN FLOV DIAGRAM WITH THICH–WIDE LINE) . FROM PIT WATER IS AGAIN PUMPED BA(ROLLING MILLS WITH OUT ANY FILTATION, DESCALING OR DEOILING / DEGREA IN FACT THERE NO ANY WTP FOR ROLLING MILLS DEPTT. OF JISICO. LTD.
THERE IS ALWAYS OVERFLOW TO DRAIN FROM THIS PIT AND CONCERNING POLUTION PROBLEM THAT OVER FLOW IS TO BE CONSIDERED AS THE MAIN POINT.


WATER WELL
CONSUMTION = 350 M³ / DAY
99.665 CUB. MTR. APPROX.
150 CUBIC METER / DAY
WTP STEEL MELTSHOP
SOFTENING, FILTRAION, COOLING TOWERS
ROLLING MILL – 1
ROLLING MILL – 2
33.845 CUB. MTR. / DAY
CHEMICAL FACTORY
110 CUB. MTR / HR.
POWER STATION ENGINE – 1
CONINUOUS FLOW
30 CUB. MTR / HR
EAF – 1
CONINUOUS FLOW
55.42 CUB. MTR. / DAY
NATIONAL STEEL R.M. FACTORY
110 CUB. MTR / HR
POWER STATION ENGINE – 2
CONTINUOUS FLOW
30 CUB. MTR / HR
EAF – 2
CONINUOUS FLOW
OVERFLOW TO DRAIN
STORAGE TANK / PIT
FOR ROOLING MILLS OUT GOING WATER
MAKEUP/DAY = 10 M³
OXYGEN PLANT
12 CUB. MTR / HR (CONTINUOUS FLOW)
AIR COMPRESSORS

water treatment plant data

Page 1

same plant builder.

DA ITALIA: OFFER COMPOSITION: –DESCALING LINE , –COOLING EQUIPMENT, –MAIN PROCESS PUMPS, –MAKE UP WATER TREATMENT, –SWICHBOARD, –SERVICES. DESCALING LINE (PLANT SECTION): FLOW RATE CUBIC METERS /HR= NO. OF PUMPS=2 ; PUMP CAPACITY EACH ONE= 40 M3/HR ; PUMP HEAD = 27 M.W.; MOTOR HP = 20 ; IMPELLER= TORQUE FLOW ; HYDROCYCLONE= 1 NO. ; SCALE PIT RECOVERY TANK= 1 NO. ; VOLUME M3=7 ; DEEP BED PRESSURE FILTER NO. =2 ; DIA= 2 METER : FILTERING RATE= CU.M.SQ.M.H =6.5 ~EXT. 13 . BACKWASH REQUIREMENTS: AIR SCOURING: BLOWERS NO.=1 ; OUTPUT SUCKED 200 CU.M.H : PRESSURE = 7 M.W.G ; BHP 10 ; MOTOR HP = 15 . BACK WASH WATER : 1ST PHASE = 50 M3/HR ; TIME = 10 MINUTES ; 2ND PHASE = 90 M3/HR ; TIME 15 MINUT HYDROCYCLONE WITH 60 DEGREE HOPPER SIZED FOR 40 M3/H FLOW. FILTER DIA=2000MM ; FILTER MEDIA DEPTH MM= 1800MM ; WORKING PRESSURE= 3 KG/CM2 EQUIPED WITH POLYPROPYLENE NOZZLES. AIR BLOWER AIR DILIVERY = 220 M3/HR ;PRESSURE = 7 MWG ; BHP= 10 ; MOTOR= 15 ; POLES: 2 .

COOLING EQUIPMENT : BASIC DESIGN DATA: WET BULB TEMPERATURE= 25 DEGR. C ; COOLED WATER TEMPERATURE= 35 DEGREE C . DISCONTINUOS FLOW: PRIMARY+TERTARY COOLING/LINE=145 M3 /HR FLOW WITH 25 C DIFFERENCE= 3625000 KCAL/HR: FROM SECONDARY COOLING/ LINE = 40 M3/HR FLOW WITH 40 C TEMP. DIFFERENCE= 1600000 KCAL/HR. TOT: 185 M3/HR/LINE A WITH AVG TEMP. DIFFERENCE OF 28 C DEG. SO TOT KCAL = 5225000 / LINE. CONTINUOUS FLOW: FROM EAF =50M3/H WITH 25 C DIFFER SO 1250000 KCAL/HR HEAT. FROM COMPRESSORS 10 M3/HR FLOW AT 10 C DIFFERENCE SO 100000 KCAL HEAT . FROM DIESEL ENGINES(2 NOS.) 230 M3/H FLOW WITH 25 C DEGREE DIFF. SO HEAT= 5750000 KCAL. SO TOT CONTNUOUS FLOW =290 M3/H WITH AVG 24.5 C DIFF. SO TOT HEAT OF CONTNOUS FLOW= 7100000 KCAL.

COOLED WATER TANK: 300 M3 ; TOT DEPTH= 3.30 METER ; WATER DEPTH= 2.7 METER. EMERGENCY ELEVATED TANK: VOLUME=150 M3 (SUGGESTED) HIEGHT= + 2 METER ABOVE GROUND LEVEL . CLORINATION: CL GAS 2 PPM.

BASIC DESIGN DATA

INCUSIONS	RAW WATER AS TDS	ANALYSIS AS CACO3	SOFTENED WAT AS CACO3	DECARB.WAT. AS CACO3
Ca	74	185	10	67
Mg	20	82		
Na	32	70	327	70
K	2.4	3	3	3
HCO3	266	218	218	18
Cl	63.2	89	89	89
So4	11.5	12	12	12
NO3	26.8	21	21	21
SIO2	13.1	13.1	13.1	13.1
Ph	8			
TOT. HARDNESS		267	10	67
TOT.ALKALINITY		218	10	18

MAKE UP RATE OF FLOW REQUIREMENT : WATER LOSSES: CONT. FLOW EVAP. 290*3.6*24 M3/DAY=250 (EXTENSION +250) ; DISC. FLOW EVAP. 185*3.7*10 M3/DAY=70/LINE (EXTEN. +70) ,EST. DRIPPING SECONDARY CIRCUIT M3/DAY=30 (EXTENSION +30); TOTAL: 350M3/DAY (EXTENSION +350). LOSSES IN CUBIC METE. PER HOUR=15 (EXTEN. +15) .

BLOW DOWN: –WITH SOFTEND MAKE–UP =15 M3 /HR.(+15), WITH DECARBON

P.T.O

BEST AVAILABLE COPY

MAKE-UP= 8 M3/HR (-8)

MAKE UP WATER TREATMENT: SOFTENING PLANT = 80 M3/HR (-20)
FILTER(SOFTENER) DIA= 1800MM; RESIN VOLUME = 3 M3; RATE OF FLOW MIN= M3/HR; MAX=85 M3/HR; FILTERING RATE(MAX RATE OF FLOW)= 24 M3/HR; VOLUMETRIC RATE(MAX RATE OF FLOW)= 28 VOL/HR; SOFTENED WATER PRODUCTION CUM = 550; REGENERATION LEVEL(NaCl 100%)= 120 GRAM/L 100FOR ONE REGENERATION = 660 KG; SODIUM CHLORIDE SUGGESTED STORAGE = 20 MT

CLORURO DI SODIO (p.m 58.454)
NACL a 20--4 C DEG.

PESO SPECIFICO	GRADI BAUME	%	GRAMMI LITRO
1.0058	0.8	1	10.05
1.0125	1.8	2	20.15
1.0258	3.6	4	41.07
1.0419	5.8	6	62.48
1.0559	7.7	8	84.47
1.0707	9.6	10	107.1
1.0857	11.5	12	130.3
1.0009	13.3	14	154.1
1.1162	15.1	16	178.6
1.1319	16.9	18	203.7
1.1478	18.7	20	229.5
1.164	20.4	22	256.1
1.1804	22.2	24	283.3
1.1972	23.9	26	311.3

IPOCLORITE DI SODIO
NACLO a 20-4 DEG.C

GRADI BAUME	DENSITA' G
1	1.007
2	1.014
3	1.021
4	1.028
5	1.036
6	1.044
7	1.051
8	1.059
9	1.067
10	1.075
11	1.083
12	1.091
13	1.099
14	1.108
15	1.116
16	1.125
17	1.134
23	1.19
28	1.24

BEST AVAILABLE COPY

NOTE :- A.M data doesnot repr
the existing situation of th
plant exactly. Because wa
cooling Tower indicated in am
has been dismantled & Two
Towers each 680m³/hr. has been in

21/12/12

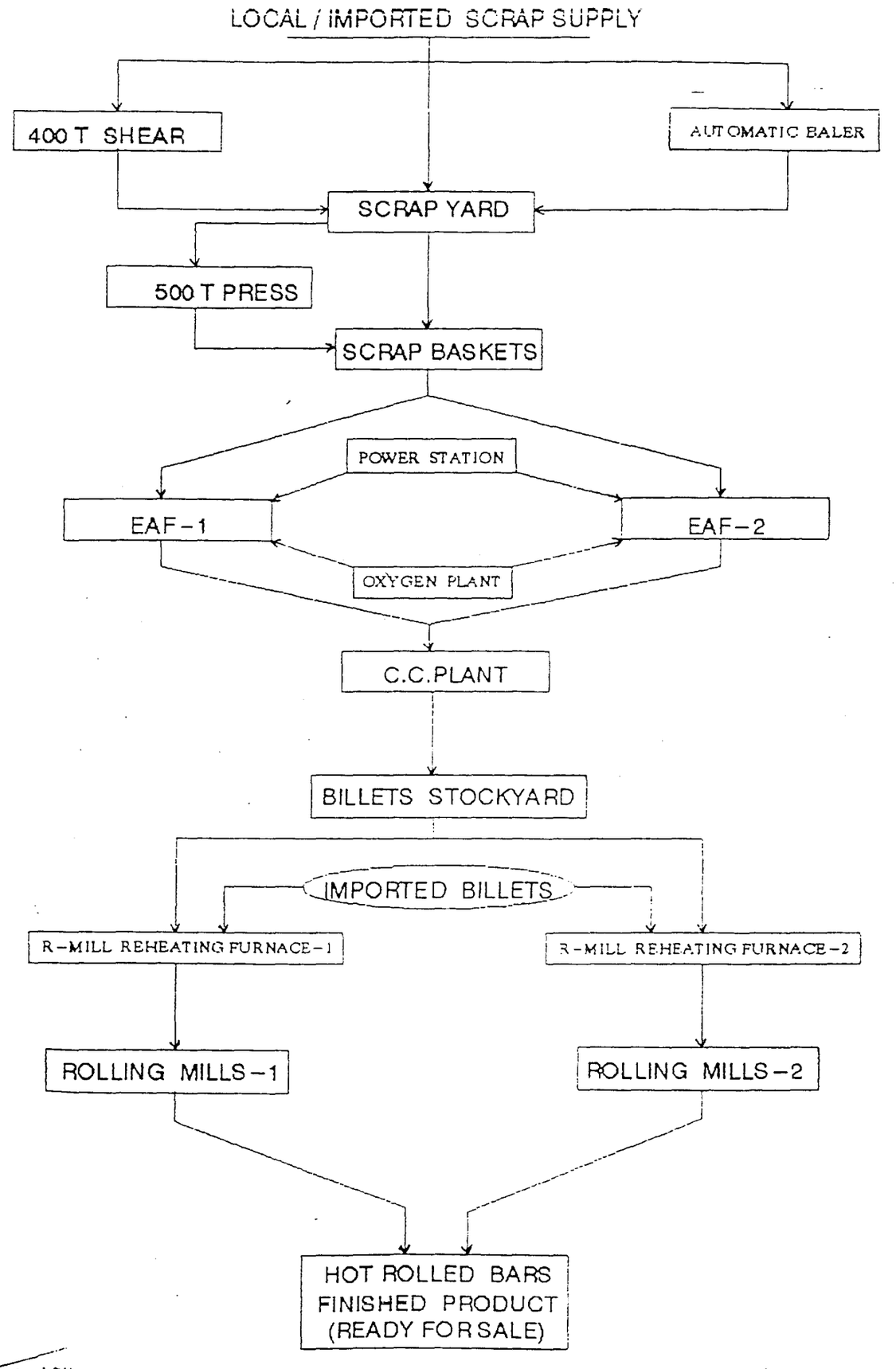
100

input materials Summary

Material used in SteelMeltShop (Approx.)

1. ferro-Manganese → 480 MT/year approx
2. ferro-silicon → 120 MT "
3. calcium floride (fluor spar) → 150 MT " "
4. coke breeze → 150 MT "
5. High Alumina bricks (80%) for EAFs Roof → 100 MT "
6. Basic ~~tr~~ Refractory bricks MgO > 92 % for EAFs → 200 MT " "
7. High Alumina bricks (80%) for Tundishes → 40 MT "
8. Gunning mix (MgO based) for HOT repair of EAFs → 300 MT "
9. Graphite Electrodes for EAFs → 200 MT "
10. High Alumina bricks (80%) for Steel ladle → 200 MT " "
11. Monolithic's (basic) for EAF Bottom → 100 MT " "
12. " for E.A.F.s launder → 50 MT " "
13. copper Moulds for cc. Machine → 50 pcs/year

P.T.O



24/12/94

AHMED

Jordan Steel

Total No's. of Employees in JIS works } = ~ 250 No.

Rolling Mills No. 1
Commissioning for production = ~ 1968

Rolling Mill No. 2
Commissioning = 1976

Steel meltshop

Production Start = 1979

Rolling Mills Production in 1993 = 3411 MT of bar

Steel Meltshop production in 1993 = 40196 good Billet's

Wastewater Treatment — Nil —

Major Source of waste water discharge } = (i) Rolling Mill depth - as there is no any w. Treatment plant.
(ii) Blowdown from "WTP" of Meltsh
(iii) Employees used water for baths e.t.c.

Facility Name :- Jisizo.

Area :- Iron & Steel (Imiajam Zarka)

Major Products :- (i) Billets (by Meltshop)
Semi-finished Product.
(ii) concrete reinforcing bars (8 ϕ ~
— finished product.

Production rate :- Meltshop → 40 000 MT/a
Rolling mills → ~ " /a.

Supplier would :-
accept expired materials Y/N — No.

NOTE :- I have found out drawing wi
from Liberary today & have sen
to Amman for Photocopy. co
will be available on 31-12-91
& onward if required.

Jordan Iron & Steel Co.

by Mr. Waleed Hussein

This establishment consists of several units each has a definite purpose. These units are:

1) Oxygen Generation Unit

The purpose of this industrial unit is to produce oxygen from air to be used in increasing the efficiency of the arch furnace and to market oxygen in cylinders for medical and industrial purposes.

2) Electricity Generation Unit

The purpose of this unit is to generate electricity by diesel generators for use in electric furnace.

3) Scrap Melting Unit

This unit aims at melting scrap in an arch furnace at which temperature rises to 1700°C. The scrap is then cast into a certain machine to produce billets.

4) Rolling Mill Units

The purpose of these unit is to manufacture steel bars (Hot Rolled Bars) from billets. These bars are used in construction industry.

Oxygen Generation Unit

Raw Materials

Only air

Manufacturing Process

- Compressing air in a several stage compressor. The pressure in each stage is as follows:

First Stage:	2.5	Kg_f / cm^2
Second Stage:	10.0	Kg_f / cm^2
Third Stage:	25.0	Kg_f / cm^2
Forth Stage	60.0	Kg_f / cm^2

As a result of compressing air, its temperature increases. Therefore water cooling should be used in the four stages.

- Treating air from oil and humidity by using Zeolite nax
- Liquefying air using the Turbine method and Throttling Valve.
- Separation of liquid Oxygen from liquid Nitrogen using a Separation Column.

Water Use in Industry

The major role of water in this process is cooling in the multi stage compressor. This important because compressing air leads to an increase in air temperature. Cooling is done after each stage before proceeding to the next stage.

After the four stages water is discharged to a main water pool where a cooling tower exists. The water is pumped to the top of the tower where it falls through a packing made of wood through a shower distributor. A high speed fan is also used. The cooled water is collected at the bottom of the tower is pumped and recycled again to the compressor in closed cooling system.

Several substances are added such as sodium hypochlorite to control algae growth and scale inhibitors such as cooltreat 603, Polytreat 200, Microtreat 2010. Dispro MC 1005 may replace Microtreat next year.

Note:
Various phosphates such as orthophosphates (Trisodium Phosphate) and complex phosphate (sodium hexametaphosphate) are used as antiscaling agents.

The addition of substances is done according to the following program:

- Preliminary Addition and is done once, the following substances are added
  - 2 liters of Cooltreat 603
  - 1.25 liter of polytreat 200

- Periodic additions
  - 100 ml of Cooltreat 603
  - 40 ml of polytreat 200

- Other additions
  - First day in first week 3 liters of Sodium Hypochlorite is added
  - First day in second week 0.75 liter of Microtreat 2010 is added
  - First day in third week 0.75 liter of Microtreat is added.
  - First day in forth week 0.75 liter of Microtreat 2010 is added

Water used should be soft water and is brought from the softener of the scrap melting. Pool volume is 50 m^3. Make up water as a result of evaporation is 10 m^3 in summer and 6 m^3.

Water is replaced and the pool is cleaned every three month from sediments. Sediments is disposed on nearby soil were infiltrating occurs to groundwater.

Electricity Generation Unit

The power station consists of four generation units: one 3.0 MVA, and three 3.6 MVA. where MVA is Mega Volt Ampere.

Water is used for cooling the engines. Sometimes, diesel leaks and cause water pollution. These leaks are the only anticipated source of water pollution.

Scrap Melting Unit

The raw material used :

- Scrap
- Calcium Florid
- Manganese
- Silicon
- Carbon

The manufacturing process:

- The scrap is melt in an arch furnace at a temperature of 1700°C.
- A sample is taken from molten iron for examination and determination of missing ingredient so they can be added later.
- Using a crane the molten iron is moved to the casting machine.
- The molten steel is cast into rectangular moulds that is cut later on to billets.

Water Use in Industry

The main water use is cooling to solidify the molten iron. This is done in the casting machine. The water discharged from the casting machine is sent to cyclones to remove suspended iron oxides and then to a sand filter. Water is then collected in a pool with a capacity of 500 m^3. This pool is fed from well water after softening. Softened water hardness is less than 15 ppm. A cooling tower is placed near the pool to cool the pool water so it can be used for cooling iron in casting machine. Thus cooling water is in a closed loop system.

Some substances are added for different purposes:

- 1.8 liter of Colltreat 603 is added everyday as a scale inhibitor.
- 7.5 liter of Microtreat 2010 is added everyday as a scale inhibitor
- .75 Polytreat 200 is added everyday as a scale inhibitor
- 1 liter of sodium hypochlorite is added everyday to control algae

Substances used as scale inhibitor be replaced next year with DISPRO MC 1005

Total hardness of pool water should be less than 30 ppm. In case hardness increases above this figure, part of the water is discharge from the pool to the simple wastewater treatment plant and softened water is added so total hardness becomes 10 ppm. Softener needs regeneration every 4 days. Make up water as a result of evaporation is estimated to be 125 m^3

Rolling Mill Unit

Raw material

Steel billets

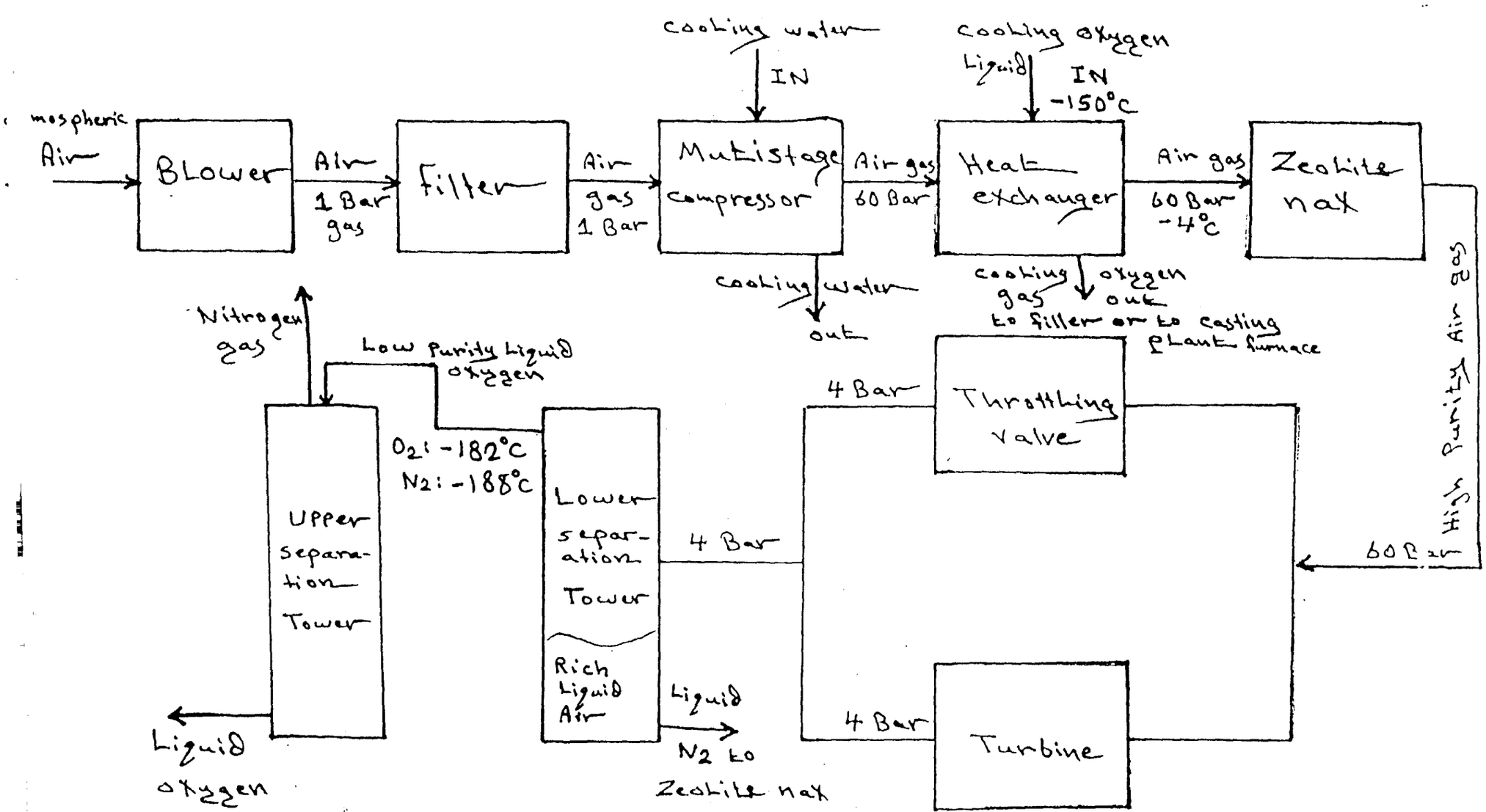
Manufacturing Process

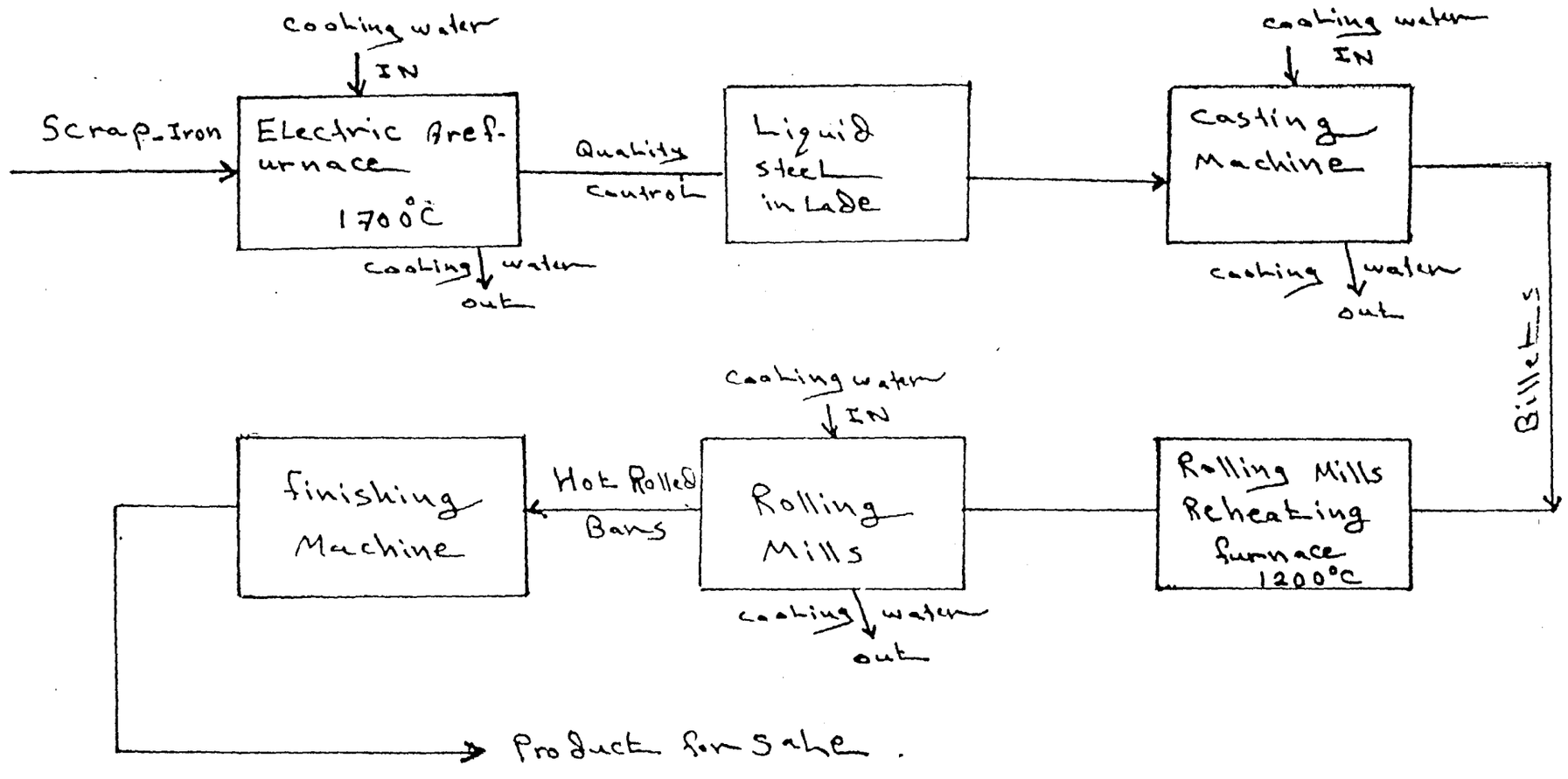
- Steel is heated in a furnace at 1200°C
- Billets pass through a rolling mill where it is rolled and its diameter is reduced.
- The bars are cut to certain lengths

Water Use in Industry

Water is mainly used in cooling. Fat and grease is introduced into water along with iron oxides. Water is discharged through lined channels into a wastewater treatment plant(WWTP). The WWTP consist of a sedimentation tank where iron oxides is precipitated then filtration. Treated water is discharged afterwards to the rolling mill. Water from the scrap melting unit and electric generation unit is also discharged to WWTP.

Water in this unit may be considered as a close system except when water overflows from the channels leading to the WWTP. In this case water is used for irrigation. Water recycled back to the rolling mill is estimated to be 800 m^3/day while make up water is estimated to be 80 m^3/day supplied from the well.


mospheric Air
Blower
Air 1 Bar gas
Filter
Air gas 1 Bar
Cooling water IN
Mutistage compressor
Air gas 60 Bar
Cooling water out
Cooling Liquid oxygen IN -150°C
Heat exchanger
Air gas 60 Bar -4°C
Zeolite nax
Cooling gas oxygen out to filter or to casting plant furnace
Throttling valve
4 Bar
High Purity Air gas 60 Bar
Nitrogen gas
Low Purity Liquid oxygen
Upper separation Tower
O_2: -182°C
N_2: -188°C
Lower separation Tower
Rich Liquid Air
4 Bar
Liquid N_2 to Zeolite nax Purifier where N_2 is heated to 40°C In order to vaporize Impurities for $1\frac{1}{2}$ h..
Turbine
Liquid oxygen by Pump to Heat exchanger


Cooling water
IN
Scrap Iron
Electric Arc Furnace
1700°C
Cooling water
out
Quality
Control
Liquid steel in Ladle
Casting Machine
Cooling water
IN
Cooling water
out
Billets
Rolling Mills Reheating Furnace
1200°C
Cooling water
IN
Rolling Mills
Cooling water
out
Hot Rolled Bars
Finishing Machine
Product for Sale.

APPENDIX C

OVERVIEW OF THE REGULATIONS APPLICABLE TO JISICO DISCHARGE

APPLICABLE REGULATORY CRITERIA

Current Status of Environmental Regulations in Jordan:

In order to assess Jordan Iron and Steel Industry Company (JISICO) compliance with applicable Jordanian standards and regulations, it is of importance at this stage to present an overview of Jordan's environmental protection control laws, standards, and regulations. Interestingly, Jordan has no comprehensive law to control water, air, and soil pollution. However, a Jordanian Environment Act (JEA) was drafted two years ago to achieve the principle objectives mentioned in the National Environment Strategy (NES) for Jordan. JEA is currently awaiting approval from the Parliament.

In general, the nature of water pollution standards and regulations in Jordan vary according to sources. Industrial wastewater discharges are regulated by the Jordanian Standard Specification number 202 (Table 1) adopted in 1981 by the Department of Standards and Specifications (DSS) and revised in 1990. Standard 202 regulates industrial wastewater discharges to rivers, wadis, groundwater, the sea, and reuse for irrigation. This standard covers 37 pollutant parameters and sets maximum allowable concentration limits of pollutants in the discharged industrial wastewater effluents. Moreover, the standard also contains narrative conditions to protect public health, aquatic life, worker health; and groundwater quality. The standard is not associated with a permitting mechanism and therefore is self-implementing.

Drinking water quality is regulated by the Jordanian standard number 286. Tables 2a - 2e present quantitative requirements of pertinent characteristics including physical, chemical,radiation, and health related issues. With regards to regulations related to the quality of treated domestic wastewater to be reused in irrigation, Jordan has neither standards nor

112

guidelines. However, it is a common practice to use the Food and Agriculture Organization (FAO) and World Health Organization (WHO) Guidelines as a reference.

Tables 3 through 5 are related to the quality of treated domestic wastewater effluents to be reused in irrigating agricultural crops. The remaining Tables 6 - 12 present the tolerance and sensitivity of crops to salinity and other specific ions like Sodium, Boron and Chloride. These are adapted from the FAO Guidelines (1985). Treated domestic wastewater is regulated by the Jordanian Standard 893 (Table 13) adopted in 1994 by DSS. Regarding air pollution, Jordan does not have any existing standards or regulations to control air pollution.

Regulations Applicable to the JISICO Discharges:

Industrial wastewater produced by the JISICO consists of cooling tower blowdown from the oxygen plant, the power station, and the rolling mill's reheating furnace. These blowdowns are discharged onto the ground, therefore the Jordanian standard 202 for industrial discharges to wadis, sea, or reuse for irrigation would apply. Other industrial wastewater discharge include the softener regeneration and sand filter backwash. These effluents are currently discharged to the rolling mill's cooling water treatment system. The rolling mill's cooling water treatment system discharges water onto the ground for irrigation of nearby trees. This discharge is also subject to Standard 202 for reuse for irrigation and, if the discharge reaches a wadi, it would be subject to standard 202 for discharge to wadis.

Table 1

Summary of requirements of Jordan Standard 202/1991 for disposal of industrial effluents.

Parameter	Maximum Allowable Limit, (mg/l)+			
	Disposal To			
	Wadis & Rivers	Sea	Groundwater Recharge	Reuse for Irrigation**
BOD5	50M	-	50M	-
COD	150M	200	150M	-
DO	1*	5*	1*	1*
TDS	3000(1)	-	1500 (1)	2000 (2)
TSS	50	-	-	100 (3)
pH (su)	6.5-9.0	5.5-9.0	6.5-9.0	6.5-8.4
Color (unit)	15	75	15	-
TC	-	4	-	-
FOG	5	10	Absent	5
Phenol	0.002	1	0.002	0.002
MBAS	25		15	-
NO3-N	12 (4)	-	12 (4)	30
NH3	5	12	5	5
T-N	-	125	-	50
PO4-P	15	-	-	-
Cl	500	-	500	350 (3)
SO4	500	-	500	400
F	1.5	-	1.5	-
HCO3	-	-	-	500
Na	-	-	400	-
Mg	-	-	-	-
Ca	-	-	-	-
SAR	-	-	-	9
Al	5	-	0.3	5
As	0.05	0.1	0.05	0.1
B	1	-	1	1 (5)
Cr	0.1	0.3	0.05	0.1
Cu	2	0.1	2	0.2
Fe	1	2	1	5
Mn	0.2	0.2	0.2	0.2
Ni	0.2	0.02	0.1	0.2
Pb	0.1	0.1	0.1	1
Se	0.02	0.02	0.05	0.02
Cd	0.01	0.07	0.02	0.01
Zn	15	-	15	2
CN	0.1	1	0.1	0.1
Hg	0.001	0.001	0.001	0.001
TCC MPN/100ml		5000	-	-
TFCC MPN/100ml	1000(6)	-	1000 (6)	1000 (6)
Nematodes	< 1	-	-	< 1

(+) All units are in mg/l except where noted.
(*) Minimum value.
(**) Depends upon, type and quantity of crops, irrigation methods,soil type, climate & groundwater in the area concerned.
(-) Undetermined.
(M) Monthly average.

Notes:
(1) TDS allowable limit is subject to the TDS concentration in the water supply and the water basin affectd.
(2) Allowable limits of wastewater reuse determine the degree of restriction (none, slight to moderate, or severe).
(3) Method of irrigation is determined by wastewater quality being used.
(4) Nitrate concentrations allowed are determined by its concentrations in the affected water basin.
(5) Could reach 3 mg/l.
(6) Geometric mean.

Table 2a
Jordanian Drinking Water Standards
A: Physical characterstics

Parameter	Permissible Limit	Max. allowable conc. in case no better source is available
Taste	aesthetically acceptable	-
Odor	aesthetically acceptable	-
Color	10 units	15 units
Turbidity	1 unit (JCU)	5 units
pH	6.5 < pH < 9	-
Temperature	8 - 25 c	-

Table 2b

Jordanian Drinking Water Standards

B: Chemical Charecterstics

Parameter	Max. Allowable Conc. mg/l
Pb	0.05
Se	0.01
As	0.05
Cr	0.05
CN	0.1
Cd	0.005
Hg	0.001
Sb	0.01
Ag	0.01

Table 2c
Jordanian Drinking Water Standards
C: Health related

Parameter	Permissible Limit mg/l	Max. allowable conc. in case no better source is avialable	Effects within max. allowable limits
TDS	500	1500	aesthetic
TH(CaCO3)	100	500	aesthetic
ABS	0.5	1	indicator
Al	0.2	0.3	aesthetic
Fe	0.3	1	aesthetic
Mn	0.1	0.2	aesthetic
Cu	1	1.5	aesthetic
Zn	5	15	aesthetic
Na	200	400	aesthetic
Ni	0.05	0.1	health
Cl	200	500	aesthetic
F	1	1.5	health
SO4	200	500	aesthetic
NO3	45	70	health

Table 2d

Jordanian Drinking Water Standards
D: Radiation

Parameter	Maximum limit Bq/l
Alpha-emitters (except for Radon)	0.1
Beta-emitters	1

Table . 2e

Jordanian Drinking Water Standards
E: Organic pollutants*

Parameter	Max. Permissible Conc. mg/l
A) Chlorinted Hydrocarbons	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
B) Chlorophenoxys	
2,4-D	0.1
2,4,5-TP (Trichlorophenoxy propionic acid)	0.01

* Other organic pollutants should not exceed the max. allowable limit set by WHO.

Table 3

Guidelines for Interpretations of water quality for Irrigation (1)

Potential irrigation problems	Units	Degree of restriction on use: None	Slight to moderate	Severe
Salinity (affects crop water availability) (2)				
EC_w (or)	dS/m	< 0.7	0.7 - 3.0	> 3.0
TDS	mg/l	< 450	450 - 2000	> 2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using (EC_w and SAR together) (3)				
SAR = 0-3 and EC_w	=	> 0.7	0.7 - 0.2	< 0.2
= 3-6	=	> 1.2	1.2 - 0.3	< 0.3
= 6-12	=	> 1.9	1.9 - 0.5	< 0.5
= 12-20	=	> 2.9	2.9 - 1.3	< 1.3
= 20-40	=	> 5.0	5.0 - 2.9	< 2.9
Specific ion toxicity (affects sensitive crops)				
Sodium (Na) (4)				
Surface irrigation	SAR	< 3	3 - 9	> 9
Sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl) (4)				
Surface irrigation	me/l	< 4	4 - 10	> 10
Sprinkler irrigation	me/l	< 3	> 3	
Boron (B) (5)	mg/l	< 0.7	0.7 - 3.0	> 3.0
Trace elements (see table E4)				
Miscellaneous effects (affects susceptible crops)				
Nitrogen (NO3-N) (6)	mg/l	<5	5 - 30	> 30
Bicarbonate (HCO3) (Overhead sprinkling only)	me/l	< 1.5	1.5 - 8.5	> 8.5
pH			Normal range 6.5 - 8.4	

(1) Adapted from University of California Committee of Consultants 1974.
(2) ECw means electrical conductivity, a measure of the water salinity, reported in deciSiemens per metre at 25C° (dS/m) or in units millimhos per centimeter (mmho/cm). Both are equivalent. TDS means total dissolved solids, reported in milligrams per liter (mg/L).
(3) SAR means sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. At a given SAR, infiltration rate increase as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw.
(4) For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most annual crops are not sensitive. With overhead sprinkler irrigation and low humidity (<30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops.
(5) For boron tolerances, see Tables 16 and 17.
(6) NO3-N means nitrate nitrogen reported in terms of elemental nitrogen (NH4-N and Organic-N should be included when wastewater is being tested).

Assumptions In the Guidelines

The water quality guidelines in Table 1 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deveations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there many be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid to arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 metres of the surface.

Methods and Timing of Irrigations: Normal surface or sprinkler irrigation methods are used. Water s applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] ≥ 15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in near daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil-water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These conditions result from a leaching fraction of 15-20 percent and irrigations that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restriction on Use: The "Restriction on Use" shown in Table 1 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clear-cut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.

BEST AVAILABLE COPY

Table . 4
Recommended maximum concentrations of
trace elements in irrigation water (1)

Element	Recommended maximum concentration(2) (mg/L)	Remarks
Al (aluminium)	5.0	Can cause non-productivity in acid soils (pH < 5.5). but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
As (arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Be (beryllium)	0.10	Toxicity to plants varies widly, raning from 5 mg/L for kale to 0.5 mg/L for bush beans.
Cd (cadmium)	0.01	Toxic to beans beets and turnips at concentrations as low as 0.1 mg/L in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co (cobalt)	0.05	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr (chromium)	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Cu (copper)	0.20	Toxic to a number of plants at 0.1-1.0 mg/L in nutrient solutions.
F (fluoride)	1.0	Inactivated by neutral and alkaline soils.
Fe (iron)	5.0	Not toxic to plants in aerated soils. but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li (lithium)	2.5	Tolerated by most crops to 5 mg/L, mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/L). Acts similarly to boron
Mn (manganeses)	0.20	Toxic to a number of crops at a few-tenths to a few mg/L, but usually only in acid soils.
Mo (molybdenum)	0.01	Not toxic to plants at normal concentrations in siol and water. Can be toxic to livestock if forage is grown in siols with high concentrations of available molybdenum.
Ni (nickel)	0.20	Toxic to a number of plants at 0.5-1.0mg/L; reduced toxicity at neutral or alkaline pH.
Pd (lead)	5.0	Can inhibit plant cell growth at very high concentrations.
Se (selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/L and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Sn (tin)		
Ti (titanium)		Effectively excluded by plants; specific tolerance unknown.
W (tungsten)		
V (vanadium)	0.1	Toxic to many plants at relatively low concentrations.
Zn (zinc)	2.0	Toxic to many plants atwidely varying concentrations, reduced toxicity at pH > 6.0 and in fine textured or organic soils.

1- Adapted from National Academy of Sciences (1972) and Pratt (1972).
2- The maximum concentration is based on a water application rate which is consistent with good irrigation practices (10000 m3/ha per years). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates lease than 10 000 m3/ha per year. The values given are for water used on a continuous basis at one site.
Source: FAO Guidelines, R.S. Ayers & D.w. Westcot (1985).

BEST AVAILABLE COPY

Table 5

Recommended microbiological quality guidelines for wastewater use in agriculture (a)

Category	Reuse conditions	Exposed group	Intestinal nematodes (b) (arithmetic mean no. of eggs per litre (c))	Faecal coliforms (geometric mean no. per 100ml) (c)	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked. sports fields, public parks, (d)	Workers, Consumer, public	<1	< 1000 (d)	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, Pasture and trees (e)	Workers	<1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation.

(a) In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly.

(b) Ascaris and Trichuris species and hookworms.

(c) During the irrigation period.

(d) A more stringent guideline (< 200 faecal coliforms per 100 ml) is appropriate for public lawns, such as hotel lawns. With which the public may come into direct contact.

(e) In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Source: Scientific group on health aspects of use of treated wastewater for agricultural and aquaculture-W.H.O.- Geneva 18-23 Nov. 1987.

BEST AVAILABLE COPY

Table 6

Chloride tolerance of some fruit crop cultivars and rootstocks.(a)

Crop	Rootstock or cultivar	Maximum permissible Cl in water without leaf injury (b),(c) (mg/L)
	Rootstocks	
Avocado (Persea americana)	West indian	180
	Guatemalan	145
	Mexican	110
Citrus (Citrus spp.)	Sunki mandarin, grapefruit	
	Cleopatra mandarin, Rangpur lime	600
	Sampson tangelo, rough lemon, sour orange, Ponkan mandarin	355
	Citrumelo 4475, trifolate orange, Cuban shaddock, Calamondin, Sweet orange, Savage citrange, Rusk citrange, Troyer citrange	250
Grape (Vitis spp.)	Salt Creek, 1613-3	960
	Dog ridge	710
Stone fruit (Prunus spp.)	Marianna	600
	Lovell, Shalil	250
	Yunnan	180
	Cultivars	
Berries (Rubus spp.)	Boysenberry	250
	Olallie blackberry	250
	Indian Summer raspberry	110
Grape (vitis spp.)	Thompson seedless, Perlette	460
	Cardinal, black rose	250
Strawberry (Fragaria spp.)	Lassen	180
	Shasta	110

(a) Data are adapted from Haas (13)

(b) For some crops, the concentrations given may exceed the overall salinity tolerance of that crop and cause some yield reduction before chloride ion toxicities. Values given are for the maximum concentration in the irrigation water. The values were derived from saturation extract data (ECe) by the following relationship : saturation extraction concentration = 1.5 water concentration.

(c) The maximum permissible values apply only to surface irrigated crops. Sprinkler irrigation may cause excessive leaf burn at values far below these, (see Table 3-10).

Source : FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table 7

GUIDLINES FOR INTERPRETING LABORATORY DATA ON WATER SUITABILITY FOR GRAPES

Potential Irrigation Problem	Unita	Degree of Restriction on Use		
		None	Slight to Moderate	Severe2
Salinity [3] *(affects water availability to crops)*				
ECw	dS/m	< 1	1.0 - 2.7	> 2.7
Toxicity *(Specific ions which affect growth of crop)*				
Sodium (Na^+)[4]	me/l	< 20	-	-
Chloride (Cl^-)[4]	me/l	< 4	4 - 15	> 15
Boron (B)	mg/l	< 1	1 - 3	> 3
Miscellaneous				
Bicarbonate (HCO_3^-)[5]	me/l	< 1.5	1.5 - 7.5	> 7.5
Nitrate-nitrogen (NO_3-N)	mg/l	< 5	5 - 30	> 30

1. Adapted from Neja et al. 1978.
2. Special management practices and favorable soil conditions are required for successful production.
3. Assumes that rainfall and extra water applied owing to inefficiencies of normal irrigation will supply the crop need plus about 15 percent extra for salinity control.
4. With overhead sprinkler irrigation, sodium or chloride in excess of 3 me/l under extreme drying conditions may result in excessive leaf absorption, leaf burn and crop damage. If overhead sprinklers are used for cooling by frequent on-off cycling, damage may occur even at lower concentrations.
5. Bicarbonate (HCO3) in water applied by overhead sprinklers may cause white deposits on fruit and leaves which reduces market acceptability, but is not toxic to the plant.

Table 8

PELATIVE SALT TOLERANCE OF VARIOUS CROPS AT GERMINATION[1]

Crop		50 percent Emergence reduction (ECe in dS/m)
Barley	*(Hordeum vulgare)*	16 - 24
Cotton	*(Gossypium hirsutum)*	15.5
Sugarbeet	*(Beta vulgaris)*	6 - 12.5
Sorghum	*(Sorghum bicolor)*	13
Safflower	*(Carthomus tinctorius)*	12.3
Wheat	*(Triticum aestivum)*	14 - 16
Beet, red	*(Beta vulgaris)*	13.8
Alfalfa	*(Medicago sativa)*	8.2 - 13.4
Tomato	*(Lycopersicon Lycopersicum)*	7.6
Rice	*(Oryza sativa)*	18
Cabbage	*(Brassica oleracea capitata)*	13
Muskmelon	*(Cucumis melo)*	10.4
Maize	*(Zea mays)*	21 - 24
Lettuce	*(Lactuca sativa)*	11.4
Onion	*(Allium cepa)*	5.6 - 7.5
Bean	*(Phaseolus vulgaris)*	8.0

1 Data taken from Maas (1984).

Table -9

Relative boron tolerance of agricultural crops (1), (2)

Very Sensitive (<0.5 mg/L)

Lemon	*Citrus Limon*
Blackberry	*Rubus spp.*

Sensitive (0.5-0.75 mg/L)

Avocado	*Persea americana*
Grapefruit	*Citrus X paradisi*
Orange	*Citrus sinensis*
Apricot	*Prunus armeniaca*
Peach	*Prunus persica*
Cherry	*Prunus avium*
Plum	*Prunus domestica*
Persimmon	*Diospyros Kaki*
Fig, Kadota	*Ficus carica*
Grape	*Vitis vinifera*
Walnut	*Juglans regia*
Pecan	*Carya illnoiensis*
Cowpea	*Vigna unguiculata*
Onion	*Allium cepa*

Sensitive (0.75-1.0 mg/L)

Garlic	*Allium sativum*
Sweet potato	*Ipomoea batatas*
Wheat	*Triticum eastivum*
Barley	*Hordeum vulgare*
Sunflower	*Helianthus anrainus*
Bean, mung	*Vigna radiata*
Sesame	*Sesamum indicum*
Lupine	*Lupinus hartwegii*
Strawberry	*Fragaria spp.*
Artichoke, Jerusalem	*Helianthus tuberosus*
Bean, Kidney	*Phaseolus vulgaris*
Bean, lima	*Phaseolus lunatus*
Groundnut/Peanut	*Arachis hypogaea*

Moderately Sensitive (1.0-2.0 mg/L)

Pepper, red	*Capsicum crucum*
Pea	*Pisum sativa*
Carrot	*Daucus carota*
Radish	*Raphanus sativus*
Potato	*Solanum tuberosum*
Cucumber	*Cucumis sativus*

Moderately Tolerant (2.0-4.0 mg/L)

Lettuce	*Lactuca sativa*
Cabbage	*Brassica oleracea capitata*
Celery	*Apium graveolens*
Turnip	*Brassica rapa*
Bluegrass, Kentucky	*Poa pratensis*
Oats	*Avena sativa*
Maize	*Zea mays*
Artichoke	*Cynara scolymus*
Tobacco	*Nicotiana tabacum*
Mustard	*Brassica juncea*
Clover, sweet	*Melilotus indica*
Squash	*Cucurbita pepo*
Muskmelon	*Cucumis melo*

Tolerant (4.0-6.0 mg/L)

Sorghum	*Sorghum bicolor*
Tomato	*Lycopersicon Lycopersicum*
Alfalfa	*Medicago sativa*
Vetch, purple	*Vicia benghalensis*
Parsley	*Petroselinum crispum*
Beet, red	*Beta vulgaris*
Sugarbeet	*Beta vulgaris*

Very Tolerant (6.0-15.0 mg/L)

Cotton	*Gossypium hirsutum*
Asparagus	*Asparagus officinalis*

(1) Data taken from Maas (1984)
(2) Maximum concentrations tolerated in soil-water without yield or vegetative growth reductions. Boron tolerance vary depending upon climate, soil conditions and crop varieties. Maximum concentrations in the irrigation wat are approximately equal to these values or slightly less.

Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table 10

Relative tolerance of selected crops to exchangeable sodium (1).

Sensitive (2)	Semi-tolerant(2)	Tolerant(2)
Avocado	Carrot	Alfalfa
(Persea americana)	*(Daucus carota)*	*(Medicago sativa)*
Deciduous Fruits	Clover, Ladino	Barley
Nuts	*(Trifolium repens)*	*(Hordeum vulgare)*
Bean, green	Dallisgrass	Beet, garden
(Phaseolus vulgaris)	*(Paspalum dilatatum)*	*(Beta vulgaris)*
Cotton *(at germination)*	Fescue, tall	Beet, sugar
(Gossypium hirsutum)	*(Festuca arundinacea)*	*(Beta vulgaris)*
Maize	Lettuce	Bermuda grass
(Zea mays)	*(Lactuca sativa)*	*(Cynodon dactylon)*
Peas	Bajara	Cotton
(Pisum sativum)	*(Pennisetum typhoides)*	*(cossypium hirsutum)*
Grapefruit	Sugarcane	Paragrass
(Citrus paradisi)	*(Saccharum officinarum)*	*(Brachicria mutica)*
Orange	Berseem	Rhodes grass
(Citrus sinensis)	*(Trifolium alexandrinum)*	*(Chloris gayana)*
Peach	Benji	Wheatgrass, crested
(Prunus persica)	*(Melilotus parviflora)*	*(Agropyron cristatum)*
Tangerine	Raya	Wheatgrass, fairway
(Citrus reticulata)	*(Brassica juncea)*	*(Agropyron cristatum)*
Mung	Oat	Wheatgrass, fairway tall
(Phaseolus aurus)	*(Avena sativa)*	*(Agropyron slongatum)*
Mash	Onion	Karnal grass
(Phaseolus mungo)	*(Allium cepa)*	*(Diplachra fusca)*
Lentil	Radish	
(Lens culinaris)	*(Raphanus sativus)*	
Groundnut *(peanut)*	Rice	
(Arachis hypogaea)	*(Oryza sativus)*	
Cram	Rye	
(Cicer arietirum)	*(Secale cereale)*	
Cowpeas	Ryegrass, Italian	
(Vigna sinensis)	*(Lolium multiflorum)*	
	Sorghum	
	(Sorghum vulgare)	
	Spinach	
	(Spinacia oleracea)	
	Tomato	
	(Lycopersicon esculentum)	
	Vetch	
	(Vicia sativa)	
	Wheat	
	(Triticum vulgare)	

Adapted from data of FAO-Unesco (1973); Pearson (1960); and Abrol (1982).
Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table 11

LABORATORY DETERMINATIONS NEEDED TO EVALUATE COMMON IRRIGATION WATER QUALITY PROBLEMS

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 - 3	dS /m
(or)				
Total Dissolved Solids	TDS	mg/l	0 - 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 - 20	me/l
Magnesium	Mg^{++}	me/l	0 - 5	me/l
Sodium	Na^{+}	me/l	0 - 40	me/l
Carbonate	CO_3^{--}	me/l	0 - .1	me/l
Bicarbonate	HCO_3^{-}	me/l	0 - 10	me/l
Chloride	Cl^{-}	me/l	0 - 30	me/l
Sulphate	SO_4^{--}	me/l	0 - 20	me/l
NUTRIENTS[2]				
Nitrate - Nitrogen	NO_3 - N	mg/l	0 - 10	mg/l
Ammonium - Nitrogen	NH_4 - N	mg/l	0 - 5	mg/l
Phosphate - Phosphorus	PO_4 - P	mg/l	0 - 2	mg/l
Potassium	K^{+}	mg/l	0 - 2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0 - 2	mg/l
Acid / Basicity	pH	1 - 14	6.0 - 8.5	
Sodium Adsorption Ratio[3]	SAR	$(me/l)^{1.2}$	0 - 15	

1. dS/m = desiSiemen/meter in S.I. units (equivalent to 1 mmho / cm - 1 millimmho / centimeter)
   mg/l = milligram per litre – parts per million (ppm).
   me/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l = 1 millimol / litre adjusted for electron charge.
2. NO3-N means the laboratory will analyse for NO3 but will report the NO3 in terms of chemically equivalent nitrogen. Similarly, for NH4-N, the laboratory will analyse for NH4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalen elemental nitrogen.
   The same reporting method is used for phosphorus.
3. SAR is calculated from the Na, Ca and Mg reported in me/l.

Table 12

Crop tolerence and yield potential of selected crops as influenced by irrigation water salinity (ECw) or soil salinity (ECe)

	Yield potential (2)									
	100%		90%		75%		50%		0% maximum(3)	
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw
Field crops										
Barley *(Hordeum Vulgare)* (4)	8.0	5.3	10	6.7	13	8.7	18	12	28	19
Cotton *(Gossypium hirsutum)*	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18
Sugarbeet *(Beta vulgaris)* (5)	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16
Sorghum *(Sorghum bicolor)*	6.8	4.5	7.4	5.0	8.4	5.6	9.9	6.7	13	8.7
Wheat *(Triticum aestivum)* (4), (6)	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20	13
Wheat durum *(Triticum turgidum)*	5.7	3.8	7.6	5.0	10	6.9	15	10	24	16
Soyabean *(Glycine max)*	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7
Cowpea *(Vigna unguiculata)*	4.9	3.3	5.7	3.8	7.0	4.7	9.1	6.0	13	8.8
Groundnut *(peanut)* *(Arachis hypogaea)*	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4
Rice *(paddy)* *(Oriza sativa)*	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6
Sugarcane (Saccharum officinarum)	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12
Corn *(maize)* *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Flax *(Linum usitatissimum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Broadbean *(Vicia faba)*	1.5	1.1	2.6	1.8	4.2	2.0	6.8	4.5	12	8.0
Bean *(phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Vegetable crops										
Squash zucchini *(courgette)* *(Cucurbita pepo melopepo)*	4.7	3.1	5.8	3.8	7.4	4.9	10	6.7	15	10
Beet, red *(Beta vulgaris)*(5)	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15	10
Squash, scallop *(Cucurbita pepo melopepo)*	3.2	2.1	3.8	2.6	4.8	3.2	6.3	4.2	9.4	6.3
Broccoli *(Brassica oleracea botrytis)*	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	14	9.1
Tomato *(Laycopersicon esculentum)*	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13	8.4
Cucumber *(Cucumis sativus)*	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10	6.8
Spinach *(Spinacia olerucea)*	2.0	1.3	3.3	2.2	5.3	3.5	8.6	57	15	10
Celery *(Apium graveolens)*	1.8	1.2	3.4	2.3	5.8	3.9	9.9	66	18	12
Cabbage *(Brassica oleracea capitata)*	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12	8.1
Potato *(Solanum tuberosum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Corn, sweet *(maize)* *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Sweet potato *(Impomoea batatas)*	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	11	7.1
Pepper *(Capsicum annuum)*	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.6	5.8
Lettuce *(Lactuca sativa)*	1.3	0.9	2.1	1.4	3.2	2.1	5.1	3.4	9.0	6.0
Radish *(Raphanus sativus)*	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	8.9	5.9
Onion *(Allium cepa)*	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.4	5.0
Carrot *(Daucus carota)*	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.0	8.1	5.4
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Turnip *(Phaseolus vulgaris)*	0.9	0.6	2.0	1.3	3.7	2.5	6.5	4.3	12	8.0
Forage crops										
Wheatgrass, tall *(Agropyron elongatum)*	7.5	5.0	9.9	6.6	13	9.0	19	13	31	21
Wheatgrass, fairway crested *(Agropyron cristatum)*	7.5	5.0	9.0	6.0	11	7.4	15	9.8	22	15
Bermuda grass *(Cynodon dactylon)* (7)	6.9	4.6	8.5	5.6	11	7.2	15	9.8	23	15
Barley *(forage)* *(Hordeum vulgare)* (4)	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20	13
Ryegrass, perennial *(Lolium perenne)*	5.6	3.7	6.9	4.6	8.9	5.9	12	8.1	19	13
Trefoil, narrowleaf birdsfoot (8) *(Lotus corniculatus tenuifolium)*	5.0	3.3	6.0	4.0	7.5	5.0	10	6.7	15	10

Table 12 Continued

	Yield potential									
	100%		90%		75%		50%		0%maximum (3)	
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	Ece	ECw
Harding grass *(Phalaris tuberosa)*	4.6	3.1	5.9	3.9	7.9	5.3	11	7.4	18	12
Fescue, tall *(Festuca elatior)*	3.9	2.6	5.5	3.6	7.8	5.2	12	7.8	20	13
_Wheatgrass, standard crested *(Agropyron sibiricum)*	3.5	2.3	6.0	4.0	9.8	6.5	16	11	28	19
Vetch, common *(Vicia angustifolia)*	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12	8.1
Sudan grass *(Sorghum sudanense)*	2.8	1.9	5.1	3.4	8.6	5.7	14	9.6	26	17
Wildrye, beardless *(Elymus truicoides)*	2.7	1.8	4.4	2.9	6.9	4.6	11	7.4	19	13
Cowpea *(forage)* *(Vigna unguiculata)*	2.5	1.7	3.4	2.3	4.8	3.2	7.1	4.8	12	7.8
Trefoil, big *(Lotus uliginosus)*	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.6	5.0
Sesbania *(Sesbania exaltata)*	2.3	1.5	3.7	2.5	5.9	3.9	9.4	6.3	17	11
Sphaerophysa *(Sphaerophysa salsula)*	2.2	1.5	3.6	2.4	5.8	3.8	9.3	6.2	16	11
Alfalfa *(Medicago sativa)*	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16	10
Lovegrass *(Eragrostis sp.)* (9)	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14	9.3
Corn *(forage)* *(maize)* *(Zea mays)*	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15	10
Clover, berseem *(Trifolium alexundrinum)*	1.5	1.0	3.2	2.2	5.9	3.9	10	6.8	19	13
Orchard grass *(Dactylis glomerata)*	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	18	12
Foxtail, meadow *(Alopecurus pratenis)*	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Clover, red *(Trifolium pratense)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, alsika *(Trifolium hybridum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, ladino *(Trifolium repens)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, strawberry *(Trifolium fragiferum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
_Fruit crops (10)										
Date palm *(Phoenix dactylifera)*	4.0	2.7	6.8	4.5	11	7.3	18	12	32	21
Grapefruit *(Citrus paradisi)* (11)	1.8	1.2	2.4	1.6	3.4	2.2	4.9	3.3	8.0	5.4
Orange *(Citrus sinensis)*	1.7	1.1	2.3	1.6	3.3	2.2	4.8	3.2	8.0	5.3
Peach *(Prunus persica)*	1.7	1.1	2.2	1.5	2.9	1.9	4.1	2.7	6.5	4.3
Apricot *(Prunus armeniaca)* (11)	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	5.8	3.8
Grape *(Vitus sp.)* (11)	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Almond *(Prunus dulcis)* (11)	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.8	6.8	4.5
Plum, prune *(Prunus domestica)* (11)	1.5	1.0	2.1	1.4	2.9	1.9	4.3	2.9	7.1	4.7
Blackberry *(Rubus sp.)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Boysenberry *(Rubus ursinus)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Strawberry *(Fragaria sp.)*	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4.0	2.7

(1) Adapted from Maas and Hoffman (1977) and Maas (1984) These data should only serve as a guide to relative tolerances among crops. Absolute tolerances vary depending upon climate, soil conditions and cultural practices. In gypsiferous soils, plants will tolerate about 2ds/m higher soil salinity (ECe) than indicated but the water salinity (ECw) will remain the same as shown in this tabel.

(2) ECe means average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, reported in decisiemens per meter (ds/m) at 25C. ECw means electical conductivity of the irrigation water in deci Siemens per meter (ds/m). The relationship between soil salinity and water salinity (ECe=1.5 ECw) assumes a 15-20 leaching fraction and a 40-30-20-10% water use pattern for the upper to lower quarters of the root zone.

(3) The zero yield potential or maximum ECe indicates the theoretical soil salinity (ECe) at which crop growth ceases.

(4) Barley and wheat are less tolerant during germination and seedling stage : ECe should not exceed 4 - 5 dS/m in the upper soil during this period.

(5) Beets are more sensitive during germination : ECe should not exceed 3 ds/m in the seedling area for garden beets and sugar beets.

(6) Semi-dwarf, short cultivars may be less tolerant.

(7) Tolerance given is an average of several varieties : Suwannee and Coastal Bermuda grass are about 20% more tolerant, while common and Greenfield Bermuda grass are about 20% less tolerant.

(8) Broadleaf Birdsfoot Trefoil seems less tolerant than Narrowleaf Birdsfoot Trefoil.

(9) Tolerance given is an average for boer, Wilmarr, Sand and Weeping Lovegrass ; Lehman Lovegrass seems about 50% more tolerant.

(10) These data are applicable when rootstocks are used that do not accumulate Na^+ and Cl^- rapidly or when these ions do not predominate in the soil.

(11) Tolerance evaluation is based on tree growth and not on yeild.

Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985)

Table 13

Summary of requirements of Jordanian Standard 893/1994 for treated domestic wastewater.

Parameter	Maximum allowable limit (mg/L)*	
	Disposed to wadis, rivers, surface water bodies, and groundwater recharge	Reuse for irrigation
pH	6.5-9	6.5-9
Temperature change (C°)	<3	-
D.O	≥1	-
TDS	3000	2000 (1)
TSS	50(3) / 200(4)	100 (1)
BOD5	50(3) / 50(4)	-
COD	150(3) / 150(4)	-
NH3	30	-
FOG	15	15
ABS	6	-
Cl2	0.5 (5)	-
Phenol	0.5	-
TFCC MPN/100mL	<1000	<1000 (6)
Intestinal nematodes	<1	<1 (6)

* All units are in mg/L except where noted.

(1) Depends on degree of restriction (none, slight to moderate, or severe).

(2) Depends on method of irrigation.

(3) Conventional wastewater treatment plants.

(4) Waste stabilization ponds.

(5) This is a minimum limit of residual chlorine and it should be linked with total faecal coliform count.

(6) FAO and WHO guidelines and their amendments should be taken into consideration.

APPENDIX D
SITE VISIT PHOTOGRAPHS

Photo 1 - Scrap steel storage

Photo 2 - Scrap steel storage

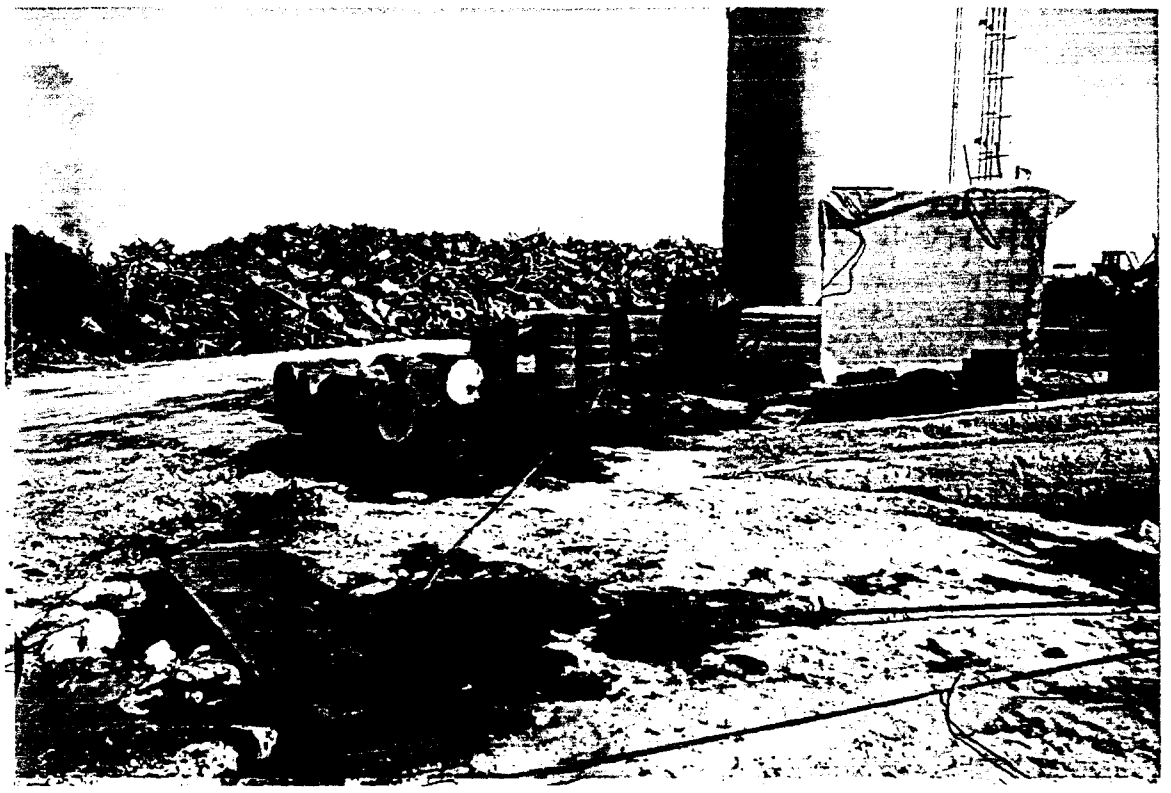


Photo 3 - Oil spill (oil storage tank in background with containment dike)

Photo 4 - Main water pipe from groundwater well

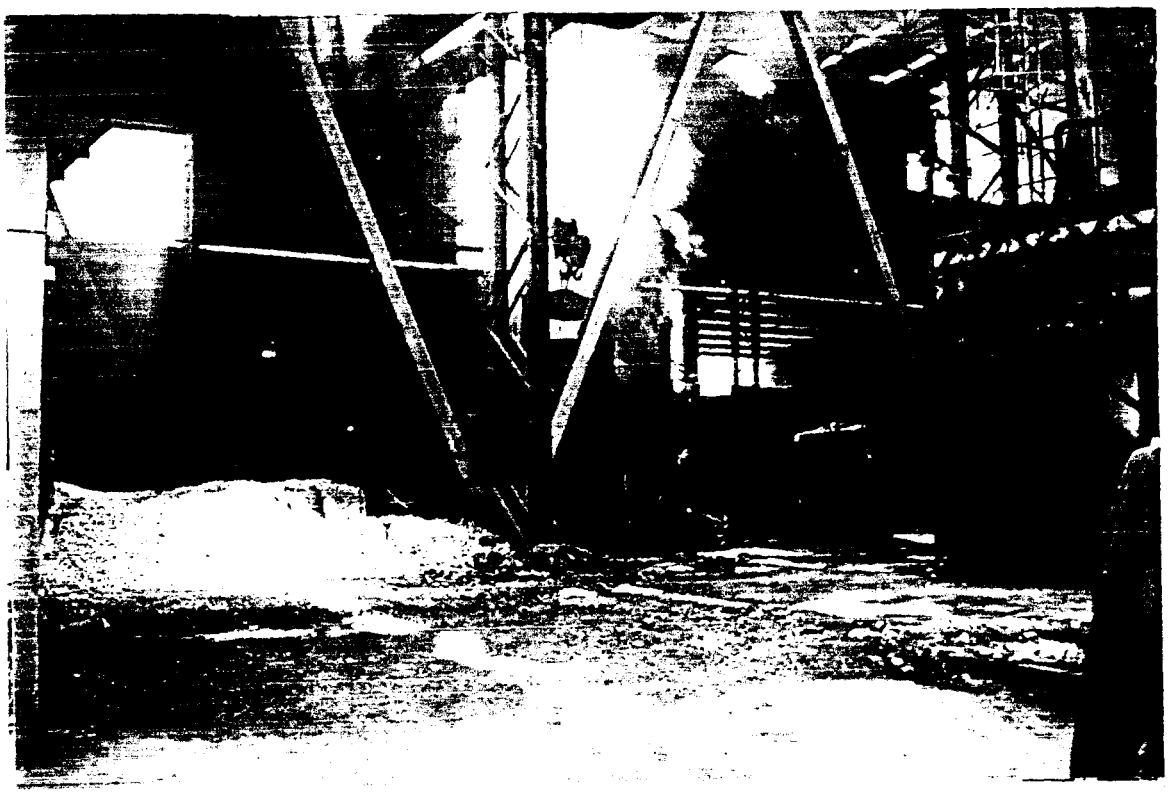
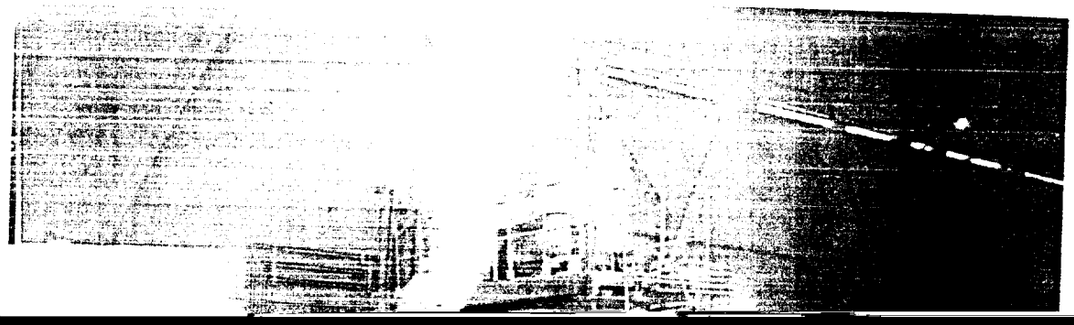


Photo 5 - Meltshop area

Photo 6 - Electric arc furnace in operation



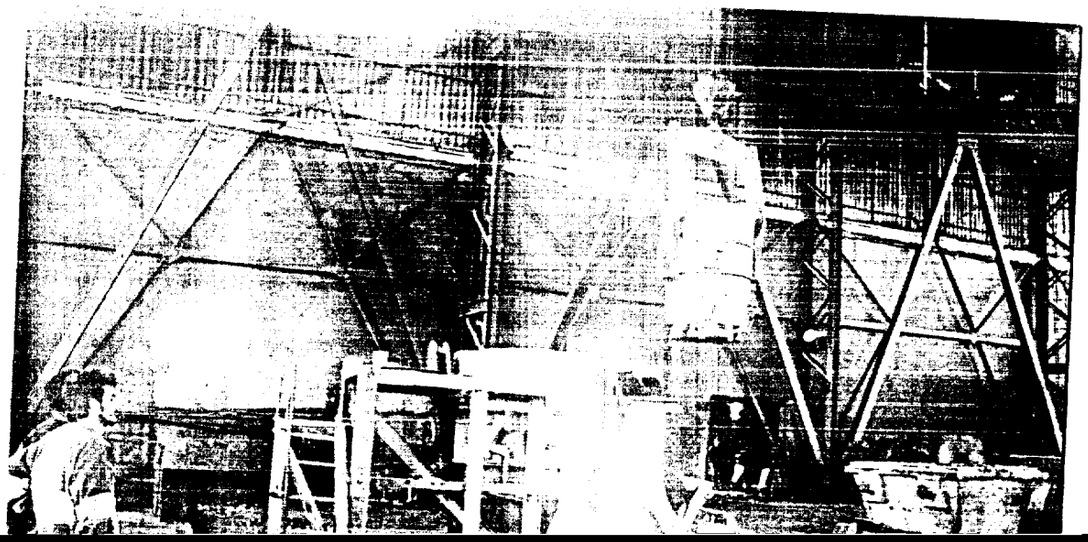


Photo 11 -
Copper tube mold

Photo 12 -
Continuous casting in operation

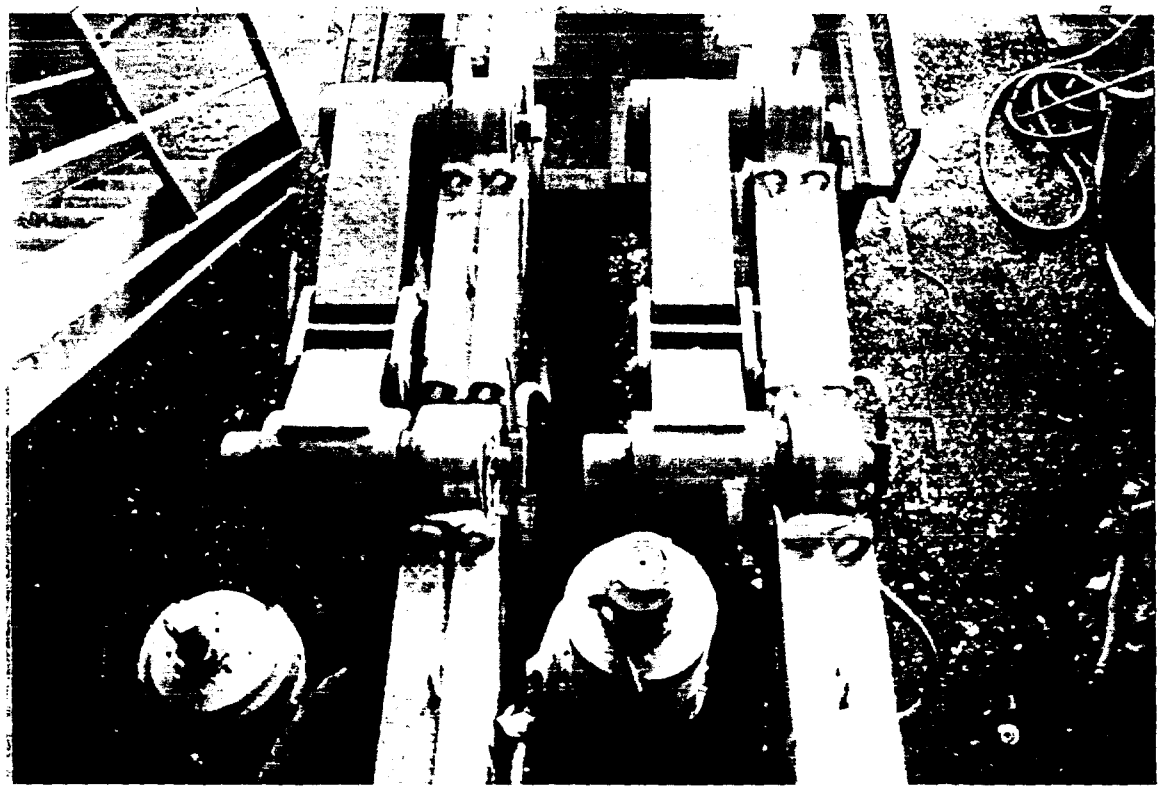


Photo 13 - Pincher rolls

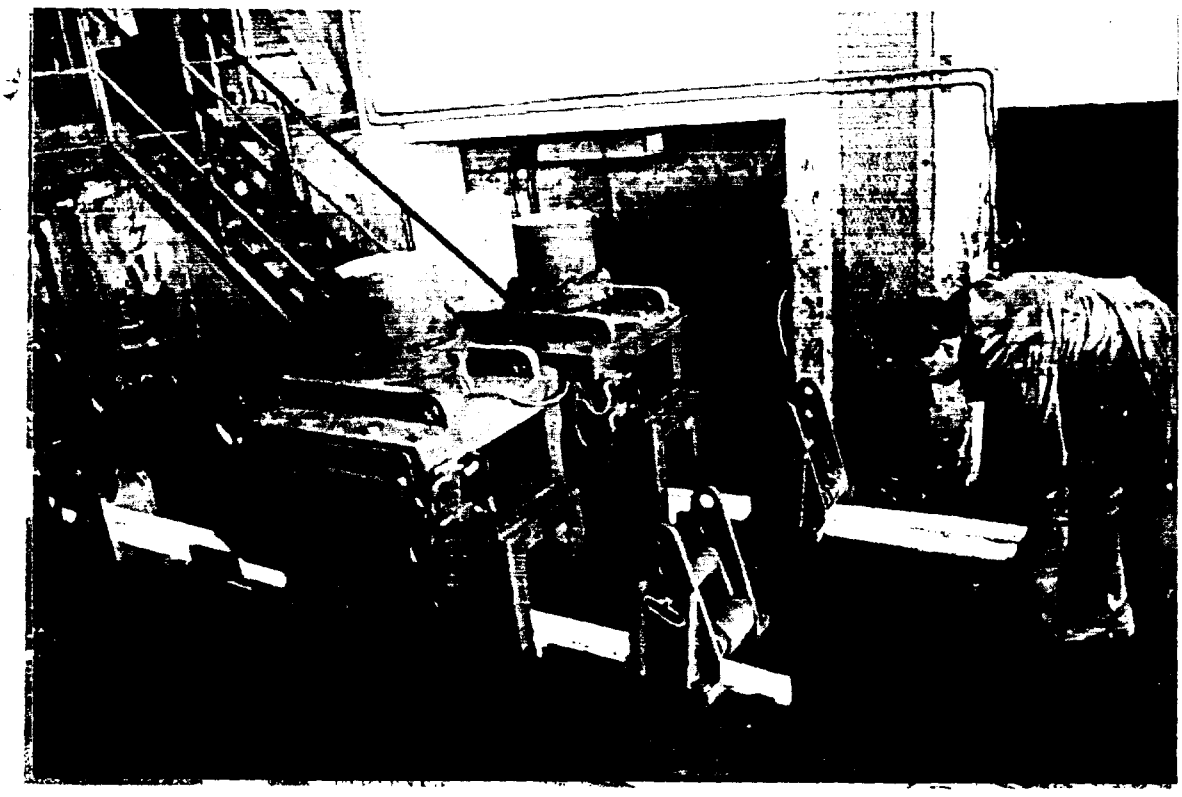


Photo 14 - Pincher rolls and hydraulic shears

Photo 15 - Hydraulic shears (in foreground), billets (in background)

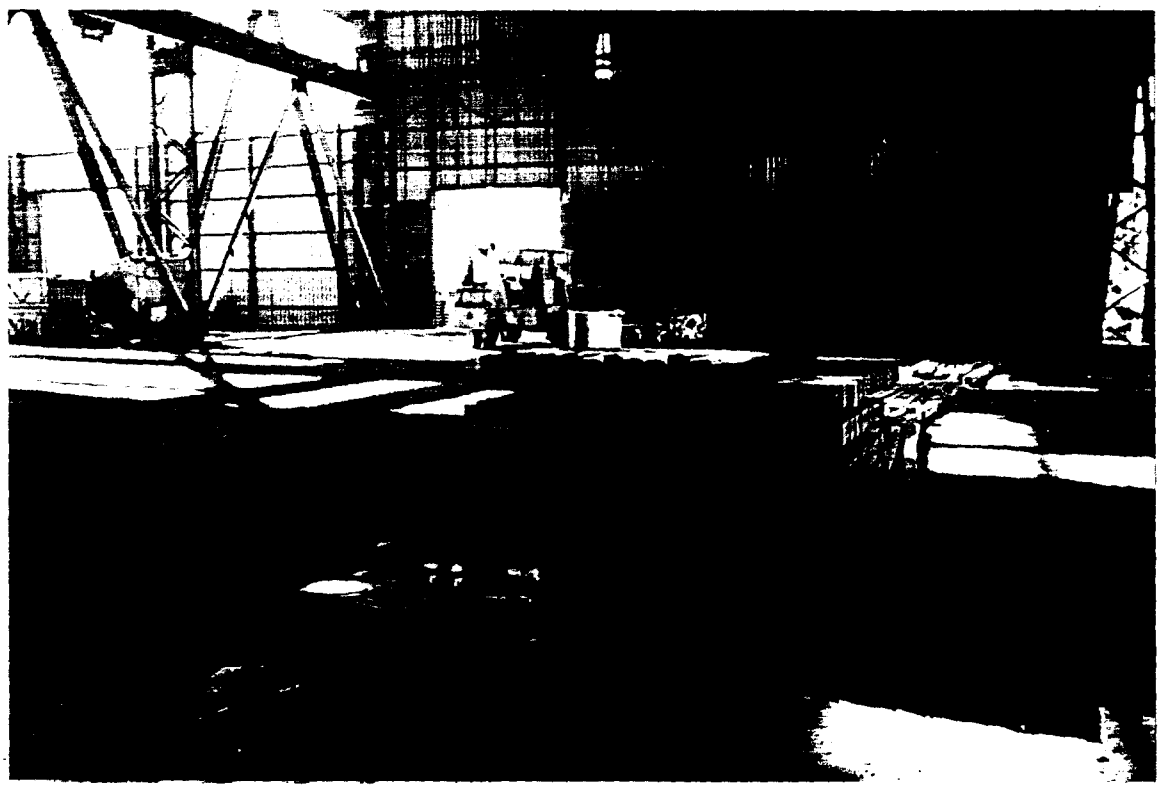


Photo 16 - Billet cooling area

Photo 18 - Reinforcement bar storage area

Photo 18 - Cooling towers

Photo 19 -
Hydrocyclone
(top right corner)

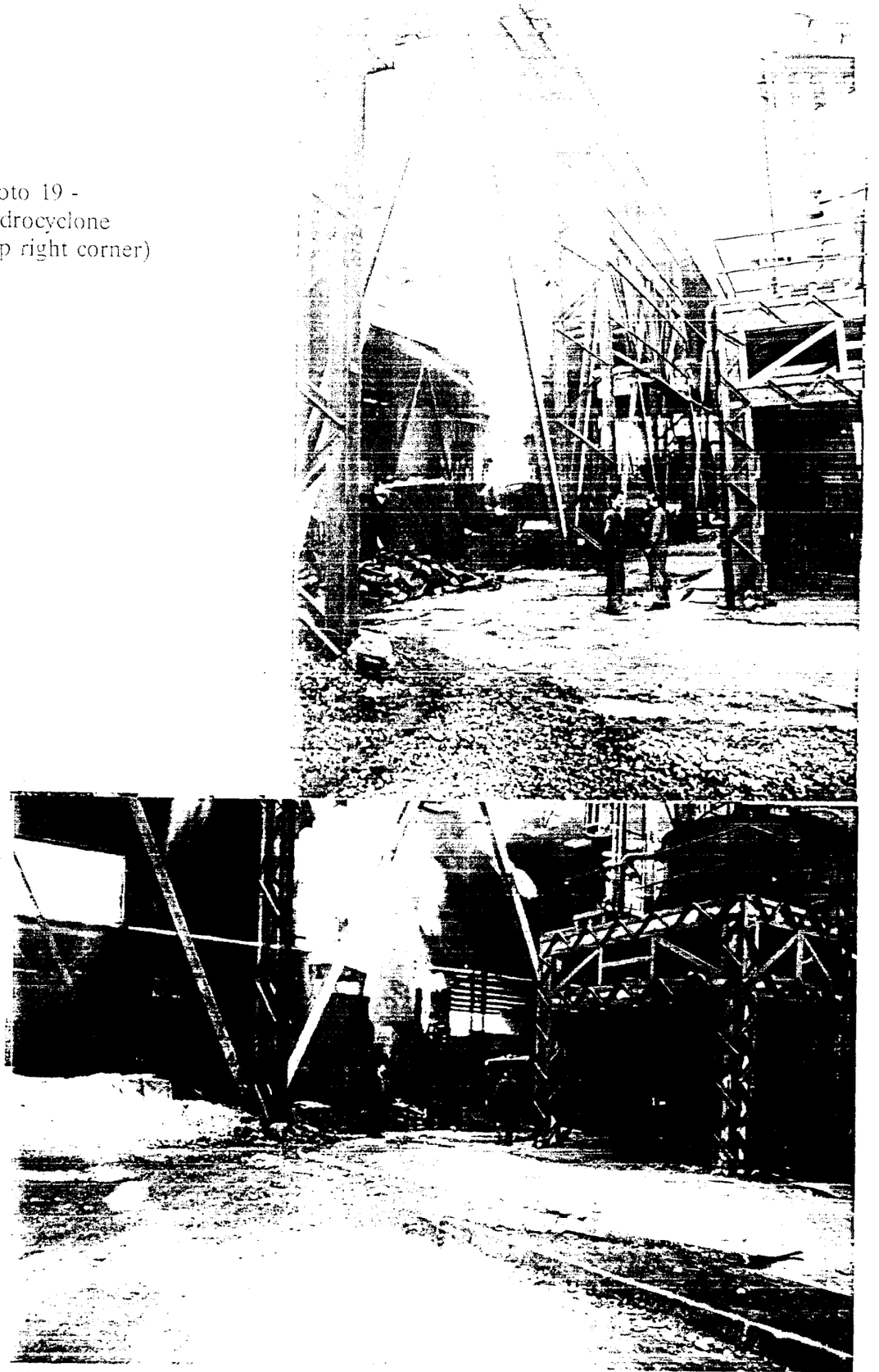


Photo 20 - Iron oxide scale tank below hydrocyclone and 2 sand filters (right)

Photo 21 -
Rolling mill wastewater
outside trench

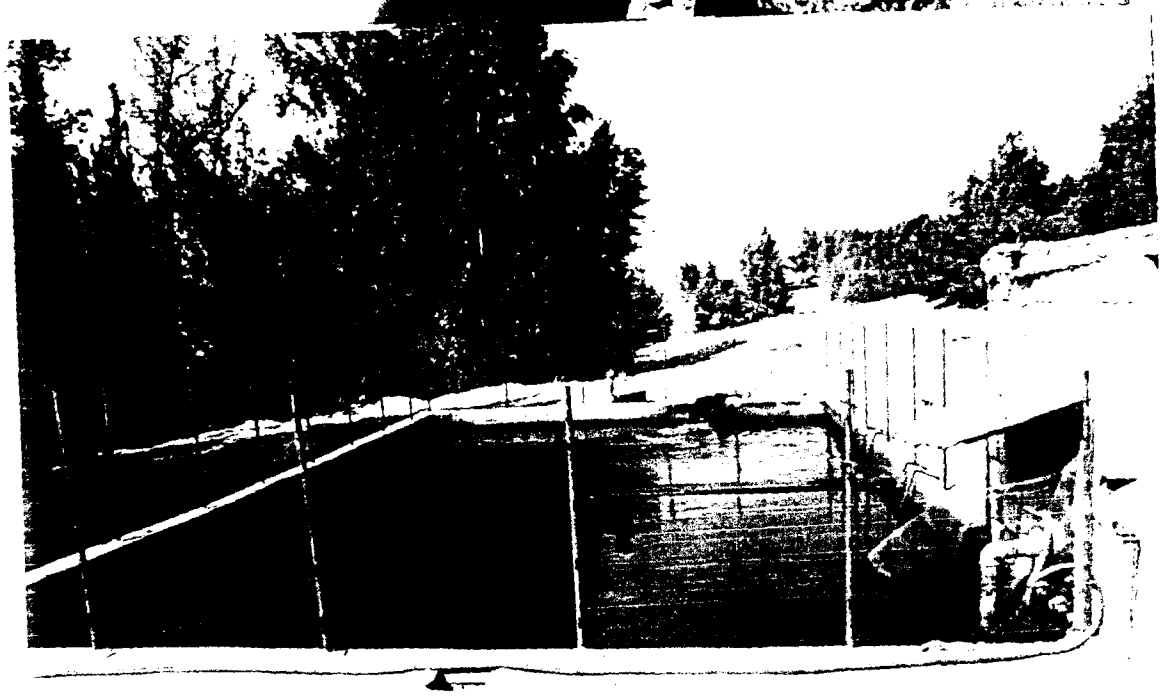


Photo 22 - Rolling mill four-chambered sedimentation basin

APPENDIX E
REFERENCES

REFERENCES

Kirk-Othmer Encyclopedia of Chemical Technology. Third Edition. John Wiley and Sons, New York. 1983.

U.S. EPA. Development Document for Effluent Limitations Guidelines and Standard for the Iron and Steel Manufacturing Point Source Category. Volumes I - IV, Effluent Guidelines Division, Office of Water Regulations and Standards, United States Environmental Protection Agency, EPA 440/1-82/024, May, 1982.

McNallan, Michael et. al. "High-Gradient Magnetic Filtration of Steel Plant Waste Water", Iron and Steel Engineer, Vol 53, No. 1, pp. 40-44, January, 1976.

APPENDIX F
PP/WM BACKGROUND REPORT

Table of Contents

Page

1.0 INTRODUCTION 1

1.1 Background 1
1.2 Objectives 2

2.0 INDUSTRIAL HISTORY 3

2.1 General 3
2.2 The Iron and Steel Manufacturing Industry in Jordan 3

3.0 PROCESS OVERVIEW 4

3.1 Ironmaking 4
3.2 Steelmaking 4
3.3 Continuous Casting 5
3.4 Hot Forming 5

4.0 WATER USE AND WASTE GENERATION IN THE IRON AND STEEL MANUFACTURING INDUSTRY 7

4.1 Water Use 7
4.2 Waste Generation 7
4.3 Wastewater Discharge Guidelines 8

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION TECHNIQUES USED BY THE IRON AND STEEL MANUFACTURING INDUSTRY 9

5.1 Water Conservation and Wastewater PP/WM Techniques 9
5.2 Solid Waste PP/WM Techniques 10
5.3 Air PP/WM Techniques 11
5.4 Treatment Technologies 12

6.0 REFERENCES

Attachment A Process Flow Diagram of the Iron and Steel Manufacturing Industry

Attachment B U.S. EPA Iron and Steel Manufacturing Limitations

Attachment C Selected Papers on Pollution Control in the Iron and Steel Manufacturing Industry

Attachment D Other Sources

Attachment E Abstracts

1.0 INTRODUCTION

1.1 Background

Under a contract with the United States Agency for International Development (USAID), Development Alternatives Incorporated (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber).

The IWDP will be performed in three phases. The first phase requires completion of ten pollution prevention/waste minimization (PP/WM) opportunity audits by DAI and its sub-contractors. The second phase requires completion of Feasibility Studies (FS) for four of the audited facilities. Finally, demonstration projects will be completed for two of the selected FS facilities.

Due to the high cost of waste treatment, as well as the need to minimize waste of raw materials and resources, it is in the best interest of businesses and industries to minimize their waste generating practices. Companies with effective PP/WM programs may well be the lowest-cost producers of goods due to their efficient practices. Waste management practices can include:

1. Reduce waste generation

   - Substitution of less hazardous raw materials in product manufacture
   - Alteration of products manufactured to eliminate need for hazardous materials use
   - Replacement or upgrading of outdated or inefficient process equipment
   - Development of employee training programs to ensure employees efficiently manage raw materials and resources.

2. Reuse waste materials prior to disposal

   - Reuse of uncontaminated raw materials and resources (including water)
   - Reprocessing of previously discarded materials (e.g., off-spec materials, used materials)
   - On site recovery of reusable materials (e.g., used solvents, waste heat, scrap).

3. Recycle waste materials

4. Treat wastes and dispose of residues.

These options, in the order presented, represent the waste management hierarchy.

1.2 Objectives

The facility PP/WM audits are designed to assess the potential for pollution prevention and waste minimization at the study facilities. The goal of each audit is to evaluate and identify all possible PP/WM, wastewater clean-up, and water conservation techniques that are appropriate for the study facility. Audit documentation will consist of a background PP/WM assessment paper and an audit evaluation report. This document is intended to serve as the PP/WM background paper for the iron and steel manufacturing industry.

The specific objectives of this audit are as follow:

1. Review general industry background data and identify "state-of-the-art" processing and waste management practices.

2. Work on-site with industry representatives, ministry officials, and other interested groups to review current processing procedures and identify possible PP/WM options.

3. Develop a report that evaluates all possible PP/WM alternatives and water conservation techniques and provides recommendations to the industry.

In order to complete the first objective, a literature review was performed. This review included searches of the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC) repository (and its corresponding database PIES), on-line library catalog databases, PP/WM bibliographical references, and personal contacts with pollution prevention specialists. The on-line library catalog databases accessed included the OCLC, an on-line catalog of approximately 15,000 libraries in the U.S. and libraries in Canada and Great Britain; the OLS, the on-line EPA library, and DIALOG, a commercial database containing abstracts of journal articles, conferences, and government documents. The review resulted in the identification of numerous references with a range of very general to very specific PP/WM techniques. Source documents were assessed to determine their applicability to this project. Material pertinent to this project have been included in Attachment C or listed in Attachments D and E.

Following completion of the literature review, the audit team will perform the on-site audit of the industrial facility. The audit will be performed with close consultation of industry representatives to ensure that they are aware of and support proposed actions. Audit activities will included the careful gathering of baseline water use and waste generation data, identification and assessment of potential PP/WM options, and solicitation of ideas and proposals from management and production line staff.

Finally, the audit findings will be summarized, and all options evaluated in the audit report. The audit will recommend the development of a site-specific program that meets the specific needs and goals of the audited facility. Audit recommendations will include both technical PP/WM recommendations (e.g., housekeeping practices, treatment options, etc.) and suggestions for PP/WM training for facility staff and follow-up studies to assess program successes.

2.0 INDUSTRIAL HISTORY

2.1 General

The manufacture of iron and steel involves many processes. A large integrated facility may be involved in most or all of the processes beginning with the production of iron, then refining it into steel and finally forming that steel into various shapes. A smaller facility may be involved in only one or two of the major processes. The various distinct and separate operations can be grouped into three major processes: ironmaking, steelmaking, and forming. Attachment A contains a general schematic of the iron and steelmaking process and a general schematic of the forming process.

Most of the iron produced in the world today is by the blast furnace process where coke (produced from coal) is combined with iron ore (and/or other iron bearing materials), limestone and oxygen (air). While the blast furnace process is the most economical for the production of large tonnage, an alternative for small tonnage production is the direct reduction process which uses carbon monoxide and hydrogen made by natural gas rather than coke and oxygen. In the past, much of the steel was produced using the basic open-hearth process. Now the more efficient basic oxygen process and the electric arc furnace process are the predominant processes used. Further refining of the steel can be conducted by vacuum degassing. The molten steel is poured into molds to form ingots or are cast into semi-finished products. The ingots are reheated and subjected to a variety of hot and cold forming and finishing operations to produce products of various shapes and sizes.

2.2 The Iron and Steel Manufacturing Industry in Jordan

There are 6 iron and steel facilities in Jordan and 3 are being built. Of the 6 iron and steel facilities the Jordan Iron & Steel Industries Company, Ltd. (JISICO) is the only facility with an electric arc furnace; the others are rolling mills. One of the three facilities being built will also have an electric arc furnace. JISICO is privately owned by a group of 40 shareholders. A description of the facility is provided below.

The JISICO meltshop uses iron and steel scrap to produce iron/steel ingots. The production rate is 45,000 tons per year (T/yr). The JISICO rolling mill uses steel ingots to produce reinforcement bars. The production rate is 100,000 T\yr.

Wastes generated by the facility include wastewater, cooling water, 1,500 T\yr of slag, 1,750 T\yr of scale, and 115 T\yr of waste oil. The slag is stockpiled outside the buildings. The scale is also stockpiled outside although some of the scale is reused in the JISICO meltshop and some is sent for reuse to the cement industry. Cooling water is recycled after treatment. Oily wastewater is treated and the free oils recovered are used as supplementary fuel oil.

3.0 PROCESS OVERVIEW

In ironmaking, coal is converted to coke which is combined with iron ore (and/or other iron bearing materials) and limestone in a blast furnace to produce iron. In steelmaking, controlled amounts of oxygen are mixed with the molten iron which is converted into steel in either open hearth, basic oxygen, or electric arc furnaces. The steel is poured into molds to form ingots. Finally, a hot rolling mill reheats the ingots and shapes them into products such as reinforcement bar. A description of each of these processes is provided in the following sections.

3.1 Ironmaking

Although there are refinements in the iron making process the basic process uses a blast furnace in which coke, iron-bearing materials (iron ore and iron scraps) and limestone or dolomite are charged into the top of the furnace and heated air is blown into the bottom. Combustion of the coke provides heat and a reducing atmosphere. The limestone forms a fluid slag which floats on top of the molten iron. Occasionally, gravel, principally silica, is added for slag composition control. This slag combines with the unwanted impurities in the iron-bearing materials. Approximately 2.0 thousand kilograms (kkg) of ore, 0.54 kkg of coke, 0.45 kkg of limestone and 3.2 kkg of air produce approximately 0.9 kkg of iron, 0.45 kkg of slag, and 4.5 kkg of blast furnace gas. The blast furnace gas is used as fuel to preheat the incoming air that is blown into the blast furnace. The molten iron is withdrawn and casts into ingots (pig iron) or ladled directly into the steelmaking furnace as molten pig iron (termed "hot metal"). The molten slag is discarded.

3.2 Steelmaking

Steel is a iron-carbon alloy containing approximately 96 percent or greater iron and less than 1 percent carbon, but the carbon component gives the steel its hardness. The basic raw materials for steelmaking are pig iron (or hot metal), steel scrap, limestone, burned lime, dolomite, fluorspar, iron ores, and iron-bearing materials such as pellets or mill scale. The pig iron consists of iron, and other elements, the most predominant being carbon, manganese, phosphorus, sulfur, and silicon. In the furnace the raw materials are melted and the iron is refined to reduce or remove these elements to specified low levels thus converting it to steel. Various alloying metals are added (as part of the charge in the furnace or to the ladle of molten steel after the steel is removed from the furnace) to produce different grades of steel.

Modern steelmaking processes all use oxygen to refine molten pig iron. The oxygen combines with the carbon in the molten iron to produce carbon dioxide and carbon monoxide which are released as exhaust gases from the furnace. The silicon, manganese, phosphorous, and other impurities oxidize into the slag. The principal steelmaking processes in use today are:

- Basic Oxygen Furnace Process - There are two designs of the basic oxygen furnace. In the top-blown basic oxygen process (BOF or BOP), oxygen is blown down onto the surface of the molten pig iron at supersonic velocities through a water cooled lance (steel pipe).

  In the bottom-blown basic oxygen process (Q-BOP), pure oxygen and carrier gases such as natural gas, propane, or nitrogen and powdered fluxes such as burnt lime are blown upward through the molten pig iron through tuyeres located in the furnace bottom.

- Open-hearth Furnace Process - The furnace is a large structure constructed primarily of refractory bricks. The molted pig iron and other material is placed in the bottom of the furnace, fuel is heated and injected into the furnace. Air used to burn the fuel is preheated in large brick chambers (called checkers) located on either side of the furnace. As the furnace

is fired at one end, the hot combustion products leave through the chamber on the other end, heating the chamber bricks. The firing and air flow is reversed so that the heat from the chamber bricks is used to preheat the air.

- Electric Arc Furnace Process - An electric arc is used to melt the raw material, steel scrap and other components. Oxygen is injected into the molten bath. The oxygen and carbon form carbon monoxide gas which bubbles out of the bath.

There are two principal types of furnaces: acid or basic. An acid furnace is lined with refractory material composed of silica sand. A basic furnace is lined with dolomite or magnesite. Both the basic and acid process removes carbon, manganese, and silicon, but phosphorus and sulfur are removed by the basic process. Therefore, if the iron is high in sulfur or phosphorus, the basic process is used.

3.3 Continuous Casting

In the continuous casting process operation, molten steel from a furnace is transferred from the ladle to the tundish. The tundish, lined with refractory bricks, maintains a constant head of molten metal that controls the casting rate. The tundish also distributes the molten steel to the casting strands. The molten steel from the tundish pours through a water cooled copper mold to produce a semi-finished product, such as a billet. As the steel emerges from the mold, the steel is sprayed with water to further cool and solidify the cast product.

3.4 Hot Forming

A variety of hot forming operations can be performed on the steel. Hot forming mills use iron or steel ingots as the raw material and through a series of hot rolling operations the steel ingot cross-section is reduced in shape and increased in length. Hot rolling mills specialize in producing specific shapes (slabs, blooms, billets, plates, strips, bars, wire). The three distinct types of rolling mills involved in the final production of bars or rods are:

- Primary Mill, called blooming mill, reduces the ingot to a bloom. The blooming mill may be coupled with the billet mill (below) so that the bloom can be immediately rolled to a billet without reheating.

- Section Mill, called billet mill, reduces the bloom to a billet. The billet mill may also reduce the bloom to the final bar or rod.

- Finishing Mill, called bar or rod mill, reduces the billet to bars or rods.

Blooming Mill - Overhead cranes with lifting tongs place the ingots into a soaking pit furnace. The furnace is partly underground, lined with refractory bricks, and fuel fired with oil or gas. The heated ingots are transferred by the cranes to ingot transfer cars that deliver the ingots to the rolling stand. The mill may be designed as either a reversing mill or a tandem mill. In a reversing mill, the ingot is rolled through the same mill stand a number of times. A tandem mill has several mill stands arranged so that the ingot is rolled forward in one direction continuously.

Billet Mill - Similar to the blooming mill and the bar mill, the billet mill may or may not have a reheat furnace. The mill is designed as a cross-country mill, a continuous mill or a three high mill. The cross-country and continuous mill designs are described below in the bar mill. The three high mill consists of three rolls mounted on a single roll housing stand, one roll above the other. Billets are rolled in one direction between the bottom and middle rolls and in the opposite direction between the middle and top rolls. Lifting and tilting tables move the billets to the two different levels.

Bar Mill - In the bar mill the billet is heated to rolling temperature in a continuous reheat furnace. The billets are fed into one end and are moved through the furnace by a billet pusher. A shear cuts the heated billets to size or removes bent ends. The heated billet is then moved through the various mill stands each decreasing and lengthening the billet to the final finished reinforcement bar size. The bar mill is either arranged in a cross-country design or a continuous design. In the cross-country design the various size roll stands (roughing, intermediate and finishing) are arranged side by side. The billet is rolled through one stand then transferred to the next, where it is rolled in the reverse direction. The continuous mill consists of a series of roll stands arranged one after the other so that the piece (billet) enters the first stand and takes one pass in each stand of rolls to merge from the last as the finished product (reinforcement bar).

Other operations performed at the mills include hand or machine chipping, scarfing, or grinding to remove surface defects. The end of the bloom, billet, or bar is cut off or "cropped" by electric or hydraulic shears.

4.0 WATER USE AND WASTE GENERATION IN THE IRON AND STEEL MANUFACTURING INDUSTRY

The iron and steel industry uses large volumes of water during production processes. Water is used for cooling manufacturing equipment and final products. Water is also used in air pollution control devices such as scrubbers to remove airborne materials.

4.1 Water Use

Ironmaking - Water is used in the blast furnace operation for two purposes: cooling of the furnace and other equipment; and, cleaning and cooling of the furnace exhaust gases.

Steelmaking - The principal water use in the steelmaking operations is for the cleaning and cooling of the furnace exhaust gases. Three different scrubbing systems are used to clean waste gases from basic oxygen furnaces: semi-wet; wet-suppressed combustion; and wet-open combustion. Electric furnaces use either semi-wet or wet systems while the open hearth furnaces use only wet systems. The semi-wet system uses less water than the wet systems.

Continuous Casting - The continuous casting process operation uses noncontact cooling water to cool the copper mold and the hydraulic machinery. Contact cooling water is sprayed onto the steel as it emerges from the copper mold. This contact cooling water becomes contaminated with the iron oxide scale that forms on the steel as it cools and solidifies. The cooling water can also be contaminated with oil and grease from the hydraulic and lubrication systems for the casting equipment (e.g., hydraulic shears and pincher rolls). Approximately 5 to 10 percent of the spray cooling water is evaporated.

Forming - Water use occurs primarily in the following areas at an hot forming mill:

- High pressure descaling spray water - When the hot steel product is being rolled, iron oxide scale (called mill scale) forms on the surface of the hot steel. The scale is removed by direct contact high pressure (1,000-2,000 psig) sprays. Approximately 4 percent of the water sprayed on the hot steel evaporates.

- Work roll and roll table spray cooling water - Roll cooling water is used to cool the work rolls of the mill stands to prevent surface cracking of the steel rolls due to sudden temperature changes. Low pressure spray cooling water is also used to keep the mill stand rolls and the table rolls cool as the hot steel passes over or in between them. Water is used to cool equipment such as hot shear equipment.

- Flume flushing - Water is used to flush the mill scale into trenches and pits.

- Waters from air pollution equipment - The scarfing operation generates fume, smoke, and waste gases. Wet scrubbers used to remove these airborne pollutants generate wastewater.

4.2 Waste Generation

Ironmaking - The major process wastewater generated by the ironmaking process is the blast furnace exhaust gas cleaning (scrubbing) and cooling wastewater. Solid wastes generated consists of the slag, in-plant scrap and blast furnace flue dust and sludges collected by the air pollution control devices.

Steelmaking - The exhaust gas cleaning and cooling wastewater is the largest volume of wastewater generated. Each of the three types of furnaces generate different wastewater volumes and pollutant characteristics. Semi-wet systems generate less wastewater because the systems use less water. Wet-suppressed combustion system wastewater is lower in suspended solids than wastewater from the wet-open combustion system. Solid wastes consists of slag, in-plant scrap and furnace flue dust and sludges.

Forming - Wastewaters from descaling, roll cooling, equipment cooling, roll tables, and flume flushing are generally discharged through trenches, called flumes, beneath the rolling mill to inground concrete or steel chambers called scale pits. These scale pits act as sedimentation tanks where the heavier solid particles settle out. Untreated wastewater from hot forming operations contain significant levels of suspended solids and oil and grease. Toxic metal pollutants are present in lesser concentrations.

Pollutants generated by the iron and steel industry include Suspended Solids (SS), oil and grease, ammonia, and metals (iron, zinc and lead), cyanide and phenol. Other metals, inorganic and organic compounds may be present in low concentrations.

4.3 Wastewater Discharge Guidelines

Several countries have established environmental regulations that apply to the wastewater discharge from the iron and steel industry. The regulations for Turkey, Japan, Germany, and the USA are presented in Attachment B.

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION TECHNIQUES USED BY THE IRON AND STEEL MANUFACTURING INDUSTRY

The iron and steel manufacturing industry has for decades practiced water conservation and reuse. In addition to control of water use, many manufacturers have explored the reuse of solid wastes. Instead of discharging these materials as wastes, prudent companies have developed techniques for further processing and recovery of these former waste materials. The pollution prevention and water conservation practices that have been implemented by the industry have usually been reported using the terms pollution control, water or wastewater treatment, waste recycling or reuse rather than pollution prevention and waste minimization. Thus the papers listed in Attachments C, D, and E do not use the term pollution prevention but instead focus on the treatment or recovery of wastes for recycle or reuse.

Structural changes, process innovations and plant engineering to increase the energy efficiency in the steel industry has contributed to pollution control or pollution reduction. Some examples are:

high top pressure blast furnaces

basic oxygen steelmaking process (replacing the basic Bessemer process)

walking beam furnaces in rolling mills

continuous casting (replacing the casting of ingot and rolling of ingots into blooms and blooms into billets)

hot charging of the continuously cast material to the rolling mill furnaces

Further energy savings and pollution reduction may come from near net shape casting of steel (Aichinger, e.t al., 1992). Process design innovations occur slowly and historically have been oriented towards increased production efficiency and not pollution prevention. The pollution prevention benefits of these design changes were incidental. For example, the electric arc furnace process which is now in prominent use, particularly in processing steel scrap and high grade metal alloys uses less water than the basic oxygen furnace process. Larger electric arc furnace units, shorter charge times, and computer aided process control have decreased electric consumption.

The integration of the various process operations from ironmaking to semi-finished or finished product by the integrated steel mills (consisting of coke plant, sintering plant, blast furnace, basic oxygen furnace, continuous casting, and rolling mill) has enabled these facilities to increase the reuse and recycle of wastes within the facility.

Many PP/WM techniques have been reported in the literature for specific iron and steel industry applications. While not all of these techniques will apply to any specific facility, certain technologies may provide ideas or inspiration for additional applications. The PP/WM techniques that have been described in the literature sources included in Attachment C or listed in Attachments D and E of this paper are summarized in this section.

5.1 Water Conservation and Wastewater PP/WM Techniques

The single greatest water conservation and wastewater PP/WM technique in the iron and steel industry is the recycling of the enormous amount of cooling water (both contact and noncontact) used throughout the process operations (furnace, continuous casting, and rolling mill). This technique was implemented decades ago. Wastewater reuse in the iron and steel manufacturing facilities in the U.S. have reported recycle rates of 98

percent for ironmaking and 96 to 100 percent for steelmaking. Ten years ago recycle rates of 60 to 77 percent were reported for hot forming operations but since then 99 percent recycle has been demonstrated for hot forming operations. The U.S. EPA reported that 25 percent of the continuous casting operations were achieving zero discharge. (U.S. EPA, 1982) Some facilities in Japan have demonstrated 100 percent reuse of wastewater. Also in Japan salt water is used in a once-through noncontact cooling system for the furnace.

Specific water conservation and wastewater reuse techniques that have enable extensive reductions in wastewater discharges include:

- Reuse of the furnace exhaust gas cleaning and cooling water after treatment
- Reuse hot mill cooling and descaling wastewater after treatment.
- Process water cascading, for example use of low quality water or process wastewater as flume flushing water.
- Use of dry air pollution control systems, such as baghouses, instead of wet air pollution control systems

Recycling not only reduces water consumption but concentrates the contaminants and makes treatment to remove these contaminants more cost efficient as well as reducing the contaminant loading.

The advances in water conservation and PP/WM in recent years has been due to improved treatment of the wastewater to enable higher recycle rates. The higher recycle rates reduce the pollutant loadings discharged to the environment.

The industry predominantly uses mechanical draft evaporative cooling towers to reduce the heat load of recycled water. Recycle systems that include evaporative cooling towers and evaporative cooling ponds at plants located in arid and semi-arid regions of the U.S. were not found to consume significant amounts of water by evaporation.

The oil and grease from equipment and machinery that contaminate the cooling water can be recovered and reused as fuel in steam boilers and reheating furnaces.

5.2 Solid Waste PP/WM Techniques

The iron and steel industry generates an enormous amount of solid waste that can become a waste disposal problem. Facilities in North America (e.g., U.S. and Canada), Europe (e.g., Sweden, Germany, Great Britain), Australia, and Asia (e.g., Japan and China) have successfully pioneered recycling and reusing the slag, dust, and iron oxide scale. Japan reports 98 percent recycle of solid waste. Solid waste recycling measures that have been practiced include:

- Use of the hot mill scale and furnace flue dust as raw material for iron or steelmaking;
- Use of in-plant scrap as raw material for iron or steelmaking;
- Use of slag from steelmaking as raw material for the ironmaking blast furnace;
- Recover of the oil and reuse as fuel; and
- Use of slag as material for roads, cement, concrete aggregate.

For example, at the Keihin Works in Japan, the oxidizing slag from the electric arc furnace is magnetically separated into a metal (iron) portion that is reused and a non-metal portion that is reused as road construction material. (Shinoda, 1980)

Recycling of converter slag back to the ironworks enables recovery of iron, manganese, and calcium oxide but results in unfavorable increases of the phosphorus content in melted iron. The steelworks has to increase the charging quantity of "lime plus dolomite" at the time of refining. The Q-BOP converter can accept material with a higher phosphorus content; it has better de-phosphorus capability. (Saigusa, et. al., 1980)

At the Rohrenwerke Bous facility in Germany, iron oxide rolling mill scale and dusts and sludges from the meltshop was converted to sponge iron in a rotary kiln and then reused in the electric arc furnace at a ratio of scrap to sponge of 3 to 1. (Eichberger, et. al., 1980)

Mill scale can be reused because of its high iron content and can replace more costly purchased iron units and can enhance quality of the sinter produced. Raw mill scale waste is composed of metallic scrap, rubble, water, mill lubricants, and rolling oils. Scrap and rubble can be removed mechanically. However oily mill scale cannot be sintered in large quantities because the oil volatilizes during sintering, creating air pollution problems or operating problems for the air pollution control devices. The volatilized hydrocarbons that are collected in the bag house or scrubber can present a fire hazard for the electrostatic precipitators of sinter strand dedusting, blind the filter bags and result in unacceptable stack emissions. Oil removal processes include: washing with water, hot alkaline or solvent or thermal incineration by direct or indirect firing. A rotary kiln incineration process can be operated to completely destroy the hydrocarbons (1500° F in the after burner). High intensity wet scrubbers remove particulates with an efficiency of 99 percent. The slurry from the scrubber is pumped to a basin where the solids settle and water is returned to the scrubber for reuse. Problems have been encountered with excessive abrasion and internal erosion, particularly on the quencher, venturi inlet, and venturi throat. These pieces need to be made of abrasion-resistant material. (Harold, 1980)

There is a patented process, INMETCO, that uses dust from steel mill furnaces and baghouses, mill scale, and grinding swarf to produce pellets that are then reduced in a rotary hearth furnace and cast into 50 pound pig ingots. (Pargeter and Weil, 1980)

At the Cockerill-Seraing facility in Belgium an experimental road was built with BOF slag. (Piret, et. al., 1980) Steel plant slag has also been used in Australia as road base, cement, and concrete aggregate (Jones and Murrie, 1980). Electric arc furnace slag is expansive and brittle due to the high lime content but can be used as road bed material and the high lime content keeps the metals from leaching into the groundwater.

5.3 Air PP/WM Techniques

The blast furnace gas, coke oven gas, converter (BOF) gas and waste steam are all reused to recovery heat and energy. The reuse of these gases have reduced the emissions of dust, sulphur dioxide, nitrogen oxides, carbon monoxide, and carbon dioxide (Aichinger, et. al., 1992). Recovery of process gases in steam boilers can further reduce NOx concentrations.

Modern reheating furnaces are fired by 150 to 200 roof burners. This high number of burners and the small distance between these burners and the surface of the reheated material increases the NOx concentrations. The use of fuel gas with a high rate of waste heat utilization for air preheating to save energy leads to higher NOx emissions but to lower SO_2 and CO emissions. (Aichinger, et. al., 1982)

The installation of air pollution control devices that use water to cool and clean the gases can increase a facility's use of water and discharge of wastewater. There are water conservation and PP/WM techniques that can reduce the water and wastewater impacts of these wet gas cleaning systems:

- Provide separate water systems for equipment cooling and gas cleaning. Equipment cooling system can be a closed-loop cooling system with cooling towers or a semi-closed loop with the cooling tower blowdown being reused as part of the water for the gas cleaning system.

- Control water application in semi-wet air pollution control systems so that no wastewater discharge is generated.

- Cascade all or a portion of the gas cooling wastewater to the gas cleaning system

- Arrange gas scrubber streams in series. The less contaminated second stage wastestream would be cooled and returned to the first stage scrubber. The more contaminated streams from the "first stage" scrubber can be treated and recycled to the second stage wastestream or to other operations.

he best option is to use dry air pollution control systems (such as baghouses) rather than wet systems, where ossible. One dry gas cleaning system consists of an evaporative cooler to cool the gases followed by a baghouse stem.

.t the U.S. Steel National-Duquesne Works the electric furnace baghouse dust was recycled back to the electric ırnace, reducing flourspar usage. The 40 tons of balled dust produced each week was consumed by back-harging about 2000 pounds of balled dust to each heat. (Harris, 1980)

.4 Treatment Technologies

ron and steel manufacturing facilities often utilize physical/chemical "in-plant" control technologies aimed at vater reuse. Recycling of wastewater can cause plugging, scaling, and corrosion if the wastewater is not treated. n-plant treatment can include:

- adding chemicals that inhibit scaling or corrosion
- providing sufficient blowdown volume to limit the build-up of dissolved solids and other pollutants
- evaporation and reuse of condensate
- removal of suspended solids and oil and grease

Wastewater treatment generally consists of physical and chemical technologies to remove suspended solids and oil and grease such as: gravity settling, neutralization, chemical precipitation and clarification, and filtration. Flocculation with polymers or other flocculent aid is often used in conjunction with sedimentation.

The current treatment technology most commonly used for cooling and cleaning water used in hot rolling and continuous casting operations is sedimentation in clarifiers at rates of 1 to 2.5 gallons per minute per square foot (gpm/ft^2). Enhanced removal is achieved with the addition of chemical flocculants. A clarifier performing optimally can achieve suspended solids concentrations in the effluent of 10 to 20 milligrams per liter (mg/L).

Sand filters can achieve an effluent with a lower suspended solids concentration than gravity settling basins and clarifiers without the addition of chemicals.

Suspended solids removal - Many types of suspended solids removal devices are used by the iron and steel industry. These include settling lagoons; clarification devices such as clarifiers, thickeners, and inclined plate separators. Treatment technologies that will achieve lower concentrations of suspended solids include coagulation and settling and sand or mixed media filtration.

Oil removal - The treatment and removal of free and emulsified oils and greases is typically accomplished by gravity separation, physical filtration and/or flotation. These treatment processes may be used alone or in combination depending on the nature of the oils and greases to be treated and the strength of the wastestream. In a scale pit where the water level and oil content vary considerably, saucer or rotating van skimmers would be better than endless rope or endless belt skimmers.

Toxic metal pollutant removal - The treatment technologies for metals removal include those used for suspended solids removal as well as chemical precipitation and magnetic filtration or separation.

High-gradient magnetic separation uses a matrix of fine ferromagnetic fibers, such as stainless steel wool, placed in a strong magnetic field, to trap magnetic, micro-size particles from water. A bench-scale Kolm-Marston type of magnetic separator has been found to reduce the suspended solids from blast furnace gas washer water to 5-20 mg/L at flow rates of 18-200 gpm/ft^2. The 200 gpm/ft^2 flow rate is two orders of magnitude higher than flow rates for sedimentation and one order of magnitude higher than deep bed filters. (McNallan, 1976)

Furnace exhaust gas cleaning systems include baghouses (a dry air pollution control system) and wet gas cleaning systems such as venturi scrubbers, adjustable orifice scrubbers, separators, spray chambers, and hydroclones.

Though not used extensively because of the costs of these treatment technologies, ion exchange, reverse osmosis, and evaporation produce high quality water and may prove economical for small closed-loop recycle systems. Further information on treatment technologies and pollution prevention practices can be found in the papers included in Attachment C or listed in Attachments D and E.

6.0 REFERENCES

Attachment A Process Flow Diagram of the Iron and Steel Manufacturing Industry

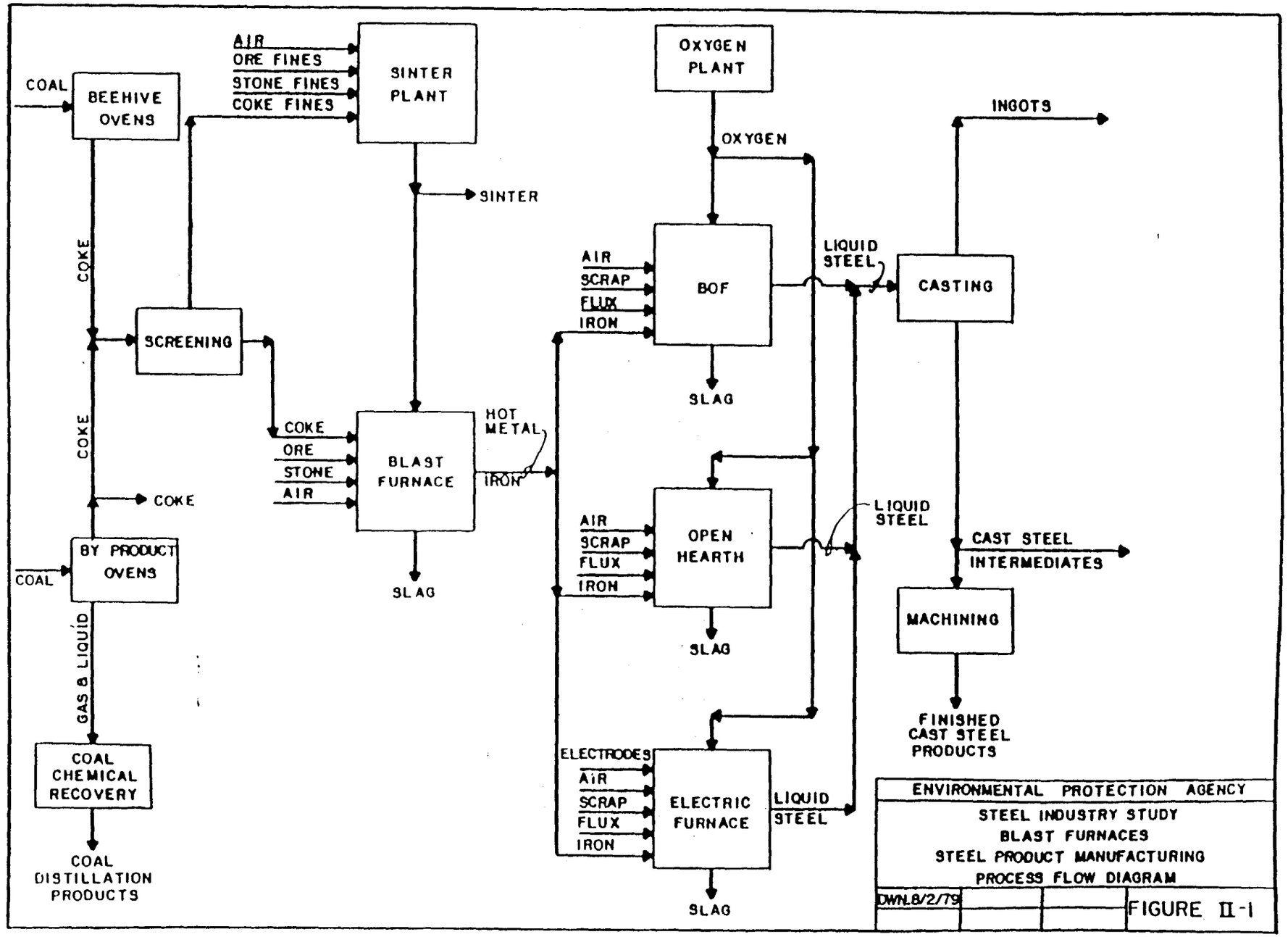
Attachment B Iron and Steel Manufacturing Wastewater Standards

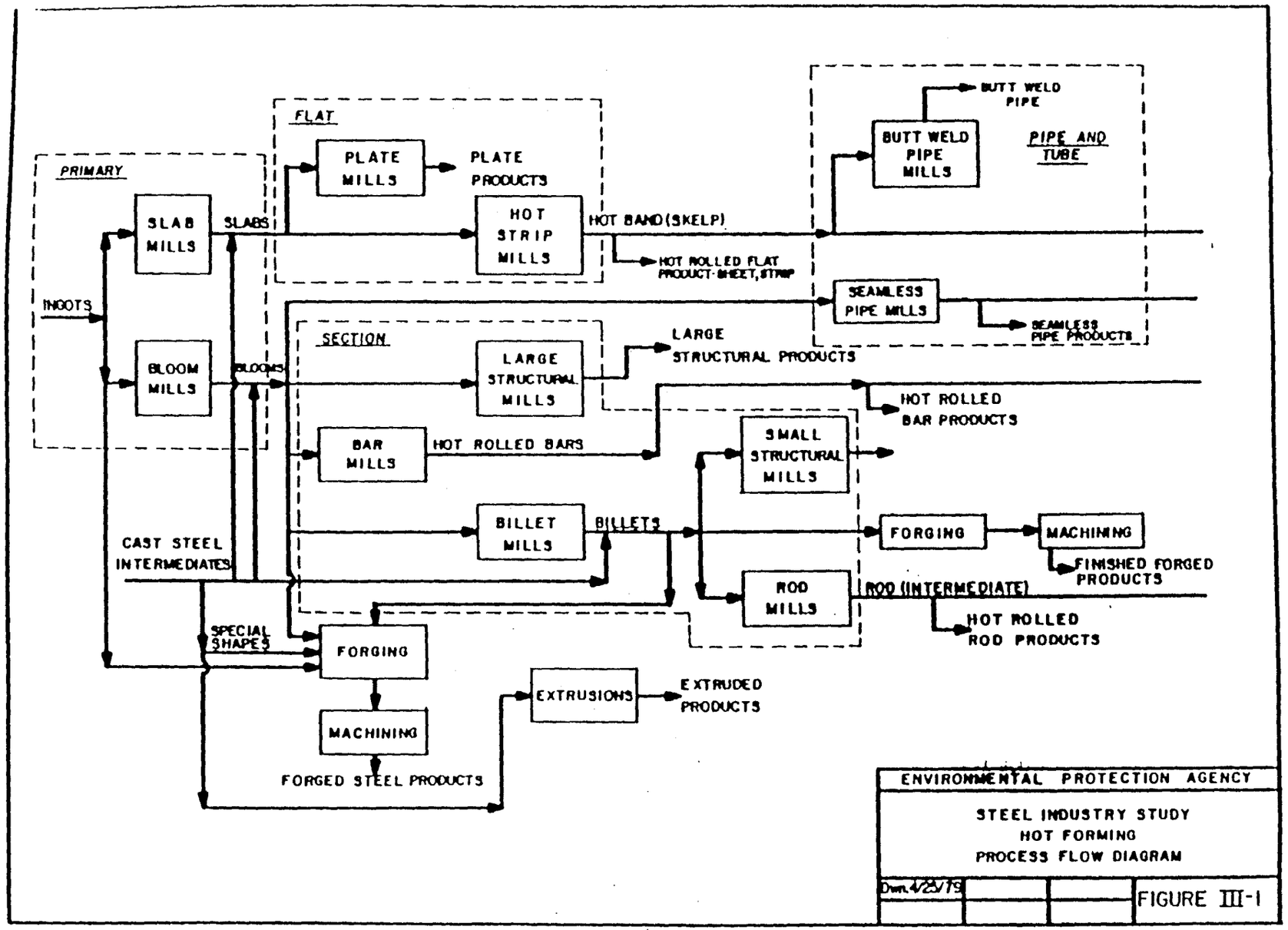
Attachment C Selected Papers on Pollution Control in the Iron and Steel Manufacturing Industry

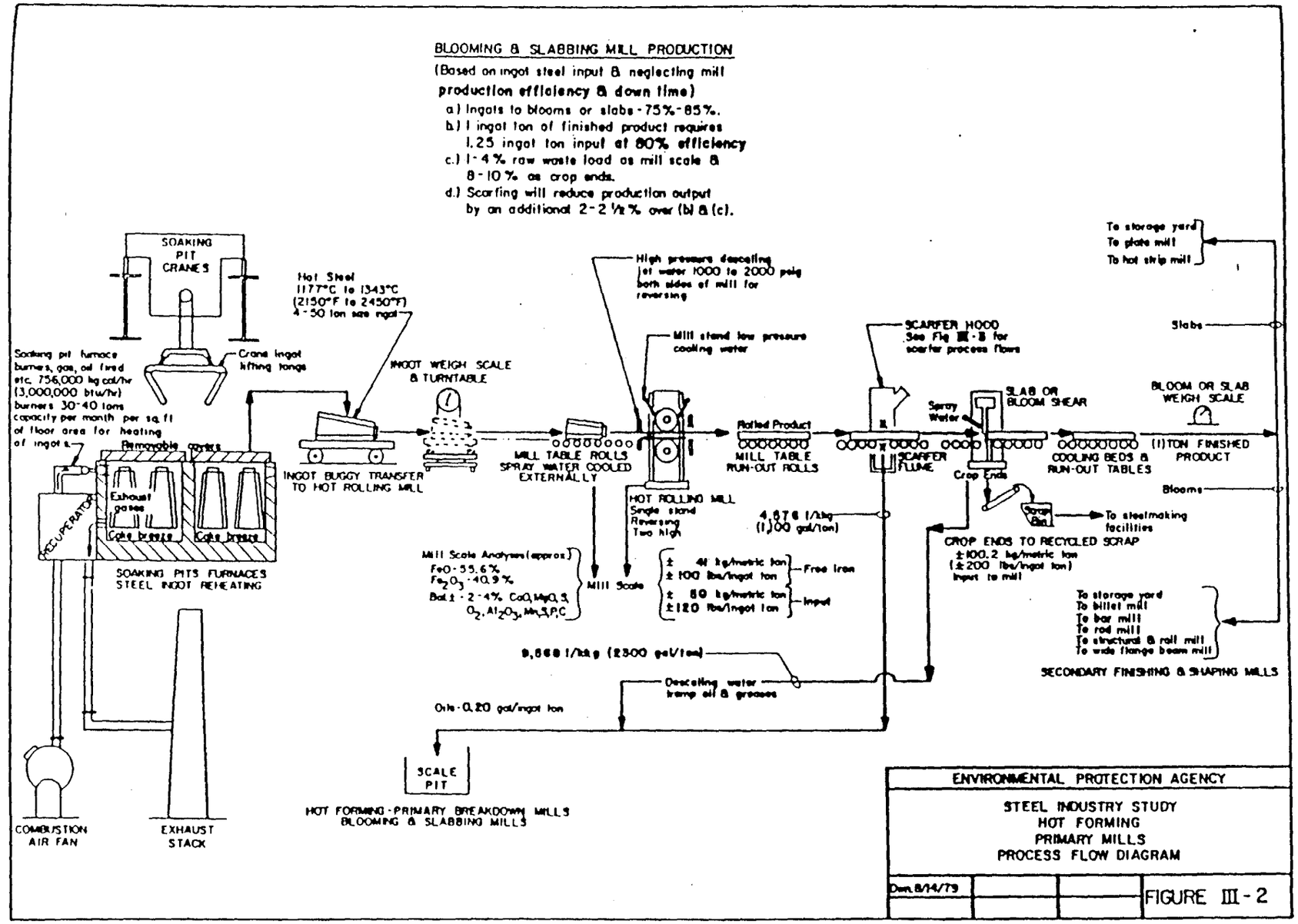
Attachment A

Process Flow Diagram of the
Iron and Steel Manufacturing Industry

(From: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel anufacturing Point Source Category, Volume I)


COAL
BEEHIVE OVENS
COKE
COKE
SCREENING
COKE
BY PRODUCT OVENS
COAL
GAS & LIQUID
COAL CHEMICAL RECOVERY
COAL DISTILLATION PRODUCTS
AIR
ORE FINES
STONE FINES
COKE FINES
SINTER PLANT
SINTER
COKE
ORE
STONE
AIR
BLAST FURNACE
HOT METAL
IRON
SLAG
OXYGEN PLANT
OXYGEN
AIR
SCRAP
FLUX
IRON
BOF
SLAG
LIQUID STEEL
AIR
SCRAP
FLUX
IRON
OPEN HEARTH
SLAG
LIQUID STEEL
ELECTRODES
AIR
SCRAP
FLUX
IRON
ELECTRIC FURNACE
SLAG
LIQUID STEEL
CASTING
INGOTS
CAST STEEL
INTERMEDIATES
MACHINING
FINISHED CAST STEEL PRODUCTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACES
STEEL PRODUCT MANUFACTURING
PROCESS FLOW DIAGRAM
DWN.8/2/79
FIGURE II-1


PRIMARY
INGOTS
SLAB MILLS
BLOOM MILLS
SLABS
BLOOMS
FLAT
PLATE MILLS
PLATE PRODUCTS
HOT STRIP MILLS
HOT BAND (SKELP)
HOT ROLLED FLAT PRODUCT-SHEET, STRIP
BUTT WELD PIPE
BUTT WELD PIPE MILLS
PIPE AND TUBE
SEAMLESS PIPE MILLS
SEAMLESS PIPE PRODUCTS
SECTION
LARGE STRUCTURAL MILLS
LARGE STRUCTURAL PRODUCTS
HOT ROLLED BAR PRODUCTS
BAR MILLS
HOT ROLLED BARS
SMALL STRUCTURAL MILLS
BILLET MILLS
BILLETS
FORGING
MACHINING
FINISHED FORGED PRODUCTS
CAST STEEL INTERMEDIATES
ROD MILLS
ROD (INTERMEDIATE)
HOT ROLLED ROD PRODUCTS
SPECIAL SHAPES
FORGING
MACHINING
FORGED STEEL PRODUCTS
EXTRUSIONS
EXTRUDED PRODUCTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
HOT FORMING
PROCESS FLOW DIAGRAM
Dwn. 4/25/79
FIGURE III-1


BLOOMING & SLABBING MILL PRODUCTION
(Based on ingot steel input & neglecting mill production efficiency & down time)
a.) Ingots to blooms or slabs - 75%-85%.
b.) 1 ingot ton of finished product requires 1.25 ingot ton input at 80% efficiency
c.) 1-4% raw waste load as mill scale & 8-10% as crop ends.
d.) Scarfing will reduce production output by an additional 2-2 1/2% over (b) & (c).
SOAKING PIT CRANES
Soaking pit furnace burners, gas, oil fired etc. 756,000 kg cal/hr (3,000,000 btu/hr) burners 30-40 tons capacity per month per sq ft of floor area for heating of ingots
Crane ingot lifting tongs
Removable covers
Exhaust gases
Coke breeze
Coke breeze
RECUPERATOR
SOAKING PITS FURNACES STEEL INGOT REHEATING
COMBUSTION AIR FAN
EXHAUST STACK
Hot Steel 1177°C to 1343°C (2150°F to 2450°F) 4-50 ton size ingot
INGOT WEIGH SCALE & TURNTABLE
INGOT BUGGY TRANSFER TO HOT ROLLING MILL
MILL TABLE ROLLS SPRAY WATER COOLED EXTERNALLY
High pressure descaling jet water 1000 to 2000 psig both sides of mill for reversing
Mill stand low pressure cooling water
HOT ROLLING MILL Single stand Reversing Two high
Mill Scale Analysis (approx.) FeO-55.6% Fe2O3-40.9% Bal. ± 2-4% CaO, MgO, S, O2, Al2O3, Mn, S, P, C
Mill Scale
± 41 kg/metric ton
± 100 lbs/ingot ton
Free Iron
± 80 kg/metric ton
± 120 lbs/ingot ton
Input
9,668 l/kg (2300 gal/ton)
Descaling water tramp oil & greases
Oils-0.20 gal/ingot ton
SCALE PIT
HOT FORMING-PRIMARY BREAKDOWN MILLS BLOOMING & SLABBING MILLS
Rolled Product
MILL TABLE RUN-OUT ROLLS
4,676 l/kg (1,00 gal/ton)
SCARFER HOOD See Fig III-B for scarfer process flows
SCARFER FLUME
Spray Water
SLAB OR BLOOM SHEAR
Crop Ends
COOLING BEDS & RUN-OUT TABLES
BLOOM OR SLAB WEIGH SCALE
(1) TON FINISHED PRODUCT
To storage yard
To plate mill
To hot strip mill
Slabs
Blooms
Scrap Bin
To steelmaking facilities
CROP ENDS TO RECYCLED SCRAP
±100.2 kg/metric ton (±200 lbs/ingot ton) input to mill
To storage yard
To billet mill
To bar mill
To rod mill
To structural & rail mill
To wide flange beam mill
SECONDARY FINISHING & SHAPING MILLS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
HOT FORMING
PRIMARY MILLS
PROCESS FLOW DIAGRAM
Dwn. 8/14/79
FIGURE III-2

Attachment B

Iron and Steel Manufacturing Wastewater Standards

The United States Environmental Protection Agency (U.S. EPA) has established numerical "effluent limitations" for several segments of the iron and steel manufacturing industry. Numerical limits have been established for facilities that discharge treated effluent directly to a receiving water. There are also limits for facilities that discharge wastewater to a municipal treatment plant.

The limitations established by U.S. EPA are based on an evaluation of the "best available treatment (BAT)" for the types of wastes generated by the iron and steel manufacturing industry. U.S. EPA gathered data on the performance of well operated treatment systems, statistically evaluated these data, and developed effluent limitations reflective of treatment system performance. Limitations are published in "production-based" format; thus, each facility will receive unique mass or concentration-based limits depending on the production rate at the facility. Unique limitations are developed for both a "daily maximum" (average over a calendar day), and a "monthly average" (average over a calendar month). Selected U.S. EPA iron and steel manufacturing effluent limitations that would apply to a facility conducting steelmaking by electric arc furnace, continuous casting, and hot rolling are provided in Table B-1 below.

Facility specific limits are imposed and enforced by the government through discharge permits. In addition, municipal governments may establish more stringent numerical limitations than the U.S. EPA limitations for industries that discharge to the municipal sewer system. These limitations may be based on the treatment capacity of the municipal treatment plant or on the technology available to industrial user to control its discharge. In the United States permits issued to the industries are enforceable by the Federal, State and local governments and private citizens.

Discharge standards that apply to iron and steel facilities in Turkey, Japan, and Germany are presented in Tables B-2, B-3, and B-4, respectively.

Table B-1 Selected EPA Effluent Limitations
for the Iron and Steel Industry

	TSS	pH	Pb	Zn	O&G
Steelmaking - EAF, semi-wet APC	ND	ND	ND	ND	-- --
Steelmaking - EAF, wet APC	0.0687 0.0229	6.0 - 9.0	0.000413 0.000138	0.000620 0.000207	-- --
Continuous casting	0.0780 0.0260	6.0 - 9.0	0.0000939 0.0000313	0.000141 0.0000469	0.0234 0.0078
Hot forming - primary mills without scarfing	0.150 0.0561	6.0 - 9.0	-- --	-- --	0.0374 --
Hot forming - section mills	0.357 0.134	6.0 - 9.0	-- --	-- --	0.0894 --

ND - No discharge
-- - No effluent limitation established
EAF - Electric arc furnace
APC - Air pollution control

Source: U.S. EPA

Table B-2 Wastewater Standards for Iron and Steel Industry in Turkey

Wastewater standards for general iron and steel production

Parameter	Instant sample (mg/liter/ton)	Composite sample (mg/liter/ton)
Chemical oxygen demand		100
Oil and grease		20
Settleable solids	0.5	
Lead		0.5
Iron		20
Zinc		4
pH	6 - 9	6 - 9

Wastewater standards for metal industry (foundries and casting plants)

Parameter	Instant sample (mg/liter/ton)	Composite sample (mg/liter/ton)
Chemical oxygen demand	200	150
Suspended solids	150	100
Oil and grease	20	10
Cadmium	1	
Mercury		0.5
Zinc	5	
Lead	2	
Copper	2	
ron	10	
Total chromium	2	
Hexavalent chromium	0.5	
Arsenic	0.1	
Aluminum	3	2
Nickel	3	
otal cyanide	0.1	
H	6 - 9	6 - 9

rce: Onur, S., "Organisation and Management of Environmental Policies and Strategies for the Iron and l Industry in Turkey," Environmental Control in the Steel Industry, International Iron and Steel Institute, ssels, 1992.

Table B-3 National Effluent Standards in Japan

Parameter	Standard (mg/liter)
arsenic	<0.5
cadmium	<0.1
copper	<3
cyanide	<1
hexavalent chromium	<0.5
dissolved iron	<10
lead	<1

Table B-4 Effluent Standards in Germany

Parameter	Standard
pH	6.5 - 9.5
sulfate	600 ppm
zinc	3 ppm
tin	3 ppm
lead	3 ppm
total chromium	2 ppm
hexavalent chromium	0.5 ppm
substances extracted by petroleum ether	20 ppm
temperature	30°C

Source: Schmidt, Artur, et. al. "Specialized Water Treatment for Environmental Control of Pickle Lines, Galvanizing Lines and Cold Rolling Mills", Iron and Steel Engineer, Vol 59, No. 3, pp.33-38, 1982.

Attachment C

Selected Papers on Pollution Control in the Iron and Steel Manufacturing Industry

NOTICE: This material may be protected by copyright law. (Title 17 U.S. Code)

Bengtsson, B., et. al. "Wastewater Treatment at Swedish Steel Mills", Journal Water Pollution Control Federation, Vol 47, No. 4, April, 1975. Reprinted with permission from Water Environment Federation.

Robertson, J. H., et. al. "Total Wastewater Control in a Large Integrated Steel Mill", Journal Water Pollution Control Federation, Vol. 51, No. 2., February, 1979. Reprinted with permission from Water Environment Federation.

Lu, W-K. "Recycling in Steel Plants and New Process Development", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 23-31, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Shinoda, Sakuei. "Total Raw Materials and Energy Recycling System of Newly Built Keihin Works", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp 32-47, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Pasztor, Laszlo. "Generation and Recycling of Pollution Control Residues in the Steel Industry", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 48-54, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Harris, Morley M. "The Use of Steel-Mill Waste Solids in Iron and Steelmaking", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 62-71, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Weidner, Thomas H. and John W. Kreiger. "Development and Application of the Green Pelletizing Process to Produce Agglomerates for BOF and Open Hearth Use", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 72-76, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Kaiser, F. T. and L. L. French. "Supplementary Hot Metal from Waste Oxides", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 77-84, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Eichberger, Heinz, et. al. "Production of Sponge Iron from Rolling Mill Scale According to the SL/RN Process", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers, Volume 1, pp. 104-108, March 25-26, 1980. Reprinted with permission from American Institute of Mining, Metallurgical and Petroleum Engineers.

Hunter, Rex A. "Technical Aspects of Waste Oil Reclamation", Recycling in the Steel Industry, Proceedings of the 1st Process Technology Conference, American Institute of Mining, Metallurgical, and Petroleum Engineers,